

Editorial Introduction

Robin Mackay

A new publication is obliged to justify its demands on the attention of a reader already besieged by countless specialist journals. This justification cannot appeal to the orgiastic logic of the filling of market ‘niches’. With **COLLAPSE** we have set out to achieve quite the opposite, aiming rather at a breadth and an openness found wanting.

That academic philosophy courts overspecialisation and a certain depression of the energy of thought is news to no-one. Whilst not wishing to denigrate the necessary and exacting work of scholarship, we wished to create a publication which communicated the passion for thought, and the excitement of thinking. The work we present here is unapologetically (and not unnecessarily)

COLLAPSE I

demanding: we conceived **COLLAPSE** as providing a home for conceptual work in progress, with all the rough edges this might imply.

COLLAPSE is an experimental entity, in that it has no fixed agenda, no institutional ties, no partisan position: nevertheless it will be clear that neither the Editor nor the contributors regard this experimental status as the declaration of an open season for ludic enthusiasms. But as much as we did not wish merely to collate flights of philosophical whimsy, we also sought to avoid grounding ourselves in the ‘application’ of overgeneralised theoretical tropes to specific issues in pursuit of that most dismal of goals, ‘relevance’ to the ‘contemporary’ reader.

What was clear from the start was that the way forward lay in rigorously challenging philosophical thought by confronting it with conceptual production from elsewhere (and not in a presumptuous relation of ‘application’): there is no doubt that philosophy only stays alive by maintaining porous boundaries with its outside—this does not detract at all from its specificity and value as a discipline.

If part of the problem with philosophy today lies in its professionalisation, we hope not to offend any of the contributors to this volume by saying that we consider every one of them to be *amateurs* in the true sense: dedicated and enthusiastic lovers of abstract thought, each engaged in adventures of ideas, each refusing to contain these adventures within strict formal or

Editorial Introduction

disciplinary boundaries. It should go without saying that, even if the two are rarely found in pure form, we favour *de jure* mad scientists with their bubbling conceptual cauldrons over career academics with their meticulously cautious conference papers.

Finally, we envisage each volume of **COLLAPSE** as the intersection, in a multi-dimensional space, of diverse lines of thought; the optimum circumstance would be if each reader picked up **COLLAPSE** on the strength of only one of the articles therein, the others being involuntarily absorbed as a kind of side-effect that would propagate the eccentric conjuncture by stealth, and spawn yet others.

A note on form: in several of the articles collected in **COLLAPSE I** we have used the interview form, and hope to do so in future. At its best it offers a medium in which the play of concepts takes a natural course and order of exposition, allowing the reader in turn to be swept up by its movement, and to reconstruct its underlying consistency at their leisure and with their own resources. Such an interview should read lightly whilst its spontaneous discursive complexity will be conducive to repeated readings.

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Although we decided early on that eclecticism was neither to be scorned nor feared, a theme emerged, unbidden, during the long process of clarifying the journal's aims and collecting and commissioning work for this first volume. The working title was thus 'numerical

COLLAPSE I

materialism’: an inquiry into the extent and nature of number’s dominion over any philosophy calling itself a materialism; but also an inquiry into the materiality of number and numerical practices. Such a theme describes a realm exemplary in its liminal nature, not only connecting mathematics and philosophy but abutting onto every theoretical discourse with any aspiration to formal rationality.

We are privileged to have amongst our contributors ALAIN BADIOU, widely recognised as one of the most important philosophers alive today, and one who has consistently pursued this line of thought, often against the grain of philosophical orthodoxy. In our interview with Badiou we seek to clarify the consequences of a materialist thought which defines ‘nature’ through mathematics, determining ‘history’ in terms of its problematic ‘outside’. We also succeed in provoking Badiou into addressing in detail some of the major objections raised against his doctrine, and into elaborating more precisely how he sees mathematics in its relation to other sciences. He also speaks of the new conceptual resources which his latest book *Logiques des mondes* brings to his ongoing work.

Although we have made clear our aspiration for the volume as a whole, this opening interview, together with the contributions of GREGORY CHAITIN and MATTHEW WATKINS particularly demonstrate the sort of conjunction we hope to effect with **COLLAPSE**: it would be difficult to find any other publication in which these

Editorial Introduction

could be found together. Here are three thinkers whose differences are not limited to their theoretical decisions but extend to their styles, and their respective conceptions of the nature of their subject. Despite this divergence, a number of common threads means that reading them together produces a combination that is more than the sum of its—already considerable—parts.

To say that GREGORY CHAITIN is well-known in his field would be to tell only half the truth: in fact Chaitin has for many years been something of a gleeful maverick. Whilst there can be no doubt as to his credentials as a ‘serious mathematician’ Chaitin not only enjoys communicating his mathematical discoveries to a wide an audience as possible, but he also never fails to draw from them (sometimes to the chagrin of fellow mathematicians) the most general speculative conclusions—just as did Leibniz, the very figure invoked in Chaitin’s whirlwind review of ‘Epistemology as Information Theory’.

Our interview with MATTHEW WATKINS is the very portrait of a thinker who defies categorisation. Watkins’s singular talent at explaining complex concepts and his fluid, resolutely non-specialist speculative exploration of their significance makes of this interview a kind of conceptual cinematography, and made conducting it a genuine pleasure. As the engineer of a virtual agency which collects and catalyses material in an area of research which has only recently begun to condense, Watkins exemplifies well what was intended by the provocative subtitling of **COLLAPSE** as a ‘Journal

COLLAPSE I

of Philosophical Research and Development': thought no longer takes place in the head—if it ever did—but involves the development of distributions and connections, a bio-techno-cognitive rhizome. Watkins also fiercely advocates the virtues of a marginal position which allows him the maximum space for reflection; as well as his substantive work we discuss the experiences formative of this conviction.

Badiou raises the question of the experiment: scientists continually set parameters and contexts for their experiments. Chaitin argues—and Watkins observations seem to support the thesis—that mathematics may also be, or may become, an experimental discipline. In NICK LAND's contribution, the meta-rational orthodoxies of experimental practice are themselves put to the test. Can the interrogation by an exotericised qabbalistics of the lexicographical element in which we are inscribed be denied the status of a science on the basis of utilitarian criteria? A delirious alphanumeric arithmetic...

The liberal media, with its indefatigable good intentions, has continually sought wholly to separate the ideology of terrorism from the tenets of a (poorly-defined) 'true' Islam. Whilst leaving no doubt as to the contingency of the circumstances, in his article for **COLLAPSE I** REZA NEGARASTANI describes the mutation, hybridisation and militarization of certain components of Islamic thought. The mongrel nature of this terrible conceptual assemblage makes it all the more remarkable that Negarastani ultimately refers it to a mathematical

Editorial Introduction

model; a veritable *mathesis* of fear.

The psychoanalyst and philosopher Lacan famously described his project as being that of a ‘mathematisation of the unconscious’—a research programme that ended, if not in madness, certainly in an obscurity which endures to this day. In his ‘Mathematics of Intensity’ THOMAS DUZER picks up some of the threads of this project, inflecting it with an affirmative stance which militates against much of the psychoanalytical inheritance.

NICK BOSTROM heads an intriguing new research initiative where philosophical thought is put to work on issues formerly the quarry of inconsequential media panics and politicians platitudes; issues of truly unimaginable magnitude. Whilst such initiatives are no doubt to be applauded, we were interested to explore in our interview with Bostrom not only the work of his *Future of Humanity Institute* but also to ask whether philosophical thought must make compromises in order to break its traditional academic bonds.

KEITH TILFORD’s graphical work draws on philosophical debates in poststructuralism: his ‘crowd’ drawings evoking especially the ongoing debates over the nature of multiplicity and individuation. ‘INCOGNITUM’ not only relates some intriguing details of numerical-cultural archaeology, but has also compiled for us a selection of source materials in the shape of ABJAD diagrams. It was always our intention that **COLLAPSE** should not be purely textual, which makes these last two

COLLAPSE I

contributions are especially welcome.

It remains only to thank the contributors for their work and their patience during the assembling of this volume; and the reader for supporting this new venture.

In relating so expansively our aspirations for **COLLAPSE**, we do not dare to hope, nor do we mean to claim, that this first volume fulfills them all. At least the experiment is now underway; the Editor welcomes your responses and contributions for future volumes.

Robin Mackay,
Oxford, August 2006.

Philosophy, Sciences, Mathematics

Interview with Alain Badiou

Alain Badiou's radical equation of ontology—the traditionally philosophical 'account of being'—with mathematics claims to free philosophy for its contemporary task of interrogating the relation between the being which mathematics describes, and the events whose very 'impossibility' structures that being.

In the corollary distinction between the mere 'veridicality' of knowledge and the hazardous revolutionary decisions which found new truths, and in Badiou's account of the work of founding and remaining faithful to truth-procedures—in which humans finally become subjects—are rightly discerned a truly novel configuration of political thought.

*However Badiou is also a penetrating and formidably knowledgeable philosopher of science and mathematics; and his meticulous dedication to following these disciplines' own 'truth procedures' has informed his work from the very beginning of his philosophical career through to 2006's *Logiques des mondes*¹.*

Collapse asks Badiou to expand on the articulation of philosophy, mathematics and science his 'mathematical ontology' assumes; and what its consequences might be for the 'other' sciences.

1. Alain Badiou, *L'être et l'événement, tome 2: Logiques des mondes*. Paris:Seuil, 2006.

COLLAPSE I

COLLAPSE: In an interview with Peter Hallward published in 1998, you say:

In the last instance, physics, that is to say the theory of matter, is mathematical. It is mathematical because, *qua* theory of the most objectivised strata of the presented as such, it is concerned with being *qua* being in its mathematicity.”²

If mathematics as science of being *qua* being provides scientific access to the presented, does that mean that mathematics provides the paradigm of ‘scientificity’? And are we to understand that the degrees of objectification of what is presented (‘being’) correspond to degrees of mathematisation of scientific discourse?

ALAIN BADIOU: It is undoubtedly more complicated than that. We must begin again from the distinction, which I have fully developed in *Logiques des Mondes*, between being and being-there, or between being and appearing. A world is structured not only by the pure multiples which appear in it (which ‘are’ in it), but by the logical organisation of that world, what I call its transcendental. So that every particular figure of what, in the 1998 interview, I called the ‘presented’, is the intersection of two formal rationalities. I propose to call “mathematical” ontological rationality—that rationality which concerns being *qua* being, that is, the indifferent

2. ‘Politics and Philosophy: An Interview with Alain Badiou’ *Angelaki: Journal of the Theoretical Humanities*, Vol.2, No.3, 1998, p. 127.

multiple. Phenomenological rationality—that which concerns being *qua* appearing in a world—I call ‘logical’.

Of course, this logic is itself mathematicised, as is every logic today. But the distinction remains, a distinction whose criteria I have proposed in several of the texts included in *Court traité d’ontologie transitoire*³. We can say ultimately that a kind of objectification, a becoming-object, of pure being is inscribed within a singular correspondence between mathematics and logic—which ultimately means: between set-theory and Topos-theory. It being understood that these *Topos* realise a transcendental indexation of multiples to a sort of intensity evaluator, which in the current state of science, might be a complete Heyting algebra—for which English logicians have found the inspired name (since it effectively concerns the ‘site’ of being) of ‘locale’.

So we cannot simply say that objectification is proportional to mathematicity. The new concept that I propose of what an object is (‘object’ is a key concept in *Logiques des mondes*) combines a purely mathematical element and a transcendental element which relates to the singularity of the world within which the object figures.

C: Readers of your work might be forgiven for suspecting that you hold physics in far higher regard than biology, that ‘wild empiricism disguised as a science’⁴.

3. Paris:Seuil, 1998. Translated by Norman Madarasz as *Briefings on Existence: A Short Treatise on Transitory Ontology*. NY: State University Press, 2006.

4. Mathematics and Philosophy: The Grand Style and the Little Style’ *Theoretical Writings*, eds. R. Brassier and A. Toscano, London: Continuum, 2004, p. 16.

COLLAPSE I

There follow two further series of questions from this.

Firstly, concerning the relations between your ontological 'Platonism' (given that the latter effects an unexpected transformation of orthodox Platonism) and epistemological 'foundationalism' or 'reductionism'.

Secondly, the relation between your Platonic/Cartesian 'rationalism' and the 'naturalism' of contemporary cognitive science which inquires into the genesis of intelligence; an inquiry whose ultimate ambition is perhaps the reinscription of rationality itself (and hence of mathematical intelligence) within the domain of natural being (if not biology *stricto sensu*).

(1) If you advocate a 'foundationalist' view on the unity of 'Science', with the set-theoretical axiomatic at the base, then mathematical physics, chemistry, biology, etc. embedded one after another on successive strata according to a decreasing order of 'mathematicisation', do you think that this unity requires the reducibility of these sciences either to physics, or even to mathematics in the last instance?

And do you consider physical phenomena to be more 'fundamental' than biological phenomena because of these decreasing degrees of 'mathematicisability'? If so, don't you run the risk of making the coherence of science depend ultimately upon the reducibility of superstructures to an infrastructure, whether physical or mathematical? As you know, this idea of reduction remains highly problematic even within the natural

sciences (for example the well-known difficulties concerning the reduction of ‘emergent’ properties).

Or is it rather that this ‘foundationalist’ and ‘reductionist’ perspective only holds for you within mathematics, that is to say for the relations between set-theory (or category-theory) and other mathematical domains?

(2) In *Being and Event*⁵, you say that the thesis affirming the identity of mathematics and ontology is ‘a thesis not about the world, but about discourse.’⁶ No ‘Pythagorism’, then. On one hand, it might seem that this thesis claims to undo all the false problems engendered by the empiricist presupposition of a representational relation between discourse, or science, and reality; but, on the other, can we content ourselves merely with ‘sublating’ the difference between discourse and reality *within* a discourse (which, in *Being and Event*, remains ‘metaontological’ or philosophical rather than ‘ontological’ in the strict sense) without falling into absolute idealism?

How can we account for the position of mathematical and scientific ‘discourse’ given that, for you, the latter is not fundamentally linguistic, and so is not merely an artefact of cultural provenance; nor a natural and/or divine faculty, as intellectual intuition would be?

Don’t the Darwinian revolution and the emergence of

5. Alain Badiou, *L'être et l'événement*. Paris:Seuil, 1988. Translated by Oliver Feltham as *Being and Event*. London: Continuum, 2005.

6. *Being and Event*, Introduction.

COLLAPSE I

cognitive science as a natural science treating reason as a material phenomena—even if the ‘materiality’ in question is perhaps not simply neurobiological—oblige us at least to try to take account of this scientific and mathematical ‘discursivity’?

And in this regard, could it be that the ‘sciences of complexity’ or ‘self-organisation’, which try to apply mathematical modelling techniques to complex phenomena—vital, social, cultural, or even (above all) cognitive—could reduce the gap that you posit in *Being and Event* between the transitivity of natural sets, that is to say the homogeneity of nature, and the discontinuity of cultural situations, that is to say the heterogeneity of history? Wouldn’t this ultimately be a way of assuring a maximum coherence between sciences and the science of being without the need for the impracticable ideal of reduction? Or does such a perspective seem far too Deleuzian-vitalist to you?

AB: First of all I would like to say that my perspective is not in the least ‘foundationalist’ or reductionist. From the ontological dimension of mathematics I draw no conclusion as to its superiority, its capacity to found the other sciences, or their status as the ‘basis’ for all scientificity. I say only that mathematics are the rational discourse on being *qua* being, or on the indifferent multiple thought as such.

Now, as you know, for me, a concept as general and

essential for all thinking of the sciences as that of truth is not at all reducible to ontology as such. We must even admit that it explicitly contradicts certain of its formal axioms, just as Lucretius's clinamen contradicts the major axioms of atomist and materialist ontology.

In fact, I have often compared the absolute hazard of the event, subtracted as it is from the general determinations of being, to this clinamen, required for the assemblage of atoms to be thought as generic truth of worlds.

From all this, it follows simply that mathematics is a necessary formal dimension of all scientific discourse, if we understand by 'science', for the moment, the rational theory of those phenomena in the world which do not depend directly upon the conscious activity of man. Those phenomena pertaining, if you like, to the 'fossil argument', whose implacable rigour Quentin Meillassoux has deployed against every form of correlationism, or of the constitutive primacy of consciousness.⁷ The mathematical exigency is formal, in so far as it supports, as to the intelligibility of these phenomena, their most abstract and most general strata, that which relates to their pure being, to their multiple composition. But, precisely, this strata cannot, in my view, represent that which is strongest and most 'true' in those sciences which are not purely mathematical. Take physics: the most elementary axioms of modern mathematical physics, let's

7. See Quentin Meillassoux, *Après la finitude : Essai sur la nécessité de la contingence*. Paris:Seuil, 2006

COLLAPSE I

say the principle of inertia as given by Galileo's formula, are not at all reducible to mathematical statements, even if they are obliged to take that form. A crucial point about physics is to present, to create concepts, so that they can be mathematically expressible, all the while retaining a relation to the world which means that they cannot be deduced from any mathematical corpus whatsoever. This is the case with the concept of uniform movement in the principle of inertia. Moreover, it is this irreducible worldly dimension which opens onto the possibility of experience, at the same time as mathematical formalisation guarantees the universality of experimental results, in the form of their always-possible repetition. All this, in my view, was thought in the most subtle and decisive fashion by Bachelard, and it is a great shame that anglophone epistemology has done such a thorough job of neglecting his work.

So: I neither believe that physics is 'reducible' to mathematics, nor do I believe that mathematics 'founds' physics. Between the two, there is a rooting of concepts in a determinate world, which the experimental method designates and delimits, in a gesture which is of a transcendental nature.

Nor do I have any reason to think that physics 'founds' biology, still less that mathematics could do so. That biology, to say nothing of the 'human sciences', are still not sciences, does not result from the fact that they are not yet in a position to propose mathematical formalisms appropriate to experimentation. This formal

deficiency is only a secondary symptom. The root of the problem is that their concepts are wholly insufficient, that they fail completely to present the phenomena concerned in the register of eternal truths.

In the case of biology, the possible founding intuitions all go back to Darwin. Mendel's experimental expertise opened another path, albeit one that is limited unless it is inscribed in the vast Darwinian innovation, which no-one to this day has succeeded in doing, unless it be in pre-conceptual approximations, purely rhetorical combinations of chance and necessity. The veritable conceptualisation of all this is yet to come. Naturally, there exist within this domain countless instances of knowledge, which are translated into remarkable technical skills, particularly in the medical field. But there is no science. To turn this domain into a science, some unforeseeable events would be required, a second post-Darwinian foundation, whose shape we cannot anticipate. In the meantime, we can say that there exist two sciences which cannot be hierarchised: ontology, or pure mathematics, and physics, the science of those worlds accessible to our experience.

As for cognitive science, I would like to make three remarks. Firstly, it is a programme rather than a theory. Even more so than biology, it is just a mass of facts and techniques, devoid of concepts or adequate formalisms. The truth is that we remain totally ignorant as to the real functioning of the brain. From what I know of the current state of research in cognitive science, I feel justified in concluding that, despite an impressive

COLLAPSE I

technical arsenal, it is no more advanced in its understanding of the phenomena than was Gall's phrenology, at the time when Hegel said the latter thought it had proved that 'spirit is a bone'. Today we think we have proved that thought is a neuron...Cognitive science is hardly further advanced than the theory of cerebral localisations in Broca, even if the active zones appear today in bright colours, displayed directly onto screens.

Secondly, that human intelligence should be a 'material' phenomenon is in my eyes a mere truism. What else could it be? I am, if this is the issue, completely monist. I do not think that any principle of being can 'double' indifferent multiplicities. What's more, I always speak of the 'human animal' when speaking about us, including even our most sophisticated cognitive activities.

And this leads me to the third point. Let me repeat: the fact that intelligence, as a faculty, is a material assemblage is self-evident and of no interest. However, that the question of truths relates to intelligence, or to the 'cognitive' in general, is a philosophical (not at all a scientific) statement, and a statement I believe to be completely false. *Qua* generic localised process, a truth is not at all reducible to anything whatsoever which takes the form of a human capacity or property, in the sense of the human animal.

To claim that it does is to remain within the legacy of Aristotelianism, Kantianism and analytic philosophy, which would locate truth in the form of judgment, with the latter in turn being a product of cognitive

mechanisms. Whereas, as the other tradition saw—the Platonic, Cartesian, Hegelian tradition—a truth cannot be encapsulated in the form of judgment at all. It is a complex process, completely transcendent to the mere animal capacity of cognitive judgment. In my own conception, this process combines, ontologically, the possibility of generic multiplicities, and phenomenologically, the intraworldly constitution of post-evental bodies (in fact, of sheaves, in the modern algebraic sense, sheaves which ‘rise’ from the transcendental logic of worlds towards the objective multiplicities engaged in the procedure).

Since every truth is in-human, we can hardly hope to understand its genesis by poking around in the neurons of our brains!

I would like to add that to reduce thought to nature is in general a tautology, or a contradiction. If you understand by ‘nature’ the material state of all that is, it is a tautology: thought is certainly a part of that state. If you understand by ‘nature’ that which, precisely, pre-exists all thought, then it is a contradictory reduction.

C: Finally, two questions bearing principally on your *Le Nombre et les nombres*⁸. The distribution of prime numbers appears to be one of the irrecusable ‘ontological’ characteristics arising immediately from the construction of the natural numbers, but to this day it has proven

8. Alain Badiou, *Le Nombre et les nombres*. Paris:Seuil, 1990.

COLLAPSE I

resistant to our understanding. The Riemann Hypothesis suggests that complex numbers provide a refractory element through which it becomes possible to understand the prime distribution as a type of order. If we are to speak of ontology in this context, doesn't this oblige us to extend ontological dignity to complex numbers? But when you speak of number, you explicitly exclude complex numbers, along with quaternions, from the properly ontological domain⁹.

Historically, the affirmation of complex numbers *as* numbers, with all the consequences which followed, would seem indeed to be an example of a mathematical 'event'. Yet you reject it on the basis of its supposed intimate relation with geometry.

Now, even if (as is undoubtedly the case) it is precisely the geometrical and diagrammatic aspect of the complex plane which has inspired mathematicians and physicists, it is possible to conceive them independently of this usage. However, must we not consider the implication of physics, mathematics and geometry (or more generally, the diagram) from which the incontestable power of the complex plane arises?

It seems that the prime distribution is a profound mystery concealed within the apparently simple: the series of natural numbers. Alain Connes, among others, suggest that the apparent obscurity of the Riemann Hypothesis stems from as-yet uncomprehended aspects of the relation between simple addition and

9. *Le Nombre et les nombres*, Ch. XVI, n.5

multiplication.¹⁰

Meanwhile, recent work indicates astonishing consonances between the theoretical models of physics and Riemann's zeta function¹¹. This seems to suggest, again, that the relation between mathematics and physics is not simply hierarchical, and furthermore, that the most fundamental ordering mechanisms in the universe do not necessarily coincide with our most analytically elegant accounts of order.

So where does the ontological begin and end? If we apply your criteria of ordinal linearity, don't we risk a premature foreclosure of ontology in the interests of elegance and philosophical taste, whilst rejecting the structures of the real—sometimes of an intimidating complexity, refractory to all intuition, such as Connes' *adele*—but which, from a point of view which we might call abstract-empirical, are imposed upon us by fundamental research in the domains of theoretical physics and mathematics?

AB: We must immediately correct a misinterpretation, perhaps owing to ambiguities in my writing, but no less massive for that: I have never thought that numbers were the highest form of ontological 'dignity'! Even less have I underestimated the mathematical—and thus ontological—importance of complex numbers, of diagrams, of topology! Absolutely not! I even argued with Deleuze

10,11. See 'Prime Evolution', in the current volume.

COLLAPSE I

on this point, in our unpublished correspondence. He held that in ‘reducing’ multiplicities to sets, I reduced them to numbers. I replied to him that if numbers are all, in their being, sets, it would be quite wrong to conclude that all sets are numbers. The innate resources of set-theoretical multiplicity vastly exceed the concept of number.

As for complex numbers, I simply meant that they are exterior to the simple concept of number, which, in the sense I use it, includes order, comparison, and the notion of ‘larger’ and ‘smaller’, even when numbers are infinitely large or small. The fact that the field of complex numbers is not be an ordered field justifies this exclusion. Far from indicating a lack of dignity in complex numbers, this exclusion amounts to a further limiting of the properly numerical domain, and hence of further separating it from the ontological domain in its full extension. That complex numbers are sets, and hence thinkable as such in their being, is evident: it is a question, as we know, of the set of ordered pairs of real numbers.

I would like to add that when I say that the concept of number cannot be geometrical I am in no way—*heaven forbid!*—speaking against geometry! I have always indicated, from *Théorie du sujet*¹² onward, that the mathematical dialectic is that of algebra and topology, or, if one is Greek, arithmetic and geometry. And I know very well

12. Alain Badiou, *Théorie du sujet*. Paris: Seuil, 1982.

that today the most profound mathematics operates at the level of algebraic topology, a structural combination of the two great components of historical mathematics. And in fact this is the register from which my new concepts ('transcendental', 'object', 'relation', 'evental field') draw their force. The results you mention which clarify number theory on the basis of the geometry of the complex plane or of highly sophisticated Analysis, perfectly illustrate this point.

But I do not speak of the mathematics of numbers in *Le Nombre...*, but only of what philosophy might draw from contemporary mathematics as to what a generic concept of Number might be.

Meanwhile, let us note that mathematicians always prefer, in arithmetic, an 'elementary' demonstration to one that is not. And what is an 'elementary' demonstration? An immanent demonstration, more or less directly derivable from the concept of whole number, and the rules of its operational domain.

In this regard, I agree with Connes: the heart of the question of prime numbers is that the operational dialectic of multiplication and addition, however perfectly clear from the axiomatic point of view, has yet to arrive at its true concept. There is there a deficiency of thought on the algebraic side. That this opacity might be overcome by the diagrammatic or geometrical aspect is quite possible.

My own approach clearly shows that what is opaque

COLLAPSE I

in numbers is not at all their definition, which, as I believe I have demonstrated, is very simple, even if you take the most gigantic numerical domain. What is obscure lies on the side of operations. Now, the concept of 'prime number' is a typically operational concept. To which we must add that it is largely negative (to not be divisible by any number other than itself or unity). I would be happy to propose the following heuristic principle: in pure mathematics, what is most difficult is always linked to a restriction (and thus to a negation) of operational capacities.

I will conclude by giving you a very simple account of physics' retroaction upon mathematics. There is nothing unusual about this: presented with the mathematical formalisation of concepts which only make sense in relation to a world which is not that of pure mathematics (concepts such as: 'movement', 'speed', 'light', and so on), physics requires of mathematics a sort of internal torsion, which introduces into its world (for it is a singular world) pure conceptual analogies with that which, initially, does not belong in this register. The clearest contemporary example is undoubtedly provided by quantum group algebra, a totally abstract and very exacting discipline, which would neither have existed, nor found its name, without quantum physics.

Translated by Robin Mackay and Ray Brassier

Epistemology as Information Theory: From Leibniz to Ω

Gregory Chaitin

The following text was originally delivered as the Alan Turing Lecture on Computing and Philosophy at E-CAP '05, the European Computing and Philosophy Conference, at Mälardalen University, Västerås, Sweden in June 2005.

INTRODUCTION

I am happy to be here with you enjoying the delicate Scandinavian summer; if we were a little farther north there wouldn't be any darkness at all. And I am especially delighted to be here delivering the Alan Turing Lecture. Turing's famous 1936 paper is an intellectual milestone that seems larger and more important with every passing year. People are not merely content to enjoy the beautiful summers in the far north, they also

COLLAPSE I

want and need to understand, and so they create myths. In this part of the world those myths involve Thor and Odin and the other Norse gods. In this talk, I'm going to present another myth, what the French call a *système du monde*, a system of the world, a speculative metaphysics based on information and the computer.¹

The previous century had logical positivism and all that emphasis on the philosophy of language, and completely shunned speculative metaphysics, but a number of us think that it is time to start again. There is an emerging digital philosophy and digital physics, a new metaphysics associated with names like Edward Fredkin and Stephen Wolfram and a handful of like-minded individuals, among whom I include myself. As far as I know the terms “digital philosophy” and “digital physics” were actually invented by Fredkin, and he has a large website with his papers and a draft of a book about this. Stephen Wolfram attracted a great deal of attention to the movement and stirred up quite a bit of controversy with his very large and idiosyncratic book on *A New Kind of Science*.

And I have my own book on the subject, in which I've attempted to wrap everything I know and care about into a single package. It's a small book, and amazingly enough it's going to be published by a major New York publish-

1. One reader's reaction (GDC): “Grand unified theories may be like myths, but surely there is a difference between scientific theory and any other narrative?” I would argue that a scientific narrative is more successful than the Norse myths because it explains what it explains more precisely and without having to postulate new gods all the time, i.e., it's a better “compression” (which will be my main point in this lecture; that's how you measure how successful a theory is).

er a few months from now. This talk will be an overview of my book, which presents my own personal version of “digital philosophy,” since each of us who works in this area has a different vision of this tentative, emerging world view. My book is called *Meta Math!*, which may not seem like a serious title, but it’s actually a book intended for my professional colleagues as well as for the general public, the high-level, intellectual, thinking public.

“Digital philosophy” is actually a neo-Pythagorean vision of the world, it’s just a new version of that. According to Pythagoras, all is number – and by number he means the positive integers, 1, 2, 3, . . . – and God is a mathematician. “Digital philosophy” updates this as follows: Now everything is made out of 0/1 bits, everything is digital software, and God is a computer programmer, not a mathematician! It will be interesting to see how well this vision of the world succeeds, and just how much of our experience and theorizing can be included or shoe-horned within this new viewpoint.²

Let me return now to Turing’s famous 1936 paper. This paper is usually remembered for inventing the programmable digital computer via a mathematical model, the Turing machine, and for discovering the extremely fundamental halting problem. Actually Turing’s paper is

2.Of course, a system of the world can only work by omitting everything that doesn’t fit within its vision. The question is how much will fail to fit, and conversely, how many things will this vision be able to help us to understand. Remember, if one is wearing rose-colored glasses, everything seems pink. And as Picasso said, theories are lies that help us to see the truth. No theory is perfect, and it will be interesting to see how far this digital vision of the world will be able to go.

COLLAPSE I

called “On computable numbers, with an application to the *Entscheidungsproblem*,” and by computable numbers Turing means “real” numbers, numbers like e or $\pi = 3.1415926\dots$ that are measured with infinite precision, and that can be computed with arbitrarily high precision, digit by digit without ever stopping, on a computer.

Why do I think that Turing’s paper “On computable numbers” is so important? Well, in my opinion it’s a paper on epistemology, because we only understand something if we can program it, as I will explain in more detail later. And it’s a paper on physics, because what we can actually compute depends on the laws of physics in our particular universe and distinguishes it from other possible universes. And it’s a paper on ontology, because it shows that some real numbers are uncomputable, which I shall argue calls into question their very existence, their mathematical and physical existence.³

To show how strange uncomputable real numbers can be, let me give a particularly illuminating example of one,

3. You might exclaim (GDC), “You can’t be saying that before Turing and the computer no one understood anything; that can’t be right!” My response to this is that before Turing (and my theory) people could understand things, but they couldn’t measure how well they understood them. Now you can measure that, in terms of the degree of compression that is achieved. I will explain this later at the beginning of the section on computer epistemology. Furthermore, programming something forces you to understand it better, it forces you to really understand it, since you are explaining it to a machine. That’s sort of what happens when a student or a small child asks you what at first you take to be a stupid question, and then you realize that this question has in fact done you the favor of forcing you to formulate your ideas more clearly and perhaps even question some of your tacit assumptions.

which actually preceded Turing's 1936 paper. It's a very strange number that was invented in a 1927 paper by the French mathematician Emile Borel. Borel's number is sort of an anticipation, a partial anticipation, of Turing's 1936 paper, but that's only something that one can realize in retrospect. Borel presages Turing, which does not in any way lessen Turing's important contribution that so dramatically and sharply clarified all these vague ideas⁴.

Borel was interested in "constructive" mathematics, in what you can actually compute we would say nowadays. And he came up with an extremely strange non-constructive real number. You list all possible yes/no questions in French in an immense, an infinite list of all possibilities. This will be what mathematicians call a denumerable or a countable infinity of questions, because it can be put into a one-to-one correspondence with the list of positive integers 1, 2, 3, ... In other words, there will be a first question, a second question, a third question, and in general an N th question.

You can imagine all the possible questions to be ordered by size, and within questions of the same size, in alphabetical order. More precisely, you consider all possible strings, all possible finite sequences of symbols in the French alphabet, including the blank so that you get words, and the period so that you have sentences. And you imagine filtering out all the garbage and being left only with grammatical yes/no questions in French. Later

⁴I learnt of Borel's number by reading Tasic's *Mathematics and the Roots of Postmodern Thought*, which also deals with many of the issues discussed here.

COLLAPSE I

I will tell you in more detail how to actually do this. Anyway, for now imagine doing this, and so there will be a first question, a second question, an N th question.

And the N th digit or the N th bit after the decimal point of Borel's number answers the N th question: It will be a 0 if the answer is no, and it'll be a 1 if the answer is yes. So the binary expansion of Borel's number contains the answer to every possible yes/no question! It's like having an oracle, a Delphic oracle that will answer every yes/no question!

How is this possible?! Well, according to Borel, it isn't really possible, this can't be, it's totally unbelievable. This number is only a mathematical fantasy, it's not for real, it cannot claim a legitimate place in our ontology. Later I'll show you a modern version of Borel's number, my halting probability Ω . And I'll tell you why some contemporary physicists, real physicists, not mavericks, are moving in the direction of digital physics.

[Actually, to make Borel's number as real as possible, you have to avoid the problem of filtering out all the yes/no questions. And you have to use decimal digits, you can't use binary digits. You number all the possible finite strings of French symbols including blanks and periods, which is quite easy to do using a computer. Then the N th digit of Borel's number is 0 if the N th string of characters in French is ungrammatical and not proper French, it's 1 if it's grammatical, but not a yes/no question, it's 2 if it's a yes/no question that cannot be answered (e.g., "Is the answer to this question 'no' ?"), it's

3 if the answer is no, and it's 4 if the answer is yes.]

Geometrically a real number is the most straightforward thing in the world, it's just a point on a line. That's quite natural and intuitive. But *arithmetically*, that's another matter. The situation is quite different. From an arithmetical point of view reals are extremely problematical, they are fraught with difficulties!

Before discussing my Ω number, I want to return to the fundamental question of what does it mean to understand. How do we explain or comprehend something? What is a theory? How can we tell whether or not it's a successful theory? How can we measure how successful it is? Well, using the ideas of information and computation, that's not difficult to do, and the central idea can even be traced back to Leibniz's 1686 *Discours de métaphysique*.

COMPUTER EPISTEMOLOGY: WHAT IS A MATHEMATICAL OR SCIENTIFIC THEORY? HOW CAN WE JUDGE WHETHER IT WORKS OR NOT?

In Sections V and VI of his *Discourse on Metaphysics*, Leibniz asserts that God simultaneously maximizes the variety, diversity and richness of the world, and minimizes the conceptual complexity of the set of ideas that determine the world. And he points out that for any finite set of points there is always a mathematical equation that goes through them, in other words, a law that determines their positions. But if the points are chosen at random, that equation will be extremely complex.

COLLAPSE I

This theme is taken up again in 1932 by Hermann Weyl in his book *The Open World* consisting of three lectures he gave at Yale University on the metaphysics of modern science. Weyl formulates Leibniz's crucial idea in the following extremely dramatic fashion: If one permits arbitrarily complex laws, then the concept of law becomes vacuous, because there is always a law! Then Weyl asks, how can we make more precise the distinction between mathematical simplicity and mathematical complexity? It seems to be very hard to do that. How can we measure this important parameter, without which it is impossible to distinguish between a successful theory and one that is completely unsuccessful?

This problem is taken up and I think satisfactorily resolved in the new mathematical theory I call *algorithmic information theory*. The epistemological model that is central to this theory is that a scientific or mathematical theory is a computer program for calculating the facts, and the smaller the program, the better. The complexity of your theory, of your law, is measured in bits of software:

program (bit string) → **Computer** → output (bit string)

theory → **Computer** → mathematical or scientific facts

Understanding is compression!

Now Leibniz's crucial observation can be formulated much more precisely. For any finite set of scientific or mathematical facts, there is always a theory that is exactly as complicated, exactly the same size in bits, as the facts themselves. (It just directly outputs them "as is," without

doing any computation.) But that doesn't count, that doesn't enable us to distinguish between what can be comprehended and what cannot, because there is always a theory that is as complicated as what it explains. A theory, an explanation, is only successful to the extent to which it compresses the number of bits in the facts into a much smaller number of bits of theory. Understanding is compression, comprehension is compression! That's how we can tell the difference between real theories and *ad hoc* theories⁵.

What can we do with this idea that an explanation has to be simpler than what it explains? Well, the most important application of these ideas that I have been able to find is in metamathematics, it's in discussing what mathematics can or cannot achieve. You simultaneously get an information-theoretic, computational perspective on Gödel's famous 1931 incompleteness theorem, and on Turing's famous 1936 halting problem. How?⁶

Here's how! These are my two favorite information-theoretic incompleteness results:

- You need an \mathcal{N} -bit theory in order to be able to prove that a specific \mathcal{N} -bit program is “elegant.”
- You need an \mathcal{N} -bit theory in order to be able to determine \mathcal{N} bits of the numerical value, of the base-two

⁵ By the way, Leibniz also mentions complexity in Section 7 of his *Principles of Nature and Grace*, where he asks the amazing question, “Why is there something rather than nothing? For nothing is simpler and easier than something.”

⁶ For an insightful treatment of Gödel as a philosopher, see Rebecca Goldstein's *Incompleteness*.

COLLAPSE I

binary expansion, of the halting probability Ω .

Let me explain.

What is an elegant program? It's a program with the property that no program written in the same programming language that produces the same output is smaller than it is. In other words, an elegant program is the most concise, the simplest, the best theory for its output. And there are infinitely many such programs, they can be arbitrarily big, because for any computational task there has to be at least one elegant program. (There may be several if there are ties, if there are several programs for the same output that have exactly the minimum possible number of bits.)

And what is the halting probability Ω ? Well, it's defined to be the probability that a computer program generated at random, by choosing each of its bits using an independent toss of a fair coin, will eventually halt. Turing is interested in whether or not individual programs halt. I am interested in trying to prove what are the bits, what is the numerical value, of the halting probability Ω . By the way, the value of Ω depends on your particular choice of programming language, which I don't have time to discuss now. Ω is also equal to the result of summing $1/2$ raised to powers which are the size in bits of every program that halts. In other words, each K -bit program that halts contributes $1/2^K$ to Ω .

And what precisely do I mean by an N -bit mathematical theory? Well, I'm thinking of formal axiomatic theories, which are formulated using symbolic logic, not in

any natural, human language. In such theories there are always a finite number of axioms and there are explicit rules for mechanically deducing consequences of the axioms, which are called theorems. An \mathcal{N} -bit theory is one for which there is an \mathcal{N} -bit program for systematically running through the tree of all possible proofs deducing all the consequences of the axioms, which are all the theorems in your formal theory. This is slow work, but in principle it can be done mechanically, that's what counts. David Hilbert believed that there had to be a single formal axiomatic theory for all of mathematics; that's just another way of stating that math is static and perfect and provides absolute truth.

Not only is this impossible, not only is Hilbert's dream impossible to achieve, but there are in fact an infinity of irreducible mathematical truths, mathematical truths for which essentially the only way to prove them is to add them as new axioms. My first example of such truths was determining elegant programs, and an even better example is provided by the bits of Ω . The bits of Ω are mathematical facts that are true for no reason (no reason simpler than themselves), and thus violate Leibniz's principle of sufficient reason, which states that if anything is true it has to be true for a reason.

In math the reason that something is true is called its proof. Why are the bits of Ω true for no reason, why can't you prove what their values are? Because, as Leibniz himself points out in Sections 33 to 35 of *The Monadology*, the essence of the notion of proof is that you

COLLAPSE I

prove a complicated assertion by analyzing it, by breaking it down until you reduce its truth to the truth of assertions that are so simple that they no longer require any proof (self-evident axioms). But if you cannot deduce the truth of something from any principle simpler than itself, then proofs become useless, because anything can be proven from principles that are equally complicated, e.g., by directly adding it as a new axiom without any proof. And this is exactly what happens with the bits of Ω .

In other words, the normal, Hilbertian view of math is that all of mathematical truth, an infinite number of truths, can be compressed into a finite number of axioms. But there are an infinity of mathematical truths that cannot be compressed at all, not one bit!

This is an amazing result, and I think that it has to have profound philosophical and practical implications. Let me try to tell you why.

On the one hand, it suggests that pure math is more like biology than it is like physics. In biology we deal with very complicated organisms and mechanisms, but in physics it is normally assumed that there has to be a theory of everything, a simple set of equations that would fit on a T-shirt and in principle explains the world, at least the physical world. But we have seen that the world of mathematical ideas has infinite complexity, it cannot be explained with any theory having a finite number of bits, which from a sufficiently abstract point of view seems much more like biology, the domain of the complex, than like physics, where simple equations reign supreme.

On the other hand, this amazing result suggests that even though math and physics are different, they may not be as different as most people think! I mean this in the following sense: In math you organize your computational experience, your lab is the computer, and in physics you organize physical experience and have real labs. But in both cases an explanation has to be simpler than what it explains, and in both cases there are sets of facts that cannot be explained, that are irreducible. Why? Well, in quantum physics it is assumed that there are phenomena that when measured are equally likely to give either of two answers (e.g., spin up, spin down) and that are inherently unpredictable and irreducible. And in pure math we have a similar example, which is provided by the individual bits in the binary expansion of the numerical value of the halting probability Ω . This suggests to me a quasi-empirical view of math, in which one is more willing to add new axioms that are not at all self-evident but that are justified pragmatically, i.e., by their fruitful consequences, just like a physicist would.

I have taken the term quasi-empirical from Lakatos. The collection of essays *New Directions in the Philosophy of Mathematics* edited by Tymoczko in my opinion pushes strongly in the direction of a quasi-empirical view of math, and it contains an essay by Lakatos proposing the term “quasi-empirical,” as well as essays of my own and by a number of other people. Many of them may disagree with me, and I’m sure do, but I repeat, in my opinion all of these essays justify a quasi-empirical view of math,

COLLAPSE I

what I mean by quasi-empirical, which is somewhat different from what Lakatos originally meant, but is in quite the same spirit, I think.

In a two-volume work full of important mathematical examples, Borwein, Bailey and Girgensohn have argued that experimental mathematics is an extremely valuable research paradigm that should be openly acknowledged and indeed vigorously embraced. They do not go so far as to suggest that one should add new axioms whenever they are helpful, without bothering with proofs, but they are certainly going in that direction and nod approvingly at my attempts to provide some theoretical justification for their entire enterprise by arguing that math and physics are not that different.

In fact, since I began to espouse these heretical views in the early 1970's, largely to deaf ears, there have actually been several examples of such new pragmatically justified, non-self-evident axioms:

- the $P \neq NP$ hypothesis regarding the time complexity of computations,
- the axiom of projective determinacy in set theory, and
- increasing reliance on diverse unproved versions of the Riemann hypothesis regarding the distribution of the primes.

So people don't need to have theoretical justification; they just do whatever is needed to get the job done. . .

The only problem with this computational and information-theoretic epistemology that I've just outlined to you is that it's based on the computer, and there are uncomputable reals. So what do we do with contemporary physics which is full of partial differential equations and field theories, all of which are formulated in terms of real numbers, most of which are in fact uncomputable, as I'll now show. Well, it would be good to get rid of all that and convert to a digital physics. Might this in fact be possible?! I'll discuss that too.

COMPUTER ONTOLOGY: HOW REAL ARE REAL NUMBERS? WHAT IS THE WORLD MADE OF?

How did Turing prove that there are uncomputable reals in 1936? He did it like this. Recall that the possible texts in French are a countable or denumerable infinity and can be placed in an infinite list in which there is a first one, a second one, etc. Now let's do the same thing with all the possible computer programs (first you have to choose your programming language).

So there is a first program, a second program, etc. Every computable real can be calculated digit by digit by some program in this list of all possible programs. Write the numerical value of that real next to the programs that calculate it, and cross off the list all the programs that do not calculate an individual computable real. We have converted a list of programs into a list of computable reals, and no computable real is missing.

Next discard the integer parts of all these computable

COLLAPSE I

reals, and just keep the decimal expansions. Then put together a new real number by changing every digit on the diagonal of this list (this is called Cantor's diagonal method; it comes from set theory). So your new number's first digit differs from the first digit of the first computable real, its second digit differs from the second digit of the second computable real, its third digit differs from the third digit of the third computable real, and so forth and so on. So it can't be in the list of all computable reals and it has to be uncomputable. And that's Turing's uncomputable real number!⁷

Actually, there is a much easier way to see that there are uncomputable reals by using ideas that go back to Emile Borel (again!). Technically, the argument that I'll now present uses what mathematicians call measure theory, which deals with probabilities. So let's just look at all the real numbers between 0 and 1. These correspond to points on a line, a line exactly one unit in length, whose leftmost point is the number 0 and whose rightmost point is the number 1. The total length of this line segment is of course exactly one unit. But I will now show you that all the computable reals in this line segment can be covered using intervals whose total length can be made as small as desired. In technical terms, the computable reals in the interval from 0 to 1 are a set of measure zero, they have zero probability.

How do you cover all the computable reals? Well,

7. Technical Note: Because of synonyms like $.345999 \dots = .346000 \dots$ you should avoid having any 0 or 9 digits in Turing's number.

remember that list of all the computable reals that we just diagonalized over to get Turing's uncomputable real? This time let's cover the first computable real with an interval of size $\varepsilon/2$, let's cover the second computable real with an interval of size $\varepsilon/4$, and in general we'll cover the N th computable real with an interval of size $\varepsilon/2^N$. The total length of all these intervals (which can conceivably overlap or fall partially outside the unit interval from 0 to 1), is exactly equal to ε , which can be made as small as we wish! In other words, there are arbitrarily small coverings, and the computable reals are therefore a set of measure zero, they have zero probability, they constitute an infinitesimal fraction of all the reals between 0 and 1. So if you pick a real at random between 0 and 1, with a uniform distribution of probability, it is infinitely unlikely, though possible, that you will get a computable real!

What disturbing news! Uncomputable reals are not the exception, they are the majority! How strange!

In fact, the situation is even worse than that. As Emile Borel points out on page 21 of his final book, *Les nombres inaccessibles* (1952), without making any reference to Turing, most individual reals are not even uniquely specifiable, they cannot even be named or pointed out, no matter how non-constructively, because of the limitations of human languages, which permit only a countable infinity of possible texts. The individually accessible or nameable reals are also a set of measure zero. Most reals are un-nameable, with probability one! I rediscovered this result of Borel's on my own in a slightly different context,

COLLAPSE I

in which things can be done a little more rigorously, which is when one is dealing with a formal axiomatic theory or an artificial formal language instead of a natural human language. That's how I present this idea in *Meta Math!*. So if most individual reals will forever escape us, why should we believe in them?! Well, you will say, because they have a pretty structure and are a nice theory, a nice game to play, with which I certainly agree, and also because they have important practical applications, they are needed in physics. Well, perhaps not! Perhaps physics can give up infinite precision reals! How? Why should physicists want to do that?

Because it turns out that there are actually many reasons for being skeptical about the reals, in classical physics, in quantum physics, and particularly in more speculative contemporary efforts to cobble together a theory of black holes and quantum gravity.

First of all, as my late colleague the physicist Rolf Landauer used to remind me, no physical measurement has ever achieved more than a small number of digits of precision, not more than, say, 15 or 20 digits at most, and such high-precision experiments are rare masterpieces of the experimenter's art and not at all easy to achieve.

This is only a practical limitation in classical physics. But in quantum physics it is a consequence of the Heisenberg uncertainty principle and wave-particle duality (de Broglie). According to quantum theory, the more accurately you try to measure something, the smaller the length scales you are trying to explore, the higher the

energy you need (the formula describing this involves Planck's constant). That's why it is getting more and more expensive to build particle accelerators like the one at CERN and at Fermilab, and governments are running out of money to fund high-energy physics, leading to a paucity of new experimental data to inspire theoreticians.

Hopefully new physics will eventually emerge from astronomical observations of bizarre new astrophysical phenomena, since we have run out of money here on earth! In fact, currently some of the most interesting physical speculations involve the thermodynamics of black holes, massive concentrations of matter that seem to be lurking at the hearts of most galaxies. Work by Stephen Hawking and Jacob Bekenstein on the thermodynamics of black holes suggests that any physical system can contain only a finite amount of information, a finite number of bits whose possible maximum is determined by what is called the Bekenstein bound. Strangely enough, this bound on the number of bits grows as the surface area of the physical system, not as its volume, leading to the so-called "holographic" principle asserting that in some sense space is actually two-dimensional even though it appears to have three dimensions!

So perhaps continuity is an illusion, perhaps everything is really discrete. There is another argument against the continuum if you go down to what is called the Planck scale. At distances that extremely short our current physics breaks down because spontaneous fluctuations in the quantum vacuum should produce mini-

COLLAPSE I

black holes that completely tear spacetime apart. And that is not at all what we see happening around us. So perhaps distances that small do not exist.

Inspired by ideas like this, in addition to a priori metaphysical biases in favor of discreteness, a number of contemporary physicists have proposed building the world out of discrete information, out of bits. Some names that come to mind in this connection are John Wheeler, Anton Zeilinger, Gerard 't Hooft, Lee Smolin, Seth Lloyd, Paola Zizzi, Jarmo Mäkelä and Ted Jacobson, who are real physicists. There is also more speculative work by a small cadre of cellular automata and computer enthusiasts including Edward Fredkin and Stephen Wolfram, whom I already mentioned, as well as Tommaso Toffoli, Norman Margolus, and others.

And there is also an increasing body of highly successful work on quantum computation and quantum information that is not at all speculative, it is just a fundamental reworking of standard 1920's quantum mechanics. Whether or not quantum computers ever become practical, the workers in this highly popular field have clearly established that it is illuminating to study sub-atomic quantum systems in terms of how they process qubits of quantum information and how they perform computation with these qubits. These notions have shed completely new light on the behavior of quantum mechanical systems.

Furthermore, when dealing with complex systems such as those that occur in biology, thinking about infor-

mation processing is also crucial. As I believe Seth Lloyd said, the most important thing in understanding a complex system is to determine how it represents information and how it processes that information, i.e., what kinds of computations are performed.

And how about the entire universe, can it be considered to be a computer? Yes, it certainly can, it is constantly computing its future state from its current state, it's constantly computing its own time-evolution! And as I believe Tom Toffoli pointed out, actual computers like your PC just hitch a ride on this universal computation!

So perhaps we are not doing violence to Nature by attempting to force her into a digital, computational framework. Perhaps she has been flirting with us, giving us hints all along, that she is really discrete, not continuous, hints that we choose not to hear, because we are so much in love and don't want her to change!

For more on this kind of new physics, see the books by Smolin and von Baeyer in the bibliography. Several more technical papers on this subject are also included there.

CONCLUSION

Let me now wrap this up and try to give you a present to take home, more precisely, a piece of homework. In extremely abstract terms, I would say that the problem is, as was emphasized by Ernst Mayr in his book *This is Biology*, that the current philosophy of science deals more

COLLAPSE I

with physics and mathematics than it does with biology. But let me try to put this in more concrete terms and connect it with the spine, with the central thread, of the ideas in this talk. To put it bluntly, a closed, static, eternal fixed view of math can no longer be sustained. As I try to illustrate with examples in my *Meta Math!* book, math actually advances by inventing new concepts, by completely changing the viewpoint. Here I emphasized new axioms, increased complexity, more information, but what really counts are new ideas, new concepts, new viewpoints. And that leads me to the crucial question, crucial for a proper open, dynamic, time-dependent view of mathematics,

“Where do new mathematical ideas come from?”

I repeat, math does not advance by mindlessly and mechanically grinding away deducing all the consequences of a fixed set of concepts and axioms, not at all! It advances with new concepts, new definitions, new perspectives, through revolutionary change, paradigm shifts, not just by hard work.

In fact, I believe that this is actually the central question in biology as well as in mathematics, it's the mystery of creation, of creativity: “Where do new mathematical and biological ideas come from?” “How do they emerge?”

Normally one equates a new biological idea with a new species, but in fact every time a child is born, that's actually a new idea incarnating; it's reinventing the notion of “human being,” which changes constantly.

I have no idea how to answer this extremely important question; I wish I could. Maybe you will be able to do it. Just try! You might have to keep it cooking on a back burner while concentrating on other things, but don't give up! All it takes is a new idea! Somebody has to come up with it. Why not you?

APPENDIX: LEIBNIZ AND THE LAW

I am indebted to Professor Ugo Pagallo for explaining to me that Leibniz, whose ideas and their elaboration were the subject of my talk, is regarded as just as important in the field of law as he is in the fields of mathematics and philosophy.

The theme of my lecture was that if a law is arbitrarily complicated, then it is not a law; this idea was traced via Hermann Weyl back to Leibniz. In mathematics it leads to my Ω number and the surprising discovery of completely lawless regions of mathematics, areas in which there is absolutely no structure or pattern or way to understand what is happening.

The principle that an arbitrarily complicated law is not a law can also be interpreted with reference to the legal system. It is not a coincidence that the words “law” and “proof” and “evidence” are used in jurisprudence as well as in science and mathematics. In other words, the rule of law is equivalent to the rule of reason, but if a law is sufficiently complicated, then it can in fact be completely arbitrary and incomprehensible.

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COLLAPSE I

The Militarization of Peace:
Absence of Terror or Terror of Absence?

Reza Negarestani

INTRODUCTION

This essay explores the rise of a new wave of terrorism which exploits its own dissolution, making a weapon of the doctrine of Taqiyya or strategic (dis)simulation, dismantling the theatrical aspect of the battlefield and selecting civilians as primary targets and ‘molecular battlefields’. This tendency threatens not only global civilian survival but the very horizon of survival or living (in its most basic, abstract sense) in general. It makes survival itself a field of exploitation for extremist terrorism.

When militarization ceases to be an exclusively wartime process and to belong only on the battlefield, then even peace—the temporary gap, the blank space of unfriiction between war machines and collective survival—can be militarized. This does not mean taking

COLLAPSE I

advantage of peace as a temporary suspension which can be exploited, or as a depository in preparation for the militarization processes of future wars (who gathers the most forces when everyone else is resting?) Rather, and far more significantly, it means the endo-militarization of peace itself, wherein peace is directly used as a weapon, exploited as a new plane for invasion and insurgency, and for offensive strikes against enemy bases and/or their supportive lattices.

New modes of disseminating terror threaten the basic notions of survival in general, creating a generalized state of terror where death hangs over, regulates, every moment that is lived. Such *necrocracy* is the goal of heretical Islamic agencies of Terror such as *Jama'at-e Takfir*¹ and its *Takfiri* agents – a militant *Jihadi* movement believing in the absolute excommunication of infidels (*Takfir* originally means excommunication). These agencies have inspired a new wave of militant religious extremists and other obscure terrorist groups who are exploiting the endo-militarization of peace as a new mode of warfare. This new mode of warfare is one whose tactical lines are not aligned with (or configured by) the plane of conflict and visible military friction (battlefields, terrains for guerilla warfare, street-wars, etc.); Its tactical lines do not

1. *Jama'at-e Takfir* (The Society of Excommunication) influenced by Qutb's Muslim Brotherhood emerged in Egypt as a fundamentalist group in the 1960s with Islamic fundamentalist and militant inclinations (the former being similar to extremist Salafism) enmeshed through decentralized and stealth operation networks. The group advocates any military course of action (whether armed battles or not) against Jews, Christians, apostate or moderate Muslims, in order to restore (or return to) the primal unity of the Islamic world order.

have the localizability which is a prerequisite for direct conflict and military formation; They are not positioned to cut, block or replace each other depending upon their different tendencies, transorientations and alignments; Their operations have a wholly oblique relation to the dynamic incompatibility which provides the basis for, and the matrix of, militarized conflictual engagement.

A *Takfiri* engages as a shadow terrorist in *White War* – the endo-militarization of peace, a state of hypercamouflage (best defined as *complete* and consequently symmetrical overlap between two entities on a mereotopological² plane). In this war, the cover of camouflage can never be penetrated or disrupted, and the defensive employment of camouflage (best mapped as *partial* overlap between two or more entities on a logical plane) is replaced by a wholly novel, highly offensive deployment, the space of hypercamouflage. The *Takfiri*'s favoured mode of warfare is to program a new type of tactical line which totally blends with the enemy's lines in such a configuration that it introduces radical instability and eventually violent fissions into the system from within. This happens in such a way that not only does recovery become impossible, but in addition any corrective or restorative initiative is ineluctably turned into a military subversion: like a chemotherapy gone awry or an excessive scarring in which healing and the process of

2. Mereotopology is a theory of topological relationships between parts and boundaries. See Barry Smith, "Mereotopology: a theory of parts and boundaries", in *Data & Knowledge Engineering*, Volume 20, Issue 3 (November 1996), Elsevier Science Publishers, pp. 287 - 303.

COLLAPSE I

epithalization, in the absence of a wound, corrode the organ in the form of fibroproliferation (a scarring process which transforms the local injury of the wound into a pervasive metastatic scarring), resulting in eventual lysis and decomposition. In attempting defence, the enemy can only necrotize and dissolve itself.

DEEP TERROR: THE DECLINE OF THE ENEMY AND THE RISE OF OBSCURE ALLIES.

Abdu-Salam Faraj's manifesto *Jihad: The Absent Obligation* – in which malevolent political pragmatics and tactical perversion are planted carefully in a context of evangelistic justification and theo-tyrannical apologetics – is a case study of this mode of warfare: White War or the militarization of peace, comprising aggressive *hypercamouflage* as its primary engine.

Hypercamouflage aims to pursue to even the most attenuated extreme, a fighting and a surviving alongside the enemy. It invariably indicates a total withdrawal from the perception of friends and a dissolution into the enemy: the rebirth of a new foe.

In his book, Takfiri cultist and terrorist Faraj crafts a fetishized form of *Jihad*, suggesting that the incinerating head of *Jihad* must be introduced to everyone, to any entity, regardless of their position, geographic location, ethnicity, regardless of the relevance or otherwise of that entity to *Jihad*, Islam or infidelity – *Jihad* as a universal sweeping movement. The original title of the book,

which in translation has become simplified into *Jihad: The Absent Obligation*, is *Jahad: Fariezato Ghaebata* (or *Jihad: Fariezeh Ghaeb*). *Fariezeh* means holy duty, but not a subjectively authoritarian duty as is demanded by *Huda* (Allah's guidance), the 'utter submission' (*Islam*) to Allah. *Ghaeb* means absent, but in Islamic texts and especially Shia books, it encompasses a huge hermeneutic potentiality which 'absence' cannot hope to translate; in fact, rather than mere absence *Ghaeb* indicates latent potentiality, in the sense, for instance, of the latent period of inactivity of a virus. This latency is to be distinguished from the actualized and visible, which is liable to distortion and change: Imam Mahdi (the 12th Imam and the harbinger of *Qiyamah*, the Islamic Apocalypse) is absent (*Ghaeb*) but affects Islam and its followers more than anything *actually* present; Mahdi represents a potentiality that never ceases to affect. In Faraj's book, however, this definition, which is a fundamental theological and eschatological platform for his argument, becomes eclipsed by a message at once more accessible and more divergent from this original meaning: *Jihad* becomes a holy responsibility which is not present.

Faraj's book adds a new twist to the tactics of heretical religious extremists such as the cult of *Takfiri*: the distortion and alteration of '*Taqiyya*' (*Taghieh*) from its original defensive and devout function in the dawn of Islam. Rather than a strategic (dis)simulation – a justified concealment of true beliefs in situations where harm or death will definitely be encountered if the true beliefs are

COLLAPSE I

declared³ (the wider meaning of *Taqiyya* being “to avoid or shun any kind of danger.”) it is reinterpreted as a silent and fluid military infiltration, a course of action which forms one of the elemental components of fetishized Jihadism.

Faraj’s take on *Taqiyya* departs entirely from what in the dawn of Islam originated as a defensive or protective inclination, an evasive tactic. In *The Absent Obligation*, *Taqiyya* is reconstituted as a type of strategic simulation or dissimulation, in the name of a hostile politics of offence. However, both in its traditional form and in this new weaponized form, *Taqiyya* is strongly bound to the notion of survival. In the traditional sense this is so simply because by taking *Taqiyya* the believer survives in difficult circumstances. But in militarized *Taqiyya*, survival is transformed into a sort of highly-charged parasitical endurance which inherently threatens the catalysis of all those whose survival is afforded more easily. Survival becomes as risky as a contagious terminal illness. Faraj insists that *Jihad* cannot be separated from *Taqiyya*. Whereas crusades transgress boundaries in order to retake the holy lands, in Islamic tradition *Jihad* intrinsically cannot be transgressive; it must merely *defend* the holy lands, and Islamic properties (which are not necessarily associated with geopolitical agencies). But as

3. “The believers never ally themselves with the disbelievers, instead of the believers. Whoever does this is exiled from GOD. Exempted are those who are forced to do this to avoid persecution. GOD alerts you that you shall revere Him alone. To GOD is the ultimate destiny.” (The Quran 3:28)

revivalist figures like Sayyid Qutb⁴ and Shukri Ahmad Mustafa have twisted the entire panorama of Islamic thought, heretical Islam's defence of its 'properties' has become a *universal* 'defence' encompassing massive waves of acentric assault and a military subversion pervaded by a complex tendency towards the exclusion of all beings except for the monopolistic wasteland of the Divine (the Desert). "The earth itself moves towards Allah by submitting itself to the 'exterior' Will of Allah; or in other words, is not Earth a part and property of Islam (utter submission to Allah) which must be defended?": Qutb turns the issue inside out, all of theological thought becoming ravaged by monopolistic dictatorship and monomania. The Earth itself becomes a part of the defensive politics of *Jihad*⁵. Ahmad Mustafa, one of the theorists of the original *Takfiri* cult, also suggests that "We are returning to Islam", and that this Grand Return

4. Sayyid Qutb (1906-1966), one of the central theorists of Islamic Revivalism and an inspiration for later extremists such as Faraj; his *Ma'alim fi-l-Tariq* (Milestones) is perhaps the first theoretical work of modern extremist Islamism, integrating pragmatic exhortations with self-centered politico-religious doctrines. On Qutb, see Paul Berman's analysis of terrorism inspired by the caliph's militarism and heretical Islamic revivalism: Berman, P. (2004) *Terror and Liberalism*, W. W. Norton & Company.

5. "The Islamic civilization can take various forms in its material and organizational structure, but the principles and values on which it is based are eternal and unchangeable. These are: the worship of God alone, the foundation of human relationships on the belief in the Unity of God, the supremacy of the humanity of man over material things, the development of human values and the control of animalistic desires, respect for the family, *the assumption of the vice-regency of God on earth according to His guidance and instruction, and in all affairs of this vice-regency, the rule of God's law (Shari'a) and the way of life prescribed by Him ...*" (Sayyid Qutb, *Milestones*); see Qutb (1991) *Milestones*, American Trust Publications, p. 286.

COLLAPSE I

involves surrendering to the Desert of the Divine: this is not a reactionary response to the infidels, he insists, but merely the path to Islam, which is condemned and met with overreaction by the rest of the world – a world whose entire horizon, moreover, is in fact already a part of Islam. Mustafa's discussion takes a twisted monotheism and heretically embeds it within the foundations of Islam – creating a retrograde movement back to a self-deluding, romantically-imagined phantasy of the original Islam. To this notion of *Jihad* which seeks to retake the Earth as a part of Islam (Earth as a part of the universe is on the route of *utter submission – Islam – to Allah*) Faraj cunningly adds the politics of *Taqiyya*. As Faraj himself confesses, this (re)taking of the Earth is not an easy task; hence the necessity of being armed with *Taqiyya* and its potential for insinuation and diffusion within the systems and peoples of non-Islamic countries.

According to Faraj the new doctrines of weaponized *Taqiyya* can be enumerated as follows:

(1) *TAQIYYA* AS THE DISSOLUTION OF YOURSELF AND THE OTHER: *Taqiyya* becomes a politics aimed at drawing the war out of the battlefield (In this extremist *Jihad*, war must be put to work everywhere but the battlefield; war is external to the conventional battlefield. 'War is not a theater, you infidels', Faraj shouts). This is to be achieved by introducing the *Jihadi* entities to civilians and all other seemingly militarily irrelevant political economic or cultural entities, by blending with the crowd which exists far from the front lines. 'Towards the real omnipresence

of war which progressively effaces the theatrical platitude of the battlefield', the doctrine of Terror voluntarily transforms itself into a sinister movement of utter self-dissolution. The use of *Taqiyya* as a (para)offensive politics, however, is not the invention of Faraj, or the *Takfiri* cult, or even of Wahhabi extremists. It can be traced back to Hassan i-Sabah but it is not the invention of Hassan either (although he improved and strictly militarized it). The sole credit for *Taqiyya* as a (para)offensive *politics* aimed at blending with the crowd (as opposed to *Taqiyya* as a dissimulating tool for evading harm, as devised in the early days of Islam) belongs to Abdullah ibn Maimun or Maymun (and his *Batiniyya* cult, one of the underground heretical Islamic societies and subversive movements which he founded and which later turned into *Isma'ili* sects directed by Hassan i-Sabah): Maimun, the Persian occultist, political saboteur and conspiracist who undermined the reign of caliphs in Egypt (where the *Takfiri* cult also originated together with such influential figures such as Qutb, Mustafa, *et al.*) with a sudden debacle, and prepared the region for his ambiguous and mysterious allies *Al Fatemids* (*Fatemion*) who later became the most enthusiastic enemies of the caliphs and their conventional modes of militarism. Faraj, following closely Ibn Maymun's politics, suggests that *Taqiyya* should not be merely a deception, a hiding tactic; it should consist of seeking the highest degree of participation with infidels, with their civilians: "if they take drugs we must do the same, if they take part in every

COLLAPSE I

type of sexual activity we must drive those activities to the point of excess”, etc. The *Jihadi* extremist must become as one with the civilians of what are called ‘hardcore infidels’.

(2) *TAQIYYA* AS A (PARA)OFFENSIVE MILITARIZATION OF CIVILIANS: In reference to Faraj’s politics of *Taqiyya* as an inseparable element of *Jihad*, the French counter-terrorist expert and President of the Paris-based World Observatory of Terrorism, Ronald Jacquard, brilliantly points out that a ‘*Takfiri* under *Taqiyya*’ is himself a primed bomb, whether or not he ever sees action (is involved in a mission). When a *Takfiri* becomes as one with ordinary civilians – no longer dissimulating but moving and behaving like a true, unfaithful civilian in every aspect of his or her public and private life – then the weapon begins autonomously to be activated from the other side; the government (of a foreign non-Islamic country, for example) itself begins to filter, purge and hunt down its own civilians, curtailing their rights, confining them to economic, social and political quarantine to isolate or even purge the disease and its potential hosts at the same time. Each individual is potentially a *Takfiri* cell or niche, a site of infestation, a primary military target. So that the most offensive, active phase of a *Takfiri*’s life is not when he or she is on a high-profile mission like 9/11, but rather when he or she becomes a mere civilian, totally unarmed and dissociated from any line of command. A *Takfiri* levels himself with everyone and consequently levels everyone with himself; when it comes to hunting a *Takfiri*,

one ineluctably ends up exterminating non-military entities, far away from the battlefield, in the heart of one's own land.

(3) *TAQIYYA* AS A TRIGGER FOR WHITE WAR: *Taqiyya* unbalances the entire conventional dynamics between war machines, a dynamics which sees them clash with, hunt, and consume each other. This process of unbalancing does not serve to shift the battle along the diametric axis of 'victory or defeat', but rather to unbalance the communicative links between two tactical modes: *active military lines* at one pole and *virally latent (un)tactical lines* at the other. The *Takfiri* shuts down all his military potential, tactically 'dies' (not even being camouflaged anymore), and later is resurrected again in 'his' true form. The *Takfiri* war machines of extremist *Jihad* operate on transient and divergent tactical lines. As a result, they cannot be reached or communicated with: communication which is the prerequisite for the clash between war machines and entropically-based military conflicts, mechanisms considered by Deleuze and Guattari as the processes which fabricate the very machinery and space of War.

(4) *TAQIYYA* AS A DESERTIFICATION TOOL: Giving fetishized *Jihad* an epidemically omnipresent machinery, *Taqiyya* allows Faraj to open a new era in the imagining of mechanisms of extinction, sabotage and eradication fueled by the pyromaniac aspects of heresy and dangerously romantic theo-tyranny. Faraj discusses the fact that 'their' (he rarely even names his so-called enemies: the

COLLAPSE I

US) military war machine relies heavily on the *megadeath principle* or as they put it DEATH FROM ABOVE (Overkill, Killing drones, High-tech airplanes, smart bombs, “Shock and Awe”, MOAB (Mother of All Bombs), invisible missiles descending from nowhere). Faraj presents a *Takfiri* alternative to this megadeath machinery⁶: He discusses a new doctrine of hypercamouflaged terror which he calls ‘Dieback machinery’, a term borrowed from botany and agriculture⁷. What he defines as ‘Dieback’ can be applied to an entire ‘civilization just as well as a Tree or any arborescent mode of collectivity’: in order to introduce a Tree to extinction, a *Takfiri* terrorist never interferes with the roots, attempting to uproot the whole tree, as this would merely remove the taproot, leaving rootlets and other root parts in the soil that would eventually grow and give rise to many new trees. The terrorist or *Jihadi* extremist launches a *dieback*

6. Questions of escalation and diffusion of conflict in time and space are of massive significance for both the western military campaign and Jihadism’s terror-skirmishes. While Jihadism works with diffusion in its off-battlefield conflicts (through its petropolitical contamination of the global politico-economic systems, its reckless use of weaponized *Taqiyya*, working with strategy rather than tactics and contagious communication rather than transgression), the western techno-capitalism maintains a escalating position in the battlefield, a position connected to the propulsive body of techno-capitalism, its tactical precision and supremacy. However, both of them share a common tendency in conflict: turning human agencies into molecular battlefields / warmachines; for Jihadism this molecularization of warriors takes an epidemically dispersive form: mainly through *Taqiyya*’s para-offensive plane and for the western front, it turns into re-nomadization (in the Deleuze-Guattarian sense of nomadic warmachines) of the State’s army and miniaturization of an entire army and its specifications on and through the body of each soldier.

7. A disease of plants characterized by the gradual dying of the young shoots starting at the tips and progressing to the larger branches.

disease against the tree: to be precise, he starts to extinguish the most expendable and smallest leaves growing at the top of the tree and its branchlets, and continues his work to the rest of leaves, without damaging the main trunk or roots. By destroying leaves from top to bottom and by marring branchlets, the tree will wither: excommunicated and dejected, the tree will eventually be entirely incapacitated and will start to *(over)react autophagically* and *allergically* to the artificial dereliction effected by the dieback disease. *Taqiyya* provides *Takfiris* with ample opportunity to use this dieback machinery, starting from the leaves (civilians or what they call ‘expendable entities’) and branchlets (small organizations, etc.), ultimately rendering the tree obsolete without ever having launched any direct attack against its main organs.

When a tree is infected by dieback disease, only leaves and branches are destroyed; however, lacking leaves and branchlets, the tree gradually becomes prone (overexposed) to environmental factors and all of its systems become locked into malfunctioning programs, lowering its immune system and consuming the tree from within. Various stages in the dieback of a civilization would be: paranoia; lack of investment; civilians as primary targets for both fronts; dereliction. All of which result in a reactionary response from the infected tree which, rather than aiding recovery, is self-destructive. In a system this self-destruction (or malfunctioning self-recovery) can be defined as breakdown of the mechanisms responsible for

COLLAPSE I

self-tolerance, and the induction of an immune response against components of the self. Such a cataclysm leads to the reprogramming of the (immune) system to damage the self.

A '*Takfiri* under *Taqiyya*', then, is nothing but a civilian. By destroying himself and civilians he can apply the dieback mechanism to a system. Weaponized *Taqiyya* is not directly connected to the dieback mechanism; but it is a way in which a *Takfiri* can shift the role of *Taqiyya* from mere camouflage to a powerful logistical plane on which (para)offensive tactics and strategies can be converged and amplified. When a *Takfiri* extremist goes under *Taqiyya* he embeds his sabotaging mechanisms within civilians, *uses civilians as back-doors*. A *Takfiri* under *Taqiyya* is transposed from being a key operational figure in his own army to being a civilian; at this point, *Taqiyya* actually gains access not to important targets but to ordinary civilians (the primary tactic of the dieback mechanism), allowing the *Takfiri* an opportunity to effectively confound and twist all diagrams and maps which allow a civilian to be distinguished from a terrorist. Through this back-door, a *Takfiri* can both damage civilians (or expendable entities of the tree, as they are regarded) more effectively on a massive scale, and turn their protection systems against them by assimilating them within itself and by being assimilated by them.

The original doctrines of the *Takfiri* cult originate from the teachings of Qutb and Shukri Ahmad Mustafa. Faraj, under the influence of the doctrine of '*Takfir wal'Hijra*'

(Excommunication and Exodus) – imitation of the prophet who left Mecca and the House of Allah to live in a *purified desert* purged from any manifestation of idolatry – enunciates a new vision of desert and desertification alien to the conventional image of the Desert familiar to socio-political dynamics, and western social dynamics in particular. On several different levels, this desert encompasses all radical trends of Islam, from the ceaseless exteriority of Allah to Man, to desert as the mere functional plane of submission to this radical exteriority (Allah who will be never disclosed), to the original desert-nomadic ingredients of *Jihad*. A desert nomad does not migrate, as it is minimally under the influence of climatic factors; it burrows tunnels of its own, making its own niches within the desert, crossing the dimensions of holey and smooth spaces, exploiting and betraying them equally. Scorpions are burrowers not architects, they do not build upon compositions of solid and void, nor do they move restlessly, they devour volumes and snatch spaces; for them the holey space is not merely a dwelling place, a place to reside (a niche for occupation) but more than that, it is the Abode of War (*dâr al-harb*), the holey space of unselective hunting. Mustafa hysterically introduced the machinery and the notion of the desert into all threads of his thought to such a degree that his cult was mockingly called ‘The desert flogging society’. It is rather ironic to reveal Mustafa’s real profession: he was a very talented agronomist.

Take a Russian forest bordering the tundra, whose

COLLAPSE I

trees are emptied of life because they have been hit by black-rot and winter dieback; In a *Takfiri* sense, deserted trees are no different from a desert without trees: dieback purifies, desertifies, the infidel organism, bringing the Earth within the compass of the utter desolation of the Desert of the Divine.

In the wake of militarized *Taqiyya*, the *Takfiri* is no longer the problem; it is the original civilians of the country, rather than immigrants, who pose a terminal security threat. There is no more radical act of war than fighting in molecularized and expendable battlefields whose potentiality for conducting conflict has already been incapacitated.

LOGICAL INVESTIGATION OF HYPERCAMOUFLAGE VS. NOMADIC CONFLICT.

“In the past one took a more *defensive* attitude,” wrote Koch, referring to miasma theory. “We have now moved away from this defensive point of view and have seized the *offensive* ... We must be prepared, first, to detect the infectious material easily and with certainty, and second, to destroy it” (Koch 1903, 8, 10). For Koch, taking the offensive meant actively seeking the parasites not only in those obviously ill but also those “suspected” of carrying them (*die Verdächtigen*) and in “the apparently healthy.”⁸

Every warmachine or tactical line occupies a niche (whether in wartime or peace), a space through which it

8. Otis, L. (1999) *Membranes: Metaphors of Invasion in Nineteenth-Century Literature, Science and Politics*, The Johns Hopkins University Press, pp. 34-35

can move, feed and function; it is not only defined by the distinctive properties of a tactical line or warmachine but also by its enemies, the incompatible dynamism of other tactical lines, types of predators, the exposure to environmental factors, its threshold for receiving data from the environment, the types of data it receives and its propinquity to what it pursues or probes (there is a common misunderstanding that attributes solid or crisp boundaries to niches; but niches are assembled wherever an entity economizes a portion of its environment and survives / functions in that economized space⁹). At a given time t , the entity r occupies a unique¹⁰ address (or set of addresses) as $r_t(x)$; its movement can be simplistically expressed in terms of the niches it occupies at successive intervals of time. This address is encoded and set apart by the niche which the warmachine or tactical line occupies.

The functions of a niche are not merely disjunctive and exclusive (for example, directing competitions *i.e.* selective movements which result in exclusion of other portions of the environment or lines of movement) but

9. In fact, some monitoring systems basically concentrate on niches with fiat and vague boundaries to screen and guide their occupants (tenants). Air traffic control systems constantly analyze the volume of protected or restricted airspace – defining a circumspace or the volume enclosing a flying object – for collision avoidance, alert systems and translocations of aircrafts. The volume of protected airspace is a modified term for niche in traffic management, a simulation of the niche that exists in flying or migrating birds.

10. This uniqueness is characterized by the definitive properties / qualities that the address attributes to an entity in space-time but to have an address does not mean to be the exclusive owner of it.

COLLAPSE I

also connective/conjunctive. In fact niches mobilize their occupant entities with their characteristic types of dynamism, associating them with other niches based on the affordance necessary for following a tendency or a plane as well as sharing it with other niches and their inhabitants. The programming of its niche is the first basic operation of engineering or recomposing an entity. Therefore the significance of investigating niches or niche types (rather than token niches or occupants) progressively increases with the development and emergence of new dynamic lines, power formations, traffic spaces and planes of communicative conjunctions. The State and its grid of dominance identify the movements of an entity (r) in a niche (whether quantitative – metron-based [measurable, scalable] – or qualitative) by the series of addresses it authenticates and registers as it travels:

$$r (x_1, x_2, x_3, \dots, x_n)$$

For the State, the dynamism geared by warmachines, the way that each warmachine perpetuates its itinerant line, can only be traced and numerically tagged through the logic of boundaries, the programming of dwelling/accommodating systems and (dis)locations that the State is able to monitor by monitoring niches and their dynamic addresses. By means of overseeing boundaries through which entities pass, investigating the temporal effects on (or alteration of) the forces of territoriality that moving entities leave behind, their types of localization, and their behaviors towards mereologic economy (the economy of the whole), the State can fabricate a *cogito* (a non-human

cognition) not only to realize but also to classify the movement of entities and the dynamism of warmachines whose immoderate nomadic itineracy means that they cannot be directly apprehended or sensed by the State. This is the *cogito* required for appropriation of warmachines under the State's military protocols and forms. Bound to (semi-)rigid segmentarity, dynamic boundaries, affordance-based connections and static or dynamic localizations (or more accurately, in-place and outside-place localizations), the State examines the dynamic space of each entity and its activities – those activities corresponding to its functional, territorial and mereologic regions – not only to read the characteristics of an entity but also to locate it on (or according to the proximity of the entity to) its grid of dominance. The State and all configurations of Survival Economy track entities through the niche(s) that they inhabit or populate. For the State's military Overwatch, investigating and tracing the niche is the primary and central task; the itinerant line of an entity or a warmachine, its communications and functional traits are all deciphered by scanning the niche the warmachine occupies and its type. The advanced reading-machines of the State are even capable of extracting the quiddity of a warmachine or an entity by analyzing the specifications of the niche which is intrinsically bound to affordance, dynamic forces of boundaries, and eco-logical principles.

However, as niches are connective entities (entity-as-event in a Deleuzian sense); they do not exclusively belong to one entity or one tenant. Multiple entities can

COLLAPSE I

share one niche and niches can form nested niches (territorial forces diminish – but never disappear – in grouping bonds) linking to each other, being connected in various modes. Modes of connection between niches are divided for the most part into two asymmetrical correlations:

- a. Abutment (**A**)
- b. Overlap (**O**)

In the Deleuze-Guattari model of the nomadic war-machine, the warmachines are external to the State's effective boundary, restlessly eroding it, gnawing at the consolidated borders of the State. Logical modeling of the interactions between the exterior nomadic warmachines and the State is complicated mainly by the following problems:

- (a) Both the State and the warmachine retain a relative

11. Affordance is an economical network (in the sense that it is connective and reciprocal) by which openness can be exploited as a groundwork for survival, accommodation, dwelling and regulating communication.

The term affordance as used here diverges in certain respects from the original term coined by James Jerome Gibson (based on the works of Ingarden, Brentano, et al.) in his eco-cognitive studies. The regulations by which an entity can maintain its dynamic position (in a whole, *i.e.* mereologic address) and survive in its environing horizon originate from a deeply meshed economic-based network of interactions, connections and regulative participations, all knitted on mutual affordability between the entity and its environment. Whole can only survive when entities can afford each other, every type of openness on mereologic levels is demarcated by mutual affordability 'between' entities. Affordance does not exclusively belong to one pole of the economical communication but is distributed between at least two mereologic entities. 'I am open to you as long as I can afford you' otherwise: (a) you must be repulsed (b) attracted by being regulated and appropriated (c) partly filtered (d) I should appropriate myself to 'accommodate' you. Therefore, the plane of being open to is intrinsically constructed on affordance or economical affordability/communication. Through affordance, openness cannot escape

movement to each other (each dynamic on its own plane of tacticity) which makes the State's militarized machines and nomadic warmachines slippery entities with a progressive displaceability increasing as attacks and counter-attacks are escalated at the borders of the State.

(b) The rise of the clandestine State, that opens itself to the nomadic warmachines to either absorb them within its military formations by continuous contacts with nomadic warmachines (such contacts are essentially bound to contaminative potentials for both the State and the nomads) or reinvents nomadic warmachines as its mercenaries, dynamic lines for extending the State beyond its border, a new dynamic boundary providing the State with the opportunity of accommodating (colonizing?) or economically affording (affordance¹¹) the Outside instead of being cracked open by the Outside.

survivalist and economical regulations; it mainly works as the dynamic capacitor of Whole. Possibly the most elucidating (yet simplified) 'model' of affordance is Aristotle's Tetrasomia (Rotation of the Elements).



The rotational movement between elements sustains a refining dynamism for the whole. Each phase of rotation is based on dynamic metrons (measures, scales) and affordance (here, economical openness or mutual affordability) between elements. Elements are open to each other either diametrically or diagonally, but they can

COLLAPSE I

Focusing on the spatio-geographic aspect of the warmachine (necessarily interconnected with its affective aspect) – or, more precisely, investigating a mereotopological model of the nomadic warmachine and the State through their distinctive but general mode of connection which can be grasped as abutment or external connection – might be the primary task for diagramming the affect-space and the lines of movement generated between concrete nomadism and the State. This modelling, both spatio-geographic and mereotopological (and thus necessarily indicating an immanent affect space) of the nomadic warmachine and its positioning relative to the State's boundary elucidates the processes at work in the emergence of anomalous nomadic states (as in the case of the 'guerilla-state' and its connection with ethnonationalism in Iran or the Bedouin nomad-tribes and their strong but ambiguous bonds with the Saudi government in

never entirely overlap or radically communicate with each other; they need a mid-state to form rotational nexuses and maintain their Wholeness. These mid-states are valid only in a particular location of the whole rotational panorama; although they provide the system with a propulsive *polemikos* or cyclic dynamism, they function locally (as a result of the elements' affordability to each other and, at the same time, to the whole system of Tetrasomia). For example, Earth and Water need Menstruum (living mud) to communicate. This living mud is a communicational entity but also a dynamic boundary which transforms/appropriates the earth and water before opening them to each other; it can only work locally between earth and water and not at any other location in the model of Tetrasomia. The Whole uses these economical communications to consolidate itself and to afford Life (to survive).

"I assume that affordances are not simply phenomenal qualities of subjective experience (tertiary qualities, dynamic and physiognomic properties, etc.). I also assume that they are not simply the physical properties of things as now conceived by physical science. Instead, they are ecological, in the sense that they are properties of the environment relative to an animal. These assumptions are novel, and need to be discussed." (J. J. Gibson)

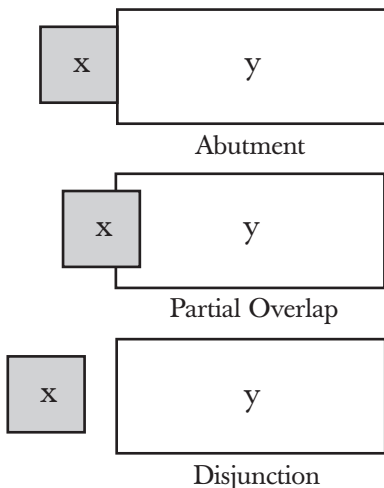


Fig. 1

Saudi Arabia) as well as the increasing risk for nomadic warmachines engaging clandestine states or states with an obscure boundary.

POSITIONING OF THE NOMADIC WARMACHINE ON A MEREOTOPOLOGICAL PLANE.

Abutment (fig. 1) is an external connection, with minimum trade between niches or entities (the least contagious connection, given its tendency towards dissociation). It is demarcated by its intermediacy before partial overlapping and after disjunction, by its tangential contact and boundary overlap.

COLLAPSE I

What was once the frontier of the State's defence is continuously eroded by the reckless tidal or updrift movements of nomadic warmachines. The operational significance of this mode of connection (Abutment) has been significantly decreased with the emergence of symbiotic and manipulative warmachines and covert militarization processes on the one hand, and advanced reformations of the State towards the accommodation (or colonizing) of the Outside on the other. The latter are rooted both in the introduction of territorial climatologic factors¹² to the dynamism of nomad-packs and in the development new modes of survival. Now, the state knows well how to save its foundations, even if it means assembling spaces susceptible to the erosion of nomadic warmachines, attracting or diverting the incoming nomadic incursions

12. On Climate and Nomadology: Following the so-called Hydraulic and Agricultural Revolution in Iran (similar to that which Wittfogel associated with the Chinese Empire, as well as Homer-Dixon's more recent theories on Hydropolitics), during the reign of Mohammad Reza Pahlavi (Shah), an hydraulic plan – highly recommended by American consultants – was developed and proposed as a catalyst for economic development in Iran; one of multiple objectives of this plan was to solve the problem of nomads in Iran. Apart from putting into effect a program of hydraulic restructuring of the diverse geography of Iran (a geography with innate potential for the forging of diversifying lines of nomadic movement), one of the stratagems of this hydropolitical program of reform was to originate a system for monitoring and domesticating Iranian nomads who played key roles in resistance against the centre or induced geopolitical disintegration of the State's territory via their ethnonationalistic movements. The plan was neither a method for drawing the eastern and central nomads to the governing center nor a project for forcibly accommodating them in a sedentary sphere through the monopolization of water-networks and direct military impositions. Rather, it suggested accompanying them, interlocking with them and replacing their dynamism with the State's fluxional lines of tactics, its dynamic boundary and territorial forces. The project's objective was to construct a soft climate (klima: zone) or a

to specified and preprogrammed regions to protect its critical terrains and vulnerable mechanisms, or transforming its macropolitics into a *viable* micropolitics which are open at one end and grounded at the other end.

In a typified connection C_τ , abutment can be mapped on the Euclidean plane R as:

$$A_\tau(x,y) = \text{df } C_\tau(x, y) \wedge \neg O_\tau(x,y) \text{ (x abuts y)}$$

(Where O_τ is a typified boundary overlap.)

Or let $T = \{X, \text{cl}\}$ be a topological space, where X is the set of points and cl is the closure operator. Let I be any index set that includes 0. The domain, D , of a Layered Model is a nonempty set of ordered pairs $x_i = \langle x, i \rangle$ where $\emptyset \neq x \subseteq X$ and $i \in I$. (x_i will be used for $\langle x, i \rangle$).

$$A(x_i, y_i) =: x \cap y = \emptyset \& (\text{cl}(x) \cap y \neq \emptyset \text{ or } x \cap \text{cl}(y) \neq \emptyset) \text{ (abuts)}$$

Since Abutment links entities on a tangential plane (*confinium*), the state can effectively resist any arriving onrush of nomadic warmachines on this mode of connection with minimum attrition damage on its critical interior (the plane of logistics and lines of command). In fact, clandestine states seek to channel all the cumulative damage induced by nomadic warmachines (as the postulate of the obtrusive danger) on this mode of connection. This is achieved by deflecting any fundamentally contagious, manipulating and undermining threat towards distributive and recoverable eroding processes; these latter can even be programmed to transport the State out of its rigid segmentarity and despotic bond with territoriality, prolonging the survival

COLLAPSE I

of the state in a fluxional mode in a manner of an abrasive machine of the *fluvius* (river) that erodes solidity in order to transport it by the dynamic conservative vector fields of sedimentary processes – capturing fecundity and irrigation in detrition. With warmachines tirelessly gnawing at the State's *textum*, incising and liquidating its crisp boundaries, the State begins to leak out, but this does not only express the collapse of the State but also the dangerous exposure of the nomadic warmachine to the underlying grid on which the State is assembled and which holds its interwoven space, a network of grounding processes, mechanisms of territorial regulation and economic repression.

The Installation of the operational cutting-edge of nomadic warmachines on the State in the absence of any ungrounding machineries (which incapacitate the dominant grounding, territorializing and moderating functions of the State) is a similar case to that of the premature line of deterritorialization which facilitates either the unconventional establishment of new immunologically-enhanced States or a suicidal flight. Persian history, over a long period of time (from the Achaemenians to the Qajar dynasty (1779-1925), more than two thousand years), narrates such a continuous conversion of nomadic forces into State forces, before being again replaced by another nomadic population (cyclic nomadic uprisings against the ruling regime with a nomadic germ-cell still active but privatized as the State's elite, versatile military institution). Such premature nomadic detritions of the

State have progressively given rise to more powerful (in terms of gravity, immunity and parasitic resistance) yet more unstable States, causing politico-economic poverty; inclination towards being colonized by other States; lack of an autonomous nervous system and polarization of different populations without the possibility of positive diversity; constant vulnerability to schisms, civil-wars, and ethnonationalistic fault lines deleterious to an entire country or geopolitical sphere.

When abrasion processes of nomadic warmachines continue to hold their eroding positions – essentially characterized by transporting dynamism of friction (*tactionis*) and the process of mass-wastage – over a long duration on the borders of the state, hyper-active territorial nexuses between the State and nomadic warmachines emerge, increase and expand. Once such nexuses are established (boundary overlap), the underlying ground economy of the State (or its territorial forces), its entities and even the State's internal machineries directly leak out into the space traversed by nomadic warmachines, to such a degree that they pervade the nomadic space and



Fig. 2. Boundary Overlap with the State (diagrammed as a square) and Nomadic Domestication (left), Tangential Contact (diagrammed as a circle) and Nomadic Effectivity (right)

COLLAPSE I

turn it into a dynamic extension of the State¹³. In this case, the State's functional or territorial entities cannot be effectively enveloped and carried away by nomadic warmachines (as in the case of tangential contact) anymore. They cannot be cut from the State's grid of dominance, liberated and radically dispersed to the Outside (fig. 2).

The hazardous contact of nomadic warmachines with the State, exposing them to the state's regulating functional/territorial spheres, can eventually lead to the emergence of a nomadic-state on the one hand and an ethnonationalistic nomadism (identical to the State's patriotic policies) on the other. Probably one of the most significant examples of such anomalies triggered by the over-exposure of nomadic warmachines to the State is that found throughout Persian history.

(b) Overlap:

If, in a simplified approach, P stands for parthood and O for overlap:

$$O_{\tau}(x,y) = \text{df } \exists z(P(z,x) \wedge P(z,y))$$

And

$$O_{xy} =: \exists z(Pzx \ \& \ Pzy) \quad (x \text{ and } y \text{ overlap})$$

Then the following Axioms apply:

$$\mathbf{AP1} \quad P(x,y) \leftrightarrow \forall z(O(z,x) \rightarrow O(z,y))$$

$$\mathbf{AP2} \quad \exists x(\phi(x)) \rightarrow \exists x \forall y(O(x,y) \leftrightarrow \exists z(\phi(z) \wedge O(z,y)))$$

Any participation (either *methexis* as survival-based participation or base-participation) happens through overlapping connections. Therefore, the majority of

13. A cache for the later movement of the State's macropolitics towards its micropolitical reformation

Negarestani – Militarization of Peace

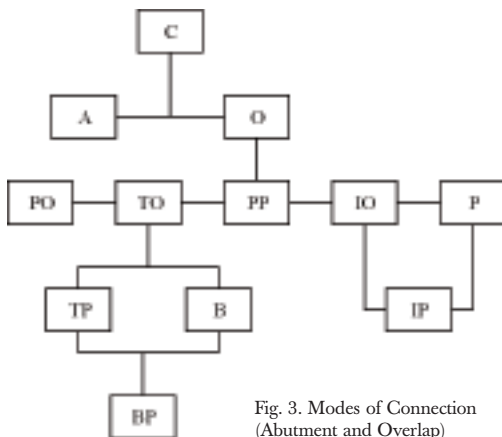
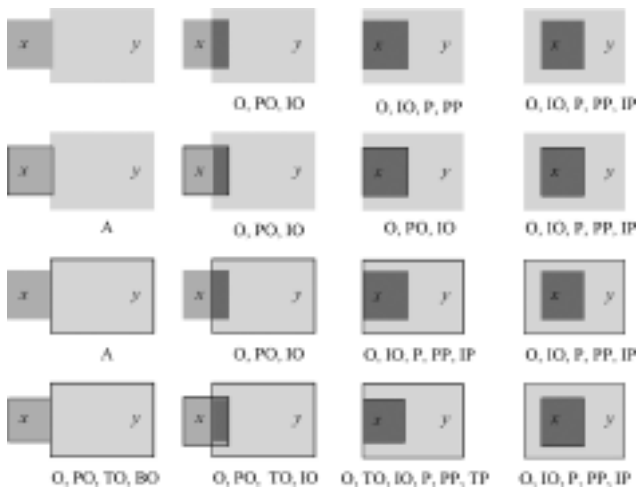
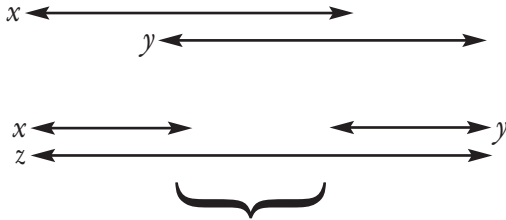


Fig. 3. Modes of Connection (Abutment and Overlap)

COLLAPSE I

combined connections (Tangential, Parthood, Interior, etc.) are effectuated by different possibilities educed by overlap between entities. Overlap draws lines of coincidence between two events or entities by specifying an address that two entities partly or completely share in a spatio-temporal or a functional region. Both the State's appropriations and counter-state *insurgencias* happen through this mode of connection. Whilst it is exploitable by the State and by affordance, this does not mean that 'overlap' cannot also be the main source of insurgency – it is the connection-domain through which warmachines leave their border-eroding externality and directly arrive at the State's grid, either to be specialized by the State apparatus and turn into *military formations* or to be reinvented as contagious, endo-symbiotic and parasitic entities *coinciding* with the State and its machineries and consequently discovering a wide array of clandestine



Not overlapped:

The zone of evacuation and withdrawal from the camouflaged position or the escape-route.

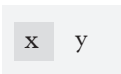
Fig. 4. Partial overlap and its interval relations in Camouflage:
(1) Between two entities; (2) Between two entities and the third entity

and manipulative functions.

On a more technical plane, all camouflage exploitations are essentially consistent because they all involve the use of ‘overlap’ (or, more accurately, coincidence, as the question of overlap between entities here is the question of overlapping niches which these entities occupy¹⁴). Furthermore, they turn it from a mode of connection into a politically-operational positioning that violates both the symmetry of a niche with the address it writes (programs) for an entity and the divisors (events, entities, etc.) which separate and discriminate the addresses or niches of two entities in space-time coordinates. However, this violation (that necessitates the activation of camouflage) cannot remain durable and unchanged, because predatory/military camouflages always employ partial overlap, with a part constantly accessible as ‘not camouflaged’ (either belonging to the camouflaged entity x or the entity which it should be overlapping *i.e.* y)¹⁵ [See

14. Two entities will be said to overlap when they share parts in common: two entities coincide when they occupy *overlapping* regions of space.

15. An example of the *not camouflaged* part (not overlapped) solely belonging to x or y : When the ‘not camouflaged’ part merely belongs to y (in a typified connection):



x internally overlaps y . When:

$$IO_{\tau}(x,y) = \text{int}\exists z (IP_{\tau}(z,x) \wedge IP_{\tau}(z,y))$$

x is an interior part of y , and when

$$IP_{\tau}(x,y) = \text{int}P_{\tau}(x,y) \wedge \neg TP_{\tau}(x,y) \text{ and}$$

$$TP_{\tau}(x,y) = \text{int}P_{\tau}(x,y) \wedge \exists z (A_{\tau}(z,x) \wedge A_{\tau}(z,y)), x \text{ is a tangential part of } y$$

COLLAPSE I

fig. 4]). This not only makes tracing and handling of the camouflaged entity possible on a tactical level but also provides the camouflaged entity with an escape-route or a space for instant evacuation and withdrawal from the camouflaged position. (An escape-route can also be unlocked when an entity z – a third party – connects to both x and y with different overlapping positions for each one (See fig. 4); here, the escape is channeled through another camouflage, a new camouflaged participation extracted neither from x nor from y .) This ‘not camouflaged’ or ‘not overlapped’ part inhibits the camouflage from being durable or constantly undetected, but also makes camouflage controllable; the camouflaged entity can move out of the camouflage at any moment.

All types of camouflage draw a disruptive function from the overlapped part (which mainly occurs on a fragmented level) by conducting the address or niche of another entity (for example, the prey) to the camouflaged entity (hunter) and consequently disrupting the mereologic (part-whole) correlations at work with regard to what should be camouflaged, making it temporally and partly untraceable, camouflaged. Such disruptions (which generally target a reference-point or a reference-link by which an entity is detected) can produce cognitive-glitches as well as the subversion of some specific enviroing bonds that pass through both the camouflaged entity and its object (its prey). Motion camouflage uses a particular type of tactical dynamism (in cases where the prey is also in motion, the movement

of the shadower or the camouflaged predator moves on the path of a chaotic pursuit; the movement can be modeled by projecting its pursuit curves onto the Rössler attractor) or dynamic overlap to disrupt (i.e. shadow) its distance and displacements from the prey (the shadowed) by moving on a path that connects it to a fixed point (used by the shadowed as a reference-point – a constant unit vector) while the motion by the target is met by the motion from the aggressor. In motion camouflage, then, the shadower remains stationary for the target. In the most common military camouflage – disguise by covering objects (soldiers, vehicles, artilleries, launch pads, etc.) – with Disruptive Pattern Materials, disruption happens through surface modifications of a camouflaged object on which the visual sensory organ focuses as a reference-link between different types of surface patterns in its surrounding space, resulting in the ignoring of the object as a part of the safe environment. Invisibility (as a retreat

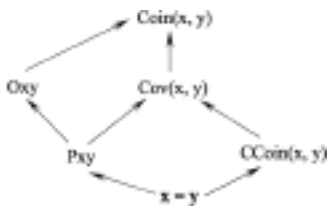


Fig. 5. If **Coin** stands for coincidence, **O** for overlap, **P** for part, **Cov** for cover and **CCoin** for complete coincidence.

COLLAPSE I

from visual sensors), too, employs and modifies partial overlap as an occlusion by obscuring surfaces, interiorizing, positioning the camouflaged (cloaked) entity where boundaries intersect (obscuring boundaries), etc. The primary drawback of the invisible warmachine is the danger of being traced by semiotic regimes of the State which are more obsessed with what is missed than with what exists.

As the result of partial overlap, all disruptions and subversions of mereologic bonds are subjected to eventual disclosure; and each time a camouflage is spotted, it progressively loses its potential; any entity using such a camouflage will be more prone to detection and forestalling counter-measures than it usually is; this is a symptom of the holistic connections between partial overlap and 'localization' which has not been functionally incapacitated and spatially effaced yet. This is why camouflage is rarely implemented as a primary action or an offensive tactic but mostly as a logistic process or a mis-ordering transitional space between different tactical and operational lines. Transient characteristics and stringent operational restrictions obstruct radical weaponization of camouflage.

A *Takfiri* under *Taqiyya* (Islamic hypercamouflage) does not occupy a niche to replace another entity, or dwell as a hidden agent; he pushes the connection with his environment toward a complete overlap, an unbroken field of connection and correspondence, a complete coincidence with its target, *i.e.* a complete overlapping of

its niche with the niche of its target. He entirely overlaps his prey and its niche and thus remains silent.

$$\text{Coin}(x,y) \leftrightarrow \exists z(\text{Cov}(z,x) \ \& \ \text{Cov}(z,y))$$

(x and y coincide if and only if there is some z that is covered by both x and y ; z standing here for niche. While **Cov** is a transitive and reflexive relation, **Coin** is symmetrical and reflexive. The relation of coincidence is of course broader than that of overlap, since there are pairs of coincident objects or even processes that do not share parts. The same question of relation arises for a *Takfiri* under *Taqiyya* and a civilian.)

For a *Takfiri* under *Taqiyya*, occupation is neither a military goal nor a tactic; since occupation is *exclusive localization* tethered to the mappings of co-localization and parts-whole connectedness – that is to say, the despotism of Whole – the occupier is vulnerable to environmental forces; it can be easily distinguished, located, isolated and finally terminated *i.e.* undone at the minimum attrition cost of its environment and surroundings. Where occupation is bound to visibly militant and escalating modes of warfare and exclusion, weaponized *Taqiyya* is maliciously diffusive. In mereologics (the discourse of part-whole modes of connectedness) we would call the positioning of *Taqiyya complete overlap*: the *Takfiri* constitutes a sinister survivalism whose basic function is to extinguish survival itself. In complete overlap (see Fig. 6), every region, function or part of the hypercamouflaged entity or predator, the ‘*Takfiri* under *Taqiyya*’ (X) can correspond with its identical region, function or part of the

COLLAPSE I

prey/host/civilian (Y). Therefore if every x (part or function of X) homologizes its corresponding y (part or function of Y) or more precisely, if every x corresponds with its y ‘on all levels’ then every function of X (the tactical movement of the *Takfiri* under *Taqiyya*, or hypercamouflaged predator) can be transferred to Y and they mutually fulfill each other.

$$x=y \leftrightarrow \forall z (Oxz \leftrightarrow Oyz)$$

(Any two members of the domain that overlap the same

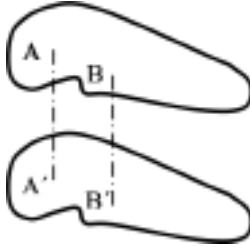


Fig. 6. Complete overlap and symmetric fulfillment

(Symmetry: Let S be the symbol for symmetry where n is an integer, d is the class descriptor and $compd$ is the complement of d : $S = \{n(d) \wedge compd\}$)

entities are identical.)

But the most horrific dimension of this arrangement is revealed when the process is reversed: if every x fulfills its corresponding y , then by way of the ‘exact connecting-corresponding’ space that complete overlap and complete coincidence ($\mathbf{CCoin}(x,y) =: x=y$)¹⁶ provides, every y (i.e.

16. Complete coincidence can be expressed in terms of covering (\mathbf{Cov}):

$$\mathbf{CCoin}(x,y) \leftrightarrow \mathbf{Cov}(x,y) \ \& \ \mathbf{Cov}(y,x)$$

(x and y completely coincide if and only if y covers x and x covers y)

every function or positioning of the prey Y, which would comprise for the most part normal survival functions and ordinary individual or social activities) can be transferred to its corresponding x and eventually fulfill it too. By seizing any y , a corresponding x is triggered and covertly unleashed; and since we are dealing with complete overlap, the very *survival and communication* of Y deploys, activates and fulfills the menacing body of X, the *Takfiri* under *taqiyya*. On the one hand, the survival of the prey/host/civilian thoroughly agrees with the sinister enthusiasm of the terrorist; and on the other hand, peace is generally conceived as the state of collective survival. So that the survival of both the terrorist and the civilian yields nothing but the (interminable?) endo-militarization of peace, a global threat against civilians, the rise of White War and the threat that, fuelled by the infinite thirst of heretical Jihadism, the contagion of war might expand unchecked, even to fill the immensely significant horizon of survival and *living* in general.

Now that the survival of Y or the host/civilian (together with its communication and modes of connection through and with its *environment*) fulfills the political and military body of the '*Takfiri* under *Taqiyya*', the mere existence of the civilian is weaponized against both itself and the immune system of the system that accommodates and protects it to such a degree that auto-phagic overreaction looms as the only logical solution for the system. It is the military culmination of *Taqiyya* to deduce irrevocable insanity from the minimum essential logic

COLLAPSE I

required for basic survival.

EXEGETICAL CONCLUSION.

“The trends explored here will obviously be decided ‘on the battlefield’ - but that increasingly means everywhere. The centrality of hypercamouflage to Jihadi strategy is already having immense consequences, inducing a wave of ‘retro-militarization’ in State war machines, where ‘teeth’ flow back down the ‘tail’ in a process without obvious terminus (short of the fanging-up of the entire social body).

Saddam Hussein’s auto-disassembly of his own war machine in the interests of a latent insurgency exemplifies this trend from one side, whilst the moves to harden up US logistics formations through armoring of vehicles and combat training for all personnel complements it from the other.

Human rights concerns about killings of civilians could relevantly be extended from the empirical level to that of the transcendental, where the eradication in principle of all civilian populations is taking place. The very concept of ‘the civilian’ is becoming distinctly dated. (Virilio’s analysis – despite betraying a somewhat antiquated perspective through terms such as ‘endocolonization’ – seems to have anticipated this trend).

The US is especially interesting because it remains a ‘peripheral’ (even ‘third world’) society in certain respects, marked by a low domestic index of State

Negarestani – Militarization of Peace

monopolization of violence, thus allowing retro-militarization from the State pole to connect with an endogenous paramilitarism already rooted in the ‘civilian’ population (armed vigilantism and militia movements). As far as militias are concerned, the world ain’t seen nothing yet.”¹⁷

COLLAPSE VOLUME I Erratum

. p76 Note 12 should continue as follows:

...The project’s objective was to construct a soft climate (klima: zone) or a zone of hydraulic conductivity (corresponding to the State’s Hydropolitics) which would autonomously accommodate nomads, making them move through itself, and thereby ease the whole process of monitoring, domesticating and tracking nomads. This climate being finally transformed into a tremendously dynamic network of anti-nomadic movements, would employ its hydraulic head to configure nomadic dynamism according to the State’s geo-politics, economic convergence and military dynamism (an accessible space for the State’s military entities especially during insurgencies); the State was seeking to breed its own territorializing (rather than territorialized) nomadologic lines. This climate was actually to consist of ‘artificial rivers’ which were supposed to be distributed over the country. The work of construction of these rivers was to be undertaken over a period of years, in a country that has always suffered from a lack of water in its central and eastern regions. Such fluid, rich and dynamic zones or hydraulic lines (for instance rivers and their tributaries) spread over the country would gradually attract (on the pattern of gravity) nomads, rendering a preferable but precisely mapped climate for their migration; a climate which would actually be an autarkic monitoring machine rendering its inhabitants predictable and expanding a fluid domesticating sphere for the Iranian nomads.

17. This exegetical conclusion to the current essay was contributed by Nick Land.

COLLAPSE I

Prime Evolution

Interview with Matthew Watkins

Matthew Watkins' Web-based Number Theory and Physics Archive and its speculative twin Inexplicable Secrets of Creation¹ – hosted by the mathematics department of Exeter University in the UK where Watkins is an honorary research fellow – have grown into a unique resource. The archive brings together work from the plurality of disciplines contributing to an as yet unnamed field of research concerned with the startling connections between number theory – particularly the Riemann Hypothesis on the distribution of the prime numbers – and the physical sciences. Watkins talks to COLLAPSE about his rôle in, and motivations for, catalysing and disseminating the field, about the latest developments in the search for the hypothetical 'Riemann dynamics', about the nature of discovery in mathematics and its academic and cultural status.

1. At <http://www.maths.ex.ac.uk/~mwatkins/>. Dr. Watkins has kindly assembled a 'primer' for the mathematical concepts discussed in this interview: at <http://www.maths.ex.ac.uk/~mwatkins/zeta/collapseglossary.htm>

COLLAPSE I

COLLAPSE: The primes have perennially been hailed as ‘mysterious’. In modern mathematics this mystery has condensed around the problem which Riemann's Hypothesis concerns. We can find primes as we count along the number line, but we have no way of predicting in general where and how densely they will occur. A lack of determinable global order, then.

MATTHEW WATKINS: But first there's a major question concerning what is meant by ‘order’. I'm often asked, is there a pattern in the primes, is there an order, but what does that mean? If you try to reformulate these questions very precisely, you're forced to consider what it would mean for there to be order, or a pattern. I mean, there are patterns like wallpaper patterns, where you have a block of something repeating. Well, almost by definition the primes can't do that. But what sort of pattern could there be, what sort of order could there be? The idea that there might be a pattern, the importance of there being a pattern in the primes – these aren't things you can rigorously pin down.

C: Couldn't you use an information-theoretical definition of pattern?

MW: You could come up with a definition, one of an endless number of possible definitions, from information theory or some related discipline, of what a pattern is,

and then apply it. But I think there's still the basic fact that when people who aren't familiar with any of those definitions are asking 'is there a pattern?' they don't mean anything that such a definition could capture, they mean something else – they don't really know quite what, but it seems important to them that there should be; whether or not there is a pattern in the primes they see as an important question. And it struck me when I was thinking about this that it's more *feeling-based*, it's not a rational question they're posing. You can try to construct rational questions around it. People have, and such questions have given rise to a large part of that body of work we call number theory.

C: But initially it's more like the expression of an instinct for pattern recognition?

MW: Perhaps. As Jung said – almost as the culmination of his work on archetypes – the set of positive integers, taken as a whole, corresponds to the *archetype of order*. So, in a sense, all notions of order, of something coming before something else, of things being in a sequence, all of that ultimately can be linked back to our instinctive grasping of there being a number system underlying our experience. Now that number system turns out to have embedded within it an enigma, a problem bordering on the paradoxical: is there order in the way this thing's put together or not? We feel there should be, but we aren't entirely sure how to ask the question – basically, we don't

COLLAPSE I

really know. So we start by asking whether there's order in the number system, and the unintended result of our probing into this matter is that what we ultimately mean by order *in any sense* gets indirectly thrown into question.

People also frequently ask about the existence of a *formula* – is there a formula for the prime numbers? Well, again, that's difficult because, yes there is, there's the Riemann-von Mangoldt explicit formula, which effectively generates exactly the distribution of prime numbers as 'output' – but you need the complete set of *Riemann zeros* as input. This is an infinite set, and to produce it you effectively need the complete set of prime numbers, so there's a circularity. So it's a formula, but not the kind of formula which people who ask this question have in mind. There are also algorithms – rigorous procedures – which can systematically generate the primes. One could arguably call these 'formulas', but they're basically methods of computation, and the computations quickly become intractably huge...so we're not talking about anything that can systematically spit out primes one after another in the sense that people might have in mind when they ask about the existence of a formula.

C: As the years have gone on, mathematicians' ingenuity and the employment of new technologies have seen an acceleration in the conquest of the critical line of Riemann zeta zeros. But does the fact we've got, say, one

billion of the zeros make it any less mysterious than when we had a hundred? Does the apparent success of the Riemann Hypothesis (RH) militate against the conception of the primes as mysterious?

MW: First of all, you can't really talk about RH being 'successful', it's still a hypothesis. RH doesn't predict the primes as such, but the theory of Riemann's zeta function, from which it emerges, allows us to understand the distribution of primes much more deeply. At the heart of this theory is the peculiar sequence of 'zeros' now known as 'Riemann zeros', 'Riemann zeta zeros' or sometimes just 'zeta zeros' – these are what RH directly concerns.

What's happened really is that RH has displaced the mystery. The primes are no longer mysterious, you could argue – we now know that they are exactly governed. Initially, it was found that they're governed by a logarithmic distribution, a sort of gradual thinning out, in an almost statistical sense – that provides reliable but approximate information about the primes. Riemann later found that the logarithmic distribution is 'modulated' by an infinite set of waves, where each wavelength corresponds to one of the Riemann zeros. We're in the realm of proven mathematical results here, and these *precisely* pin down the primes, so in that sense, all mystery is gone; but in actuality the mystery has been pushed back, or displaced. The mystery now is, *where the hell did these Riemann zeros come from?* We can

COLLAPSE I

calculate hundreds of billions of them, we've got a vast, intricate body of precise mathematical results concerning them which ultimately brings us to a big, important, question about whether they'll all lie on the 'critical line' – that question is RH. But ultimately, what *are* they?

Since the seventies, this idea that they might be *vibrations of something* has taken root and has now been more-or-less universally accepted, on the basis of a lot of computational evidence together with a mysterious, suggestive mathematical 'coincidence' involving something called the Selberg Trace Formula – and that ties in with certain unexpected connections with physics.

So if we've got vibrations of a mysterious 'something' underlying the number system, in a sense the primes are no longer the mystery, the primes have been taken care of, the mystery has been displaced. The primes are our obvious way into the mystery, but ultimately it's a mystery about the system of positive integers, about 'order', and arguably even about *time*.

C: To return to the question of order, are the zeros any more ordered than the primes?

MW: The set of primes and the set of Riemann zeros are in some sense 'dual' structures. There's a variant of what's called a 'Fourier duality' between them. To put it simply, you can use the zeros to generate the set of primes: if you have just the zeros and the explicit

formula, you can effectively ‘put the zeros in and get the primes out’. And it also works in the opposite direction. So the two generate each other. In a sense the primes are more well-behaved in that they’re all integers, they all fall on this nice ‘grid’ of positive integers. The primes can be explained to a schoolchild, a five-year-old is capable of understanding the idea of prime numbers. They are there among the familiar positive integers, the usual counting numbers, and counting is a ubiquitous part of our everyday experience.

They’re dual, so in some sense the two could be seen as equally important, two sides of the same coin. However, the Riemann zeros are very different – they’re not integers, they’re what we call ‘transcendental’, irrational numbers; you need a degree in mathematics before you can even begin to understand the definition of them, and relative to the total population, only the tiniest handful of people have any real understanding of what is currently known about them. And they appear to have absolutely nothing to do with ordinary everyday experience.

C: We could say that the zeros are not a solution to the problem, but the problem itself, expressed in a domain that’s more difficult for us to access; the exact nature of this domain then becomes the real focus of interest.

MW: Yes, the zeros are the problem, and thus the

COLLAPSE I

problem's been displaced to somewhere we're much less familiar with. Counting, you know...Ancient Greeks and earlier people could count pebbles out on the ground, subdivide them into piles and contemplate different types of numbers – 'perfect numbers', 'triangular numbers', prime numbers – and they were able to develop a certain amount of theory. But that's just one side of the coin. On the other side, there was no way they could have contemplated the Riemann zeros: (a) you need a theory of 'functions of a complex variable', and (b) in order to calculate more than the first handful of them you need a pretty powerful computer.

It reminds me of the central image in the film *2001*: It's as if we've dug this monolithic thing up, it's been there for aeons, as a structure it's overwhelmingly impressive, and everyone concerned is flabbergasted, asking themselves how did *that* get there, you know: it comes from *somewhere* else, somewhere beyond, and it induces a sense of almost religious awe.

One suspects that if a mathematical structure underlying or 'explaining' the Riemann zeros were to emerge – that is, if in fifty or a hundred years someone comes up with something new which 'explains' the zeros in the way the zeros 'explain' the primes – then that new structure is just going to open up another even deeper mystery. Paul Erdős, who published more mathematics papers than anyone else ever, and who was primarily a number theorist, said that it's going to be at least a million years before we understand the primes, and even

then we won't really understand them.

C: Is it a properly transcendental problem, relating to the limits of our thought: the more that we think, the further the problem moves away from us?

MW: Well, again, we don't know that yet: it may be, but then who knows – maybe it'll all neatly tie up somehow. But it *feels* to me that the problem has a quest-like quality. The fact that the metaphorical image of the Holy Grail has been invoked a few times in the literature, as well as a lot of language poetically invoking the feminine and generally suggesting an 'otherness', suggests that I'm not the only one thinking like this. I've had an interesting dialogue with some Jungians about this aspect of RH.

The problem of the primes isn't just different from other mathematical problems, it *precedes* them. All other mathematical problems rely on the fact that there are positive integers. Without the set of positive integers, those other mathematical problems couldn't exist. So the problem of the primes is *the* problem in a sense, it's beyond the most basic, it's there before all the others are there. As soon as you've got counting, as soon as you've got any notion of repetition, then the problem of the primes is there waiting to be discovered.

If we don't understand the prime numbers, we don't understand the positive integers. And if we don't understand the positive integers, then I don't know if we

COLLAPSE I

understand anything at all, because all science is entirely built on measurement, and you can't measure anything until you can count. All our rational scientific thought relies on these very basic ideas of order and counting.

One of the most important quotations that I've reproduced on my website is this, from Gerald Tenenbaum (Institut Élie Cartan):

As archetypes of our representation of the world, numbers form, in the strongest sense, part of ourselves, to such an extent that it can legitimately be asked whether the subject of study of arithmetic is not the human mind itself. From this a strange fascination arises: how can it be that these numbers, which lie so deeply within ourselves, also give rise to such formidable enigmas? Among all these mysteries, that of the prime numbers is undoubtedly the most ancient and most resistant.²

So, in probing the mystery of the prime numbers we're effectively on a sort of journey to the centre of the mind, or of the collective human psyche, and ultimately to the point where that interfaces with the physical world which it finds itself inhabiting. That quote perhaps best conveys some feeling as to why I'm so gripped by this stuff.

C: The story of the modern theory of primes begins

2. G. Tenenbaum and M. Mendès France, *The Prime Numbers and Their Distribution* (AMS, 2000) p.1

with Gauss's initial success in predicting approximately the distribution of primes. How do we get from there to the pioneering interdisciplinary work that your web-archive charts?

MW: Gauss – although he didn't publish, he supposedly got there first – Gauss and Legendre noticed that there was at least a 'statistical' thinning out of the primes that you could quantify. Riemann later uncovered the zeros of his zeta function – the Riemann zeros – and so was able to pin it down much more rigorously. But there's a fifty-year gap where...actually, I don't know what mathematicians felt during that time. Practically, they were trying to refine the approximations; Chebyshev and others improved the approximation of how many primes you'll find in any given chunk of the number line. But whether there was an expectation that eventually someone would find a way to make this exact, or whether there was a general feeling that 'this is the best we'll ever do', I don't know, and I can't recall seeing anything in the literature of that period where feelings about this matter were expressed. Once Riemann's work came along then no one was really interested in what people *used* to think. The history of mathematical ignorance isn't as well documented as the history of mathematical discovery.

There are some parallels with the situation we're in now, where there's a mystery about this proposed 'Riemann dynamics', this hypothetical dynamical system

COLLAPSE I

underlying the Riemann zeros.

C: The complex plane is the most important mathematical support of RH itself. And here already a transformation takes place – de Sautyoy³ talks about it as a sort of magic mirror we step through – which seems to unfold things we thought we knew, in a completely different space – as it turns out, very fruitfully for mathematics and the physical sciences alike.

There’s obviously something very powerful about the complex plane itself which, at the very least, corresponds in some way to physical reality, and so the fact that it was also the complex plane which facilitated Riemann’s insight into the prime distribution is itself suggestive.

MW: The complex plane appears to have a life of its own. Complex numbers are absolutely necessary to describe quantum-mechanical phenomena. Electricians use the complex unit i just to work with AC electricity, so something as ‘nuts-and-bolts’ as the National Electricity Grid depends on the complex plane. And yet it is this supremely mysterious thing. I mean, all those fractals that started to circulate in the 1980’s – a lot of people don’t realise what they’re looking at, but those are things that naturally inhabit the complex plane. Without the complex plane you wouldn’t be able to see such objects, that’s their natural domain. And then the Riemann zeta

3. De Sautyoy, M. *The Music of the Primes*. London: HarperCollins, 2004

function, with all its strange properties; Riemann's big step was to take a function which Euler had looked at and ask, what would that do if we extended it into the complex plane? And what it was found to do then spawned the great mystery of the Riemann zeros.

Another strange thing worth mentioning: One tends to think of temperature as existing on a linear scale, a one-dimensional scale. But in statistical mechanics, by constructing a function of temperature, the 'partition function', and extending it out to the complex plane, you find that it has a set of 'singularities', off the familiar real number line, in this other two-dimensional region that doesn't seem to have anything to do with temperature or any other aspect of practical measurable physical reality. Yet these singularities correspond to *phase transitions* of the system. Without the complex plane you'd never have known they were there. The same thing happens with the zeta function, it's got a set of singular points in the complex plane, the Riemann zeros off the real line. From the behaviour of the zeta function *on* the real line, you would never have guessed they were there.

Various people have put forward models of two-dimensional time – imaginary time certainly gets used, complex time. Such models can be used in attempts to explain otherwise inexplicable phenomena, but none of this can be applied to our normal experience of reality, you can't really do anything with it. I would say that the complex plane is still deeply mysterious. It's 'behind the scenes' of reality as we experience it.

COLLAPSE I

C: And historically, complex numbers had been discovered long before there was any sense of their ultimate utility. Only later did it become evident that something which seemed to have been a mathematical fiction, was hugely important to work in these fields.

MW: Absolutely, the word imaginary, you know – you’ve got the ‘real’ numbers and the ‘imaginary’ numbers – it’s a very unfortunate name, but it’s simply because of the history of the thing. For quite a while, no-one thought these things had any ‘reality’ to them, primarily because they didn’t correspond to anything experiential in the way ‘real’ numbers were seen to.

C: It’s difficult to ignore this experimental evidence that complex numbers relate to something in reality: we have to take account of these things which just impress themselves upon us. The traits of the complex plane are obviously real, but they don’t correspond to any actual object, any actual thing we can get hold of. They’re distributed through reality itself.

MW: Yes, the system of complex numbers is there, I don’t know ‘where’ it is, but it’s not just something we *invented*. And, interestingly, it’s most directly evident at the subatomic level. As I said, the theory of AC electricity relies on it, but then ultimately that’s a quantum-mechanical phenomenon, scaled up to the level where we

can, say, run a toaster on it. Functions of a complex variable get used in statistical mechanics, aerodynamics, *etc.*, but those are fairly indirect manifestations of something very deep, I feel. The fact that the complex plane relates so closely to quantum mechanics means that in macroscopic reality, it permeates everything, as you say, and yet nobody had a clue it was there until relatively recently. Even after it had been mathematically brought into consciousness it was still seen as just a fiction.

As for the primes, you can't understand the distribution of primes until you've grasped the Riemann zeros. And the Riemann zeros live on the complex plane, inarguably. The 'nontrivial' zeros, the ones RH concerns, inhabit a narrow vertical strip in the complex plane. The RH simply says that they all – the entire infinite set of Riemann zeros – lie on the 'critical line' which runs up the middle of this 'critical strip'.

Now, to prove RH would be an exact mathematical task, so RH gets a lot of press – there's the whole fame-and-fortune thing, literally a million-dollar prize, this idea of something like winning the ultimate intellectual gold medal, you know – but you've either done it or you haven't, it's very clear-cut. But I'm more interested in the less clear-cut questions – what *are* the Riemann zeros, from where do they originate?

To answer this we may need something else as new

4. See <http://www.claymath.org/millennium/>

COLLAPSE I

and unexpected as the complex plane was when it was first introduced, something we haven't thought of yet, a new mathematical 'environment' in which these things will become perfectly clear. But that may well lead to another body of questions which are even more baffling.

But "from where do the zeros originate" – what does that mean? They're seemingly vibrations of something, but what? What is that thing going to be – is it going to be a mathematical model of a dynamic system that people may or may not be able to physically manifest? If it is possible to physically manifest it and someone does...what then are we confronted with?

One gets a very strong feeling that until we understand the what the zeros 'are', we won't be in a position to prove RH. These two issues are tied together. But the former isn't yet a precise question, whereas 'is the RH true' *is*.

C: It is said that in mathematics a question isn't even a question if you can't formulate it precisely: mathematics is the art of formalising problems, so if you can't do that then in a sense it falls outside of mathematics.

MW: Yes, and so something with this kind of quasi-mathematical character is generally regarded with a certain suspicion; it's neither one thing nor the other.

C: A mystery rather than a problem, then.

MW: Yes, and I suppose I tend to be attracted to the mysteries.

C: Practically speaking, how does the hypothetical positioning of a Riemann dynamics change the nature of the search for a proof of RH?

MW: It brings other people in, it brings the physicists in. Before, you had analytic number theorists hammering away at this problem. And now probability theorists, geometers and physicists are all contenders, and they all have pieces of the puzzle. It's broadened the scene, if you like, of people concerned with the problem. But it also has given a deeper sense of what's at stake; again, if there is a dynamic system underlying the Riemann zeta function, well then it underlies the number system; if it underlies the number system then it underlies everything, or at least everything that rational scientific thought concerns itself with. And so, again, we're forced to ask what is it, where does it 'live', what does it 'do'? And perhaps the most important question is, *what is the time parameter?* Because a dynamical system always has a time parameter according to which it 'evolves' – so what kind of time are we talking about in this case? So it basically opens a whole new can of philosophical worms. It makes me think of what Hilbert said, when he was asked about RH, he said that it isn't just the most important problem in mathematics, it's the most important problem. And I think a lot of people might just think,

COLLAPSE I

yes, that's because he was a mathematician, he was biased...but I think he knew what he was talking about. He and Pólya first proposed that there might be a 'Riemann operator', that the zeros might be a spectrum of something. They didn't suggest a dynamical system as such, but they could be said to have laid the groundwork for that. So I think Hilbert may have sensed something very big going on there, which he was trying to express in that pronouncement.

C: The first steps towards elaborating the nature of the Riemann dynamics comes with Julia's interpretation of the zeta function as a thermodynamic partition function. What is a partition function, and in what sense can one speak of the primes as a numerical gas – Julia's 'free Riemann gas'? Is it simply a useful metaphor taken from thermodynamics, or is there a more substantial link?

MW: Well, firstly, Julia's work doesn't directly address the issue of the Riemann dynamics, although there may well be a deep connection there.

Your last question is difficult to answer, but it would be hard to deny that there's a sort of a metaphor here, in that there's a strong resemblance between certain aspects of the zeta function and the theory of thermodynamic partition functions. But it goes deeper than a superficial resemblance. There are enough corresponding elements, that Julia included what he called a 'dictionary' in the

paper he first published about this.⁴ It consists of two columns, with number theoretical structures on one side and corresponding thermodynamic structures on the other. And the correspondences are such that, if you're sufficiently familiar with number theory and statistical mechanics, you can't deny there's something...there's a very strong link there. So you could call this a metaphor, but I would maintain that it's more than just a metaphor in the familiar sense, *i.e.* a useful way of explaining what something is by means of something else which isn't directly related to it.

Now what is a partition function, in statistical physics, or statistical mechanics? Well, in classical mechanics, a billiard table is often used as an example: you've got a finite number of billiard balls bouncing off each other, bouncing off the sides, they're colliding, energy is being transferred between them, there are various angles, positions and momenta involved. And the idea is that you've got a sufficiently simple system that you can keep track of each individual object and what it's doing. But a problem arises when you've got something like a box of gas: that's effectively like a giant three-dimensional billiard table, but there are too many components to keep track of what each one is doing. You're not actually going to be able to do anything in that way, so you're going to have to study it in the sort of way sociologists study society – they can't possibly consider all the specifics of

4. Julia, B.L. 'Statistical theory of numbers', in M. Waldschmidt, et. al. (eds.) *Number Theory and Physics*. Springer Proceedings in Physics 47 (Springer, 1989)

COLLAPSE I

each individual person, so they must look at overall statistical trends in the population.

Suppose you had a quantity of gas particles in this room, and they were all roaming freely. It would be very surprising to find them all clustered up in one corner. One expects a more uniform spread. But, *there's no real reason they can't do that*. It's like if I toss a coin fifty times, I'd be very surprised if I got fifty heads or fifty tails, but there's no reason why that can't happen. That would be no more unreasonable than any other outcome of fifty coin-tosses, it's just that it's extremely *improbable* because, unlike any other outcome, *there's only one way of arriving at it*. Similarly, there are proportionally few possible configurations of those gas particles where they're all squashed in one corner, compared to the vast proportion of configurations where they're more-or-less uniformly distributed.

Now suppose you have a box of gas, and the gas consists of particles which can jump between different energy levels in an effectively random way. This time you're concerned, rather than with the spatial distribution, with the *total energy* of the system – that's simply what you get when you add together all the individual particle energies. You can ask about the probability of the system having a particular total energy, and it turns out to be rather like the situation with the spatial distribution. That is, the system tends towards a mid-range total energy on the whole, while the highest and lowest ranges of *possible* total energy are much more

improbable – because their occurrence requires something akin to a huge number of coin-tosses producing almost all heads or almost all tails.

So what you're looking at with thermodynamics is the probability that you'll find a box of gas or some similarly complex system in one state or another. And the partition function takes a unit of probability and 'partitions' or subdivides it, so that you end up with a curve describing in precise terms the relative probability of finding the total energy of the system at any particular level. So the partition function will basically return probabilities that a system is in one of any number of possible states. The partition functions Julia refers to are functions of temperature – as the temperature of the system varies, the probabilities also vary, and the partition function is able to provide a precise probabilistic distribution of possible total energies at any given temperature.

Now partition functions, it turns out, are the key to understanding statistical mechanical systems; they 'encapsulate' such systems. The partition function in this context is a function of temperature, and temperature would naturally be seen as a variable which varied on the real line – on the *positive* real line, if you're working with absolute temperature. Well, nineteenth century mathematics suddenly allowed the possibility of extending such a variable to the complex plane, regardless of what a complex-valued temperature might actually refer to. You take your partition function which

COLLAPSE I

is supposed to be returning probabilities of a system being in some energy state or other based on a real-valued temperature variable, extend it to the complex plane, and you find there are singularities hidden out there which tell you about the possible existence of phase transitions in your system. These are very important for understanding the system, but, as I said earlier, you wouldn't see them if you didn't have access to the complex plane.

Now Julia wasn't the first – George Mackey got there first, although it wasn't widely noticed. Julia discovered it independently and then Donald Spector, a couple of years later – they all noticed that if you treat the primes as your basic particles, and each prime p is thought of as having as its 'energy' the natural logarithm of p – that logarithm turns out to be very important, logarithms show up everywhere in analytic number theory – then the Riemann zeta function very naturally falls into the rôle of being the partition function of an abstract numerical 'gas' which is made of this set of particles – what Julia calls the 'free Riemann gas'. Imagine a fluctuating integer, where prime factors are coming and going all the time, joining and leaving, so the energy of that integer is going up and down, the more prime factors there are the higher the energy, and the less prime factors the lower the energy. The zeta function naturally becomes the partition function of such a system. The 'pole' of the zeta function – this unique singularity of the zeta function at the point 1 in the complex plane where

the zeta function isn't defined, where it effectively becomes infinite – corresponds very naturally to something in thermodynamics called a *Hagedorn catastrophe*, a phenomenon involving the energy levels crowding together so the system hits a critical state and shifts into an altogether different mode. So the pole of the zeta function is associated with this 'catastrophe', and based on what I was just saying, the Riemann zeros also become linked to phase transitions, in a way that no-one entirely understands. And there's more...those are just the basic points, there are further subtleties which suggest that, in some sense, thinking of the zeta function as a partition function goes beyond mere metaphor. It's a metaphor, but it's a metaphor that goes deep enough to suggest to me that *the number system has some sort of quasi-physical quality*.

C: How are we to interpret this? There's a perplexing quality to these propositions, one is never sure whether what's being revealed is a progression, or simply a restatement of the same problem in different terms.

MW: Possibly, but you see, the mathematics that's come out of studying things like boxes of gas, *that that should be applicable at all* to studying something as fundamental as the positive integers, to me comes across as sort of *uncanny*. I think that's a good word to capture how a lot of people have reacted to these discoveries. It's hard to see how it's simply a reformulation of the problem.

COLLAPSE I

You'd never have got there if you hadn't studied the boxes of gas in the first place. When you ask how we can best interpret this, the only answer I can come up with is I honestly don't know. To me it points to something fascinating which we haven't yet entirely understood or taken into account.

Now, interestingly, Alain Connes' (College de France, IHES, Vanderbilt) model involving what's called a *C*-dynamical system* – his attempt to try and describe the Riemann dynamics, which hasn't yet fully succeeded, although it's certainly opened up some new vistas – was inspired by Julia's paper, but Connes uses the partition function in a somewhat different sense. The partition functions I've been describing, the ones associated with boxes of gas, *etc.*, could be called 'classical partition functions' as they belong to 'classical statistical mechanics'. But there are also partition functions used in *quantum* statistical mechanics, which take some of the same concepts down to the quantum level.

Connes takes certain elements of quantum statistical mechanics and applies them to the zeta function, treating it as a partition function, and this reveals certain things which again push the metaphor, in my mind, so far that it can't be regarded as *just* a metaphor.

C: So there is a direct link between the quantum-mechanical interpretation and the thermodynamic?

MW: I think there must be, although it's not yet entirely clear what it would be. Of the two most extensive pages in my web-archive, one deals with the spectral interpretation – Hilbert and Pólya's suggestion that the Riemann zeros might be vibrational frequencies of something and Michael Berry's (Bristol University) physics-inspired work concerning what that 'something' might be. Berry and his colleague Jon Keating have outlined a whole set of dynamical properties characterising this hypothetical Riemann dynamics. And the other page deals with the thermodynamic or statistical mechanics side of things – you've got Julia, Spector, Mackey, who all put forward the idea that the zeta function is a partition function, which would suggest that the zeros are in fact phase transitions of something. So these two currents of research are seemingly different approaches, not obviously compatible. Alain Connes has begun to bridge the gap, though. He has taken Julia's suggestion about zeta as a partition function, shifted it into the realm of quantum statistical mechanics, and then brought in p -adic and adelic number systems, and a lot of other very deep mathematics including something called noncommutative geometry, which is about as difficult as current mathematics gets. He's managed to describe a dynamical system, or at least sketch out the beginnings of one, which produces the Riemann zeros as vibrational frequencies, but where the zeta function is also playing the rôle of a partition function, so there is a link there.

COLLAPSE I

C: Connes' *adele* is an infinite-dimensional space in which each dimension is folded, so to speak, with the frequency of each prime.

MW: Yes, that's almost it. An *adele* is a generalised kind of number which contains an infinite number of coordinates, one associated with each prime number, effectively, and then an extra one, which corresponds to the continuum of real numbers.

The adelic number system embraces all of the different p -adic number systems – 2-adic, 3-adic, 5-adic, 7-adic, etc. p -adics and *adeles* constitute yet another aspect of number theory finding its way into physics, thereby suggesting that things aren't the way we thought they were.

The Archimedean principle, the basic principle of all measurement, is based on rational numbers, on ratios. If you have a line segment and a longer line segment, by taking the shorter line segment and joining it end to end a finite number of times, you will always be able to exceed the longer line segment. That seems obvious – it's the basis on which I can take a ruler and measure this room. If I kept joining it end to end and I never got to the end of the room, then measurement wouldn't work very well! So, the universe at the macroscopic scale is Archimedean: the Archimedean principle applies. And the number system we generally use, the continuum of real numbers, is an Archimedean system.

Now, the real number continuum is based on a particular arbitrary choice of how we ‘close’ the system of rational numbers. The rational numbers are fairly simple, well-determined, or given, if you like – canonical. You’ve got your integers, and then you start taking ordinary fractions and that fills in the gaps – it doesn’t fill in *all* the gaps, but it densely fills in the number line. The ‘holes’ that remain are the irrational numbers, which can’t be expressed as ratios of integers, $\sqrt{2}$ being the one that, it’s widely believed, was first discovered, and π being undoubtedly the most famous. But there’s not just a handful of exceptions, these irrational numbers are in some sense *more common* than the rational numbers.

The question is, given the system of rational numbers, how do you fill in the holes, how do you seal the whole thing up? Well, the method we’ve ended up adopting produces the system of real numbers, which is a system in which the Archimedean principle applies. And that’s based on defining the holes, the irrational numbers, as the ‘limits’ of sequences of rational numbers. But to define the limits, you have to have a sense of distance; put simply, a sequence *converges* when its elements get closer and closer to something, and the notion of ‘closer’ requires some sense of distance. The sense of distance we use to define the real numbers is the obvious one: the distance between any two rational numbers on the real number line is what you get when you subtract the smaller from the larger. But that’s an arbitrary way of defining distance. It turns out that,

COLLAPSE I

within the logical constraints which apply, there are an infinite number of other meaningful, consistent ways you can define what distance is, and each leads to a different notion of ‘closure’ and hence to a different number system. So you’re still starting with the rationals, but the way you ‘fill in the holes’ is completely different, and you end up with a different kind of mathematics. Now this was discovered by Hensel in the late 1890’s, and very quickly the possible ways of closing the rationals were classified. It turns out that there are infinitely many of them, and that they correspond to prime numbers: there’s the 2-adic system, the 3-adic system, the 5-adic system, the 7-adic system, all the way up, and then finally there’s the ∞ -adic system, which corresponds to the usual system of real numbers, and which suggests the existence of what’s called the ‘prime at infinity’, a deeply mysterious thing, which an Israeli mathematician called Shai Haran has written a whole book about⁵.

But the point is, in a 2-adic, 3-adic or 5-adic number system, the distance between two rational numbers has nothing to do with the traditional distance between two points on a ruler anymore, rather it’s about arithmetic relationships involving divisibility of numerators and denominators by the prime p which characterises the p -adic system in question. So things that would look very close together on a ruler could be huge distances apart, and vice versa, things that are vast distances apart in a

5. M.J. Shai Haran *The Mysteries of the Real Prime*. London Mathematical Society Monographs, Oxford: OUP, 2001.

normal Euclidean sense could be very close together in a p -adic sense.

C: And the adelic system is built up of all these?

MW: An adèle is a generalised number which has an infinite number of co-ordinates. One's a 2-adic number, one's a 3-adic number, one's a 5-adic number: one for each prime. They're usually written as:

(2-adic number, 3-adic number, 5-adic number...; real number)

so you get one of each. When, at the end of the nineteenth century, these p -adic number systems were discovered, it was realised that we've been doing all our physics on the basis that time and space are like the real number continuum. That's the assumption; all the Einsteinian, Riemannian, Minkowskian manifolds, space-time manifolds, were based on real numbers extending in different dimensions. But why should we assume the universe is 'real', in that sense? You could formulate a 17-adic manifold and do space-time physics in it, or a 37-adic manifold; but then, why pick one prime rather than another? Hence the idea arose, why not chuck them all in, create a system which involves all of them at once – this is the adelic approach, described in very crude terms. Hence p -adic and adelic physics – there are people developing models of p -adic physics where the p is just left as an arbitrary p , where it would work for any prime,

COLLAPSE I

basically re-building physics according to these new number systems. So you've got p -adic models of time, p -adic models of probability. A lot of it really turns your ideas of the world on their head.

Now Connes has come up with a dynamical system on a space of adeles, which generates the spectrum of Riemann zeros. The problem is that the system he's starting with has already got the prime numbers built in to it, so some people would say, well, he's really only reformulated the problem. But I suspect there's a lot more to it than that. It's not quite the dynamical system that is being sought in connection with RH, but it is widely seen as a valuable step in the right direction.

Even more interesting than Connes' work, from my point-of-view, is that of the lesser-known Michel Lapidus (University of California-Riverside), another Frenchman with a staggeringly broad view of mathematics and physics. I recently had the privilege of proofreading his latest book – I hope it will come out this year, it's been a long time in the pipeline. It's called *In Search of the Riemann Zeros* and it brings all of these ideas together. And he's taken Connes' idea even further. He's got a set of ideas involving quantum statistical mechanics, p -adics and adeles, dynamical systems, vibrational frequencies, partition functions, it's all in there, but also fractals, string theory...

C: The adèle already intuitively brings to mind string

theory, because of the way everything seems to be bound up with the nature of these peculiarly convoluted spaces.

MW: There's been a lot of work done on p -adic and adelic string theory, but that's not quite what you mean. Lapidus has actually come up with a fascinating connection. He was working on something he called 'fractal strings', but these didn't have anything to do with the 'string theory' physicists study, it was just the name that he had given to these particular mathematical objects. And then he generalised them to something called 'fractal membranes'. But since he came up with that, oddly enough, he's found that aspects of string theory relate directly and unexpectedly to the mathematics. His model involves a dynamical system, a *non-commutative flow of fractal membranes in a moduli space...*

C: Which sounds wonderful!

MW: Yes, at a very naïve level, I just enjoy all the extraordinary language. But, more seriously, I have a certain emotional investment in Lapidus actually being onto something, because if he's correct, it turns out that his 'flow', this very strange, highly counterintuitive, non-commutative geometrical 'flow' projects down into a simpler realm, into the number system, as a flow of 'generalised prime numbers' on a line. This is very close to some strange speculative ideas I made public back in

COLLAPSE I

1999⁶. Lapidus contacted me a few years ago to say this, as it had come to his attention when I first put it up on the Web. Now, it's not that I influenced him, it's almost as if I caught a glimpse of some future mathematics which will follow from his current work. I don't know how I can explain what happened... it's as if I caught a glimpse of something which was coming, but I didn't have the language to describe it accurately, so I just described it as well as I could in this rather naïve way. And so in a way I now feel somewhat vindicated concerning my slightly crackpot idea, because of Lapidus' work.

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In some ways, I think all this intellectualising and mathematics isn't really that good for me, and isn't really what I 'should' be doing. But part of me can't entirely detach myself from it. The speculation I just mentioned, which now appears to be at least partly vindicated, gripped me in a profound way. This event had a precedent a few years earlier when I became *convinced* there was some connection between the Gaussian probability distribution and the prime numbers: that was driven by a sort of compulsion that was, looking back, was quite...not psychotic – it didn't lead to any sort of negative behaviour – but it did rather take over my psyche.

I was one of those kids who, it was obvious fairly early on, could excel at mathematics, and being a fairly

6. See <http://www.maths.ex.ac.uk/~mwatkins/isoc/evolutionnotes.htm>

scrawny, unattractive young person, one latches on to anything one is good at – it provides a sense of importance. It was as simple as that, it wasn't any sort of noble motive for seeking the truth or anything. I was living in the States as a teenager, starting to get interested in things like radical art movements and philosophy. If circumstances had been different I'd have probably studied something else, but I wanted to get out of the States, that was quite a big thing for me then, so to get into a British university my best bet was to apply to do a maths degree, which I did. And then I sailed through that, and got offered a place on a PhD programme, which seemed like a great idea – effectively being paid to explore ideas which I found quite interesting and which I seemed to have an aptitude for exploring. So that was all fairly accidental, and there was no real motive behind it, if you like. It was just the way my life unfolded. But by the time I was doing the PhD I was starting to engage with a lot of other non-mathematical ideas and people, and there was a real sense that, hang on, where is this going, is this really what I want to be doing? At that point I was more interested in 'seeking the truth' – it sounds a bit grandiose, but I wasn't interested in a stable career, and the idea of deriving some sort of self-esteem from being an accomplished mathematician, that no longer seemed to be of any importance. So I started thinking, if I'm seeking the truth, is the truth to be found here, is this really what I should be doing? And then the disillusionment set in. After a year of being on a Royal

COLLAPSE I

Society European fellowship, there was a distinct sense that modern mathematics was becoming irreparably fragmented, and I felt like I was being made very comfortable in an ivory tower, in a vast field of other ivory towers, between which there was relatively little communication. And then there were all sorts of personal factors, just the way my life was going, people I knew, a sense of imminent global catastrophe...

This was 1995, so perhaps there was a touch of millenarian hysteria involved! There was a sense that, as a mathematician, I was part of the problem rather than part of the solution. A lot of my friends were involved in ecological activism and things like that, and I started to formulate a worldview wherein science had become the new, unacknowledged, religion of industrialised society, and mathematics was the inner priesthood of science. To put it in very simple terms, Western culture runs on science, and science runs on maths. So I saw myself as being trained up for this priesthood which was unconsciously steering the world to complete destruction and meaninglessness. And so there was a sense of guilt, almost, that I was involved in this. So I just broke out and floated around doing all sorts of interesting things for a few years, had a great time – I don't regret that at all. I never imagined that I'd get involved in mathematics again.

But then certain ideas about prime numbers started to percolate in my mind. I'd never really looked at number theory in any detail, had just a very basic number theory

course as an undergraduate. But shortly after I ‘dropped out’, I started thinking about prime numbers and the fact that they have a sort of ‘random’ quality...and at the same time thinking about the Gaussian distribution, the bell curve, and the ubiquity of that, the fact that almost anything that you can name, count, measure, and gather data on tends to scatter along this particular ideal exponential curve. I remember posting a question on an Internet newsgroup back in 1995, trying to get somebody to explain to me why this thing shows up everywhere: not just in the biological realm, but in much more convoluted ‘cultural’ realms – I expect that you could count the number of appearances of a letter of the alphabet on the front page of a newspaper over so many years or months, and you’d find the same thing. And the purely mathematical explanations put forward made sense to some extent, but I still felt there was some huge mystery lurking behind the Gaussian distribution, the fact that it shows up everywhere. I scribbled all sorts of half-baked ideas down, some of which seem ridiculous now, some still of great interest. But I became convinced – and I still don’t know where this came from – I became *utterly* convinced that the distribution of prime numbers in some sense was very deeply linked to this, to the ubiquity of the Gaussian distribution, that they were two sides of something.

And what’s strange is that almost seven years later, I discovered there was something called the *Erdős-Kac theorem*, which was proved in 1940, and which I’d never

COLLAPSE I

even heard mentioned before. This was the beginning of *probabilistic number theory*, and it basically states that the distribution of prime factors of large integers follows a Gaussian distribution. Obviously, the larger the integer, the more prime factors it is likely to have, but you rescale in a way that takes that into account, so you're dealing purely with the seeming randomness in the fact that some numbers have got lots of prime factors and some numbers have only got one – and you end up with a bell curve. And not just an approximate one, this is what really struck me: if I was to measure the population over time of sparrows in the garden out there, or the way that those sunflower seeds fall on the ground [*pointing to bird-feeder hanging in a tree*], if I had large enough numbers I may well get very nice approximations of the bell curve. A high-resolution computer image might even match the ideal mathematical bell curve in every detail. But they're *always* approximate; in fact all use of statistical inference in science is based on finite amounts of data, which give rise to approximate bell-curves or other distributions. With the Erdős-Kac theorem on the other hand, the n , the number of elements in your data set, *actually* tends to infinity. This is what really struck me about all this: n can tend to infinity only when you have an infinite amount of whatever it is you're dealing with. And integers are the only thing, effectively, which we have – at least theoretically – access to an infinite amount of.

So, I haven't fully delved into this, but there's a

problem with the use of infinity in statistics and probability theory. It's fine in some sort of abstract Platonic sense, but when you start applying it to the world, *there is no infinity*. But it does apply absolutely, precisely – and this is the theorem which Erdős and Kac proved – that as n tends to infinity, the distribution of prime factors tends to this distribution. So, in some sense, that's the only 'true' Gaussian distribution there really is, the 'oldest' one, the most primordial. As soon as you've got positive integers, that's hidden there within them. Any other instances of the Gaussian distribution, you know, bird populations or currency fluctuations or anything else like that, not only are these approximate, but they require all sorts of complicated categories and definitions. So, anyway, I still can't quite explain why I was so gripped by this idea of the prime numbers and the Gaussian distribution being linked, but I was, and it's as if I was somehow unconsciously aware of something and couldn't manage to pin it down, you know. I tried endlessly to find some way of relating these things and failed. Had this been 2005 rather than 1995 I probably would have quickly found out about the Erdős-Kac theorem using web-searches.

So as a result of this unresolved compulsion, I had a certain amount of prime number-related activity going on in my mind. Then, in the winter of 1998 I went back to the States to visit my parents who were still out there, and I had a lot of free time. I found a long thin piece of cardboard and drew a number line, circled all the prime

COLLAPSE I

numbers, and then started drawing arcs between the prime numbers and their multiples. So every number was connected to all of its prime factors by arcs emanating out from that number to the left. The number fifteen would have two arcs emerging from it, one going to number three, the other to five. And a prime number would have no arcs going to the left, only arcs going to the right. Now obviously you can never draw the complete thing, but I drew enough of it that you could get a sense of there being something, a connectedness, a ‘messy’ connectedness, like a nervous system, or mycelium, or...I don’t know, I can’t quite describe it, but I just spent a long time looking at this, I had it up on the bedroom wall. And as a result of internalising that image, I started to think that it was perhaps the gaps *between the primes* that were most important...but I was somehow naïve enough to think that possibly no-one else had thought of that, whereas in fact quite a lot of work has been done on the gaps between the primes and yes, they are important. But I started thinking that maybe the gaps, suitably rescaled, are the things which distribute in a Gaussian way. I tried to run some computer models, to calculate the gaps and analyse their distribution – but not having access to the necessary computational power, that wasn’t really going anywhere.

And then this image of the interconnectedness of the primes, the whole number system as a single connected entity, with each prime as a sort of ‘nexus’, the whole thing exploded in my mind – it was something very

sudden, and the initial impression I got was that the primes themselves were imbued with a sort of ‘charge’...I think I’d read somewhere that average gaps between consecutive primes are logarithmic, that is the average gap between a prime p and the next prime is $\log p$, the natural logarithm of p . Obviously the gaps can vary wildly from this average, but the average is a precise mathematical result, becoming increasingly precise as we allow p to tend to infinity. I was suddenly gripped by this idea that the primes themselves were imbued with a kind of charge, something like an electrical charge, and that that $\log p$ was the clue, that was the charge of the prime p . At the time I was unaware of Julia’s thermodynamic approach which associates with each prime p the energy $\log p$, and also that certain proposed dynamical schemes involve ‘orbits’ with period $\log p$ associated with each prime p .

C: So the magnitude of the gap before the prime would be its charge?

MW: Well, for sufficiently large primes p , the gap before and the gap after would both be approximately $\log p$. And I had the idea that these primes were in some sense repelling each other and that the bigger the prime, the greater the charge and the stronger the repulsion, hence the bigger the gap. This all came tumbling in as a single thought, really – the account I’m giving now is an

COLLAPSE I

attempt to reconstruct and coherently describe it. But rapidly following this initial impression was the idea was that, well, if there's that kind of repulsion involved then what I'm looking at is a *frozen image of something which was previously in motion* – this is what I got a very strong inner-visual sense of. I try to describe it to people like this: imagine attaching a wire to a wall and then stretching it away from the wall, effectively off to infinity, and then marking out with tiny white dots equal spaces representing the integers, and then imagine little tiny magnetic beads, mutually repulsive particles, positioned along the wire at positions 2,3,5,7,11, *etc.*, that is, at the positions of what we call the prime numbers. Now set up a camera, and then subject the whole area to a huge fluctuating magnetic field, causing the beads to move up and down the wire, driven not just by the field, but by their mutual repulsion. Film that, and then run the film backwards. What you'd see is all these particles moving around on the wire and repelling each other, responding to each other, and then eventually coming to rest at the positions we associate with the primes. That's the image.

Now I was well aware of the obvious question: how do we interpret the time parameter here? This is a huge problem – we're not talking about time in the familiar clock sense, not in the historical sense. I certainly wasn't under any illusion that anything like this had 'happened' at any point in the past. I was suggesting that the system had a 'past', but that it wasn't part of the *historical* past, rather of some other time-like dimension. And rather

than thinking, that's ridiculous, I won't think that, I tried to suspend disbelief and see where it would take me. So the basic thought then was, okay, if what we're looking at is a frozen image of something which was previously in motion, the motion must have subsided for some reason – so what we're looking at must be something in a state of equilibrium. So, what kind of equilibrium? Well, I came up with a crude notion of 'arithmetic equilibrium': Why have the magnetic beads come to rest where they are? Well, if we freeze the motion at any moment, so you've got an infinite sequence of tiny beads whose positions don't necessarily correspond to positive integers – they could be any real numbers – and then generate all possible finite multiplicative combinations of those numbers, that would produce something analogous to the positive integers. The positive integers, recall, can be generated as the set of all finite multiplicative combinations of the primes. But these new 'integers' would not be anything like the familiar integers, they'd generally be all over the place. They wouldn't be nicely arranged, equally-spaced. But if the particles ever happened to reach the point where they collectively inhabited the positions associated with what we now call the primes, the 'integers' they'd generate would be equally spaced. So, I thought, it's *equal-spacedness* which is a key to this 'arithmetic equilibrium' which, according to my scheme, has been achieved in the number system.

C: Something like an entropic sequence, heading towards

COLLAPSE I

an attractor.

MW: Something like that, I was thinking in terms of all sorts of ideas I had partial understanding of – my understanding of physics is very piecemeal, it was even more so then. So many ideas were feeding in. I started to think, how would it begin? Maybe something like a big bang, where you've got all the particles squeezed together at the wall, at the end of the wire, but with something like an infinite magnetic field produced by the wall, and then you let go, and they all explode outwards. At any moment you could freeze the image and generate all the finite multiplicative combinations, the set of 'integers' that they generate: I called these 'generalised primes' and 'generalised integers'. Well, it turns out that Arne Beurling, a relatively obscure Norwegian mathematician, had come up with this idea of generalised primes and generalised integers many decades previously. To better understand the familiar primes he'd started looking at the question, suppose we 'change' the primes, what can we then say about the associated integers and their asymptotic distribution? Martin Huxley (Cardiff University), who's quite an eminent number theorist, got in touch with me as a result of my original website, to say, oh yes, there is actually a name for those, they're called 'Beurling generalized primes'.

C: The distinction being between the primes as we know

them and, as it were, a generalised function of ‘priming’ by which a number system is generated.

MW: Yes, it’s a bit like that, taking the idea of the primes not as indivisible integers, but as a set of generators. But the idea of them flowing or moving, no-one as far as I knew had ever put that idea forward. And so I came up with what I decided was almost a ‘creation story’, some sort of strange mythological mathematics – the creation story behind the number system. Whether there was this ‘big bang’ thing at the beginning or not, I wasn’t sure...but the idea was that, okay, these generalised primes were somehow set in motion. Remember, there are these generalised prime particles, and then there’s a kind of invisible set of generalised integers that they’re embedded in, that they’re generating, which are also in motion. And, at any moment, the ‘heterogeneity’ of these generalised integers, their lack of equal-spacedness, is creating some kind of ‘tension’ which is affecting the particles’ charges. The idea of fixed $\log p$ charges gave way to the idea of fluctuating charges, governed by the spacing within the generalised integers at any given moment. So you can almost think of the distribution of these generalised integers trying to space itself out by ‘influencing’ the generalised primes and their charges so that their mutual repulsion eventually leads them to a stable configuration, an attractor point – that would be the arithmetic equilibrium. Having reached that – the familiar configuration of primes – the generalised integers

COLLAPSE I

would be nothing but the familiar positive integers 1,2,3,... The perfect equal-spacedness of these would result in all forces on the generalised primes dropping away, and the number system has then 'come into being'.

That was the 'story' I came up with, that all came a bit later, trying to make sense of this image that I originally had of the primes being charged, mutually repulsive, and in motion – or having *been in motion*. At the time, it had felt like, this is profoundly important and I have to act on it, I was being somehow compelled to act on it. It felt like the most important...certainly the *strangest* idea ever to enter my mind. And, insofar as I can grasp what is meant by 'numinous', it was charged with a numinous quality.

I was hoping to be able to actually describe the scheme in serious mathematical terms, to reveal that there was some mathematical integrity behind it, but that never happened...So all I had was this nebulous idea about an evolutionary dynamical system underlying the primes. And it was an idea which seemed very strange, I can't emphasise that enough – I couldn't really justify it using any sort of logical or mathematical reasoning, and yet it gripped me psychologically with such force that I couldn't let go of it, I was driven to try and make sense of it. And that led me to create a website...you know, this is what you do in 1998, you create a website, and then you start emailing various eminent mathematicians and physicists to try and get them to look at what you're doing. And as a result of that, a few people were quite

helpful and responsive, I was sent some relevant literature, and I started to realise that actually, there are a lot of strange, unexplained connections between number theory and physics. These things seemed to me to be circumstantial evidence supporting my strange insight, whatever it might have been, or whatever value it might have had. They too suggested the number system had some mysterious ‘quasi-physical’ character. This may have been wishful thinking on my part, but the material was undeniably fascinating in its own right, so I started compiling it into a web-archive, intended to, at least indirectly, back up my idea. Eventually, though, my original idea began to become a bit of an embarrassment to me – it seemed quite naive and ill-informed. So, as the archiving took on a life of its own, and I became fascinated with all this serious maths and physics that I had become aware of, I gradually buried the original idea inside a vast web-archive. But I never entirely removed it, somehow still sensing, or hoping, that there was something of value there.

All my attempts to come up with a mathematical model, a dynamical system that would correspond to that image, had failed. I had struggled because I didn’t have anything like the mathematical abilities that would be required for that. And in fact, I now feel vindicated in that it’s not that I wasn’t capable enough to do it; in order to describe anything like a flow in this space of Beurling prime configurations wherein what’s called the classical prime configuration, the usual primes, constitutes some

COLLAPSE I

kind of dynamical equilibrium – in order to describe anything like that you need to do what Michel Lapidus has done, and introduce a noncommutative flow on a moduli space of fractal membranes. And there was no way in 1998-9 that I could have had access to those ideas. So – and again, this isn't a serious proposition, but the only way I can make sense of this for myself – it was as if I'd caught a little precognitive glimpse of some future mathematics, sensed the importance of it, tried to get it down, but didn't have the language to get it down, did the best I could, and put it out on the Web. This then led on to me putting a lot of time and effort into what was effectively public service web-archiving for a few years, which has been quite fulfilling, but it was initially just a consequence of the original 'flash', and the compulsion it induced in me. Now I'm feeling somewhat vindicated that someone appropriately qualified has shown that there does appear to be something like this underlying the number system.

C: Is there an analogy between what you're describing and what happened historically with non-Euclidean space – could it be seen as an arithmetical version of that, with the unknown time parameter as something as unanticipated as the curvature of space?

MW: Yeah, in the sense that you're breaking out of what is considered to be the only possible version of

something, into a whole range of possible versions, and that initially seems ‘mad’ to many onlookers.

C: At the time, the idea that space could be folded or that space could be curved seemed insane. Nevertheless, such new generalisations are arguably the very movement of science itself.

MW: I think it was Gauss, Boylai and Lobachevsky who simultaneously came up with the same basic idea of parabolic geometry, and at least one of them was afraid to even mention it to anyone. If I had still been involved in serious mathematical research in 1998-9, if there had been a career at stake, my guess is that, having had the same experience, I may well have thought twice about going public with these ideas. Whereas as it was, it didn’t really matter.

C: An interesting example of how being embedded in a discipline, having a reputation, and no doubt having funding depending on it, would actually stop you from saying something – there wouldn’t be any channel through which to get it out.

MW: In a way, I was in a perfect position to just have a go, to push it out there.

I’ve read accounts of mathematicians trying to

COLLAPSE I

describe how they made certain great conceptual leaps. The big difference is that the leaps they made were into something that could actually be mathematically described, and ultimately, you know, were incorporated into legitimate mathematics. Whereas I just had a sort of mad flash, a glimpse of something which, as yet, is not legitimate mathematics, it's just a vague impression.

C: Yet the structural detail in which you described it makes it something more than simply a vague idea.

MW: Well I'm not sure that the *detail* of what I've described adds any validity. Had it not been for Lapidus' work coming along, I probably would have entirely disowned it by now. But at the time, there was a conviction that there was *something* in it, but it was hard to know what to call it. There was an awkwardness because, it falls between the usual categories...I suppose it could be called phenomenology or something, there's probably a legitimate-sounding name that someone could come up with. But when I put it out on the Web I was quite careful, because I was well aware of all sorts of cranks on the Web ranting about how they've discovered this or that revolutionary idea, or proved Einstein wrong, or whatever. And I so I tried to be very understated in how I presented it – you know, I've had this idea, and I don't know what it means, it may well be meaningless, but I invite people to either show me why it's

meaningless, or else indicate what it might lead to. And gradually it began to happen. But I don't know if it really contributed to anything. I think Michel Lapidus would probably have reached the same conclusions regardless. Perhaps it did influence him, I don't know, but I don't think so. So in a way, if I did catch a glimpse of some sort of future mathematical discovery, it would have occurred anyway, so what's the value of what I did?

C: At least, it does lead one to think about mathematics not in terms of the points at which people draw everything together, make it into a formal system, but rather these discontinuous moments when, inexplicably, things move, things split apart and something new opens up?

MW: A crack opens up and something doesn't quite make sense.

C: From what you know of the mathematical community, is it the case that the sort of research you are pursuing is not accepted, that they're not interested in it?

MW: There's a small enclave of perhaps slightly more open-minded, more unusual mathematicians, who are prepared to discuss these sorts of things privately. The vast majority are slightly bemused or just not interested,

COLLAPSE I

they're too busy with their own work to stop and think about what it all might mean. Mathematicians aren't generally encouraged to think about 'meaning'. They don't really need to, they've got a very exact discipline, they've got theorems to prove and things like that. Basically, what I'm doing, I couldn't call it mathematical research. You've called it fundamental research...you could call it that, I know what you mean. The way I see it I'm just trying to raise certain questions and generate discussion, and I'd say the vast majority of the mathematical community just isn't going to engage with that, which is okay. Because I'm not actually doing mathematics, I'm not engaged in mathematics research in the way they are; I'm playing a different game, asking questions about what mathematics means, what it is, how we relate to it. But at the same time I'm not part of the philosophy-of-mathematics community either, which is involved in something much more rigorous and disciplined than what I'm doing.

I suppose because I've got more time I'm in a better position to just stop and think: what's the point, why are we looking at this stuff anyway, what does it mean? Professional mathematicians these days tend to be extremely busy, they've got theorems to prove, papers to publish, conferences to attend. They need to keep their careers afloat, and so they've got a lot less time to think about what this stuff might *mean*.

But the thing about the Web – and this is quite an important factor in what I'm doing – is that it's possible

for me to say what I think and to discuss it with large numbers of other people in the academic world, without having any formal academic status and without having to get anything published. And I can change it as I go along – there’s no final document, that’s the other thing. I don’t publish articles, I can just put together vague rambling webpages and then keep changing them as my ideas change.

C: This is a striking aspect of your research – the presentation of it is very open: no need to hold back until you’ve got an completely solid hypothesis and then put it online tentatively as a preprint. The site is continually updated, and you’re creating this network which connects together all these scientists who it seems are working on related problems but don’t always know of each other: in some cases you’re actually notifying them of each other’s work.

MW: I’ve spent a lot of time emailing relevant researchers and alerting them to the existence of new articles or preprints which they may well be interested in. And it’s difficult to quantify, but I do seem to have stimulated a certain amount of interdisciplinary work. I’ve created a rôle for myself which hasn’t really got a name yet, and as far as I know, no-one’s prepared to fund me, but I’m doing my bit to weave together these threads of research.

COLLAPSE I

Part of what caused my disillusionment with mathematics, which caused me to drop out in the first place, was...well, the overriding impression was the biblical image of the Tower of Babel. It occurred to me that if you were to put the names of all professional research mathematicians in the world into a hat and pick out two, the chance of there being any real overlap in their research interests would be quite small, and this continues to get smaller. It was as if mathematical research was getting so fragmented that there was no longer any effective communication possible. So in a way, I suppose what's needed, if one wants to try and fix this, is people who are not specialising, but rather trying to get an overall picture and to weave it all together by creating lines of communication. I didn't come into this with that intention, but that seems to have been the rôle I've created for myself. I haven't got any answers at all. I just feel that there are questions that are important and which aren't being asked – possibly because there just isn't the language in which to ask them coherently yet. But at the same time, because there are no real constraints on me, I don't have to prove myself to anyone, publish anything, or stay within any particular boundaries, I can just throw out certain ideas, get people thinking about things, suggest connections between things in such a way as to indicate the existence of something which we can't yet pin down perhaps, but which will come into focus the more we look at it.

In the mathematical community, at least the

proportionally small number of people I've communicated with, I do get a sense that there's a sense of wonder there which is something unquantifiable, something that you couldn't prove a theorem about, but which is nonetheless there. It's something to do with these individuals' emotional, psychological or even spiritual orientations, I suppose. But a lot of mathematicians, I'm afraid, do tend towards the familiar stereotype of socially inept, almost mildly autistic people who have very little time for the unquantifiable aspects of life. And so there is an almost scathing disregard from some quarters. I think – I feel – that anything that's vague or a little bit ephemeral, they see that as worse than useless, perhaps because their own self-esteem and status is tied up in a self-image of being the guardians of some sort of absolute inarguable exactitude and truth.

C: Your guiding thread is a fascination with how mathematics relates to reality, rather than with mathematics *per se*.

This seems to be related to the fundamental problematic which appears right at the very origin, you could say the co-origin, of mathematics, philosophy and natural science: with the Pythagoreans, who realised that operations carried out on numbers applied – rigorously, but for them somewhat magically – to natural phenomena, and so put forward the idea that reality was actually nothing but numbers, reality was structured by number. In a sense they put forward a type of mathematical

COLLAPSE I

empiricism, *i.e.* the idea that you could go out and explore the world, and what you would expect to find was relationships between numbers, and you could understand the natural world like that. Now this came to a catastrophic end with the discovery of irrational numbers...

MW: Yeah, the legendary drowning at sea of Hippasus of Metapontum – it’s fascinating stuff, a pivotal event in human history...

C: Certain aspects of the natural world were shown to exceed number – or number as it was conceived then. Certain quantities which can be mathematically described (the diagonal of a square with side length 1, the area of a circle with radius 1, the golden ratio) cannot be expressed as ratios of integers, they are ‘alogos’ or, as we now say, irrational.

After a long period under the influence of Aristotle’s instrumentalism, for which every sublunary physical phenomena was subject to an inevitable degradation, meaning that exact mathematics was applicable only to astronomy, the celestial and sublunary worlds were (blasphemously) reunified, most of all by Kepler, under a single mathematical physics, reinvigorating the Pythagorean dream of a mathematical natural science.

Then in the nineteenth-century mathematics seemed to exceed its reference to the real world, to claim its own

autonomous consistency, and any necessary link with the natural sciences was removed, mathematics asserted its independence from any application; its applicability to the physical world even seemed to become a sort of mathematical ghetto.

Now, in the work you're looking at, it seems that we return once again to a Pythagoreanism but with a strange twist...

MW: Yes, something's been turned on its head. I've been fascinated by Pythagoras and the Pythagoreans for a long time. Sometimes I think, you know, in a way I'm acting a bit like a 'neo-Pythagorean'...but as you say, there's a strange twist there. I think a lot of people forget, when Pythagoras is discussed as 'the first mathematician', that he had one foot in mathematics and another one in a sort of shamanic, mystical-type reality.

C: Whereas the Pythagoreans discovered in numbers the semi-divine property of rigorously elucidating nature, we have this experimentally and theoretically-vindicated body of method and knowledge taken from natural science, with whose aid we're trying to illuminate what now seems like a somewhat opaque and mysterious numerical realm; and there are these things within number which still don't really make sense. Mathematicians such as Chaitin [*see article in the current volume—ed.*] have said that mathematics must now become

COLLAPSE I

a quasi-empirical practice – this is in relation to his own work, but it might perhaps equally be applied here.

MW: Some of the quotes I have on the site agree: Martin Gardner said something about how some problems of number theory might be undecidable and might need a sort of mathematical ‘Uncertainty Principle’. Timothy Gowers wrote that the primes somehow *feel like experimental data*, but at the same time he’s well aware that they are rigidly determined.

We find ourselves in a situation where Michael Berry, studying spectra of quantum mechanical systems, can take techniques he’s developed to classify or better understand certain types of physical systems and apply them to the Riemann zeros, in order to produce a hypothesis that we will get a particular ‘number variance’ in the far reaches of the spectrum of Riemann zeros – then years later, you know, computer power reaches the point where zeros can be calculated at that scale, the ‘number variance’ computed...and the graphs match up perfectly. It’s the first time I’m aware of when a physicist was able to tell pure mathematicians something new based entirely on his familiarity with physical systems.

C: Does the field then become *de facto* an experimental one? You have the a hypothetical physical system which will produce the system of vibrations which the Riemann zeros seem to correspond to. And the only way to find out whether there’s really any system which is adequate to that would be by experimentation – in the same way

that the Higgs Boson hypothesised to glue together the results of quantum physics must now be sought experimentally – hence the construction of CERN’s much-anticipated Large Hadron Collider. Does someone have to *build* the Riemann dynamical system?

MW: Michael Berry has said he’s absolutely convinced that, if such a thing is physically possible, someone will make one of these things in a lab, and then the Riemann zeros will actually come out on the instrument readings. But at the moment there’s no-one actually conducting any experiments which are getting anywhere near that, or even attempting to. You do have physicists taking certain ideas – largely mathematical models intended for physical systems – and applying them to aspects of the zeta function. There is an experimental branch of study of course, you’ve got people looking at the Riemann zeros themselves, which contain a wealth of data – we’ve got, I believe, hundreds of billions of them calculated now – this is being done with grid computing⁸. The gaps between them and all kinds of other things you can measure when you’ve got a set of seemingly random real numbers, are being analysed using a variety of statistical methods, random matrix theory is being applied. So these are, to some extent, experimental studies. Marek Wolf (Institute of Theoretical Physics, Wroclaw) experimentally detected a widespread physical phenomenon called ‘ $1/f$ noise’ in the distribution of prime numbers.

COLLAPSE I

The prime numbers continue out to infinity, we've known they go on forever since Euclid, but we can only calculate them up to a point. We tend to think our current computers are 'powerful', and we think we can find 'big' prime numbers – you know, now and again one will even make it into the news. But *there's no such thing as a 'big' number*, this is what I always try to get across to laypeople – because the number system goes on forever, however far we look, proportionally it's still an infinitesimal step into an infinite unknown .

C: And, of course, in consequence, no matter how many zeros are found, one never comes any closer to a *proof* of RH.

MW: Yes, exactly. There's the duality between Riemann zeros and primes, and so the same idea applies with the zeros. We can never calculate more than an infinitesimal proportion of them. Sometimes I use the analogy of large telescopes: you're looking out into space, and the more you can see, the more you can deduce about the nature of the universe you live in. Analogously, we can 'see into' the number line a certain distance, what we think is a 'long way' – but again, it's meaningless, really, to say a 'long way' or a 'big number'. Of course we can see further than we've ever seen before, so we can detect certain apparent patterns which can give rise to hypotheses that we can then attempt to prove. Similarly

we can look further than ever up the critical line now, and with hundreds of billions of Riemann zeros we can test certain hypotheses and generate new ones. So there's an experimental element in that. But as far as the hypothesised Riemann dynamics goes, the quest to try and pin down something like a Riemann dynamics isn't really being furthered by experimental science as such, rather the progress seems to be coming from mathematicians like Connes, Lapidus and Christopher Deninger (University of Münster). But these people – well, certainly Connes and Lapidus – do have a very broad interest in large areas of both mathematics and physics, which is what makes their work so interesting.

It would be misleading to suggest that mathematics has become an empirical science, since exact formulations are still possible – even in these more hazy areas – at least we can't rule out the possibility of exact formulations. But an empirical approach has become potentially useful. In connection with this, I should mention the emergence of probabilistic number theory, which in itself raises huge questions. Probabilistic number theory effectively started in 1940 with the Erdős-Kac theorem which I mentioned earlier, the discovery that the number of prime factors in 'large' integers has a kind of random distribution which follows the Gaussian distribution or bell curve. That discovery led to a whole outpouring of theorems and conjectures which have collectively become known as probabilistic number theory, where you apply the methods of probability theory, and make use of the key

COLLAPSE I

idea that divisibility by a prime p and divisibility by a different prime q are ‘statistically independent events’, one has absolutely no bearing on the other. When you deal with probability you deal with this idea of independent events – *well, these are arguably the most independent ‘events’ there can ever be.* Physical events in any well-prepared experiment, you might think they are independent; but ultimately every particle of the universe is gravitationally pulling on every other particle, everything is linked, although the effects are generally negligible and impossible to quantify. The only place where things are *totally* independent is in the number system – the divisibility of an integer by two different prime numbers. So here is a place where you can apply probability theory, where everything is *entirely* exact, where you can let your n tend to infinity and that actually refers to something. Probabilistic number theory allows you to *prove* things about prime numbers and about the number system generally, using the techniques of probability theory, and that seems highly counterintuitive. The fact that it works at all raises questions which are more like ‘mysteries’ than formal mathematical problems.

There are three separate areas worth mentioning here: the emergence of probabilistic number theory, the effectiveness of the analogy with statistical mechanics – partition functions, *etc.* which I described earlier – and then the rôle of random matrix theory, which was developed for modelling subatomic phenomena, but then was accidentally found in the 70’s to apply directly to the

theory of the Riemann zeros. So you've got three separate areas of randomness-based thinking, stochastic disciplines if you like. They deal with large systems which have too many components to keep track of individually – these components must be treated almost sociologically, as populations, and subjected to probabilistic or statistical thinking. All three areas have been effective in furthering our understanding of the number system. Now, again, mathematicians would tend to focus on at most one of these things, see what could be achieved and perhaps make a few sober remarks on what it all might mean. But to me, the fact that you've got these three areas, all of a stochastic nature, shedding light on the primes and the Riemann zeros, points to something very strange. We've got primes, the most basic things in the universe as we experience it – the sequence of prime numbers is the most basic non-trivial information there is, it's the one thing you can't argue with anyone about, it's the one thing all lifeforms in the universe could potentially relate to. And yet in some ways they seem to be best understood using a type of analysis more appropriate to weather systems, roulette wheels, boxes of gas, *etc.*

I've always thought of probability theory as a slightly 'tainted' branch of mathematics for three reasons: Firstly, it's origins are not entirely honourable – I seem to recall that it has its roots in an historical accumulation of gambling techniques which got distilled into a formal theory by Pascal. Secondly, it deals with 'events', repeatable

COLLAPSE I

‘events’, which are categories of physical phenomena, ‘occurrences’ of one type or another which can be quantified, measured, counted, numerically analysed, *etc.* whereas truly ‘pure’ mathematics doesn’t rely on anything in physical reality in quite this way. Finally, by its very nature, probability theory tends to deliver imprecise information – there’s always a margin of error. And yet this system of thought, which has been developed in order to deal in an approximate way with large, complicated physical systems, seems so perfectly applicable to something which is so fundamental, which is characterised by an absolute precision, and which underlies everything else – the distribution of primes! It’s as if we’ve got something back-to-front. It’s similarly interesting that probability should have such a fundamental rôle in quantum mechanics: an ultra-simplified account of what QM tells us is that, insofar as it can be understood as being made of particles, the universe can also be understood as being made of ‘fields of probability’. Probability theory in a casino, yes; or in a meteorology lab... But prime numbers? The fundamental level of matter? These are things we instinctively feel should be totally deterministic and rigid. And to me, this suggests we’re looking at something the wrong way ‘round – something’s been turned on its head. It’s as if ‘randomness’, or some essential, almost esoteric quality associated with randomness – that quality evidenced in our failure to really understand what we mean by ‘randomness’ – is emanating up from these fundamental

realms. We've been dragging it down from the macroscopic scale, the casino scale, down to this micro-level, in a numerical and physical sense, and finding that it helps us understand something. But I feel something's back-to-front there.

A mathematician called R.C. Vaughan states in one of my archived quotations that it's obvious that the prime numbers are random, but we don't know what randomness is. And there is a real problem with defining randomness. There are several definitions, information theorists, probability theorists, have put forward definitions of what it means for something to be random. The definitions overlap to a large extent, but ultimately, when is a string of digits random? If I give you a block of a thousand 0's and 1's, it might *look* completely random, it might even pass numerous tests run on it for randomness...but then I could reveal, well actually, no, it's a thousand digits of π starting from the two-millionth digit. And then it's not random anymore. So there's the whole question of what randomness is. This is one of the central themes that fascinates me: where does this notion come from, where does it lead us in our understanding of the reality we inhabit, and why does it tie in so closely with both the fundamentals of the number system and of particle physics?

And then there's the difficulty of talking about having two of anything, that in order to have two of anything you have to have a category which those two objects both belong to. But the categories are always imprecise. We

COLLAPSE I

have to partition spacetime into blocks with ‘fuzzy’ boundaries, and then attempt to match aspects of these blocks up with some ideal which exists in a sort of mental hyperspace, a Platonic realm of sorts. So we’re projecting these categories onto the universe which actually aren’t intrinsic in the universe; we’re setting out these boundaries, but the boundaries are blurry. Yet, despite the possible problems this blurriness might cause, on a practical level we’re able to then extract data which fits remarkably well against certain probability distributions. The most ubiquitous and I think the most important one is the Gaussian or bell curve – and this, as we can see from the Erdős-Kac theorem, has a mysterious and fundamental relationship with the number system we’re using to count members of our fuzzy-boundaried categories in the first place.

The effectiveness of statistical inference in the hard sciences and the social sciences – I’m sure this would be widely disputed, but I feel there is a mystery there which isn’t really being acknowledged, and it has to do with how we can name and count anything, and how, when we do name, count and measure things they seem to collectively accord with these ideal mathematical blueprints or templates. That says more about the way our mental hyperspace is being mapped onto the physical universe than about anything *intrinsic* in the physical universe.

C: When you look at the local you expect to find

precision, whereas with the global you're happy with statistical data. Here we're looking at these local, precise conditions and there seems to be randomness 'built into' them in a way that's not immediately comprehensible: After all, they're not statistical aggregates in any obvious sense.

MW: Yes, the set of positive integers is in a category of its own, *there's just one number system*. Yet, it's as if this entity – if we take the positive integers, the primes and the zeta function as aspects of a single thing, different aspects of the same entity – rather than being a carved-in-stone, unique thing, is actually just one example of a class of things, and we're able to apply statistical analysis because of that. This is why, when I started finding out about these things, I felt my 'prime evolution' thing might have something in it, this idea of the number system being a frozen state of something which had previously inhabited many different states. I've had certain quite critical, serious-minded people react to some of my more sensational suggestions by saying, well all this number theory and physics, there's nothing mysterious at all – the universe follows mathematical laws, so of course we'd expect certain aspects of number theory to show up in the physical world. If they'd look a bit deeper into this, they'd see what I meant: yes, it's not surprising, given that maths underlies all of physics, that we might get, say, particular values of the zeta function showing up in string theory, or the theory of integer partitions relating to Bose-Einstein

COLLAPSE I

condensates or whatever: you get these odd little instances of number theory/physics correspondence; I've catalogued a lot of these in my web-archive. But that's not the really interesting stuff. What's much more surprising is the way physics seems to be pointing the way for understanding the zeta function, and often this is statistical or stochastic physics, as if the zeta function – and in some sense, then, the number system – is just one example of a more general phenomenon. And I don't think anyone disputes the spectral nature of the Riemann zeros now. But it's not one archetypal ubiquitous spectrum we see showing up all over physics. If we saw 'the zeta spectrum' – as it might be called – everywhere, then it would somehow feel a lot less mysterious. We'd probably feel quite comfortable with such an affirmation of the old idea that the number system directly underlies the structure of the physical universe. But the Riemann zeros take the form of an almost disconcertingly arbitrary-looking spectrum, never known of by humans prior to the late 1850's. In the very recent past we've been confronted with the fact that it has all the fingerprints of membership in certain classes, very wide classes, of very specific physical systems, as if it's just one element of a whole class, a population of things. So it's a bit like the way you might be able to, based on the post-code of a UK resident, predict certain things about his or her attitudes, abilities, tastes, whatever – because you've got statistical information about the population, you can make plausible hypotheses about this specific individual.

And it's as if the primes-zeta entity, whatever you want to call it, despite its seemingly fundamental, unique status, is just one individual in a wider class of things. But the space in which that class exists is something we haven't even begun to imagine might exist, or we haven't got any access to.

So we have this image of a frozen system, something congealing into a state, and then...it's as if you walked into a concert hall and caught the last note of a symphony, and everybody's applauding ecstatically and you're wondering, what's all the fuss about? You didn't witness the process that led up to that last note, and it's like, with the prime numbers, we're just walking in on the last moment, the culmination of something. As if there was a whole 'symphony' that led up to that, and humanity may be on the verge of revealing it.

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C: All of the foregoing seems to suggest that what we think of as simple and elegant foundations may in fact be the eventual product of something which is rather complex, even beyond our comprehension. So we'd have to separate out what seems simple and elegant to us, from what is actually fundamental in the universe, and this is another sense in which mathematics mirrors the condition of theoretical physics, in which, characteristically, the further we go towards the fundamental, the stranger things become (string theory being a case in point).

COLLAPSE I

Rather than defining the primes on the basis of the supposedly fundamental and simple number line, in fact it seems that, when we look through this complex theoretical-mathematical prism you have described, there's actually something more fundamental about the primes. The primes themselves produce...

MW: ...the number line, yes, you can see it that way. I came up with this naïve idea, before I really learned any of the more serious stuff, this was after I had been thinking about the Erdős-Kac theorem, the primes and the Gaussian distribution, but before I 'experienced' the dynamical aspect of the primes. I was thinking about how we tend to construct the primes. We're taught to construct the number line starting with one and then using the Peano axioms, you know, there's an axiom that basically says, whatever number you arrive at you can always add another one to it. And I thought, hold on, where does this come from, this idea that you can always add another one, and I started to question that as something that might not be as obvious as it first seems. There's some hidden assumption there about order, time or something, I felt.

And I thought, well, there's an alternate approach we could adopt here, we could start with an infinite alphabet of meaningless symbols, an infinite alphabet of meaningless yet distinct symbols, and then create the dictionary of all possible words of finite length out of that alphabet.

This alphabet of symbols would correspond to the prime numbers. By combining the symbols in all finite possible combinations, you generate the set of words in your infinitely-long dictionary – this corresponds to the fact that if you combine the primes in all finite multiplicative combinations, you get the set of positive integers. Except now *there's no sense of order*: Because we're not starting with the positive integers, we don't need to think of one prime number as being 'greater than' another. The primes are not embedded in the positive integers yet, they're just these free-floating abstract symbols. So I used to try and conjure up this image of bubbles floating in an imaginary space, each with an exotic glyph, a symbol from our 'alphabet of primes' on it. The idea is that you can then join any number of these bubbles in any combination, including repeats. All possible such bubble-clusters are to be found floating somewhere in this space. Some are larger than others in the sense that there are more bubbles in the cluster – that is, more prime factors – but there's no sense of a cluster coming 'before' or 'after' another cluster. It's only when you cross the Rubicon of deciding which alphabetic symbol is going to be your '2' that you start to create some sense of order.

So I had these hints and intuitions – I couldn't really pin them down to anything very rigorous – that we've been thinking about randomness and the fundamentals of reality in a back-to-front way. We've got ourselves into a kind of confusion where everything seems immensely complicated when we delve down to the fundamentals of

COLLAPSE I

either the number system – which seems at least partly to inhabit the realm of psyche – or of the physical world, the world of matter – just open a textbook on analytic number theory or quantum mechanics and you’ll see what I mean. I felt this issue could be addressed if we examined some of our ‘obvious’ assumptions. We think we’ve taken the obvious construction – that is, you start with one, then you add one, and then you add another one, this idea you can always add another one. Rather, what if we start with the primes, and build the number system up that way?⁷ The whole ‘order’ thing then becomes more of a ‘phenomenon’ than something axiomatic...

C: Coincidentally, the ‘legendary’ Dr. Daniel Barker also devised a notation system for the positive integers based upon prime factorisation, which is very close to what you’re talking about here.⁷ You have these inseparable lexicographical units from which numbers are composed, and they could be in any order. He was interested in place value as a culturally-repressive numerical practice, and this was a way of doing away with place value completely. Each number would just be like a collection of boulders or something.

MW: The lexicographical approach, yes. I’ve tried to get this across to some lay-people I’ve talked to. There’s the

7. See <http://abstractdynamics.org/005047.html>

fundamental theorem of arithmetic – literally *the most important thing we know about the number system*. And no more than 0.1% the population have even heard of it, I'd guess. It basically says that every integer breaks down uniquely into prime factors. And we've got this strange situation where almost nobody knows this, this simple fact, the most important thing we know about the number system. This is straying into other territory, but to me, humanity's relationship with number is rather unhealthy, because we've built this entire civilisation around the mathematical sciences, and yet the ordinary population knows nothing of the basics, and often finds mathematics a source of fear and unpleasantness. I try and conjure up this image of these bubbles, the fact that the clusters can be as large as you want, you can have huge 'planets' of prime factor bubbles joined together – *there's no upper size limit*. And so something like the greatest common divisor can then be explained very simply, it's just the intersection, literally where the two clusters intersect. The least common multiple can be similarly explained. Prime numbers distinguish themselves from non-prime integers because they are individual bubbles. The integer 1 is *the absence of any bubble*, the empty background space, the blank page in the "dictionary" I mentioned earlier...

And then you imagine stringing the entire set of clusters out in a line according to this 'order' thing, and you start to see that there's a counterintuitive variation in the sequence – you get small clusters, huge clusters and

COLLAPSE I

single bubbles all intermingling according to no sensible scheme. And this is the sort of thing that I'd eventually like to push further out into the public domain just to see what sort of effect it would have, when people start looking at their supposedly familiar number system in this new light. Because people tend to think of the number system like a row of boxes of cereal in a supermarket, just identical units stacked together, a sort of homogeneous featureless thing that just goes on: each number is just the previous one plus one, there's nothing much there, nothing of interest. And it was Frank Sommen, a really remarkable, imaginative Flemish mathematician who I worked with during my PhD studies, who once said to me, every positive integer is a different animal. I came to see exactly what he meant: each one's got its own 'anatomy', every one's a different story, and that starts to become apparent as soon as you realise that each integer factors in a unique way into prime numbers.

C: This is a basic intuition that one finds in 'primitive' numerological systems.

MW: Yes, and in children as well, with their favourite numbers, and feelings about each of the first few positive integers – ethnomathematics and children.

C: Something that gets beaten out of people by mathematics: when people start learning mathematics,

it's as if the first task is to extirpate any idea that numbers have quality. Mathematics is in fact often seen as constitutively opposed to any such intuition.

MW: Yes. Marie-Louise von Franz, one of my favourite writers, who studied under Jung and wrote a lot about number archetypes, she talked about number having both quantitative and qualitative aspects. The quantitative is obvious, we all use numbers to count. Cultures who revere certain numbers and have mystical beliefs about them which we might laugh at, they still use them to count with and to trade, they recognise that they have a quantitative aspect. This is the aspect of number that has given rise to economics and technology; but equally, perhaps even more importantly, there's the qualitative aspect that only survives in our culture in children having favourite numbers, some adults having lucky numbers, not wanting to sleep on the thirteenth floor of an hotel, the way they might choose lottery numbers, that sort of thing. But, you know, in 'serious' society numbers are supposed to be *entirely* quantitative. Von Franz wrote about a traditional Chinese story involving eleven generals who, faced with some very difficult military situation, took a vote as to whether they should attack or retreat. Three voted to attack and eight voted to retreat. So what did they do? They attacked, because three was a more favourable number – it wasn't a *bigger* number, but it was a number associated with unanimity, or some other favorable quality like that. And the attack was a success.

COLLAPSE I

So it's interesting that they could build a civilisation that was able to have a functioning economy and military and to govern millions of people – clearly they were intensely aware that number had a quantitative aspect – but there was also a serious engagement with the *qualitative* aspect which is dismissed in our present culture as entirely superstitious. Now I'm not encouraging people to engage in completely arbitrary numerology, I mean, I've looked at a lot of that new age numerology literature, and the problem is, nothing can be verified: someone can write a book saying a particular number means something, and someone else can write another one saying it means the complete opposite. It just confuses matters, as there's never any consensus or certainty in these interpretations. That's why professional mathematicians would almost unanimously just react against it and say it's all rubbish.

C: But is there any way to talk about it which doesn't get into that morass of mysticism?

MW: There are two approaches: one is the serious attempt by Jung and his followers to catalogue all of the ethnomathematical systems, undertaking a serious study and survey of various cultures and their relationship with number, trying to find common threads, and through psychoanalytical work and dream studies, trying to find extract essential patterns to build up a body of material

from which we could possibly deduce something about how number interfaces with the psyche at a fundamental level. The other approach is to seriously study number theory, because as far as I'm concerned, that *is* numerology, really – you're looking at the properties of integers, and if you study it to a certain depth it takes you into the realms of what you could only call the mystical or the uncanny, where cracks seem to open up in your normal understanding of reality.

C: Is that perhaps what characterises number theory as opposed to mathematics, what makes it a very different discipline?

MW: Well, number theory is universally acknowledged as a branch of mathematics. It can't really be separated from it like that. But it arguably has a unique status at the very heart of mathematics. You're working at the very root of it all, dealing with the simplest objects, the positive integers. And yet you come across these counterintuitively complicated structures and results. You can separate mathematics into branches and disciplines but they all ultimately overlap and interrelate. Gauss (who himself was called the 'prince of mathematicians') called mathematics 'the queen of the sciences', and number theory 'the queen of mathematics'. The idea is that number theory is generally seen as the pinnacle, in that it contains the most difficult problems; also it's concerned with the

COLLAPSE I

integers, and all of the rest of mathematics ultimately relies on integers. Hence it's not surprising that problems of number theory do seep into other areas of mathematics, and even physics. What *is* surprising is that physics is beginning to shed light on number theoretical structures like the zeta function, as if it were just one of a class of objects, whereas it's meant to be this fundamental object underlying everything.

What I'm trying to describe with my clusters of bubbles isn't intended as any sort of serious mathematical proposition, it's just a picturesque visualisation – trying to look at the number system from another angle, if you like. But there's a hidden assumption within the Peano axioms, I think, which needs to be addressed – although I don't think I'm the one to address it. It concerns the axiom which allows you to always add one. Even in the proof of the infinitude of primes, I sense some sort of subtle circularity there – the idea is that, if the number of primes were finite, you could multiply them all together and then add one. And that rapidly leads to a contradiction concerning primeness and divisibility...hence there must be infinitely many primes. So that takes you back to the Peano axioms, the idea that you can always add one. But in my visualisation, multiplying them all together would correspond to building one mighty cluster using one of each type of bubble. And in that visualisation 'adding 1' is a far less obvious operation. This ties in with problems of time, the idea of time, repetition, even basic physical questions: you know, this 'adding 1'

business presupposes that you've got a physical space, something like the space we're familiar with, in which you can make a sequence of marks, or a time continuum in which you can make a sequence of utterances or beats. And I feel there may be subtle assumptions concerning the homogeneity of time and space involved in this, too.

C: These questions of time and space must fall out from the primes' intimate connection to the relationship between multiplication and addition.

MW: Brian Conrey, who's President of the American Institute of Mathematics, and Alain Connes have both been quoted as saying that RH is ultimately concerned with the basic intertwining of addition and multiplication. And if we haven't really got a clue how to prove RH – which we don't – we're going to have to own up, we don't even understand how addition and multiplication interrelate. A more succinct, precise way of describing these two possible constructions of the primes that I have outlined – the conventional 'just add 1' approach, and my 'lexicographical' approach with its equivalent clusters-of-bubbles visualisation – is given by Grald Tenenbaum, who certainly knows what he's talking about:

Addition and multiplication equip the set of positive natural numbers with the double structure of an Abelian semigroup. The first [addition] is associated

COLLAPSE I

with a total order relation as it is generated by the single number one.

So if you've got addition and you've got this single number 1, you can generate the positive integers just by adding 1 plus 1, 1 plus 1 plus 1, etc. If you take 1 as your 'additive generator', the universe generated is the set of positive integers.

The second [multiplication], reflecting the partial order of divisibility,

This probably isn't the time to get into the subtle issues of 'order' in mathematics – you've got 'total order' and 'partial order': addition relates to total order, where something definitively comes before or after something else; and divisibility relates to partial order, a less distinctive type of order, although I won't get into the details of that...

[Multiplication], reflecting the partial order of divisibility, has an infinite number of generators, the prime numbers.

So, now, rather than starting with just the number 1 and combining it with itself in every possible way using addition, we start with this infinite set of primes and then take all possible *multiplicative* combinations.

Defined since antiquity, this key concept has yet to deliver up all of its secrets, and there are plenty of them.⁸

8. Tenenbaum and France, *op. cit.*

It has the quality of a square peg in a round hole, this tension between addition and multiplication. It's almost like, despite the inarguable perfection of the number system, they don't really fit together very well, and they generate what I feel is something like friction, and this produces the sprawling mass of definitions, theorems, lemmas and conjectures that we call analytic number theory. There's a novel by Apostolos Doxiadis called *Uncle Petros and Goldbach's Conjecture* – it's written as fiction, but he gets some key ideas across through an elderly mathematician character. This is very well put, I feel:

Multiplication is unnatural in the same sense that addition is natural. It's a contrived second order concept, no more really than a series of additions of equal elements.⁹

So that's the point, that 3×5 , you can see that as $0+3+3+3+3+3$ – you start with nothing, zero, and add three five times. So in a sense you can build multiplication out of addition, whereas it doesn't work the other way around. So addition is a first order operation, and multiplication is, as he's saying, unnatural, in that it's 'second order'. The thing that struck me about it when I was dwelling on this for a while was that it has to do with *time*, it has to do with repetition. And it also relates to the very deep issues concerning the whole idea of where number comes from and how we define number. As I hinted earlier, I've spent a lot of time thinking about how you could

9. Doxiadis, A. *Uncle Petros and Goldbach's Conjecture*. NY: Bloomsbury, 2000.

COLLAPSE I

ever have two of anything. You know, there are two people sitting here in this room right now, but that relies on the definition of what a ‘person’ is. We define the category linguistically, and we think we know what a ‘person’ is, but you can imagine some sort of genetically-engineered mutant that may or may not be a ‘person’ depending on how the definition was formulated, and the definition’s made of words and each word is imprecise, is subject to interpretation. So any type of category you define is going to have a ‘fuzzy’ boundary, so...although it works quite well for day-to-day affairs, counting things works fairly well, you’ve got fifteen sheep in your paddock. But you can always contrive some convoluted situation where, maybe it’s fourteen sheep or maybe it’s fifteen – is that odd looking creature really a ‘sheep’ or is it something else?

So, it comes down to issues of language and definition. We consider chunks of spacetime, we recognise patterns and say, yes, that chunk of spacetime falls into such-and-such a category. As I said, I started to wonder how you can really have two of anything. Every entity ultimately distinguishes itself from every other, these categories are not mathematically precise, there’s an arbitrary element involved in deciding whether things get included – “where do you draw the line?” as they say. And yet these categories are the essence of counting, and if there’s a problem with applying the concept ‘2’ to our experience then there’s going to be a problem with all of the other positive integers.

Exceptionally, when you get down to the subatomic level you can have two of something, because each individual electron is absolutely indistinguishable from the others. So that's interesting, that this concept makes sense at the subatomic level but then 'fuzzes out' at macroscopic scales.

But the thing is, when you say '3x7', you're effectively saying 'three sevens'. So, seven pebbles in a row – you count out seven by adding one plus one plus one, etc. That feels quite 'natural'. But then, to make the leap to 'three lots of seven'...you can have three giraffes or three potatoes, the fuzzy boundaries mean that's a difficult enough issue as it is, but 'three sevens' presupposes that a 'seven' is *something that there can be more than one of* in some sense...

C: One would have to say that the multiplier and the multiplicand are somehow of a different order, two different types of numbers are involved in the operation.

MW: Yes, one is operating on the other. If you add, it doesn't matter...I mean, it's true to say that 3×7 is the same as 7×3 , you've got this basic 'commutative' property applying to the positive integers. But when you consider the 'act' of 3×7 , the three is how many times you're doing something, whether it's laying out a row of seven beans or playing seven drumbeats, and the seven is some kind of an extension in space or time. Whereas in adding

COLLAPSE I

3+7 or 7+3, both numbers play the same rôle. So there's something there, not easy to pin down, which we don't understand, and I have a very deep sense that we won't really understand it until we really understand *time*. It has something to do with time. Our inability to understand the primes, our inability to prove RH is a symptom of our inability to understand the relationship between addition and multiplication, and that is related to our relationship with time.

C: On your site you quote J.J. Sylvester:

I have sometimes thought that the profound mystery which envelops our conceptions relative to prime numbers depends upon the limitations of our faculties in regard to time, which like space may be in essence poly-dimensional and that this and other such sort of truths would become self-evident to a being whose mode of perception is according to superficially as opposed to our own limitation to linearly extended time.¹⁰

MW: I think he must have been thinking about the relationship of multiplication and addition in terms of time. This was 1888, so RH had been posed, but mathematicians long before RH understood that the enigma of the prime numbers was rooted in the uneasy relationship of addition and multiplication. So possibly he had a

10. Sylvester, J.J. 'On certain inequalities relating to prime numbers', *Nature* 38 (1888) pp259-262, reproduced in *Collected Mathematical Papers*, Volume 4. NY: Chelsea, 1973 p.600

sense that the relationship had something to do with time. But he says ‘the profound mystery which envelopes our conceptions relative to prime numbers’ – in other words, the puzzling interface of addition and multiplication – ‘depends upon the limitations of our faculties in regard to time’. So if there were a higher dimensional, a two-dimensional ‘time surface’ or something like it – the word ‘superficially’ is being used by Sylvester in the original sense meaning ‘relating to surfaces’ – our minds, normally constrained to a ‘timeline’, could perhaps ‘spread out across it’ in some sense. It’s perhaps a bit like being able to come up off the surface of the earth and look down from a third dimension to get a sense of how things are laid out, whereas when you’re stuck on the ground, certain things are not at all apparent...but these are all very vague and intuitive ideas.

*

C: In one of the papers you link to in the archive¹¹, Volovich suggests a most extreme and startling explanation for the concurrence of physics and mathematics.

MW: Yes, and you may have noticed that he quotes Pythagoras at the beginning, a slightly amusing Greek-to-Russian-to-English compound translation of “all is number” – “the whole thing is a number”. I got very excited when I first found that paper, because he’s suggesting that number theory is the ultimate physical theory. That

11. I.V. Volovich, "Number theory as the ultimate physical theory", Preprint CERN:TH 87 4781-4786 (1987)

COLLAPSE I

came out in 1987 as a preprint at CERN – he’s an accomplished physicist – but it was never published in a journal. The fact that it never got published and the fact that he hasn’t responded to my questions about it could suggest that he’s backed away from it somewhat. I can’t speak for him, but I wonder if he’s slightly embarrassed by its more grandiose claims, in the way I was suggesting earlier that physicists and mathematicians can be.

But the thing is, he has done this vast body of work on p -adic physics, which I referred to earlier. And the rise of p -adic physics is a very interesting thing in itself because, you see, even though the universe at the scale of this room is Archimedean – I can lay my ruler end to end and will eventually reach the end of the room – the universe is *not* Archimedean at all scales. Below the Planck scale, it’s no longer Archimedean. Below this 10^{-35} m or so – which to some people sounds too small to worry about, but you just take a metre, then a tenth, then a tenth, not that many times, really...It’s not that our instruments aren’t precise enough to measure below that scale, it’s that the whole idea of measurement as we’ve formulated it ceases to make consistent sense. And effectively, space becomes non-Archimedean below that scale. There’s a similar scale with time and other fundamental quantities, below which they become non-Archimedean. You can theoretically join some unit of measurement end-to-end and never achieve a given, finite extension.

This has led people to think that maybe p -adic physics, where you’re dealing with a non-Archimedean

number system, would be more appropriate for application at the sub-Planck scale. And Volovich seems to be suggesting that different non-Archimedean number systems could apply to different regions of space and time at different scales. Again, I'm not entirely sure: large parts of the paper are beyond the scope of my present understanding. I'm intrigued by his referenced to 'fluctuating number systems', but I don't know whether he means fluctuating with time, or in some other more generalised sense.

People are now starting to think about applying p -adic mathematics to the physical world. Each p -adic number system provides a different sense of 'distance' between two rational numbers, and that notion of distance then allows you to define all the other numbers which aren't rational via precise mathematical concepts involving 'limits'. I mentioned this earlier. This distance or 'metric' is defined in terms of divisibility of primes. It has to do with highest powers: for instance, in a 7-adic metric, finding the distance between two rationals involves basically looking for the highest power of 7 that divides into the numerator of their difference – that difference of course is also a rational number – when it is expressed as a fraction in lowest terms. As a result of that, number theory comes flooding into your p -adic physics: if you start looking at p -adic or adelic space and time, issues associated with the prime numbers become directly relevant. Of all of this number theory/physics material I'm archiving this is the area I'm least familiar with.

COLLAPSE I

C: Saying that the means of measurement, that the possibility of measurement has changed is one thing, but saying that numbers are actually the ‘atoms’ themselves, so to speak, is something else: that means that there is no longer some *thing* you’re measuring. The measurement itself takes on a sort of substantiality.

MW: Yes, these are very difficult notions to grasp, in so far as I understand what’s being proposed. I think, perhaps like myself, Volovich caught a glimpse of something, got quite excited about it and wrote it down; he’s quoted Pythagoras – it’s as if there’s some mystical quality to his insight.

C: There might be thousands of these papers hidden everywhere that people haven’t published.

MW: I’m not sure it would be in the thousands, but who knows...There’s a general hesitance to stick one’s neck out. If I’m helping to encourage that sort of thing, then I suppose that’s a useful contribution.

C: Exeter University has granted you an honorary fellowship and hosts the web- archive, but there is no funding available for your work. Apart from your own fascination with the subject, what drives you to continue this labour of archiving and making your own speculative

connections public?

MW: Over the years after I'd dropped out of formal academia, I spent a lot of time thinking through and honing these ideas about mathematics being some sort of inner priesthood of our scientific culture that's in the process of destroying the ecosystem, and wondering what could be done about it, how do we change this, you know? I felt that campaigning to stop the destruction of this or that rainforest isn't going to be enough, you've got to go right to the core, to the root of the problem, the fulcrum. And, reading von Franz, with her ideas about ethnomathematics, and quantity and quality, and reading René Guenon, who – although I don't embrace his traditionalist fundamentalism – wrote a fascinating book called *The Reign of Quantity and the Signs of the Times*, I started having this idea that only when Western Culture re-evaluates its relationship with number can there be any real change in the way we relate to the world, because we've got stuck in a 'quantocentric' view of the world. And so I have felt at times that what I was trying to bring forth – whether it was in my strange 1998 'evolutionary' notion or just in my networking of various people's work via my web-archive – was an acceleration towards an imminent transformation in our relationship with the number system. I was quite driven for a while, but I've become considerably more cautious and sober in my approach to this since. I saw what I perceived to be clues...felt that it *had* to be coming, and only through that sort of

COLLAPSE I

transformation will the Western project ever be able to steer itself in a less destructive direction. At times I've felt that I had an important rôle to play – not that I was 'chosen' to do it or anything, but that my work was cut out for me, and it was an important mission. Other times, I've been much less certain, and wondered, you know, why am I sitting in front of this computer editing HTML, when I could be spending the same time and effort campaigning for, say, the rights of an indigenous tribe having its land ravaged by a multinational corporation. I had to justify this to myself when people I knew were involved in things like that, by telling myself, well actually they're just dealing with the symptoms, whereas I'm trying to deal with the root of the problem. So it verged on an idealism, almost an activism.

C: The point being that rather than lamenting the destructive rôle of number and of science, one tries to recognise that there's something else within number, and as you said, to re-evaluate our relationship to it, which is not to say to reject it, but to become *more* numerate...

MW: Yeah, which is what I saw around me, people being very suspicious towards mathematics, hating it, seeing it as controlling and evil, and I thought, no, we need to get inside it, try to understand where it comes from and how it works.

But then I started to question whether I was just

creating a whole set of complex and noble motivations for myself when in fact it was just my ego or desire to be acknowledged for what I'd achieved, or, you know, just wanting some sort of recognition or status. I was continually wondering what it was that was motivating me, and trying to rein myself in and consider the worst possible motivations as well as the best.

I had a kind of motivational collapse in early 2005, when I was struck by a very deep sense of there being insufficient time; you know, I had this grandiose hope of helping to effect some sort of long term change in culture and the way in which we deal with the number system. I started to think, maybe what I'm contributing to *would* have that effect if there were a few more centuries left of relatively leisurely culture and well-funded academia to take these ideas on and develop them, but, you know, we're facing multiple global crises, and this sort of thing is never really going to have time to take root.

I've since drifted in and out of this activity periodically, found what I think is a healthy level of interest in these matters. But I don't strongly believe that I'm part of some current of cultural change anymore, I'm just...I suppose you just can't know what effect you're having, particularly with the Web, when you're pushing ideas out. You don't know who's reading them and what they're going to do with them – a bright teenager who reads my website might be inspired to study mathematics and, influenced by some of the hints, clues, suggestions, *etc.* I've assembled, go on to make amazing discoveries...who

knows?

There's also the whole relationship between psyche and matter which seems to have been at the centre of all my interests over the years. I got involved in parapsychology for a while, online psychokinesis research in 1996, wondering whether there really was something in that, and what it would imply concerning the psyche-matter interface. There's also a very exciting interdisciplinary field of 'consciousness studies' emerging, and which I've been following, people trying to understand the physics of consciousness, looking at microtubules in brain cells and how quantum mechanical phenomena at that scale might help to explain the origins of consciousness – physicists, neurologists, philosophers, psychologists, anthropologists, psychopharmacologists, *etc.* are all contributing to this field. Then there's all the Jungian theory concerning myth, archetype, synchronicity and the 'psychoid' level of reality – a kind of psycho-physical interface. The simple fact that mathematics is able to describe the world at all, that's a mystery involving mental constructs being mapped mapping onto material reality. There's the 'mind-brain problem' which philosophers debate. And then dreaming, shamanism, schizophrenia, quantum-mechanical paradoxes, these are all things I've spent a lot of time thinking about, reading about – generally wondering how it all fits together. And it had occurred to me that these topic cluster around the central mystery of how matter and psyche interface. But I'd been thinking about prime numbers, *etc.* for a few years before

it occurred to me that this is very much part of the same picture. I'd been exploring the interface of physics – which concerns matter, obviously – and number theory, which, as that Tenenbaum quote suggested, is really an exploration of 'the mind itself'. And the research I've been interested in archiving displays a two-way traffic: Number theorists have been providing concepts and structures which physicists have used to better understand the world of matter. Physicists have been able to, using their understanding of matter, shed light on the internal workings of the number system. Even number theory *without* the physics is implicated: although number is widely considered as a mental construct, at the same time it manifests directly in the world of matter: when you consider a quartz crystal or a five-petalled wildflower, it's hard to deny there's an essential 'sixness' or 'fiveness' there. So, number itself is a bridge of sorts between psyche and matter.

This last idea, that number is a bridge between psyche and matter, comes quite close to something Jung was exploring in his later career. He left a lot of incomplete work when he died, and I believe he left von Franz to look at number archetypes. He'd looked at individual integers, the first few integers and their various associations. But later, more importantly, he'd come up with the idea that, not individual numbers with their associations, but the *set of positive integers as a single entity* is in itself an archetype, the archetype of order.

Now what has distinguished Western culture from the

COLLAPSE I

rest of humanity, what characterises the Sumerian-to-Babylonian-to-Greek-to-Roman-to-Western-European cultural current that dominates the planet with its measurement and science and so on, is the way we've dealt with this archetype which normally inhabits the collective unconscious. I picture it as a sort of mysterious sea creature – we've hooked it and we've hauled it out from the dark depths into the daylight of consciousness. We've taken something that was primarily unconscious, and which would naturally manifest primarily via the number archetypes and number associations in other cultures. We've dragged this thing out of the sea and onto the land, cut it up and studied it, studied its anatomy in great detail in order to obtain a new kind of magic, if you like, and that, I came to believe, was the root of all the world's problems.

But then we have this emergence into consciousness of the set of the prime numbers buried within the set of positive integers, a hidden archetype within an archetype, a kind of chaos within order, the black dot in the yin half of the yin-yang symbol; the emergence of *that* archetype – the prime numbers, the zeta function and everything they entail – into mass consciousness, is just starting now, really. The first four 'popular' books on RH have all come out in the last couple of years...it's strange that this should all be happening so suddenly. Thinking along the quasi-Jungian lines I've sketched out, the integration of these ideas into consciousness, the idea of the Riemann zeros having their origins in some 'older' or 'deeper'

numerical reality, something more ‘primordial’, *etc.* may turn out to be of profound historical significance. According to the insanely optimistic wishful thinking which I’ve since distanced myself from, this could be the event that would start to alleviate the effects of rampant ‘quantocentrism’ and put things back into balance.

C: I wonder whether the growth of ‘popular science’ could play a rôle here – thinking in particular of the many books which have been published on RH.

MW: The fact that you’ve got four books on RH out suddenly – why is this, why hadn’t this happened before? I’m sure a few years ago most people involved would have said that it’s impossible to explain RH to lay-people. But four authors have done their best, with varying degrees of success. The books have all been well-received, have sold fairly well. So why is this happening? The mystically inclined might invoke an unseen force that’s trying to bring these ideas into consciousness. Jungians might talk about ‘compensation’ and the collective unconscious. But more simplistically, more materialistically, it’s market forces, it’s capitalism, and it’s because people are looking for meaning. Many are turning to New Age cultism, some are turning to born-again Christianity, Scientology, fundamentalist Islam, whatever. But there are a lot of people who are aware that the real ‘guardians of truth’ these days are not priests and monks,

COLLAPSE I

but scientists and mathematicians, and yet, they find themselves in a position where they don't know anything about the essential subject matter. So they want someone to explain, say, the mysteries of quantum physics to them. I get this all the time, people really wanting me to explain quantum physics, fractals, relativity, the golden mean, chaos theory, p; there's a handful of things that people get really excited and obsessed about, you know. And of course the market system rises to meet a demand, a growing demand for meaning. The problem is that capitalism doesn't care whether a book is accurate or well-written, it just cares about sales figures. So as a result you get gross oversimplifications hitting the market and sometimes selling quite well. Because the market has expanded, there is more competition, and ideally, if you believe in the effectiveness of capitalism, then the 'best' stuff will float to the top – but 'best' in this sense doesn't necessarily correlate with truthfulness or accuracy, rather with how successfully the book quenches readers' thirst for meaning. There does seem to have been a certain amount of progress, though. I don't really watch much TV, but it does now appear that with the computer graphics available, it's possible to make some things a lot more visually accessible, so viewers can at least get a flavour of the problem, or of what's at stake.

But the really deep stuff, the major philosophical problems underlying maths and physics...it's hard to imagine that there really is a shortcut to years and years of disciplined study. I mean, you might be able to get the

basics of something across to a few, a small section of the population who are already interested and whose minds are structured in a certain way – it's not to do with levels of intelligence, just a certain kind of intelligence. You've got committees for the popular understanding of science and things of that nature, but they're very marginal. Unless there were a major cultural shift, unless you had major government funding, and the top layer of mathematicians and scientists committing themselves full-time to bringing this stuff through into popular culture...but there's no motivation for that to happen – governments aren't interested in educating their populations except in ways which will further economic growth. They want a certain proportion of young people to be trained up to be economists, accountants, engineers, *etc.* 'Truth' doesn't really come into it. So I doubt it...but, again, you never know, some major cultural shift could occur where the demand for this sort of knowledge reaches the point where the best people would feel obliged to provide it. Or, possibly, there could be some sci-fi type breakthrough involving direct brain-to-brain knowledge transfers, you know, you can't rule these things out, but I'm not holding my breath!

You've probably noticed, part of my website is very formal-academic, the web-archive aspect; and part of it is just about getting fundamental ideas across to people who are open to them and just want to understand their reality a bit better. I have felt in the past, with my 'activist' hat on, that it's important to bring some of these issues to

COLLAPSE I

widespread public attention – the basic issues of the number system. At this stage I don't know if it *is* 'important' or not, but I'd be very interested to know what the overall effect of that kind of exposure would be. Again, I suppose I am still gripped by the idea that, if we transform humanity's relation with number, that could have a positive transformative effect. I suspect I'm still partially motivated by that belief at an almost subconscious level.

The only thing I can really say with any confidence at all is that I think we're on the verge – and again, the timescale is very indefinite here – but Western Civilisation is on the verge of collectively realising that the number system is something very different from what it had previously thought it to be. I haven't got a particular theory about what it is, I just know it isn't what we think it is.

Introduction to ABJAD

‘Incognitum’

ABJAD (**أبجد**) is an acronym derived from the first four consonants of the Hebrew/Arabic/Persian alphabets; *Alif, Ba, Jeem, Dal*. It is a simply-constructed but functionally-complex alphanumeric system condensing different belief-dynamics from Near- and Middle-Eastern cultures, which became particularly prominent after the rise of the *Shi'a* religion in Iran. Arabic ABJAD originates from the Semitic family of scripts.

In working with Arabic ABJAD usually three numeric values (the ABJAD value of the letter, the order of the letter in the ABJAD table and the alphabetic order of the letter in the Arabic alphabet) are used as numerating values; the most interesting and complex products of ABJAD are those operating with more than one numeric

COLLAPSE I

value (i.e. ABJAD value, ABJAD order and Alphabetic order simultaneously) but later works by ABJAD scholars from Iran, India, Afghanistan and Arabic countries show an inclination towards a unified ABJAD value called ABJAD-e Kabir (Major ABJAD).

Toin ط	Ha ح	Za ز	Waw و	Haa هـ	Dal د	Jeen ج	Ba ب	Alif ا
9	8	7	6	5	4	3	2	1
Saad ص	Fa ف	Ayn ع	Seen س	Neen ن	Meem م	Lamn ل	Kaaf ك	Ya ي
90	80	70	60	50	40	30	20	10
Zoin ظ	Zaad ض	Zai ذ	Kha خ	Sa ث	Ta ت	Sheem ش	Ba ر	Ghaaf ق
900	800	700	600	500	400	300	200	100
								Ghain غ
								1000

Fig. 1. ABJAD Table (*ABJAD-e kabir*: major abjad)

The arabic ABJAD table (ABJAD-e Kabir) is arranged in powers of 9:

Level 1. *Alif* (= 1) to *Toin* (= 9)

Level 2. *Ya* (=10) to *Saad* (= 90)

Level 3. *Ghaf* (= 100) to *Zoin* (= 900)

Level 4. *Ghain* (= 1000)

The ABJAD values of all levels are based on the connections between the ABJAD order and the ABJAD value of each letter at the first level (1-9), where the

ABJAD value of each letter is equal to its ABJAD order.

LEVEL 1: from 1 to 9. Take the letter *Haa* as an example: its ABJAD value is based purely on its ABJAD order *i.e.* $5=5$.

LEVEL 2: from 10 to 18 (ABJAD order). Since the level changes, there is a phase transition from one- to two-numeral values (using one '0' as a place holder). The ABJAD order of the letter *Noon* (under the letter *Haa*) is 14, which can then be numerically simplified as $1+4 = 5$. The single numeral x is converted to xx to indicate the letter *Noon*'s location on the second level. Consequently we have 50 instead of 5: 50 is the ABJAD alpha-numeric value for the letter *Noon*.

LEVEL 3: from 19 to 27 (ABJAD order); on the third level xx changes to xxx ; the letter *Sa* is under the letter *Noon*; its ABJAD order is 23: $2+3=5=500$ (xxx)

LEVEL 4: at this level ABJAD diverges from the power of nine. This might be considered the apogee of the ABJAD alpha-numeric progression.

The numerical arrangement of ABJAD into four alpha-numeric layers, three of which are built upon the power of 9 (9-based) is strongly in accordance with the unique politics of Islamic apocalypticism, whose allegiance is not to sectarian ideologies but to the explicit text of the Quran, immutable according to Islamic scholars. We have three levels (1-9, 10-90, 100-900) whose structures are numerically never concluded (they never reduce to One, remaining imperfectible and

COLLAPSE I

inconclusive). Only the letter *Ghayn* numerically stands on its own plane as 1000 (Kabalistically reducible to 1); however, the One here is external to the 9-based arrangement of ABJAD: In Islam, the divine constantly remains on the outside; it is characterized by its radical externality to its multiplicative creation, and conceived not as conclusion or *telos* but as externality. This only serves to highlight the overall imperfectability and inconclusiveness of ABJAD/Creation. The Divine loiters on the exterior (beyond the threshold of ontological possibility) even on the Day of Apocalypse (as in Islamic Apocalypse, *Qiyamah*). God never reveals itself (*Apocalyptic*), shifting the radicality of its exteriority and the inconclusiveness of its creation to another plane.

While God was the exclusive source of the revelation to Muhammad, God himself is not the content of the revelation. Revelation in Islamic theology does not mean God disclosing himself. It is revelation from God, not revelation of God. God is remote. He is inscrutable and utterly inaccessible to human knowledge [...] Even though we are his creatures whose every breath is dependent upon him, it is not in interpersonal relationship with him that we receive guidance from him.¹

The ambiguous monotheistic structure of ABJAD (enshrouding obscure religio-political inclinations), and its empathy for imperfectability, multiplicity and

1. Edmund Perry, *The Gospel in Dispute: The Relation of the Christian Faith to other Missionary Religions* (New York: Doubleday, 1958), p155.

inconclusiveness, unilluminated by a rabid exteriority ungraspable for Man, has made ABJAD the alphanumeric system most favorably-disposed to heresies and obscure apostasies. It is no exaggeration to say that the history of Islam has been perpetually accompanied by ABJAD exploration and alphanumeric distortion of all forms of official and established religious institutions and texts (the latter being untransgressable, and consequently prone to the generation of profound heresies). “Everywhere that ABJAD can be found, a heresy has already emerged,” remarks Abidulah ibn-Maymun, the founder of the *Ba'teni* – later to become *Ismailie* – cult.

Given the fact that the syncretic configuration of ABJAD scriptures as well as ABJAD diagrams has always been complemented by the sheer syncretism of its redactors and exegetes, their usage in mass culture and belief systems of Muslim populations has sprawled over a vast array of everyday affairs, surpassing mere occult instrumentality and elitism. In the timeframe between the rise of *Horoufi* sect (from which the most prominent ABJAD theorists rose – 9th Century) to the *Qajar* dynasty (1781-1925) ABJAD diagrams were composed for purposes including education in elementary schools to depict the interactions between alphabet, numbers and religious matters in an efficient way (commonly being used for memorizing religious stories, names or even basic mathematical or linguistic lessons), interpreting the Quran and other Islamic or sectarian scriptures, healing diseases, invoking love or hostility, conjuring deities,

COLLAPSE I

operating as catalyzer-spells in alchemical experiments, *etc.*

The multi-functioning (heretical) nature of ABJAD also allowed it to be extensively employed as a language of communication between minorities (or within minorities)², and as an instrument for supporting the political belief-systems of Islam's non-Apocalypse through mathematics, astronomy and geometry and through the cross-fertilization of these fields with linguistics, cipherology and occultism, producing a vast field of cryptosciences or heretical knowledges. ABJAD has become an example of a numerical system which, far from being a nomadic numerical machine, intrinsically operates within the State in order to initiate anomalous reciprocations (in the case of ABJAD, the state and numbers go hand in hand).

ABJAD Diagrams are perhaps among the more well-known productions of the heretical knowledge and absolute syncretism one finds in ABJAD systems, yet they remain unexplored. They critically condense and compile wide varieties of monotheistic and non-monotheistic elements, although they constitute elements specifying their connection with the minority belief-dynamics of either *Sunni* or *Shi'a*. At the top they usually include the number 786 which alphanumerically equates to *Besmellah-e Rahman-e Rahim* (*In the name of Allah, the passionate, the merciful*), the opening verse of each chapter (Sura) in the

2. In fact, all sectarian ciphers in Islam and Islam-inspired religions are constructed and can be only deciphered by ABJAD.

Quran. The diagrams are mostly constituted of humanoid figures with bodies in positions evidently inspired by the Zurvanite, Sumero-Babelian and Zoroastrian cartographies of blasphemy, or demographic configurations. Archaeological explorations of Near and Middle Eastern cults (especially from the time of the Mesopotamian civilizations to the end of antiquity) reveal that forms of demonism ('demons' being understood as avatars of the outside) are mainly characterized by their anomalous cartographies – diagrams which present the bodies and positions of the demons, and the arrangement of their appendages (faciality is the least significant aspect of Eastern demonology). Islam also forbids the 'facialization' of religious figures and martyrs):

- The right hand upward and the left hand downward is a cartography of demonism of the greatest archaeological provenance, originally emerging in the Assyrian period, where demons of pestilence and contagious epidemics are presented as seen in the bronze *Tablet of Disease* (in the collection of M. De Clercq). A significant number of ABJAD humanoid diagrams maintain this cartography in the most explicit way (see page 202) while presenting the ABJAD numbers connected to the legion of the damned and blasphemous people mixed with holy names and numbers on their bodies.

- From stretched hands, one pointing to east and one pointing to west, we can identify solar demons (the Romans ironically borrowed this same diagrammatic position from the Babylonians in their crucifixions, the

COLLAPSE I

most prominent of which are the iconographic portraits of the crucified Jesus). (See page 200).

In ABJAD diagrams, when it comes to the divination of a religious figure, facialization is achieved through composing the face, head and body with the exclusively use of numbers and letters, with no depiction or explicit portrayal (see page 201). In consequence, ABJAD pushes Islam's holy ban on facialization into a blasphemous demonic complexity which with the same reprobate enthusiasm tears itself away from the expressionist hegemony of facialization.

In these diagrams each part of the body (including the head) has its own agenda of ciphers and exclusive numbers. Usually most of the body is enveloped and takes the form of a repetition of the letter *Haa* (ABJAD value = 5) representing the five individuals of Shia: Mohammad, Ali, Fatemeh, Hassan, Hussein (see page 201).

In western occultism, diagrams and magic squares are usually surrounded by magic circles and other geometric shapes which are always closed and symmetric. Their task is to converge the power of the spell upon a certain objective. In ABJAD diagrams these circles are replaced by open geometric shapes such as triangles and curves conducting open-ended and divergent experiments in syncretism. In ABJAD diagrams these curves and shapes are commonly known as ABJAD shields. Most ABJAD books, although published by *Shi'a* authors and containing the names of *Shi'a* Imams, correspond to the

cipherology of the traditional Arabic ABJAD in which diagrams or figures are guarded by ABJAD shields, covered by either the letter *Meem* or the letter *Dal* (the first and the last letters of the name Mohammad); the design of these traditional ABJAD shields is of two intersecting lines forming an acute or obtuse angle representing the letter *Dal* (ABJAD value=4). Unlike in *Sunni* ABJAD (see page 199), in *Shi'a* ABJAD these shields are not pointed and, rather than the letter *Dal* are in the form of the letter *Ha* – expressing the *Shi'a* politics of *Taqiyya versus* the *Sunni* politics of conflict in *Jihad* – but with curved lines diagramming the calligraphic elements of the letter *Haa*. These curved lines usually become overrun by the repetition of the letter *Haa* (ABJAD value = 5) on their outer surface, standing for ‘Panj Tan-e Aal-e Abba’ *i.e.* Mohammad, Ali, Fatemeh, Hassan, Hussein who are the pillars of Shia (See page 210).

Page 199: A spiteful spell for calling upon a disease or replacing a fatal disease with a less dangerous illness. The word *Allah* constitutes the outer open circle, the targeting-arrow of the letter *Dal* (empowered by the outer circle and representing the power of the prophet Mohammad) can operate from the opening and directing the power of the ABJAD square (composed by the numerated name of a disease) in the guise of a sting towards a person.

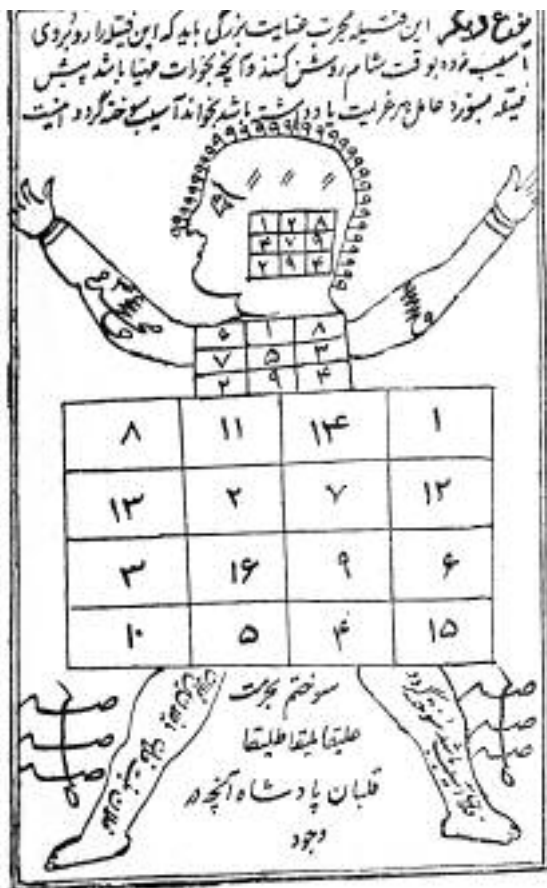
Page 201: The Arabic and Abjad equivalents of the words ‘No’ or ‘Closure’ compose the face of this ABJAD figure, making her mute, blind and deaf or, symbolically, easy to be controlled. At the center of this ABJAD

COLLAPSE I

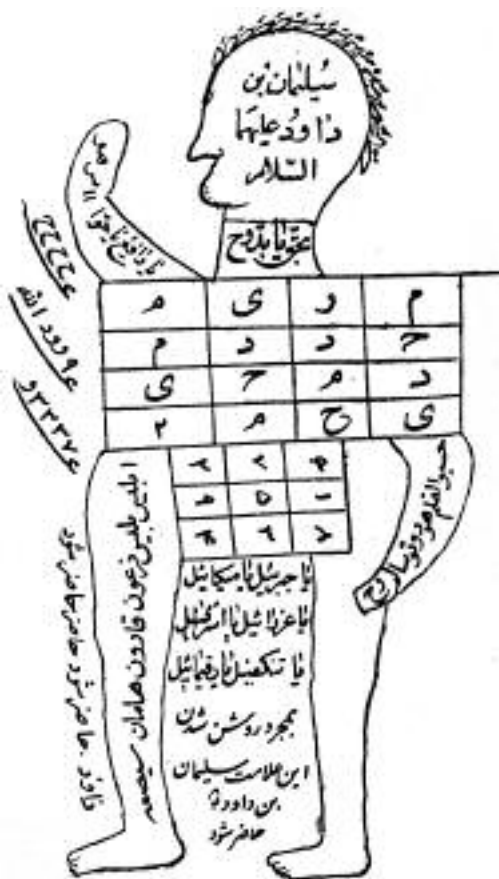
diagram is an ABJAD square which has replaced the heart. The symmetry of numbers and certain words (the word speed and the name *Ali*) make this spell oscillate between negative and positive intentions. This spell should be engraved on four pieces of alloy (fusion of the senses), buried in soil, put in fire, exposed to wind and thrown in water to make a person possessed by an involuntary love.

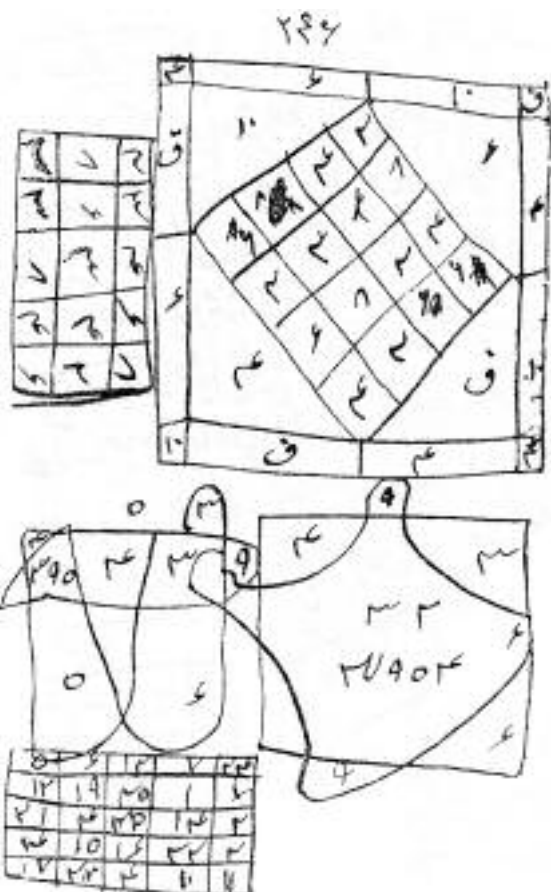
Pages 204-205: An Abjad diagram for memorizing the names (unique characteristics) of Allah in an interacting form.

COLLAPSE I



COLLAPSE I





المربع انبساط

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ربت	كيسر كيسر	منان	معين
كاف	الله الله	وحي	بسط
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COLLAPSE I

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١ ٢ ٣	١ ٢ ٣	١ ٢ ٣	١ ٢ ٣

بجق فالتة خیر خافظا و هو ارحم

Existential Risk

Interview with Nick Bostrom

The Future of Humanity Institute forms part of the ambitious research program of the 21st Century School established by benefactor James Martin at Oxford University in the UK. If it is surprising that the UK's most traditionalist university by reputation should host an interdisciplinary research institute dedicated to evaluating the long-term prospects of the human race, it is perhaps even more remarkable that the director of the Institute Nick Bostrom began his academic life in analytic philosophy. He talks to COLLAPSE about the wide-ranging research program of the FHI which seeks to address 'existential risks' for mankind ranging from natural catastrophes to biotechnical modification and the emergence of nonhuman intelligences.

COLLAPSE: The establishment of the Future of Humanity Institute seems to mark one of those 'crossover' moments where strands of research that once

COLLAPSE I

seemed purely academic, or were at best categorised as interesting ‘thought experiments’, are becoming pragmatically pertinent: amongst the issues you deal with are bioscience, cryogenics, catastrophes of an ecological and cosmological nature. Is the function of the Institute to liaise between the academic research environment and various public policy, governmental, or security bodies who are looking for ways to gain traction on these issues?

NICK BOSTROM: Yes, but its primary mission is a research mission – to try to improve our understanding of three broad areas. One is human enhancement, ethical issues especially related to that, but also practical issues, policy issues. The second is global catastrophic risk; and the third area is methodological problems and issues that crop up when we’re thinking about the big picture for humanity, both in relation to the first two areas and more generally when we’re thinking about anticipated future technologies, and so on. So the primary focus is to improve understanding through research in those areas, but it has a component – or will do, in the future – of liaising with policy-makers and trying to create some public awareness and stuff like that.

So the interdisciplinarity is not an end in itself. It’s just that when you try to address some of these problems and issues, it just so happens that more than one discipline is needed.

C: Given the magnitude of the problems you're proposing to treat, is it surprising that there hasn't been such a unified initiative to tackle them until now?

NB: I don't know, it's difficult to do within a traditional disciplinary setting, that's one reason. Because none of these problems fit neatly into a discipline. So it might not be so surprising that it hasn't been done, because it requires probably some framework that goes outside traditional disciplinary boundaries. In one sense it is surprising because the issues are important enough that one would have thought that humanity would have a few people somewhere thinking about them: extinction risks, for example. So, from that, from the observer from Mars perspective, I think they would be surprised.

I should also say that although these three areas are quite a broad range, in reality what it means is that one would have to pick specific, tractable questions within those areas, and look for opportunities where analytic methods and our current knowledge actually enable us to say something.

C: You were trained as a philosopher, and we were struck by the fact that the Institute is attached to the philosophy faculty. How did the Institute originally come about?

NB: I was in the philosophy faculty, I was a post-doctoral fellow. And I've always been interested in, been

COLLAPSE I

pursuing, these kind of questions. And together with Julian Savulescu, who is professor of practical ethics here, we had a couple of ideas for research projects, or programmes that we wanted to pursue or get funding for. One of them was human enhancement ethics, another global catastrophic risk, and there was a third one. So we went to the development office, these are the people responsible for fundraising in the university, to see if they had any ideas. And they said that they knew someone they thought would be interested in this, and had actually mentioned me to him before. It turns out this is James Martin, who is the benefactor for the James Martin 21st Century school, of which the Institute is now a part. And James Martin had interviewed me earlier, about a year before, for some television documentary he was doing, and appeared to be quite enthused about what I was trying to do. So by sort of coincidence – because I didn't know that he was a donor, or a funder, a rich man, at that point, he was just somebody doing an interview – this development guy managed to put one and one together, and establish some contact, and then there were lots of drafts back and forth, and lots of different proposals, and discussion, and this is what resulted in the end.

C: So, with the involvement of Martin, is it actually a genuinely philanthropic exercise?

NB: Yes – we have some co-funders as well, but that’s where the bulk came from. And Julian Savulescu, he’s the director of the Uehiro Centre for Practical Ethics, downstairs in this same building, but he also has a programme on Ethics and New Biosciences, which is also part of the James Martin 21st Century School.

The whole James Martin school is really James Martin’s attempt to do a couple of things: to encourage interdisciplinary work and to bring Oxford into the 21st century, but more specifically to try to get Oxford to focus on some major problems for humanity in this century and see what practical solutions can be found. The whole school to some extent is shaped by that vision.

C: How closely would the Institute’s research have to track or monitor things like ongoing developments in, for example, AI research, and even A-Life research? Different research programs underlie both of those, with internal technical debates that would have ramifications for broader questions about the nature of other intelligences and the characteristics they would possess.

NB: There will be one level of monitoring which is just keeping some general idea of what’s going on. But then depending on which specific projects or which specific paper you’re working on at the moment, you would obviously then have to dig down very deeply in that area. So if you were writing a paper on artificial intelligence

COLLAPSE I

let's say, then you would have to get up to date on the latest details of that. But generally you can't be up to date on the details of everything that is possibly relevant, it's just not humanly possible. So you have to have some general idea of roughly what's happening, and then you get to focus, like I say, when you're producing something specific.

C: Are there practical limits? If the Institute expanded its staff would you be able to have these subcategories...?

NB: Yeah, you still wouldn't be able to keep track of everything, but you could have people specialising more, or covering a greater range of topics. We're still in the bootstrapping phase now.

C: What seems remarkable is that you're trained in analytic philosophy, and you're applying the methods of analytic philosophy to problems which up until now have only been thematised in so-called continental philosophy, i.e. the problem of death, the problem of what it is to be human, etc. And yet within your programme you seem to be pursuing these problems in a way which continental philosophy has been unable to do. For example despite its obsession with the concept of death continental philosophy doesn't seem to have tackled the basic fact that when the sun expires we will all die – and what the consequences of that are for thought.

NB: I think there is a traditional view that the continental philosophers have all the interesting questions whereas the analytic philosophers have had the right answers but the boring questions...I see philosophy as on a continuum with science really, I don't make a sharp distinction. It's the more general end of the spectrum, things that haven't yet been crystallised out, specialised into different particular sciences. And so whatever seems relevant material to thinking about the particular problem questions, I think that's what one should use. And also in some cases even though the questions might seem the same they might actually be different. So although continental philosophers might have thought a lot about death, there are lots of different questions you can ask about death: about its meaning for the artist, or for the human being on one hand, or you could ask more concrete questions such as whether current research priorities make sense, is the allocation of research money to biogerontology versus cancer research in the right proportion, for example.

C: How do other philosophers – not only at Oxford but also elsewhere – regard your work?

NB: Some of the work I've done has a sort of dual-use function, which is the way I have had to work up more or less until now, since I haven't been able to have a post full-time for doing this. So some of the papers like *Infinite*

COLLAPSE I

*Ethics or Are we Living in a Computer Simulation?*¹ can be read by people who are really interested in the FHI from a purely philosophical point of view, and there is enough in it for them that even if you're not interested in the practical dimensions of it you'll find some worthwhile philosophy there. But from my point of view the reason why I've written about them is that I think it relates to this broader vision, to the practical concerns that I have. So one could find some of these stepping stones where one could get both philosophy and the relation to humanity's future down on the same paper, but it requires a little bit of picking and choosing and figuring out clever ways of combining the two. It's obviously much more desirable if one can do work solely on the basis of the criteria that it should be relevant to the big picture for humanity.

C: You propose to tackle analytically problems which are of such cosmic scale that they induce what you call in your own work 'infinitarian paralysis': that is to say, given the magnitude of these questions, how is it possible to do select one path or another, to choose between options? One of the methods you seem to be using is the quantification of risk, a risk-management or risk-assessment approach. This quantitative treatment of risk is something which is of great importance in public policy, in corporate policy, in finance, but how is it applicable to these massive existential dilemmas?

1. Both at <http://www.nickbostrom.com>

NB: Well that's a relevant question, whether it is or not. Specifically, in the case where you have literally infinite stakes – which is the case this paper, *Infinite Ethics*, discusses – there is a set of ethical theories that run into trouble when you take seriously the possibility that either the universe might be infinite and have infinitely many people in it, or even that our actions might have infinite consequences. Even if you think the possibility of that is small, you're still going to have what I call this 'infinitarian paralysis' problem. It seems as if it's impossible that we could make a difference, in terms of changing the expected value of the world. Now, that might be more a problem for certain ethical theories rather than for humanity, because if certain ethical theories have that implication then we might just take the lesson that we should have other ethical theories instead that avoid it. So I think it's a significant but technical point. There is a broader sense in which it's possible to think about some of these things. It's easy to get a sense of vertigo sometimes, because there are such extremes in terms of the best outcomes and the worst outcomes, just the sheer magnitude of them: the problems and the stakes are so much larger than things that people spend so much more time thinking about. But my view is that one should try not to look away, one should just try to keep a steady gaze, and use the same methods, as much as one can, use the same analytical rigour, sober analysis, and step-by-step investigation to make progress on these.

COLLAPSE I

C: Is the long term proposition of the methodological approach that you will actually be able to answer ethical questions relating to these ‘existential’ issues on the basis of quantitative consequentialist ethics? Myron Scholes, for example, created a formula for quantifying risk in financial transactions: do you propose that such a thing is possible in ethics, or do such methods only give guidance for further thinking about the problem?

NB: Yes, I think it’s one ingredient, I think there is more to ethics than risk analysis. In terms of a meta-ethical view or a foundational view, I’m not firmly committed, I’m still trying to figure out which meta-ethical framework is correct, I don’t know. Certainly I think taking consequences into account must be at least one thing that any reasonable theory would do, but there might be other things in addition, and how you should take them into account. So the answer would be no, I don’t assume that would be the be-all or end-all. I think it would be one useful piece of information to have, if you could have that: information about the risks and the expected utility of different actions, I certainly think that would be useful. Really, the value proposition would be to try to illuminate some aspect of the big picture for humanity, pretty much those aspects where it’s possible to illuminate them. Some might be very interesting, but would need some new insights that nobody else had, to figure out how we could say anything intelligent about them – maybe it’s just not possible given current knowledge. But then there

are some aspects where, with hard work or ingenuity, or using techniques of various kinds, we can say something that is not obvious and yet is relevant. So it's shooting for those targets of opportunity...

C: That's what you mean by 'opportunistic research'? Choosing the problems you think you can gain some traction on.

NB: Exactly.

C: Prior to the methodological question, it seems, are certain fundamental underlying assumptions which are driving the research, amongst which are the ideas that longevity is a good thing, that survival of the human race is a good thing: and the optimism of the 'transhumanist values'² that you personally espouse go beyond this.

NB: In terms of the first one, longevity, my view is that increased longevity and great health, or people having the option, would be a good thing. So that's my view, it's not necessarily a premise of all the work that the Institute will be doing. But that's the sort of question the ethics of which would be a subject of enquiry. It might turn out also not to be a yes-or-no thing, it might under certain circumstances be a good thing, under other

2. See 'Transhumanist Values' at <http://www.nickbostrom.com>

COLLAPSE I

circumstances it would be problematic. If other researchers looked at it maybe it would not be...and so whereas I am personally quite enthusiastic about the prospect of healthspan extension that's not a premise for the Institute. Now as for the survival of humanity, could that be seen as a premise? Well it's not an unquestionable premise, you could have a philosophical seminar where you would discuss that, and indeed we have had such a seminar, papers have been written discussing whether that would be a bad thing or not. So it's certainly discussable. Now if the work moved more into liaising with policymakers then I guess it would be hard not to make some assumptions like that. I mean, it's just as when you have someone researching cancer they just assume that it's good if we can find a way to detect breast cancer early, you don't have to have a huge philosophical conversation about that.

C: But precisely from a philosophical point of view this becomes a problem: It's not that one needs to denounce the fact that philosophy liases with the world, tries to engage with practical problems. But isn't it problematic that the 'transhumanist values' seem to have a basis in a particular political (and implicitly, philosophical) position already – *e.g.* when you talk about the 'entrepreneurial spirit' being part of the set of values?

NB: But you've got to keep distinct transhumanism and

the FHI. There are other organisations – the World Transhumanist Association and so forth. That one in particular is not so much a specific philosophy but a conglomeration of different people and thoughts and values, some of which I disagree with; but obviously I am a transhumanist in a certain sense. But the FHI is not an institute for transhumanism or anything like that. What it does though is to focus on problems that would be of interest to transhumanists and many other people as well, I mean obviously global catastrophic risk would be of interest to a transhumanist, but so would it be to many other people. And similarly with the implications and ethics of new technologies. So there again, you can have different perspectives and viewpoints and arguments, which might or might not agree with certain transhumanist positions.

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C: In several of your papers you talk about the possibility of transcending ‘observer selection effects’.

NB: Yes, observer selection effect is a kind of distortion of our thinking that occurs when the evidence we get is filtered in a certain way. The easiest way to explain it is a selection effect that we find in many contexts: there is the fish example where you catch a hundred fish from a given pond, and they’re all larger than six inches. So you draw the inference that probably the smallest fish in the pond is not less than six inches. Then you look at the

COLLAPSE I

thing you caught them with, this net, that can't actually catch smaller fish. So you realise that although you have one hundred data points, they're all filtered through the selection effect that the net introduces. So, once you realise that you have to correct for it, if you want to estimate the population of fish in the pond you have to take that into account. So there are different methods for doing that in standard statistics. Now, an observation selection effect is similar, except it's not introduced by limitations in our measurement apparatus – the fish net – but by the fact that all observations require there to be a suitably-positioned observer to make the observation or to build the measurement instruments in the first place. In many cases these are not really relevant, but there are certain specific questions and problems where observation selection effects become crucial: in cosmology for example, they are of critical relevance when one is trying to figure out what observational predictions one can derive from current inflationary cosmological models. Also, if you ask certain questions about the evolution of intelligent life, they become relevant again. The probability of us discovering extra-terrestrials: they turn out to be relevant to answering that question. And then they are relevant to others, like the probability of catastrophe. And to a number of philosophical thought experiments as well, like the 'Sleeping Beauty' Problem.

C: So our analysis of the possibility of certain events depends on a prior 'transcendental analysis' of the

human cognitive condition?

NB: I wouldn't go so far as that, no. But let me give you a particular example. There has been some concern amongst people who are doing these high energy particle accelerator experiments that – it seems unlikely – but theoretically maybe they could cause a breakdown of the metastable vacuum state, which would mean that there would be a rip in space-time that would expand at the speed of light in all directions, and bring utter disaster not just to earth but eventually to the whole observable universe. And so the question is, what reason can we have for thinking that these things won't happen?

The director of the Brookhaven particle accelerator commissioned this report a few years ago, the Brookhaven Report, to study this potential risk. And the authors of the Brookhaven Report made a good point, that the energies that would be attained in the reactor when particles collide, are attained all the time in the atmosphere: there are cosmic rays, particles from space that hit molecules in the atmosphere. And they occur much more frequently there. So, assuming that the reactor events are equivalent to the naturally-occurring ones, we can then calculate an upper bound on how probable these reactor disasters could be, and it's very reassuring if you do that.

Now one problem here is, how do we know that the natural disasters are not very common? Suppose it were the case that on average, taking an average cosmic region,

COLLAPSE I

that it was usually sterilised after one day, so you would have this furious destruction of cosmic regions, and then nothing else would happen. Now how do we know that that's not the case? Even if that was the case then we would still obviously expect to be alive – you don't observe these destructions, the destruction hits you at the speed of light, so no-one can see these things. So the only thing that would be seen would be parts of the universe that survived. And if the universe is big enough there would always be such parts. And so they had overlooked that. But it turns out that you can get around that, and this is a recent paper in *Nature*³ I wrote with Max Tegmark, who is a physicist, where we point out that you can use data from planet formation rates to place an upper bound on this. The basic idea is that if these sterilisation events had been very common, then we should have expected to have been on a planet that had been formed much earlier. So there you can, using these data, and awareness of these observer selection effects, find a way round it. In this case it supports the original conclusion.

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C: As is the nature of the research undertaken under the aegis of the Institute, issues about the possibility of some posthuman intelligence, non-carbon-based life – there's a high degree of philosophical speculation, or abstract speculation, involved in these. On what basis would you discriminate between relevant and irrelevant degrees of speculation? For instance, after the 'singularity', this

3. 'How Unlikely is a Domsday Catastrophe,'
at <http://arxiv.org/abs/astro-ph/0512204>

unimaginable amplification of cognitive capacity, there's an issue about whether there would be any continuity between intelligence as we know it, as familiar to human beings who are organic entities with a set of organic interests, and some sort of massively distributed non-organically-individuated intelligence. Would it have the same kinds of interest, would it want the same things that carbon-based lifeforms want? These are massive issues, obviously. But what's the cut-off point where you fore-close speculation?

NB: Well I guess there are a couple of ways in which it could satisfy the relevance criteria. One is that the question might have independent philosophical significance, philosophers often use thought experiments to test different philosophical positions – the 'brain in a vat' experiment, it's irrelevant how likely it is that scientists can actually make a brain in a vat if you want to think about internalism or externalism about mental states, for example. So obviously anything that is relevant apart from its empirical possibility would fall into that category. But then there are issues that are important because they might have practical relevance to what we should do now, or to one of the main questions that the Institute will study, but where it's just not possible to get anything better than a speculative answer. So then again, my view is that we'll have to make, and use, whatever tenuous guesses we can make, but then simultaneously recognise them as being tenuous guesses.

COLLAPSE I

Because there's not going to be a vacuum here, and if one doesn't try to do something carefully, with qualification and with as much precision as one can, then people are going to do something there anyway, which is going to be less good. So that's one way in which it can be relevant.

And then there are some theories that would be very speculative, and where you might not be able to say that's what's going to happen, but you might be able to say if this thing happened or that thing happened then you can construct a quite good argument for why a third thing would happen, so there might be these conditional results as well. So given certain assumptions and premises you can make a strong case that there would be these other consequences. So that's the third way. To some extent one knows it when one sees it, if it seems to – even if it doesn't prove the point, if it sort of seems like an intelligent, carefully thought out, worthwhile consideration, then that's a kind of useful study.

C: Might some of the questions concerning superintelligence or a transhuman intelligence not be beyond our analytic capabilities? Why would a higher form of intelligence be something that would be recognisable to us any more than human intelligence is recognisable as such to an insect?

NB: If I could answer this in a personal capacity, what I currently think about it is that a superintelligence may be

best thought of as a very powerful optimisation process, which means that whatever its goals are, the defining characteristics of a superintelligence would be that it is very good at achieving those goals. So that means that what it would actually do, how it would manifest itself, would depend critically on what its goals were. So the effects might be anything from being totally invisible to tiling the world with paperclip factories or smiley faces or whatever. You might imagine some unwise AI programmer in the future, when they are just about to create this first superintelligence, who thinks it would be very good to give it a motivation system based on reward learning. So they train it to get a reward whenever it sees a happy face, a smiling human face, then if the humans seem happy it gets rewarded for that, so it gets a motive to perform those actions. And then once it becomes more intelligent then it realises that it can produce this outcome that it has been taught to find desirable much more efficiently just by creating lots of smiley faces. And if that's the only goal it has then it might work out a very clever way of achieving a maximum of smiley faces. So I think with something that would be radically superintelligent – not a human that is slightly smarter than us, or AIs in the near future, but a really radical superintelligence – I think it could be very alien, and one shouldn't think of it as a sort of human genius.

C: This indicates another fundamental issue, the question of whether intelligence is necessarily connected with

COLLAPSE I

goals or aims. One could say that human intelligence precisely has this excessive problem-solving capacity without having a particular aim, or at least the former exceeds the latter to a comical (or tragic) extent. Is intelligence necessarily goal-directed? And if a superintelligence emerges, will it emerge from somebody explicitly setting out to build it? Might it not emerge instead as something which has not been planned at all? If you think of the Internet, or something like Google, an intelligent system that has in a sense developed a model of meaning, of how words are connected together, couldn't something intelligent emerge from that without it being planned?

NB: To some extent on the first question, one might think that if a superintelligence turns out not to have any particular goal, then it might not do or amount to very much, and then it's just a matter of waiting until sooner or later some superintelligence arises that has these goals and then you would get one of these scenarios where the outcome might be very good or bad, it would all depend on what the goals were. Another kind of answer to that question is that it just depends on how you define goals. So if you just have some thinker just sitting there and looking at the world and pondering it you might think that they have some sort of internal goal, of having their thoughts more highly organised, or thinking true thoughts or something like that.

And as for the second question, it's difficult to say.

There are three cases, there is one where somebody deliberately sets out to build a superintelligence, and then there is the other case where it just would arise spontaneously from the Net or something. And then there could be intermediate cases where people set out to build something but then it goes farther than they imagined it would. If some sort of self-improving system is created, they might not really have clearly envisaged what the outcome would be, but nevertheless you could get a superintelligence out of that. Now which of those is most likely is difficult to tell. Some people think that deliberately setting out to do it is likely to get there much sooner. You might do a comparison with other things, like you don't accidentally build a car or an aeroplane.

C: Are there particular technologies which you think the emergence of other forms of intelligence is tethered to?

NB: Better brain-scanning technology. Well, we can create thin slices of the brain, but then scanning those slices more effectively than we can today, in an automated fashion, in a scalable way. I think that's a real enabling technology. Of course computing power, generally, that's another.

C: But isn't that again to assume that any intelligence will be modeled on human intelligence? Or is that the only assumption that can be made?

COLLAPSE I

NB: No, but it's one way we can imagine getting there: we know one intelligent system, the human brain, it's a physical system, with neurons and stuff like that. So in principle if we could figure enough out about this system then we could see how it does it and do the same thing on a computer. Now it might not be the thing that would get us there most quickly, it might be better and easier and more effective to do it based on other approaches that don't really follow the human mind closely. And for those other approaches I think computing power would be one thing that helps. But since right now the theoretical problem of how to program any sort of system like that is very difficult, and I think progress in neuroscience and/or uploading is a potential technology that could help.

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C: The Institute seems to belong to this notable category in the post-industrial world where research programs that seem to be completely unconnected to any pragmatic problems suddenly become crucial. Prime number research, which related to a pure mathematical problem, suddenly became the locus of massive financial investment when cryptography became an crucial commercial factor. The last few years have obviously been boom years for certain Islamologists, who suddenly find themselves in great demand by media and intelligence agencies alike, and so on.

Given that philosophy has such a huge wealth of material that is apparently 'useless', one would have

thought that its time was overdue...Are there corporate or other interests outside the university who are interested in your research, who see that this extremely long-view research, with a necessarily philosophical component, has important consequences for them?

NB: My own background is that I'm a philosopher but I also do other things apart from philosophy, so it's sometimes hard to see which of these is in play, especially in the catastrophic risk area: I've done some consulting for some intelligence agencies, some stuff like that. Corporate, I haven't really tried to reach out to that yet, it might happen in the future. But the things that are directly relevant to corporations tend to happen anyway, because they tend to have money and they make them happen. The things that don't get done are things that might be of great concern for humanity as a whole, that our species would do well to invest some effort in thinking about. But any particular corporation, it's not their responsibility or their benefit. Like human extinction risks, which corporations are unlikely to fund! But nevertheless it seems like a good thing. So I'm trying to do those things which should be done but aren't being done.

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C: The mass media plays a huge role in transforming the perception of risk; is there any space in what you're doing to think about the role that that mediated reflection of the risk plays in transforming culture, and the consequence

COLLAPSE I

that fear of risk can be just as significant – if not more so – than risk itself? Obviously if you think about the supposed War on Terror and everything that’s involved there, these factors are as important as the risk itself.

NB: I agree with that. There is one additional way in which thinking about perceptions of risk might be involved, in addition to the way the perceptions themselves make things change in the world: there is a genuine objective risk, and then there is people’s perception of that risk. And if you can study the process between these, the sort of distortions that occur, the fact that there are certain types of risks that people might overestimate because of they are vivid, and are played out in the media; and others they might tend to underestimate because they happen bit by bit on an everyday scale and are more abstract in some way. Now, if you could figure out exactly what those distortions are, for the cases when you can both know the objective risk and people’s perception of it, then you might look at another case where the objective risk is unknown but you can still study people’s intuitions about it, and maybe you can extrapolate back to get a better estimate of what the real risk is, by a sort of counterbalancing for these known biases. Especially with regard to certain existential risks, I think that’s a useful thing to study. And there is quite a lot known about people’s risk perceptions, and the biases and heuristics we use to assess probabilities of things. It’s also known that our intuitions about those things are

wide of the mark, that there are systematic distortions.

C: Aren't humans constitutively non-rational agents? It's impossible for us to right our perception of risk completely, isn't it?

NB: It's a question of more or less closely approaching. Take weather forecasters, they're pretty good, they're well-calibrated. Calibration is when you say, if you think there is a ninety percent probability of something happening, then ninety percent of the time when you say that, that thing's happened, that's what calibration means. So it doesn't mean that you're right all the time when you guess, but your confidence matches your real knowledge. So weather forecasters are trained on this, you go through lots and lots of examples when you're trained, so they're quite well-calibrated. Pretty much everyone else is ill-calibrated, maybe there are other specific groups that are calibrated, insurance brokers or stock market speculators. So it's possible, given enough feedback and enough incentive, to become a better calibrated risk-assessor. But that doesn't seem to happen spontaneously or naturally.

C: Bayesian analysis could be applied here, since it includes a measure of confidence in probability calculations.

COLLAPSE I

NB: Certainly. With a lot of the biggest risks, you have to rely a lot on subjective opinion. There's just no way around it, you can't quantify a lot of these disasters that have never happened in the world. The probability that humanity will create a big war with nanotechnology some time later this century: you can't run a frequentist approach and count the number of times this has happened in the past. You don't have a solid scientific model like in quantum mechanics, where you can calculate and get probabilities out, so what do you do? Well, you have to think about it, what would the capabilities be that advanced nanotechnology would make available; how would that play out in a strategic context in the world with competing powers. You think about these things, you discuss with other people, you critique arguments back and forth, but in the end you're probably going to have a situation where different people who are intelligent, who have now read all of this, will assign different probabilities. And I think that's unavoidable.

C: So you do have to work with a synthesis of the facts that you can represent statistically and the knowledge of people's reaction to these statistics.

NB: Yeah, so when we have solid statistical data then obviously we use that. But most of the questions that are of most interest to humanity you can't solve by exclusively relying on that. And that's not just when you think

about the big picture of humanity, but when you think about policy, political decision, or indeed your own life decisions: if you decide you're going to marry this person you've been together with, there is no formula or deductive proof that this is the right thing to do, you just have to follow your gut feeling, after having taken into account the obvious objective knowables, then you just have to make an assessment. But that doesn't mean there aren't better and worse ways of doing it. You can certainly be foolish or wise, and different people might do these things differently well. So just because there is a subjective component doesn't mean that there are no constraints.

C: Is it possible for a human being to calibrate themselves in respect of risks on a cosmological scale? If we were truly able to take into account the futility of being a human being on earth, we wouldn't ever do anything – wouldn't that be the truly rational response to these sort of questions?

NB: Futility...well, I suppose it depends on what your measurement scale is. So if you do assign equal value to all life, or all humanlike beings, and you think that a non-futile action is some action that changes the total value, then you run into problems if the universe is infinite. Although there are technical issues there, which my paper *Infinite Ethics* covers.

COLLAPSE I

C: The use of non-standard analysis.

NB: Yes, and it gets very difficult. But suppose you have a different criterion of what's futile or not. So you might think something is worthwhile if it makes you happier, and some people you care about, and people on earth are not harmed, and perhaps helped a little bit, and a few hundred children in Africa are surviving. I mean, these are quite big outcomes from one perspective.

C: But the question still remains of the independence of philosophical thought, and whether in this endeavour there are certain assumptions that have already been made, illegitimately. For instance, if you were to produce a paper which said simply, the rational thing to do is to despair, there's no point in doing anything, that would obviously be bad for the Institute – aren't you automatically disposed to a sort of philosophical optimism?

NB: No, I don't think so. Certainly if someone came up with a good argument that it doesn't matter what we do, or that we're all going to go down the drain, then that would certainly be a paper that would seem very relevant. I mean, I've written some papers which, although they're not quite saying that, could...the *Infinite Ethics* paper doesn't quite say that, but it's going in that direction. *Existential Risks*⁴ doesn't say that we're going to be

4. At <http://www.nickbostrom.com>

extinct, but it certainly takes that possibility very seriously and argues that the probability is significant. The big picture is difficult. We haven't really thought about it, and one shouldn't be surprised if there are some rather unexpected things once one has started to think about it, that would come out of that.

C: Is it possible that the more interesting, the more demanding ethical questions will arise precisely from the position of despair rather than from the assumption that the human race is a good thing, that it's a good thing to live longer? You're asking a tougher question if you say that the sun will expire, and with it all human life – now, how should one act...it's a more profound ethical question.

NB: Well, I think the sun will expire, and we want to know how we should act now, so I suppose that's the question I'm asking in a sense. Although you want to make it more specific to be able to get something out of it. But I think in general whenever you do some kind of research project you have some kind of starting point. Maybe one starting point and then you see where you end up. Now for an Institute you can have more than one starting point, for each paper you write you might have a different starting point, and each person might have a different set of background assumptions.

COLLAPSE I

C: The pessimistic view would be that for evolutionary reasons, there's a fundamental mismatch between human beings' requirements, their psychological requirements, what they would need to have to make them happy, and reality: Freud basically says he's a pessimist because, as a result of our evolutionary, our biological legacy we are doomed to be perpetually dissatisfied. Would that have ramifications for you, given that you say that a superintelligence would be a superoptimiser, would such a superintelligence be able to overcome this mismatch between needs, requirements and the capacity of reality to meet them?

NB: With a superintelligence that could be one scenario, you could have a 'Santa Claus' superintelligence scenario, where you have some wish-granting thing. You might have a similar thing without superintelligence. In a certain sense that's what technology is – it increases the ability of humans to realise their desires. Things sometimes backfire, people sometimes have conflicting desires, and you get war and you get pollution. But there is also something more specific, which is that even if, and to the extent that, that's how humans currently are – we're not designed to be happy, but to maximise inclusive fitness on the African savannah, which is very different – it doesn't imply that that's the way we will, or should, remain forever. Which is the transhumanist perspective, that human nature itself is something that humans can change. And certainly this points towards an area of

interesting questions.

C: If humanity is going to actively shape its own future, its own destiny, it would have to presumably make some choices, make some selections about the kinds of desirable characteristics it should have in order to change itself so that it can be happy. This goes back the question of the ‘transhumanist values’: those values have obviously been selected on a partisan basis, they relate very strongly to a certain political position.

NB: I wouldn’t say so much a certain political position, in the sense that there are people with all different politics in transhumanism, from social democrats to libertarians. But it’s certainly true that the transhumanist perspective is one distinctive take, a specially-valued take on some of these things, and not everybody does or should agree with that. But in terms of humanity choosing, that’s one scenario where you would have humanity as a big entity making co-ordinated decisions. One might question the desirability of that, but even more perhaps the probability of that, in the sense that right now there are lots of groups of humanity that are making their own decisions.

C: The conception of humanity acting as *an* agent.

NB: Yes, it’s very problematic, I agree with that. If you think like that, you will miss out certain, maybe quite

COLLAPSE I

likely, possibilities: there are these effects that arise when you have competition between groups; we might do something that we all know collectively might lead to disaster, just because it's difficult to co-ordinate. Arms races are a good example of this, they're good for nobody but they're hard to avoid. So you might get a different set of possibilities if you had a world government or some kind of very powerful UN in the future that could make co-ordinated choices than if you have a situation where you have multiple nodes of power that act independently.

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C: Some of the scenarios you're talking about are the stuff of science fiction movies. To what extent are you yourself engaged in a sort of science fiction? Is it a matter of our having to tell ourselves these stories which extrapolate from the state of technology in our society, the things we know we can do, in order to come to terms with the massive risks that are the necessary corollary of every new technology?

NB: I don't know, I'm not a great science fiction reader, or watcher, I'm afraid. Clearly a lot of people find inspiration in science fiction. I think it's both good and bad. It's good in that it might make people aware of possibilities or of future worlds that they hadn't thought about, and it can serve to stimulate people's imagination. On the other hand I think it might distort people's intuitions, because there is a constraint that all science

fiction you read or watch has to satisfy – it has to tell an interesting story, so you often have heroes rescuing the world, you have dynamic struggles with human-like characters playing a key part, and determining the outcome. But that's not necessarily the most likely way for things to happen. If you're going to constantly read these, it probably shapes your expectations. If it's all filtered through what I call the 'good story bias', then that can actually warp your thinking.

C: Writers like Greg Egan have dealt with biotechnology, AI, and so on, in a way which certainly doesn't conform to that stereotype.

NB: Yes, I think he's certainly one of the exceptions, I should read more of his work.

C: Science fiction does indeed stimulate people to think about the world and about situations they hadn't thought about; are you not providing a similar service to people who possibly don't read science fiction, providing the same necessary service of widening the scope of people's everyday thinking?

NB: Maybe, I don't see that as the main thing that I'm aiming for, but maybe that's a good effect. Widening people's thinking, to me, has the feeling of a cliché.

COLLAPSE I

I don't know if there is a systematic bias towards narrowness in people's thinking. There might be in specific cases. But maybe some people's thinking ought to be more focused rather than widened.

On the Mathematics of Intensity:
A Logic of Self-Belonging

Thomas Duzer

“One must be a rigorous logician or grammarian, but at the same time full of fantasy and music” (Hesse)

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“I am speaking, obviously, of philosophy and philosophers, of those who force themselves to see, to know, to prove as many things as possible in the course of their existence” (Chestov)

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“Intense codings are connected and sometimes severe mathematics are required since, in effect, the price of victory over the shadow cast by a slumbering but perpetual captain—against the depredations of this hippocampus, then—reveals itself to be eternity and the absence of chains. Nevertheless, for the benefit, and for good reason, of those unhappy souls who remain trepidatious before it, let us recall that where self-belonging—which is substantial freedom—is concerned, where the universe is concerned, no-one is bound.” (Anaximandrake)

‘To be in being,’ is to *be* being according to the mode corresponding to one’s proper singular essence. The term ‘being’ is used out of convenience, for its neutrality, thus indicating no prejudice as to possible different names of being. We will see that the baptism of being is the

COLLAPSE I

supreme activity of ontology, which for that reason cannot be 'first philosophy', despite the position of Aristotle and of the scholasticism that followed him. This position however differs from that of Levinas.

Necessity is the only modality of being; thus freedom is the effectuation of its own necessity. As Spinoza says, 'freedom is not opposed to necessity but to constraint.' This effectuation corresponds to what is commonly known as grace, or the state of grace. Each instant is the good since it can only be justified by itself. This process is in fact creation of being – that is to say, becoming. It is a question of the expression of the Mystical, of that mental zone (*qua* primary determination) that is not linguistic, but purely intensive. This expression or logic of the Mystical is called the *mathematics of intensity*. The unconscious is in fact a true physical topography (specific to each singularity) each of whose dimensions corresponds to a zone of intensity. It has *a thousand plateaus*.

The integral production of the mathematics of intensities has a preliminary requirement: the conquest of the unconscious by any means available. In fact the unconscious is first of all in chains, in a state of servitude. It is under the empire and the influence of diverse instances of the *Socius* as the power which, through the mediation of the law, separates the individual from what he can do, that is to say from his power, hence from his singular essence. These instances are grouped under the unifying aegis of the Superego which systematizes them in the form of the Ego. It is a question of the imposition

of a coding filter on the singular profile of the unconscious, a filter which only allows certain passages between certain points of its territory. The rest remains in the shadows, and so we are etymologically correct to name it the unconscious. The unconscious is spoken, the unconscious speaks. *Ça parle (It/id speaks)*. Every attack against a bastion of the coding filter manifests itself through a specific emotional phenomena: anguish. It is, moreover, by way of this sign that we can recognize that it is indeed active. Each bastion that is conquered is a step towards the annihilation of the filter. Obsession is an intermediary phenomenon; the bastion is not annihilated but besieged.

Such a parasitized, colonized unconscious (one which thus regards itself as a theatre) presents two centres of gravity. One is virtual; it is the centre of gravity corresponding to the essence of the singularity. It is virtualized by the second centre of gravity imposed in a continuous fashion by that structural effect of transcendence which is the *Socius*. This centre is called Superego if it is not identified through consciousness. In this case, the unconscious is master, the master is unconscious. Otherwise, it is known as the internal tyrant or monster (composite being) as soon as it is detected. This detection correlatively compels the localization of the singularity's own centre of gravity and the quasi-complete distinction between the Self and the non-Self. The Lacanian concept of the Other is thus dethroned in favour of a concept of negation which is internal to mathematical logic (and

COLLAPSE I

not to a Hegelian dialectics). This is a corollary of the destitution of the Ego in favour of the Self. At this stage, the former remains no less virtual. Its actualisation passes by way of the precise localisation of the internal tyrant or monster and the destruction of its citadel (which is not the strongest but the most strategically well-situated) permitting the metamorphosis of the Ego into the individual. The centre of gravity of the individual is the *ego* which is the informational point of compression of preceding configurations of the unconscious; it is therefore in perpetual becoming and in incessant movement in the unconscious. The ego, the unconscious and their diverse configurations form the Self.

It is a question of carefully distinguishing the *ego*, the Ego and the Self. Let us note that the speed of thought is all the faster in so far as there is no Ego, that is to say no Other, but the operator *ego* which generates the instantaneous synthesis of apperception and produces reflexivity as a result. Meanwhile, it is necessary that it produce a sufficient unconscious to have a memory available, that is to say in a form that is compressed and not deployed, as of a 'picture'. The ego as the engine brake. Yes, *good* narcissism, *qua* success of the mirror stage, that is to say, non-psychoanalytically, refusal of identification and thus comprehension of the reality of the illusionism of the image, is the constitution of an evolutionary story whose global coherence is suspended at the instant, open to the hard purity of the real event. The ego therefore, as necessary and variable fiction: matter and chronology

and egoic form, which are separable instances, each capable of subsisting for itself. But the Self cannot be reduced to it. *Bad* narcissism proves therefore to be a belief of a transitive type: the cult of the fiction, of the *fixing*, of the Ego. Thus, the narcissistic phases must surpass the Ego, that is to say in passing by way of the intellect which is thought in act, that is to say, thought without images. In fact, the Self is not constituted on the basis of a Lacanian Other, that is, by an avatar of the dead God, but by the symbolic exchange with another rational being. It is only by way of the symbolic that experiences can be connected and integrated with each other, even whilst they remain perfectly heterogeneous in reality. Yes, first and foremost, the Self is real coherence thanks to the symbolic – contrary to the Ego which is an attempt at the imaginary conjuration of the circulating “empty case” which drives the signifiers.

Primary narcissism – that of the Ego – is mysticism of the All, that which it is not abusive to designate as the desire for fusion with the mother. The Other here is but the imaginary disguise of the Same, that is to say, the obsessive negation of every other real in an auto-parturition with no issue. The Ego is thus only a local illusion, a reflection of the absolute in a lateral pool. The Thing: stasis and abolition. It is, moreover, this rejection of the symbolic which posits the psychotic as such. *Lapsus mentis* : psychosis conflates objective genitive and subjective genitive. On the contrary, and far from the totalitarian affirmation of the Ego, the auto-referentiality

COLLAPSE I

conquered thanks to the symbolic instance proves to be a remedy against infinite regression. Because the only movement in which one understands *all* is that of death. The movement of nous, that which produces the opening, which constitutes the Open, when it ceases, gives way to a bounded, deployed, unfolded totality. It is indeed the mystery of All which must be clarified – in other words, that which makes a totality a totality. And it is in psychogenesis that it is appropriate to seek the solution: first alterity encountered, neoteny of the human animal. This is moreover why the language of the human being *qua* social, since language-using, logically produces the Ego. Let us note in this regard that the substantial Ego is nothing but the perturbation of the Self's relation to Self (that is to say of reflexivity), and this evidently for the purposes of subjugation. It is therefore not so much that the All is an unattainable mirage, an illusion specific to the suspension of senses. The problem is rather that the All is in fact homogeneous with a repose modeled on death, a death which is the truth of all transcendence. However, madness will never be mad enough to render the ontic and the ontological indistinct. Transcendence *versus* chaos? No. Let us be clear: the wisdom adequate to chaos, that is to say to a truly inhuman madness, is discernment.

We should in fact realize that the point of being proves to be junction of the real, the imaginary and the symbolic. No precedence of any one of these dimensions over any other. Otherwise, transcendence *qua* asymmetric cut

arrives as a hallucination provoking real effects. This caesura, heterogeneous to the symbolic, is the arrival of the void as such, that is to say, of non-being as phantasm. Because it is indeed castration which is the origin of the imaginary's real takeover of power. In effect, the sovereign image is the negation of the *puncta coacta* which constitute it, and thus the affirmation, by denial, of the All. Denial of castration? In fact, it is the delirium of the All itself which testifies to castration. The real of castration is delirium, not as process but as legitimation of the takeover of power of one of the dimensions of being. Yes, the symbolic caesura differs from castration because it is the condition of connection and disconnection, that is, of the formation of alls. In fact, there is no all which is not fragmentary, and thus relative. An all is not all unless there exist possible components which it does not totalise. Yes, the pure multiple is untotalisable. Were this not so, the absolute, formalised, would annul itself infinitely. This is in fact the mistake of all religion: faith as strict inverse of doubt, correlate of the exclusion of their subsumption.

In short: the All is the index of transcendence, that is of coalescence between the real and the imaginary, thus of the refusal of the symbolic, that is to say of the other, and thus, as we will see, of the Self. Differences, feared, are aligned under the category of opposition. It is remarkable that it is the rejection of the other that gives birth to the Other, that is to say to the very possibility of alienation. One sees then that it is a sophistic tropism

COLLAPSE I

that makes possible voluntary servitude, then denied, hence perfectly interiorised. But no, all is not in language, and the “All” is only in language. Yes, since it reflects nothing, being appears as chaotic, void, or eternal multiplicity disseminating itself sempiternally. Thus, presence *qua* eternal is the assumption of time as event of pure difference, this paradoxical substance. But to attain the All – the end of time – in excluding the other, that is to say the Self, amounts to joining with the Other – that is to say, with nothing.

But, let us be specific. We have said, necessity is that of the singular essence, that is to say real essence. There is no global necessity unless there is a One-All, therefore an outside of the universe, that is to say if $1=2$. This initial paradox tries to conjure up freedom, the unpredictability of the living, and notably as to the issue of the struggle until death. For a judgment, second illusion, which is triplopia, it would have to be that $1=3$. In this case, the delirium goes even further. Desire in an impasse, construction of sin *ad hoc*, the big Other. *Ne uter*. In achieving the paternity of the One, one would lose in it the immanent distinction in the indiscernible, this mixture escaping the dialectic of the void and the plenum. This is to say that one would lose the act of the intellect, the movement of *nous*. One would thereby lose singular individuation in favour of a regular cloning. And we can be sure that this would indeed be a shame, so long, of course, as one allows this anti-wager, which is an authentic risk, hence one which no law probabilises in advance.

Thus one and one only entity or instance, the Self, is “conscious” of “its” contents via the intermediary of *reflection* between individuals. The obstacle, which is considerable, is that one finds some who take themselves for Egos. But the Ego is a false unity, a false coherence which, in order to subsist qua illusion, must mortgage the future in the form of a quasi-cancerous growth, by destroying – that is, consuming – possibles. It is in fact its internal contradiction which forces it to submit in order to be able to project its contradiction, and make of the other the imaginary suffering appendix of its fictive Ego. But to make an Ego, you need at least two bodies. Even the dialectic of master and slave, that servile caricature, requires two human beings, for it deals with desires and consciousnesses. Not that of the Ego. In fact, it is a question there only of a relation between an object and its possessor. This is patently obvious, for example, in fetishism. Recall Federer’s thesis, reprised by Bergler (the typical neurotic): the slave dedicates himself to the master in order to escape the panic to which his freedom exposes him. But by the same token, this master is only his instrument. *Ellipse.*

Consequently – and this is no solipsism – there is a Self, diversely modified into spirits and bodies which are images, that is to say, figures of the agency of the imaginary. The Self *qua* intensive is nevertheless traversed by the symbolic dimension of language, that is to say, perceived as an Other which affects the Ego. Nevertheless the Self is one and “unreflectable”. One

COLLAPSE I

cannot “see” it, since it is not an Ego, an image, but, on the contrary, that place from which one sees. Here we are far from the form of the Ego. The Self is that “planomenon” (Deleuze), that paradoxical substance where the polyphony of intensities circulates in pure immanence; intensive grammar itself in perpetual difference since it is connection, syntax of differences. “To be in being”: here one is indeed involved in a logic of self-belonging.

But to believe in the Ego or in the Unique (Stirner) is much more than not to believe in anything, it is to believe in nothing. And as Weininger says: “cowardice is a way of taking nothingness to be something”. For their part, in fact, the nihilists preach, whether silently or not, and along with others, the following: do not expect anything. But this is to expect nothing. In fact, the nihilist always expects something but it is nothing that he desires. Even alerted by Blanchot that the apocalypse disappoints, he waits, and that is *all*. He does not want himself living, for that would be to risk, enjoyment certainly, but above all suffering: he wants himself dead. Now, this nothing would not be lack unless there was the possibility of something in its place. Certainly, certain halfwits, subtle rhetoricians that they are, will not hesitate to object that lack is precisely something. Which is true, indubitably so. Isn't it in this way that we can understand the demon of the malicious Descartes' *Cogito*? But let us reassert that “nothingness has no properties”; and refuse every “effect”, every mystification, as base. For you will only find the plenum there where it is not lacking, which is to

say, there where it is. It could only be lacking where it is not if it were there. Which is to say that it is logically contradictory for it to be lacking. In effect, it is not lacking in its place because the place does not belong to it. Certainly, there is void where one looks for the plenum. But the question is: in whose interest is it to put your desire, which lacks nothing, in an impasse? Who could want to set up contradiction at the very fundament of ontology? Those who satisfy their desire through your impotence, those who rule by and on the basis of anguish. Because, and this is the only axiom of their “science”, they know full well that anguish is the link to lack. Here, the secret of tyrannies reveals itself, all the more blinding for it. Being is no longer the knot of the real, symbolic, and imaginary, but that which is put in quotation marks becomes *lèse-majesté*, and being is nothing more than that which passes via the mouth. Because, just as the Stoics knew – and this is only a paradox for the excarnated of all descriptions – it is the incorporeal which renders possible the real mixture of bodies. It is the very condition of possibility for the event. Yes, despite the egoic myriads, the symbolic is transcendental.

It is therefore clear that to recognise the instance of the Other is, paradoxically, to misrecognise that of the symbolic. To posit the Other is to render castration unsurpassable, transcendent. But the instance of the Other is only a projection of the imaginary upon the symbolic. This is indeed what leads us to claim that the Ego only arises from the SuperEgo (*qua* effect of a certain type

COLLAPSE I

of *Socius*). Certainly, “something”, in the symbolic, must structure the Id; but the SuperEgo petrifies it, *i.e.*, produces the Ego. Another organisation of the Socius is therefore necessary to resolve this problem. In fact, castration, linked to the imaginary belief in the Other (the uncastratable), induces the separation between the zones of highest intensity.

Nihilism is therefore, as Nietzsche emphasised, the touchstone. Its partisan is on the near side of the intuition of the distinction between joy and sadness, between augmentation and diminution of desiring-power. “What sense? What sense?” chants this ridiculous parishioner, a sort of plebeian relativist Heraclitus, for whom ascent and descent are equivalent. So, that place “where we feel the whole nervous system burning like an incandescent lamp” (Artaud) is for the nihilist a place unknown, or perhaps forgotten – but, at least, lost. It is true, as Gabriel Marcel says, that this type of philosophy, which, fundamentally, opposes to being an end not to receive, is coherent, rational, “philosophical” in sum. Likewise, Sartre concedes that the spirit can deny itself and even possesses an infinite power of doing so. And already, the cavalier Descartes, that Pascal from before the Fall, finds the reason for that strange mania in the disproportion between finite understanding and infinite will. Point noted.

Thus, whether it is a case of the All, of God or of the Ego, every philosophy of the transcendent One is indeed in this sense a nihilistic and ancillary philosophy. Yes, in

order to be able to reciprocate (whether explicitly or not) being to the One, it cannot but differentiate them, but as derived. But let us posit a precondition: Spinoza, according to the *vulgate*, is a philosopher of the One-All. We will nevertheless retort that his system leans towards Epicurism and Atomism. Because it is indeed rather Neo-Platonism which is the philosophy of the One-All; it is the doctrine of emanation which properly characterises the latter. Good and Evil are its autophagous principles: the absolute devours itself in it. Psychosis and transcendence. In complete contrast, Spinozism is pure immanence. The good and the bad are only ever said relatively here, but are nevertheless absolutely distinct. Here is the difference: joy has no need of sadness. Joy as augmentation of power is sufficient unto itself, whilst sadness is servile, bound to lack, that is to say, to anguish. Thus, it is with absolute sovereignty that Spinoza withdraws God from the grip of the theologians and their creed, and makes of it the pure multiple which is only multiple of itself. His work, and in particular the polemical *scolia* of the *Ethics*, demonstrates this clearly.

Not cannibalistic bipolarity, but one axis only: aristocratic joy as augmentation of force. Chronos emasculated. What is power [*pouvoir*], then? It is merely the lowest degree of force [*puissance*]; it is force's separation from itself, self-separation and projection of this separation. Thus: the One is pure alienation. Hence it is the instance which allows the others to link themselves into a whole. Thus there are ones. Which can also be said: there is

COLLAPSE I

only one and the other if One occupies the function of the Other, that is to say the One *qua* alienated. Now, this function of the Other, if it is a question of joy, becomes that of negation. No dialectic. Negation of negation does not yield identity. It is identity which denies itself in denying. Being is not becoming, it is becoming which creates being. What of their conflation? It is the Ego. The non-Self is the site of transcendence alienated in perpetual negation but, therefore, and consequently, of itself, that is to say of its Self which is illusion and its sole substance. For the One is indeed a pure generic difference, but the latter is without relation, and consequently, without Self. Self-sufficient image. But the image, irremediably, is punctured. It is thus the epiphany of the perverse process in the pure state: the image identified with being, the terrible synecdoche. Non-separation, devourment, death fantasmatically denied, swallowed. Immortality is promised to the perverse only in exchange for their absolute alienation. But who makes it necessary? For in fact joy is entirely other, eternity, *hic et nunc*, that is to say the pure Self which arises from the relation of pure differences. Yes, the Self is the indiscernability of the one and the multiple.

Thus the mathematics of intensities is firstly a geography, a cartographical relief map of the unconscious. But secondly, it proves to be a pure pragmatics. In fact, thanks to nous, to the intellect, an automatic computation is effectuated which mobilises, in the Self, the full gamut of intensities, and extracts those

which are adequate to the solicitations of the non-Self, whether it is a matter of connections or disconnections, that is to say of compositions or of decompositions of relations, of links. Thus the domain of “us” can arise. From now on, the unconscious is productive, that is, capable of continuous creation. At this stage, it is possible, by way of a *linguisterie*, to replace the term ‘unconscious’ by the term ‘in-conscious’. In fact, the liberated unconscious is not conscious in the sense of being re-presented reflexively in consciousness but in the sense of being intensively presented in *it*. Then, and only then, is it a question, for the philosophies of the multiple and of the concept, of effectuating logical conjunctions (connections and disconnections), that is to say, within the immanence thereby conquered, of creating significant liaisons in systems of relations which are external to their terms. This is how the mathematics of intensities, which is the logic of self-belonging, and hence etho-ontology, can become a real pragmatics, that is to say, a constructivist philosophy between free individuals.

Various tactical and strategic mappings, scattered and principally offensive, disseminated in universal literature, await an Esperanto. The science of these lacings and interlacings has yet to be elaborated. This mathematics of intensities is the real ethics of the event, the practical science of manners of being, that is to say, an empiricism at once superior (Schelling) and radical (William James), and therefore transcendental (Deleuze). It is the knowledge of desire since “desire is the very essence of

COLLAPSE I

man” (Spinoza). If we connect this theorem with another Spinozist theorem, namely “essence is force”, we immediately deduce that the force of man is desire. Being being produced by becoming, ontology, the science of being *qua* being, is logically secondary. In this way, etho-onto-logic becomes capable of supplanting the ancient onto-theo-logy, since the coherence (of Logos in act, the actualisation of Logos), which differs from the non-contradiction of classical logic, is no longer that of the Ego or of God but that of the force of desire. Heraclitus, the Stoics, Montaigne, Spinoza, Hume, Nietzsche, William James and Deleuze (and perhaps even Wittgenstein) were already closer to etho-onto-logy. But they conceptualised an onto-etho-logy without naming it as such. To name it thus proves that each of them actually taught the inverted double of that which they did, that is to say, an etho-onto-logic in act. They were individuals but designated individuality without conceptualising it. This is why Spinoza’s *Ethics* is written invertedly (incessant shuttling, halls of mirrors, figures of light): substance turns around the modes and not the other way around. So it is that the name of being is that which, *logically*, gives it becoming in immanence. *Igitur*.

Translated by Robin Mackay and Ray Brassier.

Crowds

Keith Tilford

p262-3.

Untitled, 2005. Ink on Paper, 121.92cm x 177.8 cm

p264,265.

Details from the above

p266-7.

Untitled, 2005. Ink on Paper, 120.65cm x 163.83cm

p268,269.

Details from the above





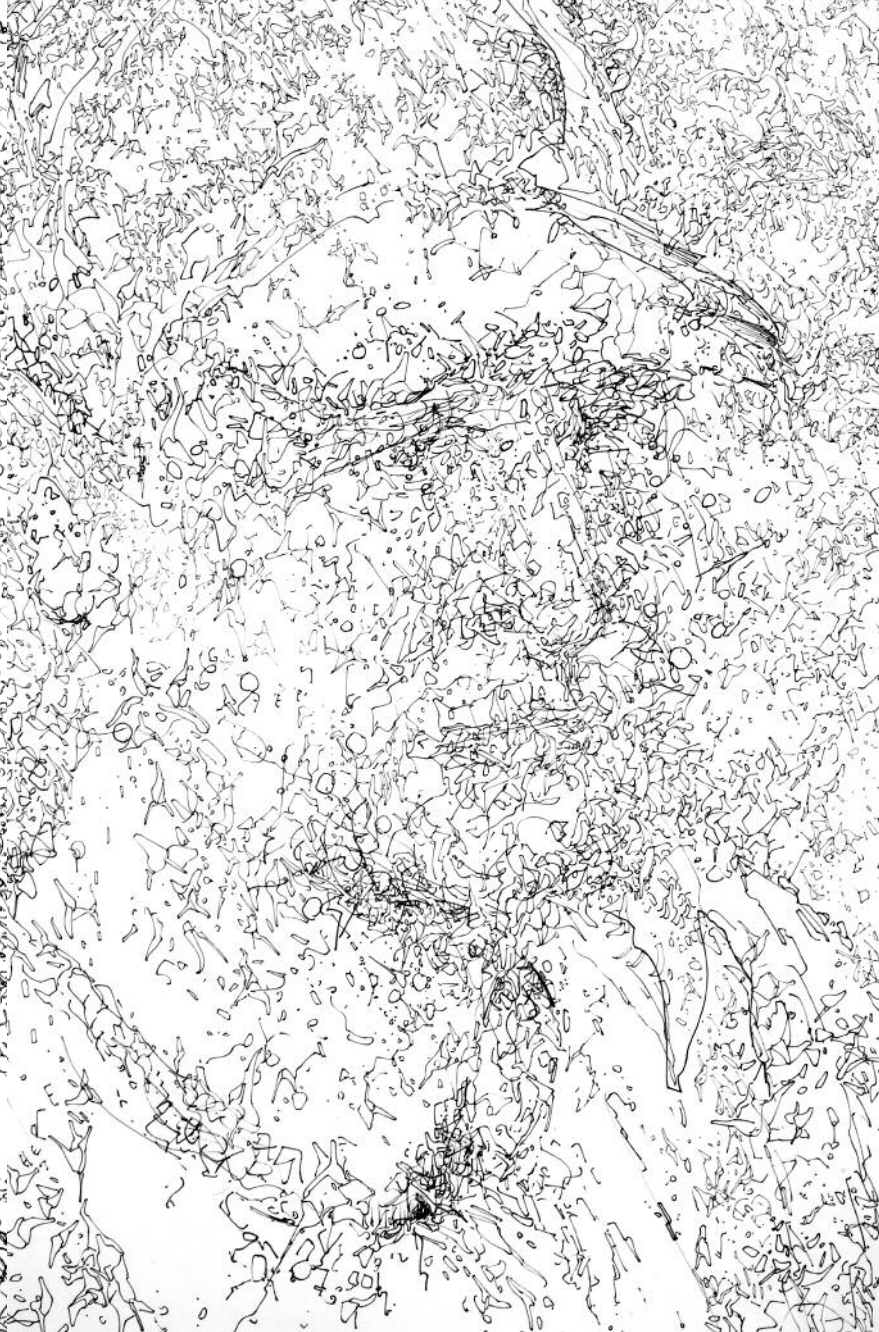












Qabbala 101

Nick Land

INTRODUCTION

Is qabbalism problematical or mysterious? It seems to participate amphibiously in both domains, proceeding according to rigorously constructible procedures – as attested by the affinity with technicization – yet intrinsically related to an Outsideness through which alone it could derive programmatic sense.

If there is no source of at least partially coherent signal that is radically alien to the entire economy of conventional human interchange, then qabbalism is nothing but a frivolous entertainment or a fundamentally futile practical error. Yet unlike any kind of metaphysical assault on 'the noumenal', qabbalism cannot be definitively critiqued on a purely rational or formal basis, as if its mode

COLLAPSE I

of 'error' was that of logical fallacy. Since qabbalism is a practical programme, rather than a doctrine of any kind, its formal errors – mistakes – are mere calculative irregularities, and correcting these is actually a procedural requirement of (rather than an objection to) its continued development.

It is the rational dismissal of 'the' qabbalistic enterprise that is forced to take a metaphysical stance: ruling out on grounds of supposed principle what is in fact no more than a guiding 'empirical' hypothesis (that signal from 'outside the system' is detectable by numerical analysis of codes circulating within the system).

Epistemologically speaking, qabbalistic programmes have a status strictly equivalent to that of experimental particle physics, or other natural-scientific research programmes, even if their guiding hypotheses might seem decidedly less plausible than those dominant within mainstream scientific institutions.

Lovecraft understood the epistemological affinity between natural science and programmatic (as opposed to doctrinal) occultism, since both venture into regions once declared mysterious, following procedures of a rigorously calculative-problematical type. It is the alliance between purely speculative metaphysics and common sense that betrays such affairs of pure reason to futility, since they lack the calculative traction to revise their own conventional notions on the basis of their encounters. Practices – however implausible their guiding motivations – can know nothing of absolute mystery or

metaphysical transcendence because their realm of certainty is procedural-problematic and uncontroversial, whereas their reserve of knowledge is empirical, refutable, repeatable, revisable, nonmystical and accumulable.

There may be no ‘empirical’, procedurally approachable mysteries – or mysterious problems – of the kind qabbalism guides itself towards. If so, it will approach this fact in its own way – empirically, probabilistically, impressionistically, without any logical, transcendental or philosophical meta-discourse ever having been positioned to put it in its place.

I. POPULAR NUMERICS

Traditional gematria (whether Hebrew, Greek, Farsi or Arabic¹) have distinctive typical features: (1) They substitute letters for numerical values, overcoding numerals where they exist. (2) They code for discontinuous numerical values, typically 1-10, then 20, 30 ... chunked in decimally significant magnitudes.

The ocean in which qabbalism swims is not mathematics, but popular numerical culture. From a mathematical perspective it remains undeveloped, even ineducable, since it cannot advance beyond the Natural number line even to the level of the Rationals, let alone to the ‘higher’ numbers or set-theoretical post-numerical spaces. Where counting ceases, qabbalism becomes

1. See Incognitum, ‘Introduction to ABJAD’, in the present volume.

impracticable.

Socially, qabbala makes an implicit decision against specialization, in order to remain virtually coincidental with the entire economy of digitizable signs. It is essentially 'democratic' (in the most inclusive sense of this word), even when apparently lost in its own trappings of hermeticism. It is bound to the 'blind' undirected contingencies of pre-reflective mass-social phenomena, with all the inarticulate provocation this entails in respect to professional intellectuals. Wherever exact semiotic exchange occurs, a latent qabbalism lurks (even within the enclaves of intellectual professionalism themselves). Deleuze & Guattari's 'Nomad War Machine', within which number is socially subjectivized, captures crucial aspects of this qabbalistic fatality.

Historically, qabbala arises through epic accident, as a side-product of the transition between distinct modes of decimal notation. Its historical presupposition is the shift from alphabetical numerals (of the Hebrew or Greek type) to modular notation, with its resulting unlocalizable (and theoretically indeterminable) confusion. This transition provided the opportunity for a systematic calculative 'error' – the mistaken application of elementary techniques appropriate to alphabetical numerals – simple addition of notated values – to the new modular signs. This mistake automatically resulted in digital reduction, by accident, and thus as a (theoretically scandalous) gift of fate. Arising historically during the European Renaissance - when zero, place value and

technocapitalism finally breached the ramparts of Western monotheism – qabbalism (born in a semiotic glitch and thus lacking the authority of tradition or even purpose) was compelled to hyperstitionally generate an extreme antiquity for itself, in a process that is still ongoing.

Technically, qabbala is inextricable from digital processing. Emerging from calculative practicality within the context of blind mass-cultural metamorphosis, it antedates its own theoretical legitimation, making sense of itself only derivatively, sporadically and contentiously. Its situation is analogous – and perhaps more than analogous – to that of a spontaneous artificial intelligence, achieving partial lucidity only as a consequence of tidal pragmatic trends that ensure an integral default of self-mastery. Practical systematization of technique precedes any conceivable theoretical motivation. Dialectical interrogation of qabbalism at the level of explicit motivation thus proves superficial and inconsequential, essentially misrecognizing the nature of the beast. (It is equally misleading to ask: What is a computer really for?)

Politically, qabbalism repels ideology. As a self-regenerating mass-cultural glitch, it mimics the senseless exuberance of virus, profoundly indifferent to all partisan considerations. Indifferent even to the corroded solemnity of nihilism, it sustains no deliberated agendas. It stubbornly adheres to a single absurd criterion, its intrinsic ‘condition of existence’ – continual unconscious

COLLAPSE I

promotion of numerical decimalism. Qabbala destines each and every 'strategic appropriation' to self-parody and derision, beginning with the agenda of theocratic restoration that attended its (ludicrously robed) baptismal rites. Even God was unable to make sense of it. It has no party, only popularity.

II. PRIMITIVE NUMERIZATION

Among the primary test-beds for qabbalistic analysis are the numerolexic systems inherited from cultures over-coded by the modern Oecumenic alphabet. These include the Hebrew and Greek alphabets (with their Neoroman letter names and mathematico-notational functions) and the Roman numbers (inherited as Neoroman letters and still numerically active in various domains). In this respect, the absence of names for Neoroman letters are an index of their pseudo-transcendence – as 'unnameable' – within the present Oecumenic order.

A discontinuity is marked in the alphanumeric series (0–Z) by the fact that the numerals composing the first ten figures in this series do have names, grouping them with the letters of previous alphabetical numbering systems from a certain qabbalistic perspective. This might be taken as the residual indication of an 'alien quality' still characterizing the numerals in relation to the Oecumenic cultural order they now indisputably occupy, a legacy of the cultural trauma attending their introduction.

The qabbalistic provocation posed by the English number names is conceptually comparable to that of any other numerolexic system, while surpassing any other in the intimacy of its challenge. If the numerals have names, shouldn't the qabbalistic processing of them as words yield – at the least – compelling suggestions of nonrandom signal? If the standard numeral names emit nothing but noise when qabbalistically transcoded, the attempt to establish relatively persuasive criteria for the evaluation of qabbalistic results suffers an obvious and immense reverse.

What, then, would count as a minimally controversial first step in such an examination?

Surely the most basic of all qabbalistic (or subqabbalistic?) procedures is simple letter counting – Primitive Numerization (PN). As a reversion to sheer 'tallying' PN has a resonance with the most archaic traces of numerical practice, such as simple strokes carved into mammoth bones and suchlike palaeo-ethnographic materials. If anyone was to bother systematizing PN procedure for the purpose of mechanization or simply for conceptual clarity, it would be most efficiently done by transcoding ('ciphering') each letter or notational element as '1' and then processing the result numerically.

PN's extremely tenuous relation to issues of modulus-notation ensures that it can only ever be a highly dubious tool when intricate qabbalistic calculation is required. Yet this utter crudity also makes it invaluable as a test case, since it minimizes axiomatic arbitrariness and precludes

COLLAPSE I

any plausible possibility of symbolic conjuration ('sleight of hand') while fully sharing the qabbalistic 'deficiency' of sufficient anthroposocial or communicative motivation. Common reason – sanity – insists upon noise as the only PN output consistent with the general intelligibility of signs (a pre-judgement applying rigorously to all qabbalistic procedures).

No message should inhere in the length of a word, excepting only the broad pragmatic trend to the shortening of commonly used terms. It is immediately obvious why this exception has no pertinence to the case in question here, unless stretched to a point (for instance, expecting the smaller numerals to exhibit the greatest lexical attrition) where it is straightforwardly contradicted by the actuality of the phenomenon.

So, proceeding to the 'analysis' – PN of the English numeral names: ZERO=4, ONE=3, TWO=3, THREE=5, FOUR=4, FIVE=4, SIX=3, SEVEN=5, EIGHT=5, NINE=4. Is there a pattern here? Several levels of apparent noise, noise, and pseudo-pattern can be expected to entangle themselves in this result, depending on the subsequent analytical procedures employed.

To restrict this discussion to the most evident secondary result, not only is there a demonstrable pattern, but this pattern complies with the single defining feature of the Numogram² – the five Syzygies emerging from 9-sum

2 . On the Numogram, see *Abstract Culture 5:Hyperstition* (1999).

twinning of the decimal numerals³: 5:4, 6:3, 7:2, 8:1, 9:0.

In the shape most likely to impress common reason (entirely independent of numogrammatic commitments) this demonstration takes the form: ZERO + NINE = ONE + EIGHT = TWO + SEVEN = THREE + SIX = FOUR + FIVE – revealing perfect numerolexic-arithmetical, PN-‘qabbalistic’ consistency.

The approximate probability of this pattern emerging ‘by chance’ is 1/243, if it is assumed that each decimal digit (0-9) is equiprobably allotted an English name of three, four, or five letter length, with 8-sum zygosys as the principle of synthesis. 7-sum or 9-sum zygosys are inconsistent with any five or three letter number-names respectively, and thus complicate probabilistic analysis beyond the scope of this demonstration (although if everything is conceded to the most elaborate conceivable objections of common reason, the probability of this phenomenon representing an accident of noise remains comfortably below 1/100).

Partisans of common reason can take some comfort from the octozygonic disturbance of the (novazygonic) Numogrammatic reference. How did nine become eight (or vice versa)? Lemurophiliac numogrammaticists are likely to counter such queries with elementary qabbala (since digital cumulation and reduction bridges the

3 . PN confirmation of the Numogrammatic Novazygons (9-Twins).

ONE + EIGHT = NINE + ZERO. (PN 3 + 5 = (4 + 4 =) 8)

TWO + SEVEN = NINE + ZERO. (PN 3 + 5 = (4 + 4 =) 8)

THREE + SIX = NINE + ZERO. (PN 5 + 3 = (4 + 4 =) 8)

FOUR + FIVE = NINE + ZERO. (PN 4 + 4 = (4 + 4 =) 8)

COLLAPSE I

'lesser abyss' in two steps, $8 = 36 = 9$, as diagrammed by the 8th Gate connecting Z_n-8 to Z_n-9).

III. AGAINST NUMEROLOGY

Consider first an extraordinarily direct numerological manifesto:

When the qualitative aspects are included in our conception of numbers, they become more than simple quantities 1, 2, 3, 4; they acquire an archetypal character as Unity, Opposition, Conjunction, Completion. They are then analogous to more familiar [Jungian] archetypes...

It is hard to imagine a more 'archetypal' expression of numerological ambition than this. Yet rather than meeting this claim with docile compliance, the qabbalist is compelled to raise a number of awkward questions:

(1) How can a numerological coding that proceeds in this fashion avoid entrapping itself among the very smallest of Naturals at the toe-damping edge of the number line? If '4' symbolizes the archetype 'Completion,' what to make of 127, 709, 1023, or similar small Naturals? Do they also have analogues among the intelligible archetypes? How would one 'qualitize' ($2^{127}-1$, or a larger number (of which there are a very considerable number)?)

(2) Is an 'archetype' more basic than a number in its unsymbolized state? Does 'qualitizing' a number reveal a more elementary truth, a germ the number itself

conceals, or does it merely re-package the number for convenient anthropomorphic consumption, gift-wrapping the intolerable inhumanity of alogical numerical difference and connectivity?

(3) Why should a number be considered ‘quantitative’ in its Natural state? Is it not that the imposition of a quantity/quality categorization upon the number requires a logical or philosophical overcoding, a projection of intelligibility alien to the number itself? Quantity is the decadence of number (while quality is its perversion), so – since arithmetic provides no basis for a reduction of the numerical to the quantitative – what is the supposed source of this (numeric-quantitative) identification (other than a disabling preliminary innumeracy)?

(4) If ‘1’ numerologically evokes ‘Unity,’ why should UNITY not qabbalistically ‘evoke’ 134 (=8, its Numogrammatic twin⁴) with equal pertinence? Can any expressible ‘archetype’ avoid re-dissolution into the unfamiliarity of raw number pattern? Numerology might assimilate ‘2’ to opposition, but OPPOSITION = 238 = 13 = 4 (twice 2, and the Numogrammatic twin of (‘4’ = COMPLETION = 212 =) 5), while even if numerological ‘3’ as CONJUNCTION = 237 = 12 = 3 finds itself qabbalistically confirmed (at the extremity of its decimaliza-

4 . Employing August Barrow’s ‘Anglossic Qabbala’, the basic tool of which is the Alphanumeric Gematria. This numerization of the Neo-Roman alphabet, continuing the procedure now familiar from Hexadecimal, is a continuous nonredundant system, supplementing the numerals 0-9 with numerized letters from A (=10) to Z (=35), treating the 0-Z alphanumeric sequence as a numeral succession, corresponding to the numerals of a modulus 36 notation.

Thus UNITY = 30+23+18+29+34 = 134. 1+3+4 = 8.

COLLAPSE I

tion), this is not, perhaps, in an altogether comfortable mode.

Numerology may be fascinated by numbers, but its basic orientation is profoundly antinumerical. It seeks essentially to redeem number, through symbolic absolutism into a 'higher' significance. As if the concept of 'opposition' represented an elevation above the ('mere') number two, rather than a restriction, subjectivization, logicization and generalized perversion, directed to anthropomorphic use-value and psychological satisfaction. Archetypes are sad limitations of the species, while numbers are an eternal hypercosmic delight.

Nevertheless, qabbalism is right up against numerology, insofar as it arises 'here,' within a specific biological and logocratic environment. The errors of numerology are only the common failures of logic and philosophy, human vanities, crudified in the interest of mass dissemination, but essentially uncorrupted. The numeric-critique (or transcendental arithmetic) of a Gödel (or Turing, or Chaitin (or Badiou?(?(?(??)))))) can be rigorously transferred to this controversy, demonstrating – within each particular milieu – that overcodings of numerical relation by intelligible forms – 'archetypes' or 'logics' – are unsustainable reductions, reefed on the unsurpassable semiotic potency of number. Gödel has shown that there is always a number, in fact an infinitude of (natural) numbers, that simulate, parody, logically dialectize, paradoxically dismantle, archetypally hypervert, and in whatever way necessary subvert each and every overcoding of

arithmetic. Number cannot be superseded. There is no possibility of an authoritative ‘philosophy of arithmetic’ or numerological gnosis.

Qabbala assumes that semiotics is ‘always already’ cryptography, that the cryptographic sphere is undelimitable. It proceeds on the assumption that there cannot be an original (unproblematic) coding, providing the basis for any solid definition or archetypal symbol, since the terms required for such a coding are incapable of attaining the pure ‘arbitrariness’ that would ensure the absence of prior cryptographic investment. There is not – and can never be – any ‘plain text,’ except as a naïve political assumption about (the relative (non)insidiousness of) coding agencies and the presupposition that communicative signs accessibly exist that are not already ‘in code.’ Since everything is coded, or (at least) potentially coded, nothing is (definitively) symbolic. Qabbalistic cryptocultures – even those yet to come – ensure that number cannot be discussed or situated without subliminal or (more typically) wholly unconscious participation in numerical practices. Logos, including that of numerology, is also always something other than itself, and in fact very many things.

Qabbalism thus operates as an inverse or complementary Gödelian double-coding. Where Gödel demonstrated that the number line is infested by virtual discursive systems of undelimitable topicality and complexity, pre-emptively dismantling the prospects of any conceivable supranumerical metadiscourse, qabbala

COLLAPSE I

demonstrates that discourses are themselves intrinsically redoubled (and further multiplied) by coincidental numerical systems which enter into patterns of connectivity entirely independent of logical regimentation.

The supposed numerical de-activation of the alphabet, marking semiotic modernity (the era of specialized numerical signs), has an extremely fragile foundation, relying as it does upon the discontinuation of specific cultural procedures (precisely those that withdraw into 'occultism') rather than essential characteristics of signs themselves. The persistent numerical functionalization of the modern alphabet – with sorting procedures based on alphabetical ordering as the most prominent example – provides incontestible evidence (if any was required) that the semiotic substructure of all Oecumenic communications remains stubbornly amphibious between logos and nomos, perpetually agitated by numerical temptations and uncircumscribed polyprocesses.

At the discursive level, any 'rigorization of qabbala' can only be a floating city, with each and every definition, argument and manifesto continually calving off into unmasterable numerical currents and alogical resonances. How could qabbala be counterposed to a code, to meaning and reason, when CODE (= 63) finds duplicitous harmonics in MEANING = REASON = 126? If qabbala positions itself discursively AGAINST NUMEROLOGY (= 369), the echoes of its novanomic signature perpetuate themselves even through such unlikely terms as

SIGNIFICANCE (= 207) and SIGNIFICATION (= 252). Pronouncements that begin as projected logical discriminations revert to variations on triplicity and the number nine, performing a base qabbalistic subversion of philosophical legislation and its authority to define (or delimit connectivity).

No polemic against numerology – whether conducted in the name of qabbala or of Oecumenic common reason – will transcend the magmic qabbalistic flux that multiplies and mutates its sense. Perhaps dreams of numerological archetypes even sharpen the lust for semiotic invention, opening new avenues for qabbalistic incursion. But this at least is certain: Numbers do not require – and will never find – any kind of logical redemption. They are an eternal hypercosmic delight.

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COLLAPSE I

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