Chaosmologies: Quantum Field Theory, Chaos and Thought in Deleuze and Guattari's *What is Philosophy*?

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Abstract
This article explores the relationships between the philosophical foundations of quantum field theory, the currently dominant form of quantum physics, and Deleuze's concept of the virtual, most especially in relation to the idea of chaos found in Deleuze and Guattari's *What is Philosophy?*. Deleuze and Guattari appear to derive this idea partly from the philosophical conceptuality of quantum field theory, in particular the concept of virtual particle formation. The article then goes on to discuss, from this perspective, the relationships between philosophy and science, and between their respective ways of confronting chaos, a great enemy but also a great friend of thought, and its greatest ally in its struggle against opinion.

Keywords: chaos, concept, philosophy, quantum field theory, science, thought, virtual

Chaos and concepts in physics and philosophy

The aim of this essay is to explore the relationships between the philosophical underpinnings of quantum field theory and Gilles Deleuze's concept of the virtual, specifically in conjunction with the idea of chaos found in Gilles Deleuze and Félix Guattari's *What is Philosophy?* The book approaches chaos by means of a particular and, in philosophy, rarely, if ever, used concept. According to Deleuze and Guattari: 'Chaos is defined not so much by its disorder as by the infinite speed with which every form taking shape in it vanishes. It is a void that is not a nothingness but a *virtual*, containing all possible *particles* and drawing out all possible forms, which spring up only to disappear immediately, without consistency or reference, without consequence. Chaos is an infinite speed of birth and disappearance' (emphasis on 'particles' added).[1] Deleuze and Guattari will go on to argue that art, science, and philosophy are different, if sometimes interrelated, ways in which thought confronts chaos — a great *enemy*, but also a *friend* of thought and its most important ally in its yet greater struggle, that against opinion, *doxa*.[2]

Although unusual elsewhere, this type of idea of chaos, or at least of *virtuality*, appears in part to be derived by Deleuze and Guattari from quantum field theory, as is also suggested by their reference to Ilya Prigogine and Isabelle Stengers' *Entre le temps et l'éternité*,[3] from which they borrow the expression 'all possible particles' (*WP*, 225, note 1). The idea relates to the so-called virtual birth and disappearance, or creation and annihilation, of particles from the so-called false vacuum, a kind of sea of energy, thus suggesting the image of chaos invoked by Deleuze and Guattari, although the term chaos itself is not used in quantum field theory in this context.

These connections between Deleuze and Guattari's concept of chaos and quantum field theory also allow me to link the idea of *chaos as the virtual* to the idea of *chaos as the incomprehensible*, which can be traced to the Ancient Greek idea of chaos as *areton* or *alogon* — that which is beyond all comprehension. This link arises from the possibility that the processes responsible for the creation or annihilation of forms, for their birth and disappearance, or for the speed of both, may not be representable or even conceivable by any means available to us. Deleuze and Guattari's invocation of black holes (whose ultimate constitution is beyond our comprehension) and surrounding elaborations in *A Thousand Plateaus* supports the significance of this concept of chaos (coupled to chaos as the virtual) in their work.[4] In addition, the connections to quantum field theory allow me to bring into consideration yet another concept of chaos, *chaos as disorder*, defined by the role of chance in its workings or in its effects. As Deleuze and Guattari's formulation indicates, the concept of chaos as disorder is not entirely put aside by them: while 'chaos' may be 'defined *not so much* by its disorder', it may partially be defined by disorder or, at least, by chance. Instead, this concept of chaos as chance and disorder, or the concept of chaos as the incomprehensible, is to some degree subordinated to the concept of chaos as the virtual. The same is true in quantum field theory, which takes over the conceptions of chaos as the incomprehensible and chaos as chance and disorder from quantum mechanics, but adds to them the concept of chaos as the virtual and gives it an analytically dominant role.[5]

One could also see at least some of the *concepts* of quantum field theory as *philosophy*, in accordance with or close to Deleuze and Guattari's argument in *What is Philosophy?* According to Frank Wilczek, a leading contemporary quantum-field theorist and a Nobel Prize laureate, 'the primary goal of fundamental physics is to discover profound concepts that illuminate our understanding of nature'.[6] The concepts Wilczek has primarily in mind are physical concepts, and they must be, given the disciplinary character of modern physics as a mathematical-experimental science. These concepts may, however, also be seen as concepts in terms of Deleuze and Guattari's concept of concept, introduced in the book. A philosophical concept in this sense is not an entity established by a generalization from particulars or 'any general or abstract idea' (*WP*, 11–12). Instead it is an irreducibly complex, multi-layered structure or architecture — a multi-component conglomerate of concepts in their conventional sense, figures, metaphors, particular elements, and so forth — and as such may define a whole philosophical matrix. As they say, 'there are not simple concepts' (15). Philosophy itself is defined by Deleuze and Guattari as a creation of new concepts and even concepts that are 'always new', thus making it, in Nietzsche's phrase, the philosophy of the future (5).

Deleuze and Guattari's description of chaos and accompanying elaborations on science (to be considered below) have been a subject of some controversy during the so-called 'Science Wars', especially in the wake of Alan Sokal and Jean Bricmont's *Impostures intellectuelles*, originally published in 1997, which considers some of these elaborations.[7] Since I have discussed the subject at length on a previous occasion, to which I permit myself to refer here, I shall restrict myself to a few essential points especially germane to the context of this article.[8] Sokal and Bricmont fail to offer an adequate reading of Deleuze and Guattari (or other authors they discuss) primarily because they miss or bypass the architecture of their philosophical concepts, defined, as I explained, by complex mixtures or *mélanges*, including when science is used. They also miss the difference between science and philosophy, or their respective ways of dealing with chaos, which is, ironically, at stake in Deleuze and Guattari's book, including in the elaborations that Sokal and Bricmont cite, but do not really read. The more nuanced complexity of the interrelationships or 'interferences' between philosophy and science, including the philosophical dimensions of scientific concepts, would require a kind of reading of the overall argument of the book that Sokal and Bricmont appear to be unwilling to undertake. Their 'readings' usually amount to citing long passages and declaring them, at best, *mélanges* of sense and nonsense, while such passages require extensive exegeses, even if one wants to be critical, and especially if one does. I am not saying that one cannot criticize Deleuze and Guattari. I am saying, however, that Sokal and Bricmont do not appear or fail to prove themselves to be in a position adequately to discriminate between what is and is not an appropriate use of science in the texts they consider.

Thus, in commenting on a long passage from *What is Philosophy?* (119–20), they say: 'With a bit of work, once can detect in this paragraph a few meaningful phrases, but the discourse is which they are immersed is utterly meaningless' (*FN*, 158). '*Utterly* meaningless'! But they do not explain why. A footnote is added: 'For example, the statement "the speed of light (. . .) where length contracts to zero and clocks stop" is not false, but may lead to a confusion. In order to understand it correctly, one must already have a good knowledge of relativity theory' (158, note 202). That may be true, but it can hardly be held against Deleuze and Guattari, who report a correct scientific finding and report it correctly, as Sokal and Bricmont acknowledge. Deleuze and Guattari's actual point in the passage is that this peculiar physical situation is strictly linked to a specific number, the speed of light, 299,796 kilometers per second. The relationships between scientific concepts and measurable numerical quantities define modern science, as Deleuze and Guattari make clear by noting that, 'the entire theory of functions [which defines the practice science] depends on numbers' (*WP*, 119). This is hardly meaningless, let alone 'utterly meaningless', but it requires a reading of what Deleuze and Guattari actually say, which is not something Sokal and Bricmont ever offer. Under these circumstances, an intellectually and ethically appropriate claim on Sokal and Bricmont's part could have been that *they cannot make sense* of this or other passages in question but not that *these passages themselves make no sense*, as they contend.

Sokal and Bricmont's statements on science sometimes have problems of their own. Their commentaries on quantum theory (their field of expertise) are not always rigorous and helpful, and sometimes are technically inaccurate. Thus, the reader of their book may indeed be confused by their discussion of Schrödinger's equation, the fundamental equation of quantum mechanics, and its linearity. They never explain an important difference between linear equations in elementary algebra (which have a form $ax + b = c$) and linear *differential* equations, such as Schrödinger's equation, which a crucial point, since it affects what kind of process the latter accounts for (*FN*, 143–5). They also appear not to realize that imaginary and complex numbers are in fact irrational, while Jacques Lacan, whom they criticize on the subject, understands this irrationality much better (*FN*, 25).[9]

These problems have a positive role to play in reminding us that scientists are not always sufficiently accurate and do not always have sufficient expertise even in their own fields, and that we should not necessarily trust them on science. So much in Sokal and Bricmont's book, and by so many, was accepted merely on the strength of their authority as scientists and their declarations concerning science and its uses and abuses, declarations unsupported by arguments. Science itself and those nonscientific readers who want to learn about it are not served well by their book. Both are served much better by an engagement with the complexity of the relationships between philosophical and scientific thought, which *What is Philosophy?* pursues as part of its approach to the question its title asks and in moving beyond it.

Physics' chaosmologies

Before addressing quantum field theory itself, I shall, by way of a background, discuss, first, classical physics and then, quantum mechanics. Classical physics is defined by the fact that it considers its objects and their behaviour as available to conceptualization and to representation in terms of particular properties of these objects and their behaviour. Such properties are abstracted and these objects idealized from actual objects in nature for the purposes of connecting the mathematics of the theory to the measurable quantities constituting the experimental data. In Deleuze and Guattari's terms, this is the way in which classical physics creates its frame of reference and, thus, *slows down* the chaos of nature and its emerging and disappearing forms, encountered by our thought (*WP*, 118).

Classical or Newtonian mechanics (which deals with the motion of individual physical objects or systems composed of such objects) accounts for its objects and their behaviour on the basis of physical concepts, such as 'position' and 'momentum', and measurable quantities corresponding to them. Classical mechanics is, thus, ontologically, *realist* because it can be seen as fully describing all of the (independent) physical properties of its objects necessary to explain their behaviour. It is, ontologically, *causal* because the state of the systems it considers at any given point is assumed to be determined (in the past) by and to determine (in the future) its states at all other points. It is, epistemologically, *deterministic* insofar as our knowledge of the state of a classical system at any point is, first of all, possible and, secondly, allows us to know, again, at least in principle and in ideal cases its state at any other point.

Causal theories need not be deterministic. While conforming to the realist and causal model of classical mechanics at the ultimate level, other areas of classical physics, such as thermodynamics and statistical physics or chaos theory complicate the situation by introducing chance and, hence, a degree of *chaos as chance* into the picture. These theories are not deterministic, even in ideal cases, in view of the great structural complexity of the systems they consider. This complexity blocks our ability to predict the behaviour of such systems, either exactly or at all, even though we can write equations that describe them and assume their behaviour to be causal. Chaos theory is also realist, insofar as it maps the behaviour of material bodies, although deterministic predictions are not possible due to the complexity of the behaviour of the systems it considers. By contrast, classical statistical physics is not realist insofar as its equations, while allowing us to make correct statistical predictions, do not describe the behaviour of its objects, such as molecules of a gas. It is, however, based on the realist assumption of an underlying non-statistical multiplicity, whose individual members conform to the causal laws of Newtonian mechanics.

In order to conceptualize the Newtonian universe, Pierre-Simone de Laplace introduced his figure of a 'demon' — an intelligent being that controls the immense machinery of the universe (*WP*, 129). A more Newtonian 'conceptual persona' is that of God as a universal clock maker. Laplace's demon may be a better figure, since it brings chance into the picture at the human level. James Clerk Maxwell introduced his, equally famous, 'Maxwell's demon' in order to explain and connect chance and the underlying causality in his kinetic theory of gases. The introduction of chance into physics was a momentous event, not least because it introduced new ways of confronting and dealing with the chaos of our interactions with nature through thought, even if not of nature itself in its ultimate constitution, which remains causal prior to quantum theory.

Quantum mechanics, especially in certain interpretations (such as that of Niels Bohr, known as complementarity, which I follow here), is neither causal, nor deterministic, nor realist in any of the senses described above, in particular insofar as it makes it impossible to assign any specific form of independent physical reality to quantum objects or processes. By the same token, the theory is *fundamentally* statistical: it involves chance irreducible to any underlying causality. It is not only that the state of the system at a given point gives us no help in predicting its behaviour or allows us to assume it to be causally determined, if unpredictable, at later points, although that such is the case experimentally is important. More radically, this state itself cannot, at any point, be unambiguously defined on the model of classical physics: hence a lack of realism or the irreducible presence of chaos as the incomprehensible at the ultimate level. A lack of causality is an immediate consequence: for, if certain processes allow for no description of any kind, they would automatically disallow a causal description.

This impossibility of an unambiguous definition of the state of the system is correlative to Heisenberg's uncertainty relations. Technically, the latter express the (strict) quantitative limits, absent in classical physics, on the simultaneous joint measurement of the so-called — by analogy with classical physics — conjugate variables, which define the motion of classical objects, such as 'position' or 'coordinate' (q) and 'momentum' (p). These limits are given by the famous formula $\Delta q \Delta p \cong h$, where h is Planck's constant, and Δ designates the degree of imprecision of measurement. The increase in precision in measuring one such variable inevitably implies equally diminished precision in measuring the other. Bohr's complementarity gives a more radical interpretation to the uncertainty relations. This interpretation prohibits even an assignment or unambiguous definition of physical properties, such as a position or a momentum, to quantum objects and behaviour, rather than only establishing the limit (defined by Planck's constant, h) upon the degree of precision with which both can be simultaneously measured. Ultimately, such an assignment is impossible even if each such variable is taken by itself. All actual physical properties considered belong to the measuring instruments involved under the impact of quantum objects, and Heisenberg's formula now applies to these properties.

Deleuze and Guattari offer the following comment on Heisenberg's uncertainty relations, made in the context of demonic 'partial observers' in science, which 'Heisenberg's demon' of uncertainty symbolizes:

> To understand the nature of these partial observers that swarm through all the sciences and systems of reference, we must avoid giving them the role of a limit of knowledge or of an enunciative subjectivity. (...) As a general rule, the observer is neither inadequate nor subjective: even in quantum physics, Heisenberg's demon does not express the impossibility of measuring both the speed [more accurately, momentum] and the position of a particle on the grounds

of a subjective interference of the measure with the measured, but it measures exactly an objective state of affairs. (*WP*, 129)

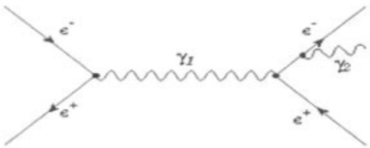
Bohr, too, stresses the objective character of all quantum mechanical observation and phenomena, and one can only speak of a 'limit of knowledge', in the sense that no knowledge of the kind classical mechanics offers as concerns its objects is available. Otherwise, quantum mechanics, *within its proper scope*, gives us as much knowledge as nature allows for. (Quantum field theory gives us more knowledge by expanding the scope of quantum theory.)

As indicated already, given the irreducible presence of chaos as the incomprehensible in quantum mechanics, its statistical character becomes objectively irreducible as well. The workings of the quantum-mechanical chance are fundamentally different from the classical picture of chance outlined above. The chance one encounters in quantum physics is irreducible not only in practice but also in principle. There is no knowledge in principle available to us, now or ever, that would allow us to eliminate chance and replace it with the picture of necessity behind it. Nor, however, can one postulate a causal dynamics as unknown or even unknowable but existing, in and by itself, outside our engagement with it. This qualification is crucial, since some forms of the classical understanding of chance allow for this type of (realist) assumption. 'Heisenberg's demon' makes chance and, hence, a certain element of disorder and of chaos as chance and disorder, unavoidable even in the case of individual elementary events (as against the classical view which relates chance to multiple processes and events), and in particular at this level. It can be shown that at the level of collective events quantum mechanics may exhibit more order than classical statistical physics does. What makes this chance or disorder irreducible is chaos as the incomprehensible, which links both conceptions of chaos in quantum mechanics.

Deleuze and Guattari's sense of chaos as the virtual still applies (as it does in classical physics), insofar as one still needs to find a way to handle the situation, physically and philosophically. Quantum mechanics predicts, and predicts *exactly*, the *probabilities* of the outcome of the relevant experiments, without (unlike classical physics) telling us anything about what happens in between or how such outcomes come about. In other words, chaos as the virtual only pertains to scientific *thought*, while chaos as the incomprehensible and chaos as chance also pertain to nature in the (chaosmic) order of quantum mechanics. Thus, all three forms of chaos — disorder, the incomprehensible, and (only at the level of thought) chaos as the virtual — are found, and are connected in quantum mechanics. Quantum field theory is different insofar as it adds chaos as the virtual to its chaosmology of nature itself, which was a momentous step in the history of physics. I shall now explain why it was compelled to move in this direction.

Suppose that one arranges for an emission of an electron from a source and then performs a measurement at a certain distance from that source. Merely placing a photographic plate at this point would do, and the corresponding traces could, then, be properly treated by means of quantum field theory. First, however, let us assume that we are dealing with the electron as a classical physical object. According to classical physics, one would encounter at this point the same object, and its position could be predicted exactly by classical mechanics. In quantum mechanics, by contrast, one would encounter either an electron or nothing, and quantum mechanics predicts the alternative probabilities for such events, for example, at fifty percent for each. This is why, as explained above, chaos as chance is unavoidable in quantum mechanics. Once the situation involves higher energies and is governed by quantum electrodynamics, the original form of quantum field theory, one may find an electron, nothing, a positron (anti-electron), a photon, an electron-positron pair, or, once we move to still higher energies or different domains governed by quantum field theory, still something else. The probabilities and only probabilities for the alternatives are properly predicted by quantum field theory, which makes chance and chaos as chance unavoidable in quantum field theory as well. The upshot is that in quantum field theory, an investigation of a particular type of quantum object (say, electrons) not only irreducibly involves other particles of the same type but also other types of particles, conceivably all existing types of particles. It is as if instead of an identifiable moving object of the type studied in classical physics, we encounter a continuous emergence and disappearance, creation and annihilation, of particles from point to point, the so-called *virtual* particle formation. While such events are in principle possible and their possibility defines the situation and what can and cannot *actually* occur, only some of them can be registered. Usually, those particles that are registered by observations are considered as 'real particles', while those that are not are considered as 'virtual particles'.

The corresponding quantum-field-theoretical *physical* concept possesses a mathematical and experimental rigour specific to science, while, however, retaining the key *philosophical* conceptual architecture of the virtual. Quantum field theory rigorously predicts which among such events can or cannot occur, and with what probability. All possible events are usually represented in terms of the so-called Feynman diagrams, after Richard Feynman, whose work brought him a Nobel Prize.[10] For example, the following diagram represents the annihilation and then the creation of an electron and a positron via a virtual photon (represented by a wavy line), with another virtual photon emitted by an electron later.



At any point of this diagram yet another virtual process (similar to the emission of a virtual photon γ_2 depicted here) may occur and hence another diagram may be inserted into it, thus leading to an interminably expandable rhizomatic structure of the type often invoked in Deleuze and Guattari's works. Every possible — virtual — event or transition can be represented by a Feynman diagram, and much of quantum field theory consists of drawing and studying such diagrams and generating predictions by using them.

Feynman diagrams are, however, just diagrams: they are pictures that help us heuristically to visualize the situation, or, in Deleuze and Guattari's idiom, to *slow down* the phenomenological chaos of the situation, to hold in mind the forms thus created, for the purposes of helping calculations. So is the 'picture' (conception) of the virtual particle formation. What actually happens at the level of such processes themselves we might no more know or even conceive of, let alone visualize, than we can in quantum mechanics, which implies the essential presence of chaos as the incomprehensible in quantum field theory. Since, in addition, all our knowledge concerning the ultimate constitution of nature is only predictive and, moreover, only statistical, chaos as chance and disorder is added to the picture as well. This is how chaos (of both quantum nature and of the mind confronting it), chaos as the incomprehensible and chaos as chance and disorder, was approached already by quantum mechanics, and it helped quantum mechanics against the *doxa* of classical physics. As it has often done before, physics had to plunge into the chaos to be able to create the order of quantum mechanics. Thus, ironically, *chaos*, chaos as the incomprehensible and chaos as chance or disorder, becomes part of a new *order* of quantum mechanics, or its chaosmos, to use James Joyce's coinage, favoured by Deleuze and Guattari. In quantum field theory, these two concepts of chaos are retained, but are not sufficient to deal with the chaos quantum field theory has to confront and to build its physical and mathematical architecture. To accomplish this task, it is compelled to engage with chaos as the virtual, to become a chaosmology of the virtual.

The concept of the virtual emerging from Deleuze's earlier works, such as *Difference and Repetition* and *The Logic of Sense*, onwards defines the virtual as *something that defines the space of what is possible and as such shapes the possible forms of the actual.*[11] This formulation is general and allows for different interpretations of the virtual, for example, on the model of classical physics, where the space of such possibilities is defined causally as the so-called phase space, which implies a realist and causal ontology, described above, and hence no chaos. This type of interpretation is found, for example, in Manuel DeLanda's work.[12] The Deleuzian virtual can also be interpreted on the model of quantum mechanics, which would prohibit a realist and causal ontology, and will introduce chaos as the incomprehensible and chaos as chance and disorder, but would not involve the concept of the virtual particle formation and, hence, no chaos as the virtual. This type of interpretation was advanced by Gilles Chatelet. It is, however, a quantum-field-theoretical concept of the virtual as chaos that, I argue, shapes the argument of *What is Philosophy?*[13]

'Casting planes over chaos': philosophy and science

Deleuze and Guattari define the difference between philosophy and science as follows:

> [P]hilosophy wants to know how to retain the infinite speed while gaining consistency, by *giving the virtual a consistency specific to it*. The philosophical sieve, as a plane of immanence that cuts through the chaos, selects infinite movements of thought and is filled with concepts formed like consistent *particles* going as fast as thought. Science approaches chaos in a completely different, almost opposite way: it relinquishes the infinite, infinite speed, in order to gain *a reference able to actualize the virtual*. By retaining the infinite, philosophy gives consistency to the virtual through *concepts*; by relinquishing the infinite, science gives a reference to the virtual, which actualizes it through *functions*. Philosophy proceeds with a plane of immanence and consistency; science with a plane of reference. (*WP*, 118; emphasis on 'particles', 'concepts' and 'functions' added)

The concept of the philosophical sieve is thus itself quantum-field-theoretical: concepts emerge in a plane of immanence similarly to the way virtual or actual particles are formed in and emerge from the false vacuum, a virtual energy field. Chaos as the virtual is itself such a philosophical concept. In its confrontation with chaos as the virtual, philosophy's thought may sometimes *hold* to a virtual 'particle' concept or (since concepts are not atomic, but have complex architectures) 'particle-conglomerate' concept, which can, if slowed-down or freeze-framed, be compared to a complex Feynman diagram. Deleuze and Guattari draw and work with such 'diagrams' of concepts, such as that of Descartes's concept of Cogito or a philosophical portrait of Kant (*WP*, 25, 56). In other words, at such junctures philosophy adopts science's way of dealing with chaos. But philosophy's thought would now hold to a concept that traverses a plane of immanence and, thus, gives this plane consistency. This is a complex philosophical concept, which cannot be further elaborated upon here. The main point is that, in contrast to philosophy, science 'freezes' chaos, or what it can in it, in slow motion or freeze-frames, such as Feynman diagrams in quantum field theory. Science, however, sometimes proceeds with the infinite speed of philosophy and, as just explained, philosophy sometimes proceeds by slowing the infinite speed of chaos down in the manner of science.

The difference between the two respective 'attitudes toward chaos', scientific and philosophical, is enabled, in the first place, by the difference in the determination of each in terms of functions and concepts, respectively.[14] Deleuze and Guattari write:

> The object of science is not concepts but rather functions that are presented as propositions in discursive systems. The elements of functions are called *functives*. A scientific notion is defined not by concepts but by functions or propositions. This is a very complex idea with many aspects, as can be seen already from the use to which it is put by mathematics and biology respectively. Nevertheless, it is this idea of the function that enables the sciences to reflect and communicate. Science does not need philosophy for these tasks. On the other hand, when an object — a geometrical space, for example — is scientifically constructed by functions, its philosophical concept, which is by no means given in the function, must still be discovered. Furthermore, a concept may take as its components the functives of any possible function without thereby having the least scientific value, but with the aim marking the differences in kind between concepts and functions. (*WP*, 117; translation slightly modified)

A philosophical concept corresponding to a mathematical or scientific object could be discovered by mathematics and science. Thus, it is a complex question of where and how, between mathematics (geometry and topology, which are already different), physics and philosophy, a modern, post-Riemannian or post-Einsteinian, philosophical concept of space has emerged. This concept can of course take on new aspects in philosophy qua philosophy, as it does in Deleuze's and Deleuze-Guattari's work. We are dealing here with a heterogeneous yet interactive *space* of relationships, where differences, similarities, and interactions are all found, but each becomes more or less crucial at different conceptual, historical, or cultural junctures. It is a dynamic space-time or a sea of energy of thought, a space at the edge of chaos — chaos as the incomprehensible, chaos as the virtual, and chaos as chance and disorder.

Deleuze and Guattari develop their argument concerning the difference between science and philosophy via the use of proper names in both fields. They write: 'If there is a difference between science and philosophy that is impossible to overcome, it is because proper names mark in one case a juxtaposition of reference and in the other [conceptual personae of philosophy] a superposition of layer: they are opposed to each other through all the characteristics of reference and consistency' (128). This argument forms a bridge to a 'demonology' of science, as part of its 'chaosmology', via the concept of the partial observer, mentioned earlier, which defines all scientific observation, although it is not to be identified with a human being and especially some subjective observer. They write:

> We are referred back to another aspect of enunciation that applies no longer to proper names of scientists or philosophers but to their ideal intercessors internal to the domains under consideration. We saw earlier the philosophical role of *conceptual personae* in relation to fragmentary concepts on a plane of immanence, but now science brings to light *partial observers* in relation to functions within systems of reference. The fact that there is no total observer that, like Laplace's 'demon', is able to calculate the future and the past starting from a given state of affairs means only that God is no more a scientific observer than he is a philosophical [conceptual] persona. But 'demon' is still excellent as a name for indicating, in philosophy as well as in science, not something that exceeds our possibilities but a common kind of these necessary intercessors as respective 'subjects' of enunciation: the philosophical friend, the rival, the idiot, the overman are no less demons than Maxwell's demon or than Einstein's or Heisenberg's observers. It is not a question of what they can or cannot do but of the way in which they are perfectly positive, from the point of view of concept or function,

even in what they do not know and cannot do. In both cases there is immense variety, but not to the extent of forgetting the different natures of the two great types. (128–9)

Although Deleuze and Guattari do not invoke the demons of quantum-field-theory, these demons hover over the book. The ways of dealing with chaos may be different in philosophy, art, and science. The concept of chaos is itself quantum-field-theoretical. The conclusion of *What is Philosophy?* envisions a possibility of a different future of thought, in which the boundary between philosophy, art, and science and even all three themselves disappears back into the chaosmic field of thought. The quantum-field-theoretical conception of chaos as the incomprehensible, as chance and disorder, and as the virtual remains in place and governs this vision as well.

'The shadow of ''people to come'''

It is, then, their connections to chaos, their greatest enemy and their greatest friend, that make art, science, and philosophy so crucial to thought—against opinion, always an enemy only, 'like a sort of ''umbrella'' that protects us from chaos'. 'But', Deleuze and Guattari say, 'art, science, and philosophy require more: they cast planes over chaos' (*WP*, 202). What is more, 'the struggle with chaos is only the instrument in a more profound struggle against opinion, for the misfortune of people comes from opinion' (206). *Thinking*, they argue, must confront chaos (208). Art, science, and philosophy are daughters of chaos, whose other parent may be thought itself (gendering would be difficult, and may be multiple on both sides): 'chaos has three daughters, depending on the place that cuts through it: these are the *Chaoids*—art, science, and philosophy—as forms of thought or creation. We call *Chaoids* the realities produced on the planes that cut through the chaos in different ways' (208).

Neither this vision nor the role of the concept of chaos in it is surprising, given the argument of *What is Philosophy?*. An unexpected and intriguing part of the conclusion, giving it its title, 'From Chaos to the Brain', is a new conception of the *brain*, rather than only the mind, that emerges by an almost sudden shift at this very point. It would not be possible to discuss this extraordinary conception, or its possible future, except by stressing its ultimate grounding in the idea of chaos and of thought, and now the brain, in confrontation with it. This grounding certainly poses new questions about the relationships between mind and the brain, or even mind and matter.

Would our conceptions of each, and of the role of chaos in each, mirror each other? Or would they be subject to different conceptions, thus complicating our picture of either, or their relationships? Would different conceptions of chaos, such as the incomprehensible, chance and disorder, or the virtual, combine differently in our theories? The different ways of confronting chaos by art, science, and philosophy already pose questions concerning their concomitant relations to thought and chaos, even if one leaves the question of the brain aside. Is it the same thought, even if chaos is the same, or are more complex heterogeneity and interactions found already at this level? Perhaps these questions still belong to our thinking as thinking through art, science, and philosophy, and will not be asked by the thought of the future, the thought of the 'people to come'. This type of questioning is where Deleuze and Guattari end their book. But they also look beyond these questions to interferences between the planes of art, science, and philosophy, interference of their wave fields, which takes us to the deeper recesses of thought. As they write:

> The three planes, along with their elements, are irreducible: *plane of immanence of philosophy, plane of composition of art, plane of reference or coordination of science; form of concept, force of sensation, function of knowledge; concepts and conceptual personae; sensations and aesthetic figures, figures and partial observers*. Analogous problems are posed on each plane; in what sense and how is the plane in each case, one or multiple — what unity, what multiplicity? But what to us seem more important now [in approaching the brain] are the problems of interference between the planes that join up in the brain. (216)

The presence of these interferences is essential for our understanding of thought and its confrontation with chaos. In question, however, are not only interferences of art in philosophy, or science in art, or philosophy in science, and so forth. Such interferences are significant, but most crucial are those that, wherever one finds them, are, ultimately, not localizable in any of these three denominations, so defining for our thought and culture now. They are, accordingly, manifestations of that which is still thought, and as such still confronts chaos, but is no longer containable by these denominations. Thus, these interferences manifest a possibility of a different future, perhaps no longer defined by art, science, and philosophy, or their relationships. The future is, as ever, the primary concern of Deleuze's or

Deleuze-Guattari's philosophy, always a philosophy of the future. They write:

> *Philosophy needs a nonphilosophy that comprehends it; it needs a nonphilosophical comprehension just as art needs nonart and science needs nonscience.* They do not need the No as beginning, or as the end in which they would be called upon to disappear by being realized, but at every moment of their becoming or their development. Now, if the three Nos are still distinct in relation to the cerebral plane, they are no longer distinct in relation to the chaos into which the brain plunges. In this submersion it seems that there is extracted from chaos the shadow of the 'people to come' in the form that art, but also philosophy and science, summon forth: mass-people, worlds-people, brain-people, chaos-people — nothinking thought that lodges in the three, like Klee's nonconceptual concept or Kandinsky's internal silence. It is here that concepts, sensations, and functions become indiscernible, as if they shared the same shadow that extends itself across their different nature and constantly accompanies them. (217–18)

These are, then, nonlocalizable interferences that are most crucial for thought, although the localizable ones remain significant, in part as harbingers of nonlocalizable ones. A given work in each domain can manifest such interferences, and for now philosophy, art, and science are the only ways to sense thought that will be defined by and define 'people to come', apart from philosophy, art, or science, but still as a confrontation with chaos. Deleuze and Guattari's concept of the brain points towards this future and the 'people to come' in — or to create — the world without art, science, and philosophy, which, as confrontations with chaos, summon these people forth.

But what kind of thought would it be? What kind of thought could it be? Would 'people to come' ask these questions? Will they ask questions, to begin with? Does thought require questions, as it seems it does for us, or it can struggle with and relate to chaos otherwise, even against opinion, which indeed does not like questions? But will opinion govern the life of the people to come, as it governs ours? It may not be a question of thought, which will struggle with chaos as it has ever done, although for now 'What is thought?' remains a question which, as a confrontation with chaos, is re-posed, along with 'What is the Brain?', by Deleuze and Guattari. It may be a question of what kind of people the 'people to come' will prove to be. A political question, at least for now? But then, such a question cannot only be political, even now.

NOTES

1 Gilles Deleuze and Félix Guattari, *What Is Philosophy?*, translated by Hugh Tomlinson and Graham Burchell (New York, Columbia University Press, 1994), 118. Henceforth *WP*.

2 Throughout this essay 'science' includes mathematics, which is in accord with Deleuze and Guattari's use of the term.

3 Ilya Prigogine and Isabelle Stengers, *Entre le temps et l'éternité* (Paris, Fayard, 1988).

4 Gilles Deleuze and Felix Guattari, *A Thousand Plateaus*, translated by Brian Massumi (Minneapolis, University of Minnesota Press, 1990), 311–15. Henceforth *ATP*.

5 In quantum field theory the effects of Einstein's relativity theory are taken into account, which make the theory relativistic, in contrast to quantum mechanics, where such effects can be neglected because the speed of the objects considered is slow vis-à-vis the speed of light.

6 Frank Wilczek, 'In Search of Symmetry Lost,' *Nature* 433 (20 January 2005), 239.

7 The book was published in English as *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science* (New York, Picador, 1998). Henceforth *FN*.

8 See Arkady Plotnitsky, *The Knowable and in the Unknowable: Modern Science, Nonclassical Thought, and the 'Two Cultures'* (Ann Arbor, University of Michigan Press, 2002). Specifically on this passage, see 277–8, note 12. The book also offers an extensive discussion of quantum mechanics along the lines of the present article and further references (29–108).

9 See *The Knowable and in the Unknowable* (particularly 204–6 on quantum mechanics and 145–7 on imaginary numbers).

10 See Richard Feynman *QED: The Strange Theory of Light and Matter* (Princeton, Princeton University Press, 1988). This is arguably the best non-technical book on the subject.

11 Gilles Deleuze, *The Logic of Sense*, translated by Mark Lester with Charles Stivale, edited by Constantin V. Boundas (London, Athlone, 1990).

12 See Manuel DeLanda, *Intensive Science and Virtual Philosophy* (London, Continuum, 2002).

13 This concept of chaos as the virtual also suggests a more dynamic, more temporal conceptuality, which may be contrasted with a more spatial view of Deleuze's thought, sometimes argued for by commentators.

14 Deleuze and Guattari also discuss mathematics in terms of 'prospects' (*WP*, 135–62). Prospects, however, are a particular (logical) type of functions, and mathematics is full of other functions, invoked throughout the book.