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Learning to swim in the Dirac Sea: Bill Ross's Order and the Virtual

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Abstract

In this article, I reflect on Deleuze's provocative critique of the second law of thermodynamics in *Difference and Repetition* by drawing his philosophy into conversation with cosmology—specifically quantum physics. In dialogue with the work of the late Bill Ross, whose recent *Order and the Virtual* represents the most substantial critical engagement with the entropic principle vis-à-vis Deleuze, I turn to the physicist David Bohm's distinction between explicate and implicate orders, which Ross argues bear strong similarities to Deleuze's actual and virtual, respectively. Bohm's theory, as Ross and others have pointed out, entails a recognition of the pluripotent creative potential of the quantum dynamisms that give rise to the spatiotemporal order—what Deleuze would describe as non-exhaustive intensive differences that are only apparently cancelled out in extensity. Here, with reference to Deleuze's distinction between the divine and human games, and their respective distributions of chance, I propose—following Ross and Bohm, as well as contemporary loop quantum gravity—an alternative to string theory most commonly associated with the physicist Carlo Rovelli: that whereas the emergent regularities of the macroscopic world are inexorably bound to the arrow of time and thus to the law of entropy, this is not the case for the divine game that takes place within the quantum foam, and that it is here that the *Eventum tantum* takes place in which all of chance—including said laws—are continuously redistributed. Turning to the both non-continuous and continuous nature of this evental dynamism relative to quantum and macrophysical realities respectively, I close by considering Ross's eschewal of dynamic systems theory in favour of other quantum-theoretic resources and suggest that perhaps both can be usefully employed to think the reciprocal becomings of Deleuze and the philosophy of cosmology.

Keywords: Deleuze, David Bohm, quantum physics, cosmology, Bill Ross, entropy, negentropy.

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"[B]ecoming is not merely a relationship of the present to a past that is gone. Rather, it is a relationship of enfoldments that actually are in the present moment… The understanding of this requires that we weave together the two principles of the *being of becoming* and the *becoming of being.*"[1]

—Bohm, "Time, the Implicate Order and Pre-Space

In some particularly challenging pages near the beginning of *Difference and Repetition*'s fifth chapter, *Asymmetrical Synthesis of the Sensible*, Deleuze appears to critically engage with the second law of thermodynamics, usually described as the inexorability of the "arrow of time." i.e., the overall tendency of the universe towards a final equilibrium of maximal entropy or "heat death."[2] At first glance, Deleuze's critique may appear to be the worst kind of "intellectual imposture." After all, the laws of thermodynamics are commonly understood to constitute the inviolable foundations of all of physics, which is why the physicist Arthur Eddington once polemically claimed that "if your theory is found to be against the Second Law of Thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation."[3] Deleuze, no stranger to provocative claims, appears wholly unbothered by such concerns and proceeds to argue that thermodynamics was in fact the furnace in which "a strange alliance at the end of the nineteenth century between science, good sense and philosophy"[4] was forged. Within this alliance the principle of difference—and by extension of change—was understood solely from the vantage point of the actual, resulting in a view that "difference is the sufficient reason of change only to the extent that the change tends to negate difference."[5] By grasping change vis-a-vis the differenciated,[6] in other words, we are led to the assumption that the unfolding of the universe follows an arrow of time that terminates in a final tepid equilibrium of absolute stability.

The gist of Deleuze's argument against this view is that the intensive and virtual orders are not subject to this supposedly universal law which results, broadly speaking, from a conflation—wrought by the good sense which forms part of the dogmatic image of thought—of the end result of processes of indi-drama-differen*t*/*c*iation and the virtual dynamisms that inform and give rise to those processes. Against this transcendental

1 David Bohm, "Time, the Implicate Order and Pre-Space," *Physics and the Ultimate Significance of Time: Bohm, Prigogine, and Process Philosophy*, ed. David Ray Griffin (State University of New York Press), 1986, 185.

2 Gilles Deleuze, *Difference and Repetition* (London: Athlone, 1994), 222–61.

3 Arthur Eddington, *The Nature of the Physical World* (Cambridge: Cambridge University Press, 1928), 74.

4 Deleuze, *Difference and Repetition*, 223.

5 Deleuze, *Difference and Repetition*, 223.

6 Recall that Deleuze distinguishes between the differen*t*iation of the virtual and the differencia-tion of the actual.

illusion,[7] Deleuze argues that "[d]ifference in the form of intensity remains implicated in itself, while it is cancelled by being explicated in extensity."[8] For this reason, he avers, we have no need to challenge the veracity of the second law qua the established in order to preserve a principle of difference or, indeed, the eternal return, for "difference has never ceased to be in itself, to be implicated in itself even while it is explicated outside itself."[9] One of the ostensible motivating factors for Deleuze's argument, beyond simply wishing to defend his philosophy of difference from what is perhaps the ultimate enemy of difference, the absolute identity of entropy's teleological endpoint, is that the second law, as Schrödinger[10] and numerous others (including, in their own manner, Ruyer and Simondon) earlier pointed out, appears to fly in the face of the profoundly negentropic nature of reality[11]—of its seemingly ubiquitous tendency towards increased order. In this regard, "[t]he principle of degradation obviously does not account either for the creation of the most simple system or for the evolution of systems."[12]

While the usual response to this line of reasoning is to argue that local order externalises its thermodynamic debt, i.e., that the overall heat death of the universe continues unabated, regardless of more proximate negentropy, Deleuze's point is, as we have seen, more far-reaching: the universe itself, in all its supposed thermodynamic unfolding, is merely the emergent spatiotemporal expression of the ostensibly inexhaustible dynamisms of the depths or intensive spatium. Or, as the late Bill Ross puts it in the groundbreaking *Order and the Virtual: The Philosophy and Science of Deleuzian Cosmology*, "[d]isequilibrium, radical chance, is a positive, indispensable, internal motor of the Chaosmos."[13] It is precisely this tension between the second law and Deleuze's philosophy of infinite folding, unfolding and refolding that frames Ross's engagement, which proceeds via a wide-ranging but careful examination that leaps from Nietzsche to Leibniz to loop quantum gravity to physicist David Bohm's remarkably Deleuzian concept of the implicate order in pursuit of a solution to the problem "can the Leibnizian-Deleuzian philosophy of difference

7 "The paradox of entropy is the following: entropy is an extensive factor but, unlike all other extensive factors, it is an extension or 'explication' which is implicated as such in intensity, which does not exist outside the implication or except as implicated, and this is because it has the function of making possible the general movement by which that which is implicated explicates itself or is extended. There is thus a *transcendental illusion* essentially tied to the qualitas, Heat, and to the extension, Entropy." (1994:229; emphasis mine)

8 Deleuze, *Difference and Repetition*, 228.

9 Deleuze, *Difference and Repetition*, 223.

10 Erwin Schrödinger, *What is Life?* (Cambridge: Cambridge University Press), 1944.

11 i.e., "the tendency of certain forms of organisation, including principally those associated with life, to form local pockets or islands of increasing order in apparent contradiction to the mandate of entropy" (Ross 2024:20).

12 Deleuze, *Difference and Repetition*, 255.

13 Bill Ross, *Order and the Virtual: The Philosophy and Science of Deleuzian Cosmology* (Edinburgh: Edinburgh University Press, 2024), 7.

coherently dismiss the heat death of the universe?"[14] In this regard, Ross's work is exemplary of the science-informed approach to Deleuze that has become increasingly common within the sprawling and heterogeneous field that constitutes contemporary Deleuze and Guattari studies. While in a recent article George Webster convincingly argues that "such scholarship typically focuses on elucidating Deleuze's claims in light of these [scientific and mathematical] engagements, rather than examining the relation between the two,"[15] *Order and the Virtual* is dedicated to precisely the latter task, which is, as Webster puts it, "to make better and more precise sense of the relationship between the sciences and Deleuze's philosophical claims… [and] to do so in a way that better advertises both the novelty and relevance of such claims to philosophers of science."[16] Indeed, as Ross describes his task, it "is not so much how to reconcile Deleuze's natural philosophy with fundamental tenets of science, as to establish what it might mean in a scientific register to accommodate the direction of travel."[17] In this regard, "there is no question which metaphysics would put in play that science does not also want to resolve."[18] Within the field of philosophy of cosmology specifically, said approach is, beyond Ross, also evident in the richly diverse engagements in the recent edited collection *Deleuze and Cosmology*,[19] as well as by seminal work in the field by physics-informed Deleuze scholars like Arkady Plotnitsky[20] and Martin Calamari,[21] not to mention Thomas Nail's Deleuze-inflected project. It thus seems increasingly evident that Deleuze and Guattari's work is rich with potential resources for grappling with cosmological questions and that this is an underexplored vein in their oeuvre. As the editors of *Philosophy of Cosmology* underscore in this regard, cosmology has long been associated with fundamental philosophical questions such as "the problem of understanding the world, including ourselves, and our knowledge, as part of the world" and a close association between the two fields stretches "from Plato and Aristotle to Nicholas of Cusa, Giordano Bruno and Kant."[22]

14 Ross, *Order and the Virtual*, 56.

15 George Webster, "The metaphysics science needs: Deleuze's naturalism," *European Journal of Philosophy* 32, no.3 (2024): 821.

16 Webster, "The Metaphysics Science Needs," 821.

17 Ross, *Order and the Virtual*, 175.

18 Ross, *Order and the Virtual*, 15.

19 Janae Sholtz and Alain Beaulieu, eds. *Deleuze and Cosmology: Between Art, Philosophy, and the Sciences*, (Edinburgh: Edinburgh University Press), 2026.

20 See, for instance Arkady Plotnitsky, "Chaosmologies: Quantum Field Theory, Chaos and Thought in Gilles Deleuze and Félix Guattari's What is Philosophy?," *Paragraph* 29, no. 2 (2006): 40–56.

21 For example, Martin Calamari, "The Metaphysical Challenge of Loop Quantum Gravity," *Studies in History and Philosophy of Science* 86, (2021): 68–83.

22 Sholtz and Beaulieu, *Deleuze and Cosmology*, 2

Games, Human and Divine

In *Order and the Virtual,* Ross's attempt to resolve the issue of Deleuze's relation to thermodynamics leads him to an interrogation of Deleuze's notion of the divine game, which is read via Nietzsche, Leibniz and Michel Serres. In *Difference and Repetition*, Deleuze famously distinguishes between two games in order to explain the repetition of difference via his unique interpretation of the notion of eternal return.[23] On the one hand, we have what he calls the "human game;" this is the game of the Same and the categorical—a game grounded in the primacy of identity and the dogmatic image of thought. Deleuze makes this clear when he notes that the human game is "indistinguishable from the practice of representation, of which it presents all the elements: the superior identity of the principle, the opposition of hypotheses, the resemblance of numerically distinct throws, and proportion in the relation between the hypothesis and the consequence."[24] This is a poor game because it is a game of simple redistribution of the actual—of "sedentary distributions" whereby "the *pre-existing rules* define distributive hypotheses according to which the results of the throws are repartitioned."[25] Pascal's wager is exemplary of this kind of game, based as it is upon a kind of pseudo-contingency that does not critically explore— and thus tacitly reifies—what gives rise to the pre-established order within which chance is distributed. The wager does not acknowledge the contingency of its own grounding and thus does not affirm the whole of chance. The divine game, on the other hand, is the game of the eternal return and serves as a positive and productive force that "affirms everything of the multiple, everything of the different, everything of chance except what subordinates them to the One, to the Same, to necessity."[26] As Deleuze avers, the divine game, which is the game of Heraclitus, Mallarmé and Nietzsche, is difficult to understand as it cannot be dealt with from within the world of representation given that it is precisely what is always distributing and redistributing this world—and here Deleuze refers to throws within the divine game as effectuating a *nomadic* as opposed to *sedentary* distribution—which in turn becomes amenable to the logic of the One, the Same and so forth. In this divine game, which Deleuze, following Lautman, describes as problematic, i.e., as a virtual problem that is non-exhaustively actualised in various solutions or throws of the dice, "there is no pre-existing rule, since the game bears already upon its own rules and since the child-player can only win, all of chance being affirmed each time and for all times."[27] This is why Deleuze can make the strange claim that the various rules resulting from each throw are "the forms of a single ontologically unique throw, the same across

23 Which he interprets as the return only of what differs: what repeats is difference.
24 Deleuze, *Difference and Repetition*, 283.
25 Deleuze, *Difference and Repetition*, 303; emphasis mine.
26 Deleuze, *Difference and Repetition*, 115.
27 Deleuze, *Difference and Repetition*, 116.

all occasions"[28]—what he will elsewhere describe as *Eventum Tantum*, one event for all events.[29]

Ross applies this notion of the divine game in proposing an approach to cosmology that eschews the absolute nature of the second principle—as well as a hylomorphic view of play—in favour of a more profound principle of difference. As he puts it, "[c]onstrued in terms of physical causality or expression, in the site of the Ideal Game, the cosmos, events are not totalisable, the world is 'open.' though this is in another sense than the one typically adopted in the register of thermodynamics, where an 'open' system is one through which external sources of energy are free to flow."[30] We can see where this provocative claim is leading: the entropic principle may be the case if we are playing the human game that evaluates the distributions of chance vis-a-vis the established, as though the rules of the universe were unchanging, but if we accept that the rules themselves may change then the second law is potentially obviated. "Rules determine the distribution of pieces, yet the distribution of pieces determines the rules; a flat ontology."[31] The implication of this view is that the universe is non-ergodic, and it is here that Ross parts ways with Nietzsche's principle of the eternal return as, on his view, tacitly assuming ergodicity via its reliance on the anachronistic—for contemporary physics—notion that the universe has already existed forever, whereas Ross follows David Bohm in arguing that "eternity means the depths of the implicate order, not the whole of the successive moments of time."[32] In fact, Ross argues via the groundbreaking work of Prigogine and Stengers[33] that said non-ergodicity is typified by the larger scale phenomena examined by chaos theory, wherein fluctuations and bifurcations in far-from-equilibrium nonlinear systems act as emergent constraint regimes on unfolding dynamics,[34] a view reiterated in Stuart Kauffman's work on the negentropic emergence of complex order in living systems.[35] In light of this we should, Ross suggests, amend Leibniz's principle of sufficient reason via Deleuze and quantum physics so that sufficient reason simply *is* disequilibrium and divergence and

28 Deleuze, *Difference and Repetition*, 283.

29 "[N]othing but the Event subsists, the Event alone, Eventum Tantum for all contraries, which communicates with itself through its own distance, resonating across all its disjunctions" (Deleuze 1990:176).

30 Ross, *Order and the Virtual*, 101.

31 Ross, *Order and the Virtual*, 94.

32 Bohm, "Time, the Implicate Order and Pre-Space," 200.

33 Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam Books), 1984.

34 Alicia Juarrero, *Context Changes Everything: How Constraints Create Coherence* (MIT Press, 2025).

35 See Stuart Kauffman, "Res Potentia And Res Extensa Linked, Hence United, By Quantum Measurement," *Physics and speculative philosophy: potentiality in modern science* eds. David Ray Griffin, Michael Epperson & Timothy E. Eastman (Boston: De Gruyter, 2016) and Stuart Kauffman, *A World Beyond Physics: The Emergence and Evolution of Life* (New York: Oxford University Press, 2019). Notably, Ross cites Kauffman's development of the notions of *res potentia* and the adjacent possible at several points in his argument.

compossibility the compossibility of *incompossibles*—a compossibility of metastability, superposition and disjunctive inclusion.

Beyond this, Ross examines the work of several theoretical physicists, most prominently Bohm and Lee Smolin, in order to put forward the view that the underlying quantum field which, on some models, gives rise to the spatiotemporal ordering of the universe is itself the site of the divine game. Essentially, the argument Ross makes is a transcendental empiricist one:

> If we proceed on the assumption that everything (even the Big Bang) is subject to law, we are irredeemably in the position of attempting to identify which among the laws we impute to our own universe could serve as the condition for any possible universe. If we think rather in terms of conditions, the transcendental point of view, in the case of both Kant and Deleuze, reminds us that the condition may not resemble in the slightest that which it conditions. The point of contention rests further on, in the formulation arising from the Ideal Game; for Deleuze, *we should not seek the laws*, the necessities which labour invisibly beneath the phenomena, *but the repetitions which serve to constitute the law (and work to undo it)*... And as much could be said for the cosmologist, who is just as surely conscious that assertions about the state of the universe are accompanied without exception by questions about conditions for the multiverse.[36]

There is, in short, at least if Ross's preferred branches of speculative quantum physics and contemporary fields like loop quantum gravity are correct, a fundamental asymmetry or inexhaustible disequilibrium to reality at a quantum level—a clinamen-like process of continuous differentiation that gives rise to the spatiotemporal order and with it to the contingent laws of that non-exhaustive ordering.[37]

36 Ross, *Order and the Virtual*, 107; emphasis mine.

37 Some readers may be reminded of Quentin Meillassoux's notion of absolute contingency at this point. Ross however underscores that this is a misreading and that Meillassoux's conception of contingency is a profoundly non-realist one given that it pays no attention to the virtual conditions - the turns within the divine game - that gives rise to the contingency he is so quick to appeal to. As Ross insightfully points out, "[t]he openness entailed by Meillassoux's contingency requires an acute adherence to the weightless equivalence of radically incongruent possibilities, without delay or retardation in actualisation, without mechanism, process or propagation. This is precisely what scientists tend to call 'magic thinking', a charge often laid at the door of religious or theological accounts of nature. Deleuze's own critique of this style of reasoning consists in the injunction always to seek virtual conditions over merely 'possible' eventualities" (Ross, 178).

The Implicate and the Explicate

This distinction between the spatiotemporal and an underlying dynamic field should remind us of the well-worn Deleuzian distinction between the virtual and the actual. Ross prefers to discuss the virtual in terms of the intensive,[38] referring frequently to Simondon in this regard, but his view is broadly similar to the picture Deleuze paints in *Difference and Repetition*. Here, Ross draws attention to a barely explored but remarkably fruitful connection between Deleuze's virtual-actual distinction and Bohm's implicate and explicate orders. In *Wholeness and the Implicate Order*, Bohm, drawing on then-contemporary theoretical physics, argues that what we usually think of as space and time—the manner in which we conceive of the former in terms of discrete spatially separated phenomena and the latter in terms of discrete temporally separated instants[39]—is what he terms the explicate or unfolded order. Bohm argues however that this common sense image is misleading and that the explicit order is quasi-supervenient upon, while also reciprocally entangled with, an enfolded high-dimensional implicate order[40] that has neither spatiality nor temporality but is instead comprised of zero-point energy fluctuations at the Planck level (10^{-33}cm), i.e., what the physicist John Wheeler once described as the quantum foam.[41] In Ross's words, "[t]he implicate order, first and foremost for Bohm, is a structuration of the prodigious energy inherent in the vacuum, the so-called "Dirac Sea," which underlies the phenomena we encounter in the explicate order."[42] The explicate order—the order of time, space, particular matter and the laws of thermodynamics—is thus just the unfolding of a series of ripples expressed on the surface of an underlying and enfolded quantum ocean and this entire movement of folding, unfolding and refolding, in which even the Big

38 As will be seen later, on some readings, e.g., DeLanda's tripartite ontology of virtual, intensive and actual, we could argue that Ross in fact conflates the virtual and intensive processes to a greater degree than is warranted.

39 This, of course, is not the view that is espoused by the "block universe" interpretation of special relativity, wherein all times exist equally as part of a four-dimensional spatiotemporal Riemannian manifold. It should be recalled in the following that quantum theory is a separate but related—and arguably even more radical—view on spatiotemporality, although some researchers, notably Carlo Rovelli, have attempted to reconcile relativity and quantum physics in contemporary loop quantum gravity.

40 Technically a recursion of increased enfolded implicate orders that in principle has no terminus: "[w]hat I propose, therefore, is a succession of vacuum states, all enfolded in the deeper implicate order, as ordinary time intervals are enfolded in the vacuum state" (Bohm, 197).

41 As Bohm explains, "[a]s physics is pursued further, we do indeed find that this atomic structure dissolves into electrons, protons, neutrons, quarks, subquarks, etc., and eventually into dynamically changing forms in an all-pervasive and universal set of fields. When these fields are treated quantum-mechanically, we find that even in what is called a vaccum there are 'zero-point' fluctuations, giving 'empty space' an energy that is immensely beyond that contained in what is recognized as matter." (Bohm,187)

42 Ross, *Order and the Virtual*, 158.

Bang is "just a 'little ripple,'"[43] is what Bohm calls the *holomovement*[44]:

> [O]ne is to begin with the holomovement, in which there is the immense 'sea' of energy… This sea is to be understood in terms of a multidimensional implicate order… while the entire universe of matter as we generally observe it is to be treated as a comparatively small pattern of excitation. This excitation pattern is relatively autonomous and gives rise to approximately recurrent, stable and separable projections into a three-dimensional explicate order of manifestation, which is more or less equivalent to that of space as we commonly experience it.[45]

Timothy Murphy, in an early article linking Bohm to Deleuze, describes the holomovement as a "differential omnipresence," explaining via analogy to holography that in order to conceive of the unfolding of the implicate order "one must imagine each point, like each moment in time, to condense within itself the entire shifting structure of that universe, viewed from different perspectives."[46] Here, "the vacuum state would be an enfolded virtual generator of times (and spaces) yet unknown and unmeasured."[47] The parallels with Deleuze's notion of the generative principle of indi-drama-different/ciation,[48] which operates as a condensed descriptor for the complex unfolding of difference detailed in chapters four and five of *Difference and Repetition*, are striking here, and one can similarly recognise a strong similarity between the Bohmian holomovement—which is the immanent expression of what Bohm, following Wheeler, terms *pre-space*[49]—and the

43 David Bohm, *Wholeness and the Implicate Order* (London: Routledge, 1980), 244.

44 Bohm refers extensively to holography in developing this term, explaining how the visible expression of the holograph is the result of the capturing of a different aspect of overall electromagnetic interference patterns/phase differences at each point of the underlying photographic medium. The holographic metaphor is evident not only in Bohm's description of the emergence of space but also when he argues that "each moment of time is a projection from the total implicate order" (Bohm,189) and that thus "all these projections into any given moment will have the past of the entire universe as their potential content, which is thus enfolded into the moment in question" (191). Or, as he says elsewhere, "[i]n terms of the implicate order one may say that everything is enfolded into everything." (Bohm, 225)

45 Bohm, *Wholeness and the Implicate Order*, 243.

46 Timothy Murphy, "Quantum Ontology, A Virtual Mechanics of Becoming," *Deleuze & Guattari: New Mappings in Politics, Philosophy, and Culture*, (1998), 223.

47 Murphy, "Quantum Ontology," 220.

48 Deleuze, *Difference and Repetition*, 246.

49 Bohm, "Time, the Implicate Order and Pre-Space." As he continues, "Wheeler has appealed to the image of space-time as a kind of very fine 'foam' out of which the familiar patterns and forms of continuous space, time, and matter emerge as approximations on the large-scale level. He is thus regarding this foam as a kind of prespace, from which ordinary space-time emerges as a suitable limiting case. However, because the structure of the foam is given by quantum laws, one should more accurately regard pre-space as a form of the implicate order." (1986:192) Bohm takes care to note that he is not arguing for a Spinozist substantialism in his use of the notion of pre-space and that the implicate order is better understood as a graph or Feynmann diagram, although he will also refer to Whiteheadean concrescence when developing his notion of a 'moment' as an unfolding of said order.

Deleuzian-Guattarian chaosmos. Indeed, cutting a section out of chaos, as Deleuze and Guattari put it,[50] is precisely a collapse of the wave function[51]—a provisional and non-exhaustive solution to a superpositional virtual problem. If, in the explication of solutions, "the differentials disappear in the result, this is to the extent that the problem-instance differs in kind from the solution-instance; it is in the movement by which the solutions necessarily come to conceal the problem."[52] Notably, in his discussion of thermodynamics, Deleuze uses remarkably Bohmian language to reiterate that that "[d]ifference in the form of intensity *remains implicated in itself*, while it is *cancelled by being explicated* in extensity."[53] As Bohm would put it, "the particle is only an abstraction that is manifest to our senses. What is is always a totality of ensembles, all present together, in an orderly series of stages of enfoldment and unfoldment, which intermingle and inter-penetrate each other in principle throughout the whole of space."[54]

Similarly to Deleuze, Bohm encourages us to consider both aspects of the folding and unfolding of reality in this regard, arguing that "[i]n the [explicate] time aspect is comprehended the *becoming of being*, while in the 'timeless' [implicate]' aspect is comprehended the *being of becoming*."[55] This goes some way towards rescuing Bohm from charges of "emanationism" that are sometimes levelled against him and which Deleuze has also occasionally been accused of based on readings that misconstrue the reciprocally imbricatory nature of the virtual-actual relationship.[56] As Bohm and his co-author F. David Peat elsewhere admit, the Bohmian view does at first appear "to reduce the time order [the explicate] so that it could, in principle, be derived completely from the timeless [the implicate] order," and this would be the case "if the 'flow' in the implicate, generative stream were only in the 'direction' from the source or origin down to ever more explicate orders of succession," but "because of the two way nature of this flow, there is an inherent dynamism in the theory and such a reduction is not possible."[57] Similarly in Deleuze's case, while a certain dogmatic image of thought arises when we think solely in terms of

50 Gilles Deleuze and Félix Guattari, *What is Philosophy?* (New York: Columbia University Press, 1994).

51 "[B]y the quantum mechanical model, what a particle is 'composed' of at the most fundamental level is a bundle of undetermined probabilities. It is the act of measurement itself which forces this wave of probabilities to collapse, thereby determining determined values for the aspect under investigation: spin, speed, direction, etc." (Ross, 41)

52 Deleuze, *Difference and Repetition*, 177–8.

53 Deleuze, *Difference and Repetition*, 228; emphasis mine.

54 Bohm, *Wholeness and the Implicate Order*, 233.

55 Bohm, "Time, the Implicate Order and Pre-Space," 197. For a useful introduction to Bohm's discussion of time that reads him via Husserlian retention-protention, see Paavo Pylkkänen, "Still or Sparkling? Past, Present and Future in Bohm's Implicate Order Approach," *Acta Philosophica Fennica* 99, (2023).

56 Peter Hallward's misrepresentation in *Out of this World* being perhaps the most well-known example here.

57 David Bohm and F. David Peat, *Science, Order and Creativity* (Abingdon: Routledge Classics, 2011), 196.

the established, it is emphatically not the case that we should simply defer to the virtual or implicate in a manner that grants it a kind of absolute ontogenetic primacy.[58] In fact to do so would be to render wholly incoherent the Deleuzian practices of vice-diction and counter-actualisation: the following of being in its becoming and the participation in the whole of the method of dramatization. Such a misreading also has fundamental implications for the neo-Bohmian philosophy of cosmology limned here. Similarly, we should take care not to impute a straightforward holism to pre-space, the implicate order or the holomovement. Again, Bohm is not endorsing any form of substantialism, and we can understand his view as closer in spirit to Deleuze's description of the virtual as continuous multiplicity: "[m]ultiplicity remains completely indifferent to the traditional problems of the multiple and the one... Multiplicity is neither axiomatic nor typological, but *topological*."[59]

Chaos and Beyond

A question arises: given this foray into Deleuzian-Bohmian philosophy of cosmology, how best can we think the underlying metaphysics of negentropy and contingency? What *kind* of thinking is best suited to a philosophy in which change is primary and where the identities that emerge within the dance of being and becoming are provisional stabilisations of an underlying dynamic of folding and unfolding? Here, as Lee Smolin says, "to speak the language of the new physics we must learn a vocabulary in which process is more important than, and prior to, stasis."[60] I would like to suggest that dynamic systems theory (DST) and specifically the phase space formalism employed within complex and chaotic systems theories holds promise in this regard. Here I part ways with Ross, who argues that the closely related frameworks of chaos theory and DST first popularised within Deleuze and Guattari studies by Manuel DeLanda[61] and which recast *Difference and Repetition*'s

58 In this regard, Dale Clisby and Sean Bowden have argued that there are three prominent readings of the virtual vis-à-vis the intensive and actual: a spurious reading that prioritises the virtual and which results in the fundamental misunderstandings evident in Badiou, Hallward and their interlocutors; a second reading – exemplified by Jon Roffe's work – that views the virtual as an aspect of the actual; and a third reading, which I broadly align with, wherein the role of the intensive is underscored within a tripartite virtual-intensive-actual schema, this being the reading developed by Manuel DeLanda, John Protevi and other scholars specifically interested in the intersections of Deleuze and science. See Sean Bowden and Dale Clisby, eds. "The Virtual, the Actual, and the Intensive: Contentions, Reflections, and Interpretations." *Deleuze and Guattari Studies* 11, no. 2, special issue, (2017): 153–5, as well as the other articles in that issue.

59 Gilles Deleuze, *Foucault*, trans. Sean Hand (London: Althone), 1988: 14; emphasis mine.

60 Lee Smolin, *Three Roads to Quantum Gravity* (Basic Books, 2003), 53.

61 Manuel DeLanda, *Intensive Science and Virtual Philosophy* (London: Continuum, 2002).

description of the intensive unfolding[62] of virtual difference as, loosely speaking, the traversal of a vector landscape or phase space populated by attractors and repellors (i.e., tendencies), is insufficient for thinking the asymmetrical synthesis of the sensible or divine game. Ross's view in this regard appears to be that the DST formalism relies on a static phase space and discontinuous traversal of this space via abrupt bifurcations, thus motivating him to argue that "there is no straightforward identification to be made between Deleuze's chaotic 'divergence' and the 'bifurcations' of chaos theory, nor can such an identification underwrite the Deleuzian Event *qua* Event; this is in effect akin to comparing the knots in a piece of wood to the sap which laid the grain!"[63] In other words, the DST approach[64] remains, for Ross anyway, at the level of the explicate and the discrete[65] and we should turn instead to quantum dynamics—loop quantum gravity, for instance—for a better model. More specifically, as he puts it, "[t]he pre-eminent character of the event for Deleuze is a reciprocal determination, a resonance between co-existent time-signatures. From this perspective, we can see more clearly the problems in identifying the Deleuzian event with the bifurcations of chaos theory; it cannot help but be continuous, since the tension between time-signatures never once ceases."[66] This seems to be a misreading of chaos theory, which is usually modelled using nonlinear differential equations. While nonlinear systems are often typified by abrupt jumps between states, these represent, as elaborated below, *outcomes* of underlying continuous dynamics. Specifically, we should not confuse the traversal of the phase diagram with the diagram or vector field itself; in fact, Deleuze himself reminds us here that "every differenciation presupposes a prior intense field of individuation… [and] any reduction of individuation to a limit or complication of differenciation, compromises the whole of the philosophy of difference."[67] In other words, the phase space should be understood more as an intensive field of individuation—or as prephased, in Simondon's terms—than as the spatiotemporal explicate order that is

62 As Bryan Noonan astutely observes, there is a close link between the notion of folding and that of multiplicity: "the seemingly innocuous English translation of multiplicité into "multiplicity"… misses the *pli* at the heart of multiplicité, a dimension of the term not missed in the alternative of manifold". See Noonan, "The Lily of the Field Sings the Glory of the Heavens: The Cosmos of the Fold," *Deleuze and Cosmology*, 143-65

63 Ross, *Order and the Virtual*, 4.

64 Ross refers solely to "chaos theory" in the book, but it seems clear that he is alluding to the broader field that includes DST, which is frequently used to model chaotic systems, e.g., as systems typified by chaotic or "strange" attractors.

65 It should be noted that the relation between the continuous and discrete within quantum physics generally and Bohm's implicate and explicate orders specifically is complex. In fact, it is possible to consider the holomovement expressed by Bohm's implicate order as simultaneously continuous *and* discrete. More generally, quantum physics is often understood as entailing *discontinuous* phenomena—from the discrete energy states of subatomic particles to the discreteness of spacetime itself on the loop quantum gravity view. The terms continuous and discrete may in fact be insufficient for thinking the reality presented by contemporary physics, analogously to how Deleuze regards the one and the multiple as insufficient for thinking the virtual.

66 Ross, *Order and the Virtual*, 104.

67 Deleuze, *Difference and Repetition*, 247.

individuated (what Simondon would describe as a single phase of being). To reiterate, it is thus emphatically not the case that we should view the dynamics of phase spaces as discontinuous, especially given that, typically, "a bifurcation event is defined as a *continuous* deformation of one vector field into another."[68] This is especially the case with second-and higher-order phase transitions, and the idea of continuously transforming and nested phase spaces and their concomitant scales of provisional stabilisation is implicit in DeLanda-style readings of Deleuze[69] while also being explicitly engaged with in recent work on sub-Riemannian manifolds that attempts to update Deleuze's reliance on Riemann for his development of the notions of continuous multiplicities and differential heterogenesis,[70] as well as within work in quantum physics itself that pertains to second- and higher-order continuous phase transitions[71] and continuous deformations of the differentiable manifolds that are frequently used to describe phase spaces.[72] Moreso, there exist well-known applications of phase spaces and manifolds in the modelling of various quantum theories and phenomena.[73] As Sarti et al. elaborate, "[d]ifferently from both mathematical physics and structural morphodynamics, where the becoming of forms emerges from generators that are homogenous in space and time, the heterogeneous dynamics in question—called heterogenesis—introduces the possibility of the mutation of laws in space and time so as to overcome any homogeneity."[74] They argue that this "can thus instantiate a dynamics of the event whereby new spaces of possibility and new forms can be generated"[75] and describe this via Heisenberg's uncertainty principle, itself closely related to the physics of probabilistic metastability Ross operates with, as a "continuous recomposition of virtualities."[76] This view is contrasted by Sarti et al. with René Thom's structural morphodynamics, which is perhaps indirectly the view of complex and chaotic

68 DeLanda, *Intensive Science and Virtual Philosophy*, 23.

69 For instance, "[a] multiplicity is a nested set of vector fields related to each other by symmetry-breaking bifurcations, together with the distributions of attractors which define each of its embedded levels" (DeLanda, 23–4).

70 A., Sarti, G. Citti, and D., Piotrowski, *Differential Heterogenesis: Mutant Forms, Sensitive Bodies*, (Springer, 2022).

71 K. Hawary, M. Azzouz., M. Baz., S. Deffner, B. Gardas and Z. Mzaouali, "Navigating the phase diagram of quantum many-body systems in phase space," *Physical Review E* 110, (2024).

72 See, for instance, X. Xie, Y. Chen and Q. Shi, "Some studies on mechanics of continuous mediums viewed as differential manifolds," *Science China Physics, Mechanics and Astronomy* 56, no.2 (2013) and X. Zhuang and N.E. E. Mastorakis, "The Dynamics of Deforming Manifold: A Mathematical Model," *Eprint arXiv*:2110.04992, 2021.

73 Superstring theory is often discussed in terms of compacted six-dimensional Calabi-Yau manifolds that combine with four-dimensional extensive spacetime to comprise reality, for instance; the generalisations of smooth manifolds in the notions of orbifolds and diffeology are sometimes also employed in descriptions of related models. Here it should be obvious that there are numerous further potential engagements between Deleuze and differential geometry than the usual analogies between classic Riemannian manifolds and the virtual that Deleuze himself employed.

74 Sarti and Piotrowski, *Differential Heterogenesis*, 2.

75 Sarti and Piotrowski, *Differential Heterogenesis*, 2.

76 Sarti and Piotrowski, *Differential Heterogenesis*, 6.

systems Ross indirectly relies upon. As they explain:

> René Thom has shown clearly that the emergence of structures requires a very particular kind of singularities defining stable basins of attraction. Indeed, the Thomian theory of structural stability in its entirety aims to pose the conditions for the stabilization of fluxes. Mathematically, this means that attractor basins are stable and oppositive relations that are implemented by means of parameters changing in an external space. These are the condition of existence for a structure. But of course there are other possible actualizations of the composition of adjoint fields including general Poincaré singularities that differ from gradient potential. Likewise, there are non-standard attractors like strange attractors, as well as solutions coming from harmonic analysis such as those at work in quantum mechanics.[77]

It should be recalled here that Thom, a player of the human, all too human game, famously waxed polemical against Prigogine and others who 'glorified chance' and fetishised a mysticism of the clinamen, preferring to align himself with the view that on final reckoning, determinism was still a viable option[78].

Beyond Thom, aversion to DST for thinking the complex holomovement-like process of differen*t*/ciation may in part also be the result of a too-close identification of intensive processes, i.e., the unfolding of various trajectories to comprise a phase portrait (a series of non-exhaustive actualisations or "integrations") and the virtual (the enfolded diagram or differentiable manifold wherein processes of differentiation express singularities that distribute the vector field). In this regard, to reiterate the difference between the phase diagram and its traversal or portrait, Deleuze draws "a sharp ontological distinction between the trajectories as they appear in the phase portrait of a system, on one hand, and the vector field, on the other,"[79] underscoring that "the specification of the singular points (for example, dips, nodes, focal points, centres) is undertaken by means of the form of integral curves, which refers back to the solutions for the differential equation," but that "[t]here is nevertheless a complete determination with regard to the existence and distribution of these points which depends upon a completely different instance—namely, the field of vectors defined by the equation itself."[80] In one sense, then, there is just the *being of becoming*—the distinction between virtual and actual—but in another there is the *becoming of being*—the intensive unfolding or holomovement.

77 Sarti and Piotrowski, *Differential Heterogenesis*, 43–4.
78 René Thom, "Stop Chance! Silence Noise!," trans. Robert Chumley, *SubStance* 12, no. 3 (1983).
79 DeLanda, *Intensive Science and Virtual Philosophy*, 22.
80 Deleuze, *Difference and Repetition*, 177.

The recent turn within Deleuze and Guattari studies to issues in cosmology—and quantum physics specifically—is encouraging both as an exemplary instance of productive dialogue between philosophy and science and also because it holds the promise of a compelling new framework for grappling with the philosophy of difference, using science to think philosophy but also explicitly calling for scientists to pay attention to the philosophy of the divine game wherein "the very mutability of constants, laws and natural kinds, and perhaps only this… could maintain an endlessly enduring complexity and underpin the infinite process of becoming."[81] Deleuzian cosmology, in other words, explicates a virtual problematic field that we would do well to vice-dict. Such vice-diction, at minimum, includes a deeper examination of the finite scope of the idea of an arrow of time within both Deleuzian metaphysics and physics, perhaps via Deleuze's distinction between Chronos and Aion[82] as two forms of time associated with the explicate and implicate orders respectively, as well as an elaboration of these two orders via the closely-related neo-Leibnizian notions of explication, implication and complication in *Difference and Repetition*. Similarly, an engagement with the distinction between static and dynamic genesis and the complex notions of quasi-causality and the dark precursor presented in *Logic of Sense* and elsewhere could benefit from being drawn into discussion with perhaps the most profound consequence of Rovelli's speculative reconciliation of relativity and quantum physics in his theorisation of loop quantum gravity: there is change without time, because time emerges from this *non-temporal* incessant change at the level of the spin foam. As Calamari describes, "fundamentally, the physical world is defined by a timeless becoming, understood as a non-temporal, or rather non-spatiotemporal, ceaseless happening of events"[83]—a radical post-Einsteinian Heracliteanism, we could say, that occurs not within space or time but as the unfolding of the explicate order. The ontologically unsettling consequence of this is that "spacetime is expected to emerge from the coarse-grained collective dynamics of non-spatiotemporal entities."[84] In terms of more standard models of quantum theory, as Michael Ardoline observes, we can also inquire further into the remarkable parallels between "quantum (Hilbert space), quasi-classical (probability density), and classical (determinate, measured result)" and Deleuze's virtual, intensive and actual respectively, as well as the similarity between "decoherence (from quantum to quasi-classical) and measurement (from quasi-classical to determinate)"

81 Ross, *Order and the Virtual*, 173.

82 As Arnaud Villani describes, with reference to cosmologuy, "[i]t is this Aionic time that virtualizes/actualizes interstitial fragments, indifferent to time and its prohibition of return, and never ceases to 'move' everything… in this *non-space* and this *non-time*, billions of stoicheia ("little bits"), remarkable and brilliant singularities of a reality moving by the force transmitted to them by chaos which distributes them on flows ready for encounters with other singularities on other flows." See Arnaud Villani, "Deleuze, an Unwitting Milesian?" *Deleuze and Cosmology*.

83 Calamari, "The Metaphysical Challenge of Loop Quantum Gravity," 70.

84 Calamari, "Immanence, Process, and Relationalism in Loop Quantum Gravity," *Deleuze and Cosmology*, 273

and the processes of individuation and actualization.[85] Finally, a closer interrogation of Bohm's work may be specifically rewarding, especially of the distinction he draws between the horizontal and vertical implicate orders, the former constituting the dynamic of folding and unfolding and the latter suggesting—in a manner resonant with Deleuze's discussion of a nesting of virtuality in his late essay, *The Actual and the Virtual*—that the implicate order itself contains multiple levels of emergence.[86]

In all of this, as Smolin intuits, a different form of thought becomes necessary if we are to produce a thought adequate to the strange new world cosmology has been describing for the past century. While our thinking in this regard is oftentimes grounded in the explicate—in the fully formed Newtonian world of extended spatiotemporal forms enjoying discrete identities and amenable to taxonomic accounts via the dogmatic image, we would perhaps do well to regard thinking itself as a becoming: not just the manipulation of already-constituted conceptual objects but as a provisional and ongoing ontogenesis—a holomovement of thought in which the subject and object of that thought arise at the same time, as part of the arising of time itself, concepts being formed and expressed in the same manner as the spatiotemporal order more generally. In this regard, in order to grasp thought not just in its being but in its becoming, the resources of nonlinear dynamic systems theory, phase diagrams and so forth can help us, perhaps, to think, as Deleuze always encourages us to, a thought without image. This would constitute a vectorisation of thought, replacing the logic of fixed identities, categories and so forth with the distributions and tendencies that populate the differential sub-Riemannian manifolds that constitute the table upon which the divine game is played. Thought too, recall, is part of cosmology. Throwing the dice once more, one time for all of time in a universe shorn of time but in which change is ceaseless nonetheless, we would do well to repeat, with difference, the ongoing cosmogonic Lucretian swerve of Deleuze's and Bohm's basic metaphysical position: "[d]isparity and dissymmetry take on their own powers at the cosmological scale. From one epoch to another, evolution outruns entropy."[87]

85 Michael Ardoline, "Deleuze and Decoherence: Approaching the Measurement Problem through Intensity," *Deleuze and Cosmology*, 223.

86 Bohm, "Time, the Implicate Order and Pre-Space," 186.

87 Ross, *Order and the Virtual*, 175.

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