Some Remarks
on the Philosophical Significance of Complexity Theory

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ELEMENTARY TERMINOLOGY

Three forms of *material systems*: closed (determined), open (random or self-organizing).

1. Closed systems have constant matter and energy. They were models for classical modern physics. Instrumentalists stress the "model" aspect. Newtonian physics proposes a model that allows approximations good enough for (military) technology. E.g., the center of gravity is only part of a model, a thought-entity, that allows for calculation: it doesn't exist in the same way realists would say atoms and molecules exist. Closed systems provide the classical image of nature as determinate system, as figured in the story of LaPlace's demon.{1} Reversibility of time's arrow: prediction and retrodiction. Or better, destruction of time and achievement of God's eye view. Problem of articulating human freedom with deterministic nature. Various dualisms: Cartesian, Kantian.

2. Open systems have flow of matter and energy through them.

A. Open random systems, like laminar flow of fluids or diffusion of gases. No models for predictability, but statistical probabilities. Classic image of "chaos."

B. Open self-organizing: studied by "chaos/complexity theory." Short-term predictability, long-term unpredictability. New image of "chaos."

We have thus broached the question of a reduction of Newtonian physics from ontology to epistemology. Some people claim that all we ever encounter, all that exist, are open systems, but treating some of them as closed, modeling their behavior by closed model and linear equations, can be technologically helpful.

Phase space: Idea developed by Henri Poincaré in late 19th century. Improved computer technology (material support of mathematics) allowed new uses. Five steps in constructing a phase space portrait of a system.

1) Identify important aspects of a system's behavior, which are called its "degrees of freedom."
2) Imagine or model a space with as many dimensions as the degrees of freedom of the system to be studied.
3) Each state of the system can then be represented as a single point, with as many values as there are dimensions. In other words, it only takes one measurement, one value, one number, to identify the state of a system with one degree of freedom: the temperature of a human being, for instance. The phase space here (instantiated in a thermometer) is only a line, while more complex phase spaces have more dimensions (temperature and pulse and blood pressure, for instance, would need three values to locate the point.)
4) The changing states of the system then trace a line, a trajectory, through phase space. In our thermometer example, the line follows only one dimension, but in more complex phase spaces the trajectory can (when random systems are studied) zoom about throughout the space, "exploring" all the permutations.
5) We can then try to solve the equations and pin down the system's behavior (closed deterministic). Sometimes we can't solve the equations, and no patterns emerge (open random). Sometimes though, in studying the system we can't solve the equations,
BUT we can identify the evolution of some patterns (open self-organizing). These patterns have various features, some of which are named: attractor, repellor, bifurcator. More on these terms later.

DELEUZE AND COMPLEXITY THEORY

According to Manuel DeLanda, in the late 60s, Gilles Deleuze began to formulate some of the philosophical significance of what is now sometimes referred to as "chaos/complexity theory," the study of "open" matter/energy systems which move from simple to complex patterning and from complex to simple patterning. Though not a term used by contemporary

scientists in everyday work (“non-linear dynamics” is preferred), it can be a useful term for a collection of studies of phenomena whose complexity is such that Laplacean determinism no longer holds beyond a limited time and space scale. Thus the formula of chaos/complexity might be "short-term predictability, long-term unpredictability."

A note on realism: I leave the last formulation at “predictable,” an epistemological term, because people get nervous with “indeterminate,” an ontological term. Thus we're only talking epistemology, or at best heuristic ontology. However, since by and large I find it useful to bracket realism / anti-realism debates, and adopt only a “weak” social constructivism, let’s not worry about this distinction. My concern is with *open materialism*, not realism. If a realist can accept an open future for mid-range physical systems, then I’m a realist.

The groundbreaking works in identifying Deleuze's (and Deleuze & Guattari's) interest in this field are Brian Massumi's *A User's Guide to Capitalism and Schizophrenia* and Manuel DeLanda's "Non-organic Life" in *Incorporations: Zone 6*; *War in the Age of Intelligent Machines*; *A Thousand Years of Nonlinear History*; and most importantly, *Intensive Science and Virtual Philosophy*. Although post-modern appropriations of science--to say nothing of critiques--have been the focus of much negative attention lately, due to the notorious Sokal hoax, there does seem to be good cause to take seriously the work of Deleuze and Deleuze & Guattari.?

Briefly, as De Landa explains, the *actual/virtual* distinction Deleuze appropriates from Bergson is put to use to distinguish between the (actual) traits of a physical system (its long-term tendencies) and the (virtual) thresholds at which it either adopts or changes those traits. Thus an actual system might, say, oscillate at one frequency within a certain range of parameters, and at another within another range. The actual behavior of the system, its oscillation at frequency #1 or #2, would be a *trait*, while oscillation frequencies #1 and #2 would be virtual "*attractors*," and the transition between #1 and #2 would be a virtual "*bifurcation*." "Attractors" receive their name by capturing the behavior of systems within a range of values of parameters -- their "basin of attraction" -- while "bifurcations" are named because they are the events by which a system moves from one attractor to another.

DeLanda isolates three types of attractors: point, loop, and chaotic. They correspond to three states: steady state, oscillation, and turbulence.

Deleuze's terminology in *The Logic of Sense* is that of trait, singularity and Event ("emission of singularities), which line up roughly with that of trait, attractor and bifurcator. The terms adopted in the collaboration with Guattari is slightly different, with "black hole" naming "attractor" and "line of flight" naming "bifurcation."

The virtual / actual distinction enables D and D/G to account for unpredictability in physical systems while still maintaining a *consistent materialism*; the virtual is "real but abstract." (Deleuze/Guattari are bold enough to do ontology. They don't want just a heuristic materialism; they want to make ontological claims.) Attractors are forms of self-organization of matter; physical systems of matter/energy flow CAN BECOME organized, even if currently random or laminar. (Thus the current interest in Lucretius and Democritus: the *clinamen*, or "swerve" is the least deviation from the laminar. Thus ancient Greek atomistic physics was a fluent dynamics, not a solid one. See Michel Serres, *Naissance de la physique*.)

Even turbulent fluids, for instance, which were classic symbols of "chaotic" matter, are embodiments or actualizations of virtual attractors, albeit "fractal" or "strange" ones. There's no real chaos in turbulence, rather fiendishly complex interactions of matter. However, laminar flows (paradoxically, "calm" fluids) or gases come close to the original sense of chaos.

In the phenomena of self-organizing systems, we find creativity, novelty, etc., but this is in matter itself: bifurcators, Events, lines of flight, are changes triggered unpredictably when sensitive systems pick up slight cues that move them onto another basin of attraction, or keep them moving about within a zone of unpredictability: in Stuart Kauffman's terms, "poised on the edge of chaos."

At this point we must introduce an important distinction between static and changing phase spaces, or in our terms between a static and *creative virtual*. While some simple systems can be modeled by a fixed phase space with a stable set of attractors and bifurcators that are merely “explored” by the system, more complex systems require for their representation a changing phase space in which the activities of the inhabitants of the system change the very nature of the space itself. Stuart Kaufmann of the Sante Fe Institute, for instance, considers the "mutual bootstrap" effect between

the "landscape" of a particular phase space and the specific trajectories resident within it. In this way the interactions of actual agents serve to change the virtual field, creating new singularities, new “fitness peaks” or attractors, as in coevolution phenomena such as that of an “arms race” between predator and prey species. Even more challenging to the notion of a fixed virtual is the case in which two systems interact (“nonlinear combinatorics”), so that there is a dynamic of dynamics as it were, a veritable explosion of singularities caused by the interaction of ever-changing landscapes. The virtual is thus not static, but constantly self-creating, differentiation as process.

In this way Deleuze and Guattari's *transcendental geophilosophy* can provide a consistent materialism without mechanistic reductionism or vitalist essentialism. We must first avoid attributing self-ordering to the rule-bound interaction of elementary components of actual physical systems (mechanism). In Deleuze and Guattari’s insistence on maintaining a strict distinction between virtual singularities and the actual system, we see that the virtual is a way of talking about the emergent properties of systems, which are not reducible to the aggregated results of simple behaviors of elementary particles, but must be discussed in their own terms. On the other hand, Deleuze and Guattari avoid vitalism by avoiding any attribution of an essence to organic life; by insisting on the phenomenon of “non-organic life,” that is, the appearance of phenomena of self-organization and novelty in physical, chemical, and geological processes, they disabuse us of any lingering humanist illusions and insert human affairs squarely in nature, parts of a creative “Earth.” In other words, Deleuze and Guattari exorcize the ghost in the machine, but in so doing leave us with a different notion of machine, that of a concrete assemblage of heterogenous elements set to work by the potentials of self-ordering and novelty inherent in the virtual singularities, the attractors and bifurcators, of the actual system and reacting back upon underlying flows as catalysts. In this way the empirical and transcendental geophilosophies of Deleuze and Guattari provide us unparalleled opportunities for research, intervention, and creation, for finding a “new earth.”

D/G critique *hylomorphism*, following Gilbert Simondon. Self-organizing matter does not need the imposition of a transcendent form to organize its putative chaos. The forced choice or exclusive disjunction: chaos or state-form, for instance, is the root of fascism. *Après nous, le déluge*. By overthrowing long-term determinism in locating innovation, novelty, creativity in matter (albeit in its virtual thresholds and changing structure of virtual fields or phase spaces), chaos/complexity disrupts the materialism = determinism equation and its concomitant forced choice of monistic materialist determinism or spiritualist dualist freedom. Common sense dictates (literally): since monistic materialism is determinism, and since we must preserve the phenomena of freedom, then we must pay the price of a spiritualist dualism.

It's important (as Gross & Levitt abjure), to specify Deleuze and D/G's "speculation." Nonlinear dynamics is well-established in physical chemistry (Prigogine) and an interesting avenue in evolutionary biology (Kauffman). Thus Deleuze was a "sensitive" who picked up currents in the air and thought through, with Guattari, what a chaos/complexity approach to what a complex econo-psycho-politics might look like. Hints and sketches of chaos/complexity used to jazz up Marx, Freud, Nietzsche, in other words. *A materialism of “bodies politic”*: both individual bodies and social organizations as material systems. On the most basic level, a body politic -- whether “somatic” (the individual body) or “social” (the band, city or empire) -- consists of material input, energy transformation, and output (work and waste). A more complex scheme is available from the study of "complexity theory,” where we see that such systems exhibit both regularity and innovation in their *patterns* (of input, transformation, and output), their *switches* (turning points between patterns), their *thresholds* (which activate switches), and in their *triggers* (events that moves a system to a threshold). A social body (the warrior band, the city or empire) can be thus seen as a body politic, a body arranged in a particular way so that work patterns are triggered by transcendent commands (“kill!”) or immanent rhetorical strategies (“let’s kill ‘em!”). A somatic or personal body is also a body politic, its energy patterns constituted by the social body which trains it for certain capabilities (the soldier stands fast, the warrior surges ahead).

NOTES

{1}.For Laplace, or more precisely, the "demon" of his thought experiment, precise knowledge of initial conditions and universal laws would yield precise knowledge of past and future conditions. The problem with some systems is their

"sensitivity" to slight deviations in our reckoning of their initial conditions. Even the slightest mistake then yields overwhelming discrepancies fairly quickly.

{2}.About DeLanda's "Non-Organic Life," no less severe critics than Paul Gross and Norman Levitt say in their *Higher Superstition: The Academic Left and Its Quarrels with Science* (Baltimore: Johns Hopkins University Press, 1994), p. 267-68n17: "[although] there is some muddle ... [it is] pretty clear and straightforward ... a good and honest job, although one might wish for a more careful delineation of how much of this is really speculative." As readers of *Higher Superstition* will attest, this is praise indeed from Gross & Levitt. Since DeLanda explicitly links his account with Deleuze & Guattari, and since Gross & Levitt somewhat approve of De Landa - although admittedly without mentioning Deleuze & Guattari by name (they do contempuously dismiss Deleuze's treatment of Riemann in his *Cinema* series, although they do not mention the similar treatment in *Mille Plateaux*) - I assume the connection of Deleuze & Guattari and complexity is at least an avenue worth pursuing.