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THE ROLE OF POINCARÉ'S STUDY OF THE CELESTIAL MECHANICS IN THE DEVELOPMENT OF DELEUZE AND GUATTARI'S CHAOSMOLOGICAL THINKING

1. Introduction

Deleuze and Guattari were attentive to the development of scientific theories in cosmology. Their numerous references in the field show that they had a real interest and made an extensive research of a wide spectrum of cosmological works. This acute reading enabled them, for instance, to identify key notions in cosmological scientific theories and integrate them in their thinking, or to distinguish standard and non-standard theories in cosmology. They were also on the lookout for "minoritary" discourses in cosmology that are not established or simply in the margins of the standard cosmological model. Deleuze and Guattari proceed intuitively in their reading of scientific theories, and this is especially true of their relationship with scientific cosmology. More precisely, they can consider a scientific notion as philosophically valid even if its scientific validity has not been empirically confirmed. They often extract one aspect of a scientific theory that become useful to their own philosophical theories, sometimes by giving it a new and unexpected twist. This creative act of interpretation is in line with the overall methodology used in their philosophical work where an original thinker or concept often becomes barely recognizable. Moreover, Deleuze and Guattari never spend time describing the historical context or novelty of scientific theories, and they never expose in details cosmological theories they are using. Their laboratory is not a conventional one as they are experimenting with scientific notions.

What is lost by this intuitive, fragmentary and creative reading is gained in the myriad of interconnections it allows with non-scientific fields such as ontology, arts or ethics. Science remains omnipresent in the work of Deleuze and Guattari, but their aim is not primarily scientific. They do not create new scientific theories and they are certainly not proposing empirical experiments to validate existing scientific theories. Their motivation and ambition remain purely philosophical. As far as cosmology is concerned, their interest is clearly turned to theoretical physics, that is to say observational cosmology has none to very little place in their thinking. From Deleuze and Guattari's philosophical standpoint, empirical evidences are secondary in the sense that they do not show much concern for factual astronomical questions, including those which might support some aspects of their "chaosmology", such as the chaotic rotation of Saturn's moon Hyperion, the real probability for Mercury and Venus to collide, the role played by chaos in galaxy formation, and so on. In their solo and collaborative works, they value instead speculative theories in scientific cosmology (world's energy regeneration, universe born of quantum fluctuations, cosmic fractals, and so on) and explore how some elements of these theories might resonate with non-scientific planes. Doing so, Deleuze and Guattari give to thinking a cosmological impulse or tonality that is dispersed throughout their work.

Relatively few commentaries are touching specifically upon "Deleuze, Guattari and cosmology" [Plotnitsky 2006; Falb 2013; Beaulieu 2016 – more sporadically or indirectly, see also: Massumi 1993; DeLanda 2002; de Beistegui 2004; Bell 2006; DeLanda 2010; Olkowski 2012; Plotnitsky 2012; Protevi 2013]. These contributions are rather cursory and do not offer extensive analysis of Deleuze and Guattari's thinking in relation with scientific cosmology, although they have prepared the ground for a deeper examination of Deleuze and Guattari's chaosmological sensitivity.

Deleuze and Guattari show a true sensibility to cosmological questioning, and to cosmological science in particular. They do not master all of the intellectual tools necessary to grasp the recent advancement in scientific cosmology in their minute details. However, they are well aware of some of the newly developed cosmological theories of their time, including alternative models to the Big Bang such as quantum cosmology which explores, among other things, the role of virtual particles in the origin and development of the universe. Deleuze and Guattari are also interested in possible applications of scientific discoveries on the evolution of the universe, such as the fractals or the thermodynamics of expansion. They quotes scientists who worked in the area of theoretical physics and astrophysics, such as Roland Omnès on the collapsing stars turning into a black holes [Deleuze & Guattari 1987, 521, n. 1], Jean-Pierre Luminet on the cosmic horizon [Deleuze & Guattari 1994, 220 n. 2] and Ilya Prigogine (who dedicated about ten years of his research to cosmological issues) in relation with virtual particles [Deleuze & Guattari 1994, 118, 225, n. 1] and chaos [Deleuze & Guattari 1994, 206, 233, n. 7]. In some cases, they refer to – or make creative use of – cosmological theories without explicitly quoting their authors, as in the case of Henri Poincaré.

In what follows, the paper discusses some of the connections between Deleuze and Guattari's thinking and Poincaré's scientific theories in celestial mechanics, with regard to chaos theory, orbital resonance, fractals theories, and the notion of problem in science and philosophy.

2. Deleuze and Guattari's chaosmos and Poincaré's three-body problem

The notion of "chaosmos" [Deleuze 1994, 57, 199, 219, 299; Deleuze & Guattari 1987, 6, 313; Deleuze & Guattari 1994, 204-208], which combines "cosmos" and "chaos", is emblematic of the hybrid mixtures or "fuzzy aggregates" that are present in Deleuze and Guattari's work. It is borrowed from James Joyce's *Finnegans Wake* where it appears as a hapax [Joyce 1966, 118]. Deleuze might have encountered the notion while reading Umberto Eco's interpretation of Joyce's "chaosmos" in the final chapter of *L'Œuvre ouverte* [Eco 1965; English version of that chapter: Eco 1989]. It is plausible to think that Eco was un intercessor between Joyce and Deleuze if we consider that, in *Difference and Repetition* [1994, 313, n. 23], Deleuze refers to Eco's book where Joyce's chaosmos is discussed. That said, both Joyce's *Finnegans Wake* and Eco's *L'Œuvre ouverte* are referenced in Deleuze's *Difference and Repetition*. And Deleuze was also a good reader of Joyce, who is an important figure in his work. In any event, the appropriation by Deleuze and Guattari of Joyce's notion of chaosmos is not a mere iteration, but rather a differential repetition. Already in *Difference and Repetition*, Deleuze gives to Joyce's chaosmos a new twist informed by the theories of complex systems – although Eco opened a similar perspective in *L'Œuvre ouverte*. Joyce might have anticipated the coming of fractal and chaos theories as he was forging the neologism, or perhaps he heard about the work of the famous French mathematician Henri Poincaré as he was writing *Finnegans Wake* in Paris in the 1920s and 1930s.

In his seminal treaty entitled *Sur le problème des trois corps et les équations de la dynamique* [Poincaré 1890], translated in English as *The Three-Body Problem and the Equations of Dynamics* [Poincaré 2017], Poincaré introduced nothing less than chaos in science by developing a groundbreaking theory of nonlinear dynamical systems [Diacu & Holmes 1996; Barrow-Green 1997]. By using mathematical tools, Poincaré successfully "solved" for the very first time the highly complex problem of gravitational interactions between three celestial bodies inherited from the Newtonian mechanics. The word "solved" is in quotation marks because the solution of the three-body problem is such that there is no determined and unique solution. Poincaré demonstrated that the three-body problem is impossible to solve. Mathematically, it is not integrable. Concretely, Poincaré showed that one cannot predict with certainty the exact location of a planet (or more generally a celestial body) interacting with two others. In other words, there is no determined location at time t or no function that would predict precisely a unique location in the future; there is instead a series of possible states that can be represented in a "phase state" or "phase space". A phase space is a two-dimension representation, or a mapping out, of the motion of a body which is moving in three dimensions by following a series of possible trajectories, each of these trajectories being determined by various initial conditions. In the case of chaotic systems, these possible trajectories are shaping a set of curves which are drawing a fractal object (later theorized by Mandelbrot in the path of Poincaré). In chaos theory, the phase space allows a visualization of the fractal attractor that is orchestrating the trajectories of the chaotic system. Poincaré's pioneering work on the mathematics of complex dynamic systems is using the phase space. He did not benefit from the necessary technological advancements, namely computer modeling, that would have allowed him to actually see and describe fractal attractors, but his outstanding mathematical skills rightly confirmed that the location of the three interacting celestial objects cannot be predicted with certainty since they are following possible trajectories, more so in a distant future. Their possible trajectories are shaping a curve which correspond to the solution of the three-body problem.

Poincaré's discovery contributed to break with Pierre-Simon Laplace's optimism regarding the celestial mechanics. Deleuze and Guattari [1994, 129, 206] seem to be pointing out implicitly to Poincaré when they posit the "constitution of a chaosmos internal to modern science" against Laplace's "God". In the 18th century, Laplace imagined a supreme intelligence potentially able to determine the location at any given time in the whole universe of any entity, from tiny atoms to planets, as long as initial conditions are provided. In Laplace's words:

> We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes [Laplace 1951, 4].

In the context of the "three-body problem", where celestial movements of planets are studied, the effect of general relativity – developed by Einstein a few decades after Poincaré's work on the three-body problem – can be neglected as the velocity of planets in the solar system is small compared to the speed of light, and the gravitational field is weak compared, for instance, to black holes. It is only in the 1990s that the "n-body problem" found its solution [Wang 1991], including for systems subjected to general relativity. The solution to the "n-body" problem involves a considerable higher level of mathematical difficulty. Poincaré's solution to the three-body problem was already a major step in understanding the dynamics of complex gravitational systems.

What Poincaré discovered is the extreme sensitivity of complex systems to their initial conditions. In other words, a small domain of initial conditions does not generate a convergence of series toward quasi-periodic solutions. Complex systems are unstable and non-periodic, they challenge determinism. A slight imprecision in the determination of the position, mass or velocity of a planet will multiply exponentially the error in predicting its exact trajectory and future coordinates at time *t*. Empirically, the degree of precision in the measurement of complex parameters can never be adequate (similar to measuring a coastline by using always smaller rulers), and so predictions reach a limit at a certain point and eventually the level of certainty reaches "0%". Poincaré proved it mathematically by studying the three-body problem for which the classical Newtonian mechanics provides no satisfying answer.

The mapping of the phase space, which allows a visual representation of all possible states of a system, and which can shape a fractal in the case of deterministic chaotic systems, is impossible to do by hand. Poincaré did not have access to the required computational tools to figure out fractals (Edward N. Lorenz and Benoit Mandelbrot will in the 1960s and 1970s) and strange attractors (introduced in the 1970s by scientists like David Ruelle, Floris Takens and Michel Hénon). Also, Poincaré associated his solution of the three-body problem neither to chaos nor to the extreme sensitivity of complex systems to initial conditions. However, his theory is clearly pointing out in these directions, which will become more obvious in the 1960s and 1970s with the development of chaos and fractal theories. This is why Mandelbrot considered Poincaré «the first student of fractal ('strange') attractors» [Mandelbrot 1982, 414; Duffy 2013, 30]. From a much broader historical perspective that goes back to the pre-Socratics, Anaxagoras is seen by some as a distant precursor of Poincaré and fractal theories [Grujić 2001]. Indeed, Anaxagoras presented an alternative view to Democritus' conception of the indivisible atoms by considering that matter can be divided *ad infinitum*. Each material part of matter contains replicas of everything else or, as Anaxagoras famously said: "In all things there is a portion of everything".

In the late 1980s and early 1990s, thanks to the advancements in computer technology, observations confirmed Poincaré's theoretical views regarding the instability of the solar system. Indeed, orbital eccentricities of planets were studied by astronomers and engineers [Sussman & Wisdom 1988; 1992; Laskar 1989; 1990; 1992; Laskar & Froeschlé 1991] who showed that various types of perturbation such as gravitational fields, variation of masses, flattening of the planets, velocity, orbital resonances, and so on, are influencing the trajectories of planets. These variations, even if very small, are enough to make of the Solar system's motion a non-periodic and chaotic system. The instability is especially significant for the inner planets (Mercury, Venus, Earth, Mars; also known as "telluric" or "rocky planets"). Jacques Laskar, who is one of the leaders in the study of the instability of the Solar system, writes:

> This does not mean that after such a short timespan we will see catastrophic events such as a crossing of the orbits of Venus and Earth; but the traditional tools of quantitative celestial mechanics (numerical integrations or analytical theories), which aim at unique solutions from given initial conditions, will fail to predict such events [Laskar 1989, 237].

The trajectories of planets remain stable and predictable for the next 10 million years or so from now, and the prediction becomes probabilistic between circa 10 and 100 million years from now. However, in about 100 million years from now «a perturbation as small as 10^{-10} of the initial conditions will lead to 100% discrepancy after» [Laskar 1989, 238]. Rest assured, the risk of a collision between the Earth and one of our neighbor planets (Venus and Mars) remains "0" for the next 100 billion years! There is a zone of clearance on each side of the Earth which might indicate that such collision between the Earth and another planet (or other planets) occurred at an earlier stage of the Solar system. It is worth noting that, not only the exact location of the Earth in a distant future cannot be predicted, but its precise trajectory in a remote past cannot be determined either. As for the outer planets of the solar system (Jupiter and on, also known as the “Jovian planets” or “gas planets”), their trajectories remain relatively stable, at least more stable than the inner planets, and there is no planetary collision in the forecast there!... However, the trajectories of Mercury and Venus are more unstable and the risk of them colliding at some point in a distant future is real.

Orbital resonance is another factor to consider in order to explain the exponential divergence in the prediction of the trajectories of celestial bodies. These resonances generate periodic disturbance by amplifying the small fluctuations of the initial conditions. For instance, an asteroid has a 2/5 orbital resonance with Jupiter if it takes Jupiter two orbits around the Sun and the asteroid five orbits around the Sun for Jupiter and the asteroid to be again at the closest from each other. The mass of Jupiter will repetitively disrupt the movement of the asteroids affected by the resonance. Today, the notion of resonance is used in various fields of mechanics to study the frequency of different systems. The philosopher and physicist Pierre-Simon Laplace (1749-1827) was the first to study orbital resonances.

3. Resonance between a physical chaosmos and a mental chaosmos

Deleuze makes a significant use of the notion of “resonance”, for instance in *Difference and Repetition* in reference to Simondon’s conception of internal resonance series which, although disparate, «maintains as a condition the requirement of resemblance between series» [1994, 318, n. 25]. Still in *Difference and Repetition*, in reference this time to Gombrowicz’ book *Cosmos* which «outlines a theory of disparate series, their resonance and of chaos» [1994, 318, n. 26]. *A Thousand Plateaus* calls attention to Simondon’s «phenomena of resonance between different orders of magnitude» [Deleuze & Guattari 1987, 522, n. 17]. In *What is Philosophy?*, the philosophical concept is said to be the «chaoid state par excellence» that «refers back to a chaos rendered consistent» [Deleuze & Guattari 1994: 208], and the philosophical concept gains its consistency when it «freely enter[s] into relationships of nondiscursive resonance» [Deleuze & Guattari 1994, 23]. There is no reference to Laplace's orbital resonance in Deleuze and Guattari's work, but clear connections can be found between their notion of resonance and the deterministic chaos, or the chaosmos, envisioned by Poincaré.

That said, the chaotic motions of planets in the Solar system, which is an empirical fact, plays no explicit role in Deleuze and Guattari's work. Neither does the dissipative processes in galaxy formation and galaxy evolution, whose dynamics prove to be equally chaotic [Contopoulos 2002]. In all likelihood, Deleuze and Guattari did not find appealing empirical evidences and their concepts call for an imaginative experimentation rather than an experimental validation. Using the divergent trajectories of planets and galaxies to support the existence of a "chaosmos" would be reductionist for Deleuze and Guattari. It would be too philosophically simplistic to turn the complexity seized by science into a universal principle. For Deleuze and Guattari, the challenge is not merely to find out if, and under which circumstances, deterministic chaos does exist; this is what astronomers and astrophysicists interested in deterministic chaos are investigating on. Rather, Deleuze and Guattari's chaosmic philosophy aims at exploring how the following three facets of reality can coexist in a hybrid universe: (1) deterministic chaos (or the chaos rendered consistent by a function, a concept or a block of sensation), (2) random chaos or chaos as disorder (or the virtual field where all possible forms are created and annihilated almost instantaneously), and (3) the classical causality (or the simple cause-effect relationship in everyday life that shall not be considered as a mere illusion).

There is perhaps a more generic reason why Deleuze and Guattari did not consider the scientifically confirmed chaotic movements of celestial objects as paradigmatic for their conception of the chaosmos. This other reason has to do, this time, with the Nietzschean call to remain faithful to the Earth. Reducing the chaosmos to a heavenly fact fails to consider that the surface of the Earth, the Earth's territories and the Earth's creatures are themselves geodynamic and intensive. Moreover, the existence of a physical chaosmos in outer space, beyond the earth's atmosphere, shall not obliterate the existence of a «mental chaosmos» [Deleuze & Guattari 1994, 208; Guattari 1992]. For Deleuze and Guattari, the physical or astronomical chaosmos finds a resonance at an immaterial level of reality since their philosophical chaosmos involves elements, such as imperceptible becomings, invisible affects, virtualities, and so on, which escape the most accurate scientific devices while being part of reality. In other words, a chaosmological imagination, far more than astronomical facts, is entailed in Deleuze and Guattari's thinking.

4. The notion of "problem" within a chaosmological framework

Deleuze and Guattari refer directly neither to Poincaré nor to Poincaré's three-body problem applied to celestial objects. Oddly enough, though, *A Thousand Plateaus* makes two references to the "three-body problem", but none of them is referencing Poincaré. Both references show an attempt to reterritorialize the "three-body problem" on other non-celestial fields: a first time in connection with the identification of a "three-body problem" analogously found in Artaud (the full, the destratified and the cancerous BwO), and a second time in relation with the smooth and the striated spaces [Deleuze & Guattari 1987, 163 and 489]. Apart from, or beyond, this creative integration of Poincaré's "three-body problem", Deleuze and Guattari showed a great interest in Poincaré's theoretical and more general views regarding the non-integrability of dynamic systems, even if the reference to Poincaré is, again, not explicit.

It is plausible that Deleuze initially encountered Poincaré's work through the exegesis of the mathematician Albert Lautman [2006] who is a significant figure in the architectonic of *Difference and Repetition* (especially in chapters 3 and 4). Deleuze highlights the metaphysical aspect of Poincaré's discovery regarding what chaos theorists (Edward N. Lorenz and others) will call, decades later, the "sensitivity to initial conditions" which makes the overall trajectory of complex systems unpredictable. The "solution" to the three-body problem in celestial mechanics might be interesting for itself, as it provides a mathematical explanation for chaotic dynamics in the physical world, but Deleuze (later on with Guattari) shows a higher fascination for the theoretical model that Poincaré developed a few years before combining it with the three-body problem. This general model is described in Poincaré's

Mémoire sur les courbes définies par une équation différentielle [Poincaré 1881-1886; with a commentary by Lautman 2006, 215-218, 228, 295].

According to Poincaré's "qualitative theory of differential equations" [Barrow-Green 1997, 29-41], presented by Poincaré in his *Mémoire*, some mathematical problems have no quantitative solution. They are not integrable and only "qualitative" information about the behavioral properties of their solutions, which are shaping geometric curves in the neighborhood of singular points, can be obtained. These singular points are of four possible types with distinct geometrical appearance: node (through which an infinite number of solutions in passing), saddle point (through which two curves are passing), focal point or foyer (around which the solution curve turns into a logarithmic spiral) and centre (around which solutions are concentric) [Lautman 2006, 216]. A passage from *Difference and Repetition* [Deleuze 1994, 177] makes a clear reference to these four types of singular points without, however, mentioning the name of Poincaré. It is an implicit reference to the famous mathematician mediated by Lautman. This passage from *Difference and Repetition*, where Poincaré's singular points are evoked, is part of an attempt to rethink the history and metaphysics of calculus as well as the notion of differentiation [Duffy 2013, 27-31]. More importantly for us here, it also aims at rethinking the traditional notion of "problem" in philosophy.

In *Difference and Repetition* [1994, 176-178], Deleuze draws an analogy between Poincaré's qualitative approach to differential equations (that will be applied to the resolution of the three-body problem) and the non-solvability of "real" philosophical problems. For Deleuze, real problems in philosophy are condemned to remain problematic as they lead potentially to an infinite number of solutions, or to other unsolvable problems. Similar to Poincaré, for whom a singular point in a complex system can only find qualitative solutions with no determined quantitative function, philosophical problems according to Deleuze can find a myriad of possible immanent solutions without transcendent explanation. In *Difference and Repetition*, there is a substantial note in which Deleuze attributes the theory of irreducible problems in mathematics to Lautman [Deleuze 1994, 324, n. 9]. However, Deleuze forgets to mention that the passage he is referring to is taken from a section entitled «Les méthodes de Poincaré» that is included in one of Lautman's books [Lautman 2006, 215-218] where Lautman is commenting on Poincaré's conception of complex solutions to problems in mathematics. Despite Deleuze's "second-hand" reading of Poincaré (through Lautman), it is striking to see the similitude between the mathematician and the philosopher with regard to their conception of "problem". See for instance the following excerpt taken from Poincaré's book entitled *Science and Method*, which sounds almost Deleuzean *avant la lettre*:

> Formerly an equation was not considered to have been solved until the solution had been expressed by means of a finite number of known functions. But this is impossible in about ninety-nine cases out of a hundred. What we can always do, or rather what we should always try to do, is to solve the problem *qualitatively*, so to speak – that is, to try to know approximately the general form of the curve which represents the unknown function. It then remains to find the *exact* solution of the problem. But if the unknown cannot be determined by a finite calculation, we can always represent it by an infinite converging series which enables us to calculate it. Can this be regarded as a true solution? [...] *There are, therefore, no longer some problems solved and others unsolved, there are only problems more or less solved, according as this is accomplished by a series of more or less rapid convergence or regulated by a more or less harmonious law* [Poincaré 1914, 37-38; we emphasize].

Poincaré's conception of a solution that remains problematic in the mathematical study of dynamic systems finds a resonance in Deleuze's critique of the dogmatic image of thought. Many passages from *Difference and Repetition* could be used to support it, including the following one which shows how Poincaré (again read through Lautman) seems to be translated in philosophical terms by Deleuze for whom Ideas are not solutions, but remains problems "more or less solved":

> We must investigate the manner in which questions develop into problems within Ideas, how problems are enveloped by questions within thought. Here too, the classical image of thought must

> be confronted with another image, this one suggested by the contemporary renaissance of ontology. […] Problems or Ideas emanate from imperatives of adventure or from events which appear in the form of questions. […] The imperatives and questions with which we are infused do not emanate from the I: it is not even there to hear them. The imperatives are those of being, while every question is ontological and distributes 'that which is' among problems. Ontology is the dice throw, the chaosmos from which the cosmos emerges [Deleuze 1994, 196, 197, 199].

In *Bergsonism*, Deleuze discusses Bergson's critique of "false problem" presented as the first rule of Bergson's method [Deleuze 1991, 15-21]. This discussion coheres in broad outline with Poincaré's conception of "problematic solutions", but one also feels that Bergson's spiritualist and anti-scientific approach is not entirely compatible with the chaosmic background of *Difference and Repetition*, and more largely with Deleuze and Guattari's chaosmological thinking. In *Difference and Repetition*, Deleuze finds in Poincaré a more suitable companion to develop his ideas surrounding the notion of "problem" in philosophy. I would venture the following interpretation: to the eyes of Deleuze, Poincaré's conception of problems that are no longer "solvable" but rather remain "more or less solved", combined with Deleuze's own attempt to develop a creative new image of thought in the field of ontology, is closer to Nietzsche's perspectivism than to Bergson's critique of false problem which remains methodologically grounded in the subject. Perspectivism has the advantage of being more respectful toward the specific logic inherent to each of the various forms of thought (science, art, philosophy), in comparison with Bergson, who invariably adopts a spiritual standpoint against the various domains of knowledge he is criticizing. Perspectivism does not hypostasize spirituality, it does not devalue the material aspects of reality. Deleuze and Guattari' Spinozism is at odds with such "a-perspectivist," subjectivist and spiritualist standpoint as shown, for instance, by their esteem for the scientific study of nature. The critique of Bergson's take on science cannot be more clearly formulated than in this passage from *What is Philosophy?*: «When philosophy relegates science to the 'already-made' and reserves for itself the 'being made', like Bergson or phenomenology, and particularly in Erwin Straus, we not only run the risk of assimilating philosophy to a simple lived but give a bad caricature of science» [Deleuze & Guattari 1987, 155]. In short, one could say that Deleuze (later on with Guattari) attempted to position Poincaré's scientific theories (read through Lautman), and Poincaré's notion of problem in particular, as Nietzschean. Poincaré's scientific notion of problem is transposed to the field of philosophy. This Nietzscheanization of Poincaré provides arguments against Bergsonism.

Similar to the "three-body problem" in celestial mechanics, philosophical problems begin, for Deleuze and Guattari, with singular points analogous to the sensitive initial conditions in science, and they invariably end up being "more or less solved". Complex scientific systems (such as n-bodies systems), no less than complex philosophical systems (such as Deleuze and Guattari's own), originate from and are projected into a semi-organized chaos. Similar to Deleuze and Guattari's concepts, which are made of singularities, Poincaré's qualitative answers to non-integrable problems are not errors, but they simply remain "vague and yet rigorous".

Scientific ideas and discoveries surrounding the three-body problem, the unpredictable trajectories of planets, the orbital resonance, the dissipative processes in galaxies, the qualitative theory of differential equations, and so on, these topics all relate to the study of the chaotic movement of celestial bodies. They show that our universe is far less ordered and harmonious than the cosmological tradition thought, from the Greeks until relatively recently. Not that the universe is totally hectic and unpredictable, but rather the universe's becoming encompasses quite a number of unforeseeable states. The scientific discoveries regarding the "chaosmic universe" interfere with Deleuze and Guattari's chaosmological thinking. As we mentioned, however, Deleuze and Guattari do not rely on scientific empirical evidences regarding the chaosmic universe to support their chaosmic philosophy because, ultimately, philosophy deals more with imagination and values than with facts. Also, they carefully avoid limiting the chaos to the realm of the celestial. For sure, fractal and chaos scientists, who are the heirs of Poincaré's discovery of non-integrable systems, do not only consider the fractal aspect of the vast universe (or multiverse) drawn by chaotic attractors. They also investigate on the fractals features of earthly objects, such as tree branches, river deltas, some flowers of vegetables, the arborescence of the lungs, and so on [Mandelbrot 1982]. However, the standpoint of fractal theorists remains (obviously) scientific, whether they are investigating on fractals from outer space or fractals down here on earth.

The novelty introduced by Deleuze and Guattari, with regard to deterministic chaos, has to do with the extension of the chaosmic in non-scientific fields, namely into cultural productions (art and philosophy), as well as with unveiling possible interferences between the "three forms of thought" (science, art and philosophy) presented as «Chaoids» [Deleuze & Guattari 1994, 208]. Deleuze and Guattari are receptive to scientific findings regarding the chaosmic aspects of nature all the way to the gigantic universe. And certainly, for them, the chaosmos is not only present in nature; there is also a chaosmos inherent to modern art as well as a mental chaosmos in philosophy. The transversal nature of Deleuze and Guattari's chaosmology is akin to the traditional cosmologies which integrated everything from the infinitely small to the infinitely big, including the human body and soul. However, the coherent and harmonious aspects inherent to ancient cosmologies leave place, for Deleuze and Guattari, to a partly undetermined universe whose organization is consistent with Poincaré's model of an unforeseeable dynamic of celestial bodies.

5. Conclusion: from conventional cosmology to nomadic chaosmology

In *A Thousand Plateaus*, Deleuze and Guattari criticize the "royal science" according to which, among other things, real problems are perfectly solvable. The critique of the royal science does not mean that scientists should abandon all endeavors aiming at solving problems. On the contrary, science made exceptional contributions in understanding the world we live in, and it did so in large part by solving problems. Deleuze and Guattari never put into question this dynamic of scientific progress. Their critique of the royal science should rather be read as a resistance to the reduction of science to a problem-solving program, a call to complexify the purpose of science, and perhaps, as well, a call to introduce more philosophy in the scientific discourse. Introducing more philosophy in science does not primarily mean developing an ethics of science in charge of assessing the value of scientific advancements. It shall rather be understood as favoring channels to debate the limits of scientific works which are aiming at solving problems in the pre-Poincaré sense. The possibilities of integrating alternative outlooks or "minoritary discourses" in science would then be more openly discussed. For Deleuze and Guattari, the assemblages or "fuzzy aggregates", which would gather conventional and less conventional attitudes, are necessary, especially in our modernity where science and imagination are more disconnected than ever. Therefore, Deleuze and Guattari's chaosmology implies a call for challenging the standard cosmological model with non-standard approaches. Although Deleuze and Guattari did not actively participate in face to face debates with physicists, they provide arguments for finding ways to destabilize preconceived ideas in science. For them, the machinery of the universe requires scientific and philosophical abstract machines. Science will certainly continue to provide astonishing answers to solvable problems, but Deleuze and Guattari would consider it reductionist if science was to confine itself to a logic of problem solving. Such a logic of problem solving belongs to the past when philosophers and scientists believed in a well-ordered and simpler cosmos.

From a Deleuzo-Guattarian perspective, the standard cosmological model could be seen as promoting a conventional attitude characteristic of the "royal science". Consequently, physicists specialized in cosmology could also read Deleuze and Guattari's work as an invitation to leave more room for a nomad science capable of following emerging chaotic lines of flight, an invitation to remain open to cosmological problems which can only be "more or less" solved. These types of problems are calling for qualitative solutions which mobilizes the imagination. This is not new to science. Indeed, independently from Deleuze and Guattari, many cosmologists already took alternative paths either by exploring deterministic chaos in the complex celestial mechanics, or by developing speculative theories regarding the origin and becoming of the universe (bubble universe, parallel universes, and so on). These speculative theories, however, are often considered as unscientific by mainstream scientists.

That said, the distinction between royal and nomad sciences might remain too general to feed up a true dialogue between philosophy and scientists working in cosmology. In order to integrate better the philosophical and scientific discourses, perhaps one would have to ask more specific questions such as: Can the Deleuzo-Guattarian theories and concepts (virtual, immanence, difference and repetition, assemblage, abstract machine, and so on) be useful for scientific cosmology? Does it have the potential to inspire new intuitions in theoretical physics? Though, no answer to such questions can be found in Deleuze and Guattari's work, and these kinds of questions should be redirected to scientists in order to avoid the indignity of speaking for others. In an interview surrounding the publication of *A Thousand Plateaus*, Deleuze once said: «It's not impossible for a philosopher to create concepts that can be used in science» [Deleuze 1995, 30]. He then evokes how Bergson influenced psychiatry, but he modestly keeps away from stating how his own concepts could or did influenced science. Aurélien Barrau [2013; 2015] is the astrophysicist who went the furthest in recognizing the relevance of Deleuze for the renewing of theoretical cosmology, but alas this recognition remains cursory. The scientific relevance of Deleuze and Guattari remains to be discussed by scientists working in cosmology. We will hopefully hear more, in the time to come, from theoretical physicists' readers of Deleuze and Guattari's work.

Deleuze and Guattari's perspective on cosmological issues remains primarily metaphysical. They do not pretend to do science, they certainly do not make scientific predictions, and they do not expect their theories to be empirically validated. They are freely inspired by scientific ideas in cosmology. As "humanists", their chaosmological standpoint relies predominantly on the readers' imagination as they identify possible zones of interference between philosophical and scientific cosmological ideas. In that sense, their posture remains purely classical. They are, in fact, taking part to a long history of continental cosmology initiated by the Greeks. In *Timaeus*, Plato [2008] famously integrated the most advanced mathematics of his time (regular polyedra, lambda geometric progression, and so on) in his speculations surrounding the armillary sphere that symbolizes the World soul. Similarly, Deleuze and Guattari's chaosmological thinking combines some of the most advanced scientific theories of their time (quantum physics, fractals, chaos theory, and so on). The difference being that, from Plato to Deleuze, the universe went from being perfectly harmonious to becoming chaosmic.

Furthermore, it might be that some scientific cosmologists still relate metaphysically, somehow secretly, by carrying unexamined preconceptions, to a more or less large extent, and in an unjustified way, to outdated ideas conveyed by tradition. In that sense, the standard cosmological model, in its attempt to offer a universal explanation by leaving little room to non-standardizable lines of flights, might be the fruit of an outdated conventionalist attitude. The opposite is also true: some philosophers might relate to wrong ideas conveyed by tradition about the cosmos. By ignorance or lack of concern, the mind of these philosophers is tied to a defunct harmonized cosmos.

Informed by scientific theories and hypothesis, Deleuze and Guattari are proposing a creative and imaginative alternative to most of the cosmological prejudices inherited from the tradition. Indeed, for Deleuze and Guattari, chaos is not pure disorder and the world is not perfectly ordered (which is a traditional view), but the universe is rather a hybrid chaosmos; there is no great celestial harmony of the spheres (promoted by Pythagoras, Kepler, and others), but rather a folding of divergent series; the universe is not static (as in all of the tradition until and including Einstein), but it rather becomes chaotically dynamic; the universe was not created by God or a divine artisan (in the Platonico-Biblical tradition), but it is rather born from a quantum void; the universe is not contained in an Euclidean space, but rather takes the shape of a fractal; the universe is not hylomorphic (to use Aristotle's terminology), but is rather in the midst of processes of individualization, and so on. In short, the fully representational cosmos in the tradition (it can be drawn!) leaves place in Deleuze and Guattari's thinking to a chaosmos which escapes representation.

These ideas are certainly subversive, but they are not subversive for the sake of being subversive. It would be a mistake to consider Deleuze and Guattari's non-representational chaosmos as the fruit of young anarchic rebels. Deleuze and Guattari's philosophical chaosmos rather comes from the mind of well-intentioned thinkers who are generously, originally and skillfully showing how much continental philosophy is behind with regard to other fields of knowledge such as scientific cosmology. Continental thinkers massively come to disregard the cosmological science, overwhelmed by the complexity of the scientific study of the universe. Deleuze and Guattari rather chose to interfere philosophically and nomadically with it. Poincaré's scientific ideas discussed in this paper are astonishingly in tune with this nomadic wandering.

References

Barrau, A. [2013], *Big Bang et au-delà*, Paris, Dunod.

Barrau, A. [2015], Deleuze l'insuffisant, https://blogs.mediapart.fr/edition/gilles-deleuze-aujourdhui/article/250515/aurelien-barrau-deleuze-linsuffisant (accessed August 8, 2022)

Barrow-Green, J. [1997], *Poincaré and the Three-Body Problem*, Rhode Island, American Mathematical Society.

Beaulieu, A. [2016], Introduction to Gilles Deleuze's Cosmological Sensibility, in: *Philosophy and Cosmology. Journal of the International Society of Philosophy and Cosmology* 16, 199-211.

Bell, J.A. [2006], *Philosophy at the Edge of Chaos. Deleuze and the Philosophy of Difference*, Toronto, University of Toronto Press.

Contopoulos, G. [2002], *Order and Chaos in Dynamical Astronomy*, Berlin, Springer.

De Beistegui, M. [2004], *Truth and Genesis. Philosophy as Differential Ontology*, Bloomington, Indiana University Press.

DeLanda, M. [2002], *Intensive Science and Virtual Philosophy*, New York, Continuum.

DeLanda, M. [2010], *Deleuze. History and Science*, New York/Dresden, Atropos Press.

Deleuze, G. [1991], *Bergsonism*, transl. H. Tomlinson and B. Habberjam, New York, Zone Books. (Original work published 1966)

Deleuze, G. [1994], *Difference and Repetition*, transl. P. Patton, New York, Columbia University Press. (Original work published 1968)

Deleuze, G. [1995], *Negotiations*, transl. M. Joughin, New York, Columbia University Press. (Original work published 1990)

Deleuze, G., Guattari, F. [1987], *A Thousand Plateaus*, transl. B. Massumi, Minneapolis, University of Minnesota Press. (Original work published 1960)

Deleuze, G., Guattari, F. [1994], *What is Philosophy?*, transl. H. Tomlinson and G. Burchell, New York, Columbia University Press. (Original work published 1991)

Diacu, F., Holmes, P. [1996], *Celestial Encounters. The Origins of Chaos and Stability*, Princeton, Princeton University Press.

Duffy, S.B. [2013], *Deleuze and the History of Mathematics*, London/ New York, Bloomsbury.

Eco, U. [1965], Chap. VI: De la 'somme' à 'Finnegans Wake.' Les poétiques de James Joyce, transl. C. Roux de Bézieux and A. Boucourechliev, in: U. Eco, *L'Œuvre ouverte*, Paris, Seuil, 169-304. (Original work published 1962)

Eco, U. [1989], *The Middle Ages of James Joyce, The Aesthetics of Chaosmos*, transl. E. Esrock, Cambridge (MA), Harvard University Press. (Original work published 1962)

Falb, D. [2013], The Circumference of the Earth. Deleuze and Cosmology, www.academia.edu/10683650/The_Circumference_of_the_Earth._Deleuze_and_Cosmology (accessed August 8, 2022)

Grujić, P.V. [2001], The concept of fractal cosmos: I. Anaxagoras' cosmology, in: *Serbian Astronomical Journal* 163, 21-34.

Guattari, F. [1992], *Chaosmose*, Paris, Galilée.

Joyce, J. [1966], *Finnegans Wake*, New York, The Viking Press. (Original work published 1939)

Laplace, P.-S. [1951], *A Philosophical Essay on Probabilities*, transl. F.W. Truscott and F.L. Emory, New York, Dover Publications. (Original work published 1814)

Laskar, J. [1989], A Numerical Experiment on the Chaotic Behavior of the Solar System, in: *Nature* 338, 237-238.

Laskar, J. [1990], The chaotic motion of the solar system: a numerical estimate of the size of the chaotic zones, in: *Icarus* 88, 266-291.

Laskar, J. [1992], La stabilité du système solaire, in: A. Dahan, J.-L. Chabert, K. Chemla (eds.), *Chaos et déterminisme*, Paris, Seuil, 170-211.

Laskar, J., Froeschlé, C. [1990], Le Chaos dans le système solaire, in: *La Recherche* 22/232, 572-582.

Lautman, A. [2006], *Les Mathématiques, les idées et le réel physique*, Paris, Vrin. (Original work published 1933-1944)

Mandelbrot, B. [1982], *The Fractal Geometry of Nature*, New York, WH Freeman and Co.

Massumi, B. [1993], *A User's Guide to Capitalism and Schizophrenia: Deviations from Deleuze and Guattari*, Cambridge, MIT Press.

Olkowski, D.A. [2012], *Postmodern Philosophy and the Scientific Turn*, Bloomington, Indiana University Press.

Plato [2008], *Timaeus and Critias*, transl. D. Lee and T.K. Johansen, London/New York, Penguin Books.

Plotnitsky, A. [2006], Chaosmologies: quantum field theory, chaos and thought in Gilles Deleuze and Félix Guattari's *What is Philosophy?*, in: *Paragraph* 29 (2), 40-56.

Plotnitsky, A. [2012], From resonance to interference: the architecture of concepts and the relationships among philosophy, art and science in Deleuze and Guattari, in: *Parallax* 18 (1), 19-32.

Poincaré, H. [1881-1886], Mémoire sur les courbes définies par une équation différentielle, in: *Journal de mathématiques pures et appliquées*, Part 1: 3^{e} série, Tome 7, 1881: 375-422; Part 2: 3^{e} série, Tome 8, 1882: 251-96; Part 3: 4^{e} série, Tome 1, 1885: 167-244; Part 4: 4^{e} série, Tome 2, 1886: 151-218.

Poincaré, H. [1890], Sur le problème des trois corps et les équations de la dynamique, in: *Acta Mathematica* 13, 1-270.

Poincaré, H. [1914], *Science and Method*, transl. Fr. Maitland, London, Thomas Nelson and Sons. (Original work published 1908)

Poincaré, H. [2017], *The Three-Body Problem and the Equations of Dynamics*, transl. B.D. Popp, Berlin, Springer. (Original work published 1890)

Protevi, J. [2013], *Life War Earth. Deleuze and the sciences*, Minneapolis, University of Minnesota Press.

Sussman, G.J., Wisdom, J. [1988], Numerical evidence that the motion of Pluto is chaotic, in: *Science* 241 (4864), 433-437.

Sussman, G.J., Wisdom, J. [1992], Chaotic evolution of the solar system, in: *Science* 257 (5066), 56-62.

Wang, Q.-D. [1991], The global solution of the n-body problem, in: *Celestial Mechanics and Dynamical Astronomy* 50 (1), 73-88.

Keywords

Deleuze; Guattari; Poincaré; chaosmos; problem

Abstract

This paper explores the way Henri Poincaré's study of the dynamic movements of celestial bodies – which announces the theory of chaos – coheres with Deleuze and Guattari's chaosmological thinking. The paper demonstrates how topics associated with chaos theory, including the limits of quantitative solutions, phenomena of orbital resonance, fractal attractors, and Poincaré's conception of unsolvable problems, intermingle with Deleuze and Guattari's philosophy. The paper supports the idea that the lines of interference between the new scientific study of chaos initiated by Poincaré, and a chaosmological thinking, are consistent within a partly undetermined universe, or chaosmos.

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