

extract from *the birth of physics*

michel serres, translated by david webb, with an introduction by bill ross

INTRODUCTION

On the occasion of a forthcoming edition of Michel Serres' The Birth of Physics in the Groundworks series with Rowman & Littlefield International, Bill Ross reflects on the unique place of this text in the philosophy of science.

In a way notably infrequent in the discourse of the philosophy of science, Michel Serres' work *The Birth of Physics* arrived with a full-blown unequivocally acknowledged seat at the table of a paradigm shift taking place within the scientific corpus of the day. Chaos theory, crystallised in the seminal work *Order out of Chaos* by Ilya Prigogine and Isabelle Stengers, forcefully foregrounded the importance and predominance of non-linear processes in the operations of nature. This work elevated the significance of the science of thermodynamics and rendered more nuanced our understanding of entropy. Serres' book is cited often in *Order out of Chaos* (more frequently in the French original than the English translation), focusing as it does on themes shared between the two: randomness, the genesis of order, the degradation of physical systems, the openness of the cosmos. The debt to Serres is perhaps most clear in the French title, *Une nouvelle alliance*; a reference to the need for a new paradigm under which to formulate the labours of the physical sciences, a paradigm to replace the Newtonian world view, a necessary

shift to encompass the non-linear signature of nature. Most of all, a recognition that pattern emerges from chaos through repetition, that the Newtonian ideal of defining eternal, unchanging, ubiquitous laws under which to comprehend any process whatever, fundamentally jibes against the grain of constantly permuting nature. Systems, however big or small, can at most form ‘alliances’, fall into more or less coherent cycles, tamp down provisional pathways. And our way of science must reflect this. No longer should we imagine that to artificially designate initial conditions, insulate the evolution of the system under consideration and calculate the result, will serve any purpose other than to deaden the likeness of that system to those in the wild; to master nature is to tame it. We shouldn’t lose sight of the scope of this new paradigm; under the Newtonian framework, the isolated experimental system was the type for *all* systems, and any statistical deviation observed from their inevitably linear progress to equilibrium was to be disregarded as negligible. The realisation that no system is isolated, all ultimately non-linear, was akin to the discovery in the 1930s that the familiar, so to speak domestic form of matter which had formed the entire focus of physics hitherto was a mere fraction of the mass represented by what is now called dark matter.

A new alliance, then. The injunction is coded into the final words of Serres’ text in a shorthand for the non-linear science to come; “Invent liquid history and the ages of water.” Serres publishes in 1977, Prigogine and Stengers in 1979. Everything happens as if the philosopher proposes and the scientist disposes. But of course not, for two reasons. Firstly, both scientist and philosopher were building on and responding to paradigms belonging to the precursor disciplines of Cybernetics and Information Theory. Serres had been weaving these threads into his ambitious Hermès series since 1969. Cybernetics had established the curious causal connections of feedback, while Information Theory had revealed the intimate association of information with physical processes through the operations of entropy. Exotic chemical cycles such as the Bénard Instability and autocatalytic reactions fed into the natural philosophy of Prigogine and Stengers, indeed Prigogine had already championed the idea of ‘dissipative structures’ some time in advance of Serres’ book. Even chaos has a history. Which gives us the second reason; it is the *depth* of history on which Serres draws which differentiates *The Birth of Physics*. If both texts are heralds of ‘the ages of water’, they are so in radically different ways. And in fact, the date of the call for a new alliance is neither 1977 nor 1979, but somewhere rather closer to 50 years BCE.

In *The Birth of Physics*, Serres acts as a conduit for the thought of the ancient Roman atomist Lucretius. He surveys the philosophical and scientific eddies downstream of that author's meditation on order and decay. Leibniz, Kant, Carnot, Boltzmann *et al*, are each in their way shown to echo themes in *De rerum natura*. Serres' faithfulness to the Lucretian text, his readiness to furnish a close reading of the whole, is matched by his ability to reinvigorate the voice for contemporary concerns, and to alight on the conceptual recurrences of Lucretian themes in subsequent ages. He draws out an inexplicit proto-calculus from the work of Archimedes, of the kind that might contemporaneously have served as the mathematics for the Lucretian model. He notes in detail the structural analogies between Leibniz' remarkably dense short piece 'On the Ultimate Origination of Things' and Lucretian cosmology. He draws attention to the presence of an oscillatory system of genesis and dissolution of spiralling worlds in Kant's *Universal Natural History and the Theory of the Heavens*, all significantly prefiguring Clausius, Boltzmann, Wiener and Prigogine. *The Birth of Physics* is very much the story of a virtual scientific spirit subsisting alongside the official history of reason, positivism and empiricism, a spirit essentially opposed to what the physicist Lee Smolin has called "physics in a box."

The Lucretian cosmos is a rich model (or, rather, set of models), one in which, as Serres repeatedly asserts, "nothing is lacking." In the beginning, a body of atoms falling equidistant through the void, at a speed which is no speed, with a movement which is no movement, since there is nothing against which to calibrate. This is, says Serres, stasis, or equilibrium. Then a deviation, which consists in nothing more than the tiniest inclination of some atom or other from the true; the *clinamen*, or swerve. We are encouraged to recognize that this most minimal angle gestures forward to the calculus of the infinitesimal. This deviation, this break from stasis, is nothing less than the genesis of time and place says Serres, for a world which could not hitherto be said to move could not be said to support elapse. From this point, atoms collide, turbulence ensues, and with it form is engendered. Is this disorder emergent from order, from the uninterrupted true downward fall, or is it the reverse, asks Serres; does the order of structure emerge from the disorder of turbulence? This is the precise question for Chaos Theory, for the ages of water. All matter is drawn down, seeking the lowest point, just as a stream finds its bed, but the true downward path, the quickest route, is ever and always deferred by criss-crossing bodies; the lowest point is always at the end of an incline. Here is the same story as told by thermodynamics, by Clausius, Carnot and Boltzmann; energy is constant, yet the long term fate of all systems is to deg-

radation, to maximum entropy. But Serres takes pains to point out that the latest chapter of our modern texts is not lacking in the original; Prigogine's dissipative structures and Rene Thom's catastrophe. The bed of the river itself gives way, all lowest points ultimately give onto points yet lower as systems exhaust their alliances, free to find their reconfigurations in an open-ended universe.

Nothing is lacking in the Lucretian model, not the operations of perception, not the material soul nor human history. All move from equilibrium to turbulence to return to equilibrium. Serres' accomplishment is an act of synthesis of all that lies downstream of the Lucretian text, and one thing more. It is the practice of an art, a new art of science. Ideas percolate through history, Serres believes; they may entertain virtual connections with each other, as Archimedes' geometry did with Lucretius' physics, as Leibniz' metaphysics did with Lucretius' cosmogony. *The Birth of Physics* is performative, it enacts what it says; it traces the recombinations of complex idea-structures in certain times and certain places, fashioned anew as they are by local constraints, allied to their own newly perceived models; for Carnot, heat engines, for Hubble an expanding universe. More particularly, *The Birth of Physics* is the first book-length implementation of the principles of the philosophy of science laid out in Serres' masterly Hermès series. It is the result of Serres' chapter by chapter visitation on some occasion of the history of scientific culture, always following the interconnected threads of an encyclopedia that contains itself.

The accompanying extract relates what Serres terms 'declination' to the notion of 'ataraxy'. Declination refers both to the original deviation of the *clinamen* and to the tendency of nature both metaphorically and sometimes literally to roll down a slope to a point of stability, an entropic decline. Yet any apparent stability is in turn dependent on an underlying metastability, the interplay of turbulence, *ataraxy*. The selection is chosen to convey both the density and the momentum of this brilliant work.

Bill Ross

TURBA, TURBO

The physical theory of turbulence contains a paradox. Laminar flow, the figure of chaos, is at first sight a model of order. The atoms pour out in parallel, without mixing or sticking to each other. These preliminary rows are already a taxonomy, as the word itself indicates. Turbulence seems to introduce a disorder into this arrangement. This is what the language means: *turbare* means a disorder, a confusion, a disruption or, as we say, a perturbation. Disorder emerges from order.

Yet it is the precisely reverse that is to be described and that occurs. Physics tries to explain how things and the world are formed naturally out of the atomic chaos, in other words how an order, or several orders, emerge from disorder. And it is turbulence that secures the transition. This seems contradictory.

The description of the chaos-cloud, of the first nebula is canonical, it is repeated in many places, and in particular in the Book V, on the birth of the world. It deals with the multiple distribution of the great elementary population at the heart of the stormy mass. The terms employed in this description belong to two families, topological and mechanical: intervals, paths and connections on the one hand, weight, movement and collision on the other. These determinations fluctuate. They fluctuate in and by turbulence. The *turbare*, here (Book V 439), is the fluctuation of figures and movements. Order or disorder, it is difficult to decide.

The vocabulary of the following lines provides a local index of the problem. Everywhere else in the poem, terms with a prefix of separation like division, disjunction and so on, indicate a drift towards disorder and what seems to be a return to chaos. Things which are already formed scatter by wear and tear, they disintegrate because they are only porous conjunctions. Everything flows and turns to dust, nothing is stable but the atom, the void and the whole, to which the operator of division can do nothing. Here, on the contrary, disjunction is arrangement, segregation constitutes coherent parts. By earth, air, fire, and water, distribution will lead to the order of the world. The interesting term here is *discludere*, to close by a limit, which has no equivalent in the French language. The dichotomy does not cut, it defines, it surrounds the closure of a limit, it delineates a boundary. Within the space thus enclosed like meets like. Or rather, conversely, the specific convergence [*convenance*] or identity, the assembly of the analogous, delimits zones in the disorder which are distinguished from each other. The earth is separated from the waters, air divides from fire. Thus the operator whose task in general is

to pulverise, works here towards distribution, towards an inchoate organization.

Weight and complexity are the engines of separation. Fall assures difference, as creation. Once again, the fall gives order, as well as drift, decline, disorder. Always the double operator: the fall, here, is productive.

What is true of the divisions and of the fall is not completely so for turbulence. When the ether was separated from the air by its lesser gravity, it tore itself from the tempests, immutable as the Pontus (which also flows), and seemed to enjoy a certain *ataraxy*. Now these troubled storms are the place both of turmoil (*turbantibus, turbare*) and of vortices (*turbinibus*). There is a distance between *turba* and *turbo*. The first designates a multitude, a large population, confusion and tumult. It is disorder: the Greek *τυρβη* (*turbe*), is also used of the mad dancing in Bacchic festivals. But the second is a round form in movement like a spinning top, a turning cone or vortical spiral. This is no longer disorder, even if the whirl is of wind, of water or of storms. In fact, the turning shifting movement is that of the stars, of the heavens, now and originally. The world in its globality may be modelled by vortices. The origin of things and the beginning of order consist simply in the narrow space between *turba* and *turbo*, an incalculable population tossed by storms, by unrest, in vortical movement. Perhaps there is an analogous distance, in French, between *turbulence* and *vortex*, if we take these words in their everyday sense, apart from fluid dynamics. The first is simply disorder and the second is a particular form in movement. Form and movement, linguistically closest to what has no form and whose movement is only fluctuating agitation.

The behaviour of the cone or the top is worth analysing. Throw this toy and describe, as Plato did, what happens. It is in movement, this is certain, yet it is stable. It even rests on its point or its pole, the more so as its movement is rapid. All children know this. But its rest is still more paradoxical. The top may move about, by translation, without ever losing its stability. To repeat, it can do so as long as it turns very quickly. Even better, its axis may lean, take on an inclination, without putting the movement of the whole in too much danger. It may again rock, by nutation, oscillating around a mean location. This very ancient and quite childish machine is marvellously instructive.

First of all, it combines all the movements known and thinkable at the time: rotation, translation, fall, leaning and swaying. An integral model, additive, overcharged, yet simple. Second, and above all, it conjoins in a simple one-off ex-

periment phenomena judged or presumed to be contradictory. It is in movement and at rest, it turns yet does not move, it rocks and is stable. The simplicity of a complexity, first and foremost, an additive machine; a synthesis of contradictions, beyond anything else. Now it may serve as a little model of the world, for a naive, simple and local orrery. It quivers, at rest, it moves forward, turning, like the heavens, like the stars.

Plato passes a little quickly over the spinning top [*Republic* 436d ff]. He describes the claim that tops are at one and the same time both stable and in movement as subtle but playful, since all that is required to escape the difficulty is to distinguish the immobile axis and the rotation of the circumference. In his eyes, this separation of the elements eliminates the contradiction. It can be done, he adds, on the condition that the axis does not lean to either side (ουδαμη γαρ αποκλινειν). If, in fact, it does lean (εγκλινη) left or right, forward or backwards, then it is clear that the top is no longer at rest. Plato has no notion here of rest in and by movement itself: the axis of the top sways around a position of balance, there is an invariance by variation. And the interlocutor, more wise than playful, can still assert that this distinction of the axis and the circumference does not lay to rest the opposition of movement and rest, nor their union, and that the top remains whole, at once whirling and stable. The fact remains that this little model in practice reunites what the dialogue holds to be contradictory. The fact remains that Plato did not give any thought to inclination, did not consider deviation, even in the angle of nutation. Lucretius, and atomist physics, covers these areas abandoned by Platonic geometricism, covers the temporarily meta-stable leaning and whirling, the concrete contradiction, the *turbo* of the top, unstable, immobile and mobile.

The children's top, στροβιλος (strobilos), the ρομβος (rhombos) or bull-roarer, games and magic rituals frozen in the diamond-form of Euclidean space, here reveal a solution, easily formed, to all the difficulties of a self-same operator functioning, almost at will, towards contradictory results. Is it stable? Yes. Is it unstable? Yes, again. Is it rotating, does it follow a circumference? Yes, ever again. The top is a *circum-stance*. Can it move forward, lightfootedly? Yes. Can it lean? Yes, in all directions. So ask some questions constructed around yes and no; the possibility of finding, building and observing an object that will not be destroyed by this difference is hereby established. The vortex is unstable and stable, fluctuating and in equilibrium, is order and disorder at once, it destroys ships at sea, it is the formation of things. And so on: the sun dries the earth, it melts wax; fire melts gold and shrinks leather; the wild olive is a feast for goats, but bitter to men;

marjoram is poisonous to pigs and a remedy that brings us back to life; atoms can be pathogenic germs. What is more, a single plant, for us too, may kill or cure us. This pharmacology is under the sign of the top. Not only is the thing decidable, but it is constructible, look at the top. That is how it is, in the thing itself, and no discourse can change it. As if the contradictions separated themselves, as if they repelled each other, in the battle of reason and language, while the contraries cohabited in the black box of things. If, one day, some subtle and playful dialectician disconcerts you, be quiet, don't answer, join the children, play at tops.

Hence there is a chaos-cloud, the *turba*, the stormy combat of atoms. The chaotic unrest or perturbation is a limitless empty space traversed by movements, collisions, intervals, paths and weights, distributed at random, without conjunction, scattered, opposed, disjunct. The Epicurean rediscovers Empedocles: struggle, war, Hatred. Collisions and encounters without union. And so here are translations, rotations, chance vibrations, here are the places of rest for the points of collision, momentary equilibria, deviation. Is it possible that at indefinite times, in unforeseeable places, here or there, yesterday or tomorrow, all these phenomena may suddenly add up, all the contradictions resolve? There is no reason why all these characteristics should not, somewhere, be co-present. Yes, it is possible theoretically. But it is also possible in practice, since we know how to construct an object that harbours within itself this combat, these oppositions, and these disjunctions, motionless and in movement, vibrating and stable, and so on. In such a place, in such a time, dissemination precipitates, as we say for a solid in solution. If this is possible and if this is constructible in practice, it will take place under the sign and the movement of the *turbo*. Figured against the backdrop, the vortex appears against chaos, and the *turbo* against the *turba*. Let there be no mistake, this has been shown.

Lucretius describes two forms of chaos: the streaming-chaos, the laminar flow of elements, a parallel flow in the void, drawn out like fibred space; the cloud-chaos, a disorganized fluctuating, Brownian mass of dissimilarities and oppositions. With declination, the vortex appeared against the backdrop of the first; now it reappears against the backdrop of the second. Whatever chaos may be, whatever may be its linguistic origin: yawn, pour, whatever the material movement of disorder may be, the solution is unchanged, the original figure and movement remain the same, it is the Democritean *dinos*. The vortex is thus the pre-order of things, their nature, in the sense of nativity. Order upon disorder, whatever the disorder may be; the vortex arises by a *fluxion* in the first hypothesis, which is that of chaos-

flow, and by *fluctuation* in the second, which is that of fluctuating chaos. There are indeed no stabilities except in a universe in which everything flows, unstable. Yes, the solution is the same; yet, it is not the same, neither for epistemology nor for the history that will follow. The first of these hypotheses opens a classical knowledge, in which disorder is minimized: it is the path which leads from Archimedes to Pascal and Newton, mechanics, hydraulics, and an infinitesimal calculus, the science of fluxions. Here, coherence is preserved between the local and the global. During the course of this history, which goes up to Laplace, and up to a dominant positivism, the second hypothesis lies dormant. Today, it is reawakening, out of some of Leibniz' dreams and from the other side of Laplace, where chaotic multiplicity slept. Order by fluctuation has become our problem, and our world has become that in which the local and the global no longer harmonize. How can something, rare, emerge from a noise? Or from a radical disorder, in absence of prior order.

SLOPE AND EXTREMA

Lines of rain traversed by the oblique flight of the thunderbolt; at one point, then another, lightning pitches all about, tearing itself from the clouds. This is the visible model, as it is realized in nature: the obliquity of a flash on a parallel field, aleatory quasi-ubiquity. The theoretical schema is given at once. Declination, angled obliquely, traverses the field of atoms moving in a straight line. They are parallel to each other, in their movement, like drops of rain. This comparison goes back to the concrete model. The lightning declines, the *clinamen* blazes, amidst the sheet of water. The notion of the vertical only arises in discussing the fall of more or less heavy bodies. In fact, everything remains equal in the infinite void, including the directions of the field. The crucial thing remains the parallelism of the flow, of the transfer, and the weight, homogenous throughout, that sweeps it along. It is an average laminar field. Traversed by declination in its obliquity, aleatory as lightning. Now it is minimal.

Let us return to the *clinamen*. To acknowledge an almost null angle where turbulence forms is accurate but not enough. First, a detour. Leibniz says somewhere that, from a young age, he debated at length whether he should keep the void and atoms. How the monadology was decided is another question. The fact remains that declination always followed him. His psychology of freedom remains linked to a deviation in balance, to an infinitesimal angle of the beam, to an imperceptible rupture of spatial symmetry. Determination and decision introduce,

of themselves, a differential asymmetry, which makes, as we say, all the difference. There is something not at rest here, disquiet, as in the pendulum of a clock. It deviates from equilibrium. Leibniz' universe is doubly regulated, by the principle *De aequiponderantibus* and by that of the small difference. By that of identity, by that of indiscernibles. The principle of sufficient reason breaks the stability with a small deviation. Such phenomena discerned in the entrails of the subject are no different from those which constitute the world. Coherence is invariable from one structure to another, psychology and metaphysics. Regulating the production of things at their root is the law of the steepest descent of heavy bodies. In which the form of the raindrop is given, once again, for example. This law is differential, by maxima and minima. Things are drawn into existence along the steepest route. They seek equilibrium, following a determinant or decisive deviation. For Leibniz as for Lucretius, the combinations that we must call atomic are linked to the idea of a sloping path. Extreme in both cases.

Whereupon for Leibniz, the maximal *thalweg* along which existents pitch. For example, the brachistochrone, or the straight line, which will become, by variational calculus, the principle of least action. Maximisation, or optimisation, will occur only if account is taken of the constraints, the global system of limitations, that are said to be inherent in creatures. It passes around obstacles, as close as possible. Even the straight line, for which space counts as a constraint. Existence is the loop of a river that has flowed to a better bed. But there is a bed, that is to say a terrain, in which the inclination hollowed out by the *thalweg* optimises the flow.

For Lucretius, the whole system of constraints tends to zero as a result of the void. Equilibrium, therefore, is not set upon a plateau: where, in infinite space, could such a plateau be found? Nor can there be any such residual original *terrenum* or residual matter in Leibniz. Equilibrium is evaluated on a parallel self-referential plane. Atoms tend, indefinitely, towards stability. Nothing can happen, nothing is produced, in a homogenous field. One could almost say that the primal flow remains in a state of final equilibrium. In Leibniz' terms would this be the greatest slope, that which would overcome all obstacles? No. The maximum, the minimum, are *only* extremes. They optimise the constraints, but they do not get rid of them. The superlative is relative, it is neither all nor nothing. Now, here, the void has removed the constraints. But, in so doing, it has made direction relative. One could say, if one wished, that the fall of atoms has a total slope or a null slope. It is flow as such, homogenous, endowed with singular force. In a certain sense it is equilibrium, though more akin to a pre-equilibrium. Thus, *declination defines a*

slope. It is the slope that begins with a loss of equilibrium, with a difference in relation to this pre-equilibrium that is the homogenous. Now the *clinamen* is indeed well-defined by Lucretius, twice over, by a minimum. It is the smallest possible slope opening the path to existence. Could this be a law of the smallest descent of heavy bodies?

Are the *De rerum natura* and the *De rerum originatione radicali* complementary to each other, in the way we speak of angles? Do they in fact describe the same process, at right angles? To the greatest slope there corresponds the smallest angle, to the maximum a minimum, to the drop of rain the drop of liquid. In fact, it is one and the same theory of extreme descent. And since declination may be reckoned from the vertical, there will be at least one figure for which the two models become identical. Slipping at some point onto a minimal *clinamen*, atoms follow the greatest slope. The birth and the origin of things flow from the same source.

Henceforth the *clinamen* is indeed the smallest deviation and the optimal slope. Here is the descent, the *thalweg*, the $\chi\rho\eta\omega\delta\eta$, *chréode*. It is the optimised road to constitution. A track opened through which the flow is swallowed up, a funnel for atoms towards conjunctive existence. Here is the bed of the river: designed, calculated, set down, as the condition of genesis. The inclined plateau where the laminar sheet hits the rapids and rolls in spirals. In annular turbulence which remains stable for a moment and then unwinds slowly down the length of the flux flowing on the plane.

At the dawn of things, in the past and to come, here and there, indefinitely, at the heart of the universe, there exists an inclined plane where coils roll by the temporal flux of matter. Where then does one place the Galilean revolution? If it has balls roll down an inclined plane, it is doubtless because it constructs a singular case of the global model conceived by the atomists of antiquity. Galileo knew how to read. The Renaissance, as far as I know, was well named.

The world, objects, bodies, my very soul are, at the moment of their birth, in. This means, in the everyday sense, that they are mortal and bound for destruction. It also means that they form and arise. Nature declines and this is its act of birth. And its stability. Atoms join together, conjunction is the strength of things, through declination. This signifies the whole of time. The past, the present, the future, the dawn of appearance and death, tenacious illusions, are only the declinations of matter. They decline and are declined like the tenses of a verb, a word

made up of atom-letters.

The world, objects, bodies, my very soul are, from the time of their birth, adrift. Adrift, down along the inclined plateau. This means, in common terms, that they irreversibly fall apart and die. The *De rerum* ceaselessly reveals mortality. But their very birth is a drift. And their stability, their conjunction, their existence, are given up to *homeorrhesis*. The drift is the whole of time: the dawn of appearance, a life marked out by finitude, disintegration, the aleatory fragmentation of multiple temporalities in infinite space. Everything drifts, whatever happens, from the original atoms, the backdrop. Everything drifts from the elementary roots: and so it is with words, these shifting aggregations of atom-letters. Here is the origin of meaning, the transverse lightning-flash on the backdrop that is the background noise. Sense is nothing but its slope, it is the sense of the slope. It is another drift.

Existence, time, meaning and language go down the inclined plane together.

MICHEL SERRES is a member of the Académie Française and the author of numerous books on philosophy and the history of science.

DAVID WEBB is Professor of Philosophy at Staffordshire University. He is the author of *Foucault's Archaeology* (EUP 2012), *Heidegger, Ethics, and the Practice of Ontology* (Continuum 2012), and many articles and translations in contemporary continental philosophy.

BILL ROSS is a PhD candidate in philosophy at Staffordshire University and a series editor of *Groundworks* (Rowman and Littlefield International).