The Final Splendor of Ancient *Rhuthmos* – (3rd century BC – 1st century BC) – part 1

Monday 10 October 2016, by Pascal Michon

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Between the 3rd and 1st centuries BC, due to the longstanding Greek presence in Southern Italy, increasing commercial contacts and finally military conquest in the aftermath of the battle of Pydna (168), the Greek culture massively penetrated the Roman world. Rhythm was one of the many concepts borrowed by the Romans during this period. We begin to better understand the history of this translation thanks to new scholarship but it certainly still needs more research. One of the most important agents in this movement was the poet Titus Lucretius Carus (c. 99 BC – c. 55 BC).

_Rhythm as *Numerus* – Lucretius' *De rerum natura* (1st cent. BC)

Lucretius was one of the last thinkers supporting genuine pre-Socratic views in Antiquity. While most of his contemporaries supported either Stoic or Platonic and Aristotelian doctrines, he championed the Epicurean worldview (341–270 BC), which was partly inspired by Leucippus (5th century) and Democritus (c. 460 – c. 370 BC). Nevertheless, one may wonder at first sight whether Lucretius significantly contributed to rhythm theory and, if he did, in what way.

Indeed, due to the rapid and deep hellenization process, the Romans adopted the Platonic and Aristotelian redefinition of the concept of *rhuthmós* as arithmetic form ordering the development in time of dance, music or speech, and probably also of physiological and medical phenomena as respiration and heart beat.

One important piece of evidence of these conceptual change and semantic extension is precisely the way the Romans translated *rhuthmós* into Latin. They felt that *numerus*, which meant "number – *ἀριθμός* – arithmós" or "a certain quantity," was perfectly fit for this use. Except in a few instances where they used *pes* for *πούς* – *feet* and *modus* for *métron/métra* – *measure/meter*, most of the time they used indistinctively the term *numerus* to designate what the Greeks called *rhuthmós* – "rhythm," "musical measure," "poetic number," "meter," "verse." Whereas for the Greek *rhuthmós* meant also "measure," "proportion" or "symmetry of parts," they associated *numerus* with the ideas of harmony, and moral and aesthetic rightness (Henry George Liddell, Robert Scott, *A Greek-English Lexicon*; Charlton T. Lewis, Charles Short, *A Latin Dictionary*).

Now, if we examine the *De rerum natura*, we find very few mentions of "*numerus*." Most occurrences refer to the common meaning of the word: "number" (1.432, 1.436, 1.446, 1.691, 2.144, 2.177, 3.376, 3.779, 5.51, 5.123, 5.180, 5.1349, 6.414, 6.485). Yet in a few instances, Lucretius refers to dance and musical "rhythms."

In Book 2, Lucretius evokes the Greek cult of Cybele. He recalls that a group of "Galli" or emasculate priests of Cybele used to play cymbals, tambourines and flutes "in Phrygian rhythms." As we saw above, Greek authors like Plato and Aristotle actually talked of "Phrygian modes," i.e. harmony and melody, rather of "Phrygian rhythms," but such particular rhythms probably existed. Moreover it does not matter here, because we are interested only in the concepts used and elaborated by Lucretius and not in the events he is talking about. Although *numerus* covers a larger field than its modern equivalent, I think it is better to always translate it with the same term "rhythm," which is the closest to its Greek equivalent: "*rhuthmós*."

> And hollow cymbals, tight-skinned tambourines
>
> Resound around to bangings of their hands;
>
> The fierce horns threaten with a raucous bray;
>
> The tubed pipe excites their maddened minds
>
> **[In Phrygian rhythm] [Phrygio numero]** ; they bear before them knives,
>
> Wild emblems of their frenzy, […]
>
> (*De Rerum Natura*, 2.618-623, trans. William Ellery Leonard, my mod.)

A few lines below, he describes the procession of the goddess' statue and focuses on some of the participants: "the Phrygian Curetes." Those were Cretan priests who kept watch upon the young Zeus by performing armed dances.

> Here is an armed troop, the which by Greeks
>
> Are called the Phrygian Curetes. Since
>
> Haply among themselves they use to play
>
> In games of arms and **[jump up in rhythm] [in numerumque exultant]**
>
> With bloody mirth and by their nodding shake
>
> […]
>
> The arm'd Dictaean Curetes, who, in Crete,
>
> As runs the story, whilom did out-drown

> That infant cry of Zeus, what time their band,
>
> Young boys, in a swift dance around the boy,
>
> **[Beating rhythmically] [in numerum pulsarent]** with the brass on
>
> brass,
>
> That Saturn might not get him for his jaws,
>
> And give its mother an eternal wound
>
> Along her heart.
>
> (*De Rerum Natura*, 2.629-639, trans. William Ellery Leonard, my mod.)

In Book 4, Lucretius presents the Epicurean theory of knowledge. Sensation occurs as a result of thin films, laminas or as he calls them "simulacra," emitted by objects that enter the appropriate sense organ. He compares them with soldiers marching in, then with dancers.

> And further, 'tis no marvel [laminas] *[simulacra]* move
>
> And toss their arms and other members round
>
> **In rhythmic time [in numerum]**—and often in men's sleeps
>
> It haps an image this is seen to do;
>
> (*De Rerum Natura*, 4.768-770, trans. William Ellery Leonard, my mod.)
>
> And what, again, of this: When we in sleep behold [the laminas dancing],
>
> **[Rhythmically] [in numerum]**, forward, moving supple limbs,
>
> Whilst forth they put each supple arm in turn
>
> With speedy motion, and with eyeing heads
>
> Repeat the movement, as the foot keeps time
>
> *[repetunt oculis gestum pede conuenienti]*?
>
> (*De Rerum Natura*, 4.788-791, trans. William Ellery Leonard, my mod.)

Lucretius is not much interested in discussing poetics and what the Greeks called *métron* – measure or poetic meter, *poús* – poetic foot or *métra* – verses (H.G. Liddell, R. Scott & S. Jones, *A Greek-English Lexicon*, 1940). As we shall see, when he briefly evokes the origin of music and poetry, in Book 5, he uses the term *numerus* to recount the first "arrhythmic" dances performed by aboriginal men then how men learned "to keep rhythm."

> [...] then would antic Mirth
>
> Prompt them to garland head and shoulders about
>
> With chaplets of intertwined flowers and leaves,
>
> And to dance onward, **[without rhythm] [extra numerum]**, with limbs
>
> Clownishly swaying, and with clownish foot
>
> To beat our mother earth
>
> [...]
>
> Such frolic acts were in their glory then,
>
> Being more new and strange. And wakeful men
>
> Found solaces for their unsleeping hours
>
> In drawing forth variety of notes,
>
> In modulating melodies, in running
>
> With puckered lips along the tuned reeds,
>
> Whence, even in our day do the watchmen guard
>
> These old traditions, and have learned well
>
> **[To keep rhythm] [numerum servare]**.
>
> (*De Rerum Natura*, 5.1399-1411, trans. William Ellery Leonard, my mod.)

Unless I am mistaken that is all we can find in *De rerum natura*. *Numerus* as translation of *rhuthmós* does not seem an important concept to Lucretius. In Book 6, where he treats of meteorological phenomena, earthquakes, volcanoes, floods of the Nile and epidemics, he never uses the term.

_ *Rhuthmic* Mathematics – Archimedes (3rd cent. BC)

But we have here to be extra careful. First, if somebody does not use a particular term, it does not mean that he or she does not reflect on a particular object or concept. This is the reason why we must differentiate between *rhuthmós* and *rhuthmos*, between the Greek word and the philosophical issue that the Greeks addressed for the first time and that is still plainly actual.

Second, we may reverse our reasoning. The dominant use of *numerus* in the sense of *arithmós* and its quasi absence in the sense of *rhuthmós* may be taken as a hint of the difficulty for Lucretius to present the atomist philosophy, especially its particular concepts of form, individual and becoming, using the translation of *rhuthmós* as *numerus*, which is precisely presupposing a Platonic and Aristotelian perspective. So, the scarcity of the uses of *numerus* as rhythm may be taken as an evidence of Lucretius' resistance to the dominant arithmetical paradigm of his time.

Therefore we have to look for rhythm beyond lexical evidence, i.e. by examining the concepts presented by Lucretius in themselves. In this instance, Michel Serres' *Birth of Physics* is certainly of great help.

As already mentioned above (chap. 1), some of Serres' claims are not compatible with philological evidence. As far as we know, Leucippus and Democritus did not use the term *rhuthmós* to name the primordial *dînos*. They did not view either the generation processes of the bodies populating the world as vortices. Except for the larger cosmic bodies, like the moon, the sun and the earth, those were brought about by stochastic encounters, bouncing and agglutination of atoms. By contrast, there are sufficient evidence to legitimately think that *rhuthmós* was used to refer to the impermanent yet consistent forms of atomic compounds, in other words that Benveniste was right and Serres wrong about the pre-Platonic meaning of the term.

Nevertheless, Serres' reflection remains inspiring regarding rhythm *per se*. He brilliantly uncovers two important aspects of Greek science that before his research were, if not entirely ignored, at least largely underestimated: the genuine power of the older mathematics to develop infinitesimal calculus and the central significance of the hydraulic model for physics. Since both innovations allowed to overcome some limitations of former arithmetic and geometry and get beyond those of physics due to the primacy of statics and Pythagorean mathematics, both have produced the conditions for a significant re-definition of *rhuthmos*.

According to Serres, the Greeks opened, much before it is commonly admitted, the path that would lead to the infinitesimal calculus. In the 5th century BC, some thinkers, Democritus (c. 460 – c. 370) and maybe others, already realized that it was possible "to construct or perceive the first possible angle, or the smallest that may be formed, so that nothing can be inserted between the two lines which open," by considering a curve and its tangent. This subtle idea resulted in a bunch of revolutionary discoveries that fecundated Greek mathematics up to Archimedes, that were eventually to be lost but that we can reconstruct from some sufficiently convincing pieces of evidence.

> If we are calculating with shapes or rectilinear solids we only need, in general, ordinary mathematics. If, on the contrary, we square or cube curved elements, we must at least switch to a differential proto-calculus. And thus to Democritus. He left two lost books on irrational lines and solids […] we know, from a reference in Plutarch and by a section of Archimedes' *Method*, that Democritus provided solutions for the volume of a cone or a cylinder, or for that of their sections, and doubtless more generally for that of a solid of revolution. Heiberg and Philippson think, correctly, that he achieved this by integration. (Serres, 2000, trans. Jack Hawkes, p. 10, same idea p. 101)

This "integral pre-method," which for the first time "raised the question of the infinitesimal" (p. 101), is called exhaustion. It is a well-known calculus method that is usually attributed to Archimedes but for wich, Serres thinks, we should credit Democritus as well. Serres presents its general features for two and three dimensions problems, while emphasizing its dynamic aspect.

> Let us return to exhaustion. Imagine a square inscribed in a circle. It does not fill it, by any means. It leaves empty places, like hollows outside the fullness of its angles. It leaves empty places. An imprint inscribed in the circle, and that does not describe it faithfully. Let us increase the number of sides, this operation absorbs the voids and fills their emptiness. The imprint little by little, begins to take up the outline, by closer and closer approximation. As the number increases, the two schema tend towards the same shape. (Serres, 2000, trans. Jack Hawkes, p. 102)
>
> If he [Democritus] knew how to integrate the volume of a conic section, or of a cone from that of a cylinder an in relation to that of the pyramid, it is no doubt because, before the great Syracusean [Archimedes], he had conceived the idea of exhaustion: to fill a curve with a polygonal outline, a circle with a square turned myriagon, a cone with a pyramid that has an increasing number of faces. (Serres, 2000, trans. Jack Hawkes, p. 102)

Then Serres convincingly emphasizes its philosophical consequences. This proto-integral-calculus and the theory of irrational numbers that accompanies it have probably been the mathematical basis for Democritus' atomistic ontology and therefore, I shall add, of his theory of form.

> It is reasonable to suppose, as do Heiberg and Tannéry, that the theory of irrational numbers served him as a springboard to atomic interpretation. In both cases, it is a question of divisibility and indivisibility. In both cases, the last division recedes beyond our reach. [...] This [the volume of a solid of revolution] presupposes a differential division, and so once again an atomist interpretation. [...] It is inevitable that the first integrator should take things to be formed of a crowd of subliminal atoms. (Serres, 2000, trans. Jack Hawkes, p. 10)

He even credits Democritus for having anticipated Lucretius' concepts of *clinamen* and *simulacra*.

> Through his approach to irrational numbers and introduction of the infinitesimal, Democritus the mathematician produces the conditions of atomism, its instruments and its objects alike; through the question of the minimum angle in contact with the circle and the sphere, he brings out declination, tangency and contingency; through the volume of solids and the pre-method of integration, he makes the theory of simulacra quantifiable and plausible. (Serres, 2000, trans. Jack Hawkes, p. 103)

The second major contribution Serres is referring to is that of Archimedes of Syracuse (287 – 212 BC). We do not know if Democritus was already capable to address, based on his lost works on differential calculus, the complex mathematical problems raised by fluid mechanics or hydraulics that ensued from his atomic ontology. But, Serres argues, we have strong evidence that Archimedes produced all necessary concepts to that end and therefore was, maybe for the first time, able to fully mathematize the Democritean atomic model (Serres, 2000, p. 11-12).

> To mathematize the model successfully, I therefore need:

> 1. A mathematical or arithmetic theory of element.
>
> 2. A geometrical theory of tangent.
>
> 3. A geometry of forms of revolution.
>
> 4. A theory of spirals.
>
> 5. An infinitesimal calculus.
>
> 6. A mechanics of equilibrium.
>
> 7. A hydrostatics.
>
> Now, as if miraculously, this list of requisites corresponds exactly to a very well-known catalogue of works [those of Archimedes]. (Serres, 2000, trans. Jack Hawkes, p. 12)

Archimedes provided during the 3rd century BC a theory of numerical increase with his *Sand-Reckoner*, a theory of spirals already integrating tangents and differential calculus with the book *On Spirals*, a theory of deviation and a theory of equilibrium with *On Plane Equilibriums*, a theory of forms of revolution with the two treatises *On Conoids and Spheroids*, and *On the Sphere and Cylinder*, and a theory of hydrostatics with his essay *On Floating Bodies*.

> Nothing is missing, now, for the mathematization of the model. It is furnished with a geometry, with a theory of numeration and numbers, with an analysis of series and large populations, with an axiom of the infinite, with a metrics and a refined description of the forms of revolution (in general conic), of spirals or vortices, of the agitated profile of the flow, with a statics and a hydrostatics of the declining angle. And its disciplines, taken together, are not disparate: they are focused, like the model itself, on a global theory of deviation. (Serres, 2000, trans. Jack Hawkes, p. 23-24)

To conclude his comments on this matter, Serres underlines both the novelty of Archimedes' thought, compared to the more famous Plato and Euclid, and consequently of his own views concerning the history of the mathematization of physics.

> Archimedes is the Euclid of the Epicurean world. […] Everything is there, nothing is lacking, the inventory is complete. Atom-grains in the infinite void, the minimal of differential angle of the vortex produced, and the deviation from equilibrium in the fluid medium. […] It begins with Democritus, and the edifice is completed, crowned, by Archimedes. A mathematical physics, close to the world and proven, in fact existed among the Greeks, who were not supposed to have one. (Serres, 2000, trans. Jack Hawkes, p. 24-25)

One could add that this mathematization of Democritean physics entailed also, most probably, the mathematization of one of the atomist concepts in which we are most interested: that of *rhuthmós* be it "impermanent form" or "way of flowing." Let us see how we can, thanks to Serres' contribution, give credit to this conjecture.

_ *Rhuthmic Ontology* – Lucretius' *De rerum natura* (1st cent. BC)

Having set up the larger scientific frame, Serres introduces Lucretius' ontology. He does not pay attention to the atoms themselves but it is worth noticing that Lucretius describes them as endowed with various size, weight, and "shape" *(figura)* which is an exact translation of the Democritean *rhuthmós*.

> And drawing from this its proof: these primal germs
>
> Vary, yet only with finite tale of shapes.
>
> For were these shapes quite infinite, some seeds
>
> Would have a body of infinite increase.
>
> (*De Rerum Natura*, 2.748-482, trans. William Ellery Leonard, my mod.)

Serres starts from Book 2 where the concept of *clinamen* – declination is introduced as *"depellere paulum, tantum quod momen mutatum dicere possis"* (2.219-220): atoms, in free fall in space, deviate, drive away, from their straight trajectory "a little, just so much that you can call it a change of movement." Their deviation is as small as possible, and the alteration in their movement is as small as description allows. Serres claims that this definition of the *clinamen* is exactly what posterior mathematicians in the 17th century will call "differential" or "fluxion."

> Anyone who has ever read any Latin texts on mathematics, and more specifically on differential calculus will recognize here two canonic definitions of the potential infinitely small and the actual infinitely small. This is not an anachronism; the relationship of atomism to the first attempts at infinitesimal calculus is well known. From the outset, Democritus seems to have simultaneously produced a mathematical method of exhaustion and the physical hypothesis of indivisibles. We can see here one of the earliest formulations of what will be called a differential. The clinamen is thus a differential, and properly, a fluxion. (Serres, 2000, trans. Jack Hawkes, p. 4)

The vortex – *dinê/dînos* in Greek – *turbo* in Latin – is, Serres claims, the primitive form of the "construction of things," of "nature in general," "according to Epicurus and Democritus."

> Now this vortex *[tourbillon]*, *δίνη – dinê / δῖνος – dînos*, is none other than the primitive form of the construction of things, of nature in general, according to Epicurus and Democritus. The world is first of all this open movement, composed of rotation and translation. (Serres, 2000, trans. Jack Hawkes, p. 6, same idea p. 50, 91)

> For Lucretius, as for us, the universe is a global vortex of local vortices. (Serres, 2000, trans. Jack Hawkes, p. 127)

As we saw above, this attribution to Democritus is a questionable claim, but it does not matter here. The question is: how does rotation appear in the laminar cascade constituted by the fall and flow of atoms? Lucretius' stunning answer is: by the *clinamen*, which is the Latin name he gives to the unpredictable swerve of atoms.

> When atoms move straight down through the void by their own weight, they deflect a bit in space at a quite uncertain time and in uncertain places, just enough that you could say that their motion has changed. But if they were not in the habit of swerving, they would all fall straight down through the depths of the void, like drops of rain, and no collision would occur, nor would any blow be produced among the atoms. In that case, nature would never have produced anything. (*De Rerum Natura*, 2.216-224, trans. Brad Inwood)

Serres underlines the basic ontological assumption that supports this statement. The agglutination of atoms by which natural things come to be—and, I shall add, take their impermanent shape or *rhuthmós*—is the result of a *turbo* which is itself triggered by a *clinamen* in the constant atomic cataract which constitutes the metaphysical dynamic background of the world as it appears to us.

> The clinamen is the smallest imaginable condition for the original formation of turbulence. In the *De finibus*, Cicero wrote that *atomorum turbulenta concursio*. Atoms meet in and by turbulence. (Serres, 2000, trans. Jack Hawkes, p. 6)

As many other specialists, Serres notices that this concept presupposes a critique of straight determinism. Declination appears in the laminar flow of atoms *"incerto tempore, incertisque locis"* – "at an indefinite time and place," (2. 218-219) i.e. by chance.

> What Lucretius says, however, remains true—that is, faithful to the phenomenon: turbulence appears stochastically in laminar flow. Why? I don't know. How? By chance, with respect to space and time. And, once again, what is the *clinamen*? It is the minimum angle of formation of a vortex, appearing by chance in a laminar flow. (Serres, 2000, trans. Jack Hawkes, p. 6)

Then Serres emphasizes the difference in Latin between *turba* – "a large population, confusion and tumult" and *turbo* – "a round form in movement like a spinning top, a turning cone or vortical spiral." But from a rhythmic perspective, this difference is clearly reminiscent of an older, now well-known, Greek opposition between something intrinsically mobile but "no longer disorder," which precisely was called *rhuthmós*, and "the mad dancing of Bacchic festivals," that was commonly considered as *arruthmía*.

> The first designates a multitude, a large population, confusion and tumult. It is disorder: the Greek *τύρβη – túrbê*, 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. (Serres, 2000, trans. Jack Hawkes, p. 28)

The process of generation, duration, and corruption of things is entirely determined by the change from *turba* into *turbo* and vice versa, and can be accounted for by what he calls "a general theory of turbulence" (p. 81).

> The world in its globality may be modeled 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. (Serres, 2000, trans. Jack Hawkes, p. 28)

The genesis of a thing starts stochastically with a *clinamen – deviation* and develops through a *turbo – vortex*. Once a minimal angle or deviation occurs in the atomic fall, the atoms start, by their interactions and the new deviations they provoke in the flow, to organize themselves into a vortex.

> The clinamen is indeed the smallest deviation and the optimal slope. Here is the descent, the *thalweg*, the *creode* [neologistic porte manteau coined by C.H. Waddington meaning "necessary path"]. It is the optimized road to constitution. A track opened trough 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. (Serres, 2000, trans. Jack Hawkes, p. 33, my expl.)

Serres insists on the fact that this process is "statistically of extreme rarity" and because it only occurs "by chance" it has been rejected by classical physics, which sought to enforce the concept of universal law.

> Yes, it holds by a miracle. And by a miracle I mean the case statistically of extreme rarity. […] Hence the scandal of declination in the eyes of classical and modern physicists: it interrupts the universality of the laws. It opens the closed system. It places the physical law under the rule of exception. Under the protective roof of its solid angle. And yet, that is the way it is. Lucretius is right. (Serres, 2000, trans. Jack Hawkes, p. 77)

Each vortex grows more or less rapidly, stabilizes, lasts for a certain amount of time, then regresses and fades away.

> The stochastically distributed exception in the cataract, under the differential cones of declination, where the flow inclines, returns in [a waterspout/a rush] *[revient en trombe]*,

> diversifies, develops locally *[se noue localement]* and constructs an aggregation that is temporarily stable because unstable. (Serres, 2000, trans. Jack Hawkes, p. 78, my mod.)

Surprisingly, Serres does not use here the term *rhuthmós* although it is clearly a process generating *rhuthmoi*, in the pre-Platonic sense. A *turbo* is characteristically an impermanent form. But some pages below, clearly alluding to the pre-Socratic terminology without yet citing his source, I mean Benveniste, he finally proposes the term "rhythm" as the most adequate term to name the basic ontological phenomenon of vortex.

> A word is needed to express the simple elements: a word like *rhème*. When the vortex constitutes it in form, it is called rhythm. [...] Everywhere there are models of the most general theory, that of floods and paths, of elementary *rhèmes*, capable of intertwining, here and there, into syrrhèmes, connective rhythms. (Serres, 2000, trans. Jack Hawkes, p. 89)

At the end of his essay, Serres claims as his own the discovery that the pre-Platonic "*rhuthmos*" was actually a "vortex in the flow," a form "adopted by atoms in conjunction in the first *dinos*."

> Direct physical experience, simple practice, reveal the *rhuthmos* in the *rhein*, or the vortex in the flow, or the reversible in the irreversible. Rhythm is a form, yes, it is the form adopted by atoms in conjunction in the first *dinos*. In the beginning is the cataract, the waterfall: here is the reversibility to this irreversibility: thus *rhuthmos*. (Serres, 2000, p. 154, trans. Jack Hawkes)

I have already shown in chapter 1 that *rhuthmós* was not used, contrarily to Serres' claim, by Democritus to designate the first *dînos* nor any other smaller *dînos*, although it was, with great probability, used for atomic compounds, i.e. any generated thing. Therefore, it is no marvel that posterior atomists like maybe Epicurus—of which we have very few texts—and with more likelihood Lucretius have used their own concept of *turbo* at least partly in the pre-Platonic sense of *rhuthmós.*

I should now add that Benveniste, contrarily to what Serres bluntly asserts, clearly anticipated this ulterior use. Let me recall here some elements that we deduced from his analysis. 1. A pre-Platonic *rhuthmós* was not a "Form," an "Idea," an εἶδος – *eîdos*, but a shape "as it presents itself to the eyes" of the observer. Far from being outer-worldly, it belonged to the phenomenal world. 2. It was not fixed, immobile, and eternal; it had a life of its own. 3. It did not "designate the fulfillment of [the] notion [of shape] but the particular modality of its fulfillment." And Benveniste concluded: 4. That was the reason why it was "appropriate for the *pattern* of a fluid element" and commonly denoted an "improvised, temporary, changeable form."

There is not a single word in that four-part definition that does not apply to Lucretius' *turbo*. A *turbo* is not an *eîdos* but an observable shape; it is not fixed, immobile and eternal and has a life of its own; since it is constantly moving yet having a certain consistency, it does not designate that peculiar shape as something fulfilled but the particular modality of its fulfillment; last but not least, it is particularly appropriate for the *pattern* of a fluid element.

We see though that there is a slight difference between the older concept of *rhuthmós* and the one that we may induce from Lucretius' concept of *turbo*, probably the same as between the proto-infinitesimal calculus developed in the 5th century and the more elaborated mathematics of the 3rd up to the 1st century. Whereas the former was an impermanent and changeable form, observed at a certain moment of time, which was very loosely defined and had still a certain duration, the latter is now intrinsically moving and changing. It is a form that is constantly in-forming, per-forming and de-forming itself. Therefore this undetermined moment of observation is now reduced to a minimum, i.e. to the infinitesimal moving time-length or "limit" between two segments of time. It is as if—to recall Benveniste —the meaning of *rhuthmós* would not any longer be determined by its older uses (as impermanent shape) but only by its morphology (as sheer mode of fulfillment), getting thus closer maybe to the core of the ancient atomist doctrine. Since this moment of suspense is definitely overcome, the last link with the Platonic paradigm is severed. *Rhuthmós* may now be taken as a pure way of flowing, a mode of fulfilling a process (generation, existence, decay, disappearance) or an action (dancing, playing music, performing, reading poetry). But this does not mean a break or a unbridgeable gap with the ancient atomist tradition. Lucretius' *turbo* is clearly a direct heir of Democritus' *rhuthmós*.

In other words, Serres is right when he claims that the Lucretian *turbo* is tightly related to the pre-Platonic *rhuthmós*. It appears as a refined version of this concept. But he is clearly wrong and also dishonest when he claims Benveniste did not anticipate this ulterior use and appropriates his discovery without citing him.

Next chapter