The ancient atomism and peculiar consequences

Francesco Castaldi - Unione Astrofili Italiani - francesco.castaldi1@gmail.com

Abstract: This study is designed to provide evidence of the numerous consequences inherent to the atomic composition of matter, beginning with vacuum space. Atoms and void are two topics that are tied both one to another and to Greek authors Leucippus and Democritus, who presented information about them. In our time, with the benefit of numerous discoveries in Physics achieved over centuries, these ideas seem obvious. However, from its first proposition in the V century B.C., the atomic theory of matter – the idea that matter is composed of tiny particles not discernible to our senses – was rejected by philosophers, most of them supporting the elemental theory, i.e. that fundamentally matter is made of few elements: fire, water, air, and earth. For many centuries, it seemed that every book concerning atomic theory had been lost. However, at the beginning of the XV century Poggio Bracciolini – a Florentine involved in Renaissance culture – discovered a medieval codex of Lucretius' *De Rerum Natura*, a complete treatise of Epicurean philosophy. Lucretius' scientific poem contained the only surviving text about the ancient atomic theory. Of course in this present work the religious and moral implications of Epicurean philosophy are not considered – its purpose is to explore possible links with the modern physical sciences.

Keywords: Titus Lucretius Caro, ancient atomism

1. Introduction

Some experimental conquests derived from antiquity are valid today: in the astronomical field the discovery of equinoxes precession was the most important. At the same level of importance, the solar orbit's eccentricity reckoned on the unequal length of seasons.

On the contrary, as a mere speculation an idea emerged and was discussed starting from its proposal: matter's corpuscular composition made of various particles out of our sensibility. In the hands of defamers, it became a theory of matter and void (space completely vacant of particles).

2. Something out of reach of our senses

Atomism could be an idea similar to others Greek philosophers in search, among the physical displays of matter, of the essential components for all things; but many of

them rejected basic opinions and four elements emerged: macroscopic, acceptable, practical issues on which discussions and imaginations can develop.

In Lucretius's *De rerum natura*, I century B.C., we find the first critical opinion against idealistic philosophers [I, 711]:[1] «extremely far from the truth». So that he defines them [I, 714-716] «who think that from these four things, from fire, earth, air and moisture, all bodies may proceed. Among the chief of whom is Empedocles of Agrigentum». On the contrary, the atoms not visible and ignored by our senses developed a series of opinions able to make them realistic, through their agglomeration.

Among the promoters, Leucippus and Democritus, V century B.C., we've got fragments and abstracts only, written sometimes after several centuries. From the ancient philosophers we have no complete books at our disposal, but only a collection, *The Presocrats*, by the philologist Herman Diels (1990). This work was enriched for several years since the beginning of the XX century. It was a timely work, but at the same time it brings to note what we lose about the original classical trends of thought, and for always. Nevertheless, vestiges always existed and Dante shows a never forgotten tradition: «Democritus who puts the world on chance» [Inferno, Canto IV, triplet 46]. Like us he knew indirect news old of centuries, but neither Dante nor others referred to Lucretius's *De rerum natura*, while he sentences to damnation as heretics «with Epicurus all his followers / who with the body mortal make the soul» [Inferno, Canto X, triplet 5].

3. Rediscovery and notes

A great jump happened when the full codex of atomistic canons reappeared in the middle of humanistic culture, the first decennials of XV century: never such an event happened in the right moment. The manuscript discovered by Poggio Bracciolini, had been written about the VII century, but it could be interesting to know in which context this happened and why. However, this one was not the unique codex saved, because there are two other tracked down about the IX century; so that we make the same questions.

To be clear, from Arabic civilisation a revival of interests arrived in Europe concerning a part of that Greek culture flowered along the Mediterranean Sea, so that it's not meaningless if philosophers as Plato and Aristotle were largely followed and studied. While the atomistic theories, representative of an important aspect of ancient culture, were despised and forgotten, *De rerum natura* survived here and there exclusively in the European Middle Ages. From the new copy ordered by Bracciolini, the diffusion of this book started, accelerated in a second time by the printed editions.

Ferrando da Brescia produced the *editio princeps* in 1473, followed by three others in the Veneto region before the end of XV century. On 1511 a professor of Bologna University, G.B. Pio, went on with an edition (Pio 1511) granting that "the Lucretian codex is accurately correct, free of all knots and difficulties; many laws, hushed up or ignored by the passed ages, are treated with peculiarity and following different Latin or

[1] From here on, we draw some inspirations from the English translation in (Lucretius 1870). As to the references, for example the verse 54 of Book II becomes [II, 54].

Greek authors". The introduction of Pio refers to atoms and void space deducing: "from here on, as Democritus does, the generated worlds of which it's supposed an endless number and which are perishable and with some parts evolving".

Other Latin editions were printed in Europe. In 1570 D. Lambin (1570) published one very accurate edition with the permit to print of king Charles IX of France. From Lambin's presentation, we check [p. 49] that the most famous ancient scholars were divided into two categories: followers of atomism, as Leucippus, Democritus, Metrodorus, Epicurus; and opponents to it as Empedocles, Plato, Aristotle, the Stoics. The first translation with comments in a vulgar language was printed in Lyon by Decouture (1685) with the *privilège du Roi* Louis XIV. Also Copernicus in his manuscript of *De revolutionibus* made an unequivocal reference to atoms, censored by his editor and never printed from the *editio princeps* on; it is however preserved in the handwritten original.[2]

4. Inside Lucretius's poem: terminology and atoms

Lucretius well knew even the linguistic difficulties for this new theory [I, 136-139]: «Nor does it escape my consideration, that it is difficult to explain in Latin verse the profound discoveries of the Greeks, especially since we must treat of much in novel words, on account of the poverty of our language, and the novelty of the subjects». Lambin's opinion was that the Latin is not poor of words, but doesn't adapt to this science.

With reference to Lucretius, he never used the word "atom"; instead of it, he employed *corpora prima*, *primordia* and others, as we'll see below. We appreciate *exordia rerum* [II, 333] as "elements" because this is valuable for us too, but the majority of translators explains *semina* [II, 284] and *principia* [II, 293] only by the term atom. On the opposite, the simple *corpora* may mean "atoms agglomeration" able to produce a body, but not always this is clarified for what we intend as to different ideas. Sometimes, without specification, Lucretius inserts his fundamental opinion: the phenomenon, he writes about, is referred to single particles or their associations, homogeneous or heterogeneous, without distinctions. Also, in the first Italian translation (Lucretius 1717) the word "atomo" never appears; the term body, if not specified, is not a problem: it's matter in any case.

4.1. The fundamentals: body and space

Lucretius's definition [I, 418-421]: «As it is, therefore, all nature of itself consists of two parts; for there are bodily substances and vacant space, in which these substances

[2] The editor, the Lutheran theologian A. Osiander, erased the phrase in his handwritten copy to print in Nurnberg, 1543. This copy disappeared, while – incredibly – the original is now preserved in Cracow, from which the anastatic printing is available (Copernicus 1973).

are situate, and in which they are moved in different directions». Lambin's explanation: [p.49]

> As a matter of fact, the void does not and cannot get anything; only it let to bodies the movement way, the space and the possibility. So that Epicurus defines it, place and space. On the contrary Empedocles and Plato and others before Plato denied the void into things. Aristotle […] admits the void beyond our world […]. Stoics say inside the world nothing is empty, while beyond it there is the endlessness.

Philosophers with a disease called *horror vacui* triumphed for two millenniums. In the meantime Lucretius defined "primary bodies" as [I, 539]: «solid and without void, they must of necessity be eternal». Moreover [I, 574; 609]: «closely compacted and of powerful strength» in order to overcome for the eternity the renovation cycles of the bodies that they constitute. With the common idea that [I, 544]: «nothing can be produced from nothing and that which has been produced cannot be resolved into nothing», almost all are consentient, Aristotle too: «*nihil ex nihilo fieri posse*».«»

Let's go on now, where Lucretius adapts an atomic bond to the comprehension of people of his times [II, 333]: «learn now, in the next place, of what nature the primordial elements of things are, and how they are very different in their forms; how they are varied by manifold shapes». And he confirms [II, 479]: «the primary atoms of things vary in figure, but only with a limited number of shapes». From this diversity a "mechanical" predisposition to bound together comes out: to our about 100 chemical elements, Lucretius set against his *primordia rerum* in a scarce number of shapes and with selective capacity to bound to each other. Consequently, it's impossible to have infinite shapes and variety without thinking to enormous atoms, because [II, 483]: «within the same individual minute frame of any seminal principle, the figures or arrangements of its parts cannot vary much among themselves». It is clear that every atomic shape has an infinite number of atoms [II, 525-528]: «for, since the diversity of their forms is finite, it necessarily follows that those which are alike are infinite, or it would appear that the sum of matter must be finite». A deduction declared unacceptable a little above.

The agglomeration of simple particles induces to think to molecules and their formation due to some characteristics of the components [II, 682]: «These things must therefore consist of various conformations of atoms». And: [II, 686-687] «Dissimilar forms of atoms, therefore, combine in one mass, and things consist of mixed seminal principles». From here he starts the comparison with the words made of various combinations of the restricted number of alphabet letters: [II, 695-698] «Likewise in other matters, many common elements, as they are the primary principles of many things, may yet exist in dissimilar combinations among themselves; so that the human race and the fruits and the rich groves, may justly be considered to consist each of distinct original particles». But Lucretius anticipates critics [II, 700]: «nor yet it is to be thought that all particles can be combined in all ways». And, figuring the resulting monsters that would occur, he adds that all bodies retain what was imprinted in their origin [II, 710]: «And it is plain that this must necessarily be the case according to strict method and laws». Here we see that the words of Dante about Democritus are not valid for Lu-

cretius, because the matter follows its own rules, as we studied in chemistry for the molecular processes.

It's time to speak about space, which intervenes in order to permit the formation of compositions starting from collisions among particles and to introduce what governs body's formation. The suggestion of vacuum space doesn't spring in the brain of atomistic philosophers as a self sustaining statement, but as a consequence of the union of elementary particles in order to produce matter, because from movement derives everything [I, 329; 336]: «nor, however, all things held enclosed by corporeal substance; for there is a void in things; […] If this were not the case, things could by no means be moved». Some passages are exemplar [II, 225-229; 235-236]:

> But if, per chance, any one believes that the heavier bodies, as being borne, more swiftly straight trough the void, might fall from above on the lighter ones and thus produce concussions, which might give rise to generative movements, he departs far from just reasoning. […] But, on the contrary, a pure vacuum can afford no resistance to anything in any space, or at any time, but must constantly allow it the free passage which its nature requires.

In void the equal fall velocity of bodies, different in weight and form, went on to generate discussions for centuries while to the atomists it was obvious. Therefore, we ask how the primitive collision happens between particles.

4.2. The clinamen

In order to realize the formation of bodies, let us see an opening phrase [II, 84-86; 95-104], followed by the conclusion [II, 238-250] after examples here omitted:

> Since the primary particles of things wander through the space, they must necessarily be carried forwards by their own gravity or by chance by a strike with another one. For when they have struck against one another it happens that they start asunder in different directions. […] No rest is allowed to the primary bodies passing through the void profound, but rather, driven by perpetual and constant motion, part when struck by another one, rebound to a great distance, and part almost are not rebounded. Whatsoever particles being brought together in a more close congeries, rebound only to small distances, as being involved by their own entangling shapes, and form the strong substance of rock and the rigid consistence of iron and a few other things of their kind.
>
> All bodies, when put into motion, must be equally borne onwards, though not of equal weights, trough the unresisting void. The heavier ones will therefore never be able to fall from above on the lighter, nor of themselves produce concussions, which may vary the motions by which nature performs her operations. For which cause it must again and again be acknowledged that bodies decline a little, but the least possible space: lest we should seem to imagine oblique motions, and truth should refute that supposition. For this we see to be obvious and manifest that heavy bodies, as far

> as on themselves, cannot, when they fall from above, advance obliquely; a fact that you may yourself see. But who is there that can check that nothing at all turns aside from the straight direction of its course?

This "clinamen", or imperceptible deflection, should insinuate if we are able or not to perceive a deviation from the vertical fall of a whatsoever body. Lucretius justifies this obvious statement to our free will when we do not trust luck or destiny of our actions [II, 255-293]. Obviously it's not the case to follow him in a similar discussion; nevertheless, from here he arrives to the important consideration around the agitation of atoms that is at the origin of formation and disintegration of matter as we know it.

4.3. The perennial agitation of particles

We finally arrived to the breach of this irrational construction based on hypothesis with no verifications. Yet, other imaginations of philosopher of the same age of atomists were for two millenniums accepted and adopted by civilisations that were, at a first sight, without relations or almost opposite to the Greek one.

All finished when more and more scholars made a rebellion in the name of atoms, because they let to perceive new points of view on the physical world. Since the beginning of his work, Lucretius promises to explain the consequences, in case we accept atomism [II, 62-65]: «I will explain by what motions the generative bodies of matter produce various things and resolve them when produced; by what force they are thus compelled to act and what activity has been communicated to them for passing throw the space».

Matter is never compact because its particles are in a continuous agitation, as we notice looking at the powder across a Sun ray in a dark room [II, 132-141]:

> Doubtless this errant motion proceeds from the primary elements. For the first primordial atoms are moved of themselves, then those bodies which are of light texture and are nearest to the nature of the primary elements [molecules] […]. Thus motion ascends from the first principles [atoms] and spread forth by degrees to our senses and to those particles which we see in the light of the sun. Though it is not clearly evident by what means it happens.

Science calls them the Brownian motions of molecules tested in fluids and studied in the middle of XIX century. But Lucretius is happy to infer [II, 312-314]: «For the nature of original principles lies far removed from our senses; for which cause, while you cannot see the thing itself, it must hide its motion too».

5. The fire

To Anaxagoras' *homeomeries* (*all already in all*), Lucretius set against – as an example – the spontaneous flames in woods stirred by winds [I, 901-903]: «And yet, the fire is not

inherent in the wood but there are in it many flammable particles which, when confluent by friction, produce a conflagration in the forests». It seems that combustible and oxygen are together in the wood, so that the heating due to friction produces fire. This idea of fire yet in flammable materials returned with the pure fire, the *phlogistus* of G.E. Stahl. Lavoisier reached the solution thank to the new discovery of oxygen (Zingales 2006).

6. Colour of the elementary particles

Another important step forward [II, 737]: «in the elementary atoms of matter there is no colour at all». This one depends on the position in which a certain body is fitted when lighted [II, 800]. As a consequence, [II, 832-833]: «So that you may from this infer that the small parts of bodies throw off all colours, before they are reduced to their ultimate atoms», which are no more visible. Besides, all particles cannot be distinguished [II, 842-864] in relation to temperature, sound, taste and odour.

7. Astronomy and cosmology

Also in relation to their contemporaries, the atomists had not profound knowledge of astronomy as we read in Book V, and exemplar is the discussion against "antipodes" people, as well as the impossibility to explain seasons [V, 1436].

On the contrary Lucretius had a modern point of view toward valid cosmological questions due to the infinity of atoms. The consequences emerged in a lot of opinions [II, 1048-1076]: «the first point is that in every direction around us, on all sides, above and below, there is no limit through to the whole of space […]. By no means can it be thought probable […] that this one globe of the earth and this one heaven have been alone produced and those innumerable particles of matter do nothing beyond […]. For which reason it is irresistibly incumbent to admit that there are other combination of matter in other place such as in this world. […] You must necessarily suppose that there are other orbs of earth in other regions of the space and various races of men and generation of beasts». All that is for the joy of fans and explorers of exoplanets and aliens.

8. A short jump in the Year of Light 2015

To the instantaneous propagation of light the atomists oppose its transportation by means of tiny atoms, with consequent maximum speed in void. But still on 1604 Kepler wrote: «There is not a material means that oppose resistance to light because it has no matter, so that its speed is infinite» (Kepler 1604, chapter I, proposition V). On the contrary, in 1638 Galileo expressed some doubts, but failed in proposing the right experiments; only O. Römer (1676) ascertained a finite value of light speed, so that aroused the problem in which medium it could be greater (Gettys 1989, p. 799).

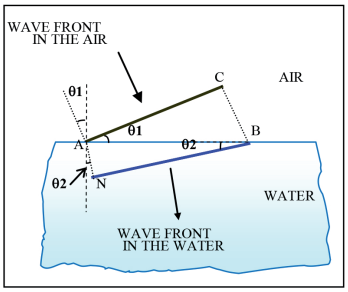

Fig. 1. Picture of Snell equation

Figure 1, according to the wave theory of Huygens, explains that the speed in water is lower than in air, according to Snell refraction law: $\sin\theta_1/\sin\theta_2$ = constant. On the contrary, Newton, setting a corpuscular theory, wrote (Newton 1730, p. 245): «If light be swifter in bodies than in vacuo in the proportion of the sine which measure the refraction of the bodies, the forces of the bodies to reflect and refract light, are very nearly proportional to the densities of the same bodies». Though with an "if", Newton's proposal was: speed v_2 in water greater than v_1 in void according to the proportion: $v_2 = (\sin\theta_1/\sin\theta_2)*v_1$; i.e. $\sin\theta_1/\sin\theta_2 = v_2/v_1$ = constant. But this inverse of speeds was mistaken as experimentally demonstrated by Foucault in 1850. As to the speed, it's in agreement with the ancient atomists.

References

Copernicus N. (1973). *Fac-similé du manuscrit du De Revolutionibus*. Paris-Warsaw-Cracow: Academie Polonaise des Sciences et Centre National de la Recherche Scientifique.

Decouture B. (1685). *De la nature des choses.* Lyon: Molin.

Diels H. (1990). *I presocratici*. Roma-Bari: Laterza.

Gettys W.E., Kellow F.J., Skove M.J. (1989), *Physics.* New York: McGraw-Hill, p. 799.

Kepler J. (1604). *Astronomiae pars optica.* Frankfurt: Marnium.

Lambin D. (1570). *De Rerum Natura*. Paris: Benenatum.

Lucretius T. (1717). *Della Natura delle Cose*. Italian translation by Marchetti A.. London: Pickard.

Lucretius T. (1870). *The nature of things*. English translation by Watson J.S.. London: Bell & Daldy.

Newton I. (1730). *Optics*. Fourth Edition. London: Innys.

Pio G.B. (1511). *In Carum Lucretium poetam commentarii*. Bologna: de Benedictis.

Zingales R. (2006). "La scoperta dell'ossigeno" [online]. URL: <http://math.unipa.it/~grim/dott_HD_MphCh/scoperta_ossigeno_zingales_06.doc> [access date: 01/04/2016].