



## THE ELEMENTARY ROLE OF THE SO-CALLED DIFFERENCES IN THE ATOMISM OF LEUCIPPUS AND DEMOCRITUS

Gustavo Laet Gomes  
Doutorando em Filosofia pela UFMG  
Membro da Cátedra UNESCO Archai (UnB)

**RESUMO:** No atomismo de Leucipo e Demócrito, tal como nos foi transmitido por Aristóteles, elementos são os átomos e tudo o mais são compostos atômicos. Ainda segundo Aristóteles, todas as características físicas dos compostos sensíveis têm de ser passíveis de remontar a seus constituintes químicos elementares. Este mesmo tipo de demanda ele coloca para a teoria atômica e considera que ela não a responde satisfatoriamente porque seus átomos impassíveis e imutáveis não podem sofrer os processos químicos básicos que testemunhamos na natureza: geração e alteração. Segundo Aristóteles, há no atomismo de Leucipo e Demócrito o que poderíamos chamar de uma *teoria das diferenças*. Os processos químicos (tais como ele os concebe) não seriam *reais*, mas apenas expressões de agregações e desagregações de átomos movendo-se no vazio. As diferenças observadas nos compostos e atestadas pelos sentidos seriam causadas por *diferenças* entre os átomos e em suas posições relativas. Neste trabalho, eu exploro essa teoria das diferenças, mostrando que ela procede, mas que é mais complexa do que Aristóteles nos sugere inicialmente. Além das diferentes formas geométricas dos átomos, importam ainda as relações que os átomos estabelecem entre si, a estrutura do composto, que pressupõe o vazio, e o movimento atômico, totalizando sete diferenças fundamentais que respondem por parte das funções que Aristóteles esperaria encontrar nos elementos de uma teoria química.

**PALAVRAS-CHAVE:** atomismo, diferenças, elementos, química antiga, Demócrito.

**ABSTRACT:** In the atomism of Leucippus and Democritus, as transmitted by Aristotle, elements are the atoms and everything else are atomic compounds. Still according to Aristotle, all of the physical features of sensible compounds must be traceable down to their elementary chemical constituents. He puts this same kind of demand to the atomic theory and considers that it falls short, because their impassive and immutable atoms cannot suffer the fundamental chemical processes that we witness in nature: generation and alteration. According to Aristotle, there is the atomism of Leucippus and Democritus something we could name as a *theory of differences*. Chemical processes (as he conceives them) would not be real, but only the expression of the aggregation and segregation of atoms moving through the void. The

differences observed in compounds and attested by the senses would be caused by *differences* between atoms and by their relative positions. In this paper, I explore this theory of differences, showing that it makes sense, but also that it is more complex than Aristotle's initial suggestion. In atomism, not only the different geometric shapes of the atoms matter, but also the relationships that atoms establish among themselves, as well as the structure of the compound, which presupposes the void, and the atomic motion, summing up a total of seven fundamental differences that respond for most of the functions that Aristotle would like to find in the elements of a chemical theory.

**KEYWORDS:** atomism, differences, elements, ancient chemistry, Democritus.

## I

I always start my speeches and texts about the atomism of Leucippus and Democritus by a somewhat brief justification about why I cannot use fragments to discuss it. These initial disclaimers serve generally for two purposes. The first is to inform (or remind) those that are not familiar with the study of atomism that we only know it second-handedly. The second is to justify somehow why almost every time we talk about atomism we have to talk about Aristotle; and, more specifically, why we have to compare aspects of the atomic theory with its correlates in Aristotelian physics — or *chemistry* — that is, with his theory of the elements and the processes through which the elements generate sensible bodies.

Neither Aristotle nor the ones who followed him until the Middle Ages, even less Aristotle's predecessors, used the term chemistry, but it is a useful term nonetheless to mark a certain scope. I call chemistry the portion of physics that deal specifically with two questions that were fundamental for Aristotle, and that seemed to have had some importance among his predecessors too, even if not necessarily with the same intensity, that is, (1) what are the ultimate constituents of all things, and (2) what sort of relationship there is between these ultimate constituents and things as we perceive them through our senses?

I insist in relativizing the importance of these questions for Aristotle's predecessors, which he called *physikoi* and *physiologoi* (i.e. physicists), because, differently than what this designation seems to imply, it is not so obvious that those were *the* most fundamental questions for those early thinkers too. Such a notion may have originated precisely from an interpretative preconception transmitted to us by the philosophical historiographical tradition that stemmed from Aristotle's testimony among his followers, starting with Theophrastus.

Thus, no matter how important the question of the principles is, the ideal path would be to consider it within the context that involves each thinker and under the light of the sort of question that might have sparked their investigations. Just to give one example, Aristotle speculates — therefore, without categorically affirming — that for Thales of Miletus the one monist principle was water (*Metaph.* A.3 983b20-21). He comes up with this from certain statements about the importance that Thales gave to water in his views regarding *physis* and the *cosmos*: that all living beings needed water to survive, that all seeds have a humid nature, that the earth floated above water, etc. (b21-27).<sup>1</sup> Thence, to affirm that, for Thales, water is the principle of everything — both as origin and as the ultimate constituent — is a possible leap, albeit a risky one. Besides, it surely echoes something that Aristotle himself suggest to be present in Anaximenes of Miletus, with his *aer* (*Metaph.* A.3 984a5-6 [DK 13 A 4]), but that, if we look carefully, points to an elemental monism such as the one conceived more than a century later by Diogenes of Apollonia.<sup>2</sup>

## II

That being said, we must concede that not every conclusion by the Aristotelian-stemmed historiography are hermeneutical leaps so risky. One of the issues that seemed to be implied in all chemical propositions from antiquity is that of the relation between *one* and *many*. With this in view, Aristotle has reason to see in the postulation of the atomist elements — which he identifies sometimes as “the plenum and the void” (τὸ πλήρες καὶ τὸ κενόν), other times as “indivisible bodies” (σώματα ἀδιαίρετα), “shapes” (σχήματα), or “tiny substances” (μικρὰς οὐσίας)<sup>3</sup> — another strategy to deal with this problem. The introduction of the void, even if this was probably not its originally intended function, solves the issue of explaining multiplicity and breaking the continuity of the plenum. The atoms, as the ultimate constituents of reality, would be, in

<sup>1</sup> These passages of *Metaph.* A.3 can be found in DK 11 A 12.

<sup>2</sup> Cf. GRAHAM, 2006, p. 292-293. Graham considers that Aristotle projects the theory of Diogenes over the first Ionians, including Thales, Heraclitus and Anaximander. This is not so strange if one considers that the theory of Diogenes was well spread at the time of Aristotle and was perhaps even popular (it is ridiculed in Aristophanes' *Clouds* as paradigmatic among philosophers and as if it had been adopted by Socrates; cf. DK 64 C 1). Given the scarcity of material about the first Ionians, Aristotle might as well have filled the gaps with Diogenes' theory.

<sup>3</sup> The references are, respectively, *Metaph.* A.4 985b4-6 (DK 67 A 6), *GC* I.1 314a21-22 (DK 67 A 9), *GC* I.2 315b6-9 (also in DK 67 A 9), and *Simp. in Cael.* I.10 [279b12] 295.1-2 (DK 68 A 37). DK 68 A 37 is the fragment of the lost treatise of Aristotle *On Democritus*, *OD* from now on.

a certain sense, its basic unity: each atom individually corresponding to the one. Well then, even if we now have multiple atoms moving about through the void, that is, a multiplicity formed by an infinity of *ones*, another question still remains: how to explain, from these two types of things — atoms and void — the occurrence of the phenomena that are presented to us by our senses?

The solution involves a combination of the multiple *ones* in order to build compounds. That is the origin of the model of aggregation and segregation (*GC* I.8 325a31-32): even though themselves imperceptible, the many *ones* distributed through the *cosmoi* congregate themselves to form the complex structures that hit our senses. Interaction is possible because they move through the void and eventually establish contact with (*i.e.* hit) one another (325a32-33). This interaction, for Aristotle, is a type of action and passion relationship, and, as such, must be part of the atomist explanation for qualitative change (325b2), increase (325b4), and generation (325a34).<sup>4</sup> The immediate consequence of the adoption of the aggregation and segregation model is that action and passion and all the other change phenomena are understood mistakenly, for they would actually be the result of the rearrangement of individual atoms within the aggregates (325a32-34).<sup>5</sup> The reason for there being action and passion on the level of compounds is because they are not real unities, but unities only insofar as aggregates. It is exactly on the points of contact between compounds, in which individual atoms meet each other, that action and passion takes place in compounds: the atoms at the contact point hit each other and this first event triggers a chained process of rearrangement due to the consequent alterations in their local sub-combinations, trajectories, and velocities.<sup>6</sup>

Yet, the mere fact of a plurality of entities that move and meet in a void is not enough to explain the complexity of sensible phenomena, for, as we know, there is a countless variety of ways in which things appear to us. Sensible compounds present an incalculable number of properties and differences. Where do these differences come from? Besides, if aggregation and segregation occur merely with absolutely equal beings, it would not be possible to distinguish the atomic theory from an elementary monism. The aggregation of these *ones* (all identical to each other) could be understood

---

<sup>4</sup> Cf. HUSSEY, 2004, p. 252.

<sup>5</sup> All these passages from *GC* I.8 are in DK 67 A 7.

<sup>6</sup> Cf. HUSSEY, 2004, p. 253.

as compression and the segregation could be understood as decompression. We would be in front of the rare and the dense, something close to the alleged model of Thales and to the models of Anaximenes and Diogenes of Apollonia.<sup>7</sup>

It is necessary, then, that there be differences between the *ones*, which are basic entities or elements. Empedocles theory, with its four elements, establish a limited number of differences. In Anaxagoras, the differences are virtually unlimited since the elements are, at least in Aristotle's interpretation, homoeomerics. And in the atomist model, the atoms differentiate themselves in shape, that is, according to infinite geometric forms.<sup>8</sup> Can only these geometric differences, plus the void, be enough to answer for all the differences in the sensible world? Aristotle thinks they cannot and accuses the atomist model of reductionism. Yet, were these the only differences proposed by the atomist model?

### III

Regarding his own elements, Aristotle presents two sets of fundamental differences that appear to be quite independent. The first one is in *De Caelo* (*DC* from now on), while the other one is in *On Generation and Corruption* (*GC* from now on). In *DC*, the fundamental differences of the elements are related to their natural motions. In *Cael.* IV.1 308a29-33 and IV.4 311b13-312a8, Aristotle concludes that there are three types of simple natural motions: *upward linear locomotion* (towards the circumference of the cosmos, and related to lightness), *downward linear locomotion* (towards the center, and related to heaviness), and *circular locomotion*. To each one of these simple motions there must correspond a single basic element (III.3 302b5-9; III.4 303b4-8; I.3 270b26-31): *fire* to the upward motion, *earth* to the downward motion, and *the fifth element* to the circular motion. *Air* and *water* are intermediates because they combine heaviness and lightness — air is heavier than fire and lighter than water, which, in its turn, is lighter than earth and heavier than air.<sup>9</sup> According to Friedrich Solmsen (1960, p. 254), there are no other differences, neither geometric, as one finds with the atomist

<sup>7</sup> For approximations more or less possible between atomism and an elementary monism, see GOMES, 2017.

<sup>8</sup> Aristotle considers that the shapes of the atoms are unlimited because of the infinite variability of the phenomena (*GCI.2* 315b9-11, DK 67 A 9). Cf. MOREL, 1996, p. 103.

<sup>9</sup> In practice, air and water are superfluous to the cosmologic framework of *DC*. They even introduce an asymmetry since the addition of two elements breaks a framework formed by three pairs — two basic motions (upwards and downwards), two primordial "powers" (lightness and heaviness), and two elements (fire and earth).

indivisibles, nor in their material substrate, that is, in the stuff with which the elements are made of, which, in the case of the atomists, Aristotle supposes to be the same, but in the case of Empedocles and Anaxagoras seems to vary.<sup>10</sup>

In *GC*, on the other hand, Aristotle establishes the differences between the elements from two pairs of fundamental qualities: hot and cold, humid and dry. They occur interleaved within the elements — fire: hot and dry; air: hot and humid; water: cold and humid; earth: cold and dry — and are what make the transformations between them possible:

from fire there will be air if one of its properties changes, the former having been hot and dry whilst the latter is hot and wet, so that if the dryness is conquered by wetness there will be air. Again, from air there will be water if the heat is conquered by cold, the former having been hot and wet, the latter cold and wet, so that if the heat changes there will be water. In the same way there will be earth from water and fire from earth. For both have counterparts relative to both: water is wet and cold, earth cold and dry, so that if the wetness is conquered there will be earth; and again, since fire is dry and hot, whereas earth is cold and dry, if the cold is destroyed there will be fire from earth. (*GC* II.4 331a26-b2; transl. Williams)

The problem is that there is no way to make these two sets of contraries — lightness and heaviness on one side, and, on the other, hot and cold, humid and dry — compatible (and Aristotle himself does not try to do it). There is nothing, for instance, that indicates that lightness amounts to hot and dry, or that hot and dry are the lightest qualities from the set of *GC*. It is the same with cold and humid, which have no relation at all with heaviness. It is neither possible to exchange the contraries between the two treatises and try to use them to arrive at the same result. Lightness and heaviness are not fit to explain the transformations of the elements in *GC*, for they lack the fundamental aspects of activity and passivity that feature the pairs hot-cold (predominantly active) and humid-dry (predominantly passive). It does not even make sense to think of heaviness affecting lightness. Similarly, the four qualities of *GC* cannot be coordinated in order to account for the basic motions to the periphery and to the center, because even being the hot commonly associated with the region closer to the stars (which are hot), and earth, being in the center (the most distant point from the periphery), be cold (*GC* II.3 330b30-33), hot and cold do not have the power to provoke local motion, only the power to heat and cool.

---

<sup>10</sup> The differences between the roots of Empedocles and the “homoeomerics” of Anaxagoras seem to be in the very nature of the material substrate. Cf. *Metaph.* A.8 988b19-989b21 (partially in DK 59 A 61).

In practice, Aristotle cannot escape a certain dualism between chemistry and cosmology. By introducing distinct principles for the two fields, it is as if he sealed a sort of limit between the two sciences.<sup>11</sup> The atomists, however, do not introduce any such dualism, making the elements themselves the cause of movement, without the need of any sort of external efficient cause.<sup>12</sup> Aristotle's solution, however, is not inelegant at all. Differently from others whose dualism implies things from totally distinct ontological realms,<sup>13</sup> Aristotle works with differences that are always qualities. Even if the relationships between the sets of differences used in *DC* and in *GC* are not necessary, so as to unify the two theories, their principles are all from the same category,<sup>14</sup> which allows Aristotle to relate them when he has to derive the characteristics of the compounds.

Now, the atomic theory, for Aristotle, seems to lack something that makes it capable of accounting for the specific differences of the compounds. According to Pierre Marie-Morel, “[b]y making the atoms and the void the only elements of nature, the atomists relegate the compound bodies to the status of provisional aggregates without real unity” (1996, p. 75; my transl.). But it is exactly from the criticism of Aristotle to this lack of substance on the realm of compounds (or the denial of the status of substance to the compounds) that one can perceive that the properties or characteristics particular to the compounds are due mainly to the atomic motion and to the atomic relations within the compounds.

#### IV

What we know about the chemistry of Leucippus and Democritus derive mainly from five testimonies by Aristotle: (1) *Metaph.* A.4 985b4-21 (DK 67 A 6), (2) *GC* I.1 314a21-24 and (3) I.2 315b6-15 (DK 67 A 9), (4) *GC* I.8 325a23-b5 (DK 67 A 7), and

---

<sup>11</sup> Cf. SOLMSEN, 1960, p. 365. Aristotle, however, is not alone in this. In Plato's *Timaeus* (52d-53a, 55d-57c), the distribution of the elements in the cosmos is due to movements that occur within the  $\chi\acute{\omega}\rho\alpha$ , while the generation of the elements is explained by means of a conversion of geometric shapes.

<sup>12</sup> Empedocles (DK 31 B 30, A 37, A 52, B 35) and Anaxagoras (DK 59 B 12) also find themselves having to recourse to principles that are external to the simple bodies in order to explain their distribution on the cosmos and the formation of the cosmogonic whirl.

<sup>13</sup> Including the inelegant attitude (from the point of view of Aristotle's methodological requirements) of including among the principles things not physical — mathematical entities, immaterial forces, and even a *mind*.

<sup>14</sup> Cf. SOLMSEN, 1960, p. 365-366.

(5) the fragment of Aristotle’s lost treatise *On Democritus*, transmitted by Simplicius (*in Cael.* I.10 [279b12] 295.1-20 [DK 68 A 37]), which I reproduce below:<sup>15</sup>

(1) Leucippus and his companion Democritus state that the plenum and the void are elements, saying that one is such as what-is and the other as what-is-not; from these, the plenum and solid as what-is, and the void [*and rare*] as what-is-not (which is why they say that what-is is no more than what-is-not, because body is no more than void); and [they say] that these are the causes of the things that are as matter. And just as those who make the underlying essence as one and generate everything else by its affections, positing the rare and the dense as principles of the affections, they too, in the same way, say that the differences are the causes of the other things. Yet they say that these <differences> are three: shape, order, and position. For they say that what-is differs in “rhysmos”, “diathigē”, and “tropē” only. From these, “rhysmos” is shape, “diathigē” order, and “tropē” position; for A differs from N in shape, AN from NA in order, and Z from N in position. As regards motion, however, namely, whence and how it occurs in the things that are, this they blithely neglected, just like the others. (*Metaph.* A.4 985b4-21 [DK 67 A 6]; my transl.)

(2) Democritus and Leucippus say that it is from indivisible bodies — infinite both in number and in the <variety of their> shapes — that everything else is composed; and that these [compounds] differ from each other in respect of what their components are, and in respect of their position and arrangement. (*GC* I.1 314a21-24 [DK 67 A 9])<sup>16</sup>

(3) Democritus and Leucippus, however, positing the shapes, make alteration and generation out of them: generation and corruption by their aggregation and segregation, alteration by their position and order. Since they thought that the truth was in what appears and that the phenomena are contrary and infinite, they made the shapes infinite, so that it is by changes in the compound that the same thing seems contrary to one person and to another, and changes itself by the admixture of the smallest thing, and may seem completely diverse due to the modification of a single thing — for it is from the same letters that “tragedy” and “trygedy” come to be. (*GC* I.2 315b6-15 [DK 67 A 9])<sup>17</sup>

<sup>15</sup> Simplicius also transmits a passage from Theophrastus in which he presents a sort of summary of the atomist doctrines of Leucippus, Democritus and Metrodorus of Chios (*Simp. in Ph.* I.2 [184b15] 28.4-31 [DK 67 A 8, 68 A 38, 70 A 3]). J. B. McDiarmid, however, points that Theophrastus commits the error of trying to conciliate the passage of *Metaphysics* A with *GC*, without noticing that Aristotle adopts different points of view in each of these works (1953, p. 129-130). In *GC*, Aristotle uses σχήματα to refer to atoms as a whole, whereas in *Metaphysics* A, the term σχήμα indicates specifically the external shape of the atoms. Thus, the apparent contradiction found by Theophrastus that the atomists first say that the atoms are immutable and then talk about change of shape does not hold. In *GC*, change happens by the interaction between atoms with different shapes, and not by the transformation of one shape into another. Morel ponders (1960, p. 106, n. 38) that these different points of view are not permanent throughout *GC*, since Aristotle mentions (in I.2 315b6-9, for instance) the other differences that he had mentioned in *Metaphysics* A.

<sup>16</sup> My translation. Δημόκριτος δὲ καὶ Λεύκιππος ἐκ σωμάτων ἀδιαίρετων τὰλλα συγκεῖσθαι φασί, ταῦτα δ’ ἄπειρα καὶ τὸ πλῆθος εἶναι καὶ τὰς μορφάς, αὐτὰ δὲ πρὸς αὐτὰ διαφέρειν τούτοις ἐξ ὧν εἰσὶ καὶ θέσει καὶ τάξει τούτων. I adopt the suggestion of Marwan Rashed (2005, p. 88-89, n. 4) who, in his translation, transposes the sentence ταῦτα δ’ ἄπειρα καὶ τὸ πλῆθος εἶναι καὶ τὰς μορφάς right next to “indivisible bodies”, in order to make it clear that this sentence qualifies σωμάτων ἀδιαίρετων and not τὰλλα. It would not be wrong if it qualified τὰλλα, but this option makes no sense with the context of the passage, which deals with the amount of principle adopted by different predecessors of Aristotle.

<sup>17</sup> My translation. For the adoption of τρυγωδία instead of κωμωδία as it appears on the manuscripts, see Rashed (2005, p. 99-100, n. 2), who adopts a correction by Martin L. West (1969, p. 150-151). Even though its use be rare, *trygedy* (τρυγωδία) is a synonym of *comedy* and its origin is attributed to Aristophanes. The very



(4) Leucippus, however, thought he had arguments that, in agreement with sensation, would not eliminate generation, or corruption, or motion and the multiplicity of things that are. Making such concessions to the phenomena, and conceding to those who argue for the One that there cannot be motion without void, affirms that the void is what-is-not and that nothing of what-is is what-is-not, for what-is in a proper sense is what is fully plenum. Nevertheless, what-is is not one, but many, infinite in number and invisible due to the smallness of their volumes. These move about in the void (for there is a void), and produce generation when they come together and corruption when they separate. Moreover, they act and are affected when they happen to come into contact (and this is why they are not one), and generate when they are composed and interlaced. But from what is truly one a multiplicity could not come to be, nor the one from what are truly many, for this is impossible. However, just as Empedocles and some of the others say that affection occur through pores, so [Leucippus maintains that] all alteration and affection occurs in this way, disintegration, that is, corruption producing itself by means of the void, and similarly growth, by the penetration of <objects> alien <to the compound>. (*GC* I.8 325a23-b5 [DK 67 A 7]; my transl.)

(5) Democritus believe that the nature of eternal things consists in an infinite number of tiny substances. For these he supposes a distinct place, infinite in magnitude. This place he designates by the names of “void”, “nothing” and “infinite”, and each of the substances by “thing”, “solid” and “what-is”. He considers the substances so small that they escape our senses. These have all sorts of forms and shapes, and differences according to magnitude. Out of these, then, as if from letters, the volumes that appear to sight and are perceptible are generated and combined. They are in conflict and borne themselves through the void both because of dissimilarity and because of the other differences already mentioned; and as they are borne, they charge one another and interlace themselves with such an interlacing that cause them to connect and to remain close to each other, but without ever generating a truly single nature out of them. For it is very naïve <to think> that two or more things could ever become one. He also claims that <the fact of> the substances remaining united for a while is the cause of the exchanges and compensations <that occur> in bodies. For <some> of them are scalene, others have the shape of a hook, others have a cavity, others are curved, and the rest have innumerable other differences. So, because of this, he considers that they hold on to one another and remain united for a while until a stronger necessity arise from their surroundings that shakes them violently, and, <becoming> separated, they disperse themselves. (Simp. *in Cael.* I.10 [279b12] 295.1-20 [DK 68 A 37]; my transl.)

From this set of five testimonies we can extract six fundamental features responsible for the differences observed in compound bodies. Aristotle refers to them simply as “differences” (διαφοραί), without specifying what exactly they refer to. The texts can give us the initial impression that they are differences pertaining to atoms alone, when, in truth, those differences are better observed in the correlation of atoms, void, and motion within the compounds. In *Metaphysics* A, Aristotle speaks of *shape* (σχῆμα), *order* (τάξις) and *position* (θέσις) (985b14-15), while in *OD* he mentions *form* (μορφή), *shape* (σχῆμα) and *size* (μέγεθος) (295.7-8). In *GC* I.1 314a23-24 he mentions *form* (μορφή) again, along with *order* (τάξις) and *position* (θέσις), while in I.2 315b7,

---

rarity of the term could explain the reason why tragedy might have been replaced for comedy in the manuscripts.

he uses *shape* (σχῆμα) and, once again, *order* (τάξις) and *position* (θέσις) (b9). Σχῆμα, τάξις and θέσις are terms that Aristotle uses to *translate* three terms that Democritus himself uses to name these differences (*Metaph.* A.4 985b15-17). Σχῆμα replaces ῥυσμός, word from the Ionic dialect that, in Attic, is written ῥυθμός, and which originates our word *rhythm*, but also means *form*, *proportion*, *arrangement* and can be thought as referring to both the *geometric shape* of the atoms and the *atomic configuration* of the compounds.<sup>18</sup> Τάξις replaces διαθιγή, *mutual contact*, and refers to the *interlacing* (περιπλοκήν) mentioned in *OD* 295.11; and θέσις replaces τροπή, a sort of *change in direction*, which is the opposite condition to interlacing, that is, the condition when the atoms, after a shock, do not remain connected, and refer also to the dispersion of atoms resulting from segregation.<sup>19</sup> Lastly we have the *void*, which, within the compounds, allows action and passion, as Aristotle describes in *GC* I.8 325a36-b5.

Summarizing, then, from the five passages quoted above, we can extract six differences:

1. the *geometric shape of the atoms*, corresponding to ῥυσμός when applied to individual atoms (translated as σχῆμα and μορφή by Aristotle);
2. the *size of the atoms* (μέγεθος), which nowadays would be more properly understood as *volume*;
3. the *configuration of the compounds*, corresponding to ῥυσμός when applied to the compounds;
4. the *interlacing* of atoms, corresponding to διαθιγή (translated by τάξις);
5. the opposite condition to interlacing, which we could denominate *repulsion* (without implying any sort of force, only the after-shock effect), corresponding to τροπή (translated by θέσις);
6. the *void within* the compounds, which participates in the structural configuration of the compounds (ῥυσμός) and also confers *density* to them.<sup>20</sup>

<sup>18</sup> I will present a paper about the interpretation of the Democritean term rhyssmos and the senses it can assume in the next conference of the *International Association for Presocratic Studies* to be held at Delphi, Greece, in June 2018. A preliminary version of the arguments to be presented there can be found in GOMES, 2018, p. 143-155.

<sup>19</sup> Cf. *SD* 295.18-20.

<sup>20</sup> Let me note here, just for the record, that four of these differences also appear in Theophr. *Sens.* 60 (DK 68 A 135) — *size*, *shape*, *order* and *position* (as expected, in Aristotelian translation). Simplicius (*in Cat.* 8 [8b25] 216.31-217.5 [≠ DK; LM 27 R34]) mentions a series of differences that had not been designated as such by

## V

To these six differences we must yet add a seventh, which appears somewhat veiled, or even involuntarily, since Aristotle does not admit it as a principle: the *atomic motion*.

In the passage we read from *Metaphysics A*, after presenting and explaining the differences that should be the cause of the compound bodies to the atomists, Aristotle adds the following sentence: “As regards motion, however, namely, whence and how it occurs in the things that are, this they blithely neglected, just like the others.” (*Metaph. A.4* 985b19-20). To Morel (1996, p. 53-54), the sentence indicates that Aristotle expected that the three differences listed previously should work as well as explanations for motion, but end up not fulfilling that properly. It does not seem to me, however, that Aristotle’s text allows such connection as straightforwardly as Morel suggests. Of course, it is pretty obvious that Aristotle missed some kind of external cause for motion in the atomic theory. A theory that, under his eyes, worked exclusively with material causes cannot have, almost by definition, a cause for motion, which would have to be some principle external to the material substrate. Morel seems to consider that Aristotle, when translating the Democritean terms that designate the differences (ρυσμός, τροπή and διαθγή) by terms with a static connotation (σχῆμα, τάξις and θέσις), would be trying to conceal the dynamic character of these differences. Yet, it seems to me that Aristotle finds himself in front of something that sounds to him as an *error of Democritus*: material principles such as the atoms should not have dynamic characteristics, for they should be eminently idle. Hence, Democritus *must have wanted to say* shape, order and position, which are differences more appropriate to material causes. It is not that Aristotle considered that the three Democritean differences were insufficient to account for motion; they simply could not be causes of motion. Thus,

---

Aristotle. It is the case of *weight* (βάρος), *compactness* (ναστότητα), *corporeality* (σωματότητα), *limits* (περάτων) and *motion* (κινήσεως). (Along with these differences he also mentions shape and size.) There are two reasons not to include the extra differences mentioned by Simplicius on the list of basic differences: because (1) some of them are not primary, in the sense that they can be directly derived from some other more fundamental difference, as, for instance, the weight of the atoms that can be derived directly from their size, given the fact that the atoms are homogeneous (*cf. Ph. I.2* 184b20-22 [≠ DK]; Theophr. *apud* Simp. *in Ph. I.2* [184b15] 26.31-27.1 [≠ DK]; Gal. *de elem. sec. Hipp. I.1* 417.7 [≠ DK]; Simp. *in Cael. III.1* [299a25] 569.6 [DK 68 A 61]), or the limits, which are given by their geometric shape; and because (2) some of these differences do not occur differently in the atoms, only in compounds, that is, because the atoms do not differ between themselves in relation to them — all atoms are equally compact or corporeal; it is only the compounds, because of density (determined by the void within), that have differences in compactness and there are no differences in corporeality (things more or less corporeal), unless this means to express density somehow.

since the atomists did not propose any other kind of cause (in his evaluation), then, as the others before them, they could not provide an adequate explanation for motion either.

As a matter of fact, what happens here is that Aristotle seems to deny to the elements of the atomic theory the malleable character that his own elements have. He confines the elements of the atomic theory as static material causes, which demand an exterior principle to be put in motion. That compounds be generated by changes of shape, order and position is something he is willing to concede, but the atomists still lack the efficient causes for these changes, as well as the formal cause — that which determines their final form, the result of the changes.<sup>21</sup>

Motion, however, works as a principle in atomism. The atoms simply *have motion*, no qualifiers needed. Their motion does not depend on a previous first cause. This means that motion — not rest — is the standard condition of everything there is in the atomist universe, a much more Heraclitean conception than Parmenidean. Regarding the differences, motion is not present only in the cases of the geometric shapes and of the sizes of the atoms, which are immutable, that is, which cannot change in form or in size. In the remaining differences, motion is always present: in the configuration of the compounds (since it is dynamic); in interlacing, which depends on the shocks between atoms to occur; in repulsion, which is the expression of the non-occurrence of interlacing after the shocks; and even in the density of the compounds, which is the dynamics established between the atomic mass and the void within. But beyond this participation of motion in four of the six differences listed above, motion itself can be considered a seventh difference because of the exchanges of atoms that occur between the compound and external environment. These exchanges can affect the whole compound producing alterations or even provoking its complete dissolution (*OD* 295.14-16).

## VI

The role of these differences is so fundamental in the atomist chemistry that Morel even suggests that they should be understood as “elements” and “material

---

<sup>21</sup> Cf. MOREL, 1960, p. 59-60. About Aristotle's critique to theories, like atomism, that do not present a formal cause, see *GCII.9*.

causes” (1996, p. 84),<sup>22</sup> implying that the differences presented in the testimonies analyzed above *are* the elements or material causes of the compounds, even more so than simply atoms and void. This can seem strange at first, since it generates an ambiguity with the atoms and the void themselves, which are also said to be elements and material causes. It makes sense, however, if we think that the differences are more directly responsible for the differences in the compounds than the atoms and the void considered in themselves. Aristotle himself gives margin to this interpretation as he presents a hierarchy of principles in *GC* II.1 329a32-35. My suggestion is to take atoms and void as a material support for the differences, and, then, the differences themselves as principles or causes of the compounds.

This is particularly useful against a critique of Aristotle that appears in *DC*:

In a way, these [Leucippus and Democritus] also make all things that are numbers and <to constitute themselves> from numbers. And even if they do not show this clearly, this is precisely what they want to say. (*Cael.* III.4 303a8-10 [DK 67 A 15]; my transl.)

In this passage, Aristotle speaks in a strange way, saying that, even if they do not say so explicitly, for Leucippus and Democritus, all things are numbers, including compounds and elements. A few lines earlier (in 303a6-7) he was saying that, for the atomists, unity and multiplicity cannot generate themselves mutually, that is, that neither the many can become one, nor the one can become many. This strengthens both the idea that compounds do not have effective but only apparent unity, and the idea that the atoms cannot be divided, because they are the only real unity. It may not be so clear at first what relation there is between these statements about the inconvertibility between unity and multiplicity, and the affirmation that all things are numbers, but they are intimately related. If the one cannot be generated from the many, this means that everything that exists is multiple, not only in the sense that many things exist, but also in the sense that everything that seems to have unity (to the senses) is, in fact, multiple, formed by the aggregation of atoms that are the only things effectively unitary in nature.

Now, number can also be understood as an abstract designation of multiple.<sup>23</sup> But in this passage, number cannot be taken simply as a synonym of multiple. It implies

---

<sup>22</sup> “A quelques nuances près, le texte [of *OD*] recoupe et complète les présentations de la *Métaphysique* et du *Traité de la génération et de la corruption* : les différences sont les éléments ou les causes matérielles des corps composés.” (1996, p. 84).

<sup>23</sup> Note that, for Aristotle, the first number is 2; 1 is principle of number, and is not itself a number (*cf. Ph.* IV.12 220a27-32).

something else. A number is formed by a unitary and uniform principle, the 1. There are not different 1's (1 and 1', for instance) forming different 2's depending on the presence of 1 or 1' in different number-compounds. 2 is always 2, 3 is always 3, etc. When saying that for the atomists all things are numbers, Aristotle is implying that the constitutive material principle of all things is uniform, without any qualitative difference, and that, for them, therefore, the cause of the compounds are mere quantitative differences of a uniform principle. This would draw atomism closer, at least in this passage, to a sort of elementary monism. To Aristotle, however, quantitative differences are not enough to generate the qualitative differences observed in the immense variety of sensible compounds.<sup>24</sup>

It is curious that in this passage of *DC* Aristotle ignores completely the differences that he himself points in the passages we have seen earlier. He seems to demand that the differences of the compounds be caused exclusively by differences present in the elements. In *GC* II, he proposes a theory that deals exactly with that. The elements are constituted of pairs of contraries (*i.e.* differences), and these are the major causes of *all* qualitative differences in the compounds. I say “major” because even Aristotle cannot dismiss the role of quantitative difference (that is, a greater or lesser presence of this or that element) in his chemistry, something evident in the case of the process of mixture.<sup>25</sup> Furthermore, the changes that occur in the realm of compounds in Aristotle's theory must reflect changes that occur with the elements themselves. For this mechanism to work, Aristotle presents a whole theory of the transformation of the elements into one another.<sup>26</sup> In practice, Aristotle's requirements for the elements unite two distinct functions in the same kind of entity: on the one side, the function of being the ultimate constituents of everything there is, and, on the other, the function of being directly responsible for the differences that are perceived in the compounds.

---

<sup>24</sup> Cf. MOREL, 1996, p. 85. This is not, therefore, a “Pythagorization” of atomism or a “numeric atomism”. About the hypothesis of a numeric atomism, see CORNELLI, 2013, p. 140-142. Aristotle attributes to Eurytus of Taranto, a Pythagorean mathematician disciple of Philolaus of Croton, the postulation of a numeric atomism (*Metaph.* N.5 1092b8-13 [DK 45 3]). There are those who suggest that this numeric atomism could be a link between Pythagoreanism and the atomism of Leucippus and Democritus, but this thesis is rejected by the majority of scholars (cf. CORNELLI, 2013, 142 & n. 391).

<sup>25</sup> See *GC* I.10.

<sup>26</sup> See *GC* II.4.

In the case of atomism, however, there seems to be a separation: on the one side we have atoms and void as the ultimate (material, in Aristotelian jargon) constituents of all things, and, on the other, the differences that are not always direct properties of such constituents, but that, when they are not their direct properties, they emerge from their relationships. If we think that the differences have, in this sense, one of the functions that Aristotle requires for the elements, we can also defend that in atomism certain elements of the compounds are changeable. The geometric shapes and the sizes of the atoms certainly are not, but the configuration of the compounds (ῥυσμός), the interlacing of atoms (διαθιγή) or their repulsion (τροπή), density and the very *chemical balance* between the compound and its external environment, which is a dynamic balance, certainly are changeable.

In this way it would be even possible to talk about generation of the elements in atomism, for, in thesis, there is nothing that would hinder the possibility that the differences could return to a previous configuration. With this, at least from the point of view of the necessity of having some sort of alteration in the realm of elements, it would be no longer possible to indicate one of the two theories as having a greater explanatory potential than the other. Aristotle himself do not indicate how his own elements can explain every single type of difference in the realm of compounds, and he could not do it, not only because of temporal restrictions, but mainly because his choice of four elements imposes him a serious limitation.<sup>27</sup>

Even more: it will not be possible to deny the presence of an efficient component and we could even find a formal component in the configuration of the compounds, which will be responsible to confer something akin to the substantial identity that Aristotle sometimes claims not to find in atomism, but some other times concedes to Democritus, as in these two testimonies with which I end this paper:

The reason our predecessors did not arrive at this kind [scil. of cause, the formal or final one] is that what the being of a thing is and the definition of its essence were lacking. It was Democritus who was the first to approach the question, not as being necessary for the theory of nature, but because he was brought to it by the things themselves [...]. (*PA* I.1 642a24-28 [DK 68 A 36]; transl. LM 27 R28)

If we look to the ancient thinkers, [the object of physics] would seem to be matter (the exception lies with Empedocles and Democritus, who touched a small part of [matters of] forms and essence). (*Ph.* II.2 194a18-21 [≠ DK]; my transl.)

---

<sup>27</sup> Cf., however, *Meteorologica* IV, which contain many descriptions of phenomena using the four elements and the exhalations.

## References

- ANGIONI, L. (2008). Aristóteles. *Metafísica*: Livros I, II e III. Campinas: Unicamp. Cadernos de Tradução nº 15.
- ANGIONI, L. (2009). Aristóteles. *Física I-II*: Prefácio, introdução, tradução e notas. Campinas: Unicamp.
- CHORÃO, F. (2009). Aristóteles. *Sobre a Geração e a Corrupção*: Tradução e notas. Lisboa: Imprensa Nacional-Casa da Moeda.
- CORNELLI, G. (2013). *In Search of Pythagoreanism*: Pythagoreanism as an Historiographical Category. Berlin-Boston: Walter De Gruyter.
- DALIMIER, C.; PELLEGRIN, P. (2004). Aristote. *Traité du ciel*: Traduction et Presentation. Paris: GF Flammarion.
- DIELS, H.; KRANZ, W. (2012). *I Presocratici*. Tradução de Giovanni Reale; Diego Fusaro, *et al.* 4ª ed. Milano: Bompiani.
- GOMES, G. L. (2017). O atomismo segundo Aristóteles: pluralismo ou monismo? *Phaine* 2, n. 3, p. 56-79.
- GOMES, G. L. (2018). A química atomista de Leucipo e Demócrito no tratado Sobre a geração e a corrupção de Aristóteles. Belo Horizonte: UFMG. (M. A. Dissertation)
- GRAHAM, D. W. (2006). *Explaining the cosmos*: The Ionian tradition of scientific philosophy. Princeton: Princeton University Press.
- HEIBERG, I. L. (ed.) (1894). Simplicii. *In Aristotelis De Caelo commentaria*. Berolini: Typis et Impensis Georgii Reimeri. Commentaria in Aristotelem Graeca, vol. VII.
- HUSSEY, E. (2004). On Generation and Corruption I. 8. In: DE HAAS, F.; MANSFELD, J. *Aristotle's On Generation and Corruption, Book I*: Symposium Aristotelicum. Oxford: Oxford University Press. p. 243-265.
- KÜHN, C. G. (ed.) (1821). Claudii Galeni. *Opera Omnia*. Lipsiae: Officina Libraria Car. Cnoblochii, vol. I.
- LAKS, A.; MOST, G. W. (2016). *Early Greek Philosophy*. Cambridge, Harvard University Press, vol. VII – Later Ionian and Athenian Thinkers (part 2).
- LEE, H. D. P. (1952). Aristotle. *Meteorologica*: With an English Translation. Cambridge: Harvard University Press.
- LOPES, R. (2012). Platão. *Timeu-Crítias*: Tradução do grego, introdução e notas. 2ª ed. São Paulo: Annablume.



- MCDIARMID, J. B. (1953). Theophrastus on the Presocratic Causes. *Harvard Studies in Classical Philology*, Cambridge, v. 61, p. 85-156.
- MOREL, P.-M. (1996). *Démocrite et la recherche des causes*. Paris: Klincksieck.
- PECK, A. L. (1961). Aristotle. Parts of Animals. In: PECK, A. L.; FORSTER, E. S. Aristotle. *Parts of Animals, Movement of Animals, Progression of Animals*: With an English Translation. 3rd ed. Cambridge: Harvard University Press. p. 3-434.
- PRIMAVESI, O. (2012). Metaphysics A: A New Critical Edition. In: STEEL, C. *Aristotle's Metaphysics Alpha*: Symposium Aristotelicum. Oxford: Oxford University Press. p. 387-515.
- RASHED, M. (2005). Aristote. *De la génération et de la corruption*: Texte et traduction. Paris: Les Belles Lettres.
- REEVE, C. D. C. (2018). Aristotle. *Physics*: Translated with an Introduction and Notes. Indianapolis-Cambridge: Hackett Publishing Company.
- ROSS, W. D. (1936). Aristotle. *Physics*: A revised text with introduction and commentary. Oxford: Clarendon Press.
- SOLMSEN, F. (1960). *Aristotle's System of the Physical World*: A Comparison with His Predecessors. Ithaca: Cornell University Press.
- WEST, M. L. (1969). An Atomist illustration in Aristotle. *Philologus*, n. 113, p. 150-151.
- WILLIAMS, C. J. F. (1982). *Aristotle's De Generatione et Corruptione*: Translated with notes. Oxford: Oxford University Press.