

# An alternative model for understanding Anaxagoras' mixture

David TORRIJOS-CASTRILLEJO (Madrid)

*Abstract.* For Anaxagoras, both before the beginning of the world and in the present, “all is together” and “everything is in everything.” Various modern interpretations abound regarding the identity of this “mixture.” It has been explained as an aggregation of particles or as a continuous “fusion” of different sorts of ingredients. However—even though they are not usually recognized as a distinct group—there are a number of other scholars who, without seemingly knowing each other, have offered a different interpretation: Anaxagoras' mixture as an “interpenetration” of different ingredients, which are as far-extended as the whole mixture is. As a result, there are different entities occupying the same place at the same time. This explanation assigns to Anaxagoras the same model of mixture which was later used by the Stoics. A new book by Marmodoro helps us to clarify this position.

Anaxagoras has been known since antiquity by his philosophical motto:  $\delta\mu\omicron\upsilon\ \pi\acute{\alpha}\nu\tau\alpha$  (“all together”). This admittedly odd expression describes his particular understanding of cosmic “mixture” ( $\sigma\acute{\upsilon}\mu\mu\iota\zeta\iota\varsigma$ ): everything is in everything. For the most part, modern scholarship surrounding this Presocratic thinker has investigated this very feature of his philosophical system. Due to the influence of Aristotelian doxography, discussion has been focused largely on the number and nature of the components in the mixture, considered mainly in their “numerical” or their “extensional” quantity. However, the bigger philosophical problem is *the physical way* in which ingredients mix. It is thus precisely this concern which will be focused upon in these pages, where I will propose that due attention should be given to a fourth quantitative dimension of mixture, a non extensional one, namely, its “density.”

In order to understand the philosophical problems involved in Anaxagoras' mixture, we need to begin by summarising his main assertions:<sup>1</sup>

1. Nothing comes into being out of nothing.
2. At the very beginning, all things were mixed.
3. There is a portion of everything in everything.
4. It is impossible to find the smallest part of anything.
5. Each thing receives its name from its most predominant ingredient.

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<sup>1</sup> I take these “principles” from the lists elaborated by Kerferd (1974), 490f. and more recently by Rapp (2007), 175.

At the very beginning, all things were mixed, and this situation is in some way still the same (ἄπλωσπερ ἀρχὴν εἶναι καὶ νῦν πάντα ὁμοῦ: DK 59 B 6): all things constitute a continuous mass and in all the extensive regions of such a continuum it is possible to find parts of all the “ingredients” that make up the entire mixture. The only difference between one region of the universe and any other is the respective proportion in which the “parts” of “ingredients” are disposed.

Here we follow a manner of speaking introduced by modern scholarship. In order to distinguish between the two aspects of Anaxagoras’ term “thing” (χρῆμα), many scholars use the terms “object” and “ingredient.”<sup>2</sup> The name “object” refers to the outcome of predominance of some things in the mixture, i. e. the perceptible emergence of some things in a region of it. On the other hand, “ingredients” are things as components of the mixture. Every “object” is not only a bunch of some predominant “ingredients” but is a region of mixture made by all ingredients, which are disposed in different proportions. Now, an object receives its name by its predominant ingredients: “hot milk” is mostly made by “milk,” “fluidity,” “white,” “hot,” etc., but it also entails very little parts of every other ingredient such as “gold,” “hair,” “black,” “cold,” etc. So, there is a somewhat ambiguous use of “thing” in order to say: “everything is in everything.”<sup>3</sup>

My purpose in these pages is to answer to this question: how are the ingredients mixed like this? How can “things” exist *in* other things? In other words: what is the concept of mixture that Anaxagoras defends? To answer to these questions, I begin by recalling the different solutions given by modern scholarship. Secondly, I will highlight a model which is not usually included among the standard solutions to this problem. I will provide a brief description of this model by comparing it with the Stoic and Aristotelian theories of mixture. Finally, I will discuss a recent book by Anna Marmodoro, which defends a new account of this unconventional model. Her publication will assist in demonstrating the advantages of my own view.

### 1. Some models of mixture to explain Anaxagoras’ physics

Interpretations of Anaxagorean mixture have been varied throughout history, but among them, a special significance should be given to that of Aristotle.<sup>4</sup> He links the doctrine of Anaxagoras with that of Democritus in *Physics* (III, 4, 203 a 22). Here, Aristotle considers homoeomereous substances to be elements *in contact*

<sup>2</sup> See, for instance, Schofield (1980), 74: “[...] in every *object* (or object-like stretch of stuff) of a given kind there is an *ingredient* of every other kind of object or stuff, and [...] ingredients are not themselves objects or object-like stretches of stuff.”

<sup>3</sup> Curd (1998), 139: “Anaxagoras uses ‘thing’ (χρῆματα) indiscriminately between things at the metaphysically basic level (‘things that are’) and things at the level of apparent coming-to-be and passing-away (‘no thing comes to be or perishes’).”

<sup>4</sup> The history of ancient interpretations of Anaxagoras’ philosophy has been investigated by Silvestre (1989). One can complement this view with the history of modern interpretation, exposed by the recent work by Rechenauer (2013), 743 f. I myself spent some pages of my book on the interpretation of mixture in Aristotle: see Torrijos-Castrillejo (2014), 315–370.

with each other. However, elsewhere he tends to understand the whole mix as a single substance (*Metaph.*, A, 8, 989 a 31, b 17) and the transformations within it as mere qualitative changes (*De gen. et corr.*, I, 1, 314 a 15).<sup>5</sup> Moreover, he also admits some harmonization of both positions by saying that the basic ingredients are comparable to a single substance, simultaneously one and many (*Phys.*, I, 4, 187 a 21–23). Given this interpretation, Anaxagoras' position would be closer to that of the Ionians. It is clear then that Aristotle does not limit himself to one interpretation, but offers varying analyses. To resolve this discrepancy, I would argue that he refers not only to Anaxagoras but also to a group of philosophers interested in his doctrine: οἱ περὶ Ἀναξαγόραν (see, for example, *De gen. et corr.*, I, 1, 314 a 25). Some of them advocate the separation and reunion of many ingredients, while others are more inclined to argue for a single reality, the mixture, which is altered by parts.<sup>6</sup>

Among modern writers, there are generally five interpretations about the nature of mixture. The first one we might call the “particulate” view. According to this interpretation, mixture is a juxtaposition of minuscule particles: overall, it would be an aggregation of actually divided parts, even though to our eyes it appears as a homogeneous continuum. It would thus be similar to a Democritean mixture (*Aetius*: DK 59 A 54).<sup>7</sup> Even so, it is difficult to understand Anaxagoras' mixture from

<sup>5</sup> This position is difficult to reconcile with the fact that Aristotle also argues that qualities are, for Anaxagoras, *substances* (if change would be merely an alteration, qualities should be “accidents”): see *Phys.*, I, 4, 188 a 12 f.; *Metaph.*, A, 8, 989 b 3; *De gen. et corr.*, I, 10, 327 b 20–22.

<sup>6</sup> Consider this important text: [a] διὰ τοῦτο γὰρ οὕτω λέγουσιν, ἦν ὁμοῦ πάντα, καὶ τὸ γίγνεσθαι τοιόνδε καθέστηκεν ἀλλοιοῦσθαι, [b] οἱ δὲ σύγκρισιν καὶ διάκρισιν (*Phys.*, I, 4, 187 a 29–31). Hence Aristotle notes the inner contradiction between an understanding of change as a system of aggregation and separation and, on the other hand, the idea of change as a mere alteration. As a result, he censures “Anaxagoras” for not understanding his own phrase: Καίτοι Ἀναξαγόρας γε τὴν οἰκείαν φωνὴν ἠγγόησεν· λέγει γοῦν ὡς τὸ γίνεσθαι καὶ ἀπόλλυσθαι ταυτὸν καθέστηκε τῷ ἀλλοιοῦσθαι, πολλὰ δὲ λέγει τὰ στοιχεῖα, καθάπερ καὶ ἕτεροι (*De gen. et corr.*, I, 1, 314 a 13–16). However, elsewhere Aristotle seems to allude to Anaxagoras by saying that the ingredients *are not* altered: ὄντων μὲν γὰρ ἔτι τῶν μειχθέντων καὶ μὴ ἠλλοιωμένων οὐδὲν μᾶλλον νῦν μεμίχθαι φασὶν ἢ πρότερον, ἀλλ' ὁμοίως ἔχειν (*De gen. et corr.*, I, 10, 327 a 35 – b 2). Some of Simplicius' words are illuminating in this regard; through which we note that, using *De gen. et corr.*, I, 1, 314 a 13–16, Alexander of Aphrodisias made efforts to identify the authentic Anaxagorean terms. Although his assertions about σύγκρισις and διάκρισις are not very accurate, he does provide an elucidation of ἀλλοίωσις: λέγει γοῦν ὡς ‘τὸ γίνεσθαι’ καὶ τὸ ἀπόλλυσθαι ‘τοιόνδε καθέστηκεν ἀλλοιοῦσθαι’· οὐ γὰρ οἰκείῳ ὀνόματι τῷ τῆς ἀλλοιώσεως κατὰ τῆς συγκρίσεως καὶ τῆς διακρίσεως ἐχρήσατο. Πορφύριος δὲ τὸ μὲν ‘ἦν ὁμοῦ πάντα’ χρήματα εἰς Ἀναξαγόραν ἀναπέμπει, τὸ δὲ ‘τὸ γίνεσθαι’ εἶναι τὸ ‘ἀλλοιοῦσθαι’ εἰς Ἀναξιμένην, τὴν δὲ ‘σύγκρισίν τε καὶ τὴν ‘διάκρισιν’ εἰς Δημόκριτον τε καὶ Ἐμπεδοκλέα (*Simplicius, In Phys.*, CAG 163, 13–18). Nevertheless, Ross' (1960), 484 f. interpretation in his commentary (187 a 31) has become the most common for *Phys.*, I, 4, 187 a 29–31: “But οἱ δὲ distinguishes those who made this identification from Anaxagoras, who has been referred to in the earlier part of the sentence. οἱ δὲ refers primarily to Empedocles, whose doctrine Aristotle often refers to as identifying γένεσις with σύγκρισις καὶ διάκρισις, though this is equally true of, and is ascribed by Aristotle elsewhere to, Anaxagoras.” On the contrary, my interpretation follows the astute point of Lanza (1966), 103: “Forse sarebbe più opportuno immaginare un doppio modo di riferire la dottrina anassagorea [by the *pensatori anassagorei*: see Lanza (1966), 102], perché anche il principio di σύγκρισις/διάκρισις le appartiene indiscutibilmente (cfr. B 17).”

<sup>7</sup> The first modern author that holds this theory could be Heinius (1753), 372–377. See also Schaubach (1827), 87, 94, etc.; Γεωργούλη, vol. 1 (1975), 112; Cappelletti (1984), 209–211, 231–232. Zevort, meanwhile, understanding these particles as points of infinitesimal size, inaugurates a line of interpretation

this “particulate” viewpoint, given that he repeatedly denies the existence of minimal or separable parts in mixture: οὔτε γὰρ τοῦ μικροῦ ἐστὶ τό γε ἐλάχιστον, ἀλλ’ ἔλασσον αἰεί (DK 59 B 3); ὅτε τοῦλάχιστον μὴ ἔστιν εἶναι, οὐκ ἂν δύναίτο χωρισθῆναι (DK 59 B 6).<sup>8</sup>

Secondly, there is a non-particulate interpretation that attempts to explain Anaxagoras’ mixture as a continuum. However, instead of being a plurality of elements, the entire mixture is reduced to a single material entity that bears all the qualitative conditions, which vary at different points. Tannery’s explanation adopted such an approach and was well received among scholars, particularly English-speakers, who followed Burnet’s example.<sup>9</sup> It is possible that a general acceptance of Kant’s understanding of matter, which is similar to this one and was explicitly referred to by Tannery, contributed to the success of this model.<sup>10</sup> Its resemblance to modern chemical models of mixture would also make it an attractive interpretation. This position needs to explain the nature of “seeds” (DK 59 B 4a, 4b), a concept that would seem to favour an atomistic comprehension. For these authors, seeds constitute a mixture of different qualities in a certain proportion. The proportion makes each type of seed give origin to a homoeomerous substance. The main difficulty with this view is its reduction of ingredients to qualities, a modern construct probably not considered by Anaxagoras. Other authors sustain a variant of such a model, in which the components of mixture are not only simply qualities.<sup>11</sup> In any case, it is likely that even qualities were regarded by the Clazomenian philosopher as subsistent realities;<sup>12</sup> hereafter, the problem would be *how* such *substances*—whatever they might be—are mixed. It is unsatisfactory to speak about “mixture,” “blend,” or “fusion” without elucidating how such a combination occurs, because one cannot presuppose that Anaxagoras sustained modern chemical models.<sup>13</sup>

Thirdly, Lanza’s position merits special treatment. He reckoned that the best way to understand Anaxagoras is to avoid attributing a mechanical conception of mat-

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followed by many authors. For Zevort, the indivisible and simple *homoeomeireiai* are characterized by their infinite smallness: see Zevort (1843), 61–72. Nietzsche considers *homoeomeireiai* as infinitesimal points (*Punkte*), each of them provided with a different quality: see *Die Philosophie im tragischen Zeitalter der Griechen*, § 16, in Nietzsche, vol. 3 (1973), 405. See also Tagliaferro (1953), 302; Raven, (1954), 128–129; Mugler (1956), 323; Gershenson/Greenberg (1964), 11–12; Sorabji (1988), 61–66; Rechenauer (2013), 755–762. These latter positions are quite close to those of the second group that we shall see, as one can glean by looking at Zafropulo, who speaks about *points-quality*, although he decidedly attacks atomistic conceptions of matter in Anaxagoras: see Zafropulo (1948), 276 ff., 282 ff. A similar approach is present in Marmodoro (2017), 86–90, which we will discuss later.

<sup>8</sup> Barnes (1982) criticized this interpretation with success, but there is much interesting material in Pepe’s work: see Pepe (1996), 43–65.

<sup>9</sup> See Tannery (1886), 256–293; Burnet (1908), 263 ff.

<sup>10</sup> See Tannery (1886), 265.

<sup>11</sup> Curd considers this position (defended by herself) as an alternative between an “Austere Ontology” (only qualities are ingredients) and an “Expansive” one (absolutely all entity is an ingredient): see Curd (2007), 157 ff.

<sup>12</sup> Hence the concept of “quality-things” coined by Cornford (1930), 83–95. See Mourelatos (1973), 16–48.

<sup>13</sup> For instance, Bailey (1964), 546 speaks of “chemical fusion” and Barnes (1982), 325 or Graham (1994), 103, 117 ff. argue in a similar way. To what model among the different models of mixture in the history of philosophy are they referring? How does an appeal to modern chemistry help?

ter to him. He sees Anaxagoras as an Ionian strongly influenced by the medical literature and mathematics of his time; thus, he would have defended a single nature beneath the whole variety of corporeal beings.<sup>14</sup> Meanwhile, Paxson defended an extreme view of mixture's unity as if it were the only entity *per se*, excluding the very idea of ingredients (even thought as qualities) to the point of denying the traditional pluralism attributed to Anaxagoras.<sup>15</sup> Thus, this position turns Anaxagoras into a quasi-monist and thereby denies the very notion of mixture as such. However, the fact remains that Anaxagoras speaks about ingredients using the plural form; for him they are *subjects*, not merely properties or predicates of a substrate. Moreover, they are *actual* in the mixture and not merely *potential*.

Recently a fourth way of interpreting mixture has been proposed, which also retains the idea of extensional continuity. This model is inspired by the modern theory of fractals and depends mostly upon the third fragment (there is no minimum but a thing can always be smaller).<sup>16</sup> Its proponents argue that things are related to the mixture and to each other as similar geometrical proportions are related to one another, i. e. regardless of size: one can expand or reduce any geometric shape indefinitely without changing its properties, so any figure could be placed in every other. These authors have undoubtedly adequately understood the quantitative structure of Anaxagoras' universe, but their model ignores the fact that he understands each ingredient not principally quantitatively (by its dimensions) but qualitatively: the unresolved problem is the way in which eidetically different substances (regardless of their respective sizes) could be together in the same place at the same time. Such a problem would also go unsolved if the model were understood not quantitatively but qualitatively, because in that case it would be a variant of the second model described above.

## 2. An alternative model for mixture in Anaxagoras

After quickly sketching four modern interpretations of mixture, I would also present a fifth which could serve as a suitable alternative. This alternative model is not yet well known and even its first exponents seem to be unaware of its originality. This fifth interpretation begins with the Italian scholar Aldo Mieli. Departing from Tannery's position, Mieli saw the infinite elements of Anaxagoras as subsistent qualities. He interprets such qualities as *substances* with a mutually-*interpenetrated* infinite extension, i. e., occupying the same space at the same time.<sup>17</sup> How-

<sup>14</sup> See Lanza (1962), 291–293. A similar position was adopted by Pepe (1996), 64–87.

<sup>15</sup> See Paxson (1983), 85–91.

<sup>16</sup> Drozdek (2005), 173: "Inherently recursive objects are described by the modern theory of fractals which are self-replicating structures that in each of their parts, however small, repeat the form of the whole. The interpretation [...] is inspired in no measure part by this theory." See Graham (1994), 109; Grujić (2001), 21–34; Graham (2006), 210–213; Drozdek (2008), 66–75.

<sup>17</sup> Mieli (1913a), 371: "Questa difficoltà [...] lo induce ad ammettere la preesistenza di tutte le infinite sostanze, le quali si trovano disseminate, in proporzione diversa, in tutto lo spazio [...], Anassagora immagina che in una qualunque particella infinitesima di spazio esistano tutte le infinite sostanze [...]. Per

ever, Mieli shows his dissatisfaction with the idea of an interpenetration of different bodies, recalling the notion of mere qualities as developed by Tannery.<sup>18</sup>

The broadest discussion of mixture in Anaxagoras as an “interpenetration” of ingredients can be found in an article by Bröcker, who ignores Mieli’s work but defends a similar interpretation.<sup>19</sup> He understands the very ingredients of mixture –which he sees as “seeds”–as continuous extensive entities, occupying the whole of infinite space. Hence, he argues that the best way to understand their spatial disposition is not to consider them as corpuscles of infinitesimal size, but as a multitude of “substances” conjointly interpenetrated: “[...] we get rather a seed as big as the world. All seeds would occupy the entire universe mutually interpenetrating.”<sup>20</sup>

The most influential scholars today (Kirk-Raven, Barnes, Sider, Schofield, Curd ...) have completely missed both Mieli’s and Bröcker’s work. While Lanza does mention Bröcker, he argues that his interpretation is unlikely.<sup>21</sup> Nevertheless, Bröcker’s theory could be revalued in our time; since it is based on a reflection of the profound influence that Eleatic philosophy exercised on Anaxagoras; something confirmed by the studies of Curd and Graham.<sup>22</sup>

In recent years, two scholars have made serious proposals for an “interpenetrating model,” as I would name it. The first of the two, Sorabji, holds a particulate version of mixture, whereby the ingredients are not only qualities but also substances divided into infinitely small parts. Until this point, Sorabji follows the first of the aforementioned interpretations. The most telling part of his study, however, concludes that both an atomistic model—as that of Sorabji—and a “blending” model—as that of Burnet and others—suppose that things *have to occupy the same place simultaneously*.<sup>23</sup> In discussing with Sorabji, Lewis re-evaluates the interpenetrating model.<sup>24</sup> He thinks that such a model would be the hidden consequence of a blending model.<sup>25</sup> However, as we saw, it is precisely the question about *how* the ingre-

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ogni punto si può quindi stabilire un’espressione  $m_1 \mu_1 + m_2 \mu_2 + \dots + m_n \mu_n$  dove le  $m$  sono coefficienti numerici che esprimono quantità di sostanza e le  $\mu$  sono le sostanze alle quali i coefficienti si riferiscono. Le  $m$  sono funzioni del posto e del tempo, abbiamo cioè  $m_i = \varphi_i(x, y, z, t)$ . Siccome poi le singole sostanze si mantengano inalterate per quantità avremo che per tutte le  $\varphi$  sarà  $d/dt \int \varphi_i(x, y, z, t) dx dy dz = 0$  dove l’integrale è supposto esteso a tutto il cosmo.” See also Mieli (1913b), 329–344; Mieli (1922), 46–53.

<sup>18</sup> Mieli (1913a), 371–372: “Espressa nel modo suddetto la teoria certamente no soddisfa [...]. Invece di quantità di sostanza diciamo ora *gruppo fisso di qualità*; e diciamo ancora che in ogni punto esistono tutti i possibili gruppi di qualità, ciascuno con un’intensità diversa.”

<sup>19</sup> See Bröcker (1942), 176–189.

<sup>20</sup> Bröcker (1942), 178: “[...] da Anaxagoras das Dasein eines Leeren leugnet (A 68), so bilden die Punkte der Samen-Individuen ein lückenloses Kontinuum. Der Unterschied zwischen einer Samenklasse und ihren unendlich vielen unendlich kleinen Individuen verschwindet, und *wir erhalten vielmehr einen Samen, der so groß ist wie die Welt. Alle Samen würden, alle einander durchdringen, das ganze Weltall ausfüllen*” (I emphasized the text translated in the body). Bröcker (1942), 180: “Jeder Same ist ein Elementarstoff, der die ganze Welt erfüllt, alle Samen *durchdringen sich gegenseitig*, so daß überall und jederzeit alle Samen beisammen sind” (my emphasis).

<sup>21</sup> See Lanza (1962), 292.

<sup>22</sup> See for example Curd (1998), 131–154; Curd (2006), 34–55; Graham (2006), 186–223.

<sup>23</sup> See Sorabji (1988), 65.

<sup>24</sup> See Lewis (2000), 1–24.

<sup>25</sup> See Lewis (2000), 3, note 7, where he quotes Kerferd, Barnes and Strang.

dients are combined that the supporters of a blending model have left unresolved. Therefore Lewis retains the standard interpretation explained above (the second interpretation), but he completes an important omission in it, assuming that the ingredients “completely occupy the same volume.”<sup>26</sup> Thus, “that all the blended ingredients are present at every location in the blend assures that everything is in everything.”<sup>27</sup>

Although these authors do not seem to be aware of the novelty of their interpretation, it could nevertheless signify a great contribution to the understanding of mixture in Anaxagoras. At the very least it could represent a substantial clarification of the second model explained above. The significance of this alternative model needs more detailed analysis. A comparison of the sources, in order to verify the plausibility of such an idea in the thought of Anaxagoras, is thus called for.

### 3. Brief description of the interpenetrating model

First, we must define what we mean by *interpenetration*. This concept is sufficiently attested to in ancient thought. The first author who explicitly brings it to light is Aristotle, when he refers to the hypothetical circumstance of “two bodies being in the same place”—something impossible for him.<sup>28</sup> This idea becomes significant in subsequent years when the Stoics develop a theory of mixture against the Aristotelian one. Given these opposed ancient interpretations of mixture, some reference to them is critical in order to explain how ingredients could be mixed in Anaxagoras' thought.

In his treatise *On generation and corruption*, Aristotle distinguishes between mere aggregation of small bodies, such as cereal grains, and a real mixture. The aggregation is only an apparent mixture even when the parts of the bodies are so small that human eye cannot distinguish between them, such as tiny particles of a powder.<sup>29</sup> We are moving in the field of Democritus' *κρᾶσις*.<sup>30</sup> According to Aristotle, a true mixture (*μίξις*) is a new substance, different from the substances that composed it.<sup>31</sup>

<sup>26</sup> Lewis (2000), 9.

<sup>27</sup> Lewis (2000), 3.

<sup>28</sup> [...] δύο ἐν τῷ αὐτῷ σώματα τόπων ἔσται [...] ἔστι δὲ καὶ τοῦτο ἀδύνατον (*De gen. et corr.*, I, 5, 321 a 8–9). See also *Phys.*, IV, 1, 209 a 7; 7, 214 b 6; *De caelo*, III, 6, 305 a 19; *De an.*, I, 5, 409 b 3; II, 7, 418 b 17.

<sup>29</sup> “Ὄταν γὰρ οὕτως εἰς μικρὰ διαιρεθῆ τὰ μινύμενα, καὶ τεθῆ παρ’ ἄλληλα τοῦτον τὸν τρόπον ὥστε μὴ δῆλον ἕκαστον εἶναι τῆ αἰσθήσει, τότε μέμικται ἢ οὐ, ἀλλ’ ἔστιν ὥστε ὅτιοῦν εἶναι μόριον τῶν μινύμενων; λέγεται μὲν οὖν ἐκείνως, ὅσον κριθᾶς μεμίχθαι πυροῖς, ὅταν ἦτισσὺν παρ’ ὄντιοῦν τεθῆ [...] Ἄν δ’ ἦ κατὰ μικρὰ σύνθεσις ἢ μίξις, οὐθὲν συμβήσεται τούτων, ἀλλὰ μόνον μεμιγμένα πρὸς τὴν αἰσθησιν (*De gen. et corr.*, I, 10, 327 b 33 – 328 a 3, 12–14).

<sup>30</sup> Δημόκριτος μὲν οὖν ἡγούμενος τὴν λεγομένην κρᾶσιν γίνεσθαι κατὰ παράθεσιν σωματῶν, διαρουμενῶν τῶν κριναμένων εἰς μικρὰ καὶ τῆ παρ’ ἄλληλα θέσει τὴν μίξιν ποιουμένων (*Alexander Aphr., De mixtione*, 2, CAG 214, 18–20).

<sup>31</sup> Ἐπεὶ δ’ ἔστι τὰ μὲν δυνάμει τὰ δ’ ἐνεργείᾳ τῶν ὄντων, ἐνδέχεται τὰ μινύμενα εἶναι πως καὶ μὴ εἶναι, ἐνεργείᾳ μὲν ἐτέρου ὄντος τοῦ γεγονότος ἐξ αὐτῶν, δυνάμει δ’ ἔτι ἑκατέρου ἅπερ ἦσαν πρὶν μινύμενα, καὶ οὐκ ἀπολωλότα: [...] πολλὰ μὲν ὀλίγοις καὶ μεγάλα μικροῖς συντιθέμενα οὐ ποιεῖ μίξιν, ἀλλ’ ἀξῆσιν τοῦ κρατοῦντος· μεταβάλλει γὰρ θάτερον εἰς τὸ κρατοῦν [...]. Ὄταν δὲ ταῖς

It is also homogeneous, i. e. each of its extensive parts is like any other and like the whole.<sup>32</sup> This is also the Aristotelian concept of “homoeomerous body.” In mead there is neither water nor honey, but it is something new: despite the fact that it has been made of such ingredients and although they could be extracted later, they do not exist anymore when the mixture is complete. They exist only potentially, but not actually, because in fact what exists is only the mixture itself.

The Stoic Chrysippus moved against the Aristotelian theory. He listed different composition types and sustained a peculiar interpretation of mixture. He spoke about a mixture where all constituents remain, even though mixed. The ingredients are completely compresent in the mixture with the same nature that they had before they were blended.<sup>33</sup> Chrysippus even criticized Aristotle stating that the ingredients of the mixture, no matter how scarce, could be spread *throughout the cosmos*, while preserving their own identity: εἰς ὄλον φησὶ τὸν κόσμον διατενεῖν τῆ κράσει τὸν [οἴνου] σταλαγμόν.<sup>34</sup> According to Aristotle, not every addition of a new ingredient produces a mixture, because a small amount of a certain product added to another considerably larger substance would merely produce the disappearance of the smaller in the bigger. So, nothing of the smaller substance remains, because it would only provide its matter while its form entirely disappears: a drop of wine is *totally dissolved* in the sea and it loses its form (*De gen. et corr.*, I, 10, 328 a 26–28). Chrysippus, however, believes that all the ingredients *actually* remain, although mixed, no matter how small the amount of each ingredient is. If a drop of wine *mixes* with the sea, the wine would actually exist *in the whole sea*, though in a very little quantity (the very detail of speaking about “a drop of wine in the sea” in the quoted text reveals the target of his attacks: the Aristotelian theory of mixture).

In Chrysippus’ mixture, when a bigger body receives another smaller body, the smaller body is present throughout the bigger and both bodies subsist *in the same space simultaneously*: two or more bodies are occupying the same place at the same time.<sup>35</sup> What was unthinkable for Aristotle is precisely what characterises mixture for Chrysippus.<sup>36</sup>

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δυνάμεσιν ἰσάζη πως, τότε μεταβάλλει μὲν ἐκάτερον εἰς τὸ κρατοῦν ἐκ τῆς αὐτοῦ φύσεως, οὐ γίνεται δὲ θάτερον, ἀλλὰ μεταξὺ καὶ κοινόν (*De gen. et corr.*, I, 10, 327 b 22–26; 328 a 24–26, 28–31).

<sup>32</sup> Φαμὲν δ', εἴπερ δεῦ μείγχθαι τι, τὸ μίχθην ὁμοιομερές εἶναι, καὶ ὡσπερ τοῦ ὕδατος τὸ μέρος ὕδωρ, οὕτω καὶ τοῦ κραθέντος (*De gen. et corr.*, I, 10, 328 a 10–12).

<sup>33</sup> Παρὰ τὴν ἔννοιάν ἐστι σῶμα σώματος εἶναι τόπον καὶ σῶμα χωρεῖν διὰ σώματος, κενὸν μηδετέρου περιέχοντος ἀλλὰ τοῦ πλήρους εἰς τὸ πλήρες ἐνδυσόμενον καὶ δεχομένου τὸ ἐπιμυγνόμενον τοῦ διάστασιν οὐκ ἔχοντος οὐδὲ χώραν ἐν αὐτῷ διὰ τὴν συνέχειαν (Plutarchus, *De communibus notitiis adversus Stoicos*, 37, 1077E).

<sup>34</sup> Plutarchus, *De communibus notitiis adversus Stoicos*, 1078E; see Alexander Aphr., *De mixtione*, 4, CAG 217, 31–32; Alexander Aphr., *De anima libri mantissa*, CAG 140, 22–24.

<sup>35</sup> σῶμα γὰρ διὰ σώματος χωρήσει δι' ὄλου καὶ δύο σώματα τὸν αὐτὸν ἐφέξει τόπον (Themistius, *In Aristotelis physica paraphrasis*, Δ, 1, CAG 104, 15–16).

<sup>36</sup> Μίξιν δ' εἶναι δύο ἢ καὶ πλείονων σωμάτων ἀντιπαρέκτασιν δι' ὄλων, ὑπομενουσῶν τῶν συμφῶν περὶ αὐτὰ ποιότητων, ὡς ἐπὶ τοῦ πυρὸς ἔχει καὶ τοῦ πεπυρακτωμένου σιδήρου, ἐπὶ τούτων γὰρ (δὲ') ὄλων γίγνεσθαι τῶν σωμάτων τὴν ἀντιπαρέκτασιν (SVF II, 471). For Zeno, see SVF I, 155 ff.; II, 468 f. See also Todd (1976), 73–88; Gould (1970), 109–112; Sorabji (1988), 79–105; Salles (2008), 9–40.



The Stoics probably took their conception of mixture from Presocratic thought in the same way that they accepted other ancient ideas rejected by Aristotle. They express formally and more accurately a notion originally proposed by the Presocratics, particularly Anaxagoras. Such an explanation of mixtures responds much better to the spirit of Anaxagoras' statements than the positions defended by his modern interpreters. Therefore, Lewis already linked Anaxagoras' notion of mixture to the one proposed by the Stoics, although he did not develop this association.<sup>37</sup>

While the idea of mixture supported by Aristotle is the fruit of a process of generation and its correlative corruption, a mixture in which the ingredients remain in act seems much more appropriate for someone who, like Anaxagoras, denies any generation or corruption (DK 59 B 17). It is even probable that, when Aristotle rejects the possibility of simultaneous presence of many ingredients in the mixture, he is thinking about an Anaxagorean model for mixture. There are three reasons to sustain such a hypothesis. Firstly, according to one of the Aristotelian interpretations of Anaxagoras' philosophy, in his mixture the ingredients would exist "not only potentially but also actually."<sup>38</sup> This is evident, since there are *actually* many things in the mixture and there is no generation or corruption.<sup>39</sup> Secondly, in the same description of mixtures from *On generation and corruption* quoted above, we can find a tacit allusion to Anaxagoras since Aristotle uses the well-known slogan *ὁμοῦ πάντα* (327 b 20): at this point, he is just speaking against those who thought that ingredients *actually* remain in the mixture, even after their blending is completed. Finally, of note is this important report of Anaxagoras' mixture, which could be seen as a description of mixture as "compresence of *many bodies* in the *same place* at the *same time*": *ὁμοῦ ποτὲ πάντα χρήματα φάναι εἶναι [...] καὶ πάντα ἄρα· καὶ ἅμα τοίνυν* ("he said that all things are *together* [...]: *all things* and *at the same time* too", *Phys.*, III, 4, 203 a 26 f.).

Indeed, this Aristotelian interpretation seems correct, given the repetitive statements of the fragments *ἐν παντὶ πάντα* and *ὁμοῦ πάντα*. The logical consequence of the actuality of all ingredients in mixture is interpenetration, as the Peripatetics concluded in the case of the Stoics' mixture. However, Aristotle finds the interpenetration of bodies a physical absurdity so blatant that he cannot imagine anyone admitting of it directly; he therefore refrains from ascribing such a model to Anaxagoras. He is convinced that no one would concede of something as irrational as the simultaneous presence of two bodies in one place. For him, interpenetration is a type of incongruous conclusion considered sufficient to refute an incorrect doctrine

<sup>37</sup> See Lewis (2000), 3. Marmodoro (2017), 156–185 developed this link but I will discuss it later.

<sup>38</sup> ὅταν γὰρ ἐν παντὶ φῆι παντός εἶναι μοῖραν, οὐδὲν μᾶλλον εἶναι φησι γλυκὴ ἢ πικρὸν ἢ τῶν λοιπῶν ὁποιασοῦν ἐναντιώσεων, εἴπερ ἐν ἅπαντι πᾶν ὑπάρχει μὴ δυνάμει μόνον ἀλλ' ἐνεργείᾳ καὶ ἀποκεκριμένον (*Metaph.*, K, 6, 1063 b 29–30; I emphasize the words translated in the body). See *Metaph.*, A, 8, 989 b 1–6; Γ, 4, 1007 b 28; 5, 1009 a 23–27; Λ, 2, 1069 b 23; the interpretation of *Phys.*, I, 4 is also similar to these accounts from *Metaphysics*.

<sup>39</sup> Sorabji (1988), 65: "Anaxagoras had no inkling of the idea later proposed by Aristotle that ingredients exist only *potentially* in a mixture. If he had had, he would, I think, have been very doubtful about it. For if bone does not exist in *actuality* in the honey, he would have wondered, how can it *explain* the fact that honey nourishes my bones?"

(see for example *De an.*, I, 5, 409 b 3). According to his laws of argument, such an assumption would be recognized as untrue by anyone.<sup>40</sup> Additionally, when he speaks of the simultaneous existence of ingredients in the mixture of Anaxagoras, he seems to take them as qualities. Aristotle could hardly consider qualities real bodies, which explain why at that moment he couldn't mention the idea of interpenetration.

If we now remind ourselves of the main assertions of Anaxagoras enumerated at the beginning, we can recognize that the “interpenetrating model” remains truthful to them and in addition provides a clearer explanation of mixture than the somewhat confusing appeal to modern concepts of fusion. Of course, there is no need to admit any generation of anything (thesis 1), because all things have already been compresent in the mixture, since the beginning (thesis 2). Every one of them is occupying the whole space of the universe. The only possible change occurs in the concentration of ingredients in different zones of the mixture, which allows them to be recognized by perception (thesis 5). However, in the original mixture as much as now, every ingredient is in every region of the mixture (thesis 3), though their concentrations are different. Finally, these changes in the concentrations happen without expelling any part of other ingredients because both mixture and all ingredients are altogether continuous, that is, there is no extensive smallest part of any of them where there would be only one ingredient without the others (thesis 4). In other words, such a mixture excludes any particulate conception of extension.

There are still some questions left open about how exactly such changes of concentration take place in Anaxagoras' universe. To explain them, let us examine a new proposal of an “interpenetrating model” that has some differences to mine, which will enable me to more plainly defend my own position.

#### 4. *Infinitesimal compresence?*

In a recent book, Anna Marmodoro provides a fresh account of an “interpenetrating model.”<sup>41</sup> She describes Anaxagoras' ingredients as “tropes” and the whole mixture as “qualitative gunk,” using terms of contemporary philosophy on matter.<sup>42</sup> She argues that, according to Anaxagoras, “the ultimate elements of our world are not matter, but instances of physical powers, tropes, and further [...] these tropes are not atomic, but gunky, i. e., such that they have proper parts ad infinitum.”<sup>43</sup> So, *prima facie*, she defends a continuous conception of mixture, since it is “atomless.”<sup>44</sup> She

<sup>40</sup> This could be an example of consensual falsity: Διαφέρει δ' ἡ εἰς τὸ ἀδύνατον ἀπόδειξις τῆς δεικτικῆς τῆ τιθέναι ὁ βούλεται ἀναιρεῖν ἀπάγουσα εἰς ὁμολογούμενον ψεῦδος (*An. pr.*, II, 14, 62 b 29–31).

<sup>41</sup> I refer to Marmodoro (2017). She already sustained her main thesis in Marmodoro (2015).

<sup>42</sup> On ‘tropes’ see, for instance, the Encyclopaedia entry of Maurin (2016): “According to trope theory, the world consists (wholly or partly) of ontologically unstructured (simple) abstract particulars or, as they are normally called, *tropes*. Tropes are *abstract* yet they are *not universal*, they are *particular* yet they are not *concrete*.” ‘Gunk’ will be described by Marmodoro herself in the following lines.

<sup>43</sup> Marmodoro (2017), 9.

<sup>44</sup> *Ibid.*, 58.

also claims that the *tropes* are “compresent” in every part of a mixture: “All opposites are [...] inseparable from one another, and compresent with one another—and it is in this sense they are all together in everything.”<sup>45</sup> Such an assertion should mean that they are continuously extended throughout the mixture and therefore interpenetrate. Certainly Marmodoro defends both continuity and a sort of interpenetration, but in a way which is far from my interpretation, as we will see.

The first peculiar point of Marmodoro's account is her insistence on the infinite division of *tropes*, which seems to contradict her defence of a *gunky* mixture: “[T]he instantiated opposites are not *divisible* into proper parts that have proper parts, etc., ad infinitum. Rather, they are actually *divided* into their gunky parts, as if the super-task of ‘chopping’ them up thoroughly had been completed.”<sup>46</sup> The logical consequence of this division would be an infinite quantity of “parts” of zero extension. However, she believes that the only way to safeguard the continuity of the *gunk* and, at the same time, to respect Anaxagoras' text is to hold the following paradoxical statement: “Anaxagoras's hunks of gunk cannot have extension, nor can they be without extension, though on account of their thorough division, we can now conclude that they *approximate zero extension as a limit*.”<sup>47</sup> Now, these parts that are both inextensive and extensive at the same time constitute a formidable self-contradiction. Of course, “approximation to zero extension” is close to the concept of “infinitesimal.” It is a useful mathematical fiction but it is impossible in reality, since it is a self-contradictory concept: an infinitesimal “part” should be without any extension (or considered as if it were without extension); but how could there be an extensive magnitude made of inextensive parts?

The main problem that I find in Marmodoro's interpretation lies in her assumption of an actual division of the mixture.<sup>48</sup> She bases this assumption on the first fragment: ὁμοῦ χρήματα πάντα ἦν, ἀπειρα καὶ πλῆθος καὶ συμικρότητα· καὶ τὸ συμικρὸν ἀπειρον ἦν (“all things were together, infinite in quantity and in smallness, for the small was also infinite”: DK 59 B 1).<sup>49</sup> Since he speaks elsewhere of “parts” of these things (DK 59 B 6, 11, 12), it is relatively easy to project an atomistic mentality onto Anaxagoras. So, according to Marmodoro *tropes* would be actually divided into parts, but their size is infinitesimal because the mixture should be continuous or *gunky*. The self-contradiction of supposing inextensive parts for extensive “wholes” is not sufficient reason to deny that Anaxagoras admitted such a thesis in his system. In fact, there are further good reasons to assure that he expressly denied any actual division in the mixture. Note these unambiguous statements: οὔτε γὰρ τοῦ συμικροῦ ἐστὶ τό γε ἐλάχιστον, ἀλλ' ἔλασσον αἰεὶ (“There is no smallest for the small, but there is something always smaller”: DK 59 B 3); ὅτε τοῦλάχιστον μὴ ἔστιν εἶναι, οὐκ ἂν δύναιτο χωρισθῆναι, οὐδ' ἂν ἐφ' ἑαυτοῦ γενέσθαι (“Since there is no smallest, nothing can be separated or generated on

<sup>45</sup> Ibid., 83.

<sup>46</sup> Ibid., 86.

<sup>47</sup> Ibid., 90.

<sup>48</sup> See *ibid.*, 8, 86–90

<sup>49</sup> See *ibid.*, 118.

its own”: DK 59 B 6). These texts speak unequivocally of a continuous conception of the mixture, which denies the existence of some “smallest part,” however tiny, because it would mean that a certain part of a single ingredient could be “separated” from the others.

As Marmodoro has to take these fragments into account, she resolutely supports a continuous or *gunky* understanding of mixture, which would be atomless. Consequently, she must sustain an essentially continuous extension, devoid of smallest parts. However, at the same time, since she presupposes the actual division of mixture, she postulates certain smallest parts. In principle, these smallest parts, resulting from an actually infinite division, would have null extension, as a *point*, so that continuity could be saved.<sup>50</sup> Immediately she is obliged to assign to these “points” a certain extension, because she recognizes that “having zero extension is not allowed in Anaxagoras’s ontology.”<sup>51</sup> Then, she attributes them an infinitesimal “extension,” which is *de facto* zero extension. The result is an undivided continuum, but divided into parts, which are not extensive, but have some extension!

Ultimately Marmodoro provides an atomistic description of “gunk” that seems to contradict this very notion. She quotes two contemporary definitions of *gunk*: “[...] an object is made of ‘atomless gunk’ if it has no (mereological) atoms as parts. If something is made of atomless gunk then it divides forever into smaller and smaller parts—it is infinitely divisible” (David Lewis);<sup>52</sup> “[...] either space and time or matter, or both, [Marmodoro inserts here: ‘or instances of physical properties, to include Anaxagoras’s version’] divide forever into smaller and smaller parts” (Achille Varzi).<sup>53</sup> It is evident that both authors are denying the existence of smallest parts; any lowest limit cannot be reached through an imaginary division of the continuous quantity. Indeed, Lewis concedes that a line could be described as “composed” by infinite points and, nevertheless, he affirms that *gunk* is, so to speak, *more continuous yet*: “However, a line segment is infinitely divisible, and yet has atomic parts: the points. A hunk of gunk does not even have atomic parts ‘at infinity’; all parts of such an object have proper parts.”<sup>54</sup> For this reason, Marmodoro prefers to refer to Varzi and interprets his words in this way: “[...] the expression ‘divide forever’ [...] may refer to potential or actual unlimited division.”<sup>55</sup> In this way, she finds

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<sup>50</sup> It would be necessary to suppose that a point is in some way “part” of a continuous magnitude: “As I understand Anaxagoras, he is saying that no instance of an opposite can be separate by itself, for the same reasons for which no point of a line can be separate by itself. The reason why a point cannot be separate by itself is that between the point and what it would be separate from, there is always a point. This is what it is to be continuum dense—namely, that there is no next point from which a point can be separate. The same goes analogously in the case of tropes: that they are continuum dense means that there is always a trope between two tropes”; Marmodoro (2017), 82. Indeed, Marmodoro seems to believe that it is as legitimate to consider the point as an “atomic” part of a continuous magnitude as it is to say that a continuum is composed of continuous magnitudes: see *ibid.*, 84, note 16. However, in another place she states: “[...] points are not parts of a line”; *ibid.*, 120, note 17.

<sup>51</sup> *Ibid.*, 94.

<sup>52</sup> *Ibid.*, 84.

<sup>53</sup> *Ibid.*, 88.

<sup>54</sup> Lewis, quoted by Marmodoro (2017), 84.

<sup>55</sup> *Ibid.*, 88.

it admissible to make the theory of *gunk* compatible with actual division into infinitesimal parts and she even qualifies her solution as “the most relevant feature of *gunk* (namely, the convergence of the parts to zero extension).”<sup>56</sup> Nevertheless, one could find puzzling that Varzi refers to *any* actual division while speaking of an “atomless *gunk*” as he is doing. If division always provides us “smaller and smaller parts” (Varzi), then there never will be any “smallest part” (as Anaxagoras himself stated: DK 59 B 3, 6), no matter how small such a smallest part could be.

Marmodoro also compares her interpretation of Anaxagoras with the Stoic model of mixture. However, she offers us a curious presentation of the Stoic understanding of the mixture. The Stoics also defend continuity of matter and it leads them to speak of infinite divisibility: τὰ σώματα εἰς ἄπειρον τέμνεσθαι (Long-Sedley 50A), πάντα εἰς ἄπειρον τέμνεται (Long-Sedley 50F). Marmodoro cites these words according to Long and Sedley's translation: “bodies are divided to infinity,” “all are divided to infinity.”<sup>57</sup> Now, with all due respect to these scholars' prestige, this translation is in fact misleading. One might better express the original text saying: bodies “divide” to infinity. This infinite division should be understood as “imperfect,” i.e. it is only a potential infinity. Therefore, it would be more correct to say that bodies “can be divided” to infinity.<sup>58</sup> In fact, if we continue reading the text omitted by Marmodoro, we find a confirmation of our interpretation: εἰς ἄπειρόν τε τούτων τεμνομένων οὔτε σῶμα ἐξ ἀπέριων σωμάτων συνέστηκεν (“but, although they divide to infinity, a body does not consist of infinite bodies”: Long-Sedley 50A; my translation). This inference would be inconsistent if we consider the bodies as actually “divided;” the point is precisely that they *can* be ceaselessly divided. There is no doubt that the Stoics are referring to the well-known “potential infinite divisibility” defended by Aristotle: εἰς ἄπειρον γὰρ διαιρετὸν τὸ συνεχές (“the continuum is divisible to infinity”<sup>59</sup>). Hence, on a certain occasion, he also affirms in a similar way: διαιρεῖται μὲν γὰρ εἰς ἄπειρα τὸ συνεχές (*Phys.*, III, 7, 207 b 16). These words can be translated as “the continuum divides to infinity.” They could not be interpreted but as expressing a potential infinity, since Aristotle only admits a merely potential divisibility and expressly denies actually infinite division.<sup>60</sup> In short, the assumption of an actual division of the mixture into infinitesimal parts causes many more problems than it solves and, furthermore, is not justified by textual evidence.

Someone might suspect that, although the Stoics followed Aristotle on this point, Anaxagoras could not have realized that a continuous quantity cannot be made up

<sup>56</sup> Ibid., 166.

<sup>57</sup> Ibid., 158.

<sup>58</sup> The most literal translation is “bodies divide to infinity” but (as we will soon see) the whole Stoic theory of matter constrains us to understand these words as a potential division. Therefore, it also would be right to write: “bodies can be divided into infinity.”

<sup>59</sup> *Phys.*, I, 2, 185 b 10; see III, 1, 200 b 20; VIII, 3, 253 b 24, etc.

<sup>60</sup> See *Phys.*, VI, 1, 231 a 24; VIII, 8, 263 b 3–7, etc. Indeed, Long and Sedley agree with my interpretation of Stoic thought in this aspect: “The main Stoic gambit in replying to both the Zenonian and the Epicurean challenge is to deny, rather as Aristotle had done, that the infinitely divisible contains an actual infinity of parts”; Long-Sedley (1983), 303.

of inextensive or point-like parts. How would one then explain his words in the first fragment? ἄπειρα καὶ πλῆθος καὶ σμικρότητα· καὶ τὸ σμικρὸν ἄπειρον ἦν (things were “infinite in quantity and in smallness, for the small was also infinite”: DK 59 B 1). As we have seen, Marmodoro believes that actual division should be sustained because of textual evidence, despite the obvious affirmations against a quantitative minimum of other fragments. For that reason, she dismisses as erroneous the interpretation given to this text by Patricia Curd, who also holds an interpretation of mixture that could be considered continuous or *gunky*.<sup>61</sup>

Curd describes the “infinite smallness” of things (ἄπειρον σμικρὸν: DK 59 B 1) as a sort of “immersion” in the mixture due to their scarcity (remember that only predominant things can be perceptible). Of course, as Marmodoro indicates, in the text, “smallness” cannot mean simply “immersion” because “immersion” and imperceptibility are precisely explained by “smallness” (οὐδὲν ἔνδηλον ἦν ὑπὸ μικρότητος, “nothing was clear because of smallness”: DK 59 B 1). However, Curd simply wanted to indicate that “smallness” in this fragment is not a small *extension* but a small *density*: “Every region of the mixture (no matter how tiny in area) contains all ingredients because there is no downward limit on how submerged an ingredient can be (there are no lower limits on the *density* of an ingredient in any volume of the mixture).”<sup>62</sup> In effect, this reading is the most coherent one for a continuous account of mixture like Curd’s and Marmodoro’s. However, Marmodoro dislikes Curd’s explanation, which understands changes inside mixture with ingredients thought of as fluids-like substances. According to Marmodoro, when many such fluid-like ingredients blend into a single continuum, “the pastes [...] must displace one another (rather than occupy the same space), and end up being juxtaposed [...]. In sum, I cannot understand how one can derive the colocation of ingredients in the mixture.”<sup>63</sup> It is surprising that Marmodoro says this, because she already has the key that provides Curd’s theory with the precision that it requires: the interpenetration of ingredients. In fact, Marmodoro herself sometimes explains the preponderance of *tropes* in the mixture in terms of “density”.<sup>64</sup> For these reasons, interpenetration could be understood rather as an improvement of the position defended by Curd and many other authors. However, at this point one could doubt whether Marmodoro’s position is a true interpenetration.

Interpenetration of ingredients can be refused on the same grounds that led Aristotle (*Phys.*, I, 4, 188 a 1 ff.) to criticise Anaxagoras’ theory: it would suppose that, in any extension of mixture, any amount of other ingredients could coexist. One could extract any amount of everything from every little fraction of mixture: for instance, a mountain of gold from a pea. To avoid such an objection, I will concentrate on the “intensive” dimension of quantity instead of the “extensive” dimension. The “intensive” dimension is analogous to the “density” mentioned by Curd. We need to pos-

<sup>61</sup> See Marmodoro (2017), 118.

<sup>62</sup> Curd (2007), 38.

<sup>63</sup> Marmodoro (2017), 117

<sup>64</sup> “[...] preponderance can be explained in terms of increase in *density*” (ibid., 64; emphasis of Marmodoro). See also ibid., 97.

tulate a constant density for every zone of mixture, which I call “absolute density,” and a “relative density” for each of the ingredients in each point of mixture; this relative density can be variable in different zones in order to justify the preponderance of some ingredients.<sup>65</sup>

To understand this postulation, one can imagine that every point of the mixture is “filled up” by different “parts” of ingredients (there is a 100% absolute density of “parts” in every point), but the amount of each of them changes in every point: for instance, in point A, one could find a 60% relative density of ‘water,’ 20% of ‘red,’ leaving the final 20% to be filled up by the rest of the ingredients of the world; in point B, one could find that 80% is ‘water’ and only 10% ‘red’ leaving the remaining 10% for the rest of the ingredients. Every point must contain the same total quantity of “parts,” i. e. 100% of “nonextensional quantity,” but the identity of such parts can be different.<sup>66</sup>

Although absolute density is always constant, there is always a finite quantity of density where there is enough *nonextensional* “room” (so to speak) to admit an “indeterminate” number of different ingredients.<sup>67</sup> Some of them (the predominant ones) would represent the major quantity of this density, while most of them would have very low relative (but never zero!) densities. In the original situation of mixture, since any ingredient was predominant, all ingredients had “indefinitely” small relative densities (but never zero). This is the meaning of the first fragment, in which Marmodoro seems to read the following out of context: ἄπειρα καὶ πλῆθος καὶ μικρότητα· καὶ τὸ μικρὸν ἄπειρον ἦν (things were “infinite in quantity and in smallness, for the small was also infinite”: DK 59 B 1). The past tense of the first fragment tells us that Anaxagoras was referring to the indefinite scarcity of every ingredient *in the original mixture*, which prevented the manifestation of all of them. However, nothing forces all of them to remain indefinitely “scarce” until “now,” when some of them have already emerged here and there; only the hidden ones will remain indefinitely scarce. Moreover, ἄπειρον could signify in this fragment not an “actual infinity” but merely an “indeterminacy”: cosmic νοῦς can recognize every

<sup>65</sup> See Torrijos-Castrillejo (2014), 91–94, esp. note 19.

<sup>66</sup> In the end, my interpretation is based on the cases that Anaxagoras proposes as evidence of his very conception of mixture (“everything is in everything”), such as nutrition: he thinks that wheat contains much less hair, flesh, bones, etc. than wheat (see Aristoteles, *De gen. an.*, I, 18, 723 a 6–11; see also Plato, *Phaed.*, 96d and DK 59 A 45, B 10). If one can compare quantities, at any time there should be some determinate terms of comparison. If something could become always scarcer than now, then it has now some determinate quantity. In the same way, a grain of wheat comes from a not excessive amount of—say—water and earth. The point of Anaxagoras is the relative amount of ingredients in an “everything in everything” mixture, not that a hidden infinite quantity of every material can be extracted from every zone of mixture (as Aristotle criticizes). The relative density of Anaxagoras' ingredients *can become* infinitely little: in this sense “smallness” is only *potentially* infinite.

<sup>67</sup> I speak here about an “indeterminate” number of sorts of ingredients. Anaxagoras probably never paid attention to the fact that an actual infinity of sorts would signify an actual infinity of finite relative densities, which are not possible in a finite absolute density; if that were possible then Aristotle would be right. So, we can “defend” Anaxagoras' view against Aristotle by saying that there is an “indeterminately” big number of ingredients (it seems better to translate ἄπειρον as “indefinite”), i. e. an incredibly big quantity, but they constitute a finite number. In DK 59 B 6 he does not say that ingredients are “infinite” but “many”: ἐν πᾶσι δὲ πολλὰ ἔνεσσι.

ingredient and every measure of them (DK 59 B 12) but our νοῦς cannot, therefore our knowledge of ingredients is still indeterminate both in number and in uncountable quantity.<sup>68</sup>

However, Marmodoro's account cannot help Anaxagoras to escape from Aristotle's criticism. *Tropes* are divided into infinitesimal parts, precisely because she thinks that such a quasi-inextensive nature permits that an actual infinity of parts could be compressible: "Anaxagoras's opposites exist in means that their shapes *approximate nonextension*. This is what allows them to overlap with each other in the same location, and thus be colocated."<sup>69</sup> So, nothing would prevent that at each point there could also be an enormous number of infinitesimal *tropes* of a single quality, even hidden ones, provided that such a number is smaller than the number of predominant *tropes*. Thus, a mountain of gold could be extracted of a pea, if there is enough "pea-ingredient" in this pea (consequently, even several pea mountains could be also extracted from the same pea!). Such a theory of infinitesimal parts postulated by Marmodoro must lead to this inevitable consequence.

Marmodoro's point is somewhat bizarre: she tries to explain a theory of continuous quantity in terms of discrete quantity. However, one should forget the very idea of numerically different extensive parts of *tropes* and concentrate rather on continuous *tropes* with different quantitative values (always a finite one) in different zones. In other words, one should solve the problem not by the "extensional" conception of quantity but by a "nonextensional" conception of quantity, namely, *density*. Otherwise, one mislays the main point of an Anaxagorean or Stoic account of mixture: the true actuality of every ingredient, despite its continuous nature. Such simultaneous actuality is not resolved by a positional theory (an atomic one or an quasi-atomic one such as Marmodoro's). On the contrary, the key is a physical assertion: that two or more different bodies could be simultaneously in the same place, in the proper and strict sense of "collocation." Simply put, both Anaxagoras and the Stoics think that the true and proper interpenetration of bodies is not impossible.<sup>70</sup>

"Interpenetration" as an explanation of a continuous mixture makes it superfluous to consider ingredients as actually divided into infinitesimal parts, since it is not necessary to reduce the extension to "collocate" many ingredients together. Moreover, prescientific common sense could easily see that, in a cup of coffee with milk, there is coffee in every place of the cup and there is also milk in every place of the

<sup>68</sup> Marmodoro (2017), 134 is proud to compare for the first time DK 59 B 12 (on νοῦς's cognition) with Theophrastus testimony on sensitive perception (DK 59 A 92), but such comparison was already made by Arleth (1895), 78. See also Torrijos-Castrillejo (2014), 201–203.

<sup>69</sup> Marmodoro (2017), 91. See *ibid.* 61–62 and 86–87. She attributes this idea also to the Stoics, even recognizing that there is no textual evidence to support it: see *ibid.*, 163–165.

<sup>70</sup> Of course, this does not occur at all physical levels: they are not saying that people could walk through walls! Indeed Anaxagoras thinks that some bodies "push" other ones (and ultimately the "first" pressure comes from motion: see DK 59 B 9). This pressure is allowed when different predominant ingredients interact with others in some conditions: for example stone expulses air or water when it falls through them because the ingredient "stone" is predominant in it; on the contrary, the low quantity of ingredient "stone," which is also present in air or water (considered as "objects"), cannot expulse ingredients "air" or "water" from them.



cup: the coffee does not expel the milk or vice versa, because they are able to coexist in the whole extension of the mixture. Both ingredients are in the same place in exactly the same sense as their mixture is.<sup>71</sup> Similarly, in this account, nothing prevents the predominance of some ingredients in different regions of a mixture, as everyone notices when a latte macchiato is served in a glass.

I hope that this discussion of Marmodoro's account shows the main contribution of an "interpenetrating model" to explain Anaxagoras' mixture. It seems relatively counterintuitive to understand a mixture made by ingredients that do not expulse the others, but it resolves many difficulties that scholars find when describing Anaxagoras' texts. It is the best way to explain both mixture and ingredients as actual and continuous without admitting of any kind of particles, even infinitesimal ones. In fact, infinitesimal particles would also be *particles*, which are not allowed in Anaxagoras' system. Consequently, Marmodoro's account fails to describe mixture in a continuous way. Similarly, she finds in Stoic mixture the best tool to formulate Anaxagoras' mixture but fails to identify the main contribution of the Stoics to a mixture where every ingredient remains in its own identity, namely, interpenetration. Certainly, the very concept of "interpenetration" could be a corollary of Peripatetics when they interpret the Stoics, but it is the only key to make sense of Anaxagorean texts. Therefore, it should be at the very least postulated.

### 5. Conclusion

We have considered five models in order to understand the nature of mixture in Anaxagoras' philosophy: a particulate model, which takes ingredients as actually divided; a "fusion" model that thinks both mixture and ingredients as continuous, but does not enough to explain which kind of "fusion" occurs; a quasi "monistic" model, which considers mixture as a single substrate within alterations in it; lastly, a "fractals" model that represents an ingenious description of Anaxagoras' statements but leaves unresolved the physical status of mixture. Thereafter, we highlighted an "alternative" model, defended by a small number of scholars and not described in enough detail until now. They defend ingredients in a mixture as interpenetrating continuous entities, which occupy the same place at the same time and produce differences in cosmos only by relative concentration. Stoic mixture provides us an ancient example of such a doctrine, and its intrinsic relation to Aristotelian texts allows us to ascribe it to Anaxagoras, since such description perfectly fits to textual evidence.

The principal evidence for the interpretation of Anaxagoras' mixture as interpenetration comes from his own statements. Firstly, the eloquent motto  $\delta\mu\omicron\upsilon\ \pi\acute{\alpha}\nu\tau\alpha$

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<sup>71</sup> Schofield (1980), 109 f. provided a description of mixture as a cup of coffee as understood by prescientific common sense. I would add to it that the first description of mixture by such common sense (if it accepts, as Anaxagoras does, that "coffee" and "milk" actually remain in the mixture of coffee with milk) would be that both coffee and milk are simultaneous located in the cup in the same sense that one would say that their mixture is located in it. Such reference to a "Stoic" model of mixture is crucial to a proper understanding of Anaxagoras' mixture.

(DK 59 B 1, 4b, 6) which means “all together,” “all at the same place” or “all at once” (Liddell-Scott). In this context, it clearly means simultaneous presence of many entities in the same place. Secondly, the inability of ingredients to separate from one another and from the mixture, even after an initial moment (DK 59 B 6, 8): in other words, the affirmation of the actual presence of parts of everything in everything (DK 59 B 6, 11, 12). Thirdly, the continuous nature of both mixture and ingredients, the consequence of which is that, no matter how small an extensional piece of mixture could be, it should contain every ingredient (DK 59 B 6).

By speaking of interpenetration as the simultaneous occurrence of all the ingredients in the same place, we are assigning to Anaxagoras neither Aristotelian notions of place, nor of body, nor, therefore, of matter.<sup>72</sup> However, in his mind, there are enough spatial and quantitative concepts to convince us that he knew what he was saying. Accordingly, we need to postulate an “intensive” dimension of quantity, namely, its so-called “density.” In a constant density, an indefinite quantity of several ingredients could coexist if they are in different concentrations at different zones. Despite its considerable complexity, the interpenetrating model represents a much more archaic, scientific approach to the notion of mixture. For anyone who has never heard of the Aristotelian theory, of atomism or, in general, of modern chemistry, the most obvious understanding of mixture would probably be the subsistence of each ingredient in every part of any given fragment of the mixture, especially if he thinks about blending liquids or metals’ alloys.

Finally, to show the advantages of our description of the interpenetrating model, we discussed Marmodoro’s most recent book, which represents a compromise between an actual division of mixture (i. e. a particulate model, *pace* Marmodoro herself) and the fusion model. She defended the continuity of mixture and proposed a sort of interpenetrating model because she admits that different *tropes* could be in the same place at the same time, and she even refers to Stoic mixture. But she reduces this compresence to infinitesimal “zones.” At the end of the day, she admits both the Aristotelian and the atomist conception for mixture: that two things cannot coexist in the same place at the same time; if in the mixture there are different things that actually conserve their own nature, then they should be in different places. The only possible way to eliminate “place,” in order to collocate different entities “in the same place,” is to put them in “no place” at all, that is, in the simplicity of the point. Nevertheless, this complex idea is not needed in order to explain Anaxagoras. It is only necessary to resolve compresence by a different physical conception of mixture, namely the one that allows the interpenetration of continuous ingredients. So, one can eliminate actual division from Anaxagoras’ mixture, since he explicitly denied it.

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<sup>72</sup> As Lanza (1965), 241 notes, Anaxagoras does not use ὕλη or σῶμα.

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Universidad Eclesiástica San Dámaso  
 Calle Jerte 10  
 28005 Madrid  
 dtorrijos@sandamaso.es