Boscovich's distinction between the potential and the actual space from the standpoint of modern search for the union of mind and nature

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Abstract

The Aristotelian distinction between potentiality and actuality concerning space was developed in Boscovich's main work *Theoria Philosophiae Naturalis* (1758), where it served him to upgrade Newton's conception of forces into a unified dynamic theory of nature. The main aim of this paper is to show that Boscovich's "Single Law of Forces in Nature" and his distinction between potential space and actual "point-particles" might be relevant and inspiring in the modern search for a unified understanding of nature: not only in regard to the unification of the four basic physical forces in the so-called "Final Theory", but also in regard to new ways for conceiving the relation between nature and mind.

Introduction

The starting point, and in some sense also the final point, of Roger Boscovich's (Ruđer Bošković) natural philosophy is the unity of science and religion. As a scientist, i.e. a "natural philosopher", and as a theologian, more accurately a Jesuit priest, he endeavored to unite the new mechanics of the 17th and 18th century with Christian-Aristotelian metaphysical concepts, while searching for the presence of the divine Mind and Providence in nature. Boscovich's natural philosophy and his conceptions of space, time and matter differ in some important aspects from Newton's, as well as from Leibniz's, however, these three great thinkers agree in the basic conviction that nature with its laws is not just a contingent "dance of atoms", as materialists claimed, but a creation or at least a "reflection" of the divine, cosmic Mind.

Nowadays, such an attitude in natural sciences is called the "Intelligent Design", and, unfortunately, it raises many misunderstandings and misconceptions. In order to solve at least some of them, we have to distinguish: (i) between theistic and pantheistic variants of the relation between Mind and Nature, i.e. between Mind's transcendence and immanence in Nature, and also possible intermediate variants of this relation; and (ii) between the philosophical, universal idea of the cosmic Mind (*Logos*) and different confessional (scriptural) figures of God, the creator of the universe. It is appropriate to consider these two distinctions also when we try to understand Albert Einstein's attitude towards religious beliefs and his famous remarks about God (see, also, Uršič 2009).

The eminent Croatian physicist Ivan Supek compared Boscovich's endeavors regarding the unity of science and religion with Einstein's views on this relation, as well as on his distinction between pantheism and theism:

> "To Einstein, Jehovah does not speak any more, but he comes closer to pantheism which, by deification of nature, throws light upon the marvelous existence of natural laws. Ruđer's last meditations also flowed in this direction, however, he strived to keep accordance with the dogma of the personal God". (Supek 2005, 20)[1]

But in both cases, in pantheism and/or in theism, scientific issues are closely related to ethics – so it was in Boscovich's time and so it is remains until today: scientific knowledge cannot be separated from ethics and humanism. Supek wrote:

> "Roger Boscovich was one of the late humanists [...] since in all his life he endeavored for the primeval unity of knowledge, arts and ethics [...] He

1 The passages from Supek 2005 are translated by the author of this paper.

> fervently tried to harmonize his research with his religious beliefs. [...] Physics, from its beginnings, has been involving transcendental trends, while mystics has eventually helped the human fantasy to set free from rigidity". (Supek 2005, 19)

I think that when speaking about nature and cosmos in the philosophical way, we must always take into account these "transcendental" issues, the epistemological and metaphysical (ontological) relations between subject and object, consciousness and matter, mind and nature. We have to develop our "human fantasy" to evade scientific "rigidity", but on the other hand, we have to be exact in scientific research as much as possible. And this corresponds to the core of Boscovich's wisdom.

"Law of Continuity" and the curve of the "Single Law of Forces in Nature"

In his principal work, *A Theory of Natural Philosophy* (*Theoria Philosophiae Naturalis*, 1758) Boscovich expressed his "Law of Continuity" in the following definition (§ 32):[2]

> "The Law of Continuity <*continuitatis lex*>, as we here deal with it, consists in the idea that [...] any quantity, in passing from one magnitude to another, must pass all intermediate magnitudes of the same class. The same notion is also commonly expressed by saying that the passage is made by intermediate stages or steps [...] single states correspond to single instants <*singulis momentis*> of time, but increments or decrements only to small intervals of continuous time <*continuis tempusculis*>". (Boscovich [1763]1922, 51-52)[3]

The physical quantities which obey, following Boscovich, the Law of Continuity are primarily space and time, and *a fortiori* motion, i.e., "dynamical" quantities are also continuous: velocity, acceleration and forces – however, *centers* of forces are *discrete* "point-particles", since matter itself is discontinuous, it is concentrated in "dimensionless" matter-points, which are centers of forces. In the "Synopsis of the Whole Work" from the second edition of *A Theory of Natural Philosophy* (Venice 1763),[4] Boscovich shortly explains the relation

2 Boscovich formulated an equivalent definition of "The Law of Continuity" already in his earlier treatise, written just on this topic: *De continuitate lege* (Boscovich [1754]1996), see § 131.

3 In this paper, all quotations from Boscovich's principal treatise *Theoria Philosophiae Naturalis* (first edition: Vienna 1758) are taken from the English translation (London 1922), which followed the "referential" *second* edition (Venice 1763).

4 Henceforth we will use the abbreviation *TNP* for this "referential" edition.

between his Law of Continuity and point-particles: he contends that in collisions of solid bodies "either there must be compenetration, or the Law of Continuity must be violated by a sudden change of velocity, if the bodies come into immediate contact with unequal velocities" (Boscovich [1763]1922, 17), but the Law of Continuity must be observed in every case, and that is because "before the bodies reach the point of actual contact, their velocities must be altered by some force which is capable of destroying the velocity, or the difference of the velocities, no matter how great that may be" (Boscovich [1763]1922, 17). This force is found in the function of distance, following Boscovich's curve of the "Single Law of Forces in Nature", as we shall see below. When the distance between particles is very small, the force grows to be very large, and this –under assumption of the Law of Continuity– enables the stability of matter by preventing the gravity to smash matter into "black holes", as we say nowadays.

But, on the other hand, Boscovich's "point-particles" *are* like black holes. It is interesting to note his explanation, regarding our difficulty to conceive the idea of non-extended matter-points when discussing the issue of elements: "it is because we are unable to perceive them by means of the senses, which are only affected by masses, and they too must be of considerable size" (Boscovich [1763]1922, 23). Point-particles can be conceived by reason alone; Boscovich compares them with Leibniz's monads, and he thinks that by introducing them into his philosophy of nature the famous Zeno's paradoxes of motion are also resolved, since they arise "from the fact that by no possible means can continuous extension be made up from things of no extent" (Boscovich [1763]1922, 23). From this statement to the conclusion that extensional "macroscopic" (as we nowadays would say) bodies are just "clouds" of energy-fields is just a short step, but Boscovich himself did not draw this radical conclusion. His "point-particles" are akin to Newton's centers of gravity, that is, abstract points for calculating gravitational interactions between solid bodies. However, the difference between these two concepts remains, since Boscovich considers "point-particles" as physically, ontologically real. This is a very interesting, but also very strange conception of matter: "the primary elements are indivisible and non-extended, and there does not exist anything possessing the property of continuous extension", so that only the "external" *connection* of these primary elements, of point-particles yields continuity – "and that is in motion" (Boscovich [1763]1922, 23).

Boscovich's idea of elements is obviously in contradiction with Descartes' *res extensa*; from a physical point of view this idea is closer to Newton's point-centers of gravity, while metaphysically it is akin to Leibniz's monads. However, Boscovich does not forget to emphasize, in contrast to Leibniz, "how greatly these points of mine differ from spirits" (Boscovich [1763]1922, 23). Spirits and souls in his meta-physics are more akin to the continuity of space (and time) as well as to the discontinuity of matter, as we shall see later. On the other hand, he stresses the difference of his philosophy of nature in comparison to Newton's (*TNP*, § 4):

> "My Theory also differs as widely as possible from that of Newton. For one thing, because it explains by means of a single law of forces all those things that Newton himself, in the last of his 'Questions on Optics', endeavored to explain by the three principles of gravity, cohesion and fermentation [...] this law is expressed by a single algebraic formula, and not by one composed of several formulae compounded together; or by a single continuous geometrical curve. For another thing, it admits forces that at very small distances are not positive or attractive, as Newton supposed, but negative or repulsive; although these also become greater and greater indefinitely, as the distances decrease indefinitely. From this it follows of necessity that cohesion [of bodies] is not a consequence of immediate contact [of particles]". (Boscovich [1763]1922, 35-37)

In Boscovich's view, the "cohesion" of bodies is due to the equilibrium of attractive and repulsive forces between discrete point-particles, which are in turn dependent of their distance. And so we come to his famous curve of the "Single Law of Forces in Nature" in *TNP*, Table I, Fig. 1, explanation in §77 (Boscovich [1763]1922, 80):

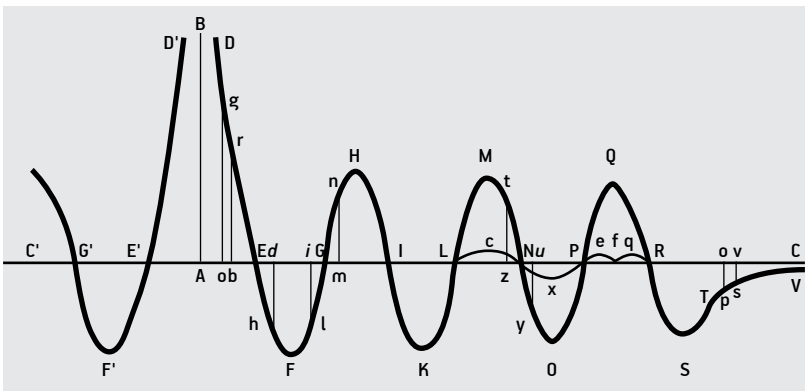

Figure 1

On the abscissa of this graph there are *distances* between point-particles (value *A* signifies zero distance), on the ordinate there are values of *forces* between point-particles, which are either *repulsive* (positive values) or *attractive* (negative values), or "in balance" (zero values). The extreme right part of the curve (sector TVC) follows approximately Newton's inverse square law of gravity. The left part of the graph, i.e. the shortest distances between point-particles (around point A) are explained by Boscovich as follows: "We have arrived therefore at repulsive forces that increase as the distances diminish, and increase indefinitely; that is to say, to the asymptotic arc, ED, of the curve of forces exhibited in Fig. 1" (Boscovich [1763]1922, 81). – *Nota bene:* in the points where the curve intersects the abscise, there is no force, so we can say that these points constitute a *static* "net" (or "grid") of point-particles. This is Boscovich's version of Newton's "cohesion" (*TNP*, §165): "I derive cohesion from those limit-points, in which the curve of forces cuts the axis, in such

a way that a transition is made from repulsion at smaller distances to attraction at greater distances" (Boscovich [1763]1922, 131).

"Net" of discrete point-particles in the continuous space – a structure which changes its configuration in time

When we use the term "net" (or "grid" or "lattice") in the context of Boscovich's "Single Law of Forces in Nature", we have to keep in mind that this representation is appropriate only for the ideal *equilibrium* state of discrete point-particles, which constitute the material world in the continuous space – this is just a timeless picture. However, this structure is constantly changing in time by following the Law of Forces, which determines attractions or repulsions among point-particles in function of their mutual distances. (We might also compare Boscovich's net of point-particles with crystal lattices in modern solid-state physics.) Boscovich further explains the nature of this structure in the following passage (*TNP*, §81):

> "Now, because the repulsive force is indefinitely increased when the distances are indefinitely diminished, it is quite easy to see clearly that no part of matter can be contiguous to any other part; for the repulsive force would at once separate one from the other. Therefore it necessarily follows that the primary elements of matter are perfectly simple, and that they are not composed of any parts contiguous to one another. This is an immediate and necessary deduction from the constitution of the forces, which are repulsive at very small distances and increase indefinitely". (Boscovich [1763]1922, 83)

These "primary elements of matter", perfectly simple point-particles, can be considered as *metaphysically conceived physical atoms* of the *actual* physical (material) reality, which rise up from potentiality to actuality, and return back to mere potentiality – in the continuous *potential* (or "imaginary") space. We may say that this idea of Boscovich is visionary and anticipates "virtual particles" in modern physics, which constantly "jump" out of the "false vacuum" in quantum fluctuations and return back to it.[5]

5 Nearly a hundred years ago, soon after the first empirical confirmations of Einstein's theory of relativity, and as the foundations of quantum mechanics were being laid, the Slovenian physicist Lavo Čermelj wrote in his monograph the following about Boscovich: "[His] material points can be located only in such mutual distances which are determined by the sites of the stabile equilibrium. Since in Boscovich's view forces are equal [isotropic] in all directions from the center [of a material point], we can compare these sites of the stabile equilibrium with the allowed circular tracks of electrons around the atom core, as Bohr's model of atom

Following Aristotle's *Physics*, motion (κίνησις) <*kýnesis*> is the "actualization of potentiality", the realization of some *finite* event and/or being *from* infinite (or at least "indeterminate") number of possibilities. Boscovich ingeniously applies the Aristotelian distinction between *dýnamis* (δύναμις) and *enérgeia* (ἐνέργεια) to the Newtonian distinction between (empty) space, which is continuous, and matter, which he considers as discrete, discontinuous – as a "net" which vibrates and changes constantly in the continuum of space, still conceived like Newtonian "absolute space", quite close to Newton's "*sensorium* of God", but in Boscovich different from the latter by being more distant to the pantheistic (Spinoza's) conception of the immanence of God's Mind in Nature itself, i.e., in the World, in space and time. We may quote several passages from *A Theory of Natural Philosophy* to illustrate Boscovich's point of view, which is also, as we shall see later, essential in his endeavor to unite science and Christian theology (religious tradition, the message of the *Bible*). But let us first think again of the difference between continuity of motion and discontinuity of matter as portrayed in the following passage (*TNP*, §143):

> "Hence I acknowledge continuity in motion only, which is something successive and not co-existent [...] Nature accurately observes the Law of Continuity, or at least tries to do so. Nature observes it in motions and in distance, and tries to in many other cases ". (Boscovich [1763]1922, 117)

Boscovich knows that there is something counter-intuitive or even paradoxical (still in the sense of Zeno's *aporias*) in his distinction between continuous motion and discrete matter, constituted from "point-particles", especially if his own "universal" Law of Continuity is taken as the basic "meta-law" of nature. Maybe this is also the reason why he mentions some examples of the just apparent material "continuity", the cases where discreteness of point-particles is hidden "in depth" (*TNP*, §144):

> "Thus, in the channels of rivers, the bends in foliage, the angles in salts, crystals and other bodies, in the tips of the claws that appear to the naked eye to be very sharp in the case of certain animals; if a microscope were used to examine

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requires" (Čermelj 1923, 13) (The quotation is translated by the author of this paper). The main point of Čermelj's treatise is to show that Boscovich's "Single Law of Forces" is a precedent of Einstein's unification of the laws of mechanics and electromagnetism, and that Boscovich's conception of "imaginary" (potential) space is a precursor of Poincaré's conventionalism, as well as of Einstein's "principle of relativity", because Boscovich already knew that "if the relations of all distances do not change, while the whole curve shrinks, all remains for us the same" (Čermelj 1923, 24). By the way, Boscovich's "relativity" of reference frames was advocated by this convicted Aristotelian also to support the "kinematic equivalence" between the Copernican and Ptolemaic system (but *not* only because of that).

> them, in no case would the point appear to be quite abrupt, or the angle altogether sharp, but in every case somewhat rounded, and so possessing a definite curvature & apparently approximating to continuity. Nevertheless in all these cases there is nowhere true continuity according to my Theory; for all bodies of this kind are composed of points that are indivisible and separated from one another ". (Boscovich [1763]1922, 119)

From the perspective of modern quantum physics, Boscovich was in principle right when negating the continuity in the physical world, however, his metaphysical "quanta", his point-particles, differ from modern quanta in an essential way: Boscovich claimed that matter-points themselves were utterly "dimensionless", while modern quanta are never without some dimension – *quantity* is meant in their very name. It seems that there is no room for ontologically *real* dimensionless "point-objects" in modern physics, albeit they occur in some theoretical models (for example, "singularities" in black-holes). After all, the very domain of physics comprises natural phenomena in space and time (or in space-time) which are supposed to be measurable, therefore dimensional. And when Boscovich states (*TNP*, §516):

> "To me, matter is nothing but indivisible points, that are non-extended, endowed with a force of inertia, and also mutual forces represented by a simple continuous curve having those definite properties which I stated". (Boscovich [1763]1922, 365)

this statement of "non-extended matter" is, from the perspective of modern physics, a hardly acceptable scientific hypothesis. Despite this, it might be relevant as a kind of *metaphor* in the philosophical and/or theological sense. I guess that the principal modern relevance of Boscovich's *Theory of Natural Philosophy* might be in his ideas concerning the relation between physical structure(s) and *mind* (and/or "soul"), presented especially in the appendices to the main work (cf. that Newton had also developed his philosophical ideas about space, time and God in his famous *sholia*, i.e. the informal comments to his scientific treatises). So, let us consider some philosophical implications and also possible suggestions of Boscovich's physical theories for the contemporary mind-body problem, especially in cosmology.

Boscovich's Aristotelian distinction between infinite potentiality and finite actuality (i.e., material reality)

In the Supplement №1 to *TNP*, titled *On Space and Time,* in §8, Boscovich distinguishes between potentially *infinite* "real points of position" and numerically *finite* "real points of matter":

> "Hence beyond and between two real points of position <*puncta loci*> of any sort there are other real points of position possible [...] without any determinate limit. There will be a real divisibility to an infinite extent of the interval between two points, or, if I may call it so, an endless 'insertibility' of real points. However often such real points of position are interpolated, by real points of matter <*puncta materiae*> being interposed, their number will always be finite [...] & there will be no gap that cannot be diminished by adding fresh points in between; although it [i.e., gaps in the space continuum] cannot be completely removed either by division or by interposition of points". (Boscovich [1763]1922, 395)

This Aristotelian distinction between *potential* infinity of space, conceived as the infinite divisibility of some space interval between two points, and the *actual* finiteness of the number of "real points of matter" is still philosophically important in considering the relation between mathematics and physics in investigations of nature. Mathematics deals with (at least) potentially infinite –after Cantor also with "actually" infinite– objects or sets, while in physics the actual infiniteness of cosmos in space and time seems to be in principle indemonstrable, since physics is an empirical science and we cannot have an "infinite experience" of physical phenomena. Modern cosmology pushes the estimated largeness of the universe further and further. It seems that the universe is *limitless*, but it cannot be positively established that it is *infinite* in space-time. A similar, yet reverse statement can be made for infinitely small distances in space-time: we simply do not know, and probably also cannot know in principle, whether space-time point-like singularities exist (in black holes?) – they are just theoretical inferences of the theory of relativity. On the other hand, if quantum theory is right (and it has never been falsified), there are no *real* point-like objects of matter and/or energy: from Max Planck onwards, particles and/or waves have always been considered as having some "dimension", some *minimal* quantity. Their energy behaves like being emitted in "wave packets" etc., and –as I have already said– that is why the very concept of "quanta" was introduced. However, quantization of matter/energy does not mean that space-time should be quantized too; most modern physical theories do *not* quantize space-time, i.e., space-time is still considered as *potentially* infinitely divisible, in spite of the smallest length, called Planck's length (or the smallest time interval; Planck's time), which is the lower limit of the current physical theories and not the ontologically smallest unit of space-time "itself" (the term "chronon" is understood at face value only by some alternative theories).

Therefore, we can say that the old Aristotelian distinction between *potential* (mathematical, at least in the classical sense) and *actual* (physical) infinity is still very relevant for modern physics and contemporary philosophy of nature. Boscovich's theory becomes problematic only if we understand his "point-particles" in a strict, ontologically real, or better said *material* sense, since matter cannot be conceived without extension. However, I think there is a solution (or maybe several solutions) to this *aporia*: Boscovich's point-particles are or would be *dimensionless only in their state of absolute rest*, i.e., only if

the "net" (or "grid" or "lattice") of matter were quite static, but that is never the case, since this "material" structure of nature is always moving, changing in time – constantly coming from infinite potentialities to (presumably) finite actualities. Otherwise said, we might state that motion or, even better, *energy,* creates the actual world from the infinite "phase space" of possibilities. By this interpretation, we also come much closer to Boscovich's statement in modern (meta)physics (*TNP,* Suppl., §9):

> "In this way, so long as we conceive as possibles <*possibilia*> these points of position, we have infinity of space, & continuity, together with infinite divisibility. With existing things there is always a definite limit, a definite number of points, a definite number of intervals; with possibles, there is none that is finite". (Boscovich [1763]1922, 395)

In analyzing Boscovich's conception of infinity, we can shortly consider his distinction of *several "orders" of infinities*, which he introduced into mathematics a century before Georg Cantor's transfinite theory of sets. However, Boscovich defined orders of infinities quite differently from Cantor: for Boscovich, the continuum of a line is infinity of the "first order", a plane is infinite in the "second order", space in the "third order". This is, of course, *not* a proper Cantorian concept of the orders or "powers" of infinities, since for Cantor, who was beside Dedekind surely the founder of the modern transfinite mathematics, all three of Boscovich's orders of infinity belong (via mapping relation) to the same order – continuum (Cantor 1984). Nevertheless, let us look for a moment how Boscovich's potential infinity of space "position points" *might* be interpreted by (or through) Cantor's conception of transfinite sets:

(1) Suppose that "points of matter" were *infinite* in number (although Boscovich argues that they are finite, their number is surely enormous, let us say some "googol number") – in this case, their cardinality would be *at most* $\aleph_0$ (Aleph-0), since they are *discrete* points, not a continuum with cardinal number $\aleph_1$ (Aleph-1), and following the famous Cantor's "continuum hypothesis", there is no other transfinite cardinal number between $\aleph_0$ and $\aleph_1$.

(2) Following Cantor's formula that continuum is the "power set" of numerical infinity $\aleph_0$, i.e., $\aleph_1 = 2^{\aleph 0}$, there are as much ($\aleph_1$) *combinations* of actual (physically real) static "set-ups" (or "nets") of "matter points" in the spatial continuum of "position points". But also in the case when "matter points" are *not* (numerically) infinite, as Boscovich claims, and their number is just some very large googol number *N*, there are still 2^N of their combinations, possible configurations of the physical "net".

From the assumptions (1) and (2) follows that the set of *possible configurations* of "matter-points" (we may also say, the power of their "phase space") is much larger than the set of all these matter-points. And if we try to interpret this consequence metaphysically, we might infer –taking into account Boscovich's thoughts about the relation of mind and nature,

which we consider in the following section– that the *possible* "phase space" of *mind* is much larger than the *actual* matter-structure of *nature*, in any finitely long period of time.

The infinite, possible space-continuum as the topos of the soul, of the Mind?

In the Appendix to *TNP*, titled *De Anima & Deo* (in English translation: *On Mind and God*), Boscovich considers, inter alia, the question in which *part* of the human body the soul is situated (Descartes suggested the pineal gland), or whether the soul is present in the *whole* body – and after having stated that this issue cannot be reliably answered by science, he proceeded to the following impressive metaphysical speculation (*TNP*, §537):

> "But if it [or she: *anima*, soul] should extend throughout a great part, or even the whole of the body, that also would fit in excellently with my Theory. For, by means of such virtual extension <*extensio virtualis*> as we discussed in §83, the mind <*anima*> might exist in the whole of the space containing all the points which form that part of the body, or that form the whole body. With this idea, in my Theory, the mind will differ still more from matter; for the simple elements of matter cannot exist except in single points of space at single instants of time, each to each, while the mind can also be one-fold, and yet exist at one and the same time in an infinite number of points of space, conjoining with a single instant of time a continuous series of points of space; and to the whole of this series it will at one and the same time be present owing to the virtual extension it possesses; just as God also, by means of His own infinite Immensity, is present in an infinite number of points of space (and He indeed in His entirety in every single one), whether they are occupied by matter, or whether they are empty". (Boscovich [1763]1922, 379)

Next to the main idea of this passage, that mind (or soul, *anima*) extends throughout "the whole of the body", another interesting concept should be noted here: the "virtual extension" of the mind in the continuum of space. Boscovich refers here to §83 in the first part of *TNP*, where he discusses whether the elements are extended and puts forward some "arguments in favour of virtual extension" (Boscovich [1763]1922, 85). From his point of view, the "elements are simple and non-composite" (Boscovich [1763]1922, 85), but this statement, without some further explication, is not compatible with their extension, since extension is composite by definition (it can be divided into parts or intervals). That is why the soul comes into play here, and Boscovich reminds the reader that the ancients already "thought that the rational soul in man, which certainly is altogether indivisible, was diffused throughout the whole of the body" (Boscovich [1763]1922, 85); this could be just an analogy, but in Boscovich's philosophy it is *more* than an analogy *de dicto*, since he is not a Cartesian dualist – on the contrary, in his monistic philosophy of nature he

eagerly tries to unite mind and matter (or body). And my conjecture, which I have already suggested above, is that Boscovich's "middle term" between mind (or soul) and body (and nature in general) is *motion*, motion in space and/or in time. The source or energy, indeed the cause (also *télos* (τέλος) in the Aristotelian sense) of motion is soul and/or mind, which enables the "virtual extension" of otherwise just "potential", discrete points of space.

This concept of soul (or mind) as the "virtual extension" in space and time of nature could be well compared with an ancient and wonderful metaphor by Plotinus about a net in the sea, which tells us how the sea (soul, mind) *embraces* the net (body) – and not *vice versa*, as we usually imagine when speaking about mind-body relation in modern times, for example, in "cognitive science". Let us quote this passage from *Enneads* (*Enn.* IV.3.9.40-45):

> "The universe lies in soul which bears it up, and nothing is without a share of soul. It is as if a net immersed in the waters was alive, but unable to make its own that in which it is. The sea is already spread out and the net spreads with it, as far as it can; for no one of its parts can be anywhere else than where it lies. And soul's nature is so great, just because it has no size, as to contain the whole of body in one and the same grasp; wherever body extends, there soul is." (Plotinus 1984, IV, 65)

When Plotinus –and already Plato in *Timaeus*– speaks of soul <*psýche*> (ψυχή), he means both, the cosmic Soul *and* an individual human soul (which both emanate from the Soul-hypostasis). The main difference between Plotinus's late pagan monism and Boscovich's philosophy of nature is the absence of the "cosmic soul" in Christian theology, since this concept would be too close to the heresy of pantheism (Newton also had to defend his concept of the absolute space as *sensorium dei* against suspicions of pantheism). However, the distinction between "cosmic Soul" and "cosmic God" (or Mind) is perhaps just a distinction of terms, since God or supreme Deity can also be *immanent* in Nature, as well as the cosmic Soul. Boscovich's conception of the relation between God, space and time may be well seen in the following passage (*TNP*, §83):

> "Further we believe that God Himself is present everywhere throughout the whole of the undoubtedly divisible space that all bodies occupy; and yet He is onefold in the highest degree and admits not of any composite nature whatever. Moreover, the same idea seems to depend on an analogy between space and time. For just as rest is a conjunction with a continuous series of all instants in the interval of time during which the rest endures; so also this virtual extension is a conjunction of one instant of time with a continuous series of all the points of space throughout which this one-fold entity extends virtually. Hence, just as rest is believed to exist in Nature, so also are we bound to admit virtual extension; and if this is admitted, then it will be possible for the primary elements of matter to be simple, and yet not absolutely non-extended". (Boscovich [1763]1922, 85)

A century and a half before Einstein, Boscovich has related space and time into a symmetrical duality, also by introducing the concept of "virtual extension" of mind (or soul) in nature. One of the most remarkable features of his natural philosophy is his sustained insistence on the bondage between mind and nature. In light of this conviction, he may be (and I think he will be even more in future) the inspirer for new "holistic" and interdisciplinary theories in physics and philosophy, as well as for new ways of collaboration of empirical and epistemic investigations in the research of nature.

Boscovich's preview of the cosmological "multiverse"

In the last section of this paper, I would like just to point out that Boscovich may also be regarded as a precursor of the modern idea of "multiverse", i.e. of a set or ensemble of many different universes, which is quite popular in modern cosmology and/or quantum physics. One of the well-known contemporary theorists who promotes the idea of the ontological reality of multiverse is Oxford physicist David Deutsch (Deutsch 2011). I have analyzed multiverse from a philosophical point of view in several papers and in the coauthored book *Mind in Nature* (Uršič, Markič, Ule 2012).

Multiverse, a set of many universes, can be conceived as a –possibly infinite– multidimensional "phase space" (in Hilbert's sense) of possible configurations, "set-ups" of physical and/or cosmological fundamental constants (or "free parameters"). In Boscovich's philosophy of nature, every material configuration, every particular structure ("net" or "grid" or "lattice") of "point-particles" in the continuum of space, can be interpreted as the actualization of one universe, evolving in time, following the curve of the "Single Law of Forces in Nature". Having this universal Law in mind, Boscovich assumes the following (*TNP*, §542):

> "Therefore the number of cases is not finite, but infinite of the order expressed by the fourth power of the number of points increased threefold at least; and that is so, even if there is a definite curve of forces which also can be varied in an infinity of ways. Hence the number of relative combinations necessary to the formation of the Universe is not finite for any given instant of time; but it is infinite, of an exceedingly high order with respect to an infinity of the kind to which belongs the infinity of the number of points of space in any straight line, which is conceived to be produced to infinity in both directions". (Boscovich [1763]1922, 381)

In this consideration, we have to remind ourselves of Boscovich's concept of the order of infinities (as outlined above); following Cantor's transfinite theory of sets, the above argumentation by Boscovich is not exactly valid, however, the very idea that the "definite

curve of forces [...] can be varied in an infinity of ways" (Boscovich [1763]1922, 381) is relevant here, since it yields a multiverse of "parallel universes", if time "has but one dimension" (Boscovich [1763]1922, 381), since "the number of combinations is infinite of an order that is immensely higher than the order of the infinity of instants of time" (Boscovich [1763]1922, 381) – and so the "higher order" of different combinations of matter-points, i.e. their different *developments* in time, is the source of a multiverse. Otherwise said, Boscovich's Law itself generates a multidimensional "phase space", which is much larger than the phase space of all possible configurations of matter in a single universe.

Moreover, Boscovich has already formulated the problem which is nowadays known as the enigma of the "fine-tuning" of our universe among many other possible "lifeless" and "chaotic" universes (*TNP*, §543):

> "[...] in this immense number of combinations, there will be, for any kind, infinitely more irregular combinations, such as represent indefinite chaos and a mass of points flying about haphazard, than there are of those that exhibit the regular combinations of the Universe, which follow definite and everlasting laws [... that is, laws of] such an Universe as we see and wonder at". (Boscovich [1763]1922, 381)

And from here there is only one step to Boscovich's theological solution:

> "Then, to overcome definitely this infinite improbability, there would be required the infinite power of a Supreme Founder selecting one from among those infinite combinations". (Boscovich [1763]1922, 381).

However, this great question still remains open, and some new (meta)physical answer might introduce some different concept of teleology of nature, maybe some "third way" between theism and pantheism, or some solution of the antinomy between God's providence and atheistic contingency of nature . In any case, it is my conviction that any better answer than those proposed in the past, should include the reality of (human) consciousness, the reality of *mind in nature*.

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