From Boskovic's Notes on the Work of Benedict Stay: A criticism of one of Newton's alleged proofs of absolute motion

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1. Boskovic's early criticism of Newton's two-spheres experiment.

I think that the outlook on the foundations of Mechanics Ruder Josip Boskovic (1711-1787) had developed in his previous works De Viribus (1745) and De Lumine (1748), is to be considered the basis for his criticism in 1755 of Newtonian absolute motion. This criticism was presented in his notes[1] on the work of his countryman, Benedict Stay, years before the compilation of his own systematic work, Theoria[2] in 1758. Stay wrote ten books with over 24,000 lines of verses on the philosophies of Descartes and Newton. Boskovic's notes comprise some thirty disquisitions on metaphysics and the philosophy of mechanics[3].

In these notes, Boskovic addresses his criticism to Newton's two-spheres experiment. (The description of the experiment, in Newton's Principia follows as is known, the description, perhaps better known, of the so called bucket or pail experiment). In the two - spheres experiment, Newton shows how the tension in a rope, which connects two spheres rotating in a circular "absolute" motion around the common baricenter, is evidence of this absolute motion, i.e. motion with respect to absolute space. He shows, moreover, how in a completely empty universe, the direction of this motion can be perceived through the change in the rope's tension following the application of an external torque.

Boskovic's criticism[4] to the Newtonian argument is as follows:

> "On this Newton's method I remarked that it appears suspect to me and not appropriate to achieve its purpose. I pass over the fact that even here the existence of the inertial forces as well as

the way by which the motions are produced by them must be assumed; about it below. The very tension of the string can be defined only by the distance of the spheres, but we cannot measure this distance with certainty unless we assume that it remains unaffected by the translatory motion, the assumption which in that immense void is risky or at least doubtful. But what above all makes everything useless, this method as well as the previous one and any other one, is the fact that if the parallel and equal motions in the same plane are communicated to us and to those bodies, all the motions mentioned above would remain altogether the same according to the accepted principles of Mechanics; also the application of forces by us would produce altogether the same motions described above. Indeed, if already some common motion in a certain plane were present, the absolute motion, composed of this common motion and the motion mentioned above which we detect in that experiment, would be different from that mentioned above. Also the part [of the revolving motion] which we regard as moving backwards, could really move forwards and vice versa. If this common motion is truly faster than the respective circular motion and if it takes place in the same plane, then these two bodies will not be in absolute motion in that plane as the experiments indicate. If we consider two points of the diameter perpendicular to the direction of the common motion where in one of these points the circular motion is added to the common motion, in other point is opposed to it, while still being overcome by it, the direction of absolute motion thus in both points would agree with the direction of the common motion. From this it seems to me absolutely evident that absolute motion cannot be differentiated in any way from the relative one".

This long and complex attack on the celebrated Newtonian argument

comprises many aspects. One of Boskovic's lines of criticism is that Newton's experiment is not convincing as a proof of absolute motion: in fact, nothing would be changed as regards the rope's tension if a uniform inertial motion in the orbital plane were impressed on the system of the spheres, although the resulting alleged absolute motion would now become different from the presumed absolute uniform circular motion, the latter being Newton's concern in his alleged proof. So we see Boskovic using Newton's own principle on mechanics, i.e. the indetectability of inertial motions, to argument against Newton's experiment. In other words, the rope's tension is not reliable as evidence of one particular absolute space and motion, because the tension remains the same for an infinity of (absolute) motions resulting from combinations of circular and inertial motions. In short, according to Boskovic, Newton's experiment would not give us any information as to which space, out of an infinite class of them, would coincide with absolute space.

Another aspect of Boskovic's criticism concerns Newton's alleged measurement of the string's tension: Newton's measurement implies that the distance between the spheres varies only as a conseguence of the changing tension; in other words, it would behave as a space-invariant, an "absolute" length. According to Boskovic's force-law theory, the distance is not space-invariant. Conseguently, Newton's argument is nullified. I wish, at this point, to emphasize the correlation between Boskovic's refutation of an absolute length and his force-law theory, because it gives us another indication of the interconnection between the various components of Boskovic's Theoria.

Another distinctive feature of Boskovic's criticism requires our attention. In the passage above, Boskovic criticizes Newton's two-spheres experiment on the grounds that, in Newton's method, "the existence of inertial forces as well as the way by which the motions are produced by them must be assumed", rather then being proved, as

was Newton's intention. Here Boskovic denies Newton's assertion that the argument of the two spheres has the character of an experimental proof of absolute motion (more precisely that the principle of absolute motion is "induced from this phenomenon"). He maintains that absolute motion and absolute space are assumptions, rather then proofs in Newton's theory, and he eliminates them from his own theory. However, Boskovic does not eliminate them just because they are "a-priori" assumptions. He himself introduces an "a priori" assumption (prova diretta "a priori") in his Theoria, i.e. his "principle of continuity"[5] (legge di continuità), as an appropriate substitute for the Newtonian postulate with the advantage of bringing more clarity and simplicity into his theory. The reason for this elimination is that absolute space and motion are not consistent with the ideas Boskovic has developed in his research.

Summarizing:

1. Boskovic's criticism of Newton's absolute motion (and absolute space) does not concern a refusal of Newton's argument on the grounds of its a-priori character (as will be the case later with Ernst Mach), but a dissent on its epistemological status (for Newton, a principle "induced" from phenomena, for Boskovic an "a priori" principle).
2. Although admitting the legitimacy of founding a theory on a-priori principles, Boskovic does not deem it convenient to introduce Newton's absolute space as an a-priori principle into his own theory. He hopes thus to achieve two advantages over Newton:
a) a diminution in the number of fundamental principles; b) a relativization of motion, which is consistent with his conception of the postulational character of mechanics (De Lumine) and his concept of a unique force-law (De Viribus Vivis).[6]

It is noteworthy how different this Boskovician frame of ideas is from that of an Ernst Mach, whose main argument against Newton is the charge that absolute space is a methaphysical concept, one not

justified in Mach's phenomenological phylosophy, hence a redundant, useless concept.

2. The "a priori" foundation of Boskovic's Theoria.

Boskovic is convinced that his Theoria (first edition 1758) is based on foundations of two different kinds. He states them explicitly in his 1762 letter[7] to Stefano Conti, calling them "extrinsic proofs" ("le prove estrinseche") and "a-priori direct proofs" ("prove dirette a-priori"):

> "I do not prove a-priori each part of my theory, but only its basis ("il suo fondamento"), which consists of in the continuity law. I deduce from phenomena alone any statement concerning the nature of forces, hence all the behaviour of the curve [i.e. the curve of force]. Indeed this is the true method for the investigation of Nature, and this means to fulfil the task which, in Newton's words, belongs to good Philosophy" (my transl.).

As to the "prove dirette a priori", he has adopted[8] in his theory the "a priori" principle of continuity, i.e. the "a-priori" necessity of assuming spatial and temporal continua. His arguments of "affilato discorso" ("sharp discourse") deal with the nature of the continuoum. In the same letter to Conti, the first part of Boskovic's discourse is, in effect, what we would call today a dissertation on the infinite divisibility of a spatial continuous interval (this argument is also met in his Dissertatio de Lege Continuitatis). He claims to have abolished any "substantial and coexistent continuum", and kept only "a continuoum of duration and of motion, to which, as I have shown, any other continuum of force, velocity, etc., can be reduced"[9]. He considers "as really continuous these two kinds of modalities (modes), i.e. duration and motion. Then «momenti» and «puncti» are terminations of the parts of these modalities"[10]. (My transl.). Boskovic here

expresses an idea of continuity which dispenses with any concept of substance or matter: a purely spatial and temporal continuity, based on the primitive concepts of motion and duration. Discontinuity and particularity are for him an illusion or a conceptual fiction. He considers[11] "the very great difficulties in a theory of non continuous existence"; one difficulty is related to the fact that, if spatial and temporal lags existed, the soul could not coexist with the points of his body, etc.

Once the "a priori" part for the foundation of his Theoria has been laid down, then Boskovic completes the task by using the Newtonian method of "deducing" the Principles from the phenomena of nature. He emphasizes[12] that in his system he has not proved "a priori" either repulsion (among material points) or attraction, but has proved these general laws and principles by extrinsic proofs ("colle sole prove estrinseche"), i.e. through observations:

> "It is from the phenomena of Nature, not from Metaphysical Speculations that it is worthwhile to draw out general laws and the principles from which the said phenomena depend"[13] (my translation).

In addition, Boskovic considers it his merit to have reduced[14] the number of Newtonian Principles, because from these Principles "he was able to extract only one: that of a nature uniform in itself and simple", i.e. his unified law of force". He hinted at this achievement in the title of his masterwork, "Philosophiae naturalis Theoria redacta ad unicam legem virium in Natura existentium", i.e. by stressing that his Theoria was "redacta ad unicam legem virium in Natura existentium", "reduced to a unitary law of the forces existing in nature".

> "In his letter[15] to Conti he explicitly declares: I added in Natura existentium in order to hint that I did not intend to lay a law prescribed by hypothesis, but rather a law whose existence

in Nature, as we observe it, can be found through those same observations" (my translation).

Boskovic uses the newtonian expression, to "deduce from phenomena" but he adds the qualification "a-posteriori": 1) "convien vedere, se io ho ben dedotte queste cose dà fenomeni a posteriori. Ora questo credo di si..." (ib. p. 79). To his correspondent's objection, he answers that he does not think it possible to prove a priori "the form of the curve expressing the force". If this were possible then one would have to admit that just one world has the possibility of existence, because the kind of logical necessity implied in a unique a-priori demonstration (a law demonstrated "a priori" must be just that and not any other) carries with it, the uniqueness of the real world. On the contrary, Boskovic believes that an infinity of other, different force - laws are possible for two reasons: first, as a consequence of the different combinations of points under the same law, and, second, from the possible existence of different elementary laws of force. It depended on God's free will to have chosen the present world that can conseguently be known "a.posteriori", i.e. by experiment.

In conclusion, a-priori principles are allowed, according to Boskovic, in physical theory, as his examples of the principle of continuity (and the principle of simplicity in Nature) demonstrates. These are not metaphysical principles, because such principles are not allowed in his theory. The principle of inertia can neither be proved [16] a-posteriori (Contra Newton) nor a-priori, as is the case for Boskovic's principle of continuity; it can be deduced from his law of force as a null-effect. Inertia thus has a precarious standing in Boskovic's Theoria. In this context, my understanding is that he speaks of "relative inertia".

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Notes

(1) R.J.Boskovic "Criticism of Newton's alleged proof of absolute motion", from explanatory notes to: Philosophiae recentioribus versibus tradita a Benedicto Stay Libri Decem, Romae 1755; III, p. 464 in: M. Capek, The concepts of space and time, their structure and their development Boston Studies, Vol. XXII, Reidel 1976,pp. 289-290.

(2) P. Rogerio Josepho Boscovich, Theoria Philosophiae Naturalis Redactad Unicam Legem Virium in Natura Existentium, Vienna, 1758. In the following, my references are to Child's Translation, 1922. In a few instances I refer to the Venetian Edition, 1763.

(3) E. Hill, "R. B. A biographical Essay", in L.L. White (ed.) R.G.Boscovich SJ,FRS (1711-1787) Allan e Unwin. 1961, pp 17-101, p 41.

(4) The passage is translated in: M. Capek, cit. p. 289.

(5) Letters of February 26, 1762, in: Ruggiero Giuseppe Boskovic, Lettere a Giovan Stefano Conti, a cura di Gino Arrighi, Leo Olschi, 1985; pp. 45-85.
p. 77 "Io non dimostro a priori alcuna parte della mia teoria, ma solo il suo fondamento consistente nella legge di continuità. Tutta la natura delle forze, e però tutto l'andamento della curva io lo deduco solamente da fenomeni. Anzi questo è il vero metodo di investigare la Natura, e questo l'adempire quello, che per bocca del Newton richiede la buona Filosofia". (My italics). Boskovic contradicts Conti's convition that the repulsive force in Boskovic's Theoria is an a-priori assumption. (Ib. p. 76).

(6) Capek appropriately underlines the originality of Boskovic's criticism also in respect to Berkeley's one, and, respectively, to the positions of Stallo and Mach. Capek, cit. pp. XL, XLI.

(7) R. Boskovic, Lettere a Stefano Conti, cit. p. 77.

(8) Ib. p. 49.

(9) Ib. p. 51

(10) Ib. p. 52

(11) Ib. p. 54

(12) "Per altro io non credo già, che si possa in alcun modo provare a priori la forma della curva esprimente la forza. Se questo si potesse, si proverebbe, che il Mondo non poteva formarsi con altre leggi; ed io credo che sono possibili infiniti altri Mondi diversissimi da questo nella serie dei fenomeni..." (Ib. p. 77).

(13) Ib. p. 76

(14) Newton wrote in his Optics, Query 31: "On the other hand, to deduce from the phenomena of Nature two or three general principles and to explain how the properties and actions of all corporate things follow from these principles, this could indeed be a mighty advance in philosophy, even if the causes of those principles had not at the time been discovered". Newton had

considered that three fundamental Principles were necessary to take account of all the phenomena: gravitation, cohesion and fermentation. Boskovic reduces them to just one, represented by his force law. Boskovic refers to the Newtonian Query 31, in Boskovic, Dissertation De Lumine Pars Secunda, Romae 1748, n. 58, and in the Preface to Theoria.

(15) Letter to S. Conti, cit. p. 77.

(16) Z. Markovic, Voce Bošković, Dictionary of Scientific Biographies, Vol. 2°, pp 326-332.
Markovic clearly states that, according to Boskovic, the principle of inertia cannot be proved a-posteriori.