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Concluding remarks. Faraday on Boscovich

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Abstract. Considerations about some papers of Boscovich's conference held in Milano on May 18, 2011 are presented. Faraday's memoir on the influence of Boscovich on his theory of matter is discussed.

Key words. Boscovich,Faraday

1. Introduction

I thank the organizers for the invitation to comment some papers presented at the conference, a very difficult task when you're dealing with a character like that Boscovich, that, according to Lancelot Law Whythe "... was mathematician, physicist, astronomer, geodesist, surveyor, engineer and architect as well as a poet, diplomatist, social figure and much-traveled personality. He combined the Roman subtlety with Serb vigor, and Slavonic intensity of imagination with Western logical precision." But a few observations are worth it.

2. Boscovich

Compared to a few decades ago, all documentation of and on Boscovich you can access is much richer. On the one hand the Inventory of the Historical Archives of the Brera Astronomical Observatory has been completed and the catalogue of Boscovich's letters kept in the Archives was published.

In addition, digitization and publication of all published works and manuscripts of Boscovich is under construction. A job that will allow scholars to access the extraordinary amount of material currently scattered in libraries and archives all over the world.

Now we come to the papers of this meeting. Some of them have offered methodological cues as the first part of Proverbio's an that of Buzzi. Proverbio has stressed the need to contextualize the ideas of Boscovich, analyzing philosophical and scientific culture of his time, without crediting the Ragusan natural philosopher with points of view that don't belong to him and without considering him at all costs a precursor of concepts that will mature later and in cultural and scientific contexts totally different.

I would stress, however, that, along with a historical reconstruction properly contextualized, you must also analyze further developments of the natural philosophy in the nineteenth century. This way you can select ideas and cultural atmosphere of the eighteenth century that will later feed scientific researches.

Buzzi's paper allows us to understand how two points of view are useful.

Buzzi talked about the opposition between Frisi and Boscovich about Newtonian approach to the concept of matter. According to Buzzi, Frisi had an idea of matter as something "dead." The main characteristic of the matter (or more precisely of the mass) was to have an intrinsic quality - inertia -, and the forces, from outside, can change only the state of motion of the mass. But, Buzzi points out, among masses a force is exerted: matter is, therefore, also a centre of force which, in Newtonian mechanics, is inside the mass. Boscovich, according to the Leibnitzian tradition, argues that the centre of force can be external to the masses. Frisi was perceived by his contemporaries, and in fact he was, a researcher along the Newtonian tradition as developed by mathematical physicists of the Académie des Sciences. Laplace, at the of end of the eighteenth century and in the first decades of the nineteenth century, had written a synthesis of the many contributions of mathematical physicists as d'Alembert, Lagrange, Laplace himself, Euler to Newtonian mechanics.

Laplacian/Newtonian synthesis was able to give an account of the most intricate natural phenomena: motion of the comets, inequalities of Jupiter and Saturn, Moon's motion, flatness of the Earth, precession of the equinoxes, etc.. In the early decades of the nineteenth century the model begun to show inconsistencies that made it difficult to deduce the behavior of some new phenomena. And, just in celestial mechanics, a field in which the Laplacian/Newtonian approach had collected the most compelling successes, it turns out, in the mid-nineteenth century, that the motion of the perihelion of Mercury isn't deducible by the Newtonian principles. But astronomers continue to use Newtonian mechanics for more than a half century, until General Relativity defined boundaries of applicability of Newtonian mechanics.

However it is in the field of electricity and magnetism that Newtonian approach shows its greater limits. Oersted's experiment (1821) (a magnetic needle near a current carrying wire rotates without moving his centre of gravity), is completely unexpected on the basis of mechanics which is able to describe natural phenomena, and then the interaction between the magnet and current carrying wire, only in terms of attraction and repulsion forces. And the same difficulties are encountered when we try to deduce from the principles of mechanics the phenomenon of electromagnetic rotations (1821), electromagnetic induction (1831) etc.. Interpretation of phenomena discovered in the field of electricity and magnetism will stress the relevance of the Boscovichian conceptions.

In summary Frisi's approach seemed to be heuristically more productive to the eyes of the contemporaries. And indeed it was, at least with regard to the celestial mechanics. But some of the Boscovichian issues, which in the eyes of some of his contemporaries (eg. French mathematical physicists) could seem obsolete, proved to be useful for the nineteenth-century new theories of electricity and magnetism.

However, the issue of Boscovich contribution to nineteenth-century scientific thought is controversial, and many historians of science are skeptical about the actual influence of Boscovich in the elaboration of the new theories. Historiographical difficulties arise, in my opinion, from the fact that Boscovichian approach isn't formalized, in contrast to Newtonian mechanics, where there is a formalized physics with its principles, its theorems and proofs, its observational and experimental controls. Boscovich's law of action is more qualitative than quantitative and it is difficult to infer from it the behavior of some natural phenomenon. But, even if Boscovich was only a metaphysical, nothing prevents us to develop a historical reconstruction in which Boscovichian "metaphysics" may provide a convincing key to understand and to interpret evolution of scientific thought in the nineteenth century. About this question I will mention in detail a Faraday's memoir. But first I want to quote an interesting problem raised in another paper.

Luca Guzzardi asks an interesting methodological question: does actually W. F. Herschel discover Uranus in 1781? The question is reasonable. Herschel didn't immediately qualify the new star as a planet. He thought it was a comet, but at the same time he had doubts due to some unexpected features of the celestial object. Guzzardi's question is interesting from epidemiological point of view only if we think of the discovery as something that comes already formulated in all its details by the head of the scientist, like Minerva from the head of Jupiter. But we can object that the discovery of something new is a process that ends only when when scientists are able to put together all the pieces of a complex puzzle. And this process takes time.

But it is also reasonable to ask why someone argues that Herschel had "discovered" the planet Uranus. In fact if you read the original memoir of Herschel you realize that the astronomer of Bath notes something strange in the observed celestial object. It looks like a comet but has no tail although it's near to the Sun. And Barnaba Oriani, when in his memoir calculates the circular orbit of the "object", calls it "singularis cometa". But in a subsequent memoir Oriani calculates the elliptical orbit that actually makes sense, in the practice of the astronomy of that time, only if you consider the celestial object as a planet.

But why, despite the doubts, do these astronomers call "comet" the new object? Because few decades before, Halley's comet was rediscovered, whose passage was predicted by Newtonian mechanics, one of its first significant observational evidence. Astronomers were ready to "see" comets rather than planets, whose numbers had been the same since prehistoric times. But Herschel was able to note unusual and abnormal behavior of the object he was observing: a necessary step in the discovery of a new phenomenon.

There were also more technical papers: I have been able to follow some of them, others less, due to my ignorance of course.

3. Faraday

Finally I want to mention and comment a memoir of Faraday about the influence of Boscovich on the development of nineteenth-century theories of electricity and magnetism.

In a letter dated January 25, 1844 to Richard Taylor, published in the Philosophical Magazine as "A Speculation touching Electric Conduction and Nature of Matter" Faraday exposes his conception of the theory of matter.

Faraday begins by outlining the principles of atomic theory which considered atoms as material particles with volume. To each of these atoms were associated, from the time of its creation, the forces so that they could lump together in order to form different substances with different properties we can observe. These atoms, while being grouped, are not in contact with each other but are at a mutual distance: the bodies being likely to change their size as a result of compression, traction or heating. In the "Speculation", Faraday objects that

"The atomic doctrine . . . is not so carefully distinguished from the facts, but that it often appears . . . as a statement of the facts themselves, though it is at best but an assumption; of the truth of which we can assert nothing, whatever we may say or think of its probability.

. . . But it is always safe and wise to distinguish, as much as is in our power, fact from theory; . . . I cannot doubt but that he who, as a wise philosopher, has most power of penetrating the secrets of nature, and guessing by hypothesis at her mode of working, will also be most careful, for his own safe progress and that of others to distinguish that knowledge which consists of assumption, by which I mean theory and hypothesis, from that which is the knowledge of facts and laws; never raising the former to the dignity or authority of the latter, nor confusing the latter more than is inevitable with the former."

So according to Faraday the atomic theory of Dalton is untenable.

"If the view of the constitution of matter was correct, and we can speak of the particles of matter and of the space between them as two different things, then space must be taken as the only continuous part. Space will permeate all masses of matter in every direction, except that in place of meshes it will form cells, isolating each atom from its neighbors, and itself only being continuous."

Faraday shows, moreover, the absurdity of the atomic theory about the empty space. In accepting the ordinary atomic theory, space should be a non-conductor in non-conducting bodies, and a conductor in conducting bodies. But if space be an insulator it cannot exist in conducting bodies, and if it be a conductor it cannot exist in insulating bodies.

At this point, Faraday claims that the phenomena can be better explained by a theory of matter as that one of Boscovich, who considers atoms simply as centers of force.

"I am not ignorant that the mind is most powerfully drawn by the phenomena of crystallization, chemistry and physics generally, to the acknowledgment of centers of force. I feel myself constrained, for the present hypothetically, to admit them, and cannot do without them, but I feel great difficulty in the conception of atoms of matter which in solids, fluids and vapors are supposed to be more or less apart from each other, with intervening space not occupied by atoms, and perceive great contradictions in the conclusions which flow from such a view.

If we must assume at all, as indeed in a branch of knowledge like the present we can hardly help it, then the safest course appears to be to assume as little as possible, and in that respect the atoms of Boscovich appear to me to have a great advantage over the more usual notion. His atoms, if I understand aright, are mere centers of forces or powers, not particles of matter, in which the powers themselves reside. If, in the ordinary view of atoms, we call the particle of matter away from the powers *a*, and the system of powers or forces in and around it *m*, then in Boscovich's theory *a* disappears, or is a mere mathematical point, whilst in the usual notion it is a little unchangeable, impenetrable piece of matter, and *m* is an atmosphere of force grouped around it."

The theory of matter of Boscovich assumes, according to Faraday, that the atoms consist only of centres of force (and not matter). When atoms are reduced to mere centres of force, matter is present everywhere, and there is no unoccupied space between them. In gases the atoms touch each other as in solids.

"In many of the hypothetical uses made of atoms, as in crystallography, chemistry, magnetism, &c., this difference in the assumption makes little or no alteration in the results, but in other cases, as of electric conduction, the nature of light, the manner in which bodies combine to produce compounds, the effects of forces, as heat or electricity, upon matter, the difference will be very great. . . .

To my mind, therefore, the *a* or nucleus vanishes, and the substance consists of the powers or *m*; and indeed what notion can we form of the nucleus independent of its powers? all our perception and knowledge of the atom, and even our fancy, is limited to ideas of its powers: what thought remains on which to hang the imagination of an *a* independent of the acknowledged forces? A mind just entering on the subject may consider it difficult to think of the powers of matter independent of a separate something to be called *the matter*, but it is certainly far more difficult, and indeed impossible, to think of or imagine that *matter* independent of the powers. Now the powers we know and recognize in every phenomenon of the creation, the abstract matter in none; why then assume the existence of that of which we are ignorant, which we cannot conceive, and for which there is no philosophical necessity?"

Faraday continues with some considerations on Boscovich model of atom.

"Before concluding these speculations I will refer to a few of the important differences between the assumption of atoms consisting merely of centres of force, like those of Boscovich, and that other assumption of molecules of something specially material, having powers attached in and around them. With the latter atoms a mass of matter consists of atoms and intervening space, with the former atoms matter is everywhere present, and there is no intervening space unoccupied by it. In gases the atoms touch each other just as truly as in solids. In this respect the atoms of water touch each other whether that substance be in the form of ice, water or steam; no mere intervening space is present.

Doubtless the centres of force vary in their distance one from another, but that which is truly the matter of one atom touches the matter of its neighbours. Hence matter will be *continuous* throughout, and in considering a mass of it we have not to suppose a distinction between its atoms and any intervening space. The powers around the centres give these centres the properties of atoms of matter; and these powers again, when many centres by their conjoint forces are grouped into a mass, give to every part of that mass the properties of matter. In such a view all the contradiction resulting from the consideration of electric insulation and conduction disappears. The atoms may be conceived of as highly *elastic*, instead of being supposed excessively hard and unalterable in form; . . . "

Faraday concludes his work with a praise of Mossotti's theory because it lies in the direction of a common origin of gravitational, electrical and aggregation forces.

Ottaviano Fabrizio Mossotti, from a theoretical different approach that kept the atomistic assumptions of molecular mechanics, had come to a unitary representation of the forces of nature that had some point of contact with the theory of Boscovich. Faraday had received from Mossotti the memoir "Sur le forces qui régissent la consititution intérieure des corps" in December 1836 and had sent it to Richard Taylor for publication in Scientific Memoirs.

Is it enough to quote Faraday's memoir just mentioned to talk about the influence of Boscovich on nineteenth-century theories of electricity and magnetism, at least with regard to Faraday?

Of course at the end of the eighteenth century and at the first half of the nineteenth century knowledge of Boscovich was part of a diffused culture among the natural philosophers, and often it occurred through readings of secondary sources. Certainly, few of them had read the original memoirs of Boscovich. The historiographical problem, then, is to understand who were the authors that have been read and which interpretation they provided of the Boscovichian thought.

So on one hand it is very difficult to understand to what extent the knowledge that some natural philosophers had about Boscovich was important in their training and in their researches; on the other hand there is no doubt that many of them were influenced by some Boscovichian considerations.

Faraday's memoir is very detailed and references to the Ragusian natural philosopher are very precise: they don't seem at all only a rhetorical artifice.