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Who let the demon out? Laplace and Boscovich on determinism

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ABSTRACT

In this paper, I compare Pierre-Simon Laplace's celebrated formulation of the principle of determinism in his 1814 *Essai philosophique sur les probabilités* with the formulation of the same principle offered by Roger Joseph Boscovich in his *Theoria philosophiae naturalis*, published 56 years earlier. This comparison discloses a striking general similarity between the two formulations of determinism as well as certain important differences. Regarding their similarities, both Boscovich's and Laplace's conceptions of determinism involve two mutually interdependent components—ontological and epistemic—and they are both intimately linked with the principles of causality and continuity. Regarding their differences, however, Boscovich's formulation of the principle of determinism turns out not only to be temporally prior to Laplace's but also—being founded on fewer metaphysical principles and more rooted in and elaborated by physical assumptions—to be more precise, complete and comprehensive than Laplace's somewhat parenthetical statement of the doctrine. A detailed analysis of these similarities and differences, so far missing in the literature on the history and philosophy of the concept of determinism, is the main goal of the present paper.

1. Introduction

It is now exactly two hundred years since Pierre-Simon Laplace stated what would become the classical expression of scientific determinism in terms of a continuous and unbreakable succession of causally linked events in the physical universe and since he illustrated the relationship between thus defined ontological determinism and mathematical predictability—the latter being a paradigmatic ideal of natural philosophy ever since the time of Galileo and Newton—with presumably "one of the most vivid images to emerge from the entire literature on determinism" (Earman, 1992, p. 241). As is well known, in a celebrated passage from his 1814 'Philosophical essay on probability' (*Essai philosophique sur les probabilités*), which first appeared as a general introduction to the second edition of his larger work 'Analytic Theory of Probability' (*Théorie analytique des probabilités*), originally published two years earlier, Laplace wrote the following:

> We ought then to regard the present state of the universe as the effect of its anterior state and as the cause of the one which is to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective positions of the beings which compose it - an intelligence sufficiently vast to submit these data to analysis - it would embrace in the same formula both the movements of the largest bodies in the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes (Laplace, 1902/1814, p. 4).

The super-powerful calculating intelligence evoked in this passage, later to be known as 'Laplace's demon' or 'Laplace's superman' (Reichenbach, 1991[1956], p. 56), who could, on knowing the present state of the universe, predict and retrodict

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its state with certainty at any given past or future instant of time, was considered not only "an enthusiastic eulogy to the scientific work of the 18th century" (Mach, 1903, p. 217), so masterly perfected by Laplace himself in the domain of celestial mechanics but also the seed of one of the fundamental principles of scientific understanding that would persist across all scientific disciplines and popular culture all the way from Laplace up to the present day—that nature is, in principle, knowable and that science can offer a detailed, precise and reliable way to that knowledge.

However, what seems to still be relatively unknown is the fact that historians of science have offered a somewhat different picture of the origins and foundations of Laplace's determinism. That his formulation of the principle of scientific determinism in the *Essai philosophique* can be best explained by an appeal to his own practical achievements in celestial mechanics is, of course, naturally tempting. As Sheynin put it, Laplace "succeeded in explaining almost all the known motions of celestial bodies of the solar system by a single law, the law of gravitation, [and] furthermore, he proved (or thought he proved) the stability of the solar system, thereby refuting Newton's idea of a deity needed to execute *reformations*" (Sheynin, 1971, p. 234). However, as Sheynin further warned, this intuitive view of the origins and foundations of Laplace's determinism is essentially incorrect, primarily because Laplace stated something very similar but in more general terms already in one of his 1773 lectures, when, being at the age of twenty-four, he was just at the beginning of his later-to-become-brilliant career as a celestial mechanician.[1] Rather, as argued by Roger Hahn, one of the most distinguished researchers of Laplace's life and work, instead of the common 'intuitive story', "actually, the reverse is the case; determinism and a strictly causal view of change in nature leaving no room for arbitrariness or lawless intervention, were in fact the metaphysical presuppositions with which he began his career" (Hahn, 1968, p. 167). This thesis has been recently strengthened by showing that these presuppositions heavily relied upon a reinterpretation of Leibniz's principle of sufficient reason and the law of continuity as derived from the principle and by convincingly demonstrating that Laplace did not and, moreover, could not derive his famous statement of determinism in a rigorous mathematical fashion from his mechanics, as the theorem about uniqueness of solutions to differential equations was developed in the later work of Cauchy in the 1820s and of Lipschitz in 1876 (Van Strien, 2014a). However, the most interesting fact historians of science have revealed (Brush, 1974, p. 33; Hahn, 1968, p. 167; Hahn, 2005, p. 58; Hondl, 1929, p. 73; Sheynin, 1973, p. 320; Stiegler, 1974, p. 310; Wolfe, 2007, p. 38) is that Laplace was actually not the first to evoke one such demon and that strikingly similar passages can be found decades before Laplace's *Essai philosophique* in the work of scholars such as Nicolas de Condorcet (*Lettre à d'Alembert*, 1768),[2] Baron D'Holbach (*Système de la nature*, 1770),[3] and Roger Joseph Boscovich (*Theoria philosophiae naturalis*, 1758). It is a contribution of Roger Boscovich to establishing the doctrine of determinism that constitutes the main focus of the present paper.

More specifically, while the relationship of Laplace with his predecessors, such as D'Holbach and Condorcet, in respect to the concept of determinism has been relatively well researched by the above-mentioned scholars, a contribution by the eighteenth century Jesuit priest, philosopher, astronomer, mathematician, engineer, architect, poet and an international diplomat Boscovich to establishing this important concept has been mentioned only in passing, without being analyzed to any significant extent. Interestingly, that Boscovich should be counted, at least, as one of the important precursors of Laplace in matters of determinism seems to be better known than it is researched, as it can occasionally be heard outside the small and closed circles of professional historians of science. Thus, for example, in his popular book *New Theories of Everything*, John D. Barrow wrote that "although the concept of determinism in classical physics has assumed the title 'Laplacean determinism', there is an earlier and more explicit statement of the idea in Boscovich's remarkable book of 1758" (Barrow, 2007, pp. 62–63). Otto E. Rössler even claimed that Laplace "had copied the later-to-be-famous passage verbatim from Boscovich's book" (Rössler, 1998, p. 88). Aside from such general and unsubstantiated claims, however, an interested reader can barely find much more detail on Boscovich's conception of determinism, whether in popular literature or in the works of professional historians of science. This is certainly unfortunate, not only because Boscovich's statement in *Theoria philosophiae naturalis* was published 56 years before Laplace's *Essai philosophique*, when Laplace was barely a 10 years old, and years before the mentioned Enlightenment philosophers, but also because there seems to be agreement among historians on the assessment that "with the exception of Boscovich, the context [of other statements of determinism, including Laplace's own] is philosophical rather than physical, and it appears that the idea did not come out of physics", as noted by Van Strien (2014a, p. 27).

Believing that the story deserves more than a few footnotes, the main purpose of this paper is to shed some additional light on Boscovich's formulation of the principle of determinism. In particular, the historical record is intended to be set straight not only by claiming the temporal priority of Boscovich's formulation of the principle of determinism in respect to Laplace's own, but also by arguing that his formulation—being based on fewer metaphysical principles and more rooted in and elaborated by physical assumptions—should be seen as more precise, complete and comprehensive than Laplace's somewhat parenthetical statement of the doctrine. To do so, in Section 2, I will first present Boscovich's conception of determinism as it is found in his 1758 *Theory of Natural Philosophy*, together with a brief outline of his unified theory of matter and motion as a necessary framework for understanding this conception. Then, in Section 3, I will analyze the main similarities and differences between Boscovich's and Laplace's

[1] In a section on chance and probability from a paper read before the Academy of Sciences on the 10th of February 1773 and published three years later, we read the following: "The present state of the system of Nature is evidently a sequel of that which was in the preceding moment, and, if we imagine an intelligence who, for a given instant, embraces all the relationships of the beings of this universe, she could determine for any time taken in the past or in the future the respective position, the movements, and generally the attachments of all these beings." (Laplace, 1776, p. 113; Translation according to R. J. Pulskamp, available at http://cerebro.xu.edu/math/Sources/Laplace/1773_all.pdf).

[2] "… if the law of continuity is not violated in the universe, one could regard its state at every instant as the result of what had to happen to matter once arranged in a certain order and then abandoned to itself. An Intelligence that would then know the state of all phenomena at a given instant, the laws to which matter is subjected, and their effects after a certain period of time, would have perfect knowledge of the System of the World" (de Condorcet, 1768, p. 4; Translation according to Van Strien, 2014a, p. 29).

[3] "Cause always produces effect; there can be no effect without cause… It must then be concluded, that motion, or the modes by which beings act, arises from some cause; and as this cause is not able to move or act but in conformity with the manner of its being, or its essential properties, it must equally be concluded, that all the phenomena we perceive are necessary; that every being in nature, under the circumstances in which it is placed and with the given properties it possesses, cannot act otherwise than it does… A geometrician, who exactly knew the different energies acting in each case, with the properties of the particles moved, could demonstrate, that, after the causes given, each particle acted precisely as it ought to act, and that it could not have acted otherwise than it did" (D'Holbach, 1835[1770], Pt. 1, chap. 4, p. 31).