The Principle of Action and Reaction According to Newton

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The principle of action and reaction is generally considered the least problematic and interesting of Newton's three laws of dynamics—least problematic because it seems self-evident, and least interesting because Newton's mechanics of *Principia* essentially represents the dynamics of a mass point, while the principle of action and reaction is mainly important in the case of a set of bodies that interact with each other. However, reading Newton's text is enough for the principle to appear equally problematic and interesting as the other two. This entry aims to justify this statement and to help clarify the meaning of the principle.

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Newton's mechanics, which was not only presented in the *Principia*, has been the subject of a huge number of writings by historians of science and beyond. Particular attention has been paid to the first two laws of motion, whereas there has been less interest in the third law, known as the principle of action and reaction (hereinafter PA) [1][2][3][4][5][6][7]. The reasons could be, on the one hand, the apparent evidence for the principle itself, (There are some difficulties in having a complete understanding of its meaning in pedagogical situations [8][9][10][11]) and, on the other hand, the modest use that Newton made of it in the *Principia* given that their own mechanics, more precisely its theoretical core, is essentially that of the mass point, while PA is mainly important in the study of systems of interacting bodies.

PA has been studied by philosophers of nature and by mathematicians from different points of view. Philosophers have been interested in its ontological and epistemological nature and have often treated it as a metaphysical principle, namely that every action corresponds to a reaction. They have all considered it a principle whose logical status is not very different from that according to which to each cause corresponds an effect. Mathematicians, more precisely mechanics scholars, started from everyday experience. According to them, for example, when two people play tug of war, it is evident that the pulling of one side corresponds to the pulling of the other. However, it is only in the 17th century with Newton that the principle reached a form that allowed for its application in a physical mathematical theory, specifying that the action and reaction have the same nature, are measurable entities, and are equal and contrary.

Ernst Mach gave great relevance to this principle, by asserting, for instance "Perhaps the most important achievement of Newton with respect to the principles is the distinct and general formulation of the law of the equality of action and reaction, of pressure and counter-pressure" [12] (p. 198). For him, it is the basis of a new formulation of mechanics. However, even Newton had to give great importance to the principle because, in the

Principia, he attributed the first two laws of motion to Galileo Galilei ("Galileus invenit" [13] (p. 21) but he gave no attribution to the third law.

In this work, I will show how PA is not as simple as it seems, and in any case, it is no longer easier to frame than the other two principles/laws of dynamics; indeed, from certain points of view, it is the most complex because it is discussed here in terms of the ontology of the force.

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