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Kant's third law of mechanics: The long shadow of Leibniz

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ABSTRACT

This paper examines the origin, range and meaning of the Principle of Action and Reaction in Kant's mechanics. On the received view, it is a version of Newton's Third Law. I argue that Kant meant his principle as foundation for a Leibnizian mechanics. To find a 'Newtonian' law of action and reaction, we must look to Kant's 'dynamics,' or theory of matter.

I begin, in part I, by noting marked differences between Newton's and Kant's laws of action and reaction. I argue that these are explainable by Kant's allegiance to a Leibnizian mechanics. I show (in part II) that Leibniz too had a model of action and reaction, at odds with Newton's. Then I reconstruct how Jakob Hermann and Christian Wolff received Leibniz's model. I present (in Part III) Kant's early law of action and reaction for mechanics. I show that he devised it so as to solve extant problems in the Hermann-Wolff account. I reconstruct Kant's views on 'mechanical' action and reaction in the 1780s, and highlight strong continuities with his earlier, pre-Critical stance. I use these continuities, and Kant's earlier engagement with post-Leibnizians, to explain the un-Newtonian features of his law of action and reaction.

A wide consensus, spanning over a century, has it that Kant's metaphysics of nature in the 1780s lays ground for Newtonian science. This claim has several guises, but all urge that, to make good sense of his *Metaphysical Foundations of Natural Science* (*MAN*), we must turn to Newton.

In this paper, I argue against one version of this idea. I examine the law of action and reaction in Kant's *mechanics*, and claim it was not meant to support *Newton's* mechanics. Instead, we should look to Leibniz and his successors to uncover its meaning and role in Kant. It turns out that he offers this law so as to solve problems in post-Leibnizian dynamics. This finding, I suggest, calls on us to rethink the basis and scope of Kant's a priori mechanics; it also warrants a revaluation of Leibniz's legacy for natural philosophy in the Age of Reason.

1. Kant and 'Newtonian' science

In the 1880s, a group of Kant scholars began to assert that his metaphysics of body is best read in the context of the rising 'Newtonian' science of its time. Though rather vague, the claim seduced enough to survive into this century, despite sporadic doubts.[1] On a closer look, the alleged link between Kant and Newton turns out to have several strands, but three stand out for my topic. (1) The strongest is an ingenious construal that Michael Friedman laid down in exquisite detail; for him, Kant's *MAN* shows that key Newtonian concepts—absolute space, true motion, and universal gravitation—need synthetic a priori principles that Kant first specifies and defends. These concepts loom large in Newton's *Principia*, but rest there on a metaphysics unacceptable to Kant. In its place, he offers the principles of transcendental idealism, which he further specifies in *MAN*, so as to ground Newton's gravitation theory and doctrine of true motion.[2] The Friedman thesis assumes that Kant and Newton work with the same laws of motion.[3] (2) Some have argued for the weaker view that Kant shows the three laws of Newton's mechanics to be derivable from resources in the First Critique. Kant's Analogies of Experience and analysis of the concept of matter—so goes the claim—yield Newton's laws, thus shown to be synthetic a priori. This view has a long lineage. It began in Germany

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[1] See, e.g., Adickes (1924) and Schäfer (1966). All translations are mine, unless noted.

[2] Cf. Friedman (1992), pp. 136–164.

[3] For him, Kant's Phenomenology "outlines a procedure for *applying* [*Kant and Newton's*] *laws of motion* . . . so as to subject the given appearances (viz., apparent motions) to the modal categories in three steps or stages."—Friedman (1994), p. 33; my emphasis.

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around 1885, and leading interpreters still defend it in our time. As a nod to its revered descent, let us call it the 'Marburg reading.'[4] (3) Finally, some take Newtonian science to be classical mechanics.[5] Here, 'classical' is opposed to 'relativistic.'[6] In *this* sense, the claim is true: Kant's *MAN* does ground *a* mechanics, and it *is* classical. But to associate it with Newton is misleading; in classical mechanics, the attribute 'Newtonian' is honorific, not descriptive. Newton voiced (or took for granted) what his foes also believed unshakably: Galilean kinematics. Their quibbles with Newton over space, time and motion do not make their own mechanics any less classical. Also, Kant grounds *classical* mechanics where few expect it—in his Phoronomy, not the oft-read Dynamics, Mechanics or Phenomenology. Lastly, this view takes some liberties with history: classical mechanics has *two* versions, with Newton to credit (in part) for one, not both. The other comes from Lagrange and others.

In this paper, I argue against (2). I explain how Newton's and Kant's laws of motion diverge, and claim it is because Kant meant his third 'mechanical' law to solve some extant problems in post-Leibnizian dynamics (Sections 1.1 and 1.2). Then I document my claim. I show that Leibniz too had a law of action and reaction (Section 2), and I recount its fate in the works of two disciples, Jakob Hermann (Section 2.1) and Christian Wolff (Section 2.2 and 2.3). Next, I show that Kant's early law of action and reaction corrects the Hermann-Wolff Reaction Principle (Section 3), and spell out its continuities with his Critical model of mechanical interaction (Section 3.1). I conclude with a brief discussion of the limits of Kant's a priori mechanics (Section 3.2), and a call for a more nuanced understanding of his foundations for physics—one that makes room for Leibniz's legacy as well.[7]

Lastly, I should make very clear that, in this paper, I am only after the third law of Kant's *mechanics*, i.e. his law of "the action of moving bodies on one another by communication of motion," as he puts it. Though he has a 'dynamical' law of action and reaction, I make no attempt to investigate its content or range; nor do I mean to deny that it is compatible with Newton's thought. In fact, I agree with scholars who claim that it can support action-at-a-distance cases such as mutual orbiting.

1.1. Newton and Kant on the laws of motion

I must begin with a closer look at the exact content and range of Newton's and Kant's laws of mechanics.[8] Early in his *opus*, Newton states three "axioms, or laws of motion." First is the Law of Inertia: a body continues with constant velocity unless an unbalanced *impressed* force acts on it.[9] The second measures an impressed force: it equals the "change in motion" of the body *acted upon*.[10] The third reveals that impressed forces come in pairs: when a force acts upon a body, the body acts back upon the source of that force. "To any action there is always an opposite and equal reaction; in other words, the actions of two bodies upon each other are always equal and always opposite in direction."

Compare these with Kant's laws. (K1) The first asserts conservation of mass throughout corporeal changes.[11] (K2) Next is *a* law of inertia: "All change in matter has an external cause. A body persists in its state (of rest or uniform motion in the same direction) unless compelled by an external cause to leave this state." (K3) Kant also has a Reaction Principle: "In all communication of motion, action and reaction are always equal to each other." Plainly, they do not map directly onto Newton's laws. Also, only two are proper laws of *motion*; the first entails nothing about the motion of bodies. So it seems hard to accept that Kant justifies Newtonian science by deriving Newton's laws of motion. Note a glaring lacuna: the key to Newton's mechanics—*impressed force* and the Second Law—is visibly absent from Kant's a priori foundations.

Some interpreters noticed this, and have argued astutely that (K2) and (K3) are equivalent to Newton's three laws. Yet accounts of this alleged equivalence have changed over time, a sign that it is not direct. At first, they claimed that Kant's K2 is equivalent to Newton's First and Second Laws.[12] But that needed emendation. If anything, Kant's law of inertia says *less* than Newton's similar law. With *Lex Prima*, Newton also codifies that only impressed force changes inertial states, not just any cause. However, Kant's law says merely that any change in a body's state is caused by external factors; it leaves their type and measure undecided. In the 18th century, Newton's impressed forces are *not* the only possible causes of dynamical change. Such causes could well be Leibnizian 'live force' or Cartesian-Malebranchist 'force of motion,' as opponents argued in the *vis viva* debates. Kant's law of inertia declares that only external causes change a body's state. But the question arises: what is the measure of these changes—how much mechanical effect does an external cause bring about? In answer, Newton offers his Second Law, which Kant lacks. Instead, advocates of equivalence argue, Kant bypasses the need for *Lex Secunda* by having his Reaction Principle govern *directly* changes in motion rather than two forces.[13] Ergo, they conclude, Kant's K2 and K3 are equivalent to Newton's three laws.

This line of argument rests on a key assumption: that Kant's and Newton's third laws have the same content and range. [14] But I submit that it requires a more sustained defense if it is to be true. Despite *verbal* similarities between the two men's claims about action and reaction, reasons for caution abound: unlike Kant, Newton gives precise, technical senses to 'action' and 'reaction'; Kant's

[4] "Kant works Newton's principles into his synthetic principles"—Cohen (1885), p. 245. For V. Mudroch it is a "fact, that the laws of *MAN* are largely identical with those of Newton's *Principia*."—Mudroch (1987), p. 78. More recently, P. Guyer has Kant "derive the three laws of Newtonian mechanics by applying the three principles of judgment," or Analogies of Experience; see Guyer (2006a, 2006b), p. 162.

[5] "The pure reason described by Kant could last no longer than the Newtonian physics, which was its proper function to justify."—Gilson (1999), p. 184. Cf. also van Fraassen (2002), p. 8; Guyer (2006b), p. 2.

[6] Presumably, it means a theory of interactions at sub-luminal speeds through forces that are functions of mass; and it assumes that length and time-interval are well-defined independent of bodies' states of motion.

[7] My argument here owes much to Eric Watkins, whose tireless efforts to highlight the post-Leibnizian context of Kant's mechanics have greatly influenced me. See Watkins (1997) and Watkins (1998a). Here, I build on Watkins' work, and extend it all the way to Leibniz.

[8] Kant offers them in "Metaphysical Foundations of Mechanics," Chap. III of his 1786 tract. He derives them from the Analogies of Experience and an analysis of the concept of matter explicated as "the movable insofar as it has moving force."

[9] "Every body perseveres in its state of being at rest or of moving uniformly straight forward, except insofar as it is compelled to change its state by forces impressed"—Newton (1999), p. 416.

[10] "A change in motion is proportional to the motive force impressed and takes place along the straight line in which that force is impressed."—Newton, *Principia*, 416.

[11] "In all changes of corporeal nature the quantity of matter as a whole stays the same, neither increased nor diminished."—Kant (1903 [1786]), p. 541. I follow convention and refer to volume and page numbers in the Prussian Academy edition of Kant's *Gesammelte Schriften*. Thus, 4: 543 refers to that edition of Kant's *Metaphysische Anfangsgründe der Naturwissenschaft*. Next two quotes: *ibidem*, 4: 543, 544.

[12] Friedman (1992), p. 145. Credit where credit is due: to my knowledge, among proponents of 'Newtonian' readings of Kant only Friedman has made sustained, repeated efforts to account for the discrepancies between Kant's and Newton's laws of motion.

[13] "Since Kant takes the equality of action and reaction, in the first instance, to govern changes of momentum (rather than the forces which produce such changes), he actually does not need to formulate Newton's second law separately."—Friedman and De Pierris (2010), fn. 31.

[14] Some 19th-century neo-Kantians first made this move: "As the third law [of mechanics], both Kant and Newton posit the principle of action and reaction."—Stadler (1883), p. 187.