Michael Friedman. *Kant's Construction of Nature: A Reading of the* Metaphysical Foundations of Natural Science. Cambridge: Cambridge University Press, 2013. xix + 624 pp. £70.00 Hb.

In this formidable book, Michael Friedman follows up his 1992 *Kant and the Exact Sciences* with a careful and insightful reading of Kant's *Metaphysical Foundations of Natural Sciences* (*MFNS).* Although up until now *MFNS* has not received the recognition it deserves due to its obscurity and difficulty, Friedman convincingly argues that the 1786 treatise is one of Kant's most important works, and that it is "impossible to fully understand the theoretical philosophy of the critical period without coming to terms with it" (1). Friedman's book is not a line by line commentary, but rather a step by step reconstruction of the main arguments of Kant's text, contextualized in relation to a) fundamental metaphysical debates between both Newton and Leibniz, and Euler and Lambert, b) the development of Kant's own thought, from the pre-critical *Physical Monodology* to the *Metaphysical Foundations* and c ) the relation between what Kant achieves in both the A and B editions of the *Critique of Pure Reason* and the goals of the *Metaphysical Foundations.* The book consists of four major chapters, along with an introduction and conclusion. Each chapter provides an exposition and analysis of each of the major divisions of the *Metaphysical Foundations,* namely, Phoronomy, Dynamics, Mechanics, and Phenomenology; the concluding chapter analyses the relation of the arguments of the first *Critique* to those of the metaphysical foundations. Friedman's argument proceeds step by step, and each section presupposes the discussion preceding it, although Freidman is always careful to remind the reader of earlier discussions.

Friedman demonstrates that a central concern driving Kant's argument in *MFNS* are the conditions of the possibility of the mathematization of nature. As such, one of Kant's central aims is the development of the necessary (but not sufficient) principles for the construction of concepts that will allow us to quantify matter and its motions, that is, apply mathematics to the natural world. As Friedman shows, the project of *MFNS* is closely bound up with further specification of the conditions of the possibility of time determination, which, as Kant had argued in the first *Critique,* are transcendental conditions of experience. A central aim of *MFNS* is to show how such time determination can proceed given the physics of Newton's *Principia,* a paradigmatic instance of a "mathematical doctrine of motion." Key to Kant's differences with Newton, however, was that while Newton believed in the existence of both absolute space and time, Kant held that space and time were mere forms of intuition; furthermore, both space and time, in and of themselves, cannot be perceived. Space, for instance, "must be designated through what can be sensed" (*MFNS* 481). Because time cannot be perceived, it cannot be a foundational measure of motion. Time, rather, must be constructed, and its construction depends on our capacity to measure perceptible motions by one another. But if motions are to measure one another, it must be possible to give an account of the *composition* of motions, and it is to such an account of how this composition is possible that Kant first turns in the Phoronomy. Here Kant discusses the composition of motions with respect to mere geometrical points having direction and speed, abstracting from characteristics of matter such as mass, density, and force, which he treats later. Freidman's chapter on the Phoronomy (63 pages) is a penetrating analysis of the single principle of the Phoronomy asserting the equality of "motion of the body in space at rest," and "rest of the body and … motion of the space in the opposite direction with the same speed" (*MFNS,* 487). He carefully demonstrates how it allows for the composition of motions in pure intuition. Such a composition of motions is the necessary first step in the mathematization of nature. As Friedman notes, "time becomes a mathematical magnitude for Kant, only by using motion as a measure–by a procedure of successive approximation in which the mechanical laws of motion, in particular, define the ultimate standard of temporal uniformity" (80). The Phoronomy exhibits only the first step of a procedure completed only in the Phenomenology for making time into a mathematical magnitude.

Whereas the Phoronomy treats matter simply as the moveable in space, the Dynamics considers matter as the moveable insofar as it *fills* a space. At issue here is an account of the filling of space that will make the concept of matter "suitable for the universal mathematization of the concept of quantity of matter effected by the Newtonian theory of universal gravitation" (380). Among other things, Freidman's chapter on the Dynamics (178 pages) details the debate between Lambert and Euler: whereas Lambert held to the idea of solid corpuscles (here solidity is taken as an absolutely unchangeable unity), Euler's theory, in contrast, aligned with the mathematical continuum models of fluid and elastic materials of the second half of the 18th century. On this score, Kant decidedly sides with Euler: matter is originally elastic all the way down. Lambert's theory erects an insurmountable limit to the application of the mathematics of the continuity of motion "at the instant of (attempted) penetration of an absolutely impenetrable or solid body" (130). For this reason, Kant rejected it as an "empty concept." Instead of the idea of solidity, we have rather the notion of a repulsive *force*; this expansive or elastic force is exerted by all the points in a space filled with matter. As Freidman points out, this conception of matter as continuum also implied a rejection of Kant's early metaphysics of the *Physical Monadology,* in which all the points of the sphere of influence of a monad are rigidly connected to a central point and as such are not independently moveable. The *MFNA*, on the other hand, rejects the view of discrete force centers, since all the points in space must be independently movable and filled with elastic matter in general (141).

Also central to the dynamical understanding of matter is the concept of the fundamental force of attraction, which Kant conceives of as a penetrating force. Friedman first traces Kant's metaphysical justifications for positing the force of attraction: without out it there can be no matter, since the repulsive force, acting alone, would extend matter infinitely. A fundamental force of attraction is therefore needed to balance out the repulsive force. He then proceeds to elucidate Kant's appropriation and justification of central elements of Newton's method in Proposition 8 of Book 3 the *Prinicipia,* through which we are able to apply the concept of the *quantity* of matter to both terrestrial and celestial bodies. We first begin with the observation of volumes, figures and relative spatial positions, and by the argument of Book 3 of the *Principia,* establish the laws of the fundamental force of attraction (universal gravitation), which then allows us to estimate quantity of matter. Friedman underscores the methodological importance of this course of action for Kant: here we have a "progressive constructive procedure for successively applying mathematical concepts to empirically given nature." The upshot of such a procedure is a "transition from the terrestrial to the celestial realm–whereby we articulate a generally applicable concept of quantity of matter suitable for establishing a privileged frame of reference relative to which both celestial and terrestrial motions may be described within a single unified system of the world" (178).

Key to the transition from the Dynamics to the Mechanics is Kant's recognition that the notion of density or the intensive filling of space, constructed in terms of attractive and repulsive forces alone, cannot be used to compare matters of specifically different kinds. The dynamical concept of density, quantity of matter, and the degree of the filling of space must thereby be replaced by corresponding mechanical concepts, especially the mechanical concept of mass, if such comparisons are to be possible. Friedman notes that, "The final lesson of the Dynamics…is that any mathematical construction of either the concept of force or the concept of quantity of matter needs to proceed via a corresponding construction of the concept of motion" (234).

Freidman's chapter on Mechanics (138 pages) provides a careful analysis of Kant's procedure for constructing these concepts (especially the construction of the quantity of matter in terms of quantity of motion), guiding the reader through Kant's three Laws of Mechanics. These are both compared with Newton's three Laws of Motion and related to the transcendental conditions of experience detailed in the Analogies of the first *Critique*. Certain necessary conditions must hold if the procedure for the comparison of quantities of matter is to be carried through, and these conditions are articulated in the three Laws of Mechanics, each of which corresponds in important ways with each of the three Analogies of experience. Kant's first proposition in the Mechanics is that "The quantity of matter, in comparison with every other matter, can be estimated only by the quantity of motion at a given speed" (*MFNS* 537). The three Laws of Mechanics that follow are conditions governing the possibility of the communication of motion, which – because it can be communicated between substances – can then become the common measure for estimating quantity of matter. Kant's first Law of Mechanics states: "In all changes of corporeal nature the total quantity of matter remains the same, neither increased nor diminished" (*MFNS* 541). Friedman demonstrates that the principle of the conservation of the total quantity of matter is ultimately, for Kant, empirically realized by the conservation of momentum in all mechanical interactions (332). As such, it significantly parallels Newtonian principles. However, it principally functions as a transcendental condition of empirical time determination. Since the quantity of matter only manifests itself in experience by "the quantity of motion at a given velocity" (*MFNS* 537), it is only through the conservation of momentum that we can become aware of the conservation of the total quantity of matter. This matter corresponds to the schematized notion of substance that must be presupposed in all causal interactions, and which, according to the first Analogy, is fundamental to all time determination.

Highly significant is Friedman's analysis of Kant's second Law of Mechanics, "All changes of matter have an external cause." Friedman both situates this Law in relation to the Leibnizian metaphysics that Kant rejects in the Amphiboly of the first *Critique,* and demonstrates its role as a necessary condition for the comparison of quantities of motion. The idea that changes of matter have an external cause amounts, ultimately, to the notion the matter is *lifeless,* that is, it has no internal, merely monadic properties from which changes in its determinations might spring. Rather, all the properties of matter are relational, and all changes in matter must be traced to external causes. Furthermore, it is precisely this *lifelessness* of matter that allows us to measure quantities of matter (through its empirical criterion of quantity of motion at a given velocity) in terms of each other through the transfer of momentum, and only if we presuppose that matter is lifeless can we also assume the conservation of momentum in all mechanical interactions. For if matter itself contained inner determinations grounding changes in its outer states, the total quanta of the transfer of momenta in mechanical interactions could not be preserved, since the inner determinations of one bit of matter might be responsible for a change in motion, rather than the outer motions of other bits of matter, and we would never have an outer constant measure of mechanical interactions. Kant contrasts his own understanding of the lifelessness of matter with the notion of the *vis inertia,* "a positive striving [of a body]to preserve its state," (*MFNS* 544) an idea put forward by Kepler, among others, and which denoted a body's resistance to be set in motion. The *vis inertia* amounts to an originally moving dynamical force that matter contains *in itself,* and is therefore quite the opposite of the *lifelessness* of matter that Kant puts forward in the second Law of Mechanics. Instead of the *vis inertia,* Kant posits the *law of inertia*, namely the idea that because matter is lifeless, it remains in a given state of motion until acted upon by an outside force. As Friedman importantly notes, "…the law of inertia binds together different and otherwise independent moments of time by specifying the naturally persisting state of motion of a body on the basis of which *changes of state* – due to the actions of external forces – can then be determinately ordered" (394). This law is key to time determination, since it allows us to determine the place of a moving body at a given moment in time if no outside dynamical forces were operative upon it before or after a given instant. If such a body changes its state, we can then infer the action of an external force.

Kant's third Mechanical Law is equally necessary for a construction of the communication of motion: "In all communication of motion, action and reaction are always equal to one another." This echoes Newton's third Law; however, Friedman demonstrates how Kant uses it in a procedure for "constructing the communication of motion between any system of interacting bodies by constructing a kind of surrogate, as it were, for Newtonian absolute space" (353). Key to this construction is the assumption that two interacting bodies are not only affected to have equal and opposite changes of momentum relative to one another, they also always exert equal and opposite forces. If we assume that two bodies always exert equal and opposite forces, the impact of the bodies can then be considered relative to the center of mass of the two colliding bodies, in terms of which the two bodies are at rest after the impact. On Kant's view, a body can only be moved insofar as it is in motion; bodies that seem to be at rest are actually in motion because the relative space (in which they appear to be at rest) is itself always in motion (e.g. a house that rotates along with the surface of the earth on top of which it sits). The third Law of Mechanics is intimately linked with the second; there are no primitive inertial forces (internal principles of activity) exerted by bodies striving to remain at rest. Hence when the motion of an accelerating body is reduced on impact with another body, this reduction is not effected by the *vis inertia* of the body it impacts, but rather because this body must itself be considered to be moving, along with the space it inhabits, in an opposite direction, so that its motion cancels that of the impacting body.

Kant's three Laws of Mechanics, closely tied as they are to the Analogies, are key to the construction of empirical time determination. The construction is crucial to Kant's project, which differed, importantly, from Newton's, in that Newton posited an absolute space and time that he took for granted. Kant recognized that we have no empirical access to absolute space or time and that we cannot, as such, begin with them as absolute measures. Rather these must be constructed in terms of the motions of bodies relative to one another, to which we do have empirical access. Friedman underscores two fundamental points concerning Kant's relation to Newton. First, a central feature of

Kant's project is the elucidation of "structural features of the concept of matter that make it suitable for the universal mathematization of the concept of quantity of matter" in the context of Newton's theory of universal gravitation (380). Kant's project is thus to clarify the conceptual connections between ideas such as the volume, density, and amount of matter, which must be precisely defined in order to have a clear idea of the empirical laws that are supposed to govern matter. Second, these structural features are conceptualized in the context of Kant's Copernican conception of space and motion, which replaces Newton's absolute space and time. Instead of an absolute space and time, Kant defines space in terms of the relative positions of the objects in it, and time in terms of the relative motions of such objects. Since these objects are always in motion, (for instance, the earth around the sun, the sun, along with its entire planetary system, within the Milky Way) there can be no absolutely privileged space in terms of which to understand the relative motions of bodies. Hence the only way that we can approximate spatial and temporal measures are through the use of the three mechanical laws that allow us to measure motions and relate bodies to one another. The Laws of Mechanics allow us to "regulate an indefinitely extended corrective procedure by which we construct better and better empirical approximations" to a privileged space and temporal uniformity (395).

The fourth chapter is devoted to the Phenomenology (150 pages). As Friedman notes, here no new determination of matter is provided; instead, the topic of this chapter has to do with the distinction between appearance and experience in the context of Kant's Copernican conception of space and motion. Given that we lack absolute spatial and temporal reference frames, how do we move from what is a *mere* appearance given a limited perspective determined by an initial reference frame to a more comprehensive, global *experience*, one which is able to take into account and set distinct reference frames in relation to one another from the standpoint of a more adequate and wide-ranging perspective? Kant's Phenomenology treats the problem in the context of determining the "true" motions of the heavens, distinguishing these from their merely "apparent" motions. How is determination of these true motions possible given that "absolute motion, thought without any relation of one matter to another, is completely impossible" (*MFNS* 559-60)? Freidman emphasizes that the notion of "absolute space" is, for Kant, an idea "which is to serve as a rule for considering all motion therein merely as relative" (*MFNS* 560). The procedure through which we reduce all motion and rest to absolute space is thus one through which we arrive at better and better successive empirical approximations of a privileged space in terms of which motion can be understood. These approximations are achieved through the work of the concepts of the understanding, through which empirical intuitions are determined. The analogies of experience, and their further determination in the three corresponding Laws of Mechanics, allow us to subject perceptions to a dynamical order of necessary connections; it is through them that we are able to move from what merely appears to *experience.* This chapter provides an indispensible guide to Kant's application of his method in the context of the problem of the determining the "true" motion of the heavens.

The book concludes with reflections on the relation between the *Metaphysical Foundations* and Kant's first *Critique.* Friedman specifies three ways in which the two works differ. First, the work of the first *Critique* is much more general than that of the *MFNS.* Second, the subject matter of the *Metaphysical Foundations* is not entirely pure, since it depends on the empirical concept of matter. Third, the emphasis of the special metaphysics of the *MFSN* is on explaining how mathematics can be applied to the specific concepts of natural science; its concern is to furnish concrete examples in which the categories and principles of the pure understanding are first realized. As such, the development of the empirical concept of matter in the *MFSN* is the very first application of the categories and principles of the first *Critique* to the empirical domain.

One of the most significant discussions in Friedman's conclusion concerns the greater generality of the first *Critique* in the context of the problem of self and nature. While the *MFSN* is exclusively concerned with the objects of outer sense, the first *Critique* treats of both inner and outer sense. As Friedman points out, inner sense has priority in the first *Critique*. There Kant argues that the goal of rational psychology to seek a priori knowledge of the soul as *object* is impossible. However, the transcendental philosophy of the first *Critique* "considers the soul as subject, as the spontaneity of the faculty of the understanding that determines the manifold of inner intuition so as to make knowledge of the objects of appearance possible" (602). Friedman's discussions of the self as determining and determinable, the paralogisms, and the role played by inner sense in the determination of both self and world as objects of experience are extremely insightful, and go a long way in helping the reader to understand the different goals of the first *Critique* and the *MFNS.*

Friedman's book is not only the best available book on the *Metaphysical Foundations,* it also provides indispensable insight into large portions of the first *Critique*, as well as illuminating both works in the context of the philosophical debates in which Kant was engaged. The book does an excellent job of showing how Kant's arguments in the *MFNS,* particularly those in the chapter on Mechanics, complete Kant's arguments for the three analogies of experience, and give a much fuller account of how time determination is possible. The one issue that requires further investigation is the precise relation of the arguments of the Analogies and the Mechanics. In his conclusion, Friedman argues that Kant's development of the empirical concept of matter is the first application of the categories; however, there is also a great deal of transcendental argumentation in the Mechanics concerning the conditions of the possibility of time determination. This seems to be more than simply an application of the categories to the empirical domain; more needs to be done to clarify the exact relation between the development of the empirical concept of matter and the transcendental elements of Kant's arguments in the Mechanics. A more precise answer to this kind of question will allow us to answer the question of whether Kant's larger method can be revised to fit the context of contemporary physics. Just how tied is Kant to Newton? Can Kant's key insights be made relevant to contemporary physics? Friedman's book provides indispensable analyses for anyone who hopes to answer these questions, but does not, however, develop this question or provide an answer to it. Given the complexities of this problem, this might be the subject of another book. Friedman's book is, nonetheless, a *tour de force*. It is one of the finest works on Kant written in the past fifty years, and no serious Kant scholar should be without it.

Jacqueline Mariña
Department of Philosophy
Purdue University