Forthcoming in *Isis*, Vol. 105, No. 2 (June 2014), pp. 432-434.
VERSION CORRECTS EULER QUOTATION FROM ANAL. MECH. §82.

Michael Friedman. *Kant's Construction of Nature: A Reading of the* Metaphysical Foundations of Natural Science. xix + 646 pp., bibl., index. Cambridge: Cambridge University Press, 2013. $110 (cloth).

Kant's *Metaphysical Foundations of Natural Science* (*MFNS*) was published in 1786, three years after the *Prolegomena* and one year before the B-Edition of the *Critique of Pure Reason*. The *MFNS* plays a doubly crucial role in Kant's work: it shows how the *Critique*'s a priori Principles of Pure Understanding become fully binding on nature, thus fulfilling one half of that book's purpose; and, because it falls between the first and second editions, it connects on many levels with Kant's revisions, which are indeed centered on questions relating to time, space and motion. The general neglect of the work among twentieth-century scholars derives from views of those such as Peter Strawson, who contended that Kant's concern with "a priori principles of natural science really does have the effect of obscuring what there is of substance in a central, and crucial section of the [*Critique*], viz. the Analogies of Experience" (*The Bounds of Sense* [Methuen, 1966], p. 23).

By contrast, Michael Friedman's work over the last thirty years has centered on restoring Kant's connection to the exact sciences, thereby inspiring a generation of younger scholars. In this long-awaited book, he offers a detailed reading of the *MFNS*, triangulating its position in Kant's work relative to the Leibniz-Clarke affair and Johann Lambert's and Leonhard Euler's reactions to it, to Kant's pre-*Critique* monadistic physics and metaphysics, and to the evolution of Kant's thought across the two editions of the *Critique* (1781 and 1787). The book is intended neither as a detailed commentary, such as Konstantin Pollok's comprehensive *Kants Metaphysische Anfansgründe der Naturwissenschaft: Ein kritischer Kommentar* (Meiner, 2001),

nor as a fully contextualized intellectual history. Rather, by analyzing Kant's theories of space, time, and motion within a thin historical slice, it will allow for further work on the "deep conceptual transformation that began with Kant's scientific situation at the end of the eighteenth century and concluded with the revolutionary new (Einsteinian) space-time theories" (p. xi).

The place of the *MFNS* in Kant's system can be illustrated by the *Critique*'s Analogies of Experience, alluded to in the quotation from Strawson, above. The *Critique*'s functions of judgment (individual, particular, general; subject-predicate, if-then, either-or; etc.) yield the table of categories, which include fundamental logico-mathematical concepts, such as those of quantity (unity, plurality, totality), and metaphysico-dynamic concepts, such as substance-accident, cause-effect, reciprocal causality, and so forth. Each category is then attached to a time-schema, to yield proto-physical concepts: logical quantity becomes the concept of number through the schema of addition (a totality of a plurality of unities—i.e., a denumerated set), causality becomes efficient causality through the schema of an event that necessitates a succeeding effect. These schematized concepts are finally projected onto space and time to produce Principles of Pure Understanding, such as that all spatio-temporal appearances can be quantified (Axioms, Anticipations) or that all events are subject to the Law of Causality (the Second Analogy). Finally, in the *MFNS*, these Principles are supplemented with the concept of matter to produce embryonic laws of nature, such as the Law of Inertia (every body persists in uniform motion unless disturbed by an external cause).

It is then clear why Friedman's approach will inevitably produce more interesting results. It allows us to see how the law of reciprocal causality of the Analogies connects to a theory of simultaneity based on causal dependencies within a space-time manifold—whereas on Strawson's approach, stripped of these connections, even what is "of substance" in the Analogies

remains obscure. And even if it cannot be said that all of Kant's analyses in the *MFNS* are convincing, it remains the case that little of the *Critique*'s first two sections (the Transcendental Aesthetic and the Analytic) is comprehensible without reference to it—and still less the significance of Kant's revisions to the A-Edition. Since the task of the *MFNS* is to lay out the panoply of physico-mathematical principles that result from realizing the Principles of Pure Understanding as material laws, it has four parts: Phoronomy (kinematics), Dynamics (theory of attractive and repulsive forces), Mechanics, and Phenomenology (theory of real vs. apparent objects). These correspond to the four subsets of the categories (Quantity, Quality, Relation, Modality) and to their respective Principles.

Kant's Construction of Nature follows these main divisions, devoting a chapter to each. Friedman's fundamental—and fundamentally correct—historical thesis is that the principles of the *MFNS* are themselves fully realized by Newton's laws of motion. That "only a Newtonian could have arisen as a Kant" was indeed a founding claim of the neo-Kantian movement; however, not since Hermann Cohen's *Kant's Theory of Experience* (1871) has it been advocated so convincingly, and never before in such detail. Viewing both Newton and Kant through the lens of space-time theories, above all the work of Howard Stein, Friedman demonstrates convincingly that the convergent procedure for determining absolute space in the Phenomenology of the *MFNS* (it is the center of mass of the solar system) is nothing other than an implementation of Newton's method for determining "true motions" in Book 3 of *Principia*. Newtonian absolute space is replaced in the *MFNS* by an "ideal" on which reason converges, but which is never given as an empirical datum.

But Friedman takes a further step, arguing in his introduction that the "general theory of motion" Kant alludes to in the B-Edition's sections on time (which "explain as much a priori

cognition as the general theory of motion evinces" [B49]) is nothing other than Newton's laws. This programmatic claim is developed further in his chapter on the Phoronomy, where he argues that Kant rejects not only Newton's doctrine of absolute space but also that of absolute time. Because of this "deeper motivation" that is "central to Kant's project," Kant must hold that "no temporal relations whatsoever can be viewed as pre-existing" and that "all temporal relations are … the products of empirical constructions … by means of the a priori principles of the understanding." Newton's laws therefore "define what we mean by true temporal uniformity. Two temporal intervals are truly equal … if … they represent the times during which an inertially moving body were to traverse equal distances" (p. 65). Because time has no "mathematical structure" at this stage (i.e., prior to the introduction of the Law of Inertia), the Phoronomy's proof of the kinematic parallelogram law must take place "instantaneously," in the tangent space of the space-time point, so that "there can be no question of what we now call affine structure" (p. 81n).

But the general theory of motion in question is neither Newton's laws, nor the *MFNS* as a whole, but only the Phoronomy of the latter. The constructions of the Phoronomy involve divisions into "time-parts," because they are constructions describing *spatia percursa*, or finite path-elements, as in the "De Motu in Genere" of Euler's *Analytical Mechanics*, specifically §82f. Euler there shows how to transform a uniform motion relative to absolute space into a uniform motion relative to any other uniformly moving frame, by appealing to the "nature of the triangle" that the motions describe. Since, Euler explains, his laws of motion hold in all such frames (§77) he does "not have to worry about absolute ~~space~~ motion." ~~which philosophers can determine relative to the fixed stars, if they like~~.

Kant precisely inverts Euler's proof: assuming Galiean relativity as the Fundamental Law of the Phoronomy, he appeals to the geometrical properties of the same triangle to prove the kinematic parallelogram law. Both thinkers thereby prove that the class of paths generated by means of Galilean transformations of the "scales" form, in Eulerian terminology, an "affine family." Both thereby satisfy the Postulates of Lambert's science of "Phoronomy," which, "puts together space and time and thereby generates the theory of motion," by showing how any uniform motion can serve as the measure of any other.

Both proofs succeed, however, under one condition only: namely, that the uniform passage of time—independent of position and state of motion—is given. The inferential structure of the Phoronomy is in other words incomprehensible unless absolute time is at least implicitly assumed (cf. Robert Palter, "Absolute Space and Absolute Motion in Kant's Critical Philosophy," *Synthese*, 1971, *23*:47–62). Since Kant explicitly asserts, at B67 of the Aesthetic, that time contains relations of simultaneity, duration, and asymmetric linear order [*Nacheinander*] "before any consciousness," and that these determine how intuitions are posited, there can be little doubt that the full mathematical structure of time is already in place at this stage. Friedman, by contrast, rejects as absurd that Kant wishes to prove the parallelogram law in pure intuition, arguing instead that Kant's concern here is with a "late medieval theory of intension and remission" (p. 60), because "there was not yet a single real number system, which was only established in the late nineteenth century" (pp. 53–54) Although Euler and Lambert form, on his account, one of the triangulation-pillars of his interpretation, neither author is discussed in this chapter.

The neo-Kantian thesis that the Aesthetic's doctrines of space and time are somehow "completed" by the Principles is widely held among contemporary Kant scholars, though its

exact consequences are often unclear. In Friedman's work, by contrast, the costs and benefits of this claim are displayed with the greatest precision: because his Kant chooses a Riemannian, additive approach to space-time geometry over a Kleinian, subtractive one, it is not only the Transcendental Aesthetic that must be eliminated, as in classical neo-Kantianism, but the Phoronomy as well. The problem is not that Friedman's reading is "too modern," but just the opposite. By interpreting Kant against the background of the fourteenth and seventeenth centuries, he buries the connection to analytical mechanics. And by eliminating the Phoronomy from Kant's system, he renders that book incongruent with the structure of the *Critique*. In sum, while *Kant's Construction of Nature* remains a rich repository of analyses of individual passages of the *MFNS* and their relation to Newton's work, neither the goal of illuminating the evolution of space-time theory nor that of connecting the *MFNS* structurally to the *Critique* is achieved. Precisely because of the power of Friedman's analyses, this is a book that must be read critically.

DAVID HYDER

References

Euler, Leonhard. *Mechanica sive Motus Scientia Analytice Exposita*, 2 vols. St. Petersburg: Academy of Sciences, 1736.

Euler, Leonhard. *Leonhard Euler's Mechanik: Oder analytische Darstellung der Wissenschaft von der Bewegung mit Anmerkungen und Erläuterungen*. Ed. By J.P. Wolfers. Greifswald: C. A. Koch, 1848.

Norton, John D. "Geometries in Collision: Einstein, Klein and Riemann," In: *The Symbolic Universe: Geometry and Physics 1890-1930*. Oxford: Oxford University Press, 1999, pp. 128-144.

Palter, Robert. "Absolute Space and Absolute Motion in Kant's Critical Philosophy," *Synthese*, 1971, *23*:47–62.