tion," the counterpart to the theoretical induction that takes place on the way to the acquisition of scientific first principles. Here Moss, uncharacteristically, stays closer to the current consensus than her own line of reasoning seems to warrant. She accepts a distinction between a merely implicit, *phantasia*-based grasp of moral first principles, produced by moral habituation, and a conceptualized grasp of those principles effected by practical intellect and necessary for *phronesis* (though she sharply distinguishes this conceptualizing step from the intuitionist grasp by means of *nous* that happens in the parallel theoretical case). But she adduces no text in which Aristotle clearly marks these as distinct temporal stages in moral development, as he does for the theoretical case. And surely full-fledged concepts of moral value, and of that value explicitly as an end, have been in play throughout the process of moral habituation.

Moss's book is lucidly written, carefully argued, and marked by philologically sensitive and philosophically acute readings of the relevant Aristotelian passages. She addresses a refreshingly broad range of English-language scholarship. Her book is essential reading for those interested in Aristotle's ethics and moral psychology.

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Michael Friedman, *Kant's Construction of Nature*.
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Michael Friedman's *Kant's Construction of Nature* is the first Anglophone book-length treatment of Kant's *Metaphysical Foundations of Natural Science*. Friedman has given us an extraordinary book—clearly the fruit of decades of thought and labor from a philosophical mind of the first order. It will be read and studied, I believe, for many years to come.

I owe special thanks to Bennett McNulty, who not only let me see his forthcoming paper, but also discussed the topics of this review extensively with me and pointed me to the passage from *De Igne*. I also want to thank Michael Friedman for generously discussing these issues with me, for clarifying his reading, and for valuable suggestions for improving this review. Last, I want to thank the organizers and participants of the Biennial meeting of the North American Kant Society at Cornell in June 2013, where these ideas were first presented.

The goal of the book is to give what Friedman calls a "reading" of Kant's *Metaphysical Foundations* that situates it in Kant's intellectual context. At around six times the length of the *Metaphysical Foundations* itself, *Kant's Construction* provides a wealth of detailed and sustained discussion of both the large themes and small points in the *Metaphysical Foundations*. Though not offering a traditional line-by-line commentary, Friedman ends up discussing virtually every paragraph of Kant's book.

In this review, I'll focus on two of the largest themes of Friedman's book. First, according to Friedman, "Kant's overall aim in the *Metaphysical Foundations* . . . is to explain how the application of pure mathematics to the empirical concepts of mathematical physics becomes possible" (88). Kant's goal is to explain, concept by concept, how the fundamental concepts of Newtonian physics—for example, *duration*, *mass*, *velocity*, and *force*—come to be measurable magnitudes. And Kant needs to give this foundation for Newton's physics without relying either on the mechanism of Descartes and his followers or on Newton's absolute space and time. Second, Friedman argues that "the general dynamical theory of matter on which Kant builds a foundation for Newton's argument is by no means intended to turn clearly empirical properties of the force of universal gravitation into a priori demonstrative truths" (531). Kant argues in the *Metaphysical Foundations* that we can know a priori that every piece of matter exerts an immediate attractive force acting at a distance on every other piece of matter. Kant also argues that we can know a priori his three mechanical laws: the law of conservation of mass as well as Newton's first and third laws (the principles of inertia and of the equality of action and reaction). But in what sense are these truths a priori? Friedman's interpretation attempts a subtle balancing act: he wants on the one hand to respect the unique place that these physical laws have for Kant, which separates them from ordinary physical laws, while on the other hand to highlight Kant's detailed reconstruction of the experimental results that underlie Newton's physics.

These two themes are on display clearly in Friedman's interpretation of one of the most well-known passages in Kant's book. At Ak 4:470, Kant claims that a proper natural science requires the application of mathematics.[1]

> I assert, however, that in any special doctrine of nature there can be only as much *proper* science as there is *mathematics* therein. For, according to

1. All translated passages from *Metaphysical Foundations* are from Kant 2002 and all translated passages from the *Critique of Pure Reason* are from Kant 1998. Citations from Kant's *Metaphysical Foundations of Natural Science* are according to the German Academy ("Ak") edition pagination (*Gesammelte Schriften*, edited by the Königlich Preußischen Akademie der Wissenschaften, later the Deutschen Akademie der Wissenschaften zu Berlin); this pagination is also given in Kant 2002. For the *Critique of Pure Reason*, I follow the common practice of citing the original page numbers in the first ("A") or second ("B") edition of 1781 and 1787, which are also given in Kant 1998.

> the preceding, proper science, and above all proper natural science, requires a pure part lying at the basis of the empirical part, and resting on a priori cognition of natural things. Now to cognize something a priori means to cognize it from its mere possibility. But the possibility of determinate natural things cannot be cognized from their mere concepts; for from these the possibility of the thought (that it does not contradict itself) can certainly be cognized, but not the possibility of the object, as a natural thing that can be given outside thought (as existing). Hence, in order to cognize the possibility of determinate natural things, and thus to cognize them a priori, it is still required that the intuition corresponding to the concept be given a priori, that is, that the concept be constructed. Now rational cognition through construction of concepts is mathematical. Hence, although pure philosophy of nature in general, that is, that which investigates only what constitutes the concept of a nature in general, may indeed be possible even without mathematics, a pure doctrine of nature concerning determinate natural things (doctrine of body or doctrine of soul) is only possible by means of mathematics. And, since in any doctrine of nature there is only as much proper science as there is a priori knowledge therein, a doctrine of nature will contain only as much proper science as there is mathematics capable of application there.

Kant's argument here depends on his conception of a proper science. A proper science is "that whose certainty is apodictic," whose "grounds or principles . . . carry with them a consciousness of their *necessity*" (Ak 4:468). Such a science would thus "treat its object wholly according to *a priori* principles," since only a priori principles can be apodictically certain.

Given this notion of proper science, the outline of Kant's argument seems to be the following:

1. A proper natural science is apodictically certain.
2. So, its laws must be a priori and necessary.
3. But to cognize something a priori = to cognize it from its mere possibility.
4. For a determinate natural thing, to cognize it from its mere possibility requires that an intuition corresponding to the concept be given a priori.
5. But to construct a concept = to give a priori an intuition corresponding to the concept.
6. And mathematical cognition = knowledge from the construction of concepts.
7. So, a natural science will be a proper science only inasmuch as mathematics is applied in it.

On this reading, which Friedman admits is a "natural" reading (28), the application of mathematics that enables physics to be a proper science is just the "construction" (*Konstruktion*) of the concepts of physics.[2] The propositions of the proper part of physics (such as Newton's first and third laws) are a priori, apodictically certain, and necessary because they can be proved by constructing the concepts of physics (along with further premises from general metaphysics, and analytic judgments)—and construction is the *a priori* presentation of an intuition corresponding to a concept. Moreover, other natural sciences fail to be proper because—as Kant says about chemistry—they contain "no concept to be discovered that can be constructed," and so their principles "are not receptive to the application of mathematics" in the sense that matters to Kant (4:470).

Friedman rejects this natural reading because he denies that the concepts of physics can be constructed in Kant's technical sense. He argues that if the fundamental concepts of physics (such as *matter*) were constructible, then we could know a priori that they are really possible. But, he argues—appealing to the General Remark to the Dynamics (4:525),[3] and the claim from the first *Critique* that "existence cannot be constructed" (A179/B221)—that Kant denies that we could know a priori that the dynamical concept of matter is really possible (sec. 19).

Having rejected this natural reading, Friedman needs an alternative reading of Ak 4:470—a reading that will interpret (i) what it means to apply mathematics in the right way, (ii) in what sense the laws of pure physics are a priori, and (iii) why a natural science has a priori laws just in case it applies mathematics in the right way. Friedman summarizes his alternative interpretation in the following way: "I argued that Kant does not mean that the empirical concept of matter is itself supposed to be mathematically constructed in pure intuition. . . . Hence a special metaphysics of any more determinate species of objects in nature must explain the possibility of applying mathematics to the

2. "Construction of concepts" is a technical term for Kant. It refers to the distinctively mathematical method of gaining a priori knowledge by producing in pure intuition an individual instance of a concept, making inferences about that particular intuited instance, and then generalizing back to all instances of a concept (A713/B741). For instance, a geometer reasons about all triangles by drawing a particular triangle—on paper or in his or her imagination—inferring that it has some property φ, and then generalizing that all triangles have φ.

3. "The concept of matter is reduced to nothing but moving forces, and one could not expect anything else, since no activity or change can be thought in space except mere motion. But who pretends to comprehend [*einsehen*] the possibility of the fundamental forces? . . . [I]f the material itself is transformed into fundamental forces (whose laws we cannot determine a priori, and are even less capable of enumerating reliably a manifold of such forces sufficient for explaining the specific variety of matter), we lack all means for constructing this concept of matter, and presenting what we thought universally as possible in intuition" (Ak 4:524–25).

specific empirical concepts involved in a proper natural science restricted to this domain. It must explain how these particular concepts acquire their precise mathematical structure" (567, cf. 28–33). On this reading, the "application of mathematics" that characterizes the proper science of physics is weaker than construction. Though the fundamental concepts of physics, such as *matter*, cannot be constructed, it is still the case that for these concepts there is a "universally applicable measure" of the magnitude of these concepts—a "general method for estimating" their quantity (569, 331).[4] Instead of deploying the constructions of these fundamental physical concepts in order to prove synthetic a priori truths, the special metaphysics of nature explains step-by-step how it is possible that these concepts come to have universally applicable methods of measurement.

Why would an explanation of the possibility of universally applicable methods of measurement require a priori laws? In a passage a few pages after the last quoted passage, Friedman writes:

> [The three laws of mechanics] allow us to extend the static measure of weight to a universal measure of quantity of matter valid for all bodies in general on the basis of the new (Newtonian) mechanical quantity of mass. We presuppose the universal applicability of the mechanical laws of motion, the equality of inertial and gravitational mass, and the universally penetrating character of gravitational force in this procedure. And it is for precisely this reason that Kant builds all three into the characteristically dynamical concept of matter that he articulates in the *Metaphysical Foundations*.
>
> It is for this reason, too, that the mechanical laws of motion and the above properties of gravitational force (the fundamental force of attraction) count as a priori for Kant. (569)

The claim here is that certain laws of physics have to be true in order for there to be a universal measurement technique for quantity of matter, or mass, and so these laws could not be empirical since any experimental confirmation of them would require measuring mass, and so would just presuppose them after all. A more evocative way of putting the point is to claim, as Friedman does at several places in his book, that the a priori laws of pure physics are in fact "implicit definitions": "The upshot, from a modern point of view, is that Kant takes the mechanical laws of motion (implicitly) to define a privileged frame of reference

4. At various places, Kant's task is described as explaining the possibility of how some concept "becomes a mathematical magnitude," is "mathematized," is "structured as a mathematical magnitude," "acquires a mathematical (measurable) structure," and is "determined as a magnitude." I take it that all of these are various ways of saying that the fundamental concepts of physics, such as *mass*, have *general* methods for *measuring* all of their instances.

in which they are satisfied: they do not state mere empirical facts, as it were, about a notion of (true or absolute) motion that is already well defined independently of these laws. The mechanical laws of motion are thereby revealed to be (synthetic) a priori principles governing the (true or actual) motion of matter" (21).[5]

To return to the interpretive questions from two paragraphs back, Friedman seems to be arguing in the following way: (i) to apply mathematics in the right way is to have a universal measurement procedure for a concept; (ii) the laws of pure physics are a priori because they are presuppositions of (or "implicitly define") a universal measurement procedure of a fundamental physical concept; and (iii) a natural science has a priori laws just in case it applies mathematics in the right way because application has presuppositions, and those presuppositions will necessarily be a priori. This reading would partially assimilate the project of the *Metaphysical Foundations* to the early logical empiricist program—first expressed explicitly in Reichenbach's (1965 [1920]) *The Theory of Relativity and A Priori Knowledge*—of identifying the constitutive principles that make possible the coordination of pure mathematics to physical objects. Reichenbach there argued that there is within Kant's writings a notion of the a priori as "constitutive of the object of experience,"[6] and a corresponding project of isolating these constitutive principles through a logical analysis of our current best physical theories. This conception of the philosophy of science and its constitutive principles was highly influential, both with later logical empiricists (who came to prefer the term "implicit definition") and with Friedman himself in Friedman 2001.

I'll be arguing momentarily that despite initial appearances, this Reichenbachian interpretation cannot be Friedman's final, considered reading of Kant's text. But first let me illustrate this conception of the metaphysics of corporeal nature by looking at Friedman's extraordinarily rich, subtle, and illuminating description of how the concept *quantity of matter* acquires a mathematical structure. The two dynamical concepts of quantity of matter (the quantity of repulsive force exerted and the quantity of attractive force exerted) are combined with the mechanical concept (inertial mass, which is manifested in the quantity of motion communicated by impact) step-by-step into a univocal concept of mass that can be measured using methods applicable to all matter, no matter what their specific variety is, whether they are moving or at rest, or whether they are celestial or terrestrial. The table gives a partial representation of these conceptual connections. For instance, using observations of celestial motions as a test for the gravitational mass of these heavenly bodies presupposes

5. See also 65, 360. Friedman here applies the point to the propositions of the Mechanics, though it is clear, I think, that he would make the same point about the propositions of the Dynamics and the Phenomenology.

6. See Reichenbach 1965, chap. 5.

the truth of Newton's law of universal gravitation and his third law. Only on the basis of Newton's moon test and Kepler's observations of planetary orbits can we conclude that these observations of celestial motions are measuring the same thing—gravitational mass—as our observations of terrestrial bodies using a balance. That inertial mass is equivalent to this notion of gravitational mass is secured only through Galileo's law of free fall. And so on.

Kant's explanation of the possibility of the universally measurable concept *mass* then proceeds in stages, explaining how each individual concept can be measured and how each concept is connected to the others. The explanation at any given stage makes use of the results of prior stages, along with the results of general metaphysics (provided in the first *Critique*), and—importantly—the *empirical* facts (underlined in my table) that a Newtonian scientist could fully justify using only the conceptual resources available at that stage. This step-by-step mathematization is the "construction" (in German, we'd say "aufbauen") in Friedman's title.

Friedman's account of the "mathematization" of the concept *quantity of matter* is simply incompatible with the Reichenbachian reading of the a priori that was sketched a few paragraphs back. Friedman identifies specific physical facts and natural laws—such as Galileo's law of free fall and Newton's moon test—that he claims Kant took both to be empirical and to play a role in "implicitly defining" the concept *quantity of matter*.[7] For this reason, Kant as Friedman interprets him is not like later philosophers such as Poincaré (2001, sec. 5), who is perfectly willing to say that the inverse square law of UG (Universal Gravitation) is not in fact empirical but instead an implicit definition. This is an illustration of the second large theme of Friedman's reading of the *Metaphysical Foundations* that I identified above: that Kant "by no means intended to turn clearly empirical properties of the force of universal gravitation into a priori demonstrative truths" (531). On the one hand, Friedman wants to respect Kant's insistence that a law such as the law of the conservation of mass is a synthetic a priori law, while, on the other, also acknowledging that for Kant this law is only meaningful if there is a universal measurement procedure for mass, which itself depends on a series of empirical facts and laws.

How does Friedman's reading successfully maintain both these ideas? How does he distinguish a priori from empirical physical laws while also recognizing that in some sense these a priori laws have an empirical basis? Friedman's

7. There is a second fatal flaw to this Reichenbachian reading. Kant denies that any other natural science besides physics is a proper science with a priori laws. And yet Kant would surely recognize that even in other sciences there are concepts whose measurement techniques presuppose the truth of empirical laws. For example, Kant himself argued in a very early work that the operation of a thermometer to measure heat depends on Amonton's law (*De Igne*, Ak 1:378), despite the fact that the science of heat is not included in the proper part of physics (Ak 4:529–30).

Table 1. The universal measurement procedure for the concept *quantity of matter.* (Empirical judgments are underlined.)

Measurement Technique	COMPRESSION TEST		IMPACT TEST		BALANCE TEST		OBSERVATIONS OF CELESTIAL MOTIONS
Concept Measured	*quantity of repulsive force*	← →	*inertial mass*	← →	*statical terrestrial weight*	← →	*celestial gravitational mass*
Precondition		The fact that impact depends on repulsive force	Law of conservation of momentum Law of inertia	Galileo's law of free fall		Newton's moon test Keplerian phenomena	Inverse square law of UG Law of action and reaction

most common approach is to characterize the specifically a priori laws of physics as "specific realizations" (65, 430, 570) of the a priori principles of general metaphysics: "[Kant] intended to elucidate the way in which the Newtonian mathematization of the concepts of mass, force, and interaction can be considered as a specific realization or instantiation of the categories of substance, causality, and community in Kant's constructive analysis. And it is for precisely this reason, for Kant, that his general dynamical theory then counts as metaphysical as opposed to (merely) physical" (531). This "top down" characterization of the a priori is not only clearly different from the "bottom up" Reichenbachian characterization of the a priori. It is also, I believe, Friedman's dominant model, while the Reichenbachian model plays the role of a heuristic or suggestive comparison intended only to get readers to understand Kant's project of identifying the preconditions of the universal measurement techniques for Newton's fundamental concepts.

It is comparatively straightforward to see what it means for the fundamental *concepts* of physics to be specific instantiations of the categories. The *Critique of Pure Reason* gives us in the First Analogy the law of general metaphysics that substance is conserved in all changes. The *Metaphysical Foundations* gives us the law of special metaphysics that the quantity of matter is conserved in all changes. So, in our world, only the concept *matter* "instantiates" the a priori concept *substance*, even though the concept *matter* is empirical. Unfortunately, though, this way of describing the specific instantiation of a priori concepts does not answer the harder question: in what sense are the a priori *laws* of physics "specific instantiations" (or as Friedman sometimes puts it, "empirical realizations" [333]) of laws of general metaphysics when other (empirical) laws of special metaphysics are not? It is certainly not enough that a physical law contain a concept such as *matter* that instantiates a general metaphysical concept: the inverse square law of UG does that, despite being empirical. There are furthermore synthetic a priori propositions of special metaphysics (such as the claim that every piece of matter exerts an immediate, attractive force acting at a distance on every other piece of matter) that are not in any direct or obvious sense "instantiations" of the laws of general metaphysics that Kant identifies in the first *Critique*.

I'll put the challenge in a more pointed way. The *Metaphysical Foundations* is written in the geometrical method: each substantive paragraph is marked as an explication, proposition, or principle, and each proposition is given an explicit proof that appeals to previous paragraphs and other facts that Kant takes to be legitimate premises. In the natural reading of Ak 4:470 sketched earlier, the laws for pure physics are a priori precisely because the latter class of legitimately available premises includes only laws of general metaphysics and propositions of pure mathematics. As "specific realizations" of the laws of general metaphysics, Friedman clearly intends the a priori laws of physics to depend for their proof at least on facts of general metaphysics and mathematics. But can

the proofs of these specific realizations *also* appeal to empirical premises? There are some places where Friedman suggests this. For instance, in the sentences that follow Ak 4:569 (quoted above), Friedman writes:

> It is for this reason, too, that the mechanical laws of motion and the above properties of gravitational force (the fundamental force of attraction) count as a priori for Kant. This emphatically does not mean, however, that he attempts to demonstrate by pure reason, independently of experience, what Newton has discovered by observation and experiment. . . . Kant explicitly recognizes, in particular, that this analysis is, in an important sense, contingent, in so far as there is an alternative mechanical concept in accordance with the system of absolute (as opposed to relative) impenetrability. And his choice of this preferred (dynamical) concept over the alternative (mechanical) concept rests, in the end, on nothing more nor less than the empirical success of Newton's theory in comparison with the opposing mechanical philosophy. (569)

Passages like this might entail that the propositions of the metaphysics of nature—such as Kant's three mechanical laws—are themselves contingent and are provable only on the basis of premises drawn from observation and experiment, *despite being a priori*. For my tastes, this is too radical a reconceptualization of the a priori: after all, Kant asserts clearly that necessity and independence from experience are two essential features of a priori truths (B2–3).

Fortunately, there is a different interpretation of the Kantian a priori that Friedman could be getting at in passages like this one—an interpretation that though not clearly and fully worked out in Friedman's book, holds out the promise of achieving the interpretive balance he wants without leading to an implausible reconceptualization of the a priori. Friedman claims that contingent, empirical facts ground Kant's choice of one *concept* of matter over another. On Kant's "dynamical" concept of matter, matter essentially has two forces, a repulsive force that acts on contact and an attractive force that acts at a distance. On the opposed "mechanical" concept, matter's essential properties are geometrical, it fills space through its mere existence, and it never acts at a distance. Plausibly, Kant's preference for the dynamical concept of matter is contained in the "explications" (*Erklärungen*) of the *Metaphysical Foundations*. For instance, in Explication 2 of the Mechanics chapter, Kant writes that "the quantity of matter is the aggregate of the movable in a determinate space" (Ak 4:537). On Friedman's view, that this concept is well defined depends, as we've seen, on a series of empirical results. For this reason, Friedman claims that Kepler's laws of planetary orbits are "essentially implicated in Kant's empirical concept" of matter (554); similarly, the empirical fact that gravitational and inertial mass are equivalent is "built into" the dynamical concept of matter (569).

Let me speculate a bit about how such an interpretation would go. On this interpretation, it is Kant's explications that are contingent and grounded in a series of empirical facts. This claim might be initially surprising, since explications, as the correlates within metaphysics and empirical science to mathematics' definitions (*Definitionen*), are analytic truths and would seem to be entirely necessary and a priori. However, Kant argues that explications of empirical concepts such as *matter* differ from mathematical definitions in two important ways. First, while a mathematical definition is a real definition and so itself exhibits the objective reality of the definiendum (A241–42), an explication of an empirical concept is merely nominal and so leaves it to experience to secure the objective reality of the explicatum. Second, while a definition of a mathematical concept (as a "made" concept) is certain and need not be revised during the course of mathematics, an explication of an empirical concept (as a "given" concept) is always provisional and will need to be revised as empirical science advances (A727–28/B755–56). Significantly, Kant argues that this revision process is fueled by "new observations" (A728/B755) and will never be complete until the empirical science is itself complete (A730/B758). These features of empirical explications fit quite well with what Friedman says about the fundamental concepts of physics. *Quantity of matter* is instantiated in our world and thus has objective reality only if the various tests for specific kinds of matter in various circumstances turn out to be equivalent, and this equivalence depends on all sorts of contingent empirical facts knowable only through observation. Similarly, for Friedman's Kant, we come to prefer one kind of explication of matter—the dynamical one—over another candidate explication only after a long process of physical discovery, where Newton's approach to physics is vindicated by its empirical success.

This way of filling out Friedman's specific realization model of the a priori provides a new way of interpreting Ak 4:470 that is distinct both from the natural reading that Friedman rejects and the Reichenbachian reading that is suggested by some of Friedman's claims. Any successful interpretation of Ak 4:470, I claimed, must answer three questions: (i) what it means to apply mathematics in the right way, (ii) in what sense the laws of pure physics are a priori, and (iii) why a natural science has a priori laws just in case it applies mathematics in the right way. On this new interpretation, as in the Reichenbachian reading, to apply mathematics in the right way is to have a universal measurement procedure for a concept. But now a law of pure physics is a priori because it is a specific realization of general metaphysical laws, where this means that the physical law is provable from mathematical facts, laws of general metaphysics, *and explications that are themselves contingent and grounded in empirical fact.* This reading successfully executes the balancing act Friedman intends. Pure physical laws such as Kant's three mechanical laws are privileged because they follow from explications, general metaphysical laws, and mathematical facts, while empirical laws such as the inverse square law of universal gravitation require

as premises additional empirical facts. And Kant still respects the detailed empirical basis for these pure laws by acknowledging the contingency and empirical basis of empirical explications.

There is obviously more philosophical work required to make coherent and determinate sense of this conception of empirical explication, and there is more detailed interpretive work needed to argue that the contingency and empiricality of Kant's metaphysical foundations for physics can be located specifically within the explications. But I do think this approach is philosophically appealing, has a plausible basis in Kant's texts, and is hinted at in many passages in *Kant's Construction of Nature*. Nevertheless, I fear that Friedman is still left with no compelling answer to question (iii) and so no satisfying reading of the argument from Ak 4:470 that a natural science has a priori laws just in case it applies mathematics in the right way. Friedman understands Ak 4:470 as arguing that there needs to be an explanation for how the empirical concepts of physics come to have universal measurement procedures, and that *this explanation will necessarily require special a priori principles*. However, if we prefer the specific realization model of the a priori (as opposed to the Reichenbachian implicit definition model), then there is no apparent reason why this explanation would require a priori principles as opposed to just empirical facts.[8] (In fact, I suspect that here Friedman's use of the language of "implicit definition" is being taken more seriously than it ought to be.)

Perhaps Friedman instead interprets "application of mathematics" in a stronger way, so that to apply mathematics in the right way is to have a universal measurement procedure whose preconditions are specific realizations of general metaphysics. This stronger interpretation would certainly provide the missing reason, since a science that has an empirical concept the measurement of which *requires a metaphysical explanation* will necessarily have a priori principles and so will be a proper science. But now a new gap opens up in the opposite direction. Why would a natural science with special a priori principles necessarily have an empirical concept the measurement of which requires a metaphysical explanation? Why couldn't a proper science just have concepts whose measurement presupposes only empirical facts, or not even have any distinctive measurable concepts at all? For these reasons, my own inclination is to read Ak 4:470 in the natural way, interpreting the "application of mathematics" in the

8. To be clear: Friedman's specific realization model of the a priori nicely substantiates Kant's conviction that the measurement procedures in the science of heat, for example, specifically presuppose only empirical laws, while the preconditions in physics include a priori laws. Amonton's law, for instance, is not a specific realization of the principles of general metaphysics. Still, though, there is no way to substantiate Kant's argument that physics applies mathematics in the right way only if it is a proper science. If "apply mathematics in the right way" means "have a universal measurement procedure," then physics and the science of heat ought to be on a par.

proper science of physics as "mathematical construction," instead of as the "existence of a universal measurement procedure whose preconditions are specific realizations of general metaphysics."[9] But the issue has hardly been settled, and the philosophical community owes Friedman its thanks for giving us a book of such depth and philosophical richness.

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9. Of course, formulating a plausible and worked-out version of the natural reading would not be without its own challenges. For a discussion of some of these challenges, see McNulty (forthcoming).