A Priori Revisability in Science

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FOREWORD

The most influential rationalist model of scientific knowledge is the three-layered model formulated recently by Michael Friedman. At its surface are the empirical laws of nature, such as Newtonian law of gravitation or Einstein's equations for gravitational field. At its deeper second level are the fundamental principles of science that determine the general spatiotemporal framework which enables the formulation and the testing of the empirical laws. At the third level are the philosophical meta-paradigms which guide the transition between scientific paradigms. The central epistemic claim of the model concerns the character of the fundamental principles; according to Friedman they are a priori, that is, they are independent from experience. Yet he is explicit that the principles change under empirical pressure. Friedman's position, however, faces the modern empiricist challenge instead of evading it: he has to explain *how* the principles could still be a priori if they change under empirical pressure. I take his defence, appealing to the old Reichenbachian notion of the constitutive a priori, as inconclusive. My general aim is to put forward a rationalist account of the scientific knowledge and I will attempt a defence of the main epistemic claims in Friedman's model, which I find vulnerable against the prevailing empiricism. The present text provides a contemporary account of the epistemic character of the principles addressing the recent work on the a priori. I argue that at least some principles within natural science are not empirically but a priori revisable, and in this way I respond to the empiricist challenge. In order to build the defence I formulate a general notion of epistemic revisability and I extract from it two corresponding kinds of specific revisabilities: a traditional empirical one and the suggested a priori revisability within natural science. I argue that the latter kind is as vital as the former and that it is also capable of meeting the argument from empirical revisability by providing an epistemic alternative of it. In this way, if some second level principles are shown to evolve through a priori revisions the leading empiricist argument fails. To demonstrate this I analyze two case studies, one from history of geometry and one from history of physics, and I show that the revisions were epistemically a priori and not empirical. The result is a two-fold one. First, a genuine alternative of empirical revisability is developed, and not just for a priori domains like mathematics but for the natural sciences. Second, a new mechanism for the dynamics of science is suggested, namely that scientific knowledge sometimes evolves through empirically independent moves. At the end, these enable a modern epistemic defence of the priori character of the second level principles in Friedman's model and thus help to keep its vitality.

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INTRODUCTION

The change of scientific theories has been in the focus of the philosophy of science ever since the latter's emergence as a philosophical discipline. The founding fathers of the discipline, the logical positivists and most notably Rudolf Carnap[1] and Hans Reichenbach,[2] demonstrated the importance of the problem in a series of influential books and papers. They developed an approach that aimed to accommodate the obvious role experience had in the development of scientific knowledge. Yet, they tried to frame this role in a framework that had rationalistic fundamentals. The clearest illustration provides Reichenbach's early work "Theory of Relativity and A priori Knowledge", where he put forward the notion of constitutive a priori principles which underlie the foundations of scientific knowledge. Later on, among others, Karl Popper[3] and Imre Lakatos[4] took on the problem of scientific change and proposed models for the theoretical dynamics that addressed its epistemic aspect. But perhaps the most influential model in our recent history is the famous model suggested in the early 1960s by the historian of science Thomas Kuhn.[5] He argued that scientific knowledge evolves by following a chain of stable periods (called "scientific paradigms") with clear rules and standards, and revolutionary periods that substitute the previous paradigms with new ones. The central point in this model was the mechanism of the very transition. Kuhn claimed that there is an inherent incommensurability between the different paradigms, and thus he raised the question about the rationality that governs the progress of science with a new force. The model of scientific revolutions explicates the *dynamics* of scientific theories but lacks the *epistemic perspective* of the logical positivistic models. Thus, a tension formed in scientific epistemology.

This tension has been addressed only very recently, on the verge of the new millennium, by Michael Friedman. He proposed a model of scientific knowledge which emerges out of the synthesis between the foundational epistemic principles of logical positivism (and especially the early Reichenbach) and the dynamics of the Kuhnian structure of scientific revolutions. The model is distinct for the epistemic nature of its fundamental principles which, according to Friedman, are independent from experience and are thus a priori. Also, it is notably the most influential contemporary rationalistic model of scientific knowledge. The model, however, meets strong resistance from the predominant scientific epistemology today, the modern empiricism. The main target for criticism in the model is not its dynamics but its epistemic commitment. Scientific empiricists argue against the a priori character of the fundamental principles of science, and thus endanger its alleged epistemic nature. In addition, the criticism bears on the dynamics of the model for if the fundamental principles are not a priori then the whole dynamics of science transforms into empirical dynamics. Therefore, it is important for Friedman to block the epistemic criticism and in particular, this should be done within the context of the modern debates on the a priori. In the exposition and the argumentation of the model, however, this is not what happens. Friedman certainly addresses the issue of empirical fallibility of the alleged a priori principles and yet his approach is not epistemic but semantic. He argues that the principles are a priori and at the same time revisable but his reasoning is that they are not empirically revisable only because they are constitutive for the possibility of their own empirical revisions. This is at the core the Reichenbachian notion of the constitutive a priori, which is nonetheless distant from the centre of the modern debates in epistemology. The property of *being constitutive for* is not difficult to recognize as a semantic and not as an epistemic property, and that is why an epistemic defence of the a priori nature of the principles in the model is *de facto* lacking. It is, nevertheless, more or less universally agreed today, that the fundamental semantic, modal and epistemic distinctions are independent. Therefore, a modern attempt to defend an epistemic notion should be based on epistemic arguments even if semantic considerations are instructive. Such a modern epistemic attempt is, however, not available and this creates a problem for the central epistemic claim in the model.

My main goal in this text is to provide at least a partial solution for this problem. In particular, I will present an epistemic defence for a specific dynamics of the a priori principles in Friedman's model. In order for the defence to be adequate to the modern epistemology I will address and sometimes follow several recent works on the nature of the a priori notion, such as the works of Albert Casullo[6] and Joshua Thurow.[7] If successful, the defence would help both the epistemic nature of the model and its dynamics. In this sense, the project is of significance for current philosophy of science for it would re-establish the best available model of scientific rationalism as an epistemically vital one. In addition, the defence would help to fill in what I take to be an epistemic gap in the model. Namely, Friedman does not answer the problem of fallibility, and consequently, he does not address the change of the fundamental principles epistemically but only semantically. He defends against standard criticism from the empirical fallibility of those principles by an appeal to the old Reichenbachian notion of constitutive a priori which, I argue, is at its core of semantic and not of epistemic nature. Thus, there exists a vacuum for a modern epistemic account of the problem of the dynamics of fundamental principles that argues about their epistemic character purely epistemically and not semantically or modally. For that purpose I will beforehand suggest and develop the epistemic conception of a priori revisability and I will apply it to some fundamental principles in the model. The notion would be developed both positively and negatively. I will positively define its characteristics and I will provide arguments for its epistemic legitimacy. I will negatively define the domain of its validity through narrowing the domain of validity of traditional rival empirical revisability and through criticizing the main empiricist arguments. At the end, I will argue about an actual historical role and significance of the notion in both mathematics and natural science.

The problem of epistemic revisability within natural science did not receive particular attention in current epistemology and has not been explained since Kuhn in sufficient detail and in its full scope. It is predominantly accepted that as far as the epistemic aspect of both general and scientific dynamics is concerned it is naturally of empirical nature. Given the fact of the existence of two epistemic kinds, a posteriori and a priori, this results thereafter in an imbalance in symmetry. Therefore, I go on and explore the notion of symmetric epistemic dynamics. Its suggested role in cases like the epistemic problems of Friedman's model of scientific knowledge, demonstrates that this area in epistemology has been unjustly neglected and deserves much greater consideration. Both notions that I suggest in the text, the general notion of *epistemic revisability* and the specific notion of *a priori revisability*, are meant as provoking a more intensive discussion. If the main line of argumentation in the text is correct, then the predominant view that the empirical revisability is the sole kind of epistemic revisability and that the dynamics of scientific knowledge is only empirical dynamics should be reconsidered.

The standard empiricist argument against the a priori steps on fallibility: a proposition could not be a priori if it is empirically revisable or worse, empirically revised. I attempt to show that the argument fails and in this I follow two main lines of argumentation. The first one is epistemic and argues that the argument rests on a tacit assumption about the relationships between the epistemic kinds of justification and revision which turns out to be mistaken. Thus the argument could not claim that the epistemic kind of a revision could actually bear on the epistemic kind of the justification. Further, since the empiricist could still insist that, even if the epistemic kind of a revision does not bear on the epistemic kind of the proposition, it nevertheless contributes to the *overall* dependence of the proposition on experience; and this hits directly into the nature of the a priori as being independent from experience. Here I argue that in fact alternative epistemic revisions which are non-empirical are, first, conceivable and second, historically actual. I develop the conception of a priori revisability, which opens the door for a priori justified propositions to be independent from experience, in response to the second step of the empiricist argument. I argue that some a priori justified propositions are a priori revisable and that thus they are independent from experience in a two-fold way; I take this to be sufficient to establish their overall epistemic status as a priori propositions. The second line of argumentation is the historical one. My illustrations are both from the domains of mathematics and natural science. I propose two case studies of what I take to be influential revisions in history of mathematics and science, and I argue that they are revisions of both a priori held and a priori revised propositions. In this way I add flesh to the conceived of epistemic conception of a priori revisability. The whole project is oriented towards the concrete goal to seal Friedman's influential neo-Kantian model of scientific knowledge against the standard empiricist criticism and for that purpose I assume the general framework of Friedman's model.

The line of argumentation in the text has the following structure. The suggested conception of a priori revisability starts with the uncontroversially recognized notion of empirical revisability and moves towards the more abstract notion of epistemic revisability. From here, given the availability of the two epistemic kinds, the empirical and the a priori kind, it follows the natural step of conceiving of the epistemically complementary sort of revision: the a priori revision within natural science. After establishing it as a legitimate epistemic alternative of empirical revisability within natural science, I argue that it is also actually functioning by providing illustrations specifically taken from the second level of Friedman's model of scientific knowledge, namely the level of fundamental a priori principles. Further, I suggest an epistemic analysis of two influential cases of revision in geometry (from the domain of mathematics) and physics (from the domain of natural science), both complying with the requirement for the second level principles which Friedman takes "to define the fundamental spatiotemporal framework within which alone the formulation and empirical testing of base principles is possible". I argue that the revision of the famous 5^{th} postulate of the Euclidean geometry and the revision of the principle of absolute simultaneity in physics are a priori revisions of a priori principles. For the first, more obvious case, I follow modern discussions in philosophy of mathematics (and especially ones that step on semantics) as well as the actual historical process of the revision. For the second case I look at thought experiments and I employ a recent interpretation of their role in natural science, put forward by James Robert Brown, which argues that some thought experiments lead to a priori knowledge about the world. In the spirit of Kuhn, who famously claimed that thought experiments often happen at the verge of the shift between scientific paradigms, I argue that sometimes, rare as it might be, science progresses by a priori moves. And in particular, these moves often concern the formulation and the revision of precisely what Michael Friedman calls "a priori constitutive principles". In order to defend this conception and my own analysis I respond to the influential empiricist account on the epistemic role of thought experiments in science, the logical reconstructability account by John Norton. In this way the a priori revisability account presented here coordinates the neo-Kantian account of scientific knowledge, proposed by Friedman, the platonic account of thought experiments of Brown and the Kuhnian dynamics of scientific paradigms. It by no means eliminates all incompatibilities between those, which in some cases, like the case of the underlying metaphysics, seem to me too difficult to overcome. Yet, it points to an important mechanism, the mechanism of a priori revisability within natural science, that is capable of regulating the common epistemic compatibility among them. And at the end of the day it is this compatibility that is of significant importance for the rationalist project.

Notes

[1] Carnap, R. [1928] *The logical Structure of the world*. Berkeley and Los Angeles: University of California Press, 1967, and Carnap, R. [1934] *The Logical Syntax of Language,* London: Kegan Paul, 1937. Also Carnap, R. [1936] "Testability and Meaning" and Carnap, R. [1947] *Meaning and Necessity*: A Study in Semantics and Logic, Chicago: University of Chicago Press.

[2] Reichenbach, Hans [1965] *Theory of Relativity and A priori Knowlegde*, Los Angeles, University of California Press.

[3] Popper, K. [1959] *The Logic of Scientific Discovery*. Hutchinson, London, 1959. and Popper, K. [1963] *Conjectures and Refutations: The Growth of Scientific Knowledge*. Routledge, London.

[4] Lakatos [1978] *The Methodology of Scientific Research Programmes: Philosophical Papers Volume 1*. Cambridge: Cambridge University Press.

[5] Kuhn, T. [1962] *The Structure of Scientific Revolutions*, 1st. ed., Chicago: Univ. of Chicago Press.

[6] Casullo, Albert [1988] "Revisability, Reliabilism and A priori knowledge" in *Philosophy and Phenomenological Research*, 49, pp. 187 – 213, and Casullo, Albert [2003] *A priori Justification*, Oxford University Press, NY.
[7] Thurow, J. [2006] "Experientially Defeasible A priori justification' in *The Philosophical Quarterly*, Vol. 56, No. 225, pp. 596 – 602.

CHAPTER I

FRIEDMAN'S MODEL OF SCIENTIFIC KNOWLEDGE

The chapter introduces the philosophical context within which arises the model of scientific knowledge put forward recently by Michael Friedman. The model attempts to respond to the problems of empiricism by suggesting a mechanism for the formation and development of scientific knowledge. I argue that the model is vulnerable to contemporary criticism from empirical revisability. Also, I argue that Friedman's own defense against this criticism fails because it borrows an outdated formulation of the notion of a priori (the Reichenbachian constitutive a priori) instead of developing a modern one. I suggest that, in order to keep the a priori epistemic character of the principles in the model, Friedman needs a stronger notion of the a priori, which is capable of meeting the empiricist criticism. This notion should be developed within the context of the current debates on the nature of the a priori, and should be able to accommodate the revisability kind of independence from experience. Section one introduces the philosophical background against which Friedman's model is built. Section two presents the three-layered structure of the model and discusses the problem of epistemic dynamics. Section three examines the model with respect to the problem of empirical revisability. Section four presents and critically explores the Reichenbachian notion of constitutive a priori which Friedman accommodates in the model. Section five suggests the new, epistemically stronger account of a priori revisability as a solution to the epistemic problem of the model.

The Epistemic Dynamics of Scientific Theories

The philosophical debate over the nature of a priori has been traditionally an epistemic debate. Epistemic problems in philosophy of science, however, need more intimate links with the results of pure epistemology for, as a rule, they often just touch upon the surface of the latter. Notable exceptions nevertheless exist, such as Reichenbach's *The Theory of Relativity and A priori Knowledge,* where he unites the depth of scientific analysis with the precision of pure epistemology. Other philosophers of science do equally well; Rudolph Carnap and Willard Quine provide further illustrations. Yet, it was not only until recently that such expert epistemologists again set the tone in the widely autonomous field of philosophy of science; Michael Friedman's model being a central theme. He follows closely in the steps of Reichenbach and Carnap and develops a modern setting for a reinterpretation of some of their main ideas; the concept of relativized a priori is the prominent one among them. Friedman is perhaps the most influential rationalist in present-day philosophy of science, a field currently resting primarily on empiricist grounds. Epistemic issues are thus of even greater importance for him, for he has to build an a priori island within a sea of empirical dependencies. Deficiencies in his position would be therefore much less tolerated than in pure epistemology, where the stakes are a bit more technical and not so engaging as in science. The present text is directed towards removing what I take to be an epistemic deficiency in the heart of Friedman's scientific model and addresses its epistemic framework. Let me provide some background.

A major theme in twentieth century philosophy of science has been the change of scientific theories. A significant amount of literature has been devoted to clarifying this problem, starting with the logical empiricists and continuing at present day with modern empiricist accounts. Among the most influential accounts is the famous model of scientific theories change proposed by Thomas Kuhn in 1962.[1] In his model, science develops through a sequence of stable periods and revisionary revolutions, and theories from one stage of development are incommensurable with theories from another stage. Kuhn's model created quite a stir when it first appeared and continues to be in the center of the contemporary discussion. Besides the rich controversy around the incommensurability thesis, it is the very nature of the scientific dynamics that is at the core of the model. A large portion of its influence is due to the proposed explanation of its nature; the dynamics of science has been in the main focus of interest even more after *The Structure of Scientific Revolutions* came out. The underlying epistemic ground for virtually all major available positions that address the problem has been one or another form of contemporary empiricism. The empiricist explanation of the problem of scientific dynamics ties it with scientific experience: it is only through experience that we could know if our hypotheses and theories are correct or on the right track, and it is only through experience that we could know if their modifications or substitutes are correct too. Together with the source epistemic claim that most if not all of our knowledge comes from experience, this furnishes an epistemically complete model of scientific change. Perhaps it would not be much of an exaggeration to say that this model is practically dominant in the contemporary scientific epistemology.

Within it scientific dynamics is empirical dynamics and any deviation from this view is as a rule regarded with a healthy dose of skepticism. The empirical dynamics is nevertheless far from uncontroversial. The increasing detachment of theoretical entities of contemporary physics from our immediate experience provides a useful illustration. The essential role of disciplines traditionally considered as non-empirical (such as mathematics and logic) for the scientific enterprise provides another illustration. The nature of the discovered micro-physical world has revealed, perhaps unexpectedly, another problem: there are components of physical reality, well formed within our best theories, that we could not possibly have (sufficiently rich) information about through measurement and experience. And this seems not to be due to imperfections of our experiential apparatus but due to the very nature of the way the things are, as revealed by the theories. A paradox emerges: on the one hand empiricism is the best weapon of contemporary science, and on the other it seems that the same science imposes limits to its application which do not look easily surmountable. If science is to avoid a fall into skepticism it has to address this problem.

One way of addressing it is to attribute suspicion to the theories and argue that because of their deficiencies we might be regarding as empirically unsolvable problems that are actually empirically solvable, and we just have to wait until technology progresses sufficiently so that we become able to probe the problematic domains. Promising as it sounds, this approach has a difficult task; for even if our theories are imperfect, as they certainly are, they are probably not so imperfect as to err on all things we could not have experience for. For example, it does not seem very likely for any empiricist theory of knowledge based on standard relativistic causality to be able to predict with sufficient certainty anything within causally decoherent domains. If I am an empiricist in a light-cone A and I want to know something happening within a light-cone B but A and B do not have common points, then any direct causal signal that could possibly carry some information from A to B or B to A would violate the physical principle of the speed of light.[2] For prediction would need a possible causal connection with the domain of the prediction and, Special Relativity embraced, no such connection could be claimed to exist without violating the limiting principle of light, one formulation of which is that no signal whatsoever could travel faster than the speed of light.

Further, within quantum mechanics there are limits to what we can know via measurement or observation, not because of imperfect technology, but because of the way the world is. Thus, we could not know simultaneously both the precise values of the position and the momentum of an elementary particle: the more we know about its position the less we know about its momentum and vice versa. The regulating principle behind this intuition-defying phenomenon is the quantum mechanical uncertainty principle and again, it seems that this limitation on our knowledge is imposed by reality itself and not by imperfections in our equipment or our theories. To give a last illustration, mathematics and logic are essential parts of contemporary science, and yet it is far from clear what is the nature of the relation between pure mathematics and logic, on the one hand, and physical world, on the other. Refusing to acknowledge the existence of a problem here is of no help. The domains of pure and applied mathematics are quite distinct, and the coordination between mathematical sub-disciplines and physical events have been notoriously difficult to spell out convincingly. Semantic considerations worsen the problem: if purely mathematical propositions and physical propositions are about to have the same truth conditions, and because the prevailing semantics in current science is one or another formulation of Tarskian semantics,[3] we would end up having a platonic account about mathematics, and usually this is not an easy pill to swallow for a natural scientist. If, on the other hand, they are not to have the same semantics, then it is not at all obvious why this should be the case; how much confidence we would be left with in our theories of knowledge, if semantics is non-homogenous even within the domain of science (as far as purely mathematical propositions and logical propositions are in a way a subset of the set of scientific propositions).

Another way of addressing the problem it is to deny that empiricism is giving us the whole story. If not all of our knowledge comes from experience then the skeptical problem loses most of its strength since, at least in principle, we could have gained some knowledge in a non-empirical way; and there are good prospects to expect that the limits imposed on observation and measurement would not limit the alleged non-empirical ways of receiving information, whatever they may turn out to be. In the case of scientific knowledge, we have to distinguish between two different senses of denying the empiricist thesis. The first sense is to deny the source claim that all knowledge comes from experience. The second sense is to deny that *experience is the driving engine behind scientific dynamics*. None of the senses would be sufficient by itself to overturn the empiricist model of scientific change. Even if some of our knowledge turns out not to come from experience, the experience might still serve its regulatory function of driving scientific changes through confirming or disconfirming scientific hypotheses and theories. And even if there is an alternative non-empirical engine behind the dynamics, the very hypotheses and theories might still well come from experience. This demonstrates the complexity of the task before the non-empiricist: on the one hand, she has to draw philosophically and scientifically respectful conceptions of non-empirical justification and revision, and on the other hand, she has to show that these conceptions have actual counterparts in historically interesting cases in science. Even a superficial acquaintance with contemporary scientific epistemology would show how unlikely to be resolved this task is. And yet there are good reasons to acknowledge the problems before scientific empiricism and even better ones to attempt to come up with an epistemically improved solution. An important qualification is in place here. None of the rival epistemic models would ever purport to substitute in full the empiricist model. The goal is not to present a model which is so radically different from the empiricist one that claims that all our knowledge does not come from experience or that all scientific changes are driven non-empirically. Far from that. The rival models would typically accept that a great deal of justification and revision indeed do come from experience. Where they differ is in claiming that experience is not the only possible and actual source of scientific justification and revision. In this sense non-empirical rival models do not substitute but *modify* the existing dominant epistemic model. Prima facie the intended modification might seem like too big a modification. Yet, from an epistemic point of view to deny the empiricist thesis is not more difficult than to deny any strong claim that pretends to achieve full or almost full generality; and the empiricist thesis is clearly doing so.[4] The requirements that a rival epistemic model should meet are far from easy. Apart from the inhospitable epistemic environment, the model should develop a positive account of non-empirical, that is of a priori justification and a priori revision, and also should show them as actually working in the history of science.

Michael Friedman's model of scientific knowledge represents probably the most influential recent case of addressing the skepticism problem by denying the empiricist thesis. Based on important features of Reichenbach's, Schlick's and Carnap's philosophies of science, the model attempts to combine, after modification, Kuhn's influential view of scientific change with the historically well known neo-Kantian position. Friedman follows the tracks of both Kant and Kuhn and his approach is positioned within a logically-empiricist framework. Since throughout the text I shall *assume* the general model of Michael Friedman I will introduce it, place it in the relevant context and critically analyze it.[5]

The Model of Scientific Knowledge and the Problem of Empirical Revisability

Friedman puts forward a complex three-layered model of a dynamical system for scientific knowledge.[6] The structure of the model is presented by the following three levels:

> *Surface* – concepts and principles of natural sciences: empirical laws of nature, like the Newtonian law of gravitation or Einstein's equations for gravitational field. Faces tribunal of experience by means of empirical testing.
>
> *Second level* – constitutive a priori principles. Defines the fundamental spatiotemporal framework, within which only the formulation of empirical laws and their testing is possible. The principles constitute Kuhnian paradigms – a relatively stable set of rules of the game that allow for problem solving of sciences and the formulation and testing of empirical law candidates. In conditions of conceptual revolution, these are the principles that change under empirical pressure and findings. In periods of revolutions, no empirical testing of them is possible.
>
> *Third level* – philosophical meta-paradigms, meta-frameworks. Guiding, motivating and sustaining the transition between the paradigms (conceptual frameworks).

He argues that the relativized a priori principles accommodate conceptual revolutions and that in fact the revolutions themselves have revealed that our scientific knowledge has foundation layers of such type. The revision of the frameworks requires expansion of our space of intellectual possibilities to such extent, that mere direct appeal to empirical evidence is not relevant during the revolutions. The philosophical and constitutive layer guides the articulation of such new space of possibilities. Therefore, the various levels of our total (scientific) beliefs are not distinguished by mere degree of epistemic security or Quinean degrees of centrality but by their different and still complementary contributions to the total development of scientific knowledge.

	Inhabitants	Properties
Meta level	Philosophical meta-paradigms or meta-frameworks	Serves as a source for suggestions and guidance of the transition from one framework [paradigm] to another.
Second level	Constitutively a priori principles: basic principles of geometry and mechanics. Define the fundamental spatiotemporal framework within which the formulation and empirical testing of base principles is possible Mathematical principles: Euclidean geometry, the geometry of Minkowski space-time, the Riemannian theory of manifolds Particularly fundamental physical principles: Newton's laws of motion The light principle The principle of equivalence.	In periods of deep conceptual revolutions they change "under intense pressure, no doubt, from new empirical findings end anomalies".
Base level	Concepts and principles of empirical natural science; empirical laws of nature like the Newtonian law of gravitation, Maxwell's equations of electromagnetism, Einstein's equations of gravitational field	Face tribunal of experience via rigorous empirical testing

Table 1-1

In this model, each scientific theory (Newtonian mechanics, Special Relativity, General Relativity) has three asymmetrically functioning parts:

a. Mathematical part – contains the basic mathematical theories, representations or structures, intended to describe the spatiotemporal framework in question [*infinite Euclidean space, 4 dimensional Minkowskian space-time, semi-Riemannian manifold*]

b. Mechanical part – in order (c) to succeed using (a) it needs principles of coordination [*Newtonian laws of motion, light principle, equivalence principle*], which set general correspondence between the mathematical part and the concrete empirical phenomena in such a way that empirical laws could have empirical meaning.

c. Physical (empirical) part – attempts to use the mathematical part in order to formulate precisely empirical laws which describe concrete phenomena [*law of universal gravitation, Maxwell's equations for EM field, Einstein's equations for gravitational field*]

Friedman is after two main desiderata. The first one is to preserve commitment to a Kantian or neo-Kantian conception of a priori principles in the exact sciences [logic, mathematics, physics]:

> "… it was not yet clear how one could preserve any kind of commitment to a Kantian or neo-Kantian conception of a priori principles in the exact sciences (as in Kant's original conception of the synthetic a priori, for example, or Rudolf Carnap's version of the analytic a priori developed in the logical empiricist tradition)…" (DOR, p. Xii)[7]

The second desideratum is to account for the dynamics of scientific knowledge. Epistemically that would include fallibility of scientific propositions and the conditions for their revision. The motivation behind the desiderata stems from three main directions: the failure of Kant's original philosophical thesis, the failure of the project of the logical empiricism and the lack of success for the dominant viewpoint:

> "Kant's original philosophical synthesis had failed due to unforeseen revolutionary changes within the sciences, and the logical empiricist's radical revision of this synthesis had also failed to do justice to the very rapid changes taking place within early twentieth century science. " (DOR, xi, preface)

> "… but I was convinced, at the same time, that the dominant view within contemporary scientific philosophy – some or another version of

> naturalistic epistemological holism – is entirely incapable of providing an adequate philosophical perspective on these sciences " (DOR, p. Xii)

Against the Kantian and logical-empiricist background, Friedman argues that we could articulate a conception of dynamical or relativized a priori principles within a historical account of the conceptual evolution of the sciences. He proposes a kind of neo-Kantian-Kuhnian synthesis in order to reach the desiderata:

> "The idea I then came up with, against this twofold background, was that one could attempt to combine aspects of Carnap's philosophy of formal languages or linguistic frameworks with fundamental features of Thomas Kuhn's much less formal theory of scientific revolutions" (DOR, p. Xii).

Friedman develops the notion of relativized a priori principles in various places but recently in the paper *Transcendental Philosophy and a Priori Knowledge: A Neo-Kantian Perspective* and in the book *Dynamics of Reason*. They are supposed to define the fundamental framework only within which the formulation and the empirical testing of empirical laws are possible. A central concern for him is to show that these principles are not empirically revisable. Proof of the opposite would endanger their status as a priori, following a widespread view according to which the a priori epistemic kind is incompatible with empirical revisability.[8] The following passages provide illustration of Friedman's view and the significance of the problem:

> "In constructing his mathematical physics Newton created, virtually simultaneously, three revolutionary advances: a new form of mathematics, the calculus, for dealing with infinite limiting processes and instantaneous rates of change; new conceptions of force and quantity of matter embodied and encapsulated in the three laws of motion; and a new universal law of nature, the law of universal gravitation. Each of these three advances was revolutionary in itself, and all were introduced by Newton in the context of the same scientific problem: that of developing a single mathematical theory of motion capable of giving a unified account of both terrestrial and celestial phenomena. Since all of these advances were thus inspired, in the end, by the same empirical problem … Quine's holistic picture appears so far correct." *(DOR p.35)*

> "Although we explicitly acknowledge that what we are calling here a priori principles (both mathematical and physical) change and develop along with the continual progress of empirical natural science, and in response to empirical findings, we still insist, against Quinean epistemological holism,

> that these principles should nonetheless be seen as constitutively a priori in something very much like the original Kantian sense." *[DOR, p. 71]*
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> "In periods of deep conceptual revolution, it is precisely these constitutively a priori principles, which are then subject to change – under intense pressure, no doubt, from new empirical findings and especially anomalies." *[Friedman, Michael [2000] "Transcendental Philosophy and A Priori Knowledge: A Neo-Kantian Perspective" in Boghossian and Peacocke (eds.) New Essays on the A priori, OUP; pp. 367 - 383; p. 383.]*
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> "If these …. Principles … can thus be empirically tested … What real point is served by continuing to characterize such principles as a priori?" *[DOR, p. 86]*
>
> "The crucial question, however, is whether such a principle can thereby become empirically false?" *[DOR, p. 87]*
>
> "What can it possibly mean to call principles a priori that change and develop in response to empirical findings?" *[DOR, p. 71]*

The obvious response would point in the direction of the principles being empirically revisable. Friedman needs a contemporary story that settles the problem of the a priority in a modern way. Also, if the constitutivity as a source of a priority is no longer available he would need another positive story about both the epistemic character of the principles and the epistemic nature of their dynamics. In *Dynamics of Reason* Friedman argues that some certain fundamental principles of science are not empirically defeasible because they provide conditions of the possibility of empirical claims and therefore the question of their being empirically false could not arise in the first place. This claim, however, could not stay in isolation. To argue that a proposition is not empirically defeasible is one thing and to argue that it is indefeasible is a completely different one. Friedman does not address directly the question of *epistemic* fallibility of fundamental principles. Yet this question should be addressed since otherwise his argument against the empirical defeasibility could be read in a broader sense to hold against *any* revisability whatsoever and thus could render the principles not merely empirically indefeasible but infallible in general. This would be too much to admit and especially in the face of the current prevailing view in epistemology that all propositions are fallible. Infallibility of the above hypothetically admitted kind would elevate the principles too highly to the status of necessarily true principles; again, this would be too strong to accept and thus it is a clear no-go option.

Relativized A priori Principles and Revisability Prospects

The problem of the epistemic character of the fundamental principles within Friedman's model is crucial for the model as far as it opens it for the empiricist criticism. Apart from the purely epistemic damage such criticism would inflict, it would also undoubtedly change the very structure of the model. For if the fundamental principles turn out to be empirically revisable, they would bear no epistemic distinction with the empirical laws proper anymore, and thus it would remain unclear why and how they could populate an entirely distinct level within the model. The dynamics of reason, which is of central concern for Friedman, would transform into empirical dynamics and the role of the reason would be massively downplayed thus annihilating Friedman's main desiderata: to preserve the Kantian spirit and to preserve a modified version of the Carnapian-Kuhnian structural model of scientific change. Therefore, it is of critical epistemic and structural importance to preserve the a priori character of the fundamental principles on the one hand, and on the other to account for the dynamics, and the dynamics of the principles in particular, in such a way that their a priori nature is kept.

In order to account for fallibility in a modern way, Friedman follows Reichenbach's division between unrevisable and constitutive a priori principles and embraces the view that the constitutive ones are revisable. In this way he avoids the strong objection from infallibility. He argues that unlike the empirical laws of nature they do not face the tribunal of experience. Nevertheless, he concedes, *they change*. What is also significant is that *they do have an empirical content*. In this way we are presented with the following picture: revisable principles that say something about the physical world and which change under pressure from empirical findings, but which are yet supposed to be a priori and not empirically fallible.

Friedman's main line of defense against empirical revisability is to maintain that the a priori principles are constitutive in the sense that they are necessary conditions of the possibility of properly empirical laws. To be constitutive in this sense would mean that if the principle(s) were not available then the empirical laws would not even possess a truth-value and/or would be meaningless. Consequently, the question about their empirical truth or falsity could not arise. In principle, an opponent might attempt to avoid a frontal attack on this constitutive function. However, she could disagree in a different way. Any constitutive principle by Friedman's own qualification does have an empirical component. Therefore, it does say something about the physical world and, in particular, about the way the physical world is. We could suppose that a scientist [or a scientific community] might hold the constitutive principle P, and by doing so she subscribes to some claim about the way the physical world is. There are two options: either she has some reasons to hold that P or she does not. Having reasons is just another way to say that the scientist has some *justification* to hold that P. Clearly, the ”no justification” option is not particularly attractive; most people would prefer to think that scientists are indeed epistemically justified in holding their [coordinative and constitutive including!] principles. In this sense, it is a legitimate scenario where Friedman would have to accept the principles as in a way being justified.

The approach he adopts to secure their a priori character is through the notion of “being constitutive for”; again, it is not clear that this avoids the question about the justification of the principles, and in particular, the question about its epistemic nature. Friedman is explicit about the epistemic nature of the principles; they are a priori, but this epistemic kind should have a clearly identified bearer. The constitutive function of the principles delivers their a priori kind to the bearer: the principles themselves. Yet the relation between the epistemic nature of the a priori and the propositions of the principles is vague; for being a priori is an epistemic property and as such it has to address the question of how it is known or how it is justified. Neither justification nor knowledge is explicitly discussed by Friedman. In the context of the modern epistemic debates it is, however, clear (and especially after the work of Casullo) that the better way of approaching the a priori is through the notion of epistemic justification. For the knowledge requirement might be (and rightfully so) considered to be too strong a requirement, but the fact that knowledge implies justification is more or less uncontroversial. Thus the epistemically minimal analysis that is to be adequate here is much safer to be cashed out in terms of justification than in terms of knowledge. In this way the primary task before the epistemologist is to spell out the relation between the alleged a priori kind and the justification of the principles.

The question about the justification of a given coordinative principle is not merely an internal, in the Carnapian sense, question. For example, when the scientist faces a choice between the old coordinative principles and the new candidates, it does not seem that this could be resolved within the paradigm [or framework]. For Carnap the external questions are not rationally decidable, but in the context of Friedman’s coordinative principles that would translate as the claim that the scientist’s choice is not rationally decidable. Probably a better way to deal with this question is to look for the decidability over boundary coordinative principles [on the