Kant and modern physics
The synthetic a priori and the distinction between modal function and entity[1]

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"I use an idea of Kant and conjecture that quantum theory therefore holds universally in experience, because it formulates the conditions for possible experience."

"Laws capable of mathematical formulation finally forms the hard core of the natural science: not the important detail, but the form of universal validity."

Carl Friedrich Von Weizsäcker

"Now the real problem of pure reason is contained in the question, *How are synthetical judgements* a priori *possible*?"

"*Physics contains synthetical judgements* a priori *as principles*"

Immanuel Kant

Summary

In order to appreciate the meaning of Kant's concern for the *synthetic apriori* a distinction needs to be made between the dimension of *functional aspects* of reality, exhibiting universal (modal) laws (holding for all possible entities), and the dimension of *entities* characterized by specified *type-laws* (only holding for a limited class of entities). In particular attention is given to some properties of the first four cosmic aspects/modes: the numerical, the spatial, the kinematical and the physical. In passing a number of related issues are adressed, such as the after-effect of the Greek *gemometrization* of matter, the Achilles' heel of *positivism* (the usage of property-terms), and an alternative formulation of the law of *energy conservation*.

Introduction

Since my student days I often asked myself what was really at stake in Kant's concern for what he called the "*synthetical a priori*." In this article it is my aim to come to terms with the *ontic foundation* entailed in Kant's distinction between "*synthetically a priori laws*" and "*empirical laws*." In order to do that we will have to take into account three distinct but coherent perspectives: (i) issues coming from the history of philosophy and physics; (ii) systematic philosophical distinctions; and (iii) an appeal to the state of affairs in modern physics.

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Entities and properties: a brief historical overview

Throughout the history of philosophy there is an awareness of the difference between *entities* and their *properties*. In Greek philosophy the dimension of entities eventually was captured by the *substance concept*. Aristotle proceeds from a *primary substance* (something supposedly purely *individual*) but he had to introduce the so-called *secondary substance* (as the *universal substantial form* of an entity) in order to safeguard the possibility of (conceptual) knowledge (cf. *Categoriae*, 1 ff.). Whereas the *substance* has an independent existence, the *accidents* are dependant upon the substance. Descartes still defines substance in this sense:

> "By substance we conceive nothing else than a thing which exists in such a way as to stand in need of nothing beyond itself in order to its existence" (*The Principles of Philosophy*, par.51).

In fact there are two ways in which one can confuse things and properties: (i) the first option attempts to treat properties as if they are *things*, i.e., it tries to *reify* properties; (ii) the second option aims at reducing things to (what we will call:) *functional* properties, i.e., it tries to *functionalize* entities (epistemologically speaking it is said to advance a *functionalist* perspective).

Classical Greek and medieval philosophy by and large adhered to a *substantialist* understanding of reality, whereas modern philosophy tends to be more *functionalist*. Almost a century ago this distinction received renewed attention through the publication of Ernst Cassirer's important work: *Substance concept and function concept* (*Substanzbegriff und Funktionsbegriff* - 1910). Cassirer comes from the Marburg school of neo-Kantian philosophy. However, in particular adherents of the Baden school of neo-Kantian philosophy, such as Heinrich Rickert, Wilhelm Windelband and Max Weber, promoted a *functionalist* understanding of reality. Rickert advances the view that the natural sciences proceed in a *generalizing* fashion, in opposition to the *individualizing* mode of thought predominant in the (historical) humanities (Rickert, 1912:68-69, 173, 197). Rickert initially develops this perspective by binding the natural sciences to the ideal of transforming all *thing concepts* into *concepts of function* (concepts of *relation*).[1] This *functionalist* orientation of both these neo-Kantian schools historically rely on Kant's quest for the *synthetical a priori*.

Remark:

> As we proceed it will become clear that we use a particular perspective in order to account for the difference between *entities* and *properties*. The *functional relation* between entities rely upon the *way* in which these entities exist. The Latin expression: *modus quo* (way/mode of being) comes to the mind and we will often substitute the term *property* with synonymous terms like *mode*, *function*, and *relation*. Our frequent use of the adjective *modal* simply refers to *aspectual dimension* of reality (related to the question about the *how*?), which ought to be distinguished from the dimension of entities (related to the question about the *what*?). The latter, concrete entities, societal collectivities and events, actually function concretely within all modes/aspects of reality - namely the numerical, the spatial, the kinematical, the physical, the biotical, the sensitive-psychical, the analytical, the cultural-historical, the sign-mode, the social aspect, the economic mode, the aesthetic facet, the jural function, the ethical mode and the certitudinal aspect.

It is therefore in advance necessary to emphasize concrete *entities* - planets, plants, animals, human beings, cultural objects, and even human societal forms (such as state, church, busi-

ness or ethnic group) encompass our experience in a way that is different from the nature and scope of the various *aspects* of reality. One can also say that the limits or *horizon* of human experience is characterized by a number of dimensions. The *dimension* of entities always refers to the entire **what**-ness of things - and as such differs from the dimension of *aspects* (*modalities*) which refers to the *way* in which various things exist. These ways of being (Latin: *modi*) bring us into contact with a very important dimension of the human experiential horizon.

In answering a *what*-question we can refer to *something*: *this* or *that*. The entrance to the dimension of entities is offered to us by the dimension of *modal aspects*. Whenever something is indicated (e.g. a lounge chair) the modal dimension calls forth the *how* question: how is the chair? is it large or small (its *spatial* way of being); cheap or expensive (*economic* function); weak or strong (*physical* aspect); beautiful or ugly (*aesthetic* modality)? The *how* question can be answered with: in this or that *way*, in distinction from the *this* or *that* which indicates the answer to the question about the concrete *what* of something.

Kant's concern for the synthetical a priori

Immanuel Kant (1724-1804) introduced a new dimension to the classical distinction between the *a priori* and the *a posteriori*. The former expression refers to that which precedes experience and makes it possible, whereas the latter one makes an appeal to knowledge coming from experience. In the *Introduction* to the second edition of *his Critique of Pure Reason* (CPR) Kant addresses the distinction between *pure* and *empirical* knowledge. Although Hume wakened him from his dogmatic "slumber" Kant did not reduce knowledge to experience as such: "But although all our knowledge begins with experience, it does not follow that it arises from experience" (CPR, B:1).

It is therefore a question which deserves at least closer investigation, and cannot be disposed of at first sight, whether there exists a knowledge independent of experience, and even of all the impressions of the sense? Such *knowledge* is called *a priori*, and distinguished from *empirical* knowledge, which has its sources *a posteriori*, that is in experience (CPR, B:2).

Kant combined this distinction with another one, that between analytical and synthetical judgments:

> Analytical judgments (affirmative) are therefore those in which the connection of the predicate with the subject is conceived through identity, while others in which that connection is conceived without identity, may be called synthetical (CPR, B:10-11).

These distinctions provide the background for the general task of a Critique of Pure Reason: "Now the real problem of pure reason is contained in the question, *How are synthetical judgements* a priori *possible*?" (B:19).

What does this entail for physics? In order to understand Kant's intention we have to look at the first examples of synthetical judgments *a priori* given by him:

> I shall adduce, as examples, a few propositions only, such as, that in all changes of the material world the quantity of matter remains unchanged: or that in all communication of motion, action and reaction must always equal each other. It is clear not only that both convey necessity, and that, therefore, their origin is *a priori*, but also that they are synthetical propositions. For in the concept of matter I do not conceive its permanency, but only its presence in the space which it fills. I therefore go beyond the concept of matter in order to join something to it *a priori*, which I did not before conceive *in it*. The proposition is, therefore, not analytical, but synthetical, and yet *a priori*, and the same applies to the other propositions of the pure part of natural science (CPR, B:117-18).

Kant here speaks about "the pure part of natural science" and he does that within the context of an early formulaiton of the law of energy conservation ("that in all changes of the material world the quantity of matter remains unchanged" - equated with the "permanency" of matter). The laws of motion, the main laws of thermodynamics and the general framework of quantum physics all share an important feature. They apparently conform to that which Kant intended with the *synthetical a priori*.

Let us consider the last extensive quote from Kant's CPR in more detail.

Matter understood in spatial terms (*res extensa*)

The way in which Kant employs the distinction between analytical and synthetical judgments (CPR, B:10 ff.) reflects a long-standing view on the nature of matter - dating back to the discovery of irrational numbers and the geometrization of space. Throughout later Greek philosophy, medieval philosophy and early modern philosophy the after-effect of this geometrization of mathematics was that the "essene" of matter was constantly described in *spatial* terms. In spite of novel ideas and perspectives, the metaphysical basis of reflection remain bound to a spatial framework - the "chain of being" having God is the *highest being* at its peak. This underlying scheme still determined Descartes' view of matter. He says that "the nature of body consists not in weight, hardness, colour, and the like, but in extension alone" (*Principles,* Part 11, IV). When Kant sets out to locate *sensibility* by separating from it everything the understanding adds by means of its concepts, he proceeds to separate from sensibility all that belongs to *Empfindung* (sensation) "so that nothing remains but pure intuition or the mere form of the phenomena" (CPR, B:36). His indebtedness to the *spatial characterization* of matter speaks even more clearly from his following words:

> Thus, if we deduct from the representation of a body what belongs to the thinking of the understanding, viz. substance, force, divisibility, etc., and likewise what belongs to sensation, viz, impermeability, hardness, colour, etc., there still remains something of that empirical intuition, viz. extension and form (B:34).

This is clearly consistent with the above quoted phrase: "For in the concept of matter I do not conceive its permanency, but only its presence in the space which it fills."

The untenability of the distinction between analytical and synthetical judgments

The remarkable situation is that long after Hobbes, who became acquainted with Galileo's law of inertia, switched from extension to "moving body" as basic denominator, Kant still clung to *space*. During the nineteenth century logicians started to question this reduction. In his *Logik* Wundt saw this clearly:

When Kant opposes the proposition "all bodies are extended" as an analytical judgment to the proposition "all bodies are heavy" as a synthetical judgment, then this opposition remains true only so long as the judging person does not start out by thinking the property weight as being enclosed in the concept body (1919:161).

In other words, if the characteristic *weight* (mass) is not *analytically* implied in the concept of a physical body, it is, logically viewed, *contradictory* to predicate weight in a so-called empirical-synthetic sense of the physical body. That is to say, if a *correct concept* of a physical body does not imply (some or other specified form) of this modal physical feature (mass) in an analytical way to begin with, it cannot afterwards be predicated of the body, except illogically. (From: P is non-Q, one cannot infer: P is (such and such) Q.)

The idea of an entity, such as a material body, entails more than merely its *spatial* properties. Kant actually had a *functionalistic* understanding of matter, excluding properties coming from the aspect of movement and the physical aspect.[2]

What is really at stake in Kant's quest for the synthetic a priori?

What Kant had in mind was a combination of two considerations: (i) acknowledging conditions making experience as such possible, and (ii) emphasizing the universality of those conditions. Implicitly this concern presupposes the mentioned age-old distinction between *entities* and *properties*. The latter, as we have expl;ained earlier, pertain to *modes or relatedness* or the *ways of functioning* of entities. The unique feature of modal functions - such as the spatial with its associated intuition of extension - or movement - with its associated intuition of *uniform flow* (constancy), is precisely given in their *universality*.

Of course, given the subject-centered status of Kant's categories of thought, he was confronted with the difficulty to explain how the determinations of the individual thinking subject can have *universal validity* ["objektive GÜltigkeit" (CPR, B:122)].

The reason why he chose to promote the thinking subject to contain (in a formal way) *the universal a priori conditions* for experience within understanding itself could be explained with reference to what is known as the *Copernican revolution* in epistemology.

Galileo believed that a body in motion will continue its motion endlessly, except when some force impinges on it (compare with regard to the though-experiment explained in his work from 1638 on two new sciences the thorough analysis of Holz, 1975:357-358). He formulates this idea in terms of the following thought-experiment: imagine a moving body being placed on a horizontal plane without any impediment. It follows that the movement of this body on the plane would be uniform and ever-enduring if the plane is extended into infinity (cf. Galileo 1973).

The way in which Galileo formulates this principle of *inertia* strongly influenced Kant (cf. Holz, 1975: 345-358). C.F. von Weizsacker (1971: 128) phrases Kant's problem in terms of the question: "What is nature, that it must obey laws which man could formulate with his understanding?" Kant, in fact, in his conception of the categories, even moved a step further.

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Galileo formulated his thought-experiment without taking account of any real sense-experience in order to arrive at his law of inertia. Apparently this law is derived *from* and prescribed *to* moving entities out of the *pure understanding* of the human being in its *spontaneous subjectivity*. This indeed represents the crucial epistemological turn in ascribing the primacy no longer to the object, but to the *subject*. In a somewhat different context, Kant wrote about the difficulty involved in this turn, namely how "*subjective conditions of thought* can have *objective validity,* that is, can furnish conditions of the possibility of all knowledge of objects" (B:122).

The way in which Kant tried to solve this problem, illustrates that, in line with the thought-experiment of Galileo, he drew the radical *humanistic* conclusion: the laws of nature are *a priori* contained in the *understanding* of the thinking *subject*: "the categories are conditions of the possibility of experience, and are therefore valid *a priori* for all objects of experience" (B:161); "Categories are concepts which prescribe laws *a priori* to appearances, and therefore to nature, the sum of all appearances" (B:163). In his *Prolegomena* we find the most explicit formulation - to which we will return below: "Understanding creates its laws (*a priori*) not out of nature, but prescribes them to nature" (1783-II: §36, 320).

Thus Kant actually elevated human understanding to become the *a priori (formal) lawgiver of nature*!

An alternative understanding of the conditions of experience

We still have not pinned down the positive side of Kant's concern for the synthetic a priori by pointing at his problematic rationalistic (and subjectivistic) conception of human understanding. In order to get closer do doing that we have to explore an alternative understanding of the universality and experience-conditioning nature of the different *modes of being* - such as the numerical, the spatial, the kinematical and the physical.

One way to approach this issue is to conjecture that these modi/functions are indeed *universal*. Since the universality here intended does not relate to entities but merely to the ways in which particular entities can function in different modes of being, it must not be confused with notions of (material) entities - such as atoms, molecules, or macro-systems. In fact the very nature of modal properties highlights an impasse for positivism. By looking this first, we will pave the way for a better understanding of the reality underlying Kant's wrestling with the synthetical a priori.

The Achilles' heel of positivism – property terms

We have mentioned that the Pythagoreans adhered to one statement above all else: *everything is number*. We have also briefly stated that after the discovery of irrational numbers - revealing within the seemingly form-giving and delimiting function of number the *formless* - Greek mathematics as a whole was transformed spatially (the *geometrization* after the initial *arithmetization*). As a consequence *material entities* were no longer described purely in *arithmetical* terms. Space now provided the necessary terms used to characterize material entities. This spatial angle of approach remained in force until the rise of modern philosophy, since philosophers like Descartes (1596-1650) and Kant (1724-1804), as we have seen, still saw in *extension* the "essence" of material things.

It was due to Galileo and Newton that the main tendency of classical physics eventually caused a shift in modal perspective by trying to describe all physical phenomena exclusively in terms of (*kinematical*) movement.[3] Writing about the foundations of physics, David Hilbert[4] refers to the *mechanistic ideal of unity in physics* but immediately adds the remark that we now finally have to free us from this *untenable ideal*.5 Since the introduction of the atom theory of Niels Bohr in 1913, and actually since the discovery of radio-activity in 1896 and the discovery of energy *quanta* modern physics realized that **matter** is indeed characterized by its *physical energy function* - the *physical aspect* of reality must be seen as the *qualifying function* of matter (cf. Stafleu, 1980:100 ff.).[6]

This brief sketch of the genesis and development of the *concept of matter* thus illustrates in which way different (modal) *property-terms* served to characterize matter - starting with the perspective of *number* and then proceeding to the aspect of *space*, the *kinematical* aspect and eventually the *physical aspect* of reality. What is important to realize is that any *description* of matter is decisively dependant upon a particular *theoretical view of reality* (Kuhn would have used the expressions *paradigm* or *disciplinary matrix*) which is entailed in the preference which is assigned to specific property-terms.

The question now is the following one: Is it possible to account for this foundational choice in an *empirical* way? In other words, is it possible to *perceive* the numerical aspect? Can we *weigh* the spatial aspect? Can we determine the *volume* of the kinematical aspect? Can we `measure' the `distance' between the spatial aspect and the physical aspect?

The obvious absurdity of these questions not only illustrates the untenability of the positivistic faith in facts, but at once points at a crucial distinction operative throughout the history of the academic disciplines (special sciences), namely the distinction between *aspects/functions/modes of relatedness/modes of being* on the one hand and *entities* on the other.

If we transform our understanding of the *a priori* such that it receives an *ontical* meaning and at the same time take Kant's *synthetic* concern to relate to the *universality* of unique, distinct but cohering modes of being, then we can conjecture that what Kant actually discovered in his CPR is *modal universality*.

Modal universality: the crux of Kant's synthetic a priori?

Let us approach this conjecture from the angle of what could be called *modal laws* and then focus on the modern history of physcis (from Newton to the 20th century).

We have mentioned that in the year 1910 Ernst Cassirer, the comprehensive and philosophical penetrating representative from the Marburg school of neo-Kantian thought, published the first edition of his work: *Substanzbegriff und Funktionsbegriff* (see Cassirer, 1953). We have aslo seen that another prominent thinker from that period, Heinrich Rickert (belonging to the Baden school of neo-Kantianism), advanced the view that the natural sciences proceed in a *generalizing* fashion, in opposition to the *individualizing* mode of thought predominant in the (historical) humanities (Rickert, 1913:68-69, 173, 197). Rickert initially develops this perspective by binding the natural sciences to the ideal of transforming all *thing concepts* into *concepts of function* (concepts of relations). This view of the natural sciences remains completely faithful to the aim of the classical science-ideal, i.e., to *reduce* all of reality to some or other modal aspect (or: *function*). The project of classical physics, finalized in its dominant *mechanistic* form by Newton, provides us with a good example of this tendency. According to this *mechanistic main trait* of classical physics everything had to be reduced to the aspect of *mechanical movement* (similar to the lasting conception of matter as something merely spatially extended).

According to Rickert the (functionalistic) logical ideal of the natural sciences finds its limit in the *uniqueness* of experiential reality itself:

That which poses an inaccessible limit to natural scientific concept formation is nothing else but the unique empirical reality itself as we intuitively experience it in the immediacy of its individuality (1913:197).

Eintein's theory of relativity and the first main law of thermodynamics[7]

Einstein's theory of *relativity* is well-known. A physicist of his stature lends credit to the popular view linked to his theory, namely that everything is *relative* and *changeable*. Remarkably, Einstein's theory rests on a fundamental presupposition which is the opposite of all *relativism*. Einstein had to start with the idea of *an order* which is *uniform* and *constant* - which means that everything which he has indicated to be relative is only relative in relation to this *constant order*.

That this is the case is evident from his postulate that the speed of light is *constant in a vacuum*. Einstein worked from the presupposition that a particular light signal would have the same constant speed (c) in relation to all possible moving systems. It was not even necessary for his theory for such a signal to actually exist. The fact that later experimentation proved experimentally that the speed of light does indeed conform to Einstein's postulate, is - as the physicist Stafleu puts it - relatively irrelevant!

The crux of Einstein's theory of relativity is therefore to be found in the nature of the *order of constancy* which it presupposes.8 From our everyday experience we are familiar with the *numerical order of succession* which conditions every act of counting: one, another one, yet another one, and so on indefinitely. Just as familiar is the *spatial order of simultaneity*. In distinction from the numerical order of succession and the spatial order of simultaneity, we furthermore experience the *order of constancy* in the kinematic aspect of pure (uniform) movement.

This means that Einstein's special theory of relativity of 1905 is a *purely kinematic theory*.9 Einstein's theory therefore did not primarily develop a theory of *relativity*, but much rather one of *constancy*.

Galileo already discovered the particular nature of the kinematic order of time, as it was revealed in his *law of inertia*. In terms of this law a body in motion would continue its movement without stopping - unless something else (a force or friction) influences it. That means that our insight into the nature of movement does not depend on a causal power. The term "cause" belongs to the *physical aspect* of our experience where we come across the effects of *energy-operation*. It cannot be emphasized enough that we can never talk of a *cause of movement*, but rather only of the cause of a *change* in movement - thus once again acknowledging the *modal* difference between the kinematical and physical aspects of reality.10

The unique nature of *constancy* (that is, the irreducibility of the kinematic aspect) is the foundation of all references to *dynamics* or *change*. Without a constant basis all talk of change is senseless. For this reason physics cannot link any meaningful content to a *discontinuous change of movement of a body* - change of movement (acceleration or deceleration) is always *continuous*, since a discontinuous change would require an infinite force which is *physically* seen an impossibility. The foundational role of the kinematical aspect with respect to the physical aspect is also clearly seen by P. Janich when he draws a "strict distinction between phoronomic (subsequently called kinematic) and dynamic statements" (1975:68). In order to experience a *discontinuous* change of motion, a *body* should undergo an infinite acceleration, requiring an infinite force - something *physically* impossible (cf. Janich, 1975:69)!11 Consequently, we can only establish physical *changes* on the basis of something *lasting* (i.e., an element of *constancy*).

This foundational position of the (kinematic) aspect of movement in a philosophical way enables us to find a more suitable formulation of the first main law of thermodynamics.

An alternative formulation of the first main law of thermodynamics

The physical aspect must not only be distinguished from the kinematic aspect lying at its foundation, since there is also an *indissoluble coherence* between these two aspects. For this reason we shall find in the physical aspect a structural moment (technically called an *analogy*) which reminds us of the foundational kinematic aspect. *Constancy* appears in the physical aspect as a structural reminder (analogy) of the meaning of motion. In philosophical terms we may therefore say that we find an analogy of the kinematic aspect at the law-side of the physical aspect, where the expression *law-side* refers to that which *determines* and *delimits* whatever if *factually subjected* to it.

A formulation of the first main law which intends to be true to this inter-modal (inter-aspectual) coherence within reality would therefore have to refer to *energy constancy* and not to energy conservation. Strictly speaking the use of the term "conservation" may even be misleading, since the activity of *retention* (conservation/"holding on") itself requires an *input* of energy - as in the case of thermodynamic "open systems" (or "steady states").12 The law of *energy constancy* highlights not only the distinct uniqueness of the kinematic and physical aspects, but, taking into account the distinction between law-side and factual side, also the indissoluble coherence between them: without the foundational position of the kinematic aspect in the order of the various cosmic aspects we would have no grounds for discerning an *analogy* of the aspect of movement in the physical aspect, that is, the analogy of *energy constancy*.

Modal universality and entitary typicality

If we have to acknowledge *universal modal laws* - such the *law of energy constancy* and Galileo's *law of inertia*, then we must ask the question how is it possible to attain knowledge of such modal laws? Discerning modal laws actually requires the distinctive feature of scholarly activities - *modal abstraction*.

Remark:

> Whoever is engaged in *modal abstraction*, relinquishes the non-relevant aspects and focuses theoretical-logical attention on one particular aspect only. The distinctive characteristic of theoretical-logical (= scientific) thought, therefore, is *modal abstraction*. Precisely because all concrete entities function in all the various aspects of reality, the abstracted modalities (aspects) provide access to an analysis of the structures of such entities.

It is only on the basis of our integral (multifaceted) *experience* of reality that we gain theoretical access to the underlying modal structure entailed in its various modal aspects. For this reason we may call this method of articulating modal properties *transcendental-empirical*. Traditionally, especially since Kant's *Critique of Pure Reason*, the word *transcendental* is employed to account for that which provides the basis of all experience in the sense that it makes possible what we experience. Unlike Kant, however, we don't want to assume that the *transcendental conditions* of experience are in advance (i.e., *a priori*) contained in the formal structure of the knowing person (Kant's forms of intuition and thought categories). Much rather, we proceed from the conviction that the *modal condition* for experiencing physical phenomena is *ontically* given in the *universal modal structure* of the physical aspect of reality. With this approach we intend to claim that the physical aspect lies at the foundation of whatever we can experience in a physical sense. An analysis of the distinct modal aspects of reality therefore rests upon a *transcendental-empirical* approach.

Against this background, furthermore, we have to acknowledge that there are *entitary laws* for different *types* of entities - succinctly designated as *type laws*. The existence of type laws enable us to classify physical entities and place them in various categories. The *typical nature* of an entity *specifies*13 the modal meaning of the aspects in which it functions. This *typical* nature of an entity provides a peculiar "colouring" to its *modal functions*. But most importantly, type laws do not hold for each and every possible kind of entity - they apply to a *limited* class of entities only. The physicist Stafleu explains this distinction as follows (1980:11, cf. pp.6 ff.):

> Hereby we distinguish laws which are valid for a limited class of subjects (typical laws) from those which are valid for all kinds of subjects (modal laws). Typical laws, in principle, delineate a class of subjects to which they apply, describing their structures and typical properties. Examples of such laws are the Coulomb law (applicable only to charged subjects), the Pauli principle (applicable to fermions), etc. Often the law describing the structure of a particular subject (e.g., the copper atom) can be reduced to some more general laws (e.g., the electromagnetic laws in quantum physics). On the other hand, modal laws are those which have a universal validity. For example, the law of gravitation applies to all physical subjects, regardless of their typical structure. We call them *modal* laws because, rather than circumscribing a certain class of subjects, they describe a *mode* of being, relatedness, experience, or explanation.

The fact that modal laws - such as those of quantum physics - hold for all possible "objects" is clearly seen by Von Weizsäcker: "Quantum theory, formulated sufficiently abstract, is a unversal theory for all *Gegenstandklassen* (classes of objects)" (1993:128). When he explains, on the next page, that one cannot derive the *kinds of entities* of experience from the universal scope of quantum theory, he aludes to what we are calling *type laws*.

At this point we may return once again to the basic question of Immanuel Kant's epistemology: *How are synthetical propositions a priori possible?* (1787:19). We have seen that he

holds the view that the thought categories of our understanding (in a formal sense) are not *derived from* nature but are *prescribed to* nature in an a priori way (1783 ‡36). Although misdirected by the rationalistic assumptions of his epistemology, Kant, in his search for the synthetic a priori, indeed struggled with the nature of *modal universality*.

To appreciate Kant's position better in this regard we have to pursue the disctintion between *modal laws* holding for whatever there is and *type laws* applicable to a limited class of entities only in terms of the distinction between what is supposedly "pure" and what is supposedly "empirical" in Kant's assessment of physical science.

Whoever modally abstracts a particular aspect in transcendental-empirical manner gains access to the (unspecified) universality of modal-functional relationships. Since modal aspects are not concrete entities or events they cannot be treated *as if* they are entitary in nature, because this would simply amount to a *reification* of modal functions. If one really wants to gain an understanding of the *type law* of any particular *kind of entities* one has to investigates those entities *empirically*.

One cannot derive the *typical nature* of different kinds of physical entities from modal analysis or abstraction - what is required is empirical testing *through experimentation*.

Positivism positively assessed: the legitimate place of experimentation

This explains why even Kant was compelled to make a distinction between his (supposedly universally valid *a priori*) *thought categories* on the one hand and so-called *empirical laws of nature* on the other hand:

> We rather have to distinguish empirical laws of nature, which always presuppose particular perceptions, from the pure or general natural laws, which, without having a foundation in particular perceptions, only contain the conditions of their necessary connection in an experience. In respect of the latter nature and possible experience are entirely the same; and since within these the law-conformity of the necessary connection of appearances in an experience (without which we are totally incapable of knowing any object of the world of the sense), actually is based upon the original laws of the understanding, so it initially does sound strange, but it is nonetheless certain, when I state with respect to the latter: understanding creates its laws (a priori) not out of nature, but prescribes them to nature (1783 § 36:320).

This distinction runs parallel with the one which we have drawn between *modal* laws and typical laws (*type laws*). Whereas Kant ought to receive credit for wrestling with the dimension of *modal universality*, positivism and neo-positivism ought to be acknowledged for their emphasis on *experimental testing* (not the same as: *verifying*!). Only through studying the *orderliness* or *law-conformity* of entities is it possible to arrive at an understanding of the *type laws* holding for that limited class of entities conforming the their peculiar type laws.

In the case of physics it requires empirical research through experimentation. Of course this does not free physics from an overarching and underlying paradigm (theoretical perspective) in which modal properties are accounted for. Sometimes this dimension the theory formation is implicitly acknowledged when reference is made to *theoretical terms* which cannot directly be tested against actual experiences.

The modal core of theory formation: can it be tested against experience of things?

By making an appeal to Dilthey's sketch of seeing natural scientific theory formation as constructing reality via logical mathematical elements of consciousness (and thus asserting the power over nature of this sovereign consciousness as an effect of the autonomy of the human intellect),14 Weyl wants to follow the conception of Hugo Dingler regarding the principle of *symbolical construction*. Weyl is convinced that the "constructive character of the natural sci-

ences, the situation that their individual propositions does not have a verifiable meaning in intuition (*Anschauung*), but that *truth* builds a *system* which can only as a whole be assessed" (1966:192) has been explained by him.

Max Planck states a similar perspective in a concise way: "Strictly seen is it totally impossible to find any physical question which can be assessed directly through measurements without the aid of a theory" (1953:341).

Weyl affirms the correctness of Dingler's definition of physics as that discipline in which the principle of symbolical construction is fully carried through and then adds a statement once again making an appeal to the above-mentioned distinction between modal universality and typicality: "But what is connected with the *a priori* construction is *experience* and an *analysis of experience through the experiment*" (1966:192).

Discussing the nature of an *a priori* synthetic element in the "empirical sciences," Stegmüller raises the following possibility - also alluding to the same issue (1969:316):

> Surely, this cannot imply that the totality of law-statements present in a natural science could be of an *a priori* nature. Much rather, such an apriorism should limit itself to the construction of a limited number of *a priori* valid law relationships, while, furthermore, all more specific laws of nature should be dependent on empirical testing.

Keeping in mind that we must distinguish laws in an *ontical* sense from our *hypothetical* law statements in *scientific formulations*, we also have to note the similarity between the just-mentioned statement of Stegmüller and the following explanation of Stafleu (related to the distinction between modal laws and typical laws):

> Whereas typical laws can usually be found by induction and generalization of empirical facts or lower level law statements, modal laws are found by abstraction. Euclidean geometry, Galileo's discovery of the laws of motion ..., and thermodynamic laws are all examples of laws found by abstraction. This state of affairs is reflected in the use of the term "rational mechanics", in distinction from experimental physics (Stafleu, 1980:11).

It must be clear that what is intended with the distinction between modal and typical laws indeed has captured the reflection of prominent thinkers. To mention one last example: C.F. von Weizsäcker. He says that although the basic assumptions of quantum theory could be written down on one page (for the mathematically trained reader!), the number of known experiences conforming to this theory runs into billions - and not a single one is found contradicting quantum theory in a convincing way. He then says, alluding to the universal validity of Kant's thought forms:

"I use an idea of Kant and conjecture that quantum theory therefore holds universally in experience, because it formulates the conditions for possible experience."15

In order to speak about entities the modal aspects have to be used as *points of entry*. Even when we refer to the *totality-structure* of an entity the employed terms stem from a unique modal aspect: the spatial mode. The term *totality* is synonymous with *coherence* and *wholeness* (and implies a multiplicity of parts - at least in the case of spatial continuity the whole is infinitely divisible).

Conclusion

Entering into a more detailed analysis of the physical qualifying function of and different types of interlacement between material entities will take us beyond the confines of a single article.

We only wanted to highlight various sides of the conjecture that Kant actually wrestled with the dimension of modal universality in his quest for synthetical a priori judgments. Our illustration came from the domain of physics, but could equally well be extended to mathematics and "metaphysics" - the supplementary two foci of Kant's CPR.

Endnotes

1. Both Cassirer and Rickert also refer to function concepts as *concepts of relation*.
2. On different grounds Dooyeweerd, Quine and Goodman questioned the distinction between analytic and synthetic judgments.
3. Once again recall what we have said about the British philosopher, Thomas Hobbes (1588-1679), who was familiar with the mechanics of Galileo enabling him - as opposed to Descartes - to employ the basic concept *moving body* as descriptive tool.
4. Perhaps the greatest mathematician of this century.
5. It is therefore strange that the contemporary physical scientist from Cambridge, Stephen Hawking, although he certainly does not any longer want to defend the said mechanistic ideal, still upholds a similar monistic ideal when he writes: "The eventual goal of science is to provide a single theory that describes the whole universe" (1987:10).
6. In general Dooyeweerd's theory of *individuality-structures* employs the notion of a *foundational* and a *qualifying* function - viewed as the two radical functions characteristic of a certain type of entities. One can also speak about the *type-law* for enttities. A molecule, for example, has a spatial foundational function and is qualified by the physical aspect of reality.
7. In this subparagraph we intend to explore the interrelationship between the modal universality of the kinematic and the physical aspects.
8. Spielberg and Bryon correctly emphasize that it is about "invariance" - i.e., constancy - although they unfortunately thereby confuse the terms *absolute* and *unchanging*: "Indeed, Einstein originally developed his theory in order to find those things that are invariant (absolute and unchanging) rather than the relative. He was concerned with things that are universal and the same from all points of view" (1987:6). The term *unchanging* is simply the denial (negation) of *change* - a physical term. The term *absolute* cannot really be applied to anything in reality, that is, not if one wants to avoid the idolization of created reality.
9. The irreducible nature of the kinematic time order is imported with the help of a subject which moves at a constant speed.
10. In his mentioned article from 1910 treating the classical *mechanistic* view of nature, Max Planck sharply and correctly distinguished between a "mechanical" and an "energetical" view of nature (1973:65).
11. The discontinuity between quantum states concerns the discrete numerical analogy within the physical aspect and it is therefore different from the acceleration or deceleration of physically qualified *bodies*. Strikingly, nonetheless, without the presence of a "constancy term", such as "state," it would be impossible to refer to the transition from one *state* to another *state*! The same remark could be extended to capture all cases

where, in a physical sense, one kind of entity changed into a different kind of entity - since then one still continues to speak about *phyisical entities*.

12. If it is the case that physicists do understand the term conservation in the sense of constancy then it would still be more correct rather to use the term *constancy*.

13. Take note that we do not say *individualizes* because universality does not exist on one end of a continuum with individuality at its other end.

14. Weyl refers to the second volume of the 1923 edition of Dilthey's *Collected Works* (p.260). Cf. Weyl 1966:192.

15. Von Weizsäcker, 1993:93. "Laws capable of mathematical formulation finally forms the hard core of the natural science: not the important detail, but the form of universal validity" (1993:113). In another context he writes that the quantitative results of astronomy are based upon physical laws and that we postulate, as a working hypothesis, a universal validity for these laws (1993:25).

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