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Space, Aether and the Possibility of Physics in Kant's Late Thought
From the *Metaphysische Anfangsgründe der Naturwissenschaft* to the
Opus postumum

1. DYNAMISM, AETHER AND THE PROBLEM OF MATERIAL
SUBSTANCE (1756-1786)

Kant's philosophy of material nature, considered as a whole, appears as an incessant struggle between dynamistic and mechanistic views. Starting from his first writings Kant tried to combine a theory of attractive and repulsive Newtonian forces with a monadological metaphysics. The initial problem, which always remained in the background in his later works, was the resolution of the (typically Wolffian) contrast between the infinite divisibility of space and the unity of material substance. The solution was to consider material extension as being the effect of a dynamic «sphere of activity» propagating from a simple monad. The corresponding repulsive force was held responsible for both the impenetrability and the elasticity of matter; the possibility of conceiving different degrees of its intensity could therefore explain specific density of different materials without resorting to the «empty delusion of imagination» of mechanical representations; finally this original repulsive force, in order to produce a determinate degree of the filling of space, required a contrary attractive force to limit its action. Hence, in the attempt to prove these propositions, Kant connected the very explication of matter with the admission of an essential and universal attractive force,

which had to be identified with Newton's gravity. This metaphysical dynamism, inspired by 18th century Newtonianism, constitutes the backbone of Kant's dynamical doctrines on material nature throughout all the critical period, although the metaphysical background of monadology, after 1781, disappears from the field of possible knowledge.¹

¹ The general aim of the *Monadologia physica* (1756) was presented as a conjunction of the doctrines of metaphysics and geometry in natural philosophy: the latter is represented by Newtonian physicists, while the former is actually Wolffian monadology – altogether different from Leibniz's original metaphysics – which admits monads as «physical points» (see KgS 2, 475). The main problem of the unity of substance in infinitely divisible space is the background of propositions 1-5. Then there are detailed arguments about the necessity of a repulsive sphere of activity (prop. 6), the correspondence of its action with the phenomena of impenetrability (prop. 8) and elasticity (prop. 13), the necessity of an opposite attractive force (prop. 10), and the possibility of originally different degrees of density (prop. 11) with a consequent critique of the alternative explanations through atoms and void (prop. 12). These arguments return in the metaphysical (but non-monadological) principles of dynamics of the *Metaphysische Anfangsgründe der Naturwissenschaft* (1786). It is very important, nonetheless, to stress the great consequence of the changing metaphysical background between 1756 and 1786, in order to understand the general problems of Kant's mature dynamism. Leibnizian metaphysics, considering space as a “well grounded phenomenon”, had the task of deducing its properties from the purely metaphysical properties of monads and their perception, without assuming any property of the confuse ideas of sensibility. Monads, therefore, could certainly not exist in space as elements of bodies, at least from the metaphysical point of view. The lack of details and the open problems of such a deduction of space (mostly expounded in unpublished writings), together with the analogy between monads and points (based on the the definition of the simple substance as not having parts and at the same time as having infinite relations with other substances: see e.g. *Principes de la nature et de la grâce*, § 2, in GP VI, 598), left some ground for Wolff's adoption of both metaphysical monads and their identification with points, together with the admission of point-like elements with no representative power. The problem lay in the very connection between monads and extension. Wolff considered monads to be different, therefore external. Yet their difference, given the absence of representations, lay in their simple position (see Wolff, *Cosmologia*, §§ 219ff., cf. § 544. On this aspect of Wolff's monadology see École 1990, 238-239 and the interesting discussion in Campo 1939, 222-228). *Situs*, in Leibniz's thought, was a purely qualitative notion, and therefore the connection of *analysis situs* and monadology could provide a metaphysical deduction of extension. This crucial point was lost under a thick fog of definitions in Wolff's writings, and the whole debate between Newtonians and Wolffians on monadology and infinite divisibility of space, which culminated in the Academy Prize Question in 1746 and the victory of Newtonians, regarded Wolffian monads as indivisible components of bodies. This is the starting problem of Kant's *Monadologia physica* (compare Euler 1768-1774, letters 125-127. On monadology in Kant's early thought see Friedman 1992 1-27. On Leibniz's original metaphysics of space see Derisi (forth.)). Once the connection of monadology with Leibniz's *analysis situs* had been lost, the definition of space as the order of coexistence had to be connected with properties of extension, thus postulating physical coexistence of

In the *Metaphysische Anfangsgründe der Naturwissenschaft* of 1786 the primitive concepts of the new *a priori* dynamics are space as the pure form of outer intuition and its filling with matter, identified with the empirical concept of impenetrability.² The demonstrative path of the *Monadologia physica* is reversed: it started from monads and then inferred a repulsive «force of

point-monads. In his treatment of physical points and space Baumgarten (*Metaphysica*, §§ 398-400) appeals to conflict and influx, and tries to connect force with spatial relation: here, at least, it is evident how the intelligent Wolffian was naturally tempted to seek such a different reconstruction of monadology. Newtonian physics, from this point of view, could easily be of help. Boscovich's monadology, for instance, arises in this context, with its attempt to reconcile «Leibniz» (i.e. point-monads as centers of force) and Newton (Boscovich 1758, § 2). Also Kant's earlier views on the filling of space have to be considered in connection with this. The *Gedanken* of 1746, in a typical (and fatally flawed) attempt to reconcile Leibniz and Newton, state the possibility of deducing the dimensions of space from the law of forces (§ 10: KgS 1, 24), whereas the latter presuppose for their very definition the concept of distance in space. In the *Monadologia physica*, on the contrary, space is a condition of the law of attractive and repulsive forces: therefore, again, space is already presupposed and not at all deduced from monadic interaction, although Kant will explicitly support such a precedence of space only in 1768 (but see, for instance, *Refl.* 3789-90, KgS 17, 293). If one supposes space to be independent from monads, the determinate filling of space (i.e. the distribution of matter in volumes) lacks a metaphysical foundation: here we have the main problem of Kantian *a priori* dynamics. It is also worth noting that in the *Kritik der reinen Vernunft* Kant seems to share the Wolffian view of monads in space, considering the Leibnizian definition of space as being based on experience and therefore as inadequate to ground the necessary validity of geometry (KrV A 40/B 57). Elsewhere, however, Kant clearly recognizes the difference between Leibniz's and Wolff's monadology (see KrV A 441-442/B 469-470). In later works Kant tries to reconcile his own views with Leibniz's original metaphysics: see MA 507-508 and the essay in reply to J.A. Eberhard, *Über eine Entdeckung, nach der alle neue Kritik der reinen Vernunft durch eine ältere entbehrlich gemacht werden soll*, 1790, KgS 8, 248-249.

² The critique of simple monads in space, in the second Antinomy of the first Critique leads to the primitive concept of the «filling of space» in the *Metaphysische Anfangsgründe*. Here this concept is apparently identified with impenetrability. Impenetrability is included in the empirical concept of matter in KrV A 848/B 876 and MA 472. Indeed, it is elsewhere conceived as the *first* ground of the cognition of matter (see MA 508-510, *Dynamik*, Proposition 5, Proof and Remark; *Prolegomena*, KgS 4, 295, KrV B 278). This priority is clearly restated in the *Phoronomie*, where perception of bodies is a condition of the experience of movement, then of the whole empirical significance of the mathematical study of pure movement (MA 482, 487; compare KrV A 41/B 58; *Refl.* 4648, KgS 17, 624-625). The *filling of space* appears in Explication [*Erklärung*] 1 of the *Dynamik*, without direct reference to impenetrability (MA 496), and is later presented as the application of the category of reality to outer intuition (MA 523). This shift from the filling of space or «solidity» (as the application of the category of reality to outer intuition and an *objective* condition of outer things) to the empirical concept of impenetrability (as the former's *subjective* ground of cognition) is somewhat vague and requires further clarification. But this does not affect our main topic.

impenetrability», while the filling of space (together with the relative position of monads and therefore, apparently, space itself) was the corresponding effect. Now impenetrability – as the filling of space – is the starting (empirical) concept and the *ratio cognoscendi* of a repulsive force, while monads are considered as ideas with no objective reality.³ Nonetheless, the very existence of different sorts of matter in space is again traced back to the contrast between original repulsion and attraction, while the basic concept of mechanical philosophy, absolutely solid matter, is considered to be an «occult quality». Indeed, not only is the filling of space in general reduced to the action of moving forces, but, as Kant writes at the beginning of the *Allgemeine Anmerkung zur Dynamik*, «everything real in the objects of the outer senses, which is not merely a determination of space (place, extension, and figure), must be viewed as a moving force».⁴

In this context, Kant's constant positing of materials such as «aether» or «heat-matter» [*Wärmestoff*] may seem inconsistent. Nevertheless, the positing of one or more materials as being present in physical space appears throughout Kant's writings on physics; moreover, the concern about the role of a cosmic material in a dynamical philosophy of material nature becomes a major

³ The first theorem of dynamics, therefore, presents an inference from the filling of space to a fundamental moving force as its ground: «Matter fills a space, not through its mere *existence*, but through a particular *moving force*» (*Dynamik*, Proposition [*Lehrsatz*] 1, MA 497). I do not intend to discuss this and other arguments of dynamics in detail, but will take for granted the doctrine of fundamental forces and will start from the problem of its actual application to matter in space as an object of outer intuition. For a critical exposition of the proof see Adickes 1924-25, I 188-189. A more detailed analysis of Kant's theorem is provided in Pecere 2004, 55-70.

⁴ MA 523. Cf. KrV B 66-67. The question is whether this «general principle of the dynamics of material nature» (MA 523) is to be taken as merely regulative. On the one hand, it introduces a discussion of properties – such a rigidity, cohesion and chemical dissolution – which pure dynamics «cannot provide» (MA 525 ff.). On the other hand, its first consequence (MA 523-4) is the denial of absolute impenetrability through the dynamical filling of space, which is the main thesis of *Dynamik*. This question of the status of dynamical principles will be of great importance for the aether theory that will take shape after 1786. Among the more recent attempts to deny the probative character of Kant's metaphysics of nature see Buchdahl 1992 (in particular chapters 1 and 10-13) and, on the same line, Brittan 1978, Harman 1982, Kitcher 1984, Duncan 1985, Butts 1986.

topic of reflection immediately after the publication of the *Metaphysische Anfangsgründe der Naturwissenschaft*, which contain the mature formulation of the *a priori* principles of dynamics. Indeed the very possibility of physics, grounded on the concept of moving forces, is associated in late manuscripts (beginning circa 1796) with the existence of a «world-matter» filling every point of space. Now, why does Kant insist on this cosmological principle of physics, and what is this cosmic material that he tries so hard to connect with the purely dynamical metaphysics of matter he defended in the critical system?

Obviously Kant, like his contemporaries, had to derive his idea of aether from a large set of hypothetical fluids and materials, commonly conjectured in physics and chemistry in order to explain different phenomena such as heat, cohesion and light.⁵ In the *Metaphysische Anfangsgründe* he focuses on the function of aether as a ground [*Grund*] of cohesion and different states of aggregation. The fundamental forces, in the demonstrative sections of the work, serve as necessary grounds of basic properties of matter such as impenetrability and mechanical mass. Nevertheless, Kant's dynamical metaphysics is unable to derive *a priori* all of the structural properties of matter: that is, neither the general cohesion of matter (as «resistance to separation» of parts), nor the rigidity of bodies (as resistance to «mutual displacement» of

⁵ As is well known these concepts, unlike – for instance – force and inertia, were not at the time elements of a successful and relatively homogeneous science, such as Newtonian mechanics became at the beginning of the 19th century. The latter, indeed, was still very far from covering every topic of natural philosophy [*Naturlehre*]. From this historical point of view, and considering Kant's resorting to aether, the *Allgemeine Anmerkung zur Dynamik* significantly shares many topics with Newton's *Scholium generale* of the *Principia mathematica* and with the *Queries* of the *Opticks*; and the *Metaphysische Anfangsgründe*, as a whole, still reflect the same division of scientific knowledge into “proper science” and open questions (although Kant's notion of proper science is different from Newton's). Aether theory was a fertile ground for the discussion of these open questions, scattered outside the citadel of proper science. The basic exposition of the development of Kant's aether theory, in the light of 18th century natural philosophy, is still Adickes 1924-25, II, 1-208. Compare also Edwards 2000, 112-144. On aether theories in 18th century Newtonian physics see the acute summary of Heilbron 1982, in part. 38-46, 60-64 and cf. Cantor – Hodge 1981.

parts).⁶ These different problems are in turn related to different hypothetical materials, which were later to be identified.

«How rigid bodies are possible» is finally regarded as «still an unsolved problem», whose solution depends on further empirical investigations. Yet some references are made to «heat» [*Wärme*] or «caloric» [*Wärmestoff*] as a specific material, distinct from aether, responsible for dilatation and elasticity. The exact relation of this material with rigid bodies is far from clear: at first it is considered as mechanically interacting with particles, then as chemically bound to bodies in a way that is explicitly opposed to any mechanical separation. Therefore it is not surprising that Kant does not refer to his own (public and private) hypothetical reflections on caloric and states of aggregation, which take place in these years and will result in the identification of caloric with the missing ground of rigidity.⁷

The uncertainty of Kant's views is even more evident in the explanation of cohesion, which is attempted in very different ways. First, in a Newtonian fashion, a cohesive force of attraction at contact is mentioned. This is not considered a fundamental force, because its action on matter is not required for the possibility of matter – which depends only on attraction and repulsion – and it is subject to various empirical conditions, hence it is not universal and homogeneous. Indeed, the very reality of this attraction, as opposed to the «apparent attraction» produced by external

⁶ For the general limitation of pure dynamics see MA 524-525, where the whole question is connected with the single problem of the determination of different densities of materials. This is indeed the common thread of the whole *Allgemeine Anmerkung zur Dynamik* and the «most important» task of natural philosophy (MA 532). For the distinction of cohesion and rigidity, which was common at the time, see MA 526-7.

⁷ See MA 530 (heat as cause of dilatation of air and mercury), MA 532 (heat as bound to bodies by «chemical penetration», and – like magnetic matter – as not present in empty interstices). The theory of states of aggregation that Kant was developing at the time assumed a primary fluidity of matter and considered rigidity as a consequence of the loss of latent heat. On all these topics, and the related manuscript reflections, see § 2 below. I have adopted here Friedman's translations of «Wärme» and «Wärmestoff», but no choice in translation can sufficiently express the modification of these concepts in Kant's writings of the '80s and '90s, or the stratification of Kant's sources in physics and chemistry.

compression, is doubted, and finally, in order to explain cohesion (and to deny physical vacuum) Kant resorts to the hypothesis of aether forcing matter into shape through its compression.⁸

That it is impossible [to assume empty space] can in no way be proved from its concept alone, in accordance with the principle of contradiction. Nevertheless, even if no merely logical reason [*Grund*] for rejecting this kind of empty space were to be found here, there could still be a more general physical reason [*Grund*] for expelling it from the doctrine of nature – that of the possibility of the composition of a matter in general, if only this were better understood. For if the *attraction* assumed in order to explain the cohesion of matter should only be apparent, not true attraction, and were merely the effect, say, of a *compression* by external matter (the aether) distributed everywhere in the universe, which is itself brought to this pressure only through a universal and original attraction, namely, gravitation (a view that is supported by several reasons [*Gründe*]), then empty space within matter, although not logically impossible, would still be so dynamically, and thus physically, since any matter would expand of itself into the empty spaces assumed within it (since nothing resists its expansive force here), and would always keep them filled.⁹

⁸ Cohesion is mentioned in MA 518 as a not fundamental but derivative property of matter, not metaphysical but physical. Here the derivative character of cohesion apparently lies in its being an attraction «limited solely to the condition of contact». In the *Allgemeine Anmerkung zur Dynamik* cohesive force and the physical conditions of its action are discussed extensively (MA 526-529). First is the fact that cohesion does not act on every other matter at once («collectively») like gravitation, but only on «one or another matter with which it comes into contact» («disjunctively»). Further reasons for the derivative character of cohesion lie in the spatial condition of contact, the lack of dependence on density (according to which, on the contrary, gravity is an essential property of matter: MA 514-515), and the temporal condition of a prior state of fluidity for cohesion to take place at all. Kant's doubts as to cohesion as a real attraction first appear in MA 552, where the very notion of cohesion as a surface force is considered inconsistent (on true and apparent attraction compare again *Dynamik*, Proposition 7, Remark 2, MA 514-515). Here the reference to surface action is connected to «external compression»: this kind of compression as produced by attracted aether is finally examined in MA 563-4.

⁹ *Allgemeine Anmerkung zur Phänomenologie*, MA 563-564. The passage must be read together with *Allgemeine Anmerkung zur Dynamik*, MA 533-534, which is worth reading in relation to our discussion: «In order now to introduce a dynamical mode of explanation (...) it is not at all necessary to frame new hypotheses. It is only necessary to refute the postulate of the merely mechanical mode of explanation – namely, *that it is impossible to think a specific difference in the density of matters without interposition of empty spaces* – by simply advancing a mode of explanation in which this can be thought

The «grounds» that are necessary to support the aether hypothesis, as we will see, may include a hidden reference to the cosmogonical role of aether, as identical with caloric. Before following these hypothetical details, nonetheless, we must observe how the concept of cohesion is connected – as suggested by the reference to «the possibility of the composition of matter in general» – to a more general, not merely empirical question: that of the dynamical ground of definite volumes of matter, which, together with density, are the constituents of material substance.

without contradiction. For once the postulate in question, on which the merely mechanical mode of explanation rests, is shown to be invalid as a principle, then it obviously does not have to be adopted as an hypothesis in natural science, so long as a possibility remains for thinking the specific difference in densities even without any empty interstices. But this necessity [note the shift from «possibility» to «necessity»!] rests on the circumstance that matter does not fill its space (as merely mechanical natural scientists assume) by absolute impenetrability, but rather by repulsive force, which has a degree that can be different in different matters; and, since in itself it has nothing in common with the attractive force, which depends on the quantity of matter, it may be *originally different* in degree in different matters whose attractive force is the same. Thus the degree of expansion of these matters, when the quantity is the same, and, conversely, the quantity of matter at the same volume, that is, its density, originally admit of very large specific differences. In this way, one would not find impossible to think a matter (as one imagines aether, for example) that completely filled its space without emptiness, and yet with an incomparably smaller quantity of matter, at the same volume, than any bodies we can subject to our experiments. In the aether, the repulsive force must be thought as incomparably larger in proportion to its inherent attractive force than any other matter known to us. And this, then, is the one and only assumption that we can make, simply *because it can be thought*, but only to controvert an hypothesis (of empty spaces), which rests solely on the pretension that such a thing *cannot be thought* without empty spaces. For, aside from this, no law of either attractive or repulsive force may be risked on a priori conjectures» – which again reduces the supposed necessity of dynamism to mere possibility. An implicit reference to aether can finally be seen in *Dynamik*, Proposition 8, Note 2, MA 518: «Since every given matter must fill its space with a determinate degree of repulsive force, in order to constitute a determinate material thing, only an original attraction in conflict with the original repulsion can make possible a determinate degree of the filling of space, and thus matter. Now it may be that the former flows from the individual attraction of the parts of the compressed matter among one another, or from the uniting of this attraction with all the matter of the universe [*aller Weltmaterie*]» – which, in the light of later manuscripts, may also be translated as «with all the world-matter». Arguments on aether as the mechanical cause of cohesion appear in manuscript reflections of the '70s (cf. Pollok 2001, 355-356). See in particular *Refl.* 44, KgS 14, 295, where aether also appears as the «Gebärmutter» of all bodies, hence as the primary matter of body formation. This conception, which can be traced back to the *Allgemeine Naturgeschichte* of 1755, will reappear in the *Opus postumum*.

Here, more than anywhere else, the shift from monadology to critical dynamism leads to a major problem. In the *Monadologia physica* material boundaries were considered as the result of the conflict of fundamental forces: the *a priori* law of these forces, largely inspired by contemporary physical speculation on force propagation, involved the determination of a surface of dynamic balance identified with the boundary of «particles». After the critique of physical monadology, the crucial representation of a privileged center of force propagation is no longer tenable, and thus collapses the possibility of a physical monadology connecting (through a single point) metaphysical substance as the center of force propagation and material substance as actually extended matter. Repulsive points no longer have logical precedence over extended matter; on the contrary, *parts* of impenetrable matter are the starting point of the whole demonstrative path of the new dynamics.¹⁰ This must be the reason why the *a priori* law of forces, grounded on basic considerations about force propagation in space, is no longer held to be valid *a priori*, but is (rather clumsily) assigned the status of a «preliminary suggestion on behalf of the attempt at such a perhaps possible construction».¹¹

¹⁰ The metaphysical – or, better, «physiological»: KrV A 845/B 873 – precedence of parts of matter with respect to points is evident in several passages of the *Metaphysische Anfangsgründe* (see *Dynamik*, Proposition 4, Proof and Remark 1: MA 503-505. Compare the passages on the concept of matter in footnote 2 above). Kant is here explicitly criticising a physical monadology where points «would exist as points prior to any possible generation of matter therefrom» (MA 521), like the one formerly held by himself (cf. Boscovich 1758, § 164: «matter is composed of perfectly indivisible, unextended, discrete points»). As is evident from Proposition 4, this is actually a consequence of the analogous characteristic of space: indeed, in the first Critique (second Antinomy) we read that «every part of the composite must occupy a space», while a point is no part of space at all, but only the limit of a given space (KrV A 435/B 463, A 438/B 466), i.e. a mathematical point is no object of a possible experience. On the problem of the shift to a non-monadological theory of matter, regarding the representation of a center of force, see Adickes 1924-25, I 189, Tuschling 1971, 57, 100-103, and Edwards 2000, 134-135. For a more extensive discussion of this metaphysical priority of parts over points see Pecere 2004, 73-87.

¹¹ MA 518. The law of forces is first formulated in proposition 10 of the *Monadologia physica*. It closely resembles Boscovich's law of forces, which was also based on point-monads (Boscovich 1758, §§ 10-15). Kant's source of inspiration, anyway, were common arguments of 18th century Newtonianism about light and force propagation (see Vuillemin 1955, 129-134; Pollok 2001, 320, footnote). The

This rejection of the earlier dynamism cannot take place without affecting metaphysical dynamics. The latter, on the whole, recognizes the possibility of an originally anisotropic *degree* of space-filling (according to the transcendent principle of reality),

Monadologia physica (KGS 2, 484) directly refers to the geometrical argument on force propagation in Keill 1701, 4. Once the existence of monads is denied, in the dynamics of 1786, there is apparently no necessity to consider such geometrical considerations to be theorems about reality. Nonetheless, once the deduction of material volume has been removed, the conflict of forces as a condition of matter remains (MA 508, where the problem, again, is to explain the origin of «a certain limit of extension» for repulsive matter). It could be, thus, that the metaphysical arguments on fundamental forces can be still connected to the geometrical argument on force propagation, leading to the law of forces in two successive steps. In the final words of the long discussion of the law of forces Kant precisely insists on this separation of a metaphysical from a mathematical step, aiming to protect the validity of the first from the dubious character of the second (MA 522-523). This leaves the question open of how can a mathematical argument be hypothetical at all (cf. KrV A 734/B 762ff.). There may be different possible reasons for Kant's hesitations. A serious objection is that the conflict of forces cannot be considered without presupposing mechanical and hence mathematical properties: for how can Newtonian forces – which are not pure movements with a mere phoronomical dimension – be defined at all before non-phoronomical concepts like density and mass, and therefore provide the ground for a determinate extension independently of mechanics? At the beginning of the *Mechanik* chapter, in fact, we immediately find volumes of matter endowed with repulsive force (Explication 2, MA 537), and this is presented as a result of the *Dynamik* chapter (Explication 1, Remark, MA 536). This objection detects a circularity in Kant's argument, and first of all denies any possible separation of metaphysical and mathematical arguments on forces. Boscovich, more coherently, analysed an analogous conflict in merely phoronomical terms: forces produced the reciprocal attraction and repulsion of «material points» and physical extension, as a condition of geometrical contact between bodies, was reduced to such an interplay of «forces» (actually accelerations); mass, finally, was reduced to the repulsive force of several monads connected by a short distance attraction expressed in the dynamical law. This could not be an explanatory and effective model, but it was logically consistent. The same cannot be easily said of Kant's different arguments on dynamical conflict: in 1756, the law of forces depends on given volumes of the spheres of activity, silently presupposing the existence of these volumes, which the monadological interaction should firstly produce. In 1786 the very metaphysical priority of the filling of space and of impenetrability («whereby it [matter] first manifests itself to our outer sense, as something real in space») over repulsive force is recognized, and this produces the obscure withdrawal of the metaphysico-mathematical argument on the law of forces. There is finally an opposition between a deduction and a postulation of volumes of matter, with the consequent analysis of dynamical conflict, although both conceptions appear in the final pages of *Dynamik*. Kant indeed, some pages after expressing his doubts on the deduction of the law of forces, presents volume and density of matter as elementary concepts of physics in the *Allgemeine Anmerkung zur Dynamik*. Only this second kind of solution will be investigated in *Opus postumum* manuscripts of the middle '90s (see below § 2).

but not of an originally anisotropic *distribution* of parts of matter: the latter claim, indeed, belongs to the fictional method of mechanism. Nevertheless the new dynamism, in order to replace the opposite doctrine, still has to somehow connect pure space with continuous matter as a filling of bounded sections of space. In a passage Kant suggests that this connection has empirical grounds: for the very filling of space, through the experience of tactile «feeling» [*Gefühl*], gives us, together with the concept of impenetrability, the concept of «the quantity and figure of something extended» [MA 510]. He also makes clear in the *Allgemeine Anmerkung zur Dynamik* that space, figure and extension do not depend on forces: this, rather surprisingly, seems to nullify every dynamical attempt at determining the surface of contact by the interplay of forces. With such a move, however, the core doctrine of material substance would become merely empirical. Indeed, the very definition of material substance as moving «in isolation from everything else existing external to it in space»¹² is an open problem for the dynamism of 1786. And even if one limits the content of pure dynamics to the admission of fundamental forces as the opposite grounds of the possibility of matter, as Kant does, it is the very representation of these forces which is again affected. For, after giving up the *a priori* law of forces, the very concept of repulsive force as a *surface* force cannot be connected *a priori* to a surface at all, as Kant's definition of contact still requires.¹³ But this means that the compromise

¹² *Dynamik*, Explication 5, MA 502. Cf. Remarks 1-2 to Proposition 4, MA 504-508.

¹³ See Explication 6, MA 511-512, and Explication 7, MA 516. Regarding the presupposition of the volume of matter for the definition of repulsive force and thus for the main arguments of *Dynamik*, Kant could reply that only generic and *undeterminate* volumes are presupposed, according to the transcendental proofs that phenomena must necessarily be extended and have a corresponding degree of reality and the empirical concept of impenetrability. However, the absence of privileged centers of force propagation renders the application of the geometrical arguments still inconsistent. This is evident in *Dynamik*, Proposition 4: here the separation of parts of matter is considered – in direct opposition to the monadist – as perfectly homogeneous to the separations of parts of space. Hence the determination of boundaries of material substances can have no real ground *a priori*. Cf. KrV A 524-525/B 552-553. The transition from metaphysical principles to mathematical physics is therefore still waiting

solution of the old law of forces as a merely mathematical problem which does not affect metaphysics, and the empirical origin of boundary determination cannot save the representation of the conflict of forces. On the other hand, Kant evidently considers the conflict of realities itself as a cornerstone of his natural philosophy to be unshaken. Dynamics, to be sure, provides the «exhibition» [*Darstellung*] of that general metaphysical concept [MA 478].

This inner tension within the *Metaphysische Anfangsgründe* explains not only the resort to aether as an additional ground of coherent volumes of matter, but also the surprising resort, in the core of pure dynamics, to the compression of «all the matter of the universe» as a possible ground of the «determinate filling» of a space by matter, that is, of density itself.¹⁴ Here, in fact, the pure conflict of forces is suddenly replaced by a conflict between original repulsion and attracted matter of the world. Moreover, if only this attracted matter of the whole world is identified with attracted aether, the grounds of the cohesion and of the composition of matter finally coincide. This step is not yet explicitly made, but it is striking how a new representation of the conflict, involving aether, constitutes the focus of manuscript reflections immediately after publication of the *Metaphysische Anfangsgründe*. In 1792, indeed, Kant will recognize a circularity in the conflict of fundamental forces, which once again suggests the necessity of a different conception of the original conflict. The element of the later theory of matter, aether, is clearly present in 1786: only, a pure dynamics cannot be saved by a merely hypothetical addition, and this will be a major topic, and torment, of later attempts to reform the representation of the conflict.¹⁵

for an adequate articulation. Again, note that the whole question will be the central topic of the *Opus postumum* (cf. below footnotes 15, 29).

¹⁴ MA 518, quoted above in footnote n. 9.

¹⁵ A circularity in the conflict model is recognized in a letter to J.S. Beck of 16 (17?) October 1792 and in Kant's preparatory notes to the letter, KGS 11, 375-377, 361-365. This recognition must have led to the concern about the origin of bodies as a fundamental problem of a priori dynamics, which dominates contemporary and later reflections. On this point see Förster 2000, 69-72, who considers this problem as the

A brief analysis of the aether argument can throw more light on this connection between the particular problem of cohesion and the general problem of material substance. Here aether is taken to be an «external matter (...) distributed everywhere in the universe», which is moved by the universal and original attraction and then exerts a pressure on matter itself. Its function, therefore, is to resist the free expansion of matter through empty space. But what is the status of this material? Although itself not perceptible, it is taken to be a reality filling space, and is therefore able to exert a pressure. Consequently, according to Kantian dynamics, it must be an impenetrable (though not coherent) matter as well as the matter it has to compress.¹⁶ Given that such an aether has to have an original attractive force itself, it may be asked how its mechanical action can be empirically determined, given its lack of cohesion.¹⁷ But first of all, if we have to accept Kant's representation of the conflict between such heterogeneous impenetrable matters, the first question is: how can this hypothetical material be detected at all, as *separated* from other matter? Indeed: how can «external» aether, as non-coherent matter, be *distinguished* at all from other materials, if the latter are

origin of Kant's recognition of a «gap» in his system in 1798. On the problem of the construction of bodies compare also Tuschling 1971, 100-103.

¹⁶ Cf. MA 496: «To *fill* a space is to resist to every movable that strives through its motion to penetrate into a certain space». In MA 534 Kant writes that we *think* the degree of repulsion of aether as «incomparably larger» than attraction, and its density therefore tends towards 0. The whole passage suggests that aether is rather an idea of reason than an actual material. Still, given its compressive action, it must be endowed with mechanical properties.

¹⁷ The question regards the mathematical applicability of the aether hypothesis, a question which Kant does not consider very much. Yet his very speculations as to whether the force exerted by a world-material is a dead force (pressure) or a living force (impact) dramatically shows how *some* mechanical representation of aether must be postulated in order to test this hypothesis in mathematical physics: at least, so far as aether and physics were conceived in the 18th century (see, for instance, *Opus postumum*, 'LB 23', KgS 21, 454; 'LB 24', KgS 21, 467-468; 'Oktavenentwurf', KgS 377, 389. Compare MA 551-552 for the same quantitative argument in another context). Finally Kant, reflecting on the status of aether, will recognize that «an absolutely imponderable matter would be one for which there would exist no assignable quantity» ('a Übergang', KgS 22, 208). At the same time, he will replace the older hypothetical reasoning with new kinds of argument about aether (see below § 3).

not originally coherent, but rather derive their cohesion from the pressure of aether? There is a vicious circle, here, for the very ground of cohesion, that is of the force which has to hold matter together in bounded sections of space, requires the distinction of different bounded sections, filled with heterogeneous matter. If this postulate is to be accepted, then matter is already taken as distributed in space according to a system of boundaries, and speculations about aether as the physical ground of cohesion are worth as much as any mechanistic conjecture.¹⁸

In the light of this analysis, the problem of cohesion *presupposes* the problem of determining the figure of matter: as such, it not only marks one of the limits of *a priori* dynamics but, more generally, it also plays a dramatic role in the confrontation between dynamical and mechanical natural philosophy. For the main argument against mechanism refers to the concept of absolute impenetrability of atoms, as a *qualitas occulta*, which is of great help in connecting physics with mathematics (through geometrical intuition), but is at the same time the cornerstone of many unnecessary postulates such as the absolute homogeneity of matter and its distribution according to atoms and void. Dynamical philosophy, on the contrary, is «more appropriate and conducive to experimental philosophy, in that it leads us to the discovery of matter's inherent moving forces and their laws», and it does not require any new hypothesis to be framed. But this account does not tell what actually happened in the dynamics of 1786. For, as we have seen, non-monadological dynamics had to give up the *a priori* deduction of volume from the law of original forces, and therefore could not assign *a priori* boundaries to matter. Hence, in order to provide a transition from general theorems on the possibility of space filling to material substance as an object of experimental philosophy,

¹⁸ This problem was to be further exacerbated by the later identification of aether with heat-matter: for the latter, as we have seen, was already conceived as both separated *and* chemically bound to matter. A similar claim about the circularity of aether as the ground of cohesion was made by Locke, *Essay*, II, XXIII, § 23. It is remarkable that this argument was used to sustain Locke's sceptical view about the ultimate comprehensibility of material properties (here, cohesion): a position held by Kant, in 1786, regarding his fundamental forces (MA 513, 534).

which is now the *only* source – through its movement – for the determination of laws of moving forces, it had to resort to the aether hypothesis. But the latter, if the present analysis is valid, is equivalent to atomistic conjectures. The struggle between dynamical and mechanical principles therefore ends in a stalemate, in which unnecessary (yet possible) absolute impenetrability is opposed to unnecessary (yet possible) aether.

Let us consider the question from another point of view. In the quoted argument about aether, together with the formation of matter, the existence of aether serves to deny empty space. This problem had already been discussed in the Anticipations of Perception chapter of the *Kritik der reinen Vernunft*, where the continuous filling of space (with the consequent denial of empty space) appears as a possible consequence of the law of continuity. There is an apparent contradiction here, for empty space in the world is considered to be in contrast with the law of continuity, because it inserts a gap in the continuum of spatial perceptions («*in natura non datur hiatus*»), yet its logical possibility is not denied.¹⁹ In fact continuity is a property of extensive magnitudes (like pure space) and it does not involve the absence of gaps of reality as such: it merely asserts that no last (i.e. simple) part is to be admitted as component of *continua* [KrV A 169/B 211]. As regards the synthesis of extended reality, the advocated law of continuity claims that no empty space may be possible as an object of experience. Kant suggests – almost tautologically – that this vacuum must violate the «continuous connection of appearances», and later misleadingly writes that the law of continuity «forbade any gap or cleft between two appearances in the sum [*Inbegriff*] of all empirical intuitions in space». Yet, what is actually stated against vacuum is the impossibility to prove an absolute absence of

¹⁹ See the long discussion in KrV A 169/B 211-A 176/B 218, where nothing less than a «transcendental proof» (KrV A 173/B 215) against mechanism is at stake. The quoted maxim, as well as the following quotation, appear in the discussion of the Third Postulate of Empirical Thought (necessity): KrV A 228-229/B 281-282.

reality in space empirically, whether immediately or mediately: not immediately, because such an absence cannot be perceived by definition; not mediately, because the degree of reality can assume infinite degrees in a single extension, therefore no inference from the perception of different degrees of quality (for instance, density) to vacuum can be made.²⁰ Elsewhere, indeed, Kant makes it clear that empty space within the world does not contradict transcendental principles [see A 431-3/B 459-61].

A denial of empty space on the basis of transcendental arguments, nonetheless, appears – and then disappears – in a rather obscure passage of the proof of simultaneity between substances.²¹ Here the necessary interaction between substances (as phenomena) is first presented as a condition of the connection of two coexisting substances through a «path of empirical synthesis»; then absence of interaction is apparently identified with empty space, so that the filling of space becomes a condition of interaction. This depends on a (momentary) identification of

²⁰ KrV A 172-173/B 214. A similar claim is made regarding the intensity of light in MA 519. Cf. KrV A 176/B 217, A 179/B 221. A mechanical version of this argument appears in the *Phänomenologie* of the *Metaphysische Anfangsgründe*, where empty space as a condition of the free motion of heavenly bodies is denied as unnecessary on the ground that «even in spaces completely filled, resistance can still be thought as small as one likes» (MA 564). This passage seems to lead to the conclusion that filled and empty space are indiscernible. This reflects experimental knowledge about vacuum: Torricelli, most significantly, made no distinction between «vacuum» [*vacuo*] and «extremely rarefied stuff» [*robba sommamente rarefatta*] in the description of his famous experiment (Torricelli 1644, 188).

²¹ KrV A 212/B 258-259: «Now if you assume that in a manifold of substances as appearances each of them would be completely *isolated*, i.e. none would affect any other nor receive a reciprocal influence from it, then I say that their simultaneity would not be the object of possible experience, and that the existence of the one could not lead to the existence of the other by any path of empirical synthesis. For if you thought that they were *separated by a completely empty space*, then the perception that proceeds from the one to the other would certainly determine the existence of the latter by means of a succeeding perception, but would not be able to distinguish whether that appearance objectively follows the former or is rather simultaneous with it» [my italics]. Then, after asserting dynamical community as the ground of simultaneity, Kant adds: «I do not in the least hereby mean to refute empty space; that may well exist where perceptions do not reach, and thus where no empirical cognition of simultaneity takes place; but it is hardly an object for our possible experience at all» (A 213/B 261), which refers to previous arguments. The proof of the Third Analogy of Experience also contains a hidden reference to a “world-matter”: see below § 4.

dynamical isolation – that is lack of interaction – with *separation through empty space*. Finally, as if Kant had obscurely perceived his own ambiguity, the possibility of empty space, given necessity of interaction, is restated. Yet the ambiguity is not totally removed, for we would now expect the interaction to be totally independent from a continuous filling of space, whereas Kant leaves the question open (and apparently left to empirical determination): dynamical community can be «mediate or immediate».

One reason for the lack of clarity in Kant's theory of empty space, in the Critique, is the peculiar status of the concept. It is no pure metaphysical idea, like the simple monad, whose merely logical possibility does not affect the field of possible experience at all. Contrary to empty space outside the world, empty space as a gap between (or within) material substances (*vacuum mundanum*) can actually have a place between outer objects, that is, it can be bounded by appearances (though its absence cannot be detected or proved, and therefore has to remain a possibility).²² But this

²² This difference between *vacuum extramundanum* and *vacuum mundanum* is expressed by Kant most clearly in the Remark to the first Antinomy. This passage has to be kept in mind in the present investigation: «Space is merely the form of outer intuition, but not a real object that can be externally intuited, and it is not a correlate of appearances, but rather the form of appearances themselves. Thus space taken absolutely (simply by itself) alone cannot occur as something determining the existence of things, because it is not an object at all, but only the form of possible objects. Thus things, as appearances, do determine space, i.e., among all its possible predicates (magnitude and relation) they make it the case that this or that one belongs to reality; but space, as something subsisting in itself, cannot conversely determine the reality of things in regard to magnitude and shape, because it is nothing real in itself. A space, therefore (whether it is full or empty), may well be bounded by appearances, but appearances cannot be bounded by an empty space outside themselves» (KrV A 431/B 459). Compare the footnote to the Antithesis's Proof: (KrV A 429/B 457), where Kant accepts Leibniz's criticism of Newtonian absolute space and clearly states the status of pure space – considered abstracting from perceptions – as a mere thought-object: «Space, prior to all things determining (filling or bounding) it, or which, rather, give an empirical intuition as to its form, is, under the name of absolute space, nothing other than a mere possibility of external appearances, insofar as they either exist in themselves or can be further added to given appearances. Thus empirical intuition is not put together out of appearances and space (out of perception and empty intuition). The one is not to the other a correlate of its synthesis, but rather it is only bound up with it in one and the same empirical intuition, as matter and its form. If one would posit one of these two elements outside the other (space outside all appearances), then from this there would arise all sorts of empty determinations of outer intuition, which,

possibility to represent empty space in the world, reflecting the views of many natural philosophers, constitutes a serious threat for dynamistic philosophy. For this possibility of empty space is of course, together with the possibility of absolute impenetrability, the principle of mechanical philosophy. The root of the problem, indeed, lies in the nature of this possibility: it is no mere logical possibility (for empty space, being identical with pure extension, does not violate the transcendental principle of possibility, and it can be well represented *in* the world), but it is not yet real possibility (for such a form without reality cannot be perceived). The question, thus, seems to consist in an imperfect distinction between geometrical space, as a representation of pure imagination, and physical space.

Such a distinction appears in the *Metaphysische Anfangsgründe*: here material space is every space (reference system) determined through perceptions, whereas pure space is a merely geometrical form, whose points can be never related with movements in experience. To identify pure space with a real space, which is the categorical mistake made in Newton's absolute space, is to confuse an object of possible experience with a regulative idea. Indeed, in order to stress the *metabasis eis allo genos* committed by the hypostatization of geometrical space, it is made clear that pure space can be itself neither filled nor empty.²³

however, are not possible perceptions. E. g., the world's movement or rest in infinite empty space is a determination of the relation of the two to one another that can never be perceived, and is therefore the predicate of a mere thought entity». This passage provides the transition, as it were, from the Transcendental Aesthetics to the discussion of empty space in the *Metaphysische Anfangsgründe* (see MA 563-64). It reveals a deep continuity with Leibniz's concept of space, which I am not able to discuss here at length (cf. MA 506-508 for Kant's attempt to comprehend Leibniz's theory of space and monads, which is very penetrating indeed and cannot be simply considered as a rhetorical move against Wolffism).

²³ See MA 563. This important statement is repeated in the *Opus postumum*, 'Übergang 12', KGS 21, 588: «Space in general is merely the subjective form of pure outer intuition *a priori*, therefore neither empty nor filled». Critical philosophy therefore admits three different non-dynamical concepts of space: first, space as *pure form of intuition* (which can be itself intuited, as formal intuition: that which leads to the most discussed identification of spatial form with the space of Euclidian geometry); second, *material space* as an empirically set system of reference for movements (whose

Yet material space is not itself a continuum of perceptions, but rather a set of material points that serve to define a reference system in the geometrical theory of movement. Between these points, again, there could be a *vacuum mundanum*. Hence the discussion on empty space leads to the same results as in the Critique: empty space retains its possibility, in spite of being the fundamental concept of a mechanistic physics. Therefore it becomes necessary to resort to aether, as a hypothetical «physical ground» against void. Here we find, starting from discussion on void, the same problem that we found starting from the filling of space. It is one and the same hypostatization of geometrical space that leads, on the one hand, to identify pure extension with physical vacuum, and, on the other hand, to identify extended quality with absolutely impenetrable atoms. Since, if pure space is given as a *physical substratum* of outer reality, one can freely determine parts of this space as empty or filled, forming the world out of atoms and void. In order to eradicate the possibility of such a hypostatical use of quantity and quality, however, the critical philosophy has to find another way to represent dynamical influence and the filling of space. On the way to such a theory, Kant will unexpectedly discover a new problem of the possibility of physics.

2. MISSING CONFLICT AND NEW CONDITIONS OF PHYSICS: *WELTSTOFF* AND THE SYSTEM OF MOVING FORCES (1786-1799)

The *Allgemeine Anmerkung zur Dynamik*, after denying the possibility of a construction of matter grounded on the fundamental forces, contains a critical exposition of the concepts «to which its specific variety must collectively be reducible». These

geometrical properties are identified with properties of formal intuition); third, once real space is defined, *absolute space* as the phoromical correlate of formal intuition, which as such is no longer a geometrical concept (which would be devoid of movement), but rather a regulative idea, corresponding to «only any other relative space, which I can always think beyond the given space, and which I can only defer to infinity beyond any given space, so as to include it and suppose it to be moved» (MA 481). On the concepts of space in the *Phoronomie* compare Vuillemin 1955, 55-60, Cramer 1986, 89.

are actually the missing properties of matter as the object of empirical physics: physical volume and density, cohesion, states of aggregation and chemical solution. Kant's reflections of the following years, from earlier *Lose Blätter* to the so called *Opus postumum*, concentrate on these concepts, leading to a gradual reappraisal of the concept of aether. Indeed the whole aether theory, as long as it was based on physical concepts, had to remain a hypothetical speculation. Only a full rethinking of both the concept and the related arguments leads to the somewhat paradoxical statement, in the late manuscripts, that aether is a «necessary hypothesis».

In order to explain the physical grounds of cohesion and states of aggregation, the earlier *Lose Blätter* (1786-1796) contain a development of the hypotheses of the *Metaphysische Anfangsgründe* on aether and caloric [*Wärmestoff*], which are still treated as distinct materials. The continuous impact of external aether, on the basis of a quantitative argument, appears as the only candidate for the explanation of cohesion. On the other side caloric, through its chemical bonding with particular materials, is considered as a solvent which renders matter fluid, whereas its unbonding is the ground of solidification, diffusion of heat and propagation of light. Throughout these reflections, Kant's hopeful search for a new theory of specific properties of matter is supported by new chemical theories on heat, which receive a mechanical interpretation. Chemical concepts like bonding and solution are conceived in terms of hypothetical vibrations of matter: fluidity corresponds to a dominant vibration of caloric, which dissolves and mixes different materials [*Stoffe*], while the formation of textures arises, after a loss of caloric, from the distribution of vibrating materials according to their different densities. The fibrous structure of crystals, chemically isolated metals and muscles constitute an empirical reference for this theory.²⁴ No

²⁴ For *cohesion* and *density* see 'LB 25', KgS 21, 415-6, 'LB 43/37', KgS 21, 422 (density depends on different repulsive forces, as in the *Metaphysische Anfangsgründe*), and *ibid.*, 423, 425, 'LB 31', KgS 21, 428 (here it depends like cohesion on conflict of vibrating

hint is given, of course, about how to estimate and empirically detect these vibrations and, on the whole, these speculations generically reflect the undeveloped status of Newtonian physics and chemistry, which in these very years was struggling to attain a quantitative foundation.²⁵

materials with aether), 'LB 32', where an estimate of cohesion as regards density and elasticity (= repulsive force) is attempted. The quantitative reasoning states that only *vis viva* ($\infty dm v$), then impact of aether, can contrast attraction ($\infty m dv$) which tends to separate parts of a body, and then explain cohesion. See for example 'LB 23', KgS 21, 454; 21, 467-8, and later 'Oktavenentwurf', KgS 21, 377, 389. The same mathematical relation is already in MA 551, applied to compressed air which holds a weight, and in MA 552. On *caloric* as ground of fluidity see for example 'LB 23', KgS 21, 452-3, 'LB 24', KgS 21, 466. Kant's attempt at an interpretation of chemical bonding in terms of vibration can be seen as another episode of his lifelong oscillation between a substantialist and a non-substantialist view of heat (see Adickes 1922 and 1924-25, II 1-3; Friedman 1992, 291-292). See in particular KgS 14, 443 for the representation of aether vibrations, as well as of inner and outer aether, in the context of the explanation of cohesion.

²⁵ The connection between new interest in aether theory and chemical theories is made evident by several short essays and statements of the years 1784-1798. Slightly before the *Metaphysische Anfangsgründe*, in the short essay *Über die Vulkane im Monde* (1785, written in 1784: KgS 8, 65-76), the hypothesis of an «original material» [*Urstoff*] of celestial bodies suggests a revision of Kant's earlier cosmogony: the formation of bodies from this material, originally diffused in gaseous form, may depend on laws of both chemical and gravitational attraction (KgS 8, 74). The whole theory depends on the chemical science of heat, particularly on Crawford (here mentioned), to which Kant dedicates particular attention in the late '80s (after the *Metaphysische Anfangsgründe*, see *Kritik der Urtheilskraft*, § 58, KgS 5, 348). This attention to chemistry even influences the choice of a new handbook for lessons on *Naturlehre* of 1785 (on the response to chemistry in these years see the penetrating reconstruction in Friedman 1992, 264-290; for the influence of chemical ideas on cosmology cf. Ferrini 2004). Behind the explanations of thermic phenomena lies a hope that chemical bonding with caloric may provide the lacking explanation for different densities, which would thus depend on different "affinities" between specific materials and heat. This is made clear in the short essay *Étwas über den Einfluss des Mondes auf die Witterung*, 1794, KgS 8, 312-323 (in part. 322), which – aside from the limited interest of the topic – is another occasion for testing the possibilities of caloric. The latter, here, is already «imponderable» and «incoercible» (*ibid.*, 321), as it will be in the whole *Opus postumum*. The influence of these new fields of interest on the development of the theory of matter after the *Metaphysische Anfangsgründe* (already stressed by Tuschling 1971, 55) should not be exaggerated. The chemical solution of caloric and bodies, together with the mixing of degrees of repulsive force, can already be found in the *Metaphysische Anfangsgründe* (MA 530-532). Moreover, in the light of Kant's attempt in the *Lose Blätter* of the same years to reduce chemical concepts to wave movements of variously dense matters, it must be stressed that fresh hopes for the physical fruitfulness of the *Wärmestoff* did not affect the *metaphysics* of matter at all. In fact, the new hypothetical applications of *Wärmestoff* attached to Kant's previous view of heat-matter, without shaking its ground, that is the common concept of 18th century Newtonian science: a Cartesian *matière subtile* trying to open its way into the Newtonian world of dynamical interactions, which was familiar to Kant from his early studies of Boerhaave. The

Most remarkable, and new, are the attempts to reduce the variable *density* of matter to a conflict which no longer takes place between the two fundamental forces, but – in different and very fragmentary versions – opposes either repulsive force and attracted aether, or the latter with the internal caloric itself. Here, again, the chemical theory of heat suggests the possibility of a variation in density by solution with caloric, but the whole process is interpreted in terms of dominant and secondary vibrations of materials, and thus as a system of conflicts. Taking the place of the earlier conflict of forces, after the recognition of the latter's circularity in 1792, it shows that Kant was in search of an alternative view. In fact this highly imaginative models will be his last attempts to explain density through a physical conflict. In these *Lose Blätter*, on the whole, no hint is given about how to connect the different explanations of *both* density and

new studies on chemistry were therefore unable to contribute towards solving the major problem of Kant's *Dynamik*, that is the uncertain status of the dynamical theory of matter, and this did not depend so much on a poor understanding of the new chemistry. True, Kant's latest writings fail to grasp the details of contemporary Newtonian chemistry, simply focusing on such general features as the crucial role of balance (even though J.B. Richter studied with him in Königsberg, graduating in 1789 with the dissertation on "The Use of Mathematics in Chemistry"). However, regarding caloric, a very similar uncertainty dominated the foremost expressions of the new chemistry. This is still evident in Lavoisier's *Traité*, where mechanical (but imponderable) *calorique* is given a major role, while being recognized as practically equivalent to repulsive force regarding the description of phenomena (see Lavoisier 1789, 1-8, the opening chapter "Des combinaisons du calorique & de la formation des fluides élastiques aëriiformes", and compare Metzger 1935, 38-44, Thackray 1970, 4-5). This caloric then did not substantially differ, as far as the mere status of concepts is concerned (which is the main problem for Kant), from Boerhaave's «fire» (see Boerhaave 1732, 71, and the whole chapter "De igne". Compare Friedman 1992, 292, who similarly concludes: «Kant's conception of the matter of heat as a universally distributed continuum in a state of perpetual vibration most closely resembles the conception of Boerhaave»). Indeed, the representation of a conflict between caloric and aether (ruling out fundamental forces), which appears as a new possibility in Kantian manuscripts, was originally to be found in Boerhaave (whereas Lavoisier considered cohesion as the effect of attraction between particles). Gehler, *Physikalisches Wörterbuch*, IV, 544-5 perfectly reflects Kant's views on *Wärmestoff*, considering Boerhaave's theory as the «state of art», merely integrated by the new discovery of the «chemical bonding» of heat-matter. Of course, the path towards a quantitative chemistry was just beginning in these years. Kant, although unable to master the details of this development, did not fail to see that concepts such as particles, imponderables and microscopic vibrations were "*a priori* thought", and still awaiting an empirical confirmation (Newtonian masses with their attractions could not intrinsically allow of this confirmation: this condemned his hypothetical efforts to failure from the outset).

cohesion by impact of aether: the proliferation of different views on the fundamental conflict actually reflects the search for a new representation of this concept of pure dynamics, which still lacks a connection with fundamental forces. The extension of the field of possible interactions (attraction and repulsion, both at contact and at distance) merely signifies the requirement of a more complex dynamics, whose actual realization was evidently impossible for Kant.²⁶

Beginning with the 'Oktavenentwurf' (1796), density (under the name of «Ponderosität») is no longer considered as the result of a conflict (though the necessity of this conflict, as we will see, remains in the background), but as a measurable quantity. Immediately, then, the attention is drawn to the fact that conditions of this measuring are properties like cohesion and coercibility of matter, notably in weighing (by levers, or the pulling of a string). The cohesion of the measuring instrument is a condition for its employment: this means that original, yet undetermined moving forces, logically anticipate any mechanical approach to matter in experimental science.²⁷ Afterwards (and largely stimulated by this single example), the concept of moving force has a major role in the manuscripts, and two different kinds of classification appear: the first places moving forces in groups according to their relations in space and time, thus defining disjunctive pairs of properties which can determine a single moving force (such as attraction/repulsion, superficial/penetrating, moment/*vis viva*, and [forces] with finite/perpetual temporal extension). This classification never reaches a definitive arrangement, and always remains formulated as one or more lists. The second kind of classification is a development of the similar classification of the properties of matter in the *Allgemeine Anmerkung zur Dynamik* (including quantity of matter, cohesion, fluidity/rigidity).²⁸

²⁶ A general classification of attraction and repulsion, which summarizes the possibilities explored in earlier leaves, appears in the 'Oktavenentwurf', KGS 21, 387 («attraction and repulsion, both as superficial force (*cohaesio et expansio*) Attraction and repulsion, both as penetrative bodily force (*gravitatio et caloricum*»). Again, all these doctrines were not absolutely new in Kant's thought: see, for instance, aether as «universal repulsive force» in KGS 14, 343.

²⁷ 'No. 3ß', KGS 22, 259, 260. See Förster 2000, 15-17.

²⁸ Earlier versions of the classifications of moving forces are really very diverse and fragmentary (see 'Oktavenentwurf', KGS 21, 374-6), or merely repeat the classification

Contrary to the first, this classification gives rise to extensive critical discussion.

The first classification of moving forces has only one significant connection with the second, and thus with the investigation on body formation which dominates the same sheets: in order to define superficial or penetrating forces (which are the basic tools of the new inquiries on the conflict), one must refer to coherent matter with boundaries. The lack of this concept in pure dynamics, indeed, is still clearly the main issue of the manuscripts. These regard, the project of a «Transition [*Übergang*] from the metaphysical principles of natural science to physics», but the the *Metaphysische Anfangsgründe*, as we read in 'LB 6', offer no actual «material», but «mere forms». Bodies have not been constructed by fundamental forces: therefore the Transition from the metaphysical principles to physics needs the new «*Mittelbegriffe*».²⁹ The dynamical requirements of instruments for the

of the *Allgemeine Anmerkung zur Dynamik* (*Ibid.*, 208-410). Only later will they gradually find a distinct and relatively constant composition: see for instance 'c' (Aug.-Sept. 1798), KgS 21, 287-8 (first classification: attraction/repulsion, moment/*vis viva*, superficial/penetrating, perpetual/[not perpetual]) and 288 (second classification: ponderability, solid/fluid, cohesion, subsistent/inherent). For early versions of the first classification see 'Oktavenentwurf', KgS 21, 387, and 'A' (1797-98), KgS 21, 307-9. In sheets before 'Elem. Syst. 1-7' the one-to-one correspondence with categories often fails, while the reflection on caloric is central. Afterwards there are articulated expositions of the second classification, following the first three titles of categories (the fourth remaining undeveloped until later 'Elem. Syst.' sheets). The parallel development of the classifications involves several tentative shifts. The concept of temporal infinity or finity of the action is transferred to the second classification, which assumes a definite form, including the concepts of ponderability (quantity), cohesibility (quality), coercibility (relation) and perpetuity (modality). At the same time, the first classification tends to replace its fourth concept with universal or limited extension [*Umfang*] of the action (see 'No. 38', KgS 21, 531-532, with both classifications. Cf. 'Elem. Syst. 4', KgS 22, 169-171, where the first classification breaks in two, regarding «space content» and «mode of action» respectively. But in 'A Elem. Syst. 1', KgS 21, 182-183, «perpetuity» returns in the first classification). A more significant overlapping of the two classifications appears in sheet 'A', and regards the connected concepts of surface force and cohesion: this recalls the problem of defining a surface force without postulating coherent matter, which we have found in the *Metaphysische Anfangsgründe*. Kant now postulates coherent *and* rigid matter.

²⁹ In 'LB 6', KgS 21, 474-6, we read that the *Metaphysische Anfangsgründe* give «no material» to physics and the Transition's «*Mittelbegriffe*» have to fill the gap [*Kluft*] between metaphysics and physics. The question is apparently summarized by the question: «how does matter produce a body?» Again, the open problem of cohesion and states of aggregation appears as the main concern of the new theory of moving forces.

measure of mass, thus, appear as no merely physical question, but as a consequence of the limits of the metaphysics of matter: indeed, metaphysics and experimental physics are separated precisely by the «gap» which the new «transition» will have to fill. The new classifications of moving forces, in contrast with physico-hypothetical work (and as an admission of the latter's intrinsic limits, as it were), appear as a recognition that empirical investigation of nature must postulate some basic concepts, such as cohesion of matter, before searching for their explanation, which requires measurement of determinate magnitudes. Drafts of the years 1796-98 confirm this general trend: the Transition project develops along two different tracks, the one concerning moving forces (as conditions), the other regarding aether theory (as an explanation of the former), their connection being the concepts of cohesion and rigidity (exactly as happened since the *Metaphysische Anfangsgründe*).

The concept of moving force, on the one hand, is gradually acknowledged as having a new status. Moving forces are merely «thinkable» forces, which are «thought *a priori*, empirically proved». The doctrine of a transition is thus a «system of application», a «topic» of functions, which as such concerns «the scientist, and not nature as an object»; its concepts are «self made».³⁰ This appears as no more than an extension of the regulative doctrine of reason, presented in the first Critique, and the characterization of the new concepts as «problematic», as well as their occasional organization in disjunctive pairs (ponderable / imponderable; cohesible / incohesible; coercible / incoercible), supports this view. The accent placed on application, nonetheless, suggests that Kant has in mind a new

The centrality of the problem of the possibility of bodies for the whole Transition project, given the continuity of matter in the *Metaphysische Anfangsgründe*, has been rightly pointed out by Tuschling 1971, 179-180 and Förster 2000, 45-50.

³⁰ Some of the clearest passages are to be found in 'α' (1797-98), with its anticipations of real forces regarding form and relations (KgS 21, 504), which concern the scientist and not the object (*ibid.* 506). They are necessary for the definition of *a priori* laws and form a «System der Anwendung» ('LB 3/4', KgS 21, 478), or a «Topic» ('LB 5', KgS 21, 485). The concepts are «selbstgemacht» (unsigned Preface draft, II Fascicle, III Sheet, KgS 21, 176-7). These are defined as «a priori gedacht, empirisch belegt» in 'c', KgS 21, 290, where they are also considered as necessary.

constitutive doctrine of experience rather than a mere rational ordering of experimental results and observations.³¹ Various arguments about the necessity of an *a priori* classification of moving forces are clearly intended to support this second view. The first alleges the dependence of proper science on systematicity and completeness of concepts (this *Leitmotiv* usually opens the drafts of Prefaces to the new work). Still, the classification of the new *Elementarlehre* rather regards fundamental properties of matter, such as ponderability, which are not merely picked up with the guiding thread of the categories, but whose reality must be postulated in order to have an experience of material substances, that is of outer objects which have a quantity of matter (hence volume and density) and a state of aggregation. The perception of an outer object («a stone»), as sheets ‘1-3η’ make clear, cannot lead to a concept of experience without moving forces [KgS 21, 162]: ponderability, for instance, is a condition for the quantity of matter to have a meaning at all [KgS 22, 217]. But coercibility and cohesion (of lever) are conditions of ponderability itself [KgS 22, 255, 259-60; 21, 294]. These properties, which provide boundaries and unity to physical parts of matter and thus belong to the possibility of material substance, are actually the core of the new investigations. Their connection with a «system of moving forces» can be understood in the light of Kant’s general views on dynamics: the objective reality of these properties must be explained by different kinds of possible moving forces (whose action would eventually be brought back to laws by means of mathematics and experiments). From this conceptual “torso”, a system of elementary «forces» begins to take shape, with each property corresponding to an *a priori* condition of physical experience (examples include ponderability, solidity/fluidity,

³¹ This paradoxical statement is put clearly in sheet ‘B Übergang’ (22, 240, 241) where Kant writes of «regulative principles which are also constitutive». Problematicity is stated, for example, in sheet ‘No. 3’, KgS 21, 358 (cf. *ibid.*, ‘3γ’, 21, 366-7; ‘3δ’, 530-1). The enumeration of disjunctive pairs of dynamical concepts, in order to anticipate real oppositions in nature, is clearly introduced in ‘A’, KgS 21, 311 (cf., in the later sheet ‘K’, KgS 22, 357).

cohesion, coercibility, but also heat).³² These new elementary concepts, which Kant tries to order according to the guiding thread of the categories, can give rise, as in the Transcendental Doctrine of Elements, to principles such as: «all matter is ponderable», which is «no empirical proposition» [KgS 21, 295]. With the language of transcendental philosophy, thus, the Transition is connected to a new «schematism of the faculty of judgement».³³ Considering such statements on the status of the new doctrine, it is unclear how the new «*Mittelbegriffe*» can remain merely problematic, and yet behave like new schemata for physics. The widely present question of body formation, indeed, cannot be considered as merely regulative, because it involves the very subject of Kant's «metaphysics of bodily nature»; and most likely the problematicity lies in the classification in itself, the *Eintheilung* of moving forces as a first step and first chapter of a new philosophical work, while successive consideration of these concepts as properties of real outer objects must lead to a judgment of necessity.³⁴ In any case these new methodical

³² See KgS 21, 307, where ponderability appears as «the first function of the moving forces according to the category of quantity» (compare at least 'A Übergang', KgS 22, 226, where the classification of forces is identified with a «system of categories»). Not only, here, appears the language of the *Elementarlehre*. The logical priority of quality (cohesion) over quantity (ponderability), moreover, is analogous to the relation between impenetrability and movement in the *Metaphysische Anfangsgründe*. Again, the crucial step in this new metaphysical deduction of categories lies in the concept of conflict, which must provide the real ground (the cause) of reality in space.

³³ See e.g. KgS 22, 263; KgS 21, 363; KgS 21, 168, 174.

³⁴ This is, indeed, what happened in the *Metaphysische Anfangsgründe*: here we find definitions of attractive and repulsive forces, and even the statement that the latter are the only possible fundamental forces (*Dynamik*, Explication 2, MA 498-99). Still, the necessity of assuming such fundamental forces as conditions of the possibility of matter has to be proved through the representation of impenetrability as a reality in space (*Dynamik*, Propositions 1 and 5). It must be noted that metaphysical theorems were synthetic propositions, that their synthetic aspect was based on pure intuition (of movement), and that it referred to the *possibility* of mathematical constructions in physics. The problem, hence, is simply how the new propositions of the Transition can be at the same time synthetic and *a priori*, without entering into the details of a new doctrine of movement, which could not avoid adopting, at this stage, the constructions of mathematical physics and therefore be identical with the physical theory itself. The crucial point seems to lie in the systematicity of the classification of «moving forces», which is necessary in order to «mould primitive perceptions, whereof the concept of these moving forces is formed, into laws of experience» (KgS 21, 367).

reflections seem to replace earlier speculations on the mechanism of aether, as if a step backwards was being made from hypothetical reasoning to a more abstract consideration of its elements and their possible use in physics.

But this is only half the story. Aether (and caloric, gradually identified with the latter)³⁵ continues to play a major role, and is presented indeed as the very source of objective reality for the new elementar properties. For instance, it is regularly considered as the cause of cohesion, in the context of the new discussion on the lever.³⁶ The shift in the reflections on moving forces only gives rise to doubts regarding the status of aether: it is no object of experience, but rather an idea, and yet a «necessary hypothesis» to explain cohesion, itself incoercible, incohesible and therefore imponderable.³⁷ These may be clarifications of the aether concept which appears in the *Metaphysische Anfangsgründe* and, once again, they may merely introduce, through the idea of an inconditioned condition for basic physical properties, a new regulative doctrine for physical investigations. Still, increasing attention is paid to the characterization of aether as «world-body», or «*Urstoff*», continually and perpetually agitated by original attraction and repulsion. The infinitely divisible «matter in general» of the *Metaphysische Anfangsgründe* is now apparently

³⁵ Regarding this identification, the discussion of which recurs throughout the whole *Opus postumum*, see its early occurrences in 'Oktavenentwurf', KgS 21, 381 and 'β', KgS 21, 256. Friedman 1992, 295 considers this identification as a new acquisition of the *Opus postumum*. Yet this idea is not only present, but even dominant, in manuscript reflections of the '70s and the whole writings of the '80s on science of nature. Indeed, the distinction between aether and heat-matter is typical of the late '90s, and is probably stimulated by the new chemical knowledge. Cf. Adickes 1924-25, II, 38-44, 143-148, 163-165.

³⁶ See e. g. KgS 22, 138-139, 158.

³⁷ The characterization of «necessary hypothesis» firstly occurs in the 'Oktavenentwurf', KgS 21, 378, where, at the same time, aether is «no object of experience», but a mere «idea». Compare, e.g., KgS 22, 587, 595. In some places it is stated that imponderability is relative, that is, it depends on the fact that world-matter cannot be compared with other matters (e.g. KgS 22, 179). At the same time, however, the dependence of ponderability on cohesion, or rigidity, of the lever, introduces the action of heat-matter and the latter's necessary imponderability, as inconditioned condition of weighing (see e.g. KgS 22, 138). This imponderability implies incoercibility, and conversely incoercibility (as an inconditioned condition of coercibility) implies imponderability.

identified with this world-matter, which is the actual subject of the fundamental forces: the cosmological beginning of the *Allgemeine Naturgeschichte* of 1755 is restored.³⁸ Again, however, it is still far from evident (as much as in '55) how secondary matter and bodies can take shape from the continuum of this world-material. Not only the capacity of caloric to chemically bind with any material cannot coexist with its mechanical action (its *vis viva* as cause of cohesion, of droplets, etc.); first of all, since it lacks definite volume and ponderability, how can such a material ever enter into any conflict?

This question, although not new, is crucial for the whole Transition project: for it is this very necessity of a conflict which connects the two heterogeneous threads of the manuscripts, presenting aether as necessary condition of the elementary properties of material substance. The problematic classification of moving forces cannot, in itself, represent any conflict of realities. On the contrary, fundamental properties like ponderability, as realities, are represented by a conflict with contrary realities: after all, this was a main tenet of Kant since the early '60s. But this leads, with apparent necessity, from the system of forces to conflicting aether. This implication dominates the approach to cohesion, considered as an effect of aether percussion, and to states of aggregation, bringing the whole theory of vibrating caloric into play again, and it more generally determines the Transition as a constitutive doctrine grounded on real opposition, rather than as a regulative doctrine grounded on logical regression to first conditions. Indeed, the representation of a necessary conflict logically precedes the latter's determination, as is confirmed by several passages where Kant acknowledges that it is actually an original movement (or moving force) which is needed for the new doctrine, while its identification with the movement of aether is a further logical step. But here we encounter the main problem of the Transition again: this movement

³⁸ This identification of aether with matter in general is already made in reflections of the '70s: see e.g. KgS 14, 334-336. Such a *de facto* identification was not made in the *Metaphysische Anfangsgründe*, probably because a complete theory of body formation, and first of all of different materials, was still lacking.

has to depend on some material substance, for the positing of some new original force is variously rejected (it is here, I believe, that the whole project loses contact with the historical development of physics and, at the same time, fatally tends towards paralogism).³⁹ Now such a substance (like any other existing substance) cannot be the element of any *a priori* knowledge. Indeed caloric itself, as the material which could produce a conflict and explain phenomena, is still recognized as hypothetical, while, as long as Kant tries to determine *a priori* its properties (by mere negative attributes), the crucial representation of a physical conflict becomes impossible. In the end no single coherent concept of caloric is defined, and no pure representation of conflict – and therefore no consistent transition to physics – can take shape.⁴⁰

This situation dominates the sheets that immediately precede, and finally introduce, aether proofs: ‘Elem. Syst. 1-7’, ‘A-B Übergang’, ‘A. Elem. Syst. 1-6’ (circa 1799). Here we find again cohesion of the lever as the effect of a conflict, and once more caloric appears as one side of this conflict, notably as a repulsive agent against gravity. Still, as world-matter, aether now includes caloric as

³⁹ There are different reasons for this rejection, and it is difficult (if not impossible) to say which comes first. In the *Metaphysische Anfangsgründe* cohesive force is already excluded from proper (*a priori*) science because it acts differently in different materials, and is as such not a universal force (that is, not a force whose law can be considered universal, as is instead the case for Newton’s gravity, and as it had to be the case for his fundamental repulsive force). This argument is repeated in earlier phases of *Opus postumum*, where the quantitative argument about the impact of *vis viva* appears, applied to different subjects such as capillarity, the formation of droplets of fluids, and the cohesion of levers and strings. On the other side, as I will argue later, aether appears to Kant as capable of explaining many phenomena, whereas cohesive force appears as an *ad hoc* hypothesis for a single phenomenon. On the separation of these scientific views from the «atomistic» program of many Newtonians see Friedman 1992, 299. A contemporary criticism of the *Metaphysische Anfangsgründe*, which clearly expresses the prevalence of atomism over dynamism in Newtonian mechanics of the time, is in Schwab 1807, see in part. 10-33. The whole book is of great interest both for the analysis of Kant’s work and as text on early 19th century atomism in general.

⁴⁰ The hypothetical status of *Wärmestoff*, as well as doubts about its being a substance or not, reflect the scientific status of the sources. See ‘LB 3/4’, KgS 21, 479-81, where Gehler’s article on “Wärmestoff” in the *Physikalisches Wörterbuch* is paraphrased. On the other hand, the classification of its properties according to negative properties rather reminds one of the formation of pure ideas of reason.

its phenomenon, and the whole conflict dissolves in its internal agitation, in which determinate materials are supposed to arise. The hypothetical status of aether is not overcome, although a new kind of argument appears in support of its existence: movement in the world can have no beginning, and must therefore be considered persistent, but its persistence requires a phenomenic «*primum mobile*», as a real ground, whose existence can be then postulated. Whatever one may think of such an argument this movement, as we have seen, can have some meaning for the Transition project only if it leads to the problematic representation of a conflict, which is still lacking in aether as a perpetually agitating «dynamical whole». This is the main flaw of the present conception of *agitating* aether as the «universal principle of the possibility of all experience» [KgS 22, 197]. On the whole, in order to produce the desired conflict, Kant continues to adhere to the hypothesis of an original material, whereby cohesive force is even said to provide a «circular» explanation [KgS 22, 586]. This position, apparently, is a consequence of Kant's reference to chemistry and the science of heat, where aether seems able to explain phenomena as different as heat, light, and «atmospheres» as causes of friction, while the analogy of magnetic matter, in the present context, does not seem to suggest any consistent hypothesis for dynamism. The scientific context, together with the metaphysical conception of conflict which guides the understanding of the corresponding physical concepts, may indeed explain why Kant feels it necessary to connect his reflections on measurability of mass with the fiction of the imponderable aether, even though his own theory of matter, like a Medusa of mechanism, is doomed to turn every given action of aether into a mechanical process, where imponderable aether cannot by definition play any role. The connection with hypotheses of empirical physics, certainly, explains Kant's hesitations in declaring the apodictic existence of aether, as well as its description as a «postulate» and then as analytical implication of dynamical concepts (for instance, of ponderability: KgS 22, 587, cohesion, 22, 197, then of the whole dynamics, 22, 200). This claim, indeed, has no privileged connection with a dynamistic physics in Kantian sense,

and even the atoms of mechanism can be considered as postulates in the same way: *were it not* for the possibility of connecting this postulate with the representation of conflict. In the light of these difficulties, it is less surprising that, as we are about to see, the next step will be the attempt to set up analytic (and thus not synthetic – at least in the sense of not resorting to pure intuition) proofs (and not postulates) of the existence of aether.

Indeed, as Kant seems to admit at times in these sheets, two different concepts of the reality of world-matter in space set the stage for his reasoning on aether, and eventually for the genesis of a paralogism. First, the filling of space in a physico-dynamical sense, which is, on the one hand, that of ordinary matter (whenever a conflict has to take place), and on the other hand the peculiar presence of an all-penetrating imponderable material (analogical to magnetic matter), which freely penetrates bodies, and thus cannot really produce impacts. Second, according to the very effective formulation of sheet ‘A Elem. Syst. 6’, the transition regards a «filling of the void with forms», which must serve for the «determinability of space and time regarding moving forces». These concepts are hard to connect with the representation of a conflict, but they appear to be coherent with the idea of a new schematism. Indeed, it is in this sheet that the first reference appears to determination of space as a self-affection of the subject, which together with the insistence on the priority of *compositio* over *compositum* – in what is probably a critical confrontation with post-Kantian idealism – refers to a transcendental order of problems.⁴¹

⁴¹ KgS 22, 187. On *compositio* and *compositum* cf. e.g. KgS 21, 274; 21, 633 and the letter to J.H. Tiefrunk of 11 December 1797, KgS 12, 222-225. Here the discussion of the priority of the conscience of a *compositio* over the intuition of the *compositum* appears as an expansion of the critical concept of schematism. The whole passage sounds like a counterpoint to contemporary reflections on the formation of bodies, which in physics has to precede their mere perception, and of the use of the concept of schematism itself. The reference to Beck and his interpretation of idealism is also explicit. Of the same period is a letter to Fichte in which Kant appears far from enthusiastic about the latter’s philosophy: two years thereafter Kant writes the Declaration on the «*Wissenschaftslehre*» (KgS 12, 221-222; 370-371). On the importance of Beck see e.g. T, KgS 353 and Förster 1993, 271-272, footnote 68. Cf. below footnote 75.

At the same time, a new thought has appeared: the investigation regards the possibility of moving forces which «[make an] impression [on] the senses». It is no surprise that such a thought, even though it is by no means an absolute novelty in Kant's thought, begins to assume a new status in these sheets, where the consideration of the subject's own body appears as a unique source of analogy in order to think of moving forces. This subjective aspect of dynamics, affection, is considered – again in sheet 'A Elem. Syst. 6' – as another possible ground to prove aether. It appears on the side of the reasoning concerning ponderability, as if the two regarded the same kind of influence.⁴² Later sheets focus on this influence on the subject, leaving physical conflict aside: still a significant ambiguity in the concept of influence announces itself in this first "aether proof", that will affect the later versions as well.

3. "ANALYTIC" PROOFS OF THE EXISTENCE OF THE WORLD-MATTER IN SHEETS 'ÜBERGANG 1-14' (1799)

The various drafts of aether proofs [*Beweise*] in sheets 'Übergang 1-14' constitute the last extensive treatment of aether, preceding a general involution of the manuscripts towards a more fragmentary form. What then is proved in these arguments? «World-matter», here, is a universal matter in general, distinguished, more explicitly than ever, from physical aether: «be it called aether, or caloric, or whatever it is no hypothetical material (for the purpose of explaining certain phenomena (...))» [KgS 21, 218]. The new concept does not

⁴² 'A Übergang 6': here *Wärmestoff* appears successively as a general «principle of the experience of space and time in the whole of the moving forces of matter» (KgS 22, 605), then as a «concept of the only possible medium in order to make [*anstellen*] experience, inasmuch the latter can be a primitive effect of the moving forces of matter on our senses» (KgS 22, 606), finally as the matter which renders ponderability possible at all, without having a weight itself, then as incoercible etc. (KgS 22, 607). The connection between heat-matter and physical conflict, far from being abandoned, is made most clearly in 'Übergang 13', KgS 21, 610: «Ponderability, coercibility, cohesion and productibility [*Erschöpfbarkeit*] presuppose moving forces, which act opposite to the latter and remove their action».

single out any particular material [*Stoff*], and the old names can be applied to it only «by analogy» [KgS 22, 594]. It is still called a material, being self-subsistent and continuously agitating. Indeed, the crucial aspect for the analysis of its concept and proof lies in its movement: it is determined as both *self-moving* and as continually *moving all bodies*. Being diffused in the whole space it is as such not subject to displacement, and therefore its movement is actually an internal vibration. But is it still a material interacting with other matter so as to form bodies? This old way of representing aether still appears;⁴³ but a different view is tested, and receives by far the greatest attention. This parting of the arguments is perfectly evident in the first draft of an explicit *a priori* proof in sheet 'Übergang 2':

There can be no experience of empty space, nor can it be inferred as an object of experience. In order to be apprised of the existence of a matter, I require the influence of a matter on my senses. Thus the proposition: "There are empty spaces" can be neither a mediate nor an immediate proposition of experience.

The writing continues, without interruption, introducing what actually is a different kind of argument, built on the following core formulation:

The proposition: "There are physical bodies" presupposes the proposition: "There is a matter whose moving forces and motion precedes the generation of a body in time".⁴⁴

The first argument, establishing the existence of a «world material» on the basis of the impossibility of experience of empty space, is the first, brief formulation of the actual proof that will be repeatedly drafted in later 'Übergang' sheets. The second, focusing

⁴³ See for instance KgS 21, 221, about the world-material as «penetrating all bodies and permanently agitating them through attraction and repulsion». Again, a major difficulty arises in connecting this transmission of movement with the material which is «no body» (21, 224) and has no determinate mass. The logical collapse of the whole reasoning is sometimes evident: «Attracting and repelling itself internally, it displaces no other [matter] but wholly penetrates it. It naturally moves primordially in order to be an object of experience» (21, 224).

⁴⁴ KgS 21, 216-217. The following text of the same sheet is quoted below: there we note how the material is «self-moving» *and* «moves» all bodies.

on a moving matter as responsible for the formation of bodies, is the latest version of earlier attempts, actually based on hypothetical reasoning. The different status of the arguments is immediately clear, at a first glance, considering the kind of conditions being referred to in both cases: in the second argument (which I shall call B) the formation of bodies is a physical topic, centred on mechanical or dynamical hypotheses, whereas in the first one (E-proof) the possibility of experience of matter – and empty space – evokes a transcendental order of problems.⁴⁵ Indeed, Kant is trying to ground the physical question on the transcendental question (in the same sheet, the ground of the assertion B is said to be contained in proof E).⁴⁶ Eventually, he will tend to abandon aether as «body forming» (though occasional references to the movement of aether and its effect on matter appear up to the last sheets). The strategy of the new proofs, in fact, is not directly to deduce properties of matter such as states of aggregation (which remain empirical data), but to argue for the existence of aether as a condition of outer perception in general: that is, of perception of distant bodies, and therefore of the quantitative determination of the interposed space which corresponds to this distance. As a name for the corresponding new concept, Kant sometimes uses the very effective formulation: «hypostatized space».⁴⁷

The core of the new proofs (E-proofs) is the statement of the necessary existence of a world-matter as the substratum of a

⁴⁵ Note how in this sheet the *vacuum mundanum*, whose uncertain discussion in the '80s we have seen in § 1, is categorically refuted (KgS 21, 218): «The distinction of matter, insofar as one body in the same space contains more or less of it, cannot be explained *atomistically* (with Epicurus), by composition of the full with the void between it – for empty space is not an object of possible experience at all (since no perception of the nonbeing of a real object is possible; only the nonperception of its being). Consequently, the universe must be thought of as completely filled with matter (without empty spaces, whether inclusive of included (intermediate spaces); for neither of these two are objects of possible experience)».

⁴⁶ KgS 21, 217, quoted below. This hopeful statement is elsewhere abandoned and the fate of the arguments separated: the world-matter will acquire different functions, but it will «not [be] body-forming» (KgS 21, 593).

⁴⁷ See e.g. KgS 21, 224. Here we find another recurrent expression: «perceptible space». Elsewhere the adjective «realized» is also used (e.g. KgS 22, 200).

persisting influence which has to connect any two points of the physical space: the pure representation of this influence, in particular, should provide *both* a condition of outer perception and of the representation of moving forces as responsible for the formation of matter (world-matter, in some versions, is even identified with the system of moving forces, as its «collective» unity). The argument, hence, has to build a bridge between the concept of matter as an object of outer perception – the empirical datum of the *Metaphysische Anfangsgründe* – and the concept of a physical space (material space, or space-matter, as one is tempted to say) as a necessary substratum for dynamical interaction, thus as a condition of dynamistic experimental physics. Therefore, the different E-proof drafts do not begin from physical concepts, such as body, but address the more general concepts which join pure metaphysics of nature and empirical physics, that is space, time and movement. The different proof drafts can indeed be reduced to three different kinds.

The first one (E_s) claims the existence of aether as a necessary condition of the experience of *space*. In some versions, Kant specifies that to have an experience of space means to be able to locate objects in space, that is to have an experience of *distance* (E_{s-d}). This kind of argument is not only the most repeated one, but also – in particular as E_{s-d} – the core of all other transcendental arguments, as I will try to show.

The second one (E_m) argues that, without the admission of the cosmic material, the experience of *movement* cannot take place.

The third one (E_t) makes an analogous claim starting from the *origin of movement in time* (or, rather, from its necessary perpetuity). Indeed, it corresponds to the earlier claim about the *primus motor* as a condition of the perpetuity of movement.⁴⁸

⁴⁸ This is called «cosmological argument» in Carrier's classification of the arguments on the existence of aether, which also includes a «chemical» and a «transcendental» argument (Carrier 1991 224). It is also recognized as one of four arguments about aether by Guyer 1991, 122. As I claimed before, this argument makes a non-critical, metaphysical claim about movement (in the spirit of Aristotle: cf. *Physics*, 251 b), but this movement must in some way be connected with the other concepts of the Transition. In sheet 'A Elem. Syst. G' this connection is apparently provided by the agitation of aether as the cause of body formation (thus connecting the movement of

In later sheets, a generalization of the proof (E_{exp}), which is not independent, simply denotes aether as a condition for the unity of perceptions: what actually presupposes the other arguments.⁴⁹

aether with what Carrier calls the «chemical» argument). Here, as I will argue later, movement plays a different role, connected with the possibility of perception, and therefore with a transcendental claim. A similar distinction of «formation of material bodies» from possibility of perception is made by Förster 2000, who separates in the latter problem two different claims, one about perception in itself, the other about the possibility of perception of space. Similarly Guyer 1991, 121-122, with the other three arguments of his classification, points 1-2 (perception of space itself) and 3 (perception of outer objects). In the following discussion I will take into account the critical work by Mathieu 1991, 117-133, Friedman 1992, 290-341 and Förster 2000, 82-101, which opened the way to the difficult task of understanding this last demonstrative effort of Kant being neither too critical nor enthusiastic. More recently, compare also the very detailed analysis in Emundts 2004, who also recognizes a transcendental claim on the possibility of experience as different from the claim on body formation (179-8).

⁴⁹ Here follows a list of proof drafts, with an indication of the original sheets and pages (including margins), KGS volume 21 page numbers and lines, and kind of argument. It is only an orientative classification, because of the frequent logical leaps, mixing of different arguments, and obscure lines in the manuscripts, which should be analysed in detail. Moreover, some of the drafts are actually short summaries of a few lines. 'Übergang 2', p. 1: 216 12-16 (E_s) and 216 16-217 7 (B) – the first statements quoted above –; 217 7-17 (E_s). 'Übergang 2', p. 2: 217 23-218 17 (E_i), 218 19-27 (E_s), 219 5-22 (E_{m+s}). 'Übergang 2', p. 3: 219 25-220 14 (E_s), 220 16-26 (E_s). 'Übergang 2', p. 4: 223 10-224 2 (E_m). 'Übergang 3', p. 1: 225 12-26 (E_{s+i}). 'Übergang 3', p. 2: 226 25-227 8 (E_{s+i}), 227 13-22 (E_i), 227 27-228 23 (2 times E_s). 'Übergang 4', p. 1: 229 15-30 (E_{s+d}). 'Übergang 4', p. 2: 232 21-233 14 (E_s), 233 16-23 (E_s+B). 'Übergang 4', p. 4: 236 8-237 3 (E_s). 'Übergang 6', p. 4: 246 5-29 (E_s). 'Übergang 7', p. 1: 535 10-536 9 (2 times E_s . Here appears also the earlier quantitative argument about *vis viva* of aether as an explanation of given phenomena). 'Übergang 7', p. 3: 539 22-540 12 (E_s), 542 3-543 11 (E_s). 'Übergang 8', p. 2: 547 7-21 (E_s), 547 22-548 4 (B). 'Übergang 8', p. 3: 549 28-550 9 (E_s). 'Übergang 8', p. 4: 551 12-25 (E_{s+i}). 'Übergang 9', p. 3: 559 5-560 8 (E_s , deleted). 'Übergang 9', p. 4: 560 23-561 12 (E_s , deleted). 'Übergang 10', p. 1: 562 21-563 15 (2 x E_{s+d} : deleted. Here also a short reference is made to aether as providing the original repulsion which enters into conflict with attraction, thus avoiding collapse of matter in one point: this recalls the attempt, in the 'Oktavenentwurf', to substitute original repulsive force with caloric). 'Übergang 11', p. 1: 572 25-573 14 (E_s). 'Übergang 11', p. 2: 575 12-19 (E_s). 'Übergang 11', p. 3: 576 10-577 4 (E_s+E_i), 577 16ff. (E). 'Übergang 12', p. 1: 581 13-24 (E, deleted), 582 17-583 19 (E_s). 'Übergang 12', p. 2: 585 22-586 5 (E), 588 17-589 3 (E). 'Übergang 12 Bogen a) S.2', p. 1: 589 21-590 9 (E_s). 'Übergang 12 Bogen a) S.2', p. 2: 591 22-592 15 (E). 'Übergang 12 Bogen a) S.2', p. 3: 592 17-593 5 (E). 'Übergang 12 Bogen a) S.2', p. 4: 594 15-596 7 (E). 'Übergang 12 Bogen b) S.2', p. 2, 600 1-8 (E). 'Übergang 12 Bogen b) S.2', p. 3: 601 7-603 2 ($E+E_s$). Claims about the existence of aether as the «collective unity of all objects» and its being a general condition of possible experience in general, without direct reference to the problem of empty space and time, are classified simply as E. Caloric, being the condition of reality in perception, is sometimes described as a phenomenical correlate of the ideal of pure reason (regarding this analogy cf. Friedman

Here are some of the clearest drafts of the different arguments (italics, with the exception of single words, are mine):

[E_s: *Übergang* 2, p. 1, KgS 21, 216-217]

There must exist a matter which, as internal, penetrates all bodies (as onus), and, at the same time, moves them continually (as potentia). It amounts to a whole, which (as a self-subsistent cosmic whole) is internally self-moving and serves as the basis of all other movable matter. Independently, [it] forms a cosmic whole from a single material (signifying merely the existence of a matter, without its particular forces – thus, in general). In this condition alone, it has moving force and – deprived of all other forces except that of its own agitation – maintains all the other moving forces in their constant and ubiquitous vigorous activity. *The ground for this assertion is: Intuitions in space and time are mere forms, and, lacking something which renders them knowable for the senses, furnish no real objects whatsoever to make possible an existence in general (and, above all, that of magnitude). Consequently, space and time would be left completely empty of experience. This material, therefore, which underlies this generally possible experience a priori, cannot be regarded as a merely hypothetical, but as a given, originally moving, world-material; it cannot be assumed merely problematically, for it first signifies [Bezeichnet] intuition (which would otherwise be empty and without perception).*

[E_{s=d}: *Übergang* 3, p. 2, KgS 21, 228]

The whole of cosmic space as an object of possible experience is not empty in any of its parts, but is a full space, for empty space is not an object of possible experience. This material which must be attributed to it in this regard is, with its properties (filling, presence – in the form

1992, 300-316, Förster 2000, 91). The claim of the existence of aether, nonetheless, depends here on the relation between world-matter as the system of moving forces and possible experience as a synthesis of perceptions. This relation, in turn, depends on the perpetual, dynamical filling of the whole space as the ground of outer perceptions which is discussed in the other kinds of proofs. Hence the reasoning about the possibility of experience is not grounded in mere concepts (like unity of experience, or even existence, as some lines can suggest), but always refers to the conditions of outer perception. Therefore, I do not consider these generic arguments – and the arguments of the ‘Übergang’ sheets in general – neither as expressions of an «ontological» proof of aether (cf. Mathieu 1984, 35-36, and, to a lesser extent, Mathieu 1991, 117-121), nor as the connection of regulative and constitutive principles of the critical system (cf. Friedman 1992, 304). It is rather the particular problem of outer perception which is always at stake, and which Kant tries to connect with the new *Elementarlehre* of moving forces in physics (then with the problem expressed by the gap between regulative and constitutive principles of natural science).

of the occupation and penetration (permeability) of all spaces), not a hypothetical material, but one that emerges from a priori concepts, according to the law of identity. For, *in virtue of this all-penetration, the unity of this material (as of space itself) is the highest principle for the possibility of experience of outer sensible beings (...). In virtue of the fact that it must be presupposed in order to determine the location in space of each matter, it is not a mere thought-object but, movable and moving, is everywhere homogeneous and unique of its kind (...)* If one speaks of attraction through empty space, then it is merely an idea.

[E_{s=d}: *Übergang 4*, p. 1, KgS 21, 229]

That by means of which space becomes an object of possible experience in general (*measure, direction etc.*) is a universally distributed, all-penetrating world-material, possessing moving forces; its actuality rests solely on the principle of the possibility of outer experience and is thus known and confirmed a priori, according to the principle of identity. For, without presupposing this material, I could not have any outer experience at all: Empty space is not an object of possible experience.

[E_m: *Übergang 2*, p. 4, KGS 21, 223]

Theorem [Lehrsatz]

Primordially moving matters presuppose a material, penetrating and filling the whole of cosmic space, as the condition of the possibility of experience of the moving forces in space. This primary material is not conceived hypothetically, for the explanation of phenomena; it is, rather, identically contained for reason, as a categorically and a priori demonstrable material, in the transition from the metaphysical foundations of natural science to physics.

Proof [Beweis]

The motion of matter in empty space is not an object of possible experience; so neither is the transition from what is full, via the void, to the full [again]. There can thus be no motion for the senses, and hence no forces moving them, save in a space filled with matter; for of this alone is it *possible* to have experience.

[E_i: *Übergang 2*, p. 2, KGS 21, 217-218]

Of the primary motion and the primordially moving matter (*materia primitiva movens*)

Matter, with its moving forces, can initiate a motion only insofar as it either sets itself in motion externally (*vis locomotiva*), or else sets each of its parts in motion relative to every other – hence internally (*vis interne motiva*). However, any absolute beginning of the motion of a *matter* is inconceivable; if it is conceded, the cessation or diminution of the motion is, then, just inconceivable – for the hindrance or resistance in the abolition of motion is itself, equally, a moving force (in opposition). To a prime mover (*primus motor*) one would have to attribute spontaneity – i.e. a willing – which wholly contradicts materiality. There follows this *a priori* valid proposition (not derived from physics – and thus empirical – but belonging to the transition from the metaphysical foundations of natural science to physics): “There exists a matter, distributed in the whole universe as a continuum [etc.]”.

Kant’s argument in E_s, expounded in very intricate sentences, can be outlined as follows. Were some part of space empty, it would be impossible to have an experience of matter as an object in space. For each time we refer to a distance in space, we assume that a continuous path must be crossed by some «transition» of reality, joining the subject as located in space to the place of distant matter: through this «transition» arises perception of distant realities. Now, how does this physical condition of affection lead to the hypostatization of space, that is to the *permanent* filling of *every* point of the continuum? For this crucial step I suggest the following reading:⁵⁰ we can retrace the paths connecting bodies (included our own) by subjective flows of visual perceptions; in order to identify any of these retraced paths with spatial intervals, we must assume that all the points along the lines continue to exist as locations of a real spatial continuum, even if they are not perceived or directly perceivable. Otherwise, there would be no reason to identify intervals in the manifold of perception with distance as a mathematical

⁵⁰ In order to understand Kant’s claim on empty space as no object of possible experience, and therefore as opposed to hypostatized space, I read the aether proofs with the help of earlier passages from the Critique on continuity (see above § 1) and on interaction (see below § 4). On the latter connection, cf. ‘K’, KgS 22, 359: since experience is always one, «it follows that the moving forces in space affecting the sense of the subject are, in virtue of their coexistence in space, already moving in all parts of the latter (for an empty space is no object of possible experience)».

concept (in this sense space as the pure form of intuition is itself no object of experience, and formal intuition cannot be identified with intuition of physical empty space: it refers, indeed, to the space of pure geometry).

Such a physical continuum is actually a condition of outer perception. As the collective representation of this reality of space, indeed, there must be a continuous (i.e. not at a distance, without gaps) and perpetual interaction between every two points of space: for such an activity crossing the paths renders the latter objects of a possible experience (eventually of measure), when the subject locates itself at the corresponding places. But a continuous interaction in space propagates as a movement (be it translation or vibration), and a movement involves a movable in space. Therefore there must be – as a condition of outer experience itself – a «self-subsistent» material filling every point of space as a substratum of this permanent movement. Kant calls such a material «world-matter», but also «perceptible space», «hypostatized space», «realized space» – indeed, it is a pure spatial extension endowed with reality (as ground of movement and therefore of perception) in every time (substantiality): the space of possible experience without qualitative *hiatus*, which the Transcendental Analytic was unable to prove.

According to my reconstruction, all arguments of the kind E_s can be reduced to E_{s-d} : the argument concerning empty space – if space is considered as the continuum of metric relations – is actually the generalization of the one concerning the experience of distance. At the same time, it is equivalent to the ones focusing on movement (E_m): for space is here identical with the system of distances joining points, and movement of a point (the same concept of the *Metaphysische Anfangsgründe*, to be distinguished from the movement of world-matter, which appears in the conclusion of the proof) is the change of its distance from other points. As to the proofs concerning the permanency of a cosmic movement in time (E_t), they actually state the impossibility of empirically assigning temporal limits to a universal movement: hence – as far as they have to prove *a priori* the existence of this movement and their substratum – they already

assume this movement in every point of space as a condition of experience, simply discussing its permanency for the sake of the unity of experience.

The fundamental corollary of these proofs, which is not so clearly stated as the proofs themselves, is the possibility of an application of «moving forces» to physical space.⁵¹ Here, indeed, two different connections are foreshadowed between world-matter and the system of moving forces. The first, much in the transcendental spirit of the proofs, can be traced back to the «determinability of space and time», hence to the experience of space as a condition of the representation of movement and therefore of Newtonian moving forces. The second connection, through the primordial activity of world-matter, introduces again the earlier cosmological theory of body formation (B-proof): physical space would be filled in every point and in every time with some dynamical activity (thanks to original «moving» aether); hence the moving forces classified in the elementary system, as specific functions of the dynamical activity of matter in space, would be ready to be applied to the manifold of perceptions in order to realize a dynamical community. Therefore we have two different arguments, one grounded on movement as the *ratio cognoscendi* of force, the other on primordial activity as the *ratio essendi* of force, while the desired conclusion is the same: the physical concept of moving force, which receives in Newton a merely mathematical foundation, has to gain objective reality, and – given the completeness

⁵¹ Aside from direct reference to the possibility of moving forces in the proofs, it must be noted how Kant several times considers the aether proofs as a medium between the «Elementary System of Forces» and the «System of the World» (which would be the territory of physics itself). Cf. Mathieu 1991, 78-80. However occasional, this idea clearly recalls the structure of Newton's *Principia*, where Books 1-2 contain a mathematical study of possible motions and Book 3, «The Motion of Bodies», contains the application of moving forces and the determination of real motions on the basis of astronomic phenomena. Indeed, the transition from mathematical moving forces to the real forces of physics constitutes the main topic of a criticism (or integration) of Newton in Kant's manuscripts of these years. Moreover, by providing this «realization» of moving forces, the activity of aether would provide that primordial movement which Newton had to refer to a supernatural cause.

of an elementary system of forces – a perfect transition is to be made from the metaphysical principles to physics as experimental science.⁵²

Now, which kind of proofs is expressed by these arguments? And what is their logical ground? It is made immediately clear that «the ground of proof [*Beweisgrund*] is subjective and derived from the conditions of possible experience» [KgS 21, 221]. According to Kant's doctrine of proofs, this means that they are, as all philosophical proofs, «acroamatic» proofs: that is proofs grounded on mere concepts. Indeed, on the one hand, no empirical intuition can prove the existence of aether, which would thus be a mere empirical concept. On the other hand, according to Kant's concept of

⁵² The fundamental ambiguity of Kant's «moving forces» will finally make impossible the formation of a single consistent argument (see below § 5). Yet another argumentative thread, which I do not discuss at length, relates «moving forces» to «materials» in a chemical sense, and considers caloric as the «primitive material» and «Basis» for the latter (see, e.g., KgS 21, 605; KgS 22, 359). This sort of reflections is closely linked to Lavoisier's chemistry by Friedman 1992, 311-316, who convincingly compares these «Stoffe» with Lavoisier's «éléments». Yet the very notion of heat-matter as a «basis» of elements and of these as «foundations [*Grundlagen*] (basis) of moving forces» is obscure, and indeed a major difficulty arises in connecting this chemical universality of caloric (in the sense of Lavoisier) with its body forming function and «moving force». Once again the problem lies, in my opinion, in the connection of chemical concepts with physico-dynamical representations. On this point, I disagree with Friedman's opinion that Kant's earlier search for a Newtonian chemistry (with specification of some «law of approach or withdrawal of the parts», MA 470-471) is abandoned, and that «in the period of the aether-deduction, Kant has come to see that a unification of physics and chemistry – and thus a truly scientific chemistry – can be elaborated in an entirely different fashion» (Friedman 1992, 311; but see 317-318, where a similar recognition of the outlined problem appears). Indeed attraction, repulsion and vibrations of aether are still the only means for an understanding of chemical bonding, as well as of body formation. It is precisely this understanding – itself actually a *desideratum* – that grounds the connection of aether as a «basis» with the system of moving forces and the main transcendental argument on the possibility of outer experience. Kant's approach to chemistry is still Newtonian and adequately outlined by the words of the *Metaphysische Anfangsgründe*: «So long, therefore, as there is still for chemical actions of matter on one another no concept to be discovered that can be constructed, that is, no law of the approach or withdrawal of the parts of matter can be specified according to which, perhaps in proportion to their density or the like, their motions and all the consequences thereof can be made intuitive and presented a priori in space (a demand that will only with great difficulty ever be fulfilled), then chemistry can be nothing more than a systematic art or experimental doctrine, but never a proper science, because its principles are merely empirical, and allow of no a priori presentation [*Darstellung*] in intuition» [MA 471].

sensibility, no pure intuition of matter is possible. It is rather space and time, as mere forms, which «lacking something which renders them knowable for the sense, furnish no real objects whatsoever to make possible an existence in general (and, above all, that of magnitude)». World-matter is thus a condition of the experience of space and time, and itself a condition of empirical intuition, therefore «it cannot be assumed merely problematically, for it first signifies [*Bezeichnet*] intuition (which would otherwise be empty and without perception)». World-matter exists because it yields the real ground of perception which is transcendently necessary to state the existence of any object. In the light of this peculiar reference to perception, Kant is able to argue that only a discursive argument can prove the existence of world-matter and that, in this sense, the latter is «given through reason alone».⁵³

In this determination of the subjective *Beweisgrund* some very general features of outer experience are taken for granted: first – according to doctrines of the Transcendental Aesthetics which Kant will never put in doubt – the very reference of perceptions to objects in space (space being a pure form of intuition) and, second, the conception of outer perceptions as grounded on affection of the senses. Together with these general premises, the core of the «Weltstoff» proofs lies in the dependence of outer affection itself on a logically two-layered universal filling of space: first, some continuous influence which *in some way fills* space (in order to give reality to spatial points, providing distance as an object of experience); second, identification of this filling with a permanent universal movement of a material substratum, which *acts on the senses* (in order to identify this continuous filling with a causal interaction). This qualitative and causal determination of the physical continuum, finally, renders possible *at once* outer perception itself (as grounded on movement affecting the senses) and physics (as grounded on the filling of space with moving forces). Given the general conditions of outer experience,

⁵³ On transcendental proofs [*Beweise*] as acroamatic proofs see Kgs A 713-738/B 741-766, in part. A 735/B 763, A 783-794/B 811-822, *Refl.* 5645, Kgs 18, 291 and cf. Capozzi 2002, 580-585.

together with their interpretation through these *termini medii*, Kant is finally able to write that existence of the world-matter follows «analytically». Thus the same conditions provide the grounds for the proofs and the determinations of the world-matter as a self-subsistent continuum. There follows that a further examination of the proofs must result mainly from the analysis of these conditions which they assign to physics. This I will do in the following paragraph, trying to understand the somewhat obscure reference to influence in these sheets in the systematical context of the critical thought.

4. AFFECTION, INFLUENCE AND PERCEPTION OF OUTER OBJECTS

At the very outset of this examination, following argument E₃, we find immediately the claim of an influence of matter on the senses: «To be apprised of the existence of a matter, I require the influence of a matter on my senses». This apparently empirical proposition has deep roots in the critical system. In the *Kritik der reinen Vernunft* affection of the senses is a distinctive mark of sensible intuition, as opposed to concept, which is grounded on a function of understanding. Affection is originally a metaphysical concept, which contains the concept of an influence, that is of a causal relation between substances. In the whole Transcendental Doctrine of Elements, nonetheless, the concept of empirical intuition does not depend on representations of substantial interaction. As to outer intuition, space is defined as the pure form of external objects, and sensation as that which gives empirical content to this form, corresponding to matter. But here – as later in the Transcendental Analytic – matter is not yet matter *in space*, nor the *correspondence* between matter and sensation can be identified with any determinate representation of affection. The doctrine of elements was not the place where the nature of such an affection, regarding inner or outer objects, could be specified.⁵⁴

⁵⁴ Among the different meanings of the word ‘matter’, in the first Critique, most refer to the content of perception in general, but not to the content of *outer* perception.

Such a place could be the *Metaphysische Anfangsgründe der Naturwissenschaft*, where matter is considered as the object of the outer senses [MA 481]. Here, indeed, an explicit physical determination of affection is stated in a rather enigmatic proposition, which introduces the general determination of matter as the movable in space. «The basic determination of something that is to be an object of outer senses had to be motion, because only thereby can these senses be affected» [MA 476]. Following this proposition, in the four sections of the work, all the properties of «matter in general» will be traced back to movement. This proposition contains the most general principle of the metaphysics of bodily nature: only motion can provide outer sense affection; therefore the object of outer senses must be «the movable in space» and produce, with its movement, empirical intuitions of matter. A brief analysis of this statement can show the uncertain relation between sense affection and influence, and help to understand the fate of these concepts in the *Opus postumum*.

It is far from evident how movement can produce affection, without the introduction of additional empirical claims on the nature of sense organs. But more importantly it is the concept of movement itself which is taken here in a different sense as throughout the rest of the work: it is not the purely phoronomic change of spatial relation, which will provide the intended reduction of material properties to a pure doctrine of motion; it is rather the transition of a causal influence through the path connecting sense organs and matter. Kant elsewhere identified such an influence with a *moving force*, rather than with a movement: a very common opinion, which was better fitted to provide a physical determination of a causal connection. However, moving force was, in the critical system, an empirical concept, as such

The physical concept, which is central in the *Metaphysische Anfangsgründe*, is sometimes mentioned [e.g. KrV, B 646], but plays no role in the Transcendental Logic, because it refers to a *particular* object of experience, not to an object of experience *in general*. The same can be said about affection: this concept, taken from metaphysics, regards both inner and outer sensations. I leave aside, here, the concept of affection as an effect of non-phenomenal things, which, if taken as actually accepted by Kant after 1770, gives birth in the critical period to the doctrine of a «double affection»: one noumenal, the other empirical [see Adickes 1929].

insufficient to ground any *a priori* inference. This relation between moving force and outer perception, indeed, cannot be found in Kant's published works. It seems, in the end, that the whole subjective foundation of metaphysics of matter through the concept of sense-affection was in need of a deeper understanding.⁵⁵

The nature of this open problem, from the standpoint of the *Metaphysische Anfangsgründe* of 1786, can be better outlined through further analysis. Sense affection requires three elements: outer objects in space, space itself as pure form of outer sensible affection, and sense organs as objects in space. Starting from these elements, how can a fundamental concept for an inquiry on the possibility of mathematical physics be defined? In the *Metaphysische Anfangsgründe*, Kant takes the empirical concept of matter as an empirical datum, and reduces its marks (like movement and impenetrability) to the pure representation of movement as a change of relations in space. This gives the possibility of an inquiry on the different properties of matter which can happen *a priori* (through pure intuition and with the guiding thread of transcendental principles). Eventually, this inquiry leads to proofs of new metaphysical principles regarding the possibility of mathematical physics (like the theorems on the fundamental forces of matter, or the law of inertia). Such an argumentative path should allow the construction of an *a priori* doctrine on empirical basis, because the particular properties of matter (and sense organs) play no role in the actual proofs regarding the essential properties of matter in general as an object of outer senses. But even if we allow such a distinction between the finite

⁵⁵ Regarding affection cf. KrV B 93. On force as the cause of outer perception see *Refl.* 35, KgS 14, 111, and 42, KgS 14, 182ff. Cf. *Refl.* 40, KgS 14, 119, where Kant draws the consequence that force is the principle of all material phenomena. The same thought is expressed more clearly in different *Nachschriften* of physics lectures: 'Berliner Physik', KgS 29, 75, 'Danziger Physik', KgS 29, 139. According to Lehmann, KgS 29, 667, the words of the 'Berliner Physik' paraphrase a line of Feder 1767, II, 4, § 3. In any case this view of sense affection was very common at the time in physics and metaphysics (see the references in Pollok 2001, 152). The problem of connecting movement (rather than moving force) and affection is evident – yet not recognized by the author – in several places of the *Opus postumum*: see e.g. KgS 21, 573, where movement appears as the cause of «excitation» [*Erregung*] of the senses.

properties constituting the logical essence of matter and the infinite empirical properties characterizing its nature,⁵⁶ another problem lies in the *connection* of matter and sense organs, which is the object of Kant's statement on affection in the Preface to the *Metaphysische Anfangsgründe*. The empirical intuition of matter, which constitutes the first step towards these principles, is grounded on a movement affecting sense organs, hence a new task immediately arises for a pure science of nature: the connection between subject as outer sense-object and matter in space has to be traced back to *a priori* conditions, independent from physiological knowledge. This means, from the point of view of the late manuscripts, that the very *existence* of distant matter in space cannot be assumed as a mere analytical consequence of the metaphysical definition of matter. A new *transcendental* problem lies in the concept of outer affection.⁵⁷

The same problem, indeed, can be derived from the third element of sense-affection, space itself, considering the concept of material space introduced in the Phoronomy. Pure space of the Transcendental Aesthetic, although itself the form of outer intuition, cannot be immediately employed in a doctrine of motion: for experience of motion requires perception of both terms of the spatial relation, matter *and* space.

In all experience something must be sensed, and that is the real of sensible intuition, and therefore the space, in which we are to arrange our experience of motion, must also be sensible – that is, it

⁵⁶ On logical essence see *Logik* ('Logik Jäsche'), KGS 9, 61 and the extensive commentary in Capozzi 2002, 499-518.

⁵⁷ Compare a marginal annotation in sheet 'Z', KGS 22, 535, where Kant considers his new inquiries on the possibility of outer perception as grounded on a different concept of matter as in the *Metaphysische Anfangsgründe*: «Matter is what makes space into an object of the senses. (Object of possible perception.) (The definition that it [matter] is the movable in space is the consequence thereof)». This transcendental function must be provided by moving force, and this (logically very ambiguous) step connects this new definition of matter with the dynamical definition of matter as having «moving force»: 'Elem. Syst. 6', KGS 22, 189-190. Note that the new definition does not involve a rejection of the earlier one. For matter as the movable in space was proved to have original moving forces in the *Metaphysische Anfangsgründe*. Yet, if matter and movement have to be empirical objects at all, in the Transition, matter must be defined as having moving force, being such a force, according to Kant's dynamical theory of perception, a condition of the experience of movement.

must be designated [*Bezeichnet*] through what can be sensed – and this, as the totality of all objects of experience, and itself an object of experience, is called *empirical space* [MA 481].

This statement leads to the well-known denial of absolute space as a possible object of physics, and its determination as a pure idea of reason, which was often celebrated by sympathetic readers [cf. MA 559]. Facing such a statement, however, one must wonder, first of all, about this identification of an empirical object with a *totality* of objects. This «material space», in fact, seems to contain at least two different concepts: first, material space as frame of reference, empirically set from time to time with the help of perceptions. Second, material space as the totality of possible objects of outer experience as perceptible places of a continuum, wherein infinite possible moving frames of reference can be «designated». This second space concept does not play any explicit role in the *Metaphysische Anfangsgründe*, yet it brings into play a problem of outer perception which regards every «material space» in the first sense: for how are distant physical points to be experienced, in order to designate a frame of reference? Is it a movement, or a force (or something else) that renders spatial points perceivable? Since these points are in fact outer objects serving to set a frame of reference, the possibility of empirical space leads to the same problem of the possibility of outer perception of matter: that is, to the problem of the nature of influence in space as a condition of outer experience. But we are able to see, from now, how this problem must involve not only the concepts of matter and affection, but the nature of space itself as a physical concept. And it is precisely this problem, I suggest, that is answered in the 'Übergang 1-14' sheets in order to prove the existence of a world-matter together with the possibility of a pure representation of dynamical influences in physical space.⁵⁸

⁵⁸ As I remarked in § 3, this problem stems from the earlier definition of the metaphysical concept of space as pure form of outer intuition, which analytically implies the existence of distant objects as a subjective condition of experience. Now I can say, more precisely, that the problem arises from the need to connect this metaphysical concept and the successive concept of material space as the empirical space of physics.

But why did the condition of influence have to be satisfied by a world-matter? That is, why did this influence have to happen in a permanently *filled space*? In order to answer this question it is useful to start from the treatment of dynamical influence in transcendental philosophy. The reference to dynamical influence as a condition of spatial coexistence, of course, was nothing new in Kant's thought. Influence, as frequently repeated in the *Opus postumum*, «constitutes community of all matter in space»:⁵⁹ with the help of this statement we are led to a striking passage from the proof of the «principle of community», the Third Analogy of Experience. Here, starting from the problem of the simultaneity between bodies, we suddenly find what seems like a hidden version of aether proof:

The word “community” [*Gemeinschaft*] is ambiguous in our language, and can mean either *communio* or *commercium*. We use it here in the latter sense, as a dynamical community, without which even the local community (*communio spatii*) could never be empirically cognized. From our experiences it is easy to notice that only continuous influence in all places in space can lead our sense from one object to another, that the light that plays between our eyes and the heavenly bodies effects a mediate community between us and the latter and thereby proves the simultaneity of the latter, and that we cannot empirically alter any place (perceive this alteration) without matter everywhere making the perception of our position possible; and only by means of its reciprocal influence can it establish their simultaneity and thereby the coexistence of even the most distant objects (though only mediately). Without community every perception (of appearance in space) is broken off from the others, and the chain of empirical representations, i. e. experience, would have to start entirely over with every new object without the previous one being in the least connected or being able to stand in a temporal relation with it. I do not in the least hereby mean to refute empty space; that may very well exist where perceptions do not reach, and thus where no empirical cognition of simultaneity takes place; but it is then hardly an object for our possible experience at all. [KrV A 213/B 260].

«Only a continuous influence in all places in space can lead our senses from one object to another», connecting us with simultaneous

⁵⁹ ‘Übergang 9’, KgS 21, 561.

outer bodies. As in the *Opus postumum*, here, in order to have an experience of simultaneous objects we must represent an influence between these objects and our sense organs. As in the *Opus postumum*, again, it is the very unity of the world, itself a consequence of the unity of experience, which depends on these conditions.⁶⁰ But there is a major difference between the claim of the simultaneity principle and the claim in the 'Übergang' proofs. Dynamical community, according to the Critique, can be immediate *or* mediate: for transcendental logic only concludes that there must be *some* influence, although – through the example of light – a hint is given about how to further determine its nature.⁶¹ The 'Übergang' proofs require it to be a *mediate* influence. There follows that the idea of space as a field for physical experience requires the admission of a filling: «No effect of the moving forces of matter can reach our sense through empty space».⁶² Empty space itself, therefore, is categorically refuted, not by a physical hypothesis – as happened in 1786 by means of aether compression – but by a postulate of possible experience, which is traced back again to the existence of a world-material.

Now, why was this condition missing in previous Kantian thought? The best way to understand this shift is to consider the main example of immediate influence at a distance, attraction, and how it is related to the problem of affection. As soon as a monadological view of attraction as an «external phenomenon» of

⁶⁰ See KrV A 219/B 266. Compare the very frequent *incipit* in reflections on the world-matter, starting from the 'Übergang' sheets: «there is only one experience», hence one space: e.g. KgS 21, 576, 592, 594-595, etc.

⁶¹ KrV A 213/B 259: «they [substances] must stand in dynamical community (immediately or mediately)». Since the determinate nature of substances is a metaphysical topic, it is perfectly clear why the nature of influence – in spite of the example of light, which I will discuss later – must remain undecided. Indeed, the later attempt to build a metaphysics of nature will lead to the sole treatment of material influence («metaphysics of thinking nature» will not be realized, because it leads only to trivial propositions on the properties of inner perceptions: MA 471). Indeed affection of inner sense, according to Kant's second edition of the Critique (1787) is actually self-affection (its material stemming from outer affection); and being it no effect of a knowable empirical substance (like soul) it cannot properly lead to any truly metaphysical doctrine.

⁶² 'Übergang u[sw]', KgS 21, 220.

physical influx is given up, an inquiry on attraction as the ground of coexistence begins in Kant's work. In the lectures on metaphysics of the '80s space itself is considered as the ground of the community of phenomenal substances.⁶³ But, as the first lines of the Third Analogy text make clear, coexistence in space itself cannot be «empirically cognized» without a dynamical community between substances as phenomena. While the nature of this influence has to remain in some ambiguity, reflections on this topic in the *Opus postumum* constitute a further negative step. Although still a supporter of action at a distance, Kant now states *not only* that action at distance is «a mere idea», that is, attraction acts *as if* there were nothing in between (depending only on the mass of the interacting bodies and distance) – what was made clear already in the *Metaphysische Anfangsgründe* [cf. MA 513] – but that space cannot *actually* be considered empty if gravitation has to be empirically detected and measured at all. The topic appears in the 'Übergang 1-14' sheets and receives extensive attention in slightly later fascicles. In sheet 'Z' (circa Aug. 1799-April 1800), most clearly, it is argued that in order to apply the gravitation law to any part of matter we have to know the places at which universal attraction acts: for in order to apply the mathematical concept of attraction to phenomena, it must firstly be possible to determine actual distances in space.⁶⁴ Therefore, given that gravitation itself is in need of a

⁶³ Such a view is suggested, firstly, from the treatment of action and reaction in the *Metaphysische Anfangsgründe*, corresponding to the Third Analogy of Experience. Here the relativity of spatial relations between material substances leads to the *a priori* proof of the Third Law of Mechanics, which indifferently regards dynamical influence as repulsive interaction at contact or attraction at a distance (MA 545, 548). At the same time, a purely "geometrical" view of community seems to ground Kant's rethinking of influx in different lectures on metaphysics: see e.g. KgS 29, 865ff. But here Kant is discussing the Wolffian concept of influx, where movements correspond to simultaneous interactions between monads, insofar as position is a property of monads and space is the ideal system of positions (cf. Baumgarten, *Metaphysica*, §§ 212, 415).

⁶⁴ 'Z', KgS 22, 529: «By what means, however, is this force which governs the whole of cosmic space made manifest – since this cannot be empirically, for it contains an *a priori* law? How shall we know the places at which this universal attraction [acts], and which, in comparison with other [forces], is of a greater or lesser moment of acceleration, in order [to determine] the distances at which the attraction acts? For of this we must previously have been informed before we can apply the law of gravitation to any particular part of matter, and *actio immediata in distans* can produce no perception for the intuiting subject, since space is empty and not at all sensible». Compare KgS 22, 524. These reflections of sheet 'Z'

previous determination of spatial relations, the place of dynamical medium for the determination of coexistence is taken by some kind of mediate influence. This influence must be conceived as acting through every point of a filled space and, indeed, Kant knows two candidates for the determination of its nature:

Light and sound (with their colors and tones) are such means of transition [*solche Übersritte*] which make representable an action at a distance (*actio in distans*) as immediately possible. We see or hear light and sound, not as immediately touching the eye or ear, but rather as an influence of sensible objects on our organ as distanced from us.⁶⁵

Given the several references to the nature of this mediate influence, elsewhere in the *Opus postumum*, it seems that we are finally able to solve the dilemma of the Third Analogy: the nature of influence at a distance, as the subjective ground of outer perception, is *light*, as the perpetual vibration of an original material diffused in the whole space. By its influence on our sense organs – and by its finite speed, as suggested in some sheets – the distance of bodies can be determined before any mechanical estimate of mass takes place.⁶⁶

may be an implicit answer to the renewed, emphatical consideration of Newtonian gravity in sheets of the same group 'A-Z' (see, e.g., KgS 22, 518, 521, and KgS 22, 528 on sheet 'Z' itself), and in particular to its occasional identification with «sensible space» in the immediately preceding sheet 'Y', KgS 22, 522. That is, after suggesting that gravitation may serve to turn pure space into an object of experience, Kant now corrects this statement and acknowledges a further condition for the application of attractive force to phenomena: this condition has to provide the required "realization" of space. Compare, for a later version of such an argument, KgS 21, 59-60.

⁶⁵ 'Z', KgS 22, 530 (I quote here from the translation in Friedman 1992, 323). See the very similar passage in KgS 22, 537 and, in the 'Übergang 1-14' sheets, KgS 21, 520, 565). Other related references are given in the following footnote.

⁶⁶ For the latter methodological suggestion, sometimes connected to Römer's experiments on the speed of light, see KgS 21, 235, KgS 22, 537, KgS 21, 71. The identification of heat-matter and light-matter occurs several times in the reflections on physics, and is not original in physics of the time. See e.g. 'Oktavenentwurf', KgS 21, 381, 383; 'β', KgS 21, 256; 'α Übergang', KgS 22, 214; IV Fascicle, Wrapper, KgS 21, 338, where light and heat are connected to electricity. The same identification appears up to the last sheets, e.g. 'S', KgS 22, 455. In the context of reflections on the *a priori* given world-matter, of course, this hypothetical doctrine assumes a transcendental function. Among such later passages see: 'Übergang 4', KgS 21, 229; 'Übergang 10', KgS 21, 565;

The consequent identification of world-matter (called «aether», «heat-matter», «*Urstoff*» etc.) with the substratum of light («light-matter») constitutes, as it were, the hypostatization which grounds the apparent logical unity of Kant's argument. For, as is made clear in several places of these and of earlier sheets, light (abstracting from subjective «feelings») is only a movement of world-matter, its rectilinear propagation, with the other one being heat. That is, one and the same world-matter is a condition of outer perception as light-matter, *and* of heat-phenomena as heat-matter. The latter's universal movement, as we know, is in turn the ground of body formation. Therefore the transcendental proof of the existence of light-matter provides at the same time the proof of the existence of heat-matter, which is therefore no longer hypothetical, but given *a priori*. The fallacy of the argument, from this point of view, is perfectly evident: for the very identification of different functions with properties of a single material, as well as the wave theory which connects light with a material substratum, are of course no analytical truths. They closely depend on physical concepts, whose status is hypothetical. Indeed, later developments in physics and chemistry led to different, more effective explanations of light, heat, and the formation of bodies, all independent from a «world-material» in the Kantian sense. The latter's connection with the general «system of forces» was thus a mere, though highly ingenious, projection of particular physical hypotheses (wave theory of light; chemical theory of heat; Kant's own chemico-dynamical account of body formation) in the region of transcendental philosophy. Considering this illusory unity of world-matter (with its different attributes) we can see that the transcendental aether proofs rest on a parallogism.⁶⁷

'Übergang 12 Bogen b) S.2', KGS 21, 605; 'AA', KGS 22, 426, and, in the last sheets of Fascicle 1: KGS 21, 55, 88, for a relevant reference to an article in the «Erlanger Literatur Zeitung» of 1801, and 105. Cf. Förster 1993, 286-287, footnote 158. For the theory of visual perception cf. *Anthropologie in pragmatischer Hinsicht*, § 19, KGS 7, 156-157.

⁶⁷ For this historical criticism of Kant's argument see Friedman's illuminating account of the «fate» of the aether proofs in Friedman 1992, 325-328. Friedman also stresses how caloric is recognized as hypothetical by Kant himself in the remainder of the *Opus postumum* (see in particular KGS 22, 84), and, given the role of the light-matter alone as a condition of outer perception, formulates the decisive question: «What, however, does light – or, in general, a

I do not believe, however, that the problem of aether proofs in the *Opus postumum* can be completely reduced to Kant being misled by physical notions of the time. Indeed, considering the open status of these reflections, we can understand how his understanding of the metaphysical concept of influence through physics and chemistry developed in these years, eventually leading to the dead end of aether proofs; but also how this understanding proceeded towards an internal reorganization of the critical philosophy of nature, which no historical development of science as such could have produced or replaced.

5. THE PARTING OF THE TRANSITION AND THE THEORY OF *A PRIORI* KNOWLEDGE

We have seen how the world-matter of aether proofs is both moving and movable. Its physical determination as heat-matter and light-matter, apparently, runs parallel to such twofold determination: so that the rectilinear movement of light and the vibrations of caloric, which apparently realize the function of different moving forces, are considered as attributes of a single cosmic material. Now, the identification of world-matter with physical materials must have been for Kant no more than a hypothesis.⁶⁸ But it was the presupposition of the compatibility of moving force *and* movement of an original material which, first of all, provided the main source of ambiguity in the whole aether theory of the *Opus postumum*. And the misunderstanding, here, lay in the concept of moving force itself.

means for our perceptual contact with objects of cognition – have to do with the “All of matter” serving as the basis for a system of the moving forces of matter? Why should our means for establishing perceptual contact with bodies, whatever this may turn out to be, *also* constitute a basis for the ideal complete science (...)?». The negative answer involves the collapse of the whole Transition project: «The aether deduction – and hence the Transition project – must in the end be considered a failure».

⁶⁸ The alternative of an unsatisfying indetermination remains: a general influence in a general *Urstoff*, to be later specified by empirically known forces. But this would be as much as considering an influence as a condition of sense affection, without knowing how such an influence is connected with the senses. Moreover, even an influence on the senses *in general* is a particular kind of influence, and nothing suggests its identification with the whole system of moving forces (as properties of matter).

This concept is indeed very ambiguous in all of Kant's writings on physics, and this obscurity is not entirely dispelled in the critical works. The definition of force as «cause of a motion» [MA 497], which provides the background for the reception of physico-mathematical definitions, did not suffice for a careful distinction of the different views of the Cartesian, Leibnizian and Newtonian traditions: the question was, indeed, if movement itself, or rather acceleration, is to be considered as a change. Kant, although accepting the Newtonian concepts of moving force and inertia, kept using the term «moving force» for the mechanical effect of impact (i.e. moment). At the same time, he referred to «movement» in both a phoronomical (v) and mechanical (mv) sense. This led to a risk of ambiguity in the use of the term 'moving force', which reflects a general state of uncertainty in physics of the time. In the *Metaphysische Anfangsgründe* this risk was limited by the separation of Dynamics and Mechanics. Yet in manuscript reflections, and in particular regarding the concept of body – as the missing link of Dynamics and Mechanics – the imprecision of the words reveals the damaging confusion in the corresponding concepts.⁶⁹

As a consequence of this ambiguity Kant can write at the same time, in the *Opus postumum*, that physics has to presuppose a «system of moving forces» and that a «moving force» is the condition of outer perceptions. Here, of course, the latter force is identified with a movement (vibration) able to exert a physical modification on sense organs, and it is evidently wrong to consider the material substratum

⁶⁹ For traces of the mechanical concept of moving force see MA 539-540 (moving force as mv) and, e.g., *Refl.* 31, *KgS* 14, 154. On Kant's general ambiguity on the mathematical meanings of force, movement and moment see Adickes 1924-25, II, 16-19, 25-38. Cf. Pecere 2004, 35-49. The confusion in the mathematical definition of force is rooted in the tormented evolution of modern mechanics (see Westfall 1971, 424-525, where the mathematical alternatives are examined on the background of 17th century mechanics). Although the question was about to disappear in the hands of the major physicists of Kant's time, a widespread uncertainty remained in German *Naturlehre*: here the metaphysical language of Wolffism («force» as «ground of change», «moving force» as «ground of movement») and the remains of Cartesian and Leibnizian hegemony in physics rendered the words of the Newtonians themselves obscure: see e.g. Eberhard 1753, § 40; Kästner 1759, I, 15-16, II, 1. Cf. Gehler, *Physikalisches Wörterbuch*, «Kraft», II (1789), 797-807, who admits a Newtonian concept of «accelerative force» ($\propto dv/dt$) and at the same time maintains the Cartesian estimate of «moving force» ($\propto mv$).

for its propagation as the «substratum», or «basis» of moving forces *in general*. This not only affects aether proofs, but, in the larger context of *Opus postumum*, renders the fundamental two-sidedness of reflections on moving forces and aether finally visible in its logical ground: a parting appears in the Transition.⁷⁰

Regarding aether proofs, as we have seen, the mechanical conception of moving force allows the agitation of a world-matter to be considered as a *substitute* of Newtonian attractive and repulsive forces, which provided the model for the metaphysical dynamics. Hence the moving force of the world-matter is identified with the living force that, since earlier reflections, had been held as a necessary condition of cohesion. It is thus a mechanical concept of force (as vibration and impact) which first of all allows the identification of a world-matter as ground of influence on sense organs with a world-matter as ground of influences on bodies – together with its hypothetical foundation in the theory of light- and heat-matter. This hypothetical background provoked, in the aether proofs, an obscurity in the notion of this moving material as the «basis» of «moving forces», which connected aether theory to the question of the elementary system of forces: for, on the one hand, this meant the identification of the system of moving forces with the totality of *actual* movements of the material itself; on the other hand, moving forces were rather forms of *possible* interaction, which the Transition could merely introduce for the sake of empirical investigation, and the material seemed to provide simply reality and permanency to their universal action, considered

⁷⁰ On this fallacious connection between moving forces and conditions of outer perception see e.g. KgS 21, 202, 591, 595-596, 601. This step is of crucial importance for the systematical role of aether proofs in the Transition, for it allows the shift from the system of perceptions to the system of moving forces, connecting a systematical place of the critical system to the new problem of physics. The shift from system of perceptions to system of moving forces, through the (ambiguous) determination of moving force as the cause of perceptions, is made evident in the reconstruction of the aether proof argument by Förster 2000, 89 (without critical remarks). It can be remarked, here, that in the *Kritik der Urteilskraft* a similar ambiguity connected the problem of the multiplicity of specific laws of moving forces in nature to the principle of the finality [*Zweckmäßigkeit*] of nature. For here the possibility of a specifically lawful nature depended on the perception of natural beauty, under the presupposition that the legality of outer perceptions is connected to an underlying systematicity of moving forces.

here as a condition of outer experience. If we consider, now, how the concept of moving force developed, along this second line of reasoning, towards a new theory of schematism, and if we connect the different concepts of force to the different concepts of the filling of space encountered in our previous reconstruction, we can finally come to a general understanding of the parting of the whole Transition project.

Right from the *Metaphysische Anfangsgründe*, three problems are connected to aether theory: (1) the possibility of a systematical physics, (2) the possibility of outer perception and, much like a corollary connected to these different problems, (3) the denial of empty space. In order to address these problems, in the *Opus postumum*, two different concepts of the filling of space – hence of influence in space – are adopted: that of a real (material) filling of space (a), and that of a possible (formal) filling of space (b).

The problem of systematical physics (1) is connected with the possibility of experience as *objective determination*, and in particular regards the objective reality of a system of moving forces. It appears in Kant's rethinking of the properties of matter in the early sheets of the *Opus postumum* and is rooted in the open problem of body formation in the *Metaphysische Anfangsgründe* [see above §1]. This thread of thought conducted firstly to the systematical classifications of *Elementarsystem* sheets, then to the theory of a new schematism [§2]. According to the idea of a «collective unity» of the «system of forces», it was at the same time related to mechanical or chemical aether, as a central concept in the scientific inquiry of the time. With the new conception of formal space-filling, however, Kant started a new reflection on physics which bore no relation to hypothetical aether movements. For a new schematism can as such regard only the *possibility* of dynamical influence: this is, in fact, the ground of its being an *a priori* operation of intellect. In aether proofs, on the other hand, the *existence* of a world-matter is at stake.

The problem of *perception of outer objects* (2) is connected to the possibility of experience as *empirical knowledge* and it provides the ground for speculations, in 'Übergang 1-14' proofs of aether, on the movement joining and filling every point of space [§3]. These

reflections descended from the problem of sense affection in the *Kritik der reinen Vernunft* and the *Metaphysische Anfangsgründe*, and were finally connected to the hypothesis of a vibrating light-matter as a medium for the determination of spatial distance [§4]. The problem of outer perception, hence, receives an answer by means of the concept of a *real* filling of space. Through this real, continuous movement affecting the senses, the concept of influence can be related to the transcendental problem of outer perception.

On the whole, then:

- a) Influence as *real* filling of space could provide *affection* by movement (2) and *denial of void* (3). But this would require the hypothesis of a moving mechanical aether (as in 1786) and the identification of aether with light-matter and of light with its vibrations. On the other hand, this could provide *no a priori foundation of the system of forces* (2), that is no schematism for physics, because aether would be homogeneous to empirical matter and not conceived *a priori*. Indeed, such a material would be hardly applicable as a physical concept (as the whole history of modern aether theory widely confirms).
- b) Influence as *possible* filling could provide the idea of a new *a priori foundation of the system of forces* (1), through a new schematism (whether constitutive and complete or regulative and incomplete). It could be connected as well with a *primordial activity (and therefore reality) in space*, in order to apply the mathematical representation of force to actual dynamical effects (such as in argument E_v). Yet such an influence evidently provides (2) *no real ground of affection* (for how can an influence *in general* affect sense organs? Gravitation, for example, does not) and (3) *no denial of physical vacuum*.

Nonetheless, the transcendental turn in Kant's reflections on aether and moving forces eventually provided an introduction – a ladder, as it were – to later reflections on physics, even though the ladder itself had to be thrown away.

On the one hand, the inquiry on the anticipation of dynamical interactions would lead to the theory of «indirect phenomenon» (or «phenomenon of second order»), in sheets 'A-Z' (circa Aug. 1799-April 1800). According to this theory, the whole system of properties and dynamical interactions determining any single physical object has to be represented *a priori* (by «self-affection»), and it logically precedes observations and experiments. Only on this basis is it possible to connect the rough manifold of perceptions with the ideal system of moving forces. Indeed, the physical «thing in itself» [*die Sache selbst*], according to this striking new epistemology, is no longer the directly perceived object, but the categorically formed, more and more determined, indirect phenomenon.⁷¹ This outlines a subtler understanding of physics as do previous Kantian views. In fact, the argumentative path of the earlier metaphysics of matter, i.e. the attempt to deduce fundamental forces from the essential properties of matter, is virtually abandoned, whereas the new theory of physics, without addressing the intricate connection of impenetrability, filling of space, repulsive and attractive force, merely anticipates schemata of moving forces in pure space. Now the substratum of this new anticipation of experience is a world-matter which is firmly conceived as a *transcendental* matter, lying «in the representative faculty of the subject» [KgS 22, 574-575]. This new doctrine would not have taken shape, therefore, had not Kant lengthily reflected on the «filling of the void with forms» which had to be connected with its previous efforts on aether.⁷²

On the other hand, the question about the experience of distance would lead to the reflections on the «self-positing» [*Selbstsetzung*] of the subject in space, as a missing condition of distance determination, joining logic and physical inquiry. Influence, as we have seen, is traced back to the pure representation of dynamical interactions in the indirect phenomenon, so that neither material objects nor dynamical

⁷¹ See e.g. KgS 21, 572. In KrV A 45/B 63 Kant gives a double meaning to the expression «Thing [*Sache*] in itself», which can refer to a metaphysical concept, devoid of objective reality, and to the object of physics. Cf. KrV B 69-70.

⁷² On the theory of indirect phenomenon see for instance the very interesting passage in 'G', KgS 22, 340-342, which would deserve a detailed commentary. Cf. Mathieu 1991, 159-161.

interactions are to be simply considered as empirical objects, but rather as schematical conditions of physical representations and experiments. Of the three elements of outer perception, outer object, intermediate space and sense organs, the latter appear in this new picture completely out of context. «Self positing», I suggest, is nothing else than a coherent adjustment of sense-affection in the context of the late *a priori* theory of physics. For, as much as it is not obvious how perceived bodies can be assigned to distant places – as long as no influence is represented –, it is also not obvious that the perceiving subject itself occupies a space at all, as long as no postulation is made about the identification of this subject with a place (leaving aside the question of a metaphysical or physiological explanation of mind-body influence).⁷³

Finally, in the light of the new theories on outer reality and perception, the very concept of physical space was in need of a reconsideration. Indeed, once the experience of distance is grounded on the anticipation of dynamical interactions, the whole identification of pure space with the physical space of physics is explicitly denied. All we can say is that a continuous spatial path must link sense organs and physical objects. This is in agreement with the Transcendental Aesthetics as long as space is considered merely as a form of exteriority, grounding *a priori* the relation of «neben einander» (which connects phenomena as being «next to one another»). But if distance (thus space) must be an object of experience, there is no reason to identify the metrical properties of Euclidian space, as a «thinkable space», with the metrical properties of physical space. In the light of the developments of aether proofs, the manifold of «sensible space» must

⁷³ On the latter point compare the short essay *Über das Organ der Seele* (1796), KGS 12, 31-35. The theory of self-positing is developed in the very fragmentary sheets 'Beilage 1-8', contained in *Opus postumum* Fascicles VII and X. For a reconstruction of this theory see Förster 2000, 101-116. Kant could find a different approach to distance determination, independent from influence and the subject's own body, and related to the mere content of perception, in the major works of Berkeley and Reid. Yet no reference to these theories appears in the *Opus postumum*.

be rather considered *a priori* undetermined as far as metrical determinations are concerned.⁷⁴

It seems, finally, that the effort of aether proofs, although in itself fallacious, opens new perspectives in the critical system. This happened in the last years of Kant's activity, when the philosopher was most probably trying to answer the new developments of transcendental idealism through an inner reform of its critical thought, but still did not have the time, nor the strength, to develop and to ponder his new perspectives.⁷⁵ It is evident, nonetheless, that Kant's reflections on physics continued to play a major role for the development of critical philosophy until his last days, and were not at all limited to the task of an "a priori foundation" of a given empirical science, as most 20th century interpreters have believed. In the light of

⁷⁴ See e.g. 'Übergang 4', KGS 21, 235: «We represent space to ourselves like any other object of sensibility in a twofold way: first, as something thinkable (*spatium cogitabile*), as far as it, being a magnitude of the reciprocally outer manifold [and] a mere form of the object of pure intuition, only lies in our representative faculty; second, though, as something sensible [*Spürbares*] (*spatium perceptibile*), as something existing out of our representation, that we perceive and must be able to draw for the sake of experience, which as an empirical representation determines [*ausmacht*] a sense object: the material which fills space». In this context one can also consider Kant's notes on a proof of the Euclidean postulate of the parallels in the first Fascicle of the *Opus postumum* (1800-1803) (although these references do not appear in connection to the problem of sensible space: see Adickes' notes to *Refl.* 5-11, KGS 14, 23-52 and Förster 1993, 277-78, footnote 106). Indeed, Kant even suggests that the dimensions of space are inserted in thinkable space by sensible space: but the whole topic demands more attention. It is interesting that a few years after the composition of these Kantian sheets, Herbart – without any knowledge of Kant's late reflections on this topic – will introduce in his metaphysics a distinction between «sensible space» and «intelligible space» (Herbart 1812, whose main theses are anticipated in the *Hauptpunkte der Metaphysik* of 1808). By means of these concepts Herbart tried to provide a deduction of space from monads in the original Leibnizian spirit, considering intelligible space as the metaphysical reality, grounded on monads, and sensible space as a mere phenomenon of the senses; yet he still lacked the geometrical doctrine of the *Analysis situs* and therefore, as well as Wolff, actually produced a different doctrine. Nevertheless, as is well known, his metaphysics stimulated Bernhard Riemann's conception of variety [*Mannigfaltigkeit*] in the famous memory of 1854, which opened the way to the widespread rejection of Kant's views on space at the end of the 19th century.

⁷⁵ The main sources for new reflections on affection and space could be Maimon, Beck, Schulz and Reinhold, as well as Fichte and Schelling. But compare, on the priority of force over empty space, also Herder 1799, 72, and Kiesewetter's answer in Kiesewetter 1799, 75, footnote (movement is the «*ratio cognoscendis*» of space). Cf. also the references to Lichtenberg in reflections of this period, which regard the idealistic views expressed in Lichtenberg 1801 (Kant received and studied a copy of this book in 1800: cf. Förster 1993, 279-80, footnote 124).

our discussion, indeed, the whole critical theory of *a priori* knowledge of nature appears to be far different from a successive “foundation” of different scientific theories, such as Newtonian mechanics, Lavoisier chemistry, etc. Rather, it appears as a complex and incessant interplay of metaphysical concepts (as material substance and conflict), mathematical notions (as continuity and moment), hypotheses of natural science (as caloric and chemical bonding), and reflection on the synthesis of sense perceptions.⁷⁶ From this point of view, in Kant's late thought, physics continued to act backwards on the more abstract principles of philosophy, as had happened since the beginning of his philosophical work. It is not odd, hence, that the title of the «transition from metaphysics to physics», which characterizes the whole *Opus postumum*, appears reversed in some of the last sheets, where we read of a «transition from physics to transcendental philosophy».

⁷⁶ Kant never intended to develop a “foundation” of Newton's physics, but simply assumed the latter as the most successful and philosophically stimulating physical theory, being convinced that the theory of gravitation could be in part derived from pure principles of the understanding. This led, of course, to a growing uncertainty among interpreters, which soon conceived Kant's *Metaphysische Anfangsgründe* as the foundation of Newton's physics (see e.g. Fries 1837, § 185, 550: «[the MA are] the complete philosophical foundation [*Begründung*] of Newton's physics and the freeing of the latter from the prejudices of Atomistic»). Most Kantians of the 19th century adhered to this view, which was to be gradually connected to positivistic views and the liberalization of axiomatic. This path led, in Marburg Neokantism, to the idea of a “Kantian” foundation of different scientific theories. Consider, e.g., the transition from Newtonian mechanics to Relativity theory in Cassirer's neokantian «*Erkenntniskritik*», where the *Metaphysische Anfangsgründe* are again reduced to a (illusory) «foundation» [*Begründung*] of Newton's mechanics, as a particular physical theory of the past (Cassirer 1921, 58. According to Cassirer Kant actually managed to produce a «philosophical transcription [*Umschreibung*] of the presuppositions of Newtonian science of nature»). This idea that Kant had attempted to carry out a foundation of Newtonian science (as well as of other scientific theories) was alimeted in 20th century philosophy of science by the dominant neopositivistic views on the relation between philosophy and scientific theories (from the Vienna Circle to Kuhn). It is expressed again, e.g., by Buchdahl 1992 and Friedman 1992. Friedman's neokantian theory of the *a priori* component of scientific theories, on the other hand, attributes to philosophy the role of reflecting on the conceptual content of science and thus of stimulating theoretical shifts and the very formation of new paradigms (Friedman 2001). This approach is far from considering philosophical reflection to merely take into account given theories and successively provide them with a “foundation”, and indeed it actually catches the spirit of Kant's original approach to science.

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KANTIAN TEXTS

Abbreviations: KgS, followed by the number of volume and page(s), stands for *I. Kant's gesammelte Schriften*, ed. Königlich Preußische Akademie der Wissenschaften (and successors), Berlin (later Berlin-Leipzig) 1900–. KrV stands for *Kritik der reinen Vernunft*, followed by the number of the pages of the first (A, 1781) and second (B, 1787) edition. *Prolegomena* stands for *Prolegomena zu einer jeden künftigen Metaphysik die als Wissenschaft wird auftreten können*, Riga 1783. MA stands for *Metaphysische Anfangsgründe der Naturwissenschaft*, Riga 1786, followed by the number of pages of the critical text in KgS, vol. 4.

The *Opus postumum* is quoted from vols. 21 and 22 of KgS, Berlin-Leipzig 1936 and 1938, edited by G. Lehmann and A. Buchenau. Sometimes a direct reference to single sheets and relative pages is given. Kant's own designations of the sheets, as well as the conventional title 'Oktavenentwurf' for the manuscript edited in KgS 21, 373–412, are given in single quotes. LB stands for *Loses Blatt* [loose leaf], and is followed by the number given by Adickes. I follow here Adickes' dating of Kant's manuscripts. The dating of the *Opus postumum* manuscripts is discussed at length in E. Adickes, *Kants Opus postumum dargestellt und beurteilt*, Berlin 1920 and substantially accepted by the KgS editors. A summary and a brief discussion of the latter datings can be found in the Introductions to Mathieu's and Förster's translations [see below].

For most quotations I use the translations listed below, for which I give no page number since they all indicate the KgS edition pagination. All the remaining translations are mine.

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