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Published in:
Hans Christian Ørsted and the Romantic Legacy in Science

Publication date:
2007

Document version
Peer reviewed version

Citation for published version (APA):
Nielsen, K., & Andersen, H. (2007). The influence of Kant's philosophy on the young H.C. Ørsted. In R. M. Brain, R. S. Cohen, & O. Knudsen (Eds.), *Hans Christian Ørsted and the Romantic Legacy in Science* (pp. 97-114). Springer.

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The Influence of Kant's Philosophy on the Young H. C. Ørsted

Introduction

In attempting to answer the question why it was H.C. Ørsted (1777-1851) who discovered electromagnetism, historians of science have discussed whether Ørsted was influenced by Schelling's *Naturphilosophie* or rather by Kant's philosophy. Thus, R.C. Stauffer (1953) and L.P. Williams (1966) have seen Ørsted's discovery of electromagnetism as closely related to the influence which J.W.F. Schelling's *Naturphilosophie* had exerted on Ørsted prior to the discovery; the main point being that Ørsted did not perceive of electricity, heat, light, and magnetism as imponderable, corpuscular fluids but as *forces* of a common origin.

A contrary view has been put forward by Shanahan (1989) who claims that the most important background to Ørsted's discovery was his knowledge of Immanuel Kant's philosophy. Although Shanahan agrees with Stauffer and Pearce Williams in that Ørsted's ideas of forces were essential to the discovery, he claims that the decisive influence came from Kant's *Metaphysical Foundations of Natural Science* published in 1786. According to Shanahan, this book introduced Ørsted to ideas that were to constitute the core of his scientific thinking throughout his life, and, furthermore, that Kant's insistence on the limited applicability of a priori methods in science contained a vital antidote to Schelling's rambling speculations. In Shanahan's words "it was [Ørsted's] deeply rooted acceptance of certain Kantian doctrines, and his explicit *rejection* of central doctrines of [Schelling's] *Naturphilosophie*, that made this discovery possible" (Shanahan 1989, p. 289).

However, as Caneva has later pointed out, "no one has yet studied Ørsted's work in its totality with due attention to the full range of his philosophical and scientific sources" (Caneva 1997, p. 48). The purpose of this paper is to undertake only a small part of this overwhelming task by examin-

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ing in detail to what extent and in which way the young Ørsted was influenced by Kantian philosophy. Our investigation deals with the period prior to 1802, the year in which Ørsted set out for his great educational journey to Germany and France. First, we shall discuss whether it is possible to point to specific factors which inspired Ørsted to take up Kant. Next, we shall discuss in what way and to what extent Ørsted accepted certain Kantian doctrines. Finally, we shall discuss how this investigation of Ørsted's writings on Kant may affect the existing views on the influence of Kant's philosophy on Ørsted.

Ørsted's pre-Kantian period 1794-1797: the promising and diligent student

Hans Christian Ørsted was born in 1777 in Rudkjøbing, the largest town on the small island of Langeland some 100 kilometers from Copenhagen. Hans Christian and his two years younger brother Anders Sandøe both showed promising intellectual abilities, and in 1794 they together moved to Copenhagen to prepare for the entrance examination for the university. The philosophical examination was passed by both of them in 1795 with distinction. At this time Hans Christian was very fond of poetry and wrote several poems to develop his skill, but he was also interested in astronomy, mathematics and physics, and he decided to study medicine. Anders Sandøe was very interested in philosophy, but decided to study law.¹

During the winter of 1795/96 Hans Christian Ørsted left Copenhagen for a while to go back to his native town to practice laboratory work under the guidance of his father who was a pharmacist with his own pharmacy and a very active chemist. In April 1797 his father certified that Ørsted possessed the skills required by a professional pharmacist, and that Ørsted had been present during the most elaborate experiments he had carried out (cf. Bærentsen & Jensen 1977, p. 16f). Thus, there is no doubt about the origin of Ørsted's experimental interest and skills. Although Shanahan in his description of the background to Ørsted's discovery of electromagnetism emphasizes how Kant repeatedly mentioned the need for experiments and observations and hence sees the writings of Kant as the principal reason why Ørsted performed experiments (Shanahan 1989, p 304), he overlooks that Ørsted was brought up in a laboratory and not in a library. This is not to say that Ørsted was not an ardent reader, but his interest in

¹ Anders Sandøe Ørsted was later to become a highly influential and respected civil servant.

experiments seems to have been developed early in his career, long before he took interest in Kant.

In 1796 the University of Copenhagen announced an essay contest within aesthetics on the topic '*How can the prose language be corrupted by coming the poetic too near? and where are the limits between the poetic and the prose expression?*'. Ørsted submitted an essay in which the main emphasis was on the position of A.G. Baumgarten (1714-1762), while there were no traces of neither romanticism, nor of Kant. As Ørsted wrote, he had not included what more recent philosophers had said about the nature of poetry since he had found no author to be more profound than Baumgarten (cf. Billeskov Jansen 1987, p. 15). Ørsted won the gold medal, and his essay was published in the journal *Minerva* in May 1797.

Also in May 1797, Ørsted passed the final examination in pharmacy with distinction. One of the examiners, the professor of medicine J.C. Tode, found the knowledge exhibited by the student so impressive that he gave a whole page in his own journal to the description of this happy incident (cf. Bærentsen & Jensen 1977, p. 17).

At the beginning of 1797, the medical faculty at the University of Copenhagen announced an essay contest on the origin and function of the amniotic fluid. Ørsted had in his first prize essay showed his ability to orient himself in a new field, developing an independent position, and he also possessed both the knowledge of chemistry and the experimental experience necessary to participate in the contest, and he submitted his second prize essay before the end of the year.

The essay was well researched. He had references to such authorities as Blumenbach, von Haller, Van den Bosch, Malpighi, Wünsch, Buffon, and several less known authors. His own chemical investigations were all qualitative tests in which he tried to nail down the components of the amniotic fluid. His main conclusion was that the fluid mainly consists of a thin, salty solution of proteins. Rhetorically, the paper was held in style of the inductive tradition so common at the time. It contained several warnings against conclusions not based on careful observations. Thus, in the introduction the young author warned against the seductive workings of the inquiring human mind:

With the bright colours of imagination it paints what reliable experience has not show it and creates easily overthrown theories where facts do not guide it. However, if we do not want to give up for ever the hope of attaining some certainty in this, we must first investigate more closely the part of it which immediately offers itself to our senses, for the disagreement of

the greatest natural philosophers prove that even in this we have not proceeded as far as we could have (Ørsted 1797b/1998, p. 4).

This view returned again later in the essay, when Ørsted had to admit that the sum of knowledge about the origin of the amniotic fluid was insufficient to decide conclusively on the question of the origin of the amniotic fluid. Here Ørsted stated that

I do not think that we know anything more definite about the origin of the amniotic fluid at the present time. Perhaps some fortunate discoveries of the future we will be able to shed more light on this issue. We must only try as much as possible to avoid theories about it as long as we do not have sufficient data on which to build them (Ørsted 1797b/1998, p. 14).

There was not a single trace of Kant's philosophy in this essay either, but clear evidence of a young scholar eager to convince the professors of the university that he was playing strictly by the recognized rules, that only when sufficient *facts* are at hand theories may be formulated – cautiously. The official evaluation of Ørsted's prize essay stressed three points: the essay was well organized with clear and thorough descriptions; in the chemical analysis Ørsted had shown diligence; and he had tried to mediate the conflicting views of chemistry of that time (Ørsted 1797b/1998, p. 3f.). To temper claims about Kant's influence in relation to Ørsted's understanding of the importance of experimental evidence, it should also be noted that Anja Jacobsen has convincingly argued that in his methodological novelty in this prize essay – the use of chemical analysis to decide a medical question – Ørsted was inspired by the view of chemistry introduced by Lavoisier (Jacobsen 2000, p. 8-9).

Again, Ørsted won the gold medal. Hence, by now he had distinguished himself three times on quite different subjects in the small academic circles in Copenhagen: by the prize essay in aesthetics, by the prize essay in medicine and by passing the final examinations in pharmacy with distinctions. He had fitted perfectly into the role of the well-behaved prodigy who played strictly by the recognized rules.

The spread of Kantian philosophy

During the last two decades of the 18th century, Kant's philosophy spread from Königsberg through Germany, and gradually to other European countries as well, such as Holland (Van der Wyck 1899, 1903; Wielma 1988), Sweden (Vannérus 1901), and Denmark (Thuborg 1951). Kantian philosophy was in opposition to the reigning Leibniz-Wolffian philosophy, and it met much resistance, mainly due to its various political and theological implications.

In many places, the conflict took form of a generational clash. In Stockholm, for example, eager young Kantians stated publicly that the old philosophical system was in need of reform and that such a reform had been initiated and carried out by the genius Kant (cf. Vannérus 1901, p. 260), while their main opponent, professor Christiernin, had attacked 'the new philosophy' in the newspaper *Uppsala Tidning*. Feelings were so intense that it came to a public confrontation at which – so the story goes – Christiernin opposed the gathering youth, giving the academic guards orders to 'beat them, stab them, shoot them, I take full responsibility for any loss of life'. After this incident the government had to intervene, and Christiernin was suspended by the university's vice-chancellorship (cf. Vannérus 1901, p. 262).

In Copenhagen, Kant's philosophy became immensely popular among young people during the later half of the 1790s.² Among the most eager young Kantians was Hans Christian Ørsted's brother Anders Sandøe Ørsted, with whom Hans Christian shared room and money until the summer of 1801.

In Denmark, the first reference in writing to Kant seems to be an anonymous article from 1789 published in the periodical *Minerva* with the title: 'The Kantian definition of thought'. The first university lectures on Kant's philosophy were held in 1793 by C. Hornemann who had been studying Kant's writings since 1784 (cf. Thuborg, p.10). In 1791 Hornemann had gone to Jena to hear Reinhold, Fichte's predecessor, and upon his return he started a series of lectures on *Critique of pure Reason*, but he died prematurely at the end of 1793. Hornemann's lectures were popular, and they invoked a remarkable Kant-enthusiasm among young intellectuals in Copenhagen.

An intense debate developed in a number of periodicals, and around 1796 a downright craze had developed. Silver medals showing Kant's portrait were sold, it was suggested to make Kant's philosophy the

² For an overview of the early Kantianism in Denmark, see Thuborg 1951.

basis of politics and of the judicature system, Kant was claimed to be the new Messiah *etc.* Anders Sandøe entered the public debate in 1797, but already the year before he had found reading Kant to be the best cure against weak nerves. In 1798 he portrayed Kant as a giant who had managed to crush all earlier philosophical systems and stop their destruction of moral order. To Anders Sandøe, Kant had given the moral sciences a new foundation that “would defy eternity” (Thuborg 1951, p. 17).

Ørsted’s transitory period 1798-1799: the prudent advocate

Ørsted began making references to Kant’s philosophy in 1798. During 1798 and 1799 he worked on three projects more or less simultaneously: A series of four essays on chemistry, a critical essay review of a new edition of the leading Danish textbook on physics and chemistry, and a long essay on Kant’s metaphysics of science. In these three projects he, with increasing enthusiasm, presented Kant’s ‘dynamical system’ as a superior alternative to the reigning atomism.

The four essays on chemistry were published under the title of ‘Letters on Chemistry’ in the same periodical which had brought his prize essay on the amniotic fluid (Ørsted 1798a, 1798b, 1799a, 1799b). In form and content the letters were clearly aimed at a lay audience. The main subject was heat and combustion and in a plain language Ørsted provided pedestrian explanations of various fundamental ideas: the difference between physics and chemistry, the function of a thermometer, the process of distillation, the meaning of concepts like latent heat, heat capacity, heat conductivity etc. Without any reservations, combustion was explained the basis of the sanctioned theory of Lavoisier.

Kant was briefly mentioned in the first of the letters, in which Ørsted claimed that matter possesses two powers, a cohesive force and an expansive force. He emphasized that he could “not, without straying too far from [his] goal, inform [the reader] of the profound investigations on which depends the evidence that bodies really do possess these fundamental forces” (Ørsted 1798a/1998, p. 27), but instead limited himself to mentioning

some experiences which, to some extent, could serve to convince [the reader] of the existence of the cohesive force at any rate. If you take two polished glass plates and put one on top of the other, you observe that they stick together; if you put one drop of mercury next to another, they unite; and if you dip your finger into water, the moisture sticks to it; all

this proves that one body displays a cohesive force with another (Ørsted 1798a/1998, p. 27)

One may here note the remarkable difference between this rather thin experimental evidence for the existence of the two fundamental forces and his warnings the previous year against letting the human mind create “easily overthrown theories where facts do not guide it.”

The second chemical letter dealt specifically with the nature of heat. Like Kant, Ørsted claimed heat to be material. In a note he added that he had always considered heat to be material since it could pass from one body to another and a mere quality could not do that. However, he also noted that he had later been further convinced by the argument that “bodies have only two fundamental forces, the expansive force and the cohesive force, and it is possible to derive all others forces from these. The cause of heat acts in such a way that it cannot be conceived as one of these original or derived forces, so it must be materiel” (Ørsted 1798/1998, p. 29n). In his explanation of the various phenomena related to heat, Ørsted was utterly conventional. He operated with the material heat as being “free” or “bound”, and he explained the transition of a body from one state to another as a process in which the body liberates or binds material heat, and thus reproduced the French caloric theory. Although he had started referring to Kant’s dynamical view of matter, he still remained largely within the accepted chemical framework.

Ørsted’s transitory period 1798-1799: The provocative reviewer

In his second project from the years 1798-1799, Ørsted went a step further to use Kant’s dynamical theory of matter as his main weapon in an attempt to challenge the socially most prominent scientist in Copenhagen, the Lord Steward, Adam Wilhelm Hauch. Hauch had introduced Lavoisier’s chemistry in Denmark, and he was also the owner of one of the largest collections of scientific instruments in the World, of course by far the largest in Copenhagen.

Hauch was head of the royal stables and gave lectures in his “Physical Cabinet”. His textbook on natural science from 1794 became quite popular and the first volume of a second, expanded edition appeared in 1798. Ørsted made an essay review in three parts for one of the leading journals (Ørsted 1798c, 1799c, 1799d), attacking Hauch for not taking Kant’s dynamical view of matter into account. Thus, Ørsted’s main objection

against Hauch's book "concern[ed] the author's philosophy of nature. He follows here the atomistic system" (Ørsted 1798c/1920, vol. III, p. 28). According to Ørsted "this system leaves the question unanswered: Why do bodies occupy space?" (*ibid.*). Ørsted's main argument was that any atomistic answer to the question 'Why does matter occupy space?' would be circular: Atomists claim that matter fills space because it consists of impenetrable particles. How can these particles be impenetrable? Because they fill space, etc. Thus, one was led to the expansive force of the dynamic system which the atomic system had intended to avoid. Ørsted mentioned F.A.C. Gren and reproached Hauch for failing to mention how this writer had shown "how the results of the new philosophy could prove useful for physics" (Ørsted 1798c/1920, vol. III, p. 29), but he also emphasized that he did not want to enter into more detailed arguments since he intended to publish a more detailed survey very soon.³

The publication of the second volume of Hauch's textbook was delayed, and this gave Hauch the opportunity to add a supplement in which he answered Ørsted's objections. He accepted some of the more trivial points raised, though not all of them, but he did not simply accept the objections to the atomistic system. Although he did admit the dynamical system some ground, he "did not dare to judge the one system better than the other, but was convinced that they both deserve to be known" (Hauch 1799, p. 770). Hence, Hauch did not give up his position, but instead demonstrated his knowledge of both systems and argued that in the dynamical system the assumed repulsive force was superfluous. In an elegant manner he also revealed that he knew the identity of the anonymous reviewer by mentioning that this reviewer as well as Mr. Ørsted were defenders of the dynamical system, which hitherto "had not been explained with such clarity as one could wish" (Hauch 1799, p. 770). Hauch held his arguments against the dynamical system as well as the rest of his response in a polite tone. Ørsted stated his appreciation of this in the second part of his review, which was now no longer anonymous (Ørsted 1799c/1920, vol. III, p. 38). In this second part of the review Ørsted again stressed the advantages of the dynamical system, but now in an even more daring manner. He might have hoped for a fight, but what he had obtained was even better: Hauch had treated him as a peer.

³ Ørsted here alluded to his *Fundamentals of the metaphysics of nature* which will be dealt with below.

In July 1800, a chair in physics at the University of Copenhagen became vacant. Ørsted wanted the chair but knew that the influential professor of astronomy, Thomas Bugge, would be against his candidacy. To get support Ørsted wrote to P.C. Abildgaard, the founder of The Royal Veterinary College, who answered that he had already told a few friends that he would prefer to see Ørsted in that chair. Further, he recommended Ørsted to approach Hauch for advice and support, “for I know that he has much respect for your expertise”.⁴ Ørsted’s review had not been without effect.

Kant’s Metaphysical Foundations of Natural Science

The third of Ørsted’s three projects was to introduce Kant’s *Metaphysical Foundations of Natural Science* to a Danish audience. In *Metaphysical Foundations* Kant elegantly combined two objectives. On the one hand Kant hoped that a better understanding of his philosophy could be achieved by giving an example *in concreto* of how to use the abstract principles and concepts of the transcendental philosophy (see e.g. Friedman 1992, p. 136f. and Plaass 1965, §0.5). On the other hand, Kant wanted to use the principles of transcendental philosophy to find the a priori sources for the Newtonian laws and concepts and thus provide apodictic certainty to the most prominent contemporary theory which served as a paradigm for how science ought to be (Kant 1786, p. A: XIII. See also Friedman 1992, sec. 3.I). Hence, by analyzing Newtonian mechanics according to the principles of transcendental philosophy, Kant obtained both to show how his philosophy worked in actual practice, and to provide Newtonian mechanics with an a priori foundation.

The basis for *Metaphysical Foundations* was thus the principles of Kant’s *Critique of pure Reason*.⁵ In this work Kant had described how our knowledge springs from two sources of the mind: the capacity of receiving the yet unprocessed impressions of some object, and the capacity to recognize the object from these representations through the process of thought.

When we experience something, an object affects our faculty of representation and gives rise to a sensation. This sensation is transformed into an appearance by the two forms of intuition, time and space. Thus, the appearance is a representation of the object which has not yet been pro-

⁴ Abildgaard to Ørsted, Aug. 22, 1800, in M. Ørsted (1870), p. 6.

⁵ The first edition of *Critique of pure Reason* appeared in 1781, but in 1786 Kant made a major revision which appeared the following year. In the meantime he had published *Prolegomena to Any Future Metaphysics* in 1783. *Metaphysical Foundations* appeared at the same time as he revised *Critique of pure Reason*, in 1786.

cessed by thought. Thought is then involved when a particular representation is recognized as an instance of a concept. The act of recognizing a particular representation as an instance of a concept is called the judgment.

The basic concepts of the understanding are the categories. By abstracting from the actual content of all possible judgments, Kant deduced twelve basic forms which he divided into four classes: quantity, quality, relation and modality. Since on Kant's view all judgments had take one of these twelve forms, the basic conditions for any experience can be derived by applying the twelve basic forms of judgments to the concepts involved in the experience in question.

Metaphysical Foundations was the concrete application of all these abstract rules on our experience of the external world, that is, on the objects that affect our external senses. For an object to be an object of the external senses, the object must be sensible – “something” must be sensed by us. The aim of *Metaphysical Foundations* was therefore to show which a priori judgments could be deduced by applying the twelve categories to this “something”, the external matter.

But instead of simply applying the twelve categories on the concept “matter”, Kant made an important move. By the end of the introduction to *Metaphysical Foundations* he claimed that “[t]he fundamental determination of a something that is to be an object of the external senses must be motion for thereby only can these senses be affected. The understanding leads all other predicates which pertain to the nature of matter back to motion; thus natural science is throughout either a pure or an applied doctrine of motion.” (Kant 1786, p. A:xxi). Kant did not extend his argument to explain why the external senses could only be affected by motion. However, if matter is to be experienced, it must first be represented as an appearance, where the appearance is the sensation ordered in both time and space. Purely spatial appearances would be geometry, and appearances purely in time would be arithmetic (cf. Kant 1783/1976, §10), but the combination of time and space is motion.⁶ Thus, based on the claim the fundamental determination

⁶ Similar interpretations have been suggested by e.g. Schäfer 1966 and Plaass 1965. It should be noted that the central claim that motion must be the fundamental determination was treated in different ways by Kant's contemporary readers. Thus, while some reviewers of *Metaphysical Foundations* quoted the claim unquestioned (e.g. *Wirzburger gelehrte Anzeigen* July 28 1787, *Philosophische Annalen* April 1787, *Allgemeine deutsche Bibliothek* June 1787; all in Landau 1991) others critically asked whether the claim was a statement a priori or not (*Jenaische gelehrte Anzeigen* March 5 1787, in Landau 1991). However, in this paper we shall not enter the discussion of how this controversial claim of Kant's is to be interpreted, but only draw attention to the fact that the claim is essential to the whole project of *Metaphysical Foundations*; a fact that is important when turning to Ørsted's writings.

must be motion, his investigation of the basic conditions for our experience of the outer world was transformed from an investigation of which a priori judgments can be deduced by applying the categories to the concept of “matter” to an investigation of which a priori judgments can be deduced by applying the categories on the concept of “motion”. Therefore, *Metaphysical Foundations* contained four parts, investigating *motion* with respect to quantity, quality, relation and modality.

Although *Metaphysical Foundations* seem to have attracted less attention than some of Kant’s other works (Carrier 1990, p. 198), it found plenty of adherents. Among the contemporary scientists such figures as von Arnim, Baader, Hildebrandt, Richter, Scherer and Weiß explicitly adopted it (see e.g. Carrier 1990). The methodology of *Metaphysical Foundations*, to subsume something given under the categories, was broadly adopted among scholars of various fields as “applications of Kant’s philosophy” on the respective field. However, works adopting this methodology were often attacked from two sides: being too little speculative for the philosophers, but too short of scientific facts for the scientists.

Ørsted’s Kantian period 1799-1802: the youthful, radical know-all

Ørsted’s third project from this period - to introduce Kant’s *Metaphysical Foundations* to a Danish audience - was also the most ambitious. Rather than simply translating the book, Ørsted made a 40-page paraphrase which also followed a different structure than Kant’s book and he therefore titled it *Fundamentals of the metaphysics of nature. Partly according to a new plan.* (Ørsted 1799e/1998, pp. 46-78). It was printed in 1799 in the leading pro-Kantian journal *Philosophisk Repertorium* on which editorial board both the Ørsted brothers served. Later the same year Ørsted reworked *Fundamentals of the Metaphysics of Nature* into a thoroughly revised and slightly shorter version in Latin which he submitted as his doctoral thesis with the title *Dissertation on the Structure of the Elementary Metaphysics of External Nature* (Ørsted 1799f/1998). Finally, in 1802 while Ørsted was in Germany as part of his educational journey, a third, revised version was published in German under the title *Ideas of a new architecture of the metaphysics of nature* (Ørsted 1802).

Two problems immediately catch the eyes in Ørsted’s interpretations of *Metaphysical Foundations*. First, Ørsted discarded Kant’s central claim that the fundamental determination of a something that is to be an object of

the external senses must be motion. Second, apparently Ørsted did not understand the a priori character of Kant's concept of matter, and accused Kant for building his theory on empirical grounds.

As described above, Kant claimed that motion was the fundamental determination of a something that is to be an object of the external senses. Consequently, the understanding would trace all judgements of matter back to judgements of motion. However, Ørsted took a completely opposite view and separated the investigation of matter from the investigation of motion. He therefore went through the four classes of categories twice. He did this in each of the three works in which he build on Kant's *Metaphysical Foundations*, that is, *Fundamentals of the Metaphysics of Nature* from 1799 (Fundamentals), *Dissertation on the Structure of the Elementary Metaphysics of External Nature* likewise from 1799 (Dissertation), and *Ideas of a new architecture of the metaphysics of nature* from 1802 (Ideas).

It is noteworthy that Ørsted did not provide much argument for why he opposed Kant on this very central point. In the first of the three editions, the Danish *Fundamentals*, he even provided an argument for Kant's claim that motion is the fundamental determination of a something that is to be an object of the external senses:

Nothing can be perceived by the external senses except in time and space. When we contemplate matter, which is what we call each object for the external senses, in these two forms, the notion of motion and rest arises, the former by contemplating it at different times in changed relations to the rest of space, the latter by contemplating it as present in one space for some time. Here, then, we see the emergence of a pure *doctrine of motion*. (Ørsted 1799e/1998, pp. 47f.)

However, after having provided this argument explaining why the fundamental determination of anything that has to be an object of the external senses must be motion, he immediately added that:

in addition to this, the metaphysics of nature must also contain another part, which will teach us what properties we must necessarily presuppose in matter if it is to become an object of our external senses. This might be called a pure *doctrine of matter*. (Ørsted (1799e/1998, p. 48)

Consequently, he concluded that *each* of these two doctrines had to be taken through the four classes of categories, and he therefore ended with a division into eight parts. He realized that this was at odds with Kant's work and admitted in the introduction that, "[a]nyone who is familiar with Kant's

metaphysics of nature will see that this division is somewhat different from that of the famous thinker" (Ørsted 1799e/1998, p. 48). However, as an actual *argument* for his deviation he merely hoped "that the following will demonstrate sufficient grounds for my deviation. Here I can state no other than the one I have just put forward, viz., the division itself" (*ibid.*)

Ørsted's opposition to Kant's central claim developed with each of his three works. In the Danish *Fundamentals*, he introduced the doctrine of matter by the argument quoted above and treated the doctrine of motion first and the doctrine of matter second. However, in the opening sentence of the treatment of the quantity of matter he stated that

As we have seen above, that which is movable in space is called matter, and we regarded it in this manner throughout the doctrine of motion, but the first notion we have of matter is that it is the object for the external senses. (Ørsted 1799e/1998, p. 59)

Apparently, not only did he not accept Kant's claim that the understanding leads all other predicates which pertain to the nature of matter back to motion, he even insisted that the notion of matter was prior to the notion of motion. This led to a major structural change of his treatment when he revised it into the Latin version, *Dissertation*, published later the same year. Here he reversed the order of the sections, treating the doctrine of matter before the doctrine of motion, with the argument that

The doctrine of matter must come before the doctrine of motion, for without knowledge of extension, shape, and several other properties of matter, no doctrine of motion can be established. (Ørsted 1799f/1998, p. 83)

This forced him to introduce two new definitions of matter and motion, since matter could no longer be defined simply as the movable. Instead, he suggested that

What is real and is located in space we call *matter*, and its changes, which likewise can only occur in space, we call *motion*. Thus, two doctrines arise, one of matter, the other of the motion of matter. (Ørsted 1799f/1998, p. 82)

This seems to be a quite naïve realist view quite at variance with Kant's position. Thus, on a truly Kantian view, space (and time) only pertain to the *appearances* which arise when the two forms of intuition transform sensations, but not to the objects that give rise to the sensations by affecting our faculty

of representation. Hence, on this view, to talk of the real and its location in space is simply a contradiction in terms.

Yet, this was only an anticipatory step toward the view of the latest paper, the German *Ideas* from 1802, in which he not only regarded matter as the fundamental concept, but even reduced the science of motion to a part of the science of matter:

The real in space we call matter and the changes thereof we call movement. Hence, the science of movement, because movement as changing of matter concerns the relations of this, belongs to the science of the relation of matter. (Ørsted 1802, p. 21, our translation)

Thus, Ørsted ended in a position that was as contrary to the one expressed by Kant as one can possibly imagine. Further, to discard Kant's determination of matter as the movable left Ørsted with a problem. If his doctrine of matter should not be led back to the doctrine of motion, he had to find another fundamental determination of matter on which to ground the doctrine. For this purpose he took recourse to Kant's transcendental logic in the *Critique of pure reason*, more specifically to the axioms of intuition and the anticipations of perception which form part of the analysis of the possibility of synthetic judgments.

Thus, he quoted the axioms of intuition to state that "every object of the external senses must have extensive size" (Ørsted 1799e/1998, p. 59) and the anticipations of perception as "in all phenomenal the real, as an object of perception, always has intensive size, i.e. degree" (Ørsted 1799e/1998, p. 60). However, Kant's axioms of intuition stated that "all *intuitions* are extensive magnitudes" (Kant 1781/1997, p. B: 202, italics added), not that the *object for the external senses* must have an extensive size. Apparently, Ørsted failed to see the difference between the object for the external senses and the intuition which result when the object has given rise to a sensation and this sensation has been further transformed into an appearance – exactly that mistake of which Kant called "the chicanery of a falsely instructed reason, which erroneously thinks of freeing the objects of the senses from the formal condition of our sensibility, and, though they are mere appearances, represents them as objects in themselves" (Kant 1781/1997, p. A:166).

But having introduced 'the real', Ørsted continued this argument claiming that "The real in phenomena, then, manifests itself to our senses through the intensive size of its quality, i.e. through a force. Now, matter is the real in material objects ... and consequently we must attribute force to

matter. No change, and therefore no effect, can happen in sensible nature except through motion, so the force of matter can create nothing but motion, and consequently it must be a motive force" (Ørsted 1799e/1998, p. 60).

In this way Ørsted made matter a more fundamental concept than motion and force. In his own opinion the argument also did away with the "contingency" of Kant's matter concept. Towards the end of *Dissertation* which – as mentioned above – in structure an argument differs substantially from Kant's *Metaphysical Foundations*, Ørsted gave a very brief outline (in fact no more than at table of contents) of Kant's book and then proceeded to give it "a critical scrutiny" (Ørsted 1799f/1998, pp. 93-96). What concerned Ørsted was that Kant only wanted to investigate from a priori principles *how* matter is possible as object of experience, not *that* matter is possible. The latter, Kant claimed, we only know by empirical observation. In Ørsted's opinion this claim flawed Kant's whole endeavor which was to deduce the laws of external experience altogether a priori and thus with apodictic certainty. "Therefore, Kant offends against his own principles when he states that the notion of matter must be derived from experience, for in this way its universality and necessity will be lost. Further, if the very notion of matter is contingent, the deduced laws of nature cannot become necessary." (Ørsted 1799f/1998, p. 96).

A priori laws of chemistry

In *Metaphysical Foundations* Kant had concluded that as long as no underlying principle of how matter interacts with matter can be found, an a priori deduction of the principles of chemistry will not be possible. All that we know about chemical changes will therefore be based on observation and not on first principles and chemistry will remain "a systematic art, an experimental doctrine, but never proper science". (Kant 1786, p. A: V).

Ørsted touched on this question much later in his career.⁷ It clearly had his interest in *Fundamentals*, too, but he offered no solution. Instead he

⁷ E.g. in *First Introduction to General Physics*: "The theory of motion has been almost completely transformed into mathematics. The theory of force awaits the inventive mind which can lead it to the same point" (Ørsted 1811/1998, p. 296). Ørsted was more confident in 1846 when he gave a lecture to an assembly of natural scientist in Kiel: "One must admit that the chemical laws of nature are laws of reason [Fornuftslove] like the mechanical laws. ... Nowadays we already perceive the basis for the mathematical laws of the connections of material parts to one another, and the relations between shapes and constituents are beginning to dawn on us; I say dawn ... because [recent discoveries] apparently only make up the first light for *that* which we may

admitted that “To indicate the causes of chemical action with strict philosophical precision, is not so easy as it might seem at first glance now that we have all the fundamental laws of the action of matter”. (Ørsted 1799e/1998, p. 71). He went on to demonstrate that attempts to solve this problem made previously, by Eschenmayer and Schelling respectively, were miserable failures.

In *Dissertation*, however, Ørsted boldly presented ideas concerning the relationship between cohesion and the two fundamental forces which he thought could be developed into the foundation for chemistry found lacking by Kant. According to Kant, the forces responsible for cohesion were not fundamental, but were derived forces, and as such only to be known to us through empirical investigations. Ørsted immodestly confessed that he originally intended to follow in Kant’s footsteps, but “when I thought it over more carefully I was forced to leave that trail” (Ørsted 1799f/1998, p. 84).

Ørsted’s new and apparently original idea was, for a given body, to regard cohesion as a result of the combination of the attractive and the repulsive forces taking place within that body, since it was obvious that the repulsive force – in opposition to its attractive counterpart – was not active outside the limits of the body. Chemical action between two bodies, A and B, required close proximity and Ørsted now explained how, at the point of contact, the attractive force of body A will interact (in the manner of the combination of such forces which give rise to cohesion) with the repulsive force of body B. And vice versa. If the new forces of cohesion were strong enough to overcome the original cohesive forces, the bodies, according to this explanation, could enter into a new chemical combination and thus produce a new body. “Here we have only aimed at demonstrating the possibility of an a priori chemistry. However, through a more thorough investigation along these lines, I hope we shall one day be able to know the whole doctrine of chemical affinities.” (Ørsted 1799f/1998, p. 93).

Newtonian mechanics

As has already been stated, a major motive for Kant in writing *Metaphysical Foundations* was the wish to demonstrate that there is no contradiction between the epistemology laid out in his *Critique of Pure Reason* and the fundamental laws of mechanics as formulated in Newton’s *Principia*. In his sec-

expect in the future”. (Ørsted 1848–49/1978, pp. 117f., our translation)

ond chapter, termed “Metaphysical Foundations of Dynamics”, Kant treated matter with relation to the categorial class “quality”. He discussed various forms of forces (friction, cohesion, elasticity, chemical action, surface forces, penetrating forces) and came to the significant conclusion that his own attractive force was identical to Newton’s gravitational force. In the following chapter, termed “Metaphysical foundations of Mechanics” he took great pains to derive Newton’s three laws of motion from first principles.

In Ørsted’s interpretations the emphasis was quite different and the Newtonian element significantly reduced. In *Fundamentals* Ørsted did mention that the general attractive force is the same as gravity, and then went on to briefly derive the laws of motion (Ørsted 1799e/1998, p. 64 and 66-69). In *Dissertation*, however, gravity is only mentioned in passing, and Newton’s laws are dealt with in a single sentence: “From this [i.e. an argument about relative motion] it is possible to deduce the *Kantian theorem* that ‘the action is equal to the reaction’” (Ørsted 1799f/1998, p. 90, emphasis added). As if to substantiate his disapproval of the Newtonian description of celestial mechanics, Ørsted in an appendix speculated about the perpetual motion a heavenly body moving around a central body. Where Kant had pictured a space filled with matter of a density lower than anything which we can try out in experiments, thus keeping open the possibility of an infinitely fine aether (Kant 1786, p. A: 103ff.), Ørsted now claimed that “... a vacuum can by no means exist.” (Ørsted 1799f/1998, p. 99). Therefore a body moving through space would always be pushing matter aside, and in order to be eternal its motion would have to be sustained by some external agent. Ørsted briefly considered if the attractive force from the central body could be such an agent, but realized that his argument required a tangential force. He then suggested a most un-Newtonian explanation, “Some sort of matter emanating from the central body hits the moving body in such a way that the impulse is resolved into two forces; the direction of one goes through the centre of the body, and at the same time it becomes a *tangent* to the curved line along which the body to be moved will go.” (Ibid)

What kind of Kantian?

We are now in a position to evaluate the relation of the young Ørsted's natural philosophy to some of the central themes in Kant's philosophy. For a start, we think that it is important to emphasize that Ørsted explicitly stated that on certain points he deviated from Kant and that he wanted to "improve" on him. (Ørsted 1799e/1998, p. 48 and Ørsted 1799f/1998, p. 80).

As we have seen, Ørsted came precariously close to equate "an appearance" with "a thing in itself", and thus presented himself as a naïve realist. Rather amazing, since he claimed all along to be working on the basis of Kant's epistemology. Apparently the same inclination towards naïve realism guided Ørsted in his main discontent with *Metaphysical Foundations*, namely his claim that Kant's investigation of matter was not based on first principles. "The first point which I think deserves censure is that this most astute man did not deduce the laws of external experience altogether a priori but, on the contrary judged that that empirical properties ought to be attributed to matter, ..." (Ørsted 1799f/1998, p. 96). A sweeping and blunt criticism when one considers how explicit Kant was in pointing out that his only purpose was to deduce those properties that matter as a sensual possibility must necessarily possess, in case it is to be sensed by us. In his own words, the conditions for working on the basis of transcendental philosophy were clear: "Now to cognize anything a priori is to cognize it from its mere possibility." (Kant 1786, p. A IX).

Ørsted's lack of interest in the compatibility between transcendental philosophy and Newtonian physics must be viewed in the light of his insistence that a philosophical foundation for chemistry can be found in spite of Kant's claim of the opposite. In *Fundamentals* Ørsted clearly regretted that such a foundation had not been found, and in *Dissertation* he put forth a daring and somewhat flimsy hypothesis with the effect that - in his own eyes - he proved Kant wrong on this much discussed point.

In fact, Ørsted fully embraced only two sets of ideas from Kant. One was Kant's analysis of the faculty of understanding, in particular the conviction that all judgments must conform to the structural templates given by the twelve categories. In his analyses in the works referred to here, Ørsted closely followed Kant's method of analyzing a subject by treating it in relation to the four classes of categories, and Ørsted later reflections on the nature of a natural law seemed to be heavily inspired by Kant's notion of categories (see e.g. Ørsted 1844).

The second idea fully assimilated by Ørsted was Kant's anti-atomism, and the idea that the world is most adequately understood and

described through the application of the concept of forces. Thus it seems that already in the years 1798-1799 Ørsted reached the conclusion that he wanted to be a chemist and that he wanted to understand not only chemical processes but the entire firmament on a “dynamical” basis. This leaves us with the impression not of a philosopher – or at least of a philosopher of such unsophisticated breed, that finer distinctions concerning his philosophical susceptibility appear a bit moot - but of a determined, gifted, pragmatic, and very ambitious young chemist.

Acknowledgements: We would like to thank Margit Stougaard Christiansen, Anja Skaar Jacobsen, Kenneth Caneva and Ole Knudsen for valuable comments on earlier versions of this paper and for their patient urging on the project.

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