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PHILOSOPHY OF SCIENCE BETWEEN PHYSICS AND CHEMISTRY

The paper deals with the main problems of the philosophy of science from a new perspective. The analysis takes off from Rein Vihalemm's novel approach to scientific research called practical realism. From this perspective science is not only theoretical but first and foremost a practical activity. This kind of approach puts chemistry rather than physics into the position of a typical science as chemistry has a dual character resting on both constructive-hypothetico-deductive (ϕ-science) and classifying-historico-descriptive (non-ϕ-science) types of cognition. Chemists deal with finding out the laws of nature like the physicists. However, in addition to this they deal with substances or stuff that is rather an activity typical to natural history. The analysis of the dual character of chemistry brings forward the need to analyse philosophically the reasons why physics has held the position of the only science proper so far. This can be and done from the perspective of practical realism as well. There is a brief look into the essence of biology in the paper. The conclusion is, however, that the typical science of dual character is chemistry and this philosophical discovery may change the future perspective of the whole philosophy of science.

Key words: dual character of chemistry, ϕ-science, philosophy of science, physics, practical realism, Rein Vihalemm.

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Физика мен химияның арасындағы ғылым философиясы

Мақалада ғылым философиясының негізгі мәселелері жаңаша қарастырылады. Талдау Рейн Вихалемнің ғылыми ізденістерге практикалық реализм деп аталатын жаңа көзқарасына негізделген. Бұл көзқарас бойынша, ғылым теориялық қана емес, ең алдымен практикалық қызмет болып саналады. Мұндай ұстаным физиканы емес, химияны жалпы қабылданған, типтік ғылымдар қатарына қосады, себебі химия танымның конструктивті-гипотезалық-дедуктивті (ϕ-ғылым) типіне ғана емес, классификациялау-тарихи-сипаттау (ϕ-ғылым емес) типіне де сүйенетіндіктен, екі жақты сипатқа ие. Физиктер сияқты, химиктер де табиғат заңдарын анықтаумен айналысады. Оған қоса, олар заттармен немесе материалдармен жұмыс істейді, ал бұл – табиғатты зерттеу тарихына тән қызмет түрі. Химияның екіжақты сипаты физиканың осы уақытқа дейін нағыз ғалым болып саналуының себептерін философиялық тұрғыдан талдау қажет екендігін көрсетеді. Мұны практикалық реализм тұрғысынан да жүзеге асыруға болады. Мақалада биологияның мәні қысқаша қарастырылады. Алайда химия екіжақты сипатқа ие ғылым деген қорытынды жасалған және бұл философиялық жаңалық бүкіл ғылым философиясының даму болашағын өзгерте алады.

Түйін сөздер: химияның екіжақты сипаты, ϕ-ғылым, ғылым философиясы, физика, практикалық реализм, Рейн Вихалем.

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Философия науки между физикой и химией

В статье по-новому рассматриваются основные проблемы философии науки. Анализ основан на подходе Рейна Вихалема к научным исследованиям, который называется практическим реализмом. С этой точки зрения, наука является не только теоретической, но прежде всего практической деятельностью. Такой подход ставит химию, а не физику в положение типичной науки, поскольку химия имеет двойственный характер, опираясь как на конструктивно-гипотезо-дедуктивный (ϕ-наука), так и на классификационно-историко-описательный (не ϕ-наука) типы познания. Химики, как и физики, занимаются выяснением законов природы. Тем не менее, в дополнение к этому, они имеют дело с веществами или материалом, что является довольно типичной деятельностью в истории изучения природы. Анализ двойственного характера химии указывает на необходимость философского анализа причин, по которым физика до сих пор занимала позицию настоящей науки. Это может быть сделано и с точки зрения практического реализма. В статье кратко рассматривается сущность биологии. Однако делается вывод, что химия является типичной наукой двойственного характера, и это философское открытие может изменить перспективу всей философии науки.

Ключевые слова: двойственный характер химии, ϕ-наука, философия науки, физика, практический реализм, Рейн Вихалем.

Introduction

Historical background of the modern scientific method, as well as the development of the technological civilization, put physics in a special position in science. This became the view in Galileo's approach already that put in place the basic methodology of scientific research: formulating testable hypotheses, testing them repeatedly by means of the experiment and expressing the findings in the language of mathematics. This is a perfect methodology for classical mechanics and by and large fits all of physics, at least until Ilya Prigogine introduced the methodology of self-organizing systems and Hermann Haken started to develop synergetics. Anyway, since the times of Galileo and Newton, physics has retained its position as the only science proper. Different kinds of positivists, starting from the initiator of the approach Augusté Comté through the logical positivists up to the so-called post-positivists, only strengthened this special position of physics. Physics-likeness became an important characteristic for any kind of science, even the social one. Let us remember that Comté introduced the term 'social physics' to refer to social research at first and only later it was changed to 'sociology'. However, there is an obvious need for a philosophical analysis of the position of physics in addition to the historical explanation. It is interesting that philosophy of science becoming an important field in the XX century was largely due to the emergence of nonclassical science, quantum mechanics and relativity theories, early in the century. In a way, philosophy of science received a momentum in result of physics becoming less physics-like that it was before. Strangely enough, this revolution in science in Kuhnian sense did not undermine the exemplary status of physics among sciences but even strengthened it. Philosophy of science, actually remained philosophy of physics for decades. Philosophers of science asked all kinds of questions concerning the only science proper. However, the most basic problem, why one has to take exactly physics as the model, never really came up.

In order to initiate the analysis of the basic problem mentioned above, we need to remind ourselves about the main issue in the philosophy of science, the problem of demarcation. Addressing this central problem will help us to begin taking a deeper philosophical look into the issue of the special position of physics. The two classical solutions to this problem of demarcation are well known and widely discussed, the criteria of verification and falsification. However, these classical solutions do not help us in our current task. They both actually say that a scientific hypothesis has to be testable. This requirement does not single physics out anyhow. We can have perfectly testable hypotheses in social science, not to speak about biology or chemistry. Fortunately, contemporary philosophy of science includes a quite recent approach that creates

an appropriate framework for the philosophical analysis of the special position of physics. The Estonian philosopher of science Rein Vihalemm initiated this approaches that bases on an original solution of the problem of demarcation roughly at the turn of the century.

Φ-science or non-ϕ-science

About two decades ago, Rein Vihalemm came forward with the idea of making a distinction between two types of cognition: constructive-hypothetico-deductive and classifying-historico-descriptive. (Vihalemm, 2011). There is a long tradition to call the scientific method hypothetico-deductive. William Whewell normally gets the credit for introducing the concept. Why add 'constructive'? Where does this development come from and what is the justification?

According to Rein Vihalemm, the scientist does not possess the God's eye view concerning reality. She does not know and will never know how the world really is. Reality does not reveal itself in the form of research objects, entities that allow themselves to be studied by the scientific method. The researcher has to construct the object of research according to the requirements of her cognitive capacity and principles of the research methodology. Obviously, the approach is Kantian by its nature. Kant's apriorism is clearly visible but there is a difference as well. The structure of human cognitive capacity does not set the scene alone. Reality is there as well and actually takes up the leading role.

We are now facing the question whether Vihalemm's approach should be classified as a kind of constructive empiricism. Still, Vihalemm's own position is that we are actually having a kind of realism here, namely practical one. We are leaving a further explanation of this issue to a later point. Currently, let us just acknowledge that exact natural science bases on the type of cognition that we call constructive-hypothetico-deductive.

The next question would be, whether there is a branch of science that is entirely constructive-hypothetico-deductive. The answer is obvious – physics. Still, it is not clear that all of physics would fit into this category. The pure specimen of a constructive-hypothetico-deductive type of science is perhaps just classical mechanics. After all, physics is a living and developing field of science and at some point might grow out of the limits of the constructive-hypothetico-deductive ideal. This is the reason why Rein Vihalemm developed a model of science based on the constructive-hypothetico-deductive cognition. He called the model ϕ-science, stressing its closeness to physics with the first letter of the Greek word *Physica*. Classical physics is ϕ-science proper. There can be doubts about the non-classical physics (quantum mechanics and theories of relativity) but this is still rather ϕ-science as well because there is no irreversibility. Time has no meaning in classical as well as non-classical physics. At times, the constructive moment concerning the research object is even stronger in non-classical physics. We cannot experience the subatomic world or the speed of light directly. Therefore, we have to work with idealised concepts. The situation looks different with the so-called post-non-classical science. Vyacheslav Styopin introduced the term considering mostly the approach of Ilya Prigogine and his followers. The main difference with the former types of physics here is that the requirement for the reproducibility of the experiment does not hold. All processes that are going on in reality are taken as irreversible ones. Irreversibility becomes an objective principle. It is no longer just due to the limits of human sense-experience. Due to these fundamental changes, post-non-classical physics is not purely ϕ-science and introducing the model instead of just referring to physics itself as an example of science proper becomes justified. There is an even wider implication here. The whole philosophy of science becomes better grounded. It is obvious now that it does not equate with the philosophy of physics. Already today, part of physics appears to be non-ϕ-science, i.e. it rather bases on classifying-historico-descriptive type of cognition. In an analogous way, Styopin could not just refer to Prigogine's works because there are other approaches in physics there as well, that do not entirely belong to ϕ-science, i.e. synergetics, chaos theory, bifurcation theory, etc.

Let us now turn to chemistry and put the question whether chemistry is a ϕ-science or a non-ϕ-science or both to some extent. The ϕ-science part would require chemistry to have strong physics-likeness. However, by all evidence chemistry does not reduce to physics. The possibility of this reduction would not have remained undiscovered for such a long time. On the other hand, chemists are looking for the laws of nature and succeed, at least sometimes. By all evidence, there is a part of chemistry that is physics-like and another part that is not physics-like, i.e. part of chemistry must be ϕ-science and another part has to be non-ϕ-science or of the natural history type. Interestingly, we really do find these two characters in chemistry.

The dual character of chemistry has been noticed and pointed out by Rein Vihalemm as well as some other philosophers of science, like Bernadette Bensaude-Vincent and Jonathan Simon (2008) but not exactly in the same way. Historically, chemistry has rather been a natural history type of discipline. Despite this, it evolved as a branch of modern science and did not equate with alchemy in the XVII century already. However, there is chemistry as ϕ-science there as well. This part of chemistry deals with the laws of nature. We need to take a deeper look here what does it mean to deal with, or rather try to find out, the laws of nature and how do physics and chemistry differ on this respect if they do. If we speak about scientific knowledge then the ϕ-scientific one tends to be the most trustworthy (Müürsepp, 2011: 61-73).

Our analysis of the latter problem will base on Rein Vihalemm's approach to science that he named 'practical realism'. The approach bases on five theses that say the following:

«1. Science does not represent the world «as it really is» from a god's-eye point of view. Naïve realism and metaphysical realism have assumed the god's-eye point of view, or the possibility of one-to-one representation of reality, as an ideal to be pursued in scientific theories, or even as a true picture in the sciences.

2. The fact that the world is not accessible independently of scientific theories – or, to be more precise, paradigms (practices) – does not mean that Putnam's internal realism or «radical» social constructivism is acceptable.

3. Theoretical activity is only one aspect of science; scientific research is a practical activity and its main form is the scientific experiment that takes place in the real world, being a purposeful and critical theory-guided constructive, as well as manipulative, material interference with nature.

4. Science as practice is also a social-historical activity which means, amongst other things, that scientific practice includes a normative aspect, too. That means, in turn, that the world, as it is accessible to science, is not free from norms either.

5. Though neither naïve nor metaphysical, it is certainly realism, as it claims that what is «given» in the form of scientific practice is an aspect of the real world. Or, perhaps more precisely, science as practice is a way in which we are engaged with the world» (Lõhkivi, Vihalemm, 2012: 3).

Practical realism was not born out of nothing. Rein Vihalemm points out several predecessors of his approach (Vihalemm, 2011: 46-60). At this point, let us just emphasise Joseph Rouse's explanation of the practice based science: «… the question is not how we get from a linguistic representation of the world to the world represented. We are already engaged with the world in practical activity, and the world simply is what we are involved with. The question of access to the world, to which the appeal to observation was a response, never arises. The important categories for characterizing the ways the world becomes manifest to us are therefore not the observable and unobservable (empirical and metaphysical – P.M.). We must ask instead about what is available to be used, what we have to take account of in using it, and what we are aiming toward as a goal» (Rouse, 1987: 143).

Quite obviously, it is chemistry, rather than physics that works best as a model for practical realist treatment of science. Practical realism might even shift the focus of the whole philosophy of science. For more than a century, the latter was undisputedly physics centred. Chemistry very seldom achieved special mention beside physics. It was rather taken as something like a younger brother of physics, as the same type of science as physics, just a bit underdeveloped as compared to the 'big brother'. The practical realist approach enables to show that chemistry is definitely a science in its own right. More than that, chemistry need not be analysed taking physics as a model but a philosopher of science might act *vice versa* as well. The position of physics among sciences may become better analysable on the background of its relationship to chemistry.

In Rein Vihalemm's understanding of pure science (ϕ-science), chemistry plays a special role. It is a mixture of ϕ-science and non-ϕ-science as it connects to both constructive-hypothetico-deductive and classifying-historico-descriptive types of cognition. Thus, chemistry provides us a good basis for analysing the difference between physics-like science and natural history. It is interesting that the existence of chemistry alone prevents us from identifying exact science with physics. This means that there is a need to analyse philosophically the special status of physics. We cannot take this for granted any longer. We cannot exclude the option that this analysis may even dethrone physics from its seemingly firm top position.

The history of chemistry is a good example how a cognitive approach to nature evolved into science (in the modern sense). Physics, in the form of classical mechanics, was born parallel to this evolvement. Physics started as pure science and therefore it initially became the model. Or rather, the methods of classical mechanics became the

role models for the whole science. However, non-classical and especially post-non-classical physics are not really entirely pure science. One just needs to consider the changing role of the experiment, the problems with reproducibility (Müürsepp, 2013). Interestingly even in the context of the experiment, chemistry take up a significant, perhaps even the leading position. Chemical experiments expose better the need to drop the requirement of reproducibility and the objective unidimensionality of time even in exact science.

The Laws of Nature or the Laws of Physics and Chemistry

The next issue to be resolved is the question whether it might be that chemistry was part of natural history before becoming real physics-like science but turned entirely into the latter in the course of time. This is still not the case. Up to this day, chemistry does not deal with the laws of nature only. However, what does it mean to deal with the laws of nature for physics and chemistry? Does it work the same way? If so then we could still equate the ϕ-science part of chemistry with physics and only the natural history part will remain as a discipline in its own right. In the most radical case, chemistry might split up into physics and biology.

Let us take a brief look at the most famous law of nature chemistry as ever provided, Mendeleev's periodic law. It is not a mathematically formulated law of physics. Still, it is a law of nature. According to Rein Vihalemm, it is exact in the same philosophical sense as the laws of physics (Vihalemm, 2015: 11). How to understand this? The periodic law looks quite different of the laws of physics. Vihalemm explains that the periodic system of chemical elements was established by constructing an idealised system of idealised elements. What is a chemical element after all? Vihalemm puts the answer like this:»… a fundamental idealisation substantiated by experimental chemistry – namely, a definite position in the periodical system based on the periodic law» (Vihalemm, 2015: 12). Vihalemm emphasises that the chemical element is actually not an entity that we can find in nature but rather an idealised construction of the human mind. Interestingly enough, however, the periodical table of elements of Mendeleev is by no means an arbitrary construction but reflects an aspect of reality. There is the system there in reality, although it has been exposed by means of constructed idealised entities. The process of constructing the research object is there like in physics. Still, the result is different. The law of periodicity is a law of chemistry, not of physics. Chemistry really has a dual character, seeking laws of nature and describing reality in the style of natural history. The example of the periodic law is a perfect illustration to most if not all theses of practical realism. Chemistry is a practical science (see Müürsepp, 2016) as the experiment plays a central role even in the process of making the law of periodicity. However, formulating the law would not work without an underlying theory or paradigm.

There is a very legitimate question there, is chemistry specific in its dual character or do we have the same or at least something similar in biology? We have to admit that contemporary biology provides us with a similar situation to some extent at least, especially as far as molecular biology and genetics are concerned. That side of biology has the essence of a ϕ-science. Thus, strictly speaking, biology is also a science of a dual character. It will be very interesting to follow from the philosophical point of view the forthcoming developments in biology. At this point, biology does not really compare with chemistry yet concerning its impact as a science of dual character. Rein Vihalemm explains that the resistance of the material is too strong (Vihalemm, 2015: 12). The material here would be living matter. Dealing with life, biology cannot really obtain the constructive character. It has to remain based on the classifying-historico-descriptive type of cognition, to remain a non-ϕ-science. However, there may be the tendency to become a science that is closer to chemistry. After all, there is biochemistry that deserves also special philosophical attention. Let that remain, however, a topic for further analyses.

Chemistry and Philosophy of Technology

As mentioned above, there are other thinkers in addition to Rein Vihalemm, who have noticed the dual character of chemistry. Bernadette Bensaude-Vincent and Jonathan Simon, for instance, have interesting observations. They call chemistry an archetypal techno-science because it cannot restrict itself to pure theory but always engages with productive practice (Bensaude-Vincent, Simon, 2008: 5). This is a quite different dualism compared to Vihalemm at first glance. However, Bensaude-Vincent and Simon also point out an aspect of chemistry that supports the practical realist understanding of science. The authors emphasise that throughout the last couple of centuries physics has promoted pure theory

over other forms of science (Bensaude-Vincent, Simon, 2008: 5). As physics had the position of the role model, anything practical concerning science became an indication of being away from the ideal. Research in chemistry, however, reminds us about the practical side of science. Bensaude-Vincent and Simon observe: »Indeed, we want to place special emphasis on this idea that theory and substance are co-produced by the chemist in the laboratory» (Bensaude-Vincent, Simon, 2008: 6). This idea takes Bensaude-Vincent and Simon close to practical realism and other ideas of Vihalemm. The produced substance (or stuff) is not constructed. It is a real product of chemistry and dealing with it bases on the classifying-historico-descriptive type of cognition. As a general conclusion, Bensaude-Vincent and Simon introduce the term 'operational realism'. They emphasise that the term was coined under the influence of the chemists' activities in the laboratory and add an ambitious belief that the basics of the philosophy of science will be rethought under the influence of their approach (Bensaude-Vincent, Simon, 2008: 8).

Unfortunately, there is not very active rethinking in sight so far. Practical realism of Rein Vihalemm is the only visible attempt to start the process of the philosophical analysis of the central position of physics in science. Due to Vihalemm's untimely death in 2015, however, all these plans have remained unfulfilled.

Conclusion

As it has been revealed from different angles, chemistry is a special kind of science because of its dual character. This philosophical discovery supports the practice-based approach in the philosophy of science and opens up new developments like analysing philosophically the special position of physics as the only science proper and the role of biology as a possible competitor of chemistry for securing leadership as an interesting case of dual character.

Lately, we are witnessing a kind of separate and quite active development of philosophy of chemistry and philosophy of biology as well as philosophy of physics to some extent. Hopefully, the above analysis rather draws attention to the need of keeping philosophy of science as such in focus as well. The different scientific disciplines are not natural kinds. As shown above, they have their overlapping 'grey' areas. By specialising narrowly on the philosophical analysis of different disciplines, we may lose sight of the most interesting and perhaps the most important problems, namely what is it that actually unites the different disciplines and what is different between them.

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