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Philosophy in science – a case study of the reception of the Special and the General Theory of Relativity in Kraków and Lwów before 1925

Abstract

A centenary of Einstein's General Theory of Relativity brings forward some questions with regard to the impact of Einstein's theory on philosophy. This theory, and the chronologically earlier Special Theory of Relativity, have had many important philosophical implications. In Poland they provoked interesting philosophical discussions before WWII. The history of those discussions reveals numerous noteworthy facts concerning the relationships between mathematics, physics and philosophy.

A case study of the reception of the Special and General Theory of Relativity in Kraków and Lwów before 1925 focuses on the peculiar specificity of exact sciences and philosophy in Polish Galicia. The concept of "philosophy in science" coined

PUBLICATION INFO	Studia Historiae Scientiarum	e-ISSN 2543-702X ISSN 2451-3202		DIAMOND MODEL OPEN ACCESS

CITATION
POLAK Paweł 2016: Philosophy in science – a case study of the reception of the Special and the General Theory of Relativity in Kraków and Lwów before 1925. *Studia Historiae Scientiarum* 15, pp. 245–273. DOI: 10.4467/23921749SHS.16.010.6153 Available online: http://pau.krakow.pl/SHS/shs-15-2016-10.pdf

RECEIVED: 21.12.2015 ACCEPTED: 12.10.2016 PUBLISHED ONLINE: 24.11.2016	ARCHIVE POLICY Green SHERPA / RoMEO Colour	LICENSE CC BY NC ND	Crossref

WWW	http://pau.krakow.pl/Studia-Historiae-Scientiarum/ http://ejournals.eu/Studia-Historiae-Scientiarum

by Michael Heller is particularly suitable for describing this specificity.

The article begins with a short overview of the early reception of the Special Theory of Relativity in Kraków. Next, it shows how the discussions during the 10th and 11th Congresses of Polish Physicians and Natural Scientists (Lwów 1907, Kraków 1911) influenced the reception of the STR. What is also discussed are the roots of the specificity of the reception in Lwów, i.e. the influence of the considerations about the foundations of mechanics and a public philosophical debate around Einstein's theories. In order to demonstrate how different the reception of these theories was in Kraków, a description is provided of a methodological debate between S. Zaremba and T. Banachiewicz. Some notes are also added about the concurrent styles of philosophy of science (philosophy of nature). The article ends with conclusions about the specificity of Kraków's and Lwów's styles of philosophy in science.

This study reveals that in this period Einstein's theories significantly stimulated philosophical considerations in Poland. These considerations have become an important supplement to the scientific activity in Kraków and Lwów.

Keywords: *history of physics • philosophy of science • philosophy in science • philosophy of physics • Special Theory of Relativity • General Theory of Relativity • Albert Einstein • Ernst Mach • Bronislaw Biegeleisen • Maksymilian T. Huber • Stanislaw Loria • Zygmunt Zawirski • Stanislaw Zaremba • Tadeusz Banachiewicz • Lwów • Kraków*

Filozofia w nauce – studium przypadku recepcji szczególnej i ogólnej teorii względności w Krakowie oraz we Lwowie przed rokiem 1925

Streszczenie

Setna rocznica sformułowania przez Alberta Einsteina ogólnej teorii względności jest doskonałą okazją do ponownego postawienia pytań o wpływ wspomnianej teorii na filozofię. Interesującą perspektywę oferują badania z zakresu historii

nauki i historii filozofii, które pozwalają dokładniej przyjrzeć się procesowi recepcji wspomnianej teorii. Proces ten jest ważnym źródłem wiedzy o kształtowaniu się relacji nauk przyrodniczych i filozofii, gdyż poprzez analizę wskazywanych trudności i kontrowersji pozwala zidentyfikować wiele ukrytych założeń o charakterze filozoficznym, które trudno dostrzec na innych etapach rozwoju nauki. Dzięki temu analiza procesu recepcji nowych teorii naukowych staje się wyróżnionym przedmiotem analiz relacji matematyki, nauk przyrodniczych i filozofii. Z tych względów warto przyjrzeć się interesującym dyskusjom i polemikom, które miały miejsce w obrębie nauki polskiej.

Szczególnie interesujące polemiki i dyskusje wokół teorii względności rozegrały się w Krakowie i we Lwowie przed rokiem 1925. Wspomniane ośrodki zostały wybrane również z tego względu, że w początkach XX wieku, wykorzystując możliwości polityczno-kulturalne powstałe w związku z istnieniem stosunkowo szerokiego zakresu autonomii Galicji, stały się one najważniejszymi centrami rozwoju nauki polskiej. Sytuacja ta zadecydowała również o połączeniu wymienionych ośrodków stosunkowo silną siecią powiązań, widocznych szczególnie na gruncie fizyki. W obu miastach powstała również specyficzna (choć z zachowaniem pewnych lokalnych odrębności) odmiana refleksji nad nauką, którą dogodnie jest określić przy pomocy pojęcia „filozofii w nauce" stworzonego przez M. Hellera.

Opracowanie rozpoczyna się od krótkiego przybliżenia historii recepcji szczególnej teorii względności w Krakowie. W procesie tym najistotniejszą rolę odegrał August Witkowski, który już w 1905 roku docenił znaczenie pierwszych prac Einsteina. Kolejne punkty zwrotne w procesie recepcji teorii Einsteina wyznaczyły dwa kolejne Zjazdy Lekarzy i Przyrodników Polskich, które odbyły się kolejno we Lwowie w 1907 r. i w Krakowie w 1911 r. Pierwszy z nich zadecydował o popularyzacji idei relatywistycznych pośród przyrodników polskich, a kolejny – o popularyzacji ich wśród filozofów. Dla zrozumienia lokalnej specyfiki filozoficznych rozważań prowadzonych w ośrodku lwowskim odwołamy się do rozwoju recepcji wokół podstaw mechaniki. Zagadnienie to szczególnie mocno interesowało lwowskich uczonych z tej racji, że Lwów był do 1915 roku jedynym polskim ośrodkiem akademickim rozwijającym nauki

techniczne i koncentrował w naturalny sposób większość polskich uczonych zajmujących się nauką mechaniki. To właśnie środowiska związane z lwowską Szkołą Politechniczną odegrały ważną rolę w późniejszych dyskusjach wokół szczególnej i ogólnej teorii względności.

W dalszej kolejności szkicowo zaprezentowana zostanie lwowska polemika wokół teorii względności i dla kontrastu ukazana zostanie o wiele krótsza polemika rozgrywająca się w Krakowie. Szczególna uwaga zostanie poświęcona dorobkowi Zygmunta Zawirskiego, który w swej działalności podjął problematykę poruszoną w obu ośrodkach i przedstawił najbardziej interesujące rozważania ukazujące nowoczesną wizję filozofii uprawianej w ścisłym kontakcie z naukami przyrodniczymi.

Prezentowany styl filozofii w nauce rozwijany w Krakowie i Lwowie został również skrótowo skonfrontowany z konkurencyjnymi filozoficznymi reakcjami na teorie Einsteina: z refleksją rozwijaną w obrębie Szkoły Lwowsko-Warszawskiej (Kazimierz Ajdukiewicz) i z wybraną refleksją neoscholastyczną (Feliks Hortyński SJ, Ludwik Wrzoł SJ, Jan Stepa). Na tym tle lepiej można dostrzec specyfikę filozofii analizowanej w tym studium przypadku – najważniejsze uwagi na ten temat zostały zawarte w zakończeniu niniejszej pracy.

Niniejszy artykuł ukazuje fakt, że szczególna i ogólna teoria względności Einsteina znacząco wpłynęły na rozwój refleksji filozoficznej w Polsce. Warto również zaznaczyć, że refleksja filozoficzna stała się w opisywanym okresie ważnym uzupełnieniem pracy naukowej przyrodników, co decyduje również o specyfice rozwoju ówczesnej nauki.

Słowa kluczowe: *historia fizyki • filozofia przyrody • filozofia w nauce • filozofia fizyki • szczególna teoria względności • ogólna teoria względności • Albert Einstein • Ernst Mach • Bronisław Biegeleisen • Maksymilian T. Huber • Stanisław Loria • Zygmunt Zawirski • Stanisław Zaremba • Tadeusz Banachiewicz • Lwów • Kraków*

1. Introduction

The centenary of the General Theory of Relativity (GTR) is a good point for questions about the philosophical reception of Einstein's theories. The Special Theory of Relativity (STR) and the General Theory of Relativity have raised some deep questions about the nature of physical reality.

The reception of Einstein's theories in Poland was a subject of many publications of Bronisław Średniawa (1979; 1985; 1986; 1987; 2001; 2006). The historical, theoretical and philosophical context of this process was also described in many publications of the last decade (e.g. Bażański 2005; Wróblewski 2006a; 2006b; Polak 2012). The early reception of the STR & the GTR in Poland was also a subject of detailed studies (Polak 2007; 2011a; 2013; 2014a; 2014b).

These publications have shown interesting relationships between the reception of Einstein's theories and the development of Polish philosophy of nature (philosophy of science)[1] in Kraków and Lwów. The first of them was widely recognized as an important milieu of the philosophy of nature in the first part of the 20th century (Heller, Mączka 2007; Polak 2006; 2011b). On the other hand, Lwów was known only as a center for analytical philosophy (e.g. Woleński 1985), and the philosophical milieu was constrained only to the Lwów-Warsaw School (LWS) founded by Kazimierz Twardowski. The studies into the reception of Einstein's theories revealed interesting and important philosophical considerations of scientists in Lwów which cannot be attributed to the Lwów-Warsaw School (Polak 2012). These studies raised questions concerning the influence of the reception of these theories on the development of philosophy in Poland. Very interesting questions concern the specificity of these philosophical considerations provoked by new and revolutionary scientific theories.

In this article, I would like to show a case study of the most important contributions to the philosophical reception of the STR &

[1] In Polish philosophy in the 20th century the term *filozofia przyrody* ('philosophy of nature') was still in use. This term could be translated as 'philosophy of science', but in Polish philosophy the latter has a more precise meaning, i.e. epistemology and methodology of science. The philosophical considerations described in this article partly belong to philosophy of nature and partly to, strictly considered, philosophy of science. This shows the specificity of these considerations.

the GTR in Poland. I have chosen the period of 1905–1925 as it is in that time that Einstein's theories provoked the majority of philosophical considerations. The aim of this case study is to demonstrate how Einstein's theories affected and stimulated the development of Polish philosophy of science.

In order to describe the specificity of this philosophical reflection, I would like to use the term 'philosophy in science', promoted by Michał Heller (1986). This is a kind of philosophy of science which is inspired by scientific research and uses arguments derived from science in the considerations on classical philosophical problems. This style in philosophy started in the late 19th century and became important in the 1920s and 1930s (see Tatarkiewicz 1998, pp. 262–265). 'Philosophy in science' stresses the fact that science contributed to the development of philosophy, and some scientists and philosophers were the proponents of this philosophy strictly tied with science. This kind of philosophy is not identical with positivism, because it assumes neither reduction of philosophy to science, nor rejection of classical philosophical topics, such as metaphysics.

In this article philosophy in science is considered – according to Heller (2011) – as a reflection on traditionally philosophical themes in science. Both STR & GTR are typical examples of physical theories which had a strong impact on the philosophical considerations on space and time (Tatarkiewicz 1998, pp. 273–274).

I will start with a short overview of the early reception of the STR in Kraków. Next, it will be shown how the discussions during the 10th Congress of Polish Physicians and Natural Scientists in Lwów and the 11th Congress of Polish Physicians and Natural Scientists in Kraków influenced the reception of the STR. After that, the specificity of reception in Lwów will be shown, namely the influence of these considerations on the foundations of mechanics and a public philosophical debate around Einstein's theories. As a means to present the differences in the reception of these theories in Kraków a methodological debate will be described, which took place between S. Zaremba and T. Banachiewicz. Some notes on the concurrent styles of philosophy of science (philosophy of nature) will also be added. The article will be ended with conclusions regarding the specificity of this style of philosophy.

2. Early reception of the Special Theory of Relativity (STR) in Kraków

At the turn of the 20th century August Witkowski's research and philosophical considerations created important foundations for the rejection of the concepts of mechanical ether and for the reception of new relativistic ideas in Kraków (Polak 2013). August Witkowski was interested in theoretical physics (esp. theory of light, electromagnetism) but he did not create his own theoretical description of relativistic phenomena. However, he perfectly understood the main ideas which led to the STR.

At the beginning of the 20th century he anticipated some ideas of geometrization of physical laws and he supposed that the physical concept of space should be connected with the concept of time (see Witkowski 1901, p. 2). In a public lecture entitled "Ether", delivered in 1902 at the Jagiellonian University in Kraków, he presented a critique of the concept of mechanical ether (Witkowski 1903). He also described the problems connected with the Lorentz's length contraction hypothesis. Firstly, he stated that it was a bold hypothesis. Witkowski probably meant that this hypothesis could have an *ad hoc* character (he accepted bold hypotheses which were consistent with the system of physical knowledge). Secondly, he stated that Lorentz's hypothesis contradicted the principle of action and reaction. The main ideas of this critique are very similar to the article by Poincaré (1900) but there is no direct evidence of Poincaré's influence. Witkowski formulated two criteria of physical theories. The first one is 'convergence with the principle of action and reaction'. The second states that "our mind cannot recognize absolute motion". The rejection of absolute motion is an important step to formulate the principle of relativity. However, the formulation of the second criterion in the terms of psychology was not convenient for physics.

According to Stanisław Loria, August Witkowski was the first Polish physicist who recognized the significance of Einstein's article (1905) soon after its publication. In autumn of 1905 Witkowski ordered Stanisław Loria to prepare a presentation of Einstein's ideas at a scientific seminar. Witkowski told Loria: "A new Copernicus has been born! Read Einstein's paper!" In this way Kraków became one of the three places in 1905 where Einstein's theory was taken into consideration.

In 1909 Witkowski delivered a public lecture on 'the principle of relativity' in the Academy of Arts and Sciences in Kraków. It was a very interesting introduction to the main ideas of Einstein's STR with many profound philosophical remarks. Witkowski made these philosophical remarks on the basis of his research in physics. His philosophy was intrinsically connected with his scientific activity. From the philosophical point of view, it was a combination of particular methodological and epistemological issues (see Polak 2013). It was typical of the new philosophy of nature developed in Kraków by natural scientists (see Polak 2011b).

Witkowski rejected Newton's absolute notions of space and time and accepted Einstein's relative notions, because for him it was the only way to avoid the contradictions in physical explanations of nature. He also rejected the notion of substantial ether for the same reason. These are very good examples of the new style of philosophy in science – the classical problems of space and time were considered on the basis of a physical theory. Unfortunately, after Witkowski's death in 1913 the philosophical considerations on STR were almost entirely abandoned in Kraków since the end of World War I.

3. STR on the 10th and 11th Congress of Polish Physicians and Natural Scientists

During the 19th century, Poland remained partitioned and the conditions for the development of Polish culture and Polish science were generally unfavorable. However, since the 1870s the situation in Galicia, the southern part of partitioned Poland, a part of Austria-Hungary, started to change. The Galician autonomy allowed for the reconstruction and growth of Polish science. Thanks to this process Polish scientists from all parts of partitioned Poland tried to establish mutual cooperation. The most effective means to accomplish that goal was the Congress of Polish Physicians and Natural Scientists (CPPNS). During these congresses, philosophers worked together with natural scientists, which helped to develop a philosophy with a very close connection to science.

During the 10th CPPNS held in July 1907 in Lwów a young scientist Jakob J. Laub presented his paper (1907) "Optyka ciał ruchomych" ("Optics of moving bodies") based on his German article "Zur Optik bewegter Körper". Laub was born in Rzeszów, in Galicia, studied at the

Jagiellonian University in Kraków and at universities in Vienna and Göttingen. In 1905 Laub presented Einstein's paper "Zur Elektrodynamik bewegter Körper" at Wilhelm Wien's seminar in Würzburg.

Laub's lecture in Lwów was the first presentation of STR for Polish scientists. Many physicists and mathematicians from Lwów and Kraków were present at this lecture, namely L. Böttcher, J. Puzyna, T. Godlewski, M.T. Huber, W. Natanson, S. Zaremba et al. Years later, M.T. Huber stated that "We were transfixed by the audacity and novelty of [Einstein's] ideas, and in the first moment we were unable to entirely comprehend it and unable to do any critical evaluation" (Huber 1920a, p. 4). Laub's talk was a turning point in the growth of interest in STR in Kraków and Lwów. It is worth mentioning that the extended version of the lecture was published next year in Polish (Laub 1908).

The 11th CPPNS held in Kraków in July 1911 started an interest in the philosophical consequences of Einstein's theory. Before this congress I could find only one significant consideration (apart from Witkowski's lecture) about philosophical consequences of STR. In an article published in February and March 1911 Bronisław Biegeleisen, an engineer from Lwów, used some arguments from STR in a critique of Bergson's concept of time (Biegeleisen 1911, pp. 78–79).

During the 11th CPPNS, Polish physicist Henryk Merczyng (from Saint Petersburg) presented the speech about concepts of time and space in Einstein's STR (Merczyng 1911). Many Polish philosophers attended this speech, e.g. Kazimierz Twardowski, Jan Łukasiewicz, Władysław Witwicki, Bronisław Bandrowski, Marian Raciborski, Adam Stögbauer, Stanisław Garfein-Garski. Soon after this congress STR became very well known among Polish philosophers and inspired many philosophical comments.

4. Considerations on the foundations of mechanics in Lwów, and their importance for the philosophy in science

In order to understand the specificity of philosophy inspired by STR & GTR it needs to be to mentioned that in the first decades of 20th century Lwów became the most important center of Polish philosophy and science. Lwów was a capital of Galicia with two Polish academic schools:

Lwów University and Polytechnical School. At the Lwów University analytical philosophy was developed by Kazimierz Twardowski and his students, but they were not interested in the philosophical aspects of scientific theories (with the exception of Zygmunt Zawirski's activity described below).

The Polytechnical School was until 1915 the sole Polish technical academic school, and it played a crucial role in the development of engineering in Poland. Many famous Polish engineers studied there. We would also like to stress that this School played an important role in the development of the philosophy in science in Lwów. It is connected with the discussion on the foundation of mechanics.

Mechanics played a role as a fundamental theory of technology at that time, so the scientists from Polytechnical School were deeply interested in any changes in this domain. It is worth adding that the foundations of mechanics were also considered as the foundations of physics in the late 19th century.

Philosophical issues of the foundations of mechanics became popular in Lwów during the reception of Ernst Mach's critique of Newtonian mechanics. His book *Die Mechanik in ihrer Entwickelung* (Mach 1883) (English translation: *The Science of Mechanics*, 1893) had an impact on Lwów's scientists. This book was cited in textbooks of mechanics until the late 1930s (e.g. Banach 1938). The second source of philosophical influence was a book of an American philosopher John Bernard Stallo, entitled *The Concepts and Theories of Modern Physics* (Stallo 1882). The 3rd edition of this book was translated into German (Stallo 1901). Ernst Mach added a foreword and expressed his praise to Stallo's philosophical critique of the foundations of mechanics. The third very important source of philosophical inspiration were the translations of Henri Poincaré's books, which showed a new view of scientific methodology.[2]

Mach's critique of Newton's absolute notions of time, space and motion provoked some discussion in Lwów about the foundations of mechanics. It could be classified as philosophy in science, because the development of mechanics provoked a discussion about the classical

[2] More on the inspiration for the considerations about the foundations of mechanics in Lwów see Polak 2012, chapter 3.

epistemological problems concerning the knowledge of the nature. It was a source of the subsequent considerations about the philosophical notions of time, space, causation etc. We will focus now on the most important publications which created the philosophical foundation for the reception of the STR & the GTR.

Bronisław Biegeleisen, a student of engineering at the Polytechnic School wrote a long article about the development of the concept of motion in mechanics. It was published in "Przegląd Filozoficzny" (Philosophical Review) (Biegeleisen 1901; 1902a). In this paper, Biegeleisen showed an interesting analysis and critique of the existing concepts of absolute motion. In his historical presentation of the development of this concept he used arguments from the analysis of Ernst Mach, Emil Budde, Ludwig Lange, Henrich Streintz and Eugène Vicaire. Biegeleisen tried to conduct a critical evaluation of the existing ideas, however, he sometimes added his own elements of critique, especially in the analysis of Euler's arguments for absolute motion. Biegeleisen's article showed that some scientific problems, e.g. the concept of absolute motion, provoked philosophical considerations. These considerations were closely tied with their scientific inspirations, i.e. Biegeleisen used traditional philosophical methods for solving some problems concerning the limits of scientific explanation.

This type of philosophical considerations was continued in his next article about Stallo's philosophy (Biegeleisen 1902b). In this publication Biegeleisen expressed how important the considerations around the foundations of mechanics were to engineering. The main problem for Biegeleisen was the rejection of mechanicism as a philosophy and a worldview. Biegeleisen stressed that the new philosophical concept is needed to replace mechanicism. He believed that Stallo's philosophy could be this concept, but he overestimated its importance. Biegeleisen did not continue this direction of considerations and concentrated on the use of some arguments from science for philosophical discussions. For example, he used some arguments from the STR to criticize, as mentioned earlier, Bergson's concept of time and Stanisław Brzozowski's philosophy (Biegeleisen 1911).

Lucjan Böttcher, a mathematician, also developed some philosophical considerations in the context of the research into the foundations of mechanics but his method was slightly different from the one of

Biegeleisen. He criticized some aspects of Stallo's philosophy and tried to evaluate epistemological aspects of the foundations of mechanics (Böttcher 1902). For him, the most important philosophical problem was the consistency of the system of assumptions and fundamental principles of mechanics. The second problem was the *a priori* justification of them.

Three years later, he published another article (Böttcher 1905), which was an attempt to formulate the psychological foundations of mechanics. It was an attempt to resolve the second philosophical problem outlined in the previous publication. Böttcher tried to use, popular at that time, a form of justification based on the reduction of mechanical notions to psychological concepts. He was influenced by Wundt's lectures and his considerations were close to some concepts of Twardowski. Böttcher's attempts did not influence other scientists because there was no general agreement for this type of epistemological reduction.

It should be mentioned that scientists from Lwów's Polytechnic School tried to understand more deeply the foundations of mechanics in different ways (e.g. Maksymilian T. Huber, Cezary Russyan, Alfred Denizot). These philosophical considerations led them either to accept the STR as a theory clarifying the foundations of mechanics (e.g. M.T. Huber), or to reject Einstein's theory because of the assumption that the concept of absolute motion was valid (A. Denizot). It shows that some philosophical assumptions led scientists to different attitudes toward the STR.

The considerations around the foundations of mechanics in Lwów not only created the philosophical background for the reception of the STR & the GTR, but also started a new type of philosophical considerations, closely tied with scientific problems. This type of minimalistic philosophy, very similar to August Witkowski's approach, became very interesting for some philosophical milieus of Lwów. This type of philosophy was not identical to the analytical philosophy of Twardowski's followers. The main difference was in the goals: the aim of this type of reflection was to understand science, to evaluate its concepts critically, and to contribute to the development of science. Scientists would focus on the philosophical problems connected with the fundamental notions of mechanics (e.g. time, space, motion) and the methodological aspects

(e.g. the role of mathematics, the structure of scientific explanation). This type of philosophy was also involved in a very interesting philosophical debate concerning the acceptance of the STR & the GTR.

5. Philosophical debate in Lwów concerning the Special and the General Theory of Relativity

Einstein and his Theory of Relativity became famous in November 1915 (see Pais 2005, chapter 16). Unfortunately, the reception of GTR and the information about the confirmation of Einstein's theory were delayed in Poland due to the Polish-Soviet War (February 1919 – March 1921). The first known Polish newspaper article about the famous joint meeting of the Royal Society and the Royal Astronomical Society, where the observations of Eddington and Crommelin were discussed, appeared in Kraków at the beginning of February 1920. This article was entitled "Einstein and Newton" and it was published in a conservative newspaper "Czas" (Sułkowska 1920a; Sułkowska 1920b). The two out of three parts of this article described philosophical aspects of Einstein's theory. Sułkowska shortly characterized the philosophical context of this theory. She also presented some aspects of the impact this new theory would have on the philosophical view of nature and some methodological aspects connected with this theory.

The reception of the information about Einstein's fame were delayed in Lwów even more than in Kraków, because of communication problems caused by the war. The first notes about Einstein, in a sensational tone, were published in Lwów at the beginning of October 1920. October 9th, 1920 one of Lwów's newspaper, *Słowo Polskie* published a fiercely sensationalistic and aggressive feuilleton "Teorja relatywności i Albert Einstein" (Theory of relativity and Albert Einstein) (Zachariewicz 1920).

Julian Edwin Zachariewicz was a journalist and a philosopher (he belonged to three philosophical societies), but he was generally interested in some popular topics in the philosophy of religion (e.g. the critique of Ernst Haeckel's monism). Zachariewicz, who had just returned from Berlin, tried to report a vivid and aggressive debate on Einstein's theory held in Germany (especially in Berlin, more on this topic, see Schlicker

1979; Pyenson 1987; Pais 2005, chapter 16d; Rowe 2006; Hoffmann 2006, p. 141n; van Dongen 2007). Unfortunately, Zachariewicz did not do it critically enough and his article was full of misunderstandings of the theory and showed his scientific ignorance. Zachariewicz tried to formulate some philosophical arguments against the theory, but they were incorrect and based on the misunderstandings of modern physics.

Maksymilian Tytus Huber, a professor of Lwów's Polytechnical School, gave a long and accurate reply to Zachariewicz's attacks on Einstein and his theory (Huber 1920a; 1920b; 1920c; 1920d; 1920e). Huber strongly criticized Zachariewicz's feuilleton and presented the basic information about STR and GTR. He tried to explicate the methodological specificity of modern physics and he described the role of mathematics in physics in the light of the new theories. It is an interesting approach in the debate on the role of mathematics in natural sciences dating back to Aristotle. Other philosophical problems of these theories were described with the use of Moritz Schlick's quotation (Schlick 1917). It could be assumed that Huber found Schlick's considerations on Einstein's theory very accurate. Later on Huber published a few more developed articles about the STR & the GTR (e.g. Huber 1921; 1925). He tried to show more precisely the meaning of Einstein's new ideas for physics and for philosophy.

These articles demonstrated that – for Huber – philosophical aspects of Einstein's theory were closely tied with the problem of the foundations of mechanics, with strong influence of M. Schlick's interpretation. Huber stated that his previous considerations on the foundations of mechanics had created for him a convenient foundation for the reception of the GTR, and for the acceptance of new, relativistic fundamental concepts and notions. For Huber, the new Einstein's theories were the natural consequence of the development of mechanics and physics. The philosophical importance of this theory was expressed in the change of fundamental notions and in its methodology. For Huber, also the development of a new relativistic cosmology had an important philosophical meaning, because it showed that the classical philosophical dichotomy: finite (bounded) vs infinite (unbounded) universe, is no longer valid in the light of Einstein's cosmology. Huber also stressed that the GTR and the new relativistic cosmology provided, from the philosophical point of view, the most consistent scientific world view.

Huber's articles swayed Zachariewicz toward the acceptance of Einstein's theory (more on this topic, see Polak 2012, pp. 303–305, 395–401) but the debate around Einstein's theory in Lwów was developing independently. The most important part of the debate concerning STR & GTR took place in the Polish Polytechnic Society in Lwów. In his two lectures (November 24, 1920 and December 1, 1920), Stanisław Loria presented the main ideas of the GTR and its philosophical consequences (Loria 1921a).

Loria's philosophical considerations included in the lectures were similar to Huber's deliberations. He emphasized the specificity of Einstein's method to redefine the fundamental notions, but he discounted the epistemological considerations. It shows that Loria also looked on the STR & the GTR in the perspective of the consideration around the foundations of mechanics. He also drew attention to the fact that the GTR demonstrated the inadequacy of the earlier philosophy of nature, which could not properly explain the physical reality. For Loria, the science forms its own philosophy of nature, because it was science that coined the fundamental philosophical notions, such as space, time or matter. He was not a proponent of the positivistic reduction of philosophy to science. He emphasized that science is the origin of philosophical considerations and that it is science that leads to classical philosophical problems, but in a new context.

Loria, unlike the majority of positivists at that time, accepted ontology as such and he showed that the GTR imposed some changes in the classical thinking about the substance, because in the space-time continuum one cannot talk about the changes in time of any object. Loria also drew attention to the ontological importance of the notion of a physical field, which should be a fundamental notion of ontology. These philosophical considerations were developed also in the Loria's opening university lecture entitled "Eter i materja" ("Ether and matter") (Loria 1921b). In this lecture he demonstrated the development of the notion of 'ether'. The rejection of this concept was the turning point in the formulation of new physics based on the concept of a physical field and a new philosophy tied with it.

The lectures triggered long discussion about this theory (until the end of December 1920). Wacław Wolski, an engineer and a logician, was the main opponent of Loria's. He published a long response to Loria's

lectures entitled "In Defense of the Absolute" („W obronie Absolutu") in *Słowo Polskie* (Wolski 1920a; 1920b; 1920c; 1920d; 1920e).

Wolski, unlike Loria, stressed that physics have to be built on the basis of philosophical assumptions (e.g. the assumption of the absolute character of space and time). He represented a style of debate different from the philosophy in science. For him, philosophy was generally independent of science, because it formed the fundamentals of science. These expectations were similar to neo-scholastic thinking, however Wolski tried to form his own concept of the philosophy of nature. Wolski's long article consists of many philosophical errors and misunderstandings. It was criticized by Zygmunt Zawirski (1921b; 1921c) and this type of philosophy was generally rejected in the 1920s after Wolski's death.

Another style of philosophical reflection was displayed by Kazimierz Ajdukiewicz, a member of the Lwów-Warsaw School. In his article, he tried to define, independently of scientific theories, the notion of simultaneity. He used conventionalism for this purpose and tried to examine the meaning of the intuitive notion of simultaneity. For him, this notion played a crucial role in the definition of the concept of time. At the end of the publication, Ajdukiewicz tried to compare his notion with Einstein's notion in the STR. This work is only slightly inspired by the STR, but the philosophical considerations did not use any arguments or methods derived from science, so it also could not be characterized as philosophy in science.

The debates in Lwów involved many peoples (see Polak 2012), but the main approaches were already characterized. A separate account of Zawirski's publications will be presented below, because of their significance and their connection with the scientific milieus of both Lwów and Kraków. In the following part, I am going to characterize the specificity of the STR's & the GTR's influence on philosophy in Kraków.

6. Stanisław Zaremba and Tadeusz Banachiewicz – two opposite views on the structure of a scientific theory (Kraków)

Independently of the Lwów debates a short debate developed in Kraków, concerning methodological aspects of STR & GTR. In the early 1920s, Stanisław Zaremba (1863–1942), a mathematician, developed

a methodological critique of STR & GTR (Zaremba 1920; 1922a; 1922b; 1922c; 1922d; 1922e; more on this topic, see Polak 2014b). Zaremba's main objections were that Einstein's theory had many internal errors (caused by contradictions in hidden assumptions), and the theory could not be confirmed or rejected by any observation.

Zaremba tried to examine the logical structure of Einstein's theory. He treated the physical theory like theories in mathematics – the theory was a deductive consequence of a set of physical axioms. For him, every physical theory should have an axiomatic form. Zaremba made also a very controversial philosophical assumption: physical concepts should be defined outside any theoretical frame. Zaremba chose the concepts of Newtonian mechanics as valid for every physical theory. It could be supposed that he chose the classical concepts, because he acknowledged them as an expression of intuitive knowledge. This erroneous assumption caused Zaremba's critique to fail, but he provoked a discussion about the axiomatization of physical theories and other methodological issues.

Zaremba's philosophical considerations could be regarded as a specific form of analytical philosophy of science. Zaremba used mathematical and metamathematical methods to analyze physics; it was an expression of his striving for extreme exactness and precision in methodological and philosophical considerations (see e.g. Zaremba 1920; 1923; 1937, see also Polak 2014b; 2015). Zaremba's philosophy could be considered as philosophy in science, because of the mathematical and physical inspirations of consideration about space and time. Despite very controversial philosophical assumptions, it was an interesting attempt to exploit scientific results and methods to tackle classical philosophical problems.

In one of his articles, Tadeusz Banachiewicz (1882–1954) provided a reply to Zaremba's approach (Banachiewicz 1923). He focused on the methodological and conceptual aspects of Einstein's theories and he intentionally avoided other philosophical considerations. Banachiewicz presented a strong critique of Zaremba's misunderstandings of the STR & the GTR (Banachiewicz stated that Zaremba did not even understand the STR). He argued that axiomatic form is generally not necessary for a physical theory, and only well-developed (finished) physical theories could be presented in this form. Banachiewicz criticized

Zaremba's formalism in physics and he showed that the main methodological problem was Zaremba's "theory of metrology", which was defined independently of physical theories like STR or GTR. In other words, it could be said that Banachiewicz pointed out that operational definitions of physical notions should be defined only within a particular theoretical frame, and a change of the theory may influence both the change in the fundamental notions and the theoretical structure. Banachiewicz critical remarks were interesting contributions to the development of philosophy in science in Kraków, because they showed that scientists could contribute in a critical way to philosophical considerations. This debate inspired only a few publications but it strongly influenced the reception of GTR in Kraków (see: Średniawa 1986; 1987).

It is worth adding that in Kraków also neo-scholastic philosophers (mostly Jesuits) were interested in Einstein's theory. The most interesting representative was Feliks Hortyński SJ (1869–1927), who was interested in the development of modern physics; in many aspects his considerations were close to philosophy in science but there was also an important difference due to his dogmatic acceptance of some elements of the Aristotelian view of nature. Hortyński appreciated Einstein's theory and its philosophical influence. Unfortunately, he tried to make a use of this theory for the Aristotelian philosophy of nature. He thought that relativistic notions of time and space are better for the neo-scholastic philosophy of nature that absolute Newtonian notions. Hortyński did not understand that Einstein's theory assumed some philosophical concepts, contradictory to the Aristotelian philosophy. Other Jesuits from Kraków and their collaborators had other problems with the understanding of the physical and philosophical importance of Einstein's theories. They were more (Wrzoł 1926) or less skeptical (Stepa 1927) of the validity of STR & GTR. These neo-scholastic attempts are interesting examples of the philosophy of science (philosophy of nature), which was competitive to the philosophy in science described earlier, but did not play any important role in the debates around Einstein's theories in Poland.

7. Zygmunt Zawirski on the philosophical aspects of the GTR

The most important part of the philosophical considerations inspired by the reception of the STR & the GTR are the publications of Zygmunt Zawirski (1882–1948). He was Kazimierz Twardowski's student, and he is mentioned as a member of the Lwów-Warsaw School, but his style of philosophical reflection was closer to the philosophy of scientists from Kraków and Lwów rather than other students of Twardowski. He is a good representative of the well-developed Polish philosophy in science.

Zawirski was deeply interested in philosophical implications of Einstein's theory. He gave a precise reply to Wolski's philosophical objections (Zawirski 1921b; 1921c; 1921d; 1921e; 1921f). He also published a long article "Refleksje filozoficzne nad teorją względności" ("Philosophical Reflections on the Theory of Relativity") in "Przegląd Filozoficzny", in which he presented his replies to the well-known philosophical objections against STR & GTR. This article also showed the main philosophical issues concerning these theories (Zawirski 1920 [published in 1921 and backdated by the editorial board]; see also Polak 2007). Zawirski's article shows that he saw Einstein's theory as an important contribution to the research into the foundations of physics. Zawirski was interested not only in the foundations of mechanics, he was also interested in the theoretical and epistemological background of the whole physical knowledge.

Due to post-war difficulties, he published his next article "Fizykalna teoria względności a relatywizm filozoficzny" ("Physical theory of relativity and philosophical relativism") in eleven parts in a newspaper, and only later as a separate booklet (Zawirski 1921a). In this publication, Zawirski critically examined Joseph Petzold's use of the STR as an argument for positivistic relativism. It was a pretext to examine the relationship between Einstein's theory and philosophy. Zawirski stressed that the GTR changed the philosophical view on physical reality, and that this theory was the culmination of the development of the ontology of nature. These conclusions are typical for Polish philosophy in science, because of its interest in classical ontological problems (it

is worth adding that a decade later the logical positivism of the *Wiener Kreis* rejected ontology as a nonsense).

The aforementioned articles of Zawirski led him to create the most advanced analysis of GTR's impact on philosophy, published in Kraków in *Kwartalnik Filozoficzny* (Zawirski 1923; 1924a; 1924b; 1924c). These works were connected with the beginning of Zawirski's cooperation with Władysław Heinrich, the founder of Kraków's philosophy of nature, and they also reflected some influence of the scientific milieu of Kraków. In 1924, based on these works, Zawirski obtained his habilitation in philosophy at the Jagiellonian University in Kraków.

The main aim of Zawirski's article "Metoda aksjomatyczna a przyrodoznawstwo" ("The Axiomatic Method and Science") was to examine the influence of the axiomatization process of the GTR on epistemology. He also wanted to show the possibility of a new scientific worldview (*Weltanschauung*). Zawirski found in the GTR the source of new inspirations for these two classical philosophical problems. The second of them would not be considered by philosophers from the Lwów-Warsaw School – it thus revealed the specificity of Zawirski's philosophy, connected both with the analytical philosophy of LWS and the philosophy in science developed by the scientists in Kraków and Lwów.

Zawirski preformed a detailed analysis of Hilbert's and Weyl's axiomatization of GTR. He examined the relationships between geometry and physical theories, and an attempt to use a neo-Kantian philosophy to explain the role of the axiomatic method (but he rejected the already existing neo-Kantian interpretations of the GTR). Zawirski demonstrated some limitations of Kantian epistemology in the interpretation of the GTR. He also thought that the constitutive principles of science should be gradually changed, and they should correspond to earlier principles. Zawirski also preformed an analysis of the role of intuition in the modern science, and gave an implied reply to some of Zaremba's problems.

In his next paper Zawirski (1924c) showed the methodological and epistemological significance of the GTR for philosophy. He also stated that the principle of causality should be complemented with assumption of the continuity and the finite speed of interactions.

Zawirski's publications are the best examples of the style represented by philosophy in science. He made use of Einstein's theory for deep

analyses of classical philosophical problems. Zawirski showed that the GTR had significant impact on philosophy. His philosophy was inspired by many, but he tried to find his own solutions of philosophical problems posed by modern science. His philosophy was closely tied with modern science, but he avoided both reducing it to science and developing it totally independently of science.

A few years later, Zawirski wrote a very interesting article concerning the notion of time (Zawirski 1936). He made use of the style of philosophy described earlier to explain the development of this notion in philosophy and science. He showed how science influenced the changes in the philosophical concept of time. One part of this publication is dedicated to a description of the STR's influence on the concept of time. However, Zawirski actually believed that the GTR had insignificant impact on the philosophy of time.[3] This article was awarded the prestigious international *Prix E. Rigano* by the *Scientia* magazine.

8. Conclusions

This case study has demonstrated that Einstein's theories significantly inspired philosophical considerations in Poland. The milieus of Kraków and Lwów had their own specificity, shaped historically, but there are many forms of cooperation between these milieus, which led to similar forms of philosophical thinking. It is worth adding that until World War I they were the only two Polish scientific centers in which Polish science and Polish philosophy could develop freely, profiting from the Galician autonomy. In this way, the type of philosophy described here became a very important part of Polish philosophy in the 1920s.

The reception of the STR started in Kraków, but after the philosophical considerations had been published a few years later Lwów became the most important place for philosophical discussions on the STR & the GTR. The specificity of the STR's & the GTR's reception in Lwów was related to the already existing considerations about the foundations of mechanics, influenced by mechanics in Polytechnical

[3] Zawirski did not consider the concept of time in a relativistic cosmology.

School. The problems of the absolute vs relative notions of time and space were the most important issues in the debates, but later a broader set of philosophical problems inspired by these theories was considered (e.g. the role of mathematics in physics, the epistemology of science, causation, the role of axiomatization in physics).

Many physicists were interested in the philosophical implications of Einstein's theories (especially at the beginning). It should be stressed that some philosophers (e.g. J. Zachariewicz, W. Wolski) could not even understand the STR because of gaps in education and some erroneous *a priori* assumptions. However, some scientists also could not accept this theory because of some *a priori* (philosophical) assumptions. For example Alfred Denizot (from Lwów) assumed that absolute motion is real, and Stanisław Zaremba (from Kraków) assumed that the measurements in physics have to be done on the basis of Newtonian mechanics (the consequence of this assumption is a rejection of the relativity of simultaneity). It should be emphasized that some philosophers understood the STR & the GTR and could present very interesting philosophical considerations about these theories (e.g. Zawirski).

Generally, it was the epistemological and methodological implications of the STR & the GTR that were the most important both for scientists and for philosophers. What is truly interesting is the fact that these considerations frequently took into account some metaphysical questions and this was the distinctive characteristic of the presented philosophy in science, distinguishing it from the positivistic and neo-Kantian philosophies.

This case study also showed that this type of philosophy had mainly two competitive types of philosophy. On the one hand, there was the neo-scholastic philosophy of nature, developed in the context of restoration of Christian philosophy, inspired by the encyclical *Aeterni Patris*. On the other hand, there was a part of the analytical philosophy of the Lwów-Warsaw School, which tried to develop philosophical foundations of science independently of scientific theories (e.g. Ajdukiewicz).

Polish philosophy in science, developed in the context of the reception of modern physical theories, was largely unknown abroad. Although the World War II, the loss of Lwów and its scientific milieu,

as well as the repressions during the communist period weakened this type of philosophy in Poland, it has become a lasting philosophical tradition (Polak 2011b) and is still being developed in Kraków.

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