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Scientific contacts of Polish physicists with Albert Einstein

Abstract

Scientific relations of Polish physicists, living in Poland and on emigration,with Albert Einstein, in the first half of 20th century are presented. Two Polish physicists, J. Laub and L. Infeld, were Einstein's collaborators. The exchange of letters between M. Smoluchowski and Einstein contributed essentially to the solution of the problem of density fluctuations. S Loria, J. Kowalski, W. Natanson, M. Wolfke and L. Silberstein led scientific discussions with Einstein. Marie Skłodowska-Curie collaborated with Einstein in the Commission of Intelectual Cooperation of the Ligue of Nations. Einstein proposed scientific collaboration to M. Mathisson, but because of the breakout of the 2nd World War and Mathisson's death their collaboration could not be realised. Contacts of Polish physicists with Einstein contributed to the development of relativity in Poland.

(1) Introduction

Many Polish physicists of older generation, who were active in Polish universities and abroad before the First World War or in the interwar period, had personal contacts with Einstein or exchanged letters with him.

Contacts of Polish physicists with Einstein certainly inspired some Polish theoreticians to scientific work in relativity. These contacts encouraged also Polish physicists to make effort in the domain of popularization of relativity and of the progress of physics in the twenties and thirties. We can therefore say that the contacts of Polish physicists with Einstein contributed to the development of theoretical physics in Poland.

Information about the contacts of Polish physicists with Einstein was published in many articles and papers. The short synthetic information of the contacts of some Polish physicists with Einstein was published in the article by Maciej Suffczyński, *At the Centenary of Einstein* [1.1] and B. Średniawa, "Scientific and personal contacts of Polish physicists with Einstein" [1.2].

(2) August Witkowski and Stanisław Loria

The interest in the theory of relativity arose in Poland very early, soon after the publication of Einstein's paper *On the Electrodynamics of Moving Bodies* [2.1] in 1905. Einstein's theory attracted in Poland at first the attention of Cracow physicists. In the first years of 20th century the chair of experimental physics at Jagellonian University was filled by August Witkowski (1854–1913) [2.2], Władysław Natanson was then professor of theoretical physics. Witkowski, who worked experimentally in in the physics of low temperatures, was also deeply interested in the problems of theoretical physics, especially in the theories of the ether, space and time. He was therefore well prepared to the quick understanding and reception of the theory of relativity and he became one of its adherents. His collaborator of that time, Stanisław Loria (1883–1958) mentioned about Witkowski's enthusiasm towards the theory of relativity and towards Einstein in the words [2.3]:

> I heard Einstein's name for the first time from August Witkowski. It happened some months after the publication of the dissertation "On the Electrodynamics of Moving Bodies". Witkowski recommended me warmly to read this paper. He expressed the

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> opinion, that it will change our basic conceptions of physics. About its young author he said enthusiastically: "It is possible that he will prove to be the second Copernicus".

Witkowski did not meet Einstein personally. Loria became personally acquainted with Einstein in 1913 at the Meeting of German Scientists and Doctors in Vienna, which took place in September 21–28, 1913 [2.4]. Loria was then privatdocent of Jagellonian University in Cracow, Einstein was already professor in Zurich. Loria remembered the talks with Einstein during the long walks in Prater. In later years Loria exchanged twice letters with Einstein. The first correspondence took place in 1918. Loria wrote about it [2.3]:

> I wrote for the first time to him when I took the chair of physics in Lvov in 1919, I found myself in the situation, which was very difficult from the scientific point of view. The living conditions were very hard, shortage of new books and journals and of financial means for purchasing them, loneliness because of the absence of fellows with similar scientific interests, lack of any stimulation to scientific work. In this situation I turned myself towards some of the friends among physicists, also to Einstein, with the request to send me the reprints of their papers published in several last years. Einstein sent me then the whole bundle of his publications from the years 1913–1919. with a very nice letter, in which he apologized that he did not send me all his papers, because he lacked some of them. Fortunately, among those, which came from this and other sources there was enough material for a study of the theory of relativity.

Loria's study resulted at first in his lectures and discussion at the Polish Politechnical Society in November and December 1920 and the in two editions of the first Polish book on Einstein's theory.

Loria wrote about his second exchange of letters in 1932 with Einstein in the words [2.3]:

> For the second time I turned myself towards Einstein, when I happened to ask him (and Schroedinger), if they could give the opinion about the papers of the candidate whom I proposed to Rockefeller grant. This candidate was my assistant and docent of Lvov University at that time Leopold Infeld, [B.Ś.] Einstein's response came immediately, it was very friendly and cordial, and the opinion, which could be positive because of the good qualifications of the candidate, was successful.

(3) Jakub Laub

Jakub Jan Laub (1881–1962), ([3.1] – [3.4]), born in Rzeszów in Galizia, began his studies of physics at Jagellonian University in Cracow and continued them in Vienna and Goettingen. In 1905 he went to Wilhelm Wien to Wuerzburg and began the experimental research on the properties of the secondary cathode rays produced by Roentgen rays as his doctoral work. Wien was then the editor of the *Annalen der Physik*. In 1905 he received Einstein's paper *On the Electrodynamics of Moving Bodies* [2.1] to be published in the *Annalen*. When this paper appeared, Wien recommended Laub to report it at the next seminar [3.5], [3.6]. After Laub's lecture the participants of the seminar agreed that it would be difficult to accept the ideas of relativity. Next year, during the doctoral examination, Laub defended the theory of relativity, provoking the consternation of the members of the examining commision. But Wien was satisfied with "Laub's work and Laub obtained his Ph.D. degree. In July 1907 Laub published his three first papers [3.7 a,b,c] on special relativity, entitled *On the Optics of Moving Bodies.* In these papers he was busy with the calculation of the Fizeau drag coefficient, basing on special relativity, without the use of the concept of the ether. In his first paper he calculated this coefficient in the first approximation (and obtained the same result as Lorentz in the theory of electrons). In the second paper and in the third one he calculated exactly the longitudinal and transversal Fizeau's drag coefficients by applying Einstein's formula of the composition of velocities.

In February 1908 Laub wrote a letter [3.8] to Einstein to Berne. Laub asked Einstein if he could come to Berne and work with Einstein in the theory of relativity for three months. Einstein's response has not been preserved, but it must have been favourable, because in next three months Einstein and Laub worked together in Berne. As the result of this work they published two common papers on special relativity. In the first one *On the Basic Electromagnetic Equations for Moving Bodies* [3.9], they investigated the transformations of the vectors $\vec{E}, \vec{D}, \vec{H}, \vec{B}$, which define electric and magnetic fields, they studied the laws of the transformations of the charge and of the current density and of the four-vectors of electromagnetic fields in isotropic dielectric media. In a short note: *Bemerkung zu unserer Arbeit* "*On the Basic...*" [3.10] they made corrections and supplements to the above mentioned paper. In their second paper: *On the Ponderomotoric Forces Exerted on Resting Bodies in Electromagnetic Field* [3.11], Einstein and Laub generalised the formula for Lorentz force exerted on the moving charge e in the electromagnetic field in the resting isotropic dielectric medium

$$K = e\,(\vec{E} + \vec{v} \times \vec{B}) \qquad (1)$$

to the case of the uniform translational motion of this medium. They criticised Minkowski's formula, which was obtained immediately from (1) when it was subject to Lorentz transformation. This Minkowski's formula for that force can be noted in the four-dimensional notation as

$$K_\mu = eB_{\mu\nu}u^\nu \qquad (2)$$

where $B_{\mu\nu}$ is the bivector of the electromagnetic field, composed of the components of the vectors $\vec{E}$ and $\vec{B}$, and u^ν is the four-velocity).

Einstein and Laub asserted that Minkowski's formula gave only the component of electromagnetic force, perpendicular to the four-vector of the velocity of the charged particle and did not take account of the parallel component. They tried to calculate the electromagnetic force by calculating the displacement current and polarization current and obtained the formula different from (1). This paper and Minkowski's results provoked a discussion, which lasted a couple of years. It turned out that Minkowski's formula (2) was correct. The detailed discussion is presented in the ninth Chapter of L.Pyenson's book *Young Einstein* [3.2].

Laub, who was not restricted by any fixed employment, could freely travel and could contact physicists and mathematicians. Einstein worked then in the Patent Office in Berne and his possibilities to establish contacts were limited. Therefore Laub's information about the reception of relativity, brought by Laub from his travels, were for Einstein very valuable. Laub worked later in Heidelberg in Philippe Lenard's laboratory on the applications of relativity to dispersion phenomena and on the article on the experimental verification of relativity, intending to make habilitation. But the relation between Lenard and Laub deteriorated and Lenard did not admit Laub in 1910 to habilitation procedure. Einstein was indignant.

In 1911 Laub moved to Argentina. He stayed there as the professor of academic schools until the outbreak of the First World War. In the inter-war years he choose the diplomatic career and performed the duties of Argentina's representative in some capitals of Europe (in the years 1937–1939 in Warsaw). He spent the years of the Second World War in Argentina and in 1945 he came back to Europe. In 1953 he settled in Switzerland as the professor of Fribourg University. He died in 1962.

(4) Józef Wierusz Kowalski

Józef Wierusz Kowalski (1866–1927), [4.1], [4.2] studied in Goettingen, where he took his doctor degree in physics. Then he stayed shortly in Berlin, Wuerzburg and Zurich, where he obtained the engineer diploma. He habilitated himself in Berne in physics and physical chemistry. In 1894 he was appointed to professorship in physics at Fribourg University, where he worked until 1915. The Fribourg years were the most important ones in his scientific work. He was busy in physical chemistry, in the study of electrical discharges and then he turned himself to experimental and theoretical investigations of luminescence and phosphorescence, especially in low temperatures [4.3], [4.4]. In those years Kowalski (as well as his assistant Ignacy Mościcki (later professor of Lvov Technical University and the president of Polish Republic in 1926–1939), had scientific contacts with Einstein. We mention here two scientific Kowalski's contacts with Einstein. In first years of 20th century a theory of Thomson was widespread in the domain of luminescence. It was based on the hypothesis, that in luminescent materials two atomic systems existed. One of them stopped the electrons, which then gained energy in the second system and were able to radiate. Kowalski was doubtful to this theory. He had a personal discussion with Einstein [4.4], who supposed that the energy of radiation was partly due to the molecular motion in the body. Hence it followed that the luminescence spectrum should depend on the temperature. Kowalski's experiments, made in the temperatures of 18–20°C and –185^{0}C confirmed Einstein's suggestion (see [4.5]).

In 1907 Einstein proposed [4.6] the device for measurements of small electric charges. He called it "Maschinchen" (a small machine). It was soon built by Paul and Conrad Habichts. Kowalski was interested in this device and he wrote to Einstein [4.7]:

> Today I read in the Physikalische Zeitschrift about your project of measuring electricity. I am very interested in it and I would readily build such an instrument.

In 1915 Kowalski moved to Warsaw, where he began to lecture physics at the University and the Technical University and organized the institute of physics of the University. In 1919 he passed to diplomatic service in which he was active until his death in 1927 [4.8].

(5) Marian Smoluchowski

In the first years of 20th century as well Einstein as Smoluchowski (1872–1917), [5.1–5.3] were interested in the phenomena of density fluctuations in gases and in liquids and in the effects connected with them, such as Brownian motion, opalescence near the critical state and the blue colour of the sky.

(5.1) Brownian motion

The first papers, explaining the effect of Brownian motion were published by Einstein in 1905 and 1906. Their titles were: *On the Motion of the Particles Suspended in Liquids, Required by the Molecular-Kinetic Theory of Heat* [5.4], and *On the theory of Brownian Motion* [5.5]. When these papers appeared, Smoluchowski published the paper *On the Kinetic Theory of Brownian Motion and the Suspensions* in 1906 [5.6]. In the mentioned papers as well Einstein as Smoluchowski calculated, using quite different methods, the mean square displacement of the particle of suspension in Brownian motion.

Smoluchowski mentioned in the introduction to this paper [5.6] about both Einstein's publications [5.4] and [5.5] ...

> elaborated already some years ago the kinetic theory of this phenomenon [i.e. Brownian motion,B.S.], which seemed to me the most probable one; I have not published hitherto the results since I wanted to verify them by the most exact experimental methods. But in the meantime the discussion on this subject was re-opened by two theoretical Einstein's papers, ([5.4] and [5.5], B.Ś), in which the author calculated the displacement of tiny granules, which must arise due to the molecular motion, and from the agreement with Brownian motion he concludes on their kinetic nature. In Einstein's formulas I found the part of my findings and his final result, which, though obtained by quite different method, agrees completely with mine. Therefore I publish my argumentation, especially because my method seems to me to be clearer and therefore more convincing than Einstein's method which is not free from objections.

Having derived the formula for mean square displacement of the granule in Brownian motion Smoluchowski remarked:

> I shall not enter into the discussion of very ingenious Einstein's arguments but I would like to remark that they rely upon indirect conclusions, which do not seem to me completely convincing.

Smoluchowski's paper attracted the interest of Einstein, who wrote the letter [5.7] to Smoluchowski on April 11, 1908:

> Dear Sir,
>
> Together with this card I send you those of my papers in which you could be interested. Simultaneously I ask you kindly to send me your papers since I would like to study them more carefully.
>
> With best regards, yours devoted A. Einstein

(All letters exchanged between Einstein and Smoluchowski were written in German).

Also in the letter from January 1909 to Jean Perrin [5.8] (written in French), Smoluchowski again acknowledged Einstein' s priority in the explanation of the phenomenon of Brownian motion. In this letter he wrote: *Concerning the derivation of the formula*

$$\Delta n = \sqrt{\frac{RT}{N}\frac{t}{3\pi r\eta}}$$

> I should like to state that the priority is of course due to Einstein (1905), the author whose ingenuity and talent inspire my deep respect. It's my fault that I have delayed until July 1906 the publication of my investigation on this subject, in which I was busy since 1900 (work of Mr. Exner). I derived this formula (obtaining a somewhat different numerical value of the coefficient due to other method of approximation) by an immediate method different from that of Mr. Einstein's... In my paper from 1906 I gave at first the general analysis of experimental data about Brownian motion, which could be applied to the comparison with the theory, the problem, which Einstein did not consider at all.

Einstein characterised Smoluchowski's paper [5.6] on Brownian motion in the necrology [5.9], written in 1917 after Smoluchowski's death:

> Smoluchowski delivered a particularly beautiful and visual method of this phenomenon, when he started from the law of the equipartition of the kinetic theory... It requires, that the particle of the diameter of about 1μm (and of the density of water), moved in the state of thermodynamical equilibrium with the mean velocity of 3 mm per second; since Smoluchowski stated quantitatively that this velocity, incessantly destroyed by internal friction is again restored by irregular molecular collisions, he arrived to the explanation of this phenomenon.

But Einstein regarded his own method as more general one, since he wrote in his letter to Seelig from September 15, 1953 [5.10]:

> Smoluchowski's paper [5.6] is based on mechanics, while my research assumes in fact only the law of osmotic pressure. Smoluchowski's paper concerns only gases and it did not achieve the satisfactory degree of acuracy.

In his second paper on Brownian motion [5.5] Einstein studied the motion of the granules of the suspension under the influence of external forces and calculated the mean square displacement of the granule subject to elastic force

$$F = -kx, \quad k = const > 0 \qquad (3)$$

along the x-axis.

Smoluchowski resumed this problem. In a lecture, entitled: *Phenomena Opposing to the Ordinary Thermodynamics, Which Could Be Verified Experimentally* [5.11], delivered at the 84th Congress of Naturalists in Muenster, he gave the review of phenomena, which were inconsistent with the Second Law of Thermodynamics. In this lecture he presented the above mentioned Einstein's result from [5.5], concerning Brownian motion in the presence of the elastic force and then he pointed to the possibility of performing an experiment with a tiny mirror hanging on a thin thread, performing torsional oscillations and subjected also to Brownian motion, resulting from collisions of air molecules with the mirror.

In the paper: *On Some Examples of Brownian Motion Under the Influence of External Forces,* [5.12] Smoluchowski calculated the probability of finding the particle of the suspension at the time t, between x and $x+dx$, when it was subjected to elastic force and was in position x at the time $t=0$. He also determined the time of recurrence to the position x. The method of calculation here was different from that of Einstein's, namely by solving the so called Smoluchowski's integral equation for this case.

The experiments suggested by Smoluchowski were performed in the thirties with the torsional pendulum (called Smoluchowski's pendulum) by Gerlach [5.13] and by Kappler [5.14]. These experiments verified the results of Smoluchowski's calculations (see also [5.15]).

(5.2) Opalescence in critical state and the blue colour of the sky

In his paper *On the Irregularities in the Distribution of the Gas Molecules and Their Influence on Entropy and the Equation of State* [5.16] from 1904 Smoluchowski considered for the first time the problem of density fluctuations: the density of gas or liquid is not exactly uniform in the whole volume occupied by gas or liquid, but undergoes fluctuations. In a small volume v of the gas or liquid in the reservoir of macroscopic volume V the number n of molecules is not constant, but changes, fluctuating around the mean number ν of particles in the volume V. The compression of the number of particles in the volume v is defined as

$$\delta = \frac{n-\nu}{\nu} \qquad (4)$$

In the above mentioned paper Smoluchowski calculated the mean compression $\sqrt{<\delta^2>}$ for ideal gas and obtained

$$\sqrt{<\delta^2>} = \frac{1}{\sqrt{\nu}} \qquad (5)$$

In the next paper: *Kinetic Theory of Opalescence in Gases and Other Related Phenomena* [5.17] Smoluchowski calculated in 1907 the mean compression of the molecules of the van der Waals gas. He obtained the result that the density fluctuations should generate

> the ocurrence of the phenomena characteristic for opaque media, i.e. effects of opalescence and the so called "Tyndall effect" which consists in the scattering of radiation passing through opaque medium.

According to Pais [5.18], Smoluchowski saw not only the true reason of critical opalescence, but also the connection of this effect with the blue colour of the sky and with the reddening of the sun during sunset. Smoluchowski quoted also and discussed also Rayleigh's formula for scattering the radiation by the particles of dust in the medium, small compared with the wave length of the incident light. He did not, however, calculate the scattering of light by small volumes of gas, in which fluctuation of density caused the change of the scattering of light.

Such a calculation was done by Einstein in the paper *Theory of the Opalescence of Uniform Liquids and Mixtures of Liquids in the Vicinity of Critical State* [5.19]. This paper began with the words:

> Smoluchowski proved that the opalecence of liquids in the vicinity of critical state and of mixtures of liquids in the vicinity of the critical composition of the mixture and of critical temperature can be explained in a simple way from the point of view of the theory of heat ... he didn't, however, perform the exact calculation of the amount of light scattered aside. This gap should be presently filled.

Einstein performed the calculations by the method similar to that of Rayleigh's by considering the scattering of light not on the particles of dust, as Rayleigh did, but on those small volumes of the medium, where the densities were different from the mean density. In this calculation Einstein used Maxwell equations, the Lorentz-Lorentz formula giving the relation between the refraction coefficient and the dielectric constant, and assumed, like Rayleigh, that the particles of the medium filled the reservoir in a quite unordered way. Einstein's calculations gave the same result as those of Rayleigh. Einstein remarked that

> It is here noteworthy, that our theory doesn't make any immediate use of the assumption on the discontinuous distribution of matter.

In 1911 Smoluchowski published the paper *The Contribution to the Theory of Opalescence in Gases* [5.20]. Basing on the van der Waals equation, he calculated there the intensity of the scattered wave of light in the gas, which was under the conditions near the critical state, where the above quoted Einstein's theory ceased to be valid and compared his results with the work of Kamerlingh-Onnes and Keesom [5.21]. In the supplement to this paper, entitled *About the Blue Colour of the Sky* [5.20], Smoluchowski repeated Einstein's remark that Einstein's formula for scattering of light on the molecules of ideal gas was identical with Rayleigh's formula, which was considered as explaining the blue colour of the sky, although it was based on the assumption that the molecules of the gas were uniformly distributed and took into account only the optical discontinuities on the "surfaces" of the molecules.

But, according to Smoluchowski, this scattering on the inhomogenuities of gas density was not the only cause of scattering, since besides it there ocurred also the scattering on the molecules, which should double the intensity of the opalescence calculated by Rayleigh and Einstein. According to Smoluchowski the theory of opalescence should be modified by the application of the theory of electrons (comp. [5.22]) and by the consideration of scattering on electrons, and not on whole molecules. Smoluchowski's remark provoked Einstein's reaction. In the letter [5.23] to Smoluchowski from November 11, 1911 he wrote

> Thank you very much for the interesting papers sent to me, which interest me, like everything what you write. But in the new paper of opalescence there is something what I cannot accept (on the blue colour of the sky) and on what I would like to turn your attention. In my opinion Rayleigh's consideration concerns only irregularly distributed particles and only in this case it is right... because only then the particles emit n times more energy than one particle, while in the case when they are regularly distributed and when there are enough particles in the cube of the side equal to the wavelength, we would obtain the ideal transparent medium with much better approximation. Therefore, besides the explained by you fluctuating opalescence, there does not exist also the "molecular opalescence", but Rayleigh considers just the special case of our problem and the consistence of his final formula with mine is not an accident.

Smoluchowski answered by the letter [5.24] from December 12, 1911:

> I must admit that your remark concerning Rayleigh's formula for the opalescence of the ideal gas is completely right... The formula is right only under the assumption of the irregular distribution (of this type as exists in the ideal gas), one cannot speak on the superposition of two effects, as I presented it in the annex to my little paper on opalescence. Now I am surprized that I put out this theorem and I think that I would not do it ... if I had Rayleigh's paper before my eyes. I shall give the rectification at the next occasion and I thank you for your friendly remark.

In the later article [5.25] *On Thermodynamic Fluctuations and Brownian Motion* Smoluchowski wrote:

> Initially I thought that there exist two independent reasons of the opalescence of gases in normal state: the scattering caused by the particles themselves (according to Rayleigh) and scattering provoked by the inhomogeneites in the distribution of the gas density. Today I incline myself rather to the conviction that it is not so, and both factors are just identical.

In the footnote Smoluchowski added I ove the cristalization of this opinion to the private talk with Einstein. But Smoluchowski noted, that

> Einstein's method cannot be completely satisfactory, since it is based on the half empirical Lorentz's formula and on Maxwell's electromagnetic equations, while from the present-day point of view the mechanism of electromagnetic phenomena consists in the motions of electrons, and the exact theory should be properly based on the considerations of these motions.

Smoluchowski's intuition was correct. After the publication of Einstein's paper further investigations in the theory of opalescence have been performed until now. A few years after the publication of Einstein's paper, the papers of Ornstein and Zernicke [5.26] were published, in which the correlations of fluctuations in small volumes of gases were considered.

(6) Maria Skłodowska-Curie

The many years' friendship and mutual respect joined Marie Curie and Einstein. Their first meeting took place in 1909 in Geneva, where in the days of September 7–9 the celebration of the 350th anniversary of Geneva University was organized. Two hundred ten delegates were invited. Hundred ten of the participants were honoured by awarding them the h.c. doctorates, among them Marie Curie and Einstein [6.1]. Two years later Marie Curie and Einstein met at the First Solvay Congress in Brussels, from October 30 to November 3, 1911 [6.2].

In the years 1911 and 1912 Einstein, who was then professor of the German University in Prague, obtained several offers of taking chairs at European universities. One of the proposals came from the Federal Technical University (ETH) in Zurich. Einstein wished to come from Prague to Zurich and therefore accepted readily this offer, declaring in the letter from November 18, 1911 to professor Marcel Grossmann his desire to return to Zurich. Then the authorities of the ETH sent the application to the Swiss Federal Ministery in Berne for appointing Einstein to the post of the professor of theoretical physics at ETH. Marie Curie and Henri Poincaré were requested to express their opinions about Einstein. The opinion of Marie Curie, written in French dated on November 11, 1911 and sent from Paris to the professor of ETH, Pierre Weiss was enthusiastic [AE 8 422], (see [6.3] and also [6.1], p.162).

> ...I have just obtained your letter, in which you asked me about my personal impression concerning Mr. Einstein, whom I had the pleasure to meet recently. You wrote me also that Mr. Einstein wished very much to return to Zurich and could soon have the possibility in this respect. I often admired the papers published by Mr.Einstein, concerning the problems of modern theoretical physics. Besides, I am convinced that theoretical physicists agree in their opinions that these papers are of the first rank, in Brussels where I participated in the scientific congress, in which also Mr. Einstein took part, I was able to appreciate the clarity of his thought, the extent of his argumentation and the depth of his erudition. If we take into consideration that Mr. Einstein is still very young, we are justified in keeping great hopes in him and in seeing in him one of the leading theoreticians of the future. I think, that the scientific institution, which would give Mr. Einstein the means for work, which he wishes, either by appointing him the already existing chair or by creation for him the chair in the conditions he merits, could only be greatly honored by such a decision and would certainly render the great service to science. If I could contribute by my opinion in a small degree to the solution desired by Mr. Einstein, I would be greatly pleased.

At the end of the year 1912 Einstein took the post of the professor of theoretical physics at the ETH in Zurich. In March 1913 Einstein came with his wife Mileva to Paris, where he delivered the lectures for the French Physical Society [6.4]. Durhig this stay in Paris they were guests of Marie Curie. In return, Einstein invited Marie Curie to an excursion in the Swiss Alps.

Marie Curie accepted Einstein's invitation. Their next meeting took place in 1913. She came to Zurich with her daughters Irene and Eve. Then Einstein with Marie Curie, her daughters, with his wife Mileva and with Einstein's older son Hans Albert went for a forthnight wandering in the Alps. This excursion was remembered after many years by Hans Albert Einstein [6.5] and by Eve Curie [6.6].

When in 1914 the First World War broke out, the contacts between people living behind the war fronts became impossible and after the end of the war the mutual hostility did not expire. Einstein was one of the first scientists, who attempted to break the barrier of hostility between Frenchmen and Germans. Having obtained the invitation of Paul Langevin he arrived on March 28, 1922 in Paris [6.7].

He delivered his first lecture in College de France on March 31, 1922. Among the scientists invited to this lecture were Marie Curie, Jean Perrin, Emile Borel and Paul Painleve. In next days, until April 8, Einstein gave lectures in other institutions and scientific societes in Paris. Having returned home he wrote on July 4, 1922 from Berlin [EA 34–773] to Marie Curie:

> ...I remember with particular pleasure the hours full of harmony, which I spent with you, with Langevin and other nice colleagues in Paris. I am particularly grateful to Langevin, whose moving care I shall never forget. Weyl just wrote me about him with enthusiasm. I beg you to greet him and to accept my friendly regards to you.

In order to reconstruct the international cooperation in the domains of science and culture, which was interrupted by the war, the League of Nations in spring 1922 founded the International Commission of International Cooperation (Commission Internationale de Cooperation Intellectuelle). Sir Eric Drummond, the secretary-general of the League of Nations invited Einstein, in the letter from May 17, 1922, to join the Commision. Marie Curie, who was also invited to participate in the Commision, wrote to Einstein, who hesitated, whether he should accept the proposal of joining the Commision. Einstein agreed after a short reflection.

But soon, after the assasination of minister Rathenau and because of growing anti-Semitism in Germany, Einstein declared his resignation of the membership in the Commission.

But Marie Curie expressed in the letter [AE 34-775] from July 7, 1922 her deep discontent because of Einstein's decision to retreat from the Commission. She was convinced that Einstein could, merely by his personal values, exercise the strong influence in the struggle for tolerance and asked him to change his decision.

Einstein, however, upheld his decision, writing to her in the letter [AE 34-776, from July 22, 1922]:

> Among intellectuals there prevails the non-describable anti-semitism, mainly since the Jews, in relation to their number, play a non-proportional role in public life and besides it. Many of them (like me) engage themselves in international activity. Therefore, really, the Jew is not suitable to be the mediator between German and international intelligentsia. Somebody should be elected, who has the inner and undisturbed bonds with German intelligentsia and who has the reputation of being the "authentic German". (I think of such men as Harnack or Planck, though I do not want, however, to propose anything in this question).

In the next letters, namely in Einstein's letter [AE 34–403] from December 25, 1923 and Marie Curie's letter [AE 34–804] from January 6, 1924 concerning the Commission of Intellectual Cooperation the temper was more quiet and contained also the terms of mutual respect and friendship. The exchange of their letters lasted until the year 1932. In the letters they wrote remarks about the Commission, about Marie Curie's travel (o the United States in 1932 and about the Solvay Congress from 1932).

Marie Curie died on July 4, 1934.

(7) Władysław Natanson (1864–1937)

Władysław Natanson [7.1] was not engaged in scientific research in relativity, but he acquainted himself very early with this theory. It is known that he listened to the lecture of Jakub Laub in June 1907 at the Xth meeting of Polish Physicians and Naturalists in Lvov and participated in the discussion after that lecture.

Natanson included relativity into his lectures of theoretical physics, which he delivered during many years at Jagellonian University. These lectures were mentioned by Leopold Infeld in his memoirs [7.2]:

> I heard Einstein's name for the first time in the year 1917 during the second year of studies at Jagellonian University. It was so: professor Natanson delivered in this time the lectures of the theoretical physics; he lectured it in beautiful manner, so beautiful that the difficulties disappeared, all seemed to be settled, solved, explained once for all...

Einstein and Natanson became friends during a year-long Natanson's stay in Berlin in 1915. In summer 1914 Natanson spent his holidays with his family at the seaside in Belgium and the outbreak of the First World War found him there. After some time Natanson succeeded to come to Berlin with his family, where he lived during the year 1915, before he could return to Cracow. Einstein often visited the Natansons and led long discussions with Natanson [7.3]. Einstein's and Natanson's friendship were deepened by the fact, that during the First World War Einstein, because of his pacifistic convictions, which he strongly proclaimed, was then boycotted by the nationalistically oriented scientific community of Berlin. Einstein's and Natanson's friendly feelings did not finish when Natanson left Berlin, five Einstein's letters [7.4] to Natanson have been preserved in Jagellonian Library in Cracow.

(8) Mieczysław Wolfke

Mieczysław Wolfke (1883–1047) [8.1–8.5] obtained his Ph.D. degree in Breslau in 1910. Then he stayed in Jena and in Karlsruhe and soon he moved to Zurich, where he habilitated himself at the Federal Technical University (ETH) [8.6], in virtue of the paper entitled *General Theory of Independently and Dependently Radiating Objects* [8.7], which was written in Karlsruhe.

In 1914 Wolfke made his habilitation and obtained the post of “Privatdozent” also at the Philosophical Faculty II of University of Zurich in virtue of the same paper, which was positively judged by professors Laue and Kleiner. Since then Wolfke delivered lectures at Federal Technical University in Zurich. Let us mention one of his lectures: *The Principle of Relativity,* (summer semester 1915 and winter semester 1916/1917. It was one of the first lectures on relativity.

During his stay in Zurich Wolfke was in friendly relations with Einstein [8.4]. According to the private information of prof. Karol Wolfke, Son of prof. Mieczysław Wolfke, Einstein often visited Wolfkes and “played violin with father’s piano accompaniment”.

During the years spent in Breslau and Zurich Wolfke was interested mainly in optics and in radiation theory.

In his most important optical paper [8.8] he formulated the method of two-graded optical projection. This method, rediscovered in 1948 by Dennis Gabor became the basis of holography.

In the domain of the theory of radiation Wolfke introduced, basing on the idea of Joffe [8.9], the concept of the atom of light ("Lichtatom") and molecule of light ("Lichtmolekule") [8.10]. By means of these concepts he derived and interpreted Planck’s formula for the density of the black body radiation [8.11]. According to Wolfke, the energy of radiation is distributed in atoms of light, which are point-like and each of them has the energy $h\nu$. But atoms of light differ from light quanta (photons), introduced by Einstein in 1905. The main difference between photons and atoms of light lies in the fact, that atoms of light can be absorbed in groups, while light quanta are absorbed separately. By applying the concepts of light atoms and light molecules Wolfke derived Plank’s formula for the density of the energy of black body radiation as the superposition of the energies of light molecules. Later Wolfke published short articles [8.12], [8.13], on his theory.

In 1922 Wolfke took the post of the head of one of the laboratories of physics at Warsaw Technical University. After the Second World War he returned to the problem of atoms of light and of light molecules. He sent a (not preserved) letter, containing his ideas to Einstein to Princeton. In answer Einstein accepted in his letter from July 12, 19 16 the critical attitude against the concepts of atoms of light and molecules of light [8.14].

In answer to crtitical Einstein’s arguments contained in this letter, Wolfke attempted, in the letter [8.15] to Einstein, to defend the modified concepts of light atoms and light molecules.

Wolfke died in Zurich on May 4, 1947.

(9) Jan Weyssenhoff

Jan Weyssenhoff (1889–1972) [9.1], professor of theoretical physics at Vilna University and later at Cracow University from 1935, studied in Cracow in the years 1907–1911. The outbreak of the war in 1914 found him in Switzerland, where he remained until 1919. He took his doctorate in theoretical physics at Zurich University in 1916. In Zurich he had an opportunity to meet Einstein. Many years later he described his meetings with Einstein in the article *Remarks on Einstein’s Life and Work at the Background of my Own Reminiscences* [9.2]. Their first meeting took place in June 1916. During that meeting Weyssenhoff told Einstein about his doctoral dissertation. In the evening of that day during a social meeting Weyssenhoff listened to Einstein’s discussion with Einstein’s friend Michèle Besso about the problems of general relativity.

Three years later, namely in 1919, Einstein came again from Berlin to Zurich to deliver lectures in special and general relativity. Weyssenhoff had then the opportunity of closer scientific contacts with Einstein. He listened to Einstein lectures and took part in seminars and discussions which Einstein participated in [9.3].

These contacts with Einstein had certainly serious influence on further Weyssenhoff’s scientific activity after his return to Poland. In 1935 he went for the three-months stay to the Institute of Advanced Study to Princeton, where he met Einstein again. Weyssenhoff recalled in his article [9.2] that Einstein invited him to his room in the Institute to tell him about his new idea. Einstein told him about his work with Natan Rosen, in which they assumed that matter is imbedded in the places, where the determinant *g* of the metric tensor $g_{\mu\nu}$ vanished. Weyssenhoff was very impressed with this talk. But soon Einstein abandoned this idea.

In Cracow Weyssenhoff worked in the years 1938 and 1939 with Myron Mathisson and then during the war and after it with his young collaborators on the theory of relativistic spin particles (see e.g. [9.4]).

(10) Leopold Infeld

Leopold Infeld (1898–1968) [10.1], was the Polish physicist, who kept the longest and closest contacts and collaboration with Einstein. Born in Cracow, Infeld studied physics there for four years and listened there to professor Natanson's lectures. Then he went in 1919 to Berlin to finish there his studies. But he could not matriculate at the University of Berlin because of the anti-Polish feelings prevailing there in this time. Therefore he turned himself personally to Einstein with a request for help [10.2], [10.3]. It was their first meeting. Einstein recommended Infeld to Planck and because of Planck's recommendation Infeld could study at Berlin University for one year.

Having returned to Cracow, Infeld presented before professor Natanson his doctoral dissertation done in Berlin, written in Polish, entitled *Light Waves in the Theory of Relativity* [10.4]. In virtue of this dissertation he took in 1921 his Ph.D. in physics in Cracow.

During the next sixteen years Infeld maintened the loose correspondence with Einstein. When the translation of Infeld's popular book (written in Polish as *New Ways of Science)* into English was ready, Einstein, requested by Infeld, wrote the preface to it. The translation appeared in 1934 as *The World in Modern Science: Matter and Quanta* [10.6].

The next several-years' contacts and scientific collaboration of Einstein and Infeld started in 1936 ([10.7–9]). Einstein was then professor of the Institute of Advanced Study in Princeton. Infeld, who was at that time the docent of Lvov University, obtained, thanks to Einstein's efforts the year-long grant in Princeton Institute and came there in September of that year.

He started to work with Einstein and Banesh Hoffmann on the problem of the derivation of the equations of motion from the equation of gravitational field. As the result of their research they published in 1938 the paper *Gravitational Equations and the Problem of Motion* [10.10], known as the *EIH* paper (see also [10.11] and [10.12]) from the initials of the authors. In this paper the gravitational field in vacuo with singularities (representing heavy bodies), was considered. The authors derived at first the field equations (beyond the singularities of the field) in the approximation of slow motions of the singularities against the velocity of light. The assumption that the motions were slow, allowed to formulate the "new approximation method", according to which the components of the metric tensor were expanded into the series according to the powers of $1/c$ (c is the velocity of light in vacuo). In this method the time derivatives could be shifted to the next approximation. By application of this method to the equations of the gravitational field and by taking as the zeroth approximation the Newtonian theory, the authors calculated the gravitational field in post-Newtonian approximation. Then the equations of motion were derived for the system of two bodies. The singularities were surrounded by two-dimensional surfaces in three-dimensional space. The integrability conditions of the field equations in the post-Newtonian approximation allowed to determine the motions of the singularities at first in Newtonian approximation and then in the first post-Newtonian one.

These last equations, derived in the paper *EIH* were integrated by H.P. Robertson for the case of the system composed of a heavy body and the testbody [10.13]. Robertson obtained the same motion of Mercury's perihelion as the well known motion derived from the equations of geodesies. During this year Infeld, supported by Einstein, made efforts to get the prolongation of the grant for the next year, but his request was rejected. Then, in order to remain longer in Princeton he proposed Einstein to write the common popular scientific book. The income gained from this book could assure Infeld the possibility of prolonging his stay in Princeton. Einstein agreed and soon their common book *The Evolution, of Physics* appeared [10.14].

The income from this book allowed Infeld to remain in Princeton, until the paper *EIH* was finished.

In summer 1939 Infeld left Princeton and took the post of the professor of theoretical physics at Toronto University. But he continued his collaboration with Einstein by means of the exchange of letters and during short stays in Princeton, where he visited Einstein. From this collaboration two their common publications resulted, one in 1940 and the other in 1944 . They were the continuations of the paper *EIH*. Their titles were respectively: *The Gravitational Equations and the Problem of Motion.* 77, [10.15] and *On the Motion of the Particles in General Relativity Theory* [10.16].

There the calculations were performed, contrary to those in *EIH*, not in particularly chosen frames of reference, but in general ones and the methods of approxiations were improved. They consisted in introducing fictious gravitational fields of dipole character to the real gravitational fields. This introduction made the procedure of solving the equations of the equations of motion much easier. Then the fictions fields were removed because they had not physical meaning. The calculations in [10.16] were so tedious, that they were not quoted in the publication; only the information was given in the paper, that the manuscript, containing calculations, was deposed in the Institute of Advanced Study.

In 1950 Infeld returned from Canada to Poland, where he took the post of the professor of theoretical physics at Warsaw University. In next years he founded there the Warsaw school of relativity. Under Infeld's direction the problem of obtaining the equations of motion from the equations of gravitational field was further investigated. We mention here Infeld's paper [10.17] from 1954, namely *On the Motion of Bodies in General Relativity Theory,* which was the continuation of the papers from 1940, 1944 and 1949. Here Infeld used Dirac's delta function and applied the law of the conservation of energy and momentum. It simplified considerably the difficult and tedious calculations of the three preceding papers with Einstein in such a degree, that they could be published in the 17-pages paper.

Let us remark that Einstein wrote by his own initiative the preface to the English translation of Infeld's book (written in Polish) *Whom Gods Love* about Evariste Galois, which appeared in 1948.

During next years Infeld and Einstein exchanged many letters. Infeld obtained the last Einstein's letter three months before Einstein's death. Infeld published nineteen Einstein's letters in his memoirs [7.2]. There Infeld citied the original texts of Einstein letters written to him in German and their translations into Polish. In the letter from November 11,1952 Einstein wrote:

> You asked me about scientific matters, namely about field theory. At the moment I have nothing printed. But it stands so that the inner difficulties and alternatives are completely removed. ... But the possibility of comparison with the facts belongs, alas, to far future.

In 1955 Infeld wrote to Einstein the letter, where he suggested him to arrive in Berlin to deliver the lecture in connection with the 50th anniversary of the foundation of relativity. Einstein answered (letter dated on January 12, 1955) [10.18]:

> I am, alas, or should I say, thanks to God not enough in good health to appear at such oficial occasions. I think that it would be nice if you explain in your sermon that the essential point of the theory lies in the general principle of relativity, since the majority of contemporary physicists have not yet understood this.

It was the last Einstein's letter to Infeld. Infeld's lecture *On the Equations of Motion* [10.19] was delivered in Berlin on March 19, 1955.

(11) Ludwik Silberstein

Ludwik Silberstein (1872–1948) [11.1], born in Warsaw, studied in Cracow, Heidelberg and in Berlin, where he took his Ph.D. degree in 1894. In 1895–1897 he worked as an assistant of physics at Lvov University, in the years 1898–1904 he was a lecturer at Bologna University and in 1904–1920 lecturer in Rome. Then, in 1920 he moved to England and then soon he went to United States, where he worked as physicist until 1919 for the Concern of Kodak. After 1930, until his death in 1948 he was a consultant for his firm. During his stay in United States he delivered ttheory of relativity at Cornell University and at the Universities of Chicago and Toronto. He worked in statistical physics, theory of relativity and optics. He published the textbooks: *Theory of Relativity* in 1914 and the monography *The Size of the Universe* in 1930. Until 1914 Silberstein had contacts with Polish physicists.

He published his papers, written in English, on the quaternion formulation of special relativity, also in Polish translation. He wrote also in Polish language the textbook, entitled *Electricity,* which was praised by Smoluchowski as the work better than the generally used in that time Abraham's textbook about electricity! Also the translation into Polish of Silberstein's textbook *Theory of Relativity* was announced, but it failed because of the outbreak of the war in1914.

Silberstein had a critical attitude against relativity. His controversy with Einstein in the years 1933–1936 was the testimony of this criticism. We shall present the history of their relations and of their controversy, basing on the article of P. Havas [ll.2], entitled *The General Relativistic Two-Body Problem and Einstein-Silberstein Controversy*.

The exchange of letters between Einstein and Silberstein began in 1918 and concerned mainly relativity, but touched also social problems. They met in spring 1921 in Princeton and possibly also in Chicago, when Einstein came to the United States in the cause of Zionism.

In the autumn of that year professor Gale, the Dean of the Science Faculty of the University of Chicago, offered Einstein the post of the professor and head of studies and investigations of theoretical physics at the Physics Department of that University. He also offered Silberstein the post of the theoretical physics professor, collaborating with Einstein. Silberstein transmitted both offers to Einstein. He stressed that intellectual and social atmosphere at Chicago University was very favourable to Einstein, in contrast to the hostile emotions against relativity and against Einstein, prevailing in some scientific and political circles in post-war Germany. But Einstein did not accept this proposition, since he did not want to break scientific and social bounds, which joined him with Berlin and was not willing to change the society among which he hitherto lived.

After Einstein's refusal of moving to Chicago, the correspondence between him and Silberstein became less intensive. In Silberstein's letters written in that time his great respect to Einstein was evident.

When Hitler came to power in Germany in 1933, Einstein moved to the United States and took the post of the professor in Princeton. In that year the controversy between Silberstein and Eistein began about the problem of the existence of the static solutions of the equation of gravitational field of the system of two heavy bodies in general relativity theory. Already in 1919 HermannWeyl found the exact solution of the gravitational field of the system of two bodies separated from each other by a closet surface (to prevent the case of one body placed inside the other) [11.3]. In order to keep them in relative rest, the introduction of tension is needed, for instance by an elastic rod placed between them. In 1924 H.E.Curzon [11.4] found the exact static solution of the field equations of the two - body system having two resting singularities. But he did not notice, that in this system the third singularity of the gravitational field had to exist on the line joining these two bodies (correspondingly to the necessity of placing there a rod, or to the introduction of forces other than gravitation, for instant electric forces). Silberstein repeated in 1933 the error of Curzon (not knowing, anyway his paper). He found the same expression as Curzon, for the static field of two singularities, maintaining that in this system no further singularities existed. Since the equations of the gravitational field had the physically non allowed solutions, he stated that the general theory of relativity, in particular the equations of gravitational field should be changed. Before the publication Silberstein sent his results to Einstein in the letter [EA 27–059] from December 3, 1933. This letter provoked the exchange of letters and the controversion between Silberstein and Einstein about the problem of gravitational field of two-body systems. This controversion, lasting three years, is presented in details in Havas' paper [11.2], we shall therefore limit ourselves, basing on this article, to the short presentation of the polemics.

Einstein did not agree (his letter [EA 21–061]) with the above mentioned result of Silberstein's and maintened that the gravitational field had a singularity, placed on the line joining the two point-like singularities, representing both heavy bodies. But Einstein made an error in his calculation and Silberstein wrote about this error in the next letter to Einstein. Then Einstein admitted that Silberstein was right and tried with Rosen [11.5] to modify the equations of gravitational field; this attempt was not, however, continued.

In autumn 1935 Silberstein prepared the publication of the paper, containing the results of his work about the two-body system. In the letter [EA 21–074] he asked Einstein for his opinion, but he did not wait for Einstein's answer and he sent the manuscript to "Physical Review", where it was accepted and published [11.6]; Silberstein informed Einstein about it. In the next letter Einstein wrote that he regarded Silberstein's results as erroneus ones and dissuaded him from its publication. In this letter he sent Silberstein the calculation, in which, however, he repeated the error from the preceding letter. In answer Silberstein abandoned his polite tone and wrote that Eistein had already accepted his earlier result. This letter stimulated Einstein to treat this question seriously. He sent Silberstein a letter, where he showed the place where Silberstein's error was rooted. But Silberstein didn't again acknowledge Einstein's arguments. After the new exchange of letters Einstein declared that he would not continue the polemics and did not answer further Silberstein's letters, which were written in sharper and sharper tone.

The controversion was finished by the letter of Einstein and Rosen to Physical Review [11.7], where they gave the correct solution of the problem and by Einstein's letter [EA 21–085] from March 10, 1936 to Silberstein. In this letter Einstein wrote that after the publication of Silberstein's paper [11.8], he considered as necessary to correct Silberstein's error publicly.

Seized by the friendly and quiet tone of Einstein's letter, Silberstein apologized to Einstein in the letter [EA 21–088] from March 17, 1936. The further correspondence, concerning mainly also the problem of the gravitational field of one or two bodies and Silberstein's objections to the method of Einstein Infeld and Hoffmann's, was led in quiet and friendly atmosphere. We close the presentation of this controversion with the remark of P. Havas' who stated that, although Silberstein made the principal error, Einstein particularly at the beginning of the controversion was not quite right, because his aversion to the singularities caused, that during the discussion he changed his point of view and did not give the decisive answer immedlately. The comprehensive correspondence Einstein and Silberstein's elucidated the modes of thinking of both antagonists in this controversion, but contributed principally nothing to the explanation of the problem of two singularities.

But people were further involved in the problem of two bodies and of singularities in general relativity. Among the list of references citied by P.Havas we direct the attention of the reader on two articles of G.Szekeres [11.8] of the properties of two body systems and of N.Schleifer [11.9] on the singularities of Riemannian manifolds.

(12) Myron Mathisson

Myron Mathisson (1897–1940) [12.1],[12.2], born in Warsaw, studied physics in the years 1920–1924 at Warsaw University. Having completed his studies, he took irregularly jobs and made research in theoretical physics, especially in deriving the equations of motion of the particles from the equations of gravitational field. He finished his first work, entitled *The Laws of Inertia in General Relativity* [12.3] in 1927. (Let us remark that in the same year Einstein and Grommer published their first paper [11.4] about the derivation of the equations of motion from the equations of gravitational field). Mathisson, in his above mentioned first work, derived the equations of geodesies from the field equations by applying the method different from that of Einstein and Grommer's.

Mathisson's method followed Weyl's approach [12.4] from the year 1923 to the problem of deriving the equations of motion from the gravitational field equations (though Mathisson did not quote Weyl's publication). Mathisson considered the world lines of material points as the singularities of gravitational field. He enclosed each of the singular world-lines by a four-dimensional tube. Inside each of the tubes he split the metric tensor into the sum of two tensors, one describing the "gravitational background" (in most applications it was the metric tensor of special relativity) and the other, the metric tensor of a weak gravitational field, describing the deviation from the background in the vicinity of the tubes. Outside the tube this weak field satisfied (in the first approximation) partial differential equations (following from the equations of gravitational field), in which the energy- momentum tensor appeared. These equations were supplemented by the "normalisation condition", imposed by the vanishing of the four-divergence of the tensor of energy and momentum. Next, instead of considering (as Einstein and Grommer did), the world-line, on which the energy-momentum tensor was singular, as the singular world-line of the gravitational field, Mathisson extended the metric tensor and the tensor of energy and momentum from outside of the tube to its interior. In this way he replaced both singular tensors by nonsingular ones.

Then Mathisson introduced the arbitrary four-dimensional vector field, which vanished outside a certain four-dimensional region. By means of this arbitrary field he obtained from the equations of gravitational field the variational principle for this field. This principle allowed to change the quadruple integral, containing the components of the tensor of energy and momentum of gravitational field, into the curvilinear (in four dimensions) integral along the world line of the particle; as well as to write down the variational principle along this world-line. Assuming, in addition, that the gravitational field had spherical symmetry in an appropriate system, Mathisson derived the equation of geodesies and showed that the mass of this particle is constant.

Having finished that work, Mathisson wrote to Einstein a letter [EA 18–001] (in French) on February 18, 1929 with a request for help in his difficult material situation and promised to send Einstein, in a week, his (still unpublished) paper, which he reported in detail in this letter. (We present the exchange of letters between Einstein and Mathisson's, basing mainly on the article [10.9] of P.Havas). Mathisson criticised there Einstein's and Grommer's method and also the non suffcient precision of Weyl's method and remarked that:

> My calculation clearly proved that one could push the necessary approximations further; they do not yield any additional equations, which could make the quantum phenomena conceivable... (Translation from French by P.Havas)

Mathisson's paper made strong impression on Einstein, because he invited Mathisson (in a nonpreserved letter) to Berlin, offering him collaboration. But Mathisson presumed, however, that he was not enough prepared to the collaboration with Einstein and he requested Einstein only (letter [EA 18–004] from February 23, 1930) for supporting his paper at professor Białobrzeski (from Warsaw University) in his applications for obtaining the doctoral degree. Einstein gave, in the letter [EA 18–006] from February 27, 1930, to professor Bialobrzeski his warm support. Mathisson took his Ph.D. degree in 1932. His doctoral dissertation was entitled *The Laws of Inertia in General Relativity.* At the same time Einstein began to apply for the Rockefeller grant for Mathisson, however, unsuccessfully. In 1932 Mathisson habilitated himself at Warsaw University. After habilitation Mathisson remained in Warsaw until 1933, and there he lectured theoretical physics at University. In 1933 he obtained the invitation to Paris to the collaboration with Jacques Hadamard in the domain of the partial differential equations of the second order of hyperbolic type. Mathisson stayed in Paris for two years. In 1935 Einstein, who was then professor at the Institute of Advanced Study in Princeton, tried to contact Mathisson, through mediation of Hadamard's, (letter [EA–053] from November 3, 1935) since then the possibility of the invitation of Mathisson to Princeton was opened. But Einstein's letter has not found Mathisson in Paris, since he just left Paris for Warsaw and then for Kazan in the Soviet Union, where he received the post of the professor at Kazan University. Einstein's letter arrived to Kazan seven months later.

Mathisson answered Einstein (letter [EA 18–054] from July 23, 1936) that because of his duties performed in Kazan he would not be able to arrive to Princeton earlier than in the academic year 1937/38. But, when in the Soviet Union Stalin's purges began, Mathisson went hastily back in 1938 to Poland. There he obtained, thanks to the efforts of professor Weyssenhoff, a grant founded by a group of rich Polish businessmen, which allowed him to devote himself to scientific research and he moved to Cracow. His collaboration with professor Weyssenhoff and with his Cracow group lasted one year.

In spring 1939 Mathisson left for France and then to England, where he died in 1940. In spite of all Einstein's efforts his collaboration with Mathisson was not realized.

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