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Erich Kretschmann. The Life of a Theoretical Physicist in Difficult Times

Wolfgang Gebhardt[1]

Preliminary Remarks

In the year 2015, the physics community celebrated the 100th anniversary of Albert Einstein's General Theory of Relativity, which Einstein published in its final form in November 1915. In this context it seems fitting to remember the life of another physicist who contributed through his careful investigations and profound criticism to the early acceptance of Einstein's famous theory. This scientist was Erich Kretschmann (1887–1973), whose two most extensive publications appeared in 1915 and 1917 in the *Annalen der Physik*. Between 1946 and 1952, in the last period of his professional life as a physicist, Kretschmann was a full professor of theoretical physics at the Martin-Luther-Universität Halle. I attended his lectures as an undergraduate student of physics and mathematics and took examinations there in my second year.

Inquiring into Kretschmann's life was no easy task. I could trace little information regarding his professional career, and I still do not know much about his personal life. He was a bachelor, and his younger sister, who became his sole heiress, remained unmarried. Therefore no descendants are alive today, and my search was confined to some collected official correspondence, a few private letters, and some curricula vitae which I found in the archive of the Martin-Luther-Universität Halle.

Childhood and Adolescence

Erich Kretschmann was born on July 14, 1887 in Berlin as the first child of Joseph Kretschmann (1847–1931), a construction site foreman, and his wife Johanna Kretschmann, *née* Randel (1857–1938).[2] In Germany the job title "foreman" means a site agent who

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[2] E. Kretschmann, curriculum vitae, September, 1938: Als Sohn des Bauführers und späteren Baurats Joseph Kretschmann und seiner Ehefrau Johanna geb. Randel wurde ich am 14. Juli 1887 in Berlin geboren und röm. Kath. getauft. Ich bin rein arischen Stammes. Die Vorschule besuchte ich von Michaelis 1893 bis Ostern 1896 in Berlin-Grunewald und anschließend bis 1899 die drei ersten Klassen des humanistischen Joachimsthalschen Gymnasiums in Berlin-Wilmersdorf. Ende 1898 siedelten meine Eltern nach Königsberg über.

supervises the workers at a construction site and who is responsible for the execution and quality of the work. In the present day a foreman is usually a graduate of an engineering faculty, an occupational profile that has probably not changed much since 1900. Therefore we can reasonably assume that Kretschmann's parents were middle class people, not rich but well-to-do. The family was Roman Catholic. As he grew up, Erich felt increasingly alienated from his parents' beliefs, and eventually became a nonbeliever. The official expression at that time for people who did not belong to a specific religion was *gottgläubig* (believing in God). When in 1938 Erich justified his leaving the Church, he explained that his faith and his metaphysics relied rather on the fundamentals of modern science and scientific realism than on a religious belief. Furthermore, he explained that he had waited respectfully with his exit until his mother had passed away.

He entered elementary school in Berlin. In 1899, the family moved to Königsberg in Eastern Prussia (the town is now Russian and has been renamed Kaliningrad). Erich attended junior high school. In the third grade, at fourteen, he suddenly became plagued by depression and nervous exhaustion. He seemed unable to go to school or to learn. After three years however his sufferings had subsided enough that he could return to academic life. He succeeded, and graduated at the age of nineteen, a highly gifted young man. Passing the final examination enabled him to enroll at a university. The nature of his mental crisis remained ambiguous. The diagnostic findings from Dr. E. Hallervorden, a psychiatrist from Königsberg, are given in the medical terminology of the time and certainly differ from a present day report.[3] A psychotic disease at fourteen seems rather unlikely. It is more probable that he suffered from a psychosomatic unbalance, perhaps due in part to a strict education and the general morals of the time. The fact that he grew up in a Catholic family, living in Prussia as part of the diaspora, may also have contributed to his state of mind. Dr. Hallervorden ends his report from 1912 with the statement that in Erich's case, a more ordered and hygienic life would alleviate the nervous symptoms. Indeed, young Kretschmann went on to follow the

[3] Medical report from Dr. E. Hallervorden, psychiatrist, Königsberg, September, 1912: Herr cand. phil. Erich Kretschmann von hier—25 Jahre—hat während seines Wachstums und Entwicklungsalters vom 14. Jahre ab eine schwere Neuro- & Psychopathie (depresssive Zwangsvorstellungen mit den Erscheinungen nervöser Erschöpfbarkeit) durchgemacht. Drei Jahre, von der Untersekunda ab, musste der Schulbesuch ganz unterbleiben. Darauf bestand der wenn auch kranke, so doch hochbegabte junge Mann nach 2jährigem ärztlich modifiziertem und mit größter Schonung geübten Schulbesuch im 19ten Jahre das Abiturexamen. Die Krankheitserscheinungen sind durch vorsichtiges hygienisch geregeltes Leben allmählich zurückgedrängt, und der Patient hat seitdem Mathematik und Physik studiert. Wie für das bisherige gilt auch für sein ferneres Leben ein auf dem Prinzip der Schonung basierte Führung desselben als Bedingung fortschreitenden Gesundens und Gesundbleibens.

recommendations of his doctor and seemingly kept an ascetic lifestyle as he grew older. There was one positive aspect to his young afflictions however: his condition disqualified him from any kind of military service. As he wrote in one of his short autobiographies: "For the military service I was permanently disabled." This saved him from having to serve in the First World War during his most creative years, and likewise prevented him from being drafted later on.

University Studies

Erich Kretschmann was nineteen years old when he enrolled at the Ludwig-Maximilians-Universität in Munich in 1906. In the second term he studied in Berlin, and in the third at Göttingen, where he attended lectures given by Woldemar Voigt (1850–1919) and David Hilbert (1862–1943). For his sixth term, he returned to Berlin, where he stayed until 1912. He became a student of Max Planck and participated in his problem-solving courses. He also took lab courses taught by Robert Wichard Pohl (1884–1976) and James Franck (1882–1964), at that time both co-workers of Heinrich Rubens (1865–1922) in Berlin. Kretschmann obtained his doctorate on the twentieth of May 1914, with a dissertation written under Max Planck, titled *Eine Theorie der Schwerkraft im Rahmen der ursprünglichen Einsteinschen Relativitätstheorie*. In the same year he returned to live with his parents in their Königsberg residence. He continued to work independently on problems of theoretical physics. He participated in talks and colloquia at the Institute of Technical Physics at the Universität Königsberg under Professor Walter Kaufmann (1871–1947). In the years 1917 to 1919 he taught arithmetic, mathematics, and physics as a representative of a senior schoolteacher at the municipal Kneiphöfschen Gymnasium and later at the Waldschule at Metgethen. This was probably a fairly secure way for a theoretical physicist to survive financially in these difficult times of war.[4]

[4] E. Kretschmann, curriculum vitae, September, 1938: Dort [in Königsberg] war ich von Ostern 1899 bis Juni [90] und wieder von Ostern 1904 bis zur Reifeprüfung, die ich im Frühjahr 1906 bestand, Schüler des humanistischen altstädtischen Gymnasiums. Die Unterbrechung des Schulbesuchs von 1901 bis 1904 wurde durch Nervenkrankheit verursacht. Von Ostern 1906 ab studierte ich Physik und Mathematik, das erste Semester in München, das zweite in Berlin, das dritte bis fünfte in Göttingen besonders bei Waldemar Voigt und David Hilbert. Vom sechsten Semester ab bis Ostern 1912 war ich wieder in Berlin an der Universität eingeschrieben und bildete mich weiter hauptsächlich in den Vorlesungen und Übungen von Max Planck und im physikalischen Praktikum unter Rubens. Am 20. Mai 1914 promovierte ich ebendort bei M. Planck zum Dr. phil. mit einer theoretischen physikalischen Arbeit. Vorher, am 1. Oktober 1913 war ich bei dem Fußinfanterieregiment "von Lingen" in Königsberg als einjähriger Freiwilliger eingetreten, aber nach einem Monat als "dauernd untauglich" entlassen. Den gleichen Bescheid erhielt ich nach mehreren Untersuchungen während des Krieges.

The Two Publications from 1915 and 1917

In 1915 and 1917 Kretschmann published two rather lengthy papers in the *Annalen der Physik* with the following titles: "Über die prinzipielle Bestimmbarkeit berechtigter Bezugssysteme beliebiger Relativitätstheorien" and "Über den physikalischen Sinn der Relativitätspostulate. Albert Einsteins neue und seine ursprüngliche Relativitätstheorie." When we compare these titles with that of his thesis we may conclude that Kretschmann had restarted and extended his investigation on relativity and gravitation at Königsberg. The first two-part paper is concerned with Einstein's Special Theory of Relativity (STR) as well as with various alternatives being discussed at that time in Germany. At the beginning of the twentieth century, most physicists were convinced that the movement of light with finite velocity, feasible even in a vacuum, requires a very light gas-like substance, the ether, a kind of super-elastic medium. The famous Michelson experiment was set up to test just this model: the ether drift by the motion of the Earth in interplanetary space. However, the experiment did not show any of these expected effects, since there is no ether. Einstein obviously took little notice of Michelson's experiment. In his STR, he considers only the concept of the electromagnetic field and a vacuum speed of light "c" which is the same in all directions and reverence systems. The assumption of an ether seemed to be unnecessary. Another obstacle was the role that space and time still played in philosophy: Kant and his followers presupposed that the concepts of space and time are integral parts of our process of gaining knowledge and inseparable from it. Therefore in a strict sense one could argue that space and time themselves cannot be made objects of our empirical research. Kretschmann's 1915 paper is in its first part concerned with Einstein's STR and with those alternatives still in discussion. Kretschmann explains profoundly how we experience space, and how spatial expansions and distances can in principle be measured. Reading this section, one still feels the influence of nineteenth-century physiology, when researchers discussed how our organs of perception afford us verifiable cognition.

In the second part of his 1915 paper, he discusses the STR specifically in relation to ideas of symmetry. When there are two reference systems (x, y, z, ct) and (x', y', z', ct') in uniform motion relative to each other, the dashed coordinates are transformed to the original by a Lorentz transformation and vice versa. They form a vector space. Its symmetry group of all transformations L is the Lorentz-group of the STR. Kretschmann points out that "relativity" means a Lorentz invariance of physical laws, and only in this context does the concept of "relativity" have a definitive meaning. The practical consequence for Kretschmann is to

recommend the use of invariants instead of spacetime-points or the paths of particles (world lines).

Of more importance is the second publication from 1917, a work still referenced today by people working in gravitational physics and with the General Theory of Relativity (GR). In this paper Kretschmann asks if the GR is really a theory of relativity in the strict sense worked out for the STR. If this were true, there should be a symmetry group which leaves the points and paths in a Riemannian manifold invariant. This could only involve transformations of the general linear group GL. Thus he finds that in general cases, only the unit transformation leaves spacetime-points and -curves invariant. Therefore he concludes that GR is on the contrary an "absolute theory" and that the concept of "relativity" should be kept exclusively for the STR. Furthermore, general covariance seems to Kretschmann too far-reaching a concept, since with some mathematical skill any physical theory can be made covariant. In his further analysis he tries to find a more physical meaning for Einstein's equations. He finds that a scaling of the metric $g_{\mu\nu}$ by a constant λ also leaves the physical laws invariant. He investigated the propagation of light ($ds^2 = 0$) and the motion of particles ($ds^2 < 0$). Under the condition $\partial \int ds = 0$ two geodesics can coincide once at the most at a common point, a statement where Kretschmann is in full accord with Einstein.

Einstein responded in a short paper published in the *Annalen*: "Prinzipielles zur allgemeinen Relativitätstheorie."[5] He first makes clear that the GR rests on three main points of view: firstly, the relativity principle; secondly, the equivalence principle; and finally Mach's principle. He then concedes that the objections of "Herrn Kretschmann" are correct. However, he would not recommend "Kretschmann's advice" to write all physical laws in covariant form.

This statement seems to me a polite and humorous rejection of Kretschmann's slightly polemical exaggeration.

[5] See (Einstein 1918, 578–581).

Career at Königsberg

In the years 1894 to 1924 Paul Volkmann (1856–1938) was a full professor at the Universität Königsberg (or the Albertina) and held a position as a director of the mathematical-physical laboratory and the mathematical-physical seminar, two nineteenth-century institutions which vanished after Volkmann's retirement.[6] Walter Kaufmann (1871–1947) held the chair for experimental physics. Kaufmann was one of the first experimentalists who succeeded in measuring the velocity-dependence of electron mass.[7]

Kretschmann was habilitated on 30 April, 1920 and received his license to lecture at the Albertina and the title of *Privatdozent* on June 29, 1922. The script of his habilitation work was concerned with the Theory of Radiation. In 1921 he published the essence of this work in the *Annalen der Physik*, with the title "Über die Wirkung des Planckschen Oszillators auf die spektrale Energieverteilung des Strahlungsfeldes." With the *Lehrauftrag für theoretische Physik* received in June 1922, he was paid for his teaching. In the following years he wrote several reports for the *Beiblätter der Annalen der Physik* and *Physikalische Berichte*.

Finally on March 22, 1926 Erich Kretschmann became an *Extraordinariat* without being a state officer. Although sufficiently paid, it was a position which however gave him only limited rights in the internal academic administration. An *Extraordinariat* is not usually guaranteed any rooms besides one office, nor are they given a secretary or any financial provision from the university. In favorable cases, a certain agreement may be arranged with the full professor of experimental physics who would support work on a problem of common interest. This situation made it difficult for the *Extraordinariat* to follow his own research interests. Kretschmann's move from the field of relativity to the field of quantum statistics of electrons thus seems only logical. Nothing is known about the relations between Erich

[6] More information about Volkmann's activity is found in Jungnickel, E. and McCormmach, R. *Intellectual Mastery of Nature*.

[7] E. Kretschmann, curriculum vitae, September, 1938, continues: Nach der Promotion arbeitete ich weiter selbständig im Hause meiner Eletern in Königsberg und beteiligte mich im Institut für praktische Physik durch Vorträge in dem physikalischen Kolloquium unter Prof. W. Kaufmann. Vom Beginn des Jahres 1917 ab bis Ostern 1919 unterrichtete ich außerdem als Vertreter eines Oberlehrers zunächst im Kneiphöfschen Gymnasium der Stadt und, während des letzten Halbjahres an der "Waldschule Metgethen" bei Königsberg in Rechnen, Mathematik und Physik. Zugleich arbeitete ich wissenschaftlich weiter und habilitierte mich mit einer strahlungstheoretischen Arbeit am 30. April 1920 an der Albertina-Universität in theoretischer Physik. Am 29. Juni 1922 erhielt ich einen Lehrauftrag für dieses Fach an der genannten Universität und wurde am 22. März 1926 zum "nichtbeamteten außerordentlichen Professor" ebendort ernannt. Diese Stellung bekleidete ich seitdem bis heute ohne irgendeine Nebenbeschäftigung. Hauptgegenstand meiner wissenschaftlichen Arbeit sind und bleiben die allgemeinen Grundlagen physikalischer Gesetzmäßigkeiten. Doch bin ich auf diesem Gebiet noch zu keinem befriedigenden Ergebnis gekommen und habe darüber auch noch nichts veröffentlicht.

Kretschmann and Walter Kaufmann, although they were probably satisfactory. At the end of the nineteenth century, the physics building was renovated and enlarged. Both the experimental and the theoretical physics departments gained sufficient space in the new building. In 1925 Richard Gans became full professor of theoretical physics. Between 1925 and 1935, both Gans and Kretschmann gave alternating basic lectures in theoretical physics (mechanics, theory of heat, statistical physics, electrodynamics, optics, and atomic physics). They also offered together an "introduction to autonomous scientific work in theoretical physics."[8] This cooperation ended in 1933 when Adolf Hitler came to power. Richard Gans was dismissed at the age of 55. Walter Kaufmann was forced into early retirement at the age of 64. With these dismissals, Kretschmann probably lost two supporters. When in 1936 two institutes were newly founded, one concerned with experimental physics, one with theoretical, Kretschmann was excluded and not brought into either of them. Fritz Sauter (1906–1983), a licensed lecturer at the Albertina, became deputy director of the theoretical institute and was later promoted. Between 1939 and 1942 he was full professor of theoretical physics at the Albertina.

It is not known how much commitment Kretschmann gave to his career, and how often he travelled or attended scientific conferences. He probably relied modestly on his publications, accumulating a considerable body of scientific work: fourteen papers over fifteen years, seven of them concerned with relativistic physics. In a letter from 14 November, 1927 Arnold Sommerfeld (1868–1951) wrote to Karl Försterling (1885–1960), a full professor of theoretical physics at Köln:

> Furthermore, Dr Kretschmann, *Privatdozent* in Königsberg, comes to my mind, completely dedicated to relativity and electron statistics. It would be good to get him away once from Königsberg.[9]

Arnold Sommerfeld himself originated from Königsberg and had studied mathematics there. Mathematics had a distinguished tradition in nineteenth-century Königsberg, involving the likes of Neumann and Jacobi, who founded the Mathematical-Physical-Seminar at the

[8] The announcements are found in the *Vorlesungsverzeichnis der Albertina von 1927*.

[9] Letter of A. Sommerfeld to K. Försterling, München, November 14, 1927: Lieber Herr Kollege, Ich bin sehr erstaunt, daß Heitler Ihnen noch nicht geschrieben hat. Er war auf dem Wege zu Ihnen, ist aber in Göttingen von Born als Assistent festgehalten worden. Sie sollten also nicht auf ihn warten. Ich bringe daher nochmals Dr. Pollaczek in Vorschlag, über den ich Ihnen schrieb. Ferner fällt mir ein: Dr. Kretschmann, Privatdozent in Königsberg, sehr gründlich, speziell Relativitätstheorie und Elektronenstatistik zu Hause. Es wäre ihm ganz gut, wenn er einmal von Königsberg fortkäme. Mit freundlichen Grüßen, A. Sommerfeld.

Albertina in 1834. The last directors of the seminar were the physicist P.Volkmann and the two mathematicians E.Mayer and K.Knopp. Even the famous mathematicians Minkowski, Hurwitz, and Hilbert spent the early years of their careers at Königsberg. Sommerfeld's well-meant suggestion was not fulfilled however, at least not before the end of the Second World War.

Did Kretschmann come under pressure in 1933 when Hitler came to power? Probably not, but he was certainly not considered the first choice for the Ministry in Berlin. His competence in special and general relativity, now denounced by some groups as 'Jewish physics', probably made him seem suspect to the new ruler and their followers. At 22 German universities Nazified students celebrated a ritualistic burning of books from Jewish and Marxist-sympathising authors. This also happened in Königsberg in May 1933, and probably included books from and about Albert Einstein.

Had there been party members and agitators among the young generation of physics lecturers? Unfortunately yes. Arthur Stuart (1899–1974) was a gifted expert on molecular physics who shortly taught at the Albertina as a licensed lecturer. He was a leading member of the Nationalsozialistischer Deutscher Dozenten Bund (NSDD). Although his thesis adviser was James Franck and although he worked as a postdoctoral fellow under Otto Stern, he was an anti-Semite and ardent supporter of Hitler's aggressive politics. In a letter to G. Stetter from 1939 he complained about the protective strategy of the German Physical Society (DPG), who kept their Jewish members for as long as possible.[10] In 1937 Wilhelm Schütz (1905–1978) was appointed full professor of experimental physics and successor to Walter Kaufmann. Schütz was addressed by Stuart in 1939 as a party member. When the DPG was ready to elect a new president in 1939, Schütz wrote a letter to Stuart where he expressed his dissatisfaction with the handling of the problem of Jewish memberships and he hoped "that the society finds a *Führer* (leader) who shapes its fate in a positive and wholehearted attitude in support of the third empire." After 1933 a new topic appeared In the *Vorlesungsverzeichnis* (university calendar): "Political Education." There one finds the announcements of the NSDD and the Nationalsozialistische Deutsche Studentenschaft (NSDS) and their respective organizations, thus demonstrating the growing power and penetration of the new Nazi regime.[11]

It is not known if Kretschmann had thesis students of his own to supervise, but it seems unlikely. There is no second author in his publications. The few physics students who were

[10] See (Hoffmann, Walker 2006)
[11] Vorlesungsverzeichnisse der Albertina von 1933–1944.

studying at the Albertina were probably in most cases preparing for a career in industry. The few who were interested in the new studies in the "new physics" may have decided to go to Munich or Göttingen. Later in the 1930s, Kretschmann seemed to have managed the lecture courses in theoretical physics (mechanics, electrodynamics, thermodynamics, and atomic physics), including problem-solving courses, by himself or in turn with Fritz Sauter.

However, Kretschmann was not fully satisfied with his efforts. In November 1938, after the death of his mother, he wrote in an undated biographical note: "The main subject of my scientific work is the fundamentals of the physical laws. However, in this field I have not been satisfied and I have published nothing in this respect." He continues to complain that he has not published anything since 1937, whereas in 1939 two papers should have been ready for publication. He justified this silence on the basis of his mother's long-term illness, and the liquidation and sale of the family home, all of which became his responsibility. He moved out, but had difficulty finding suitable accommodation. Between February and October 1938, he had to move apartments five times. In 1939, the request to perform militarily useful work complicated his scientific survival. Nevertheless he received a *Treuemedaille* (loyalty medal) in 1942 from the Reichsregierung for his professional commitment.

In the summer of 1939, the science faculty at the Albertina served 188 students in total. Note that (natural) science at the Albertina involved mathematics, physics, biology, geology, and agriculture. It is not known how many students studied physics, probably 30 or 40. However, after the beginning of the Second World War, the number of physics students probably decreased rapidly. Those happy young soldiers who gained a leave of absence to finish their studies at the university or take final examinations used the "trimester" in the years 1940 and 1941. During this time Kretschmann announced only "Theoretical Physics, subject open to choice." This was probably a very realistic decision, but one not taken by his colleagues.

De profundis. Escape and Emergency Accommodation

In August 1944, British aircraft raided Königsberg and destroyed large parts of the old town, including university buildings. By January 1945, the Eastern Front was rapidly approaching. An income and property list from January 1, 1945, which Kretschmann probably prepared in the weeks before leaving the town, provides some information. In addition to this list, Kretschmann received an income at Königsberg of 600 RM per month and held a property worth 80,000 RM. The value of the currency has changed since then, roughly by a factor of

seven. Friedrich Hoffmann, who had been university chancellor since 1922, closed the university on January 27, 1945 because of the threat from the enemy. The Universität Greifswald was planned as a first shelter. But the Red Army advanced so swiftly that many members of the Universität Königsberg simply absconded to somewhere in Schleswig-Holstein, the most northern German province, an area which soon came under the protection of the British occupation zone. Flensburg was a contact point for searches and requests, from where Chancellor Hoffmann reached out to find the dispersed members and their families. Kretschmann found accommodation at Rendsburg (Schleswig-Holstein), at the address Waldstrasse 24. When Hoffmann's request to help the Alberta members reached Kretschmann, he gave a clear and helpful response that he would be willing to do whatever he could to find people new positions. However, he insisted on two conditions: the applicants should not be not be implicated in past political activities, and they should also be willing to accept a post in the Russian occupation zone.

In 1946, Kretschmann wrote several letters to Günther Mönch, who had recently become full professor of applied physics as well as director of the II. Physical Institute at the Universität Halle. It seems that Mönch wired Kretschmann twice, but the printed text is not available. In Halle the position of full professor and director of the Institute of Theoretical Physics was vacant. Adolf Smekal (1895–1959) was the holder of this position until 1945 when American troops forced him and several other scientists out of Halle into the American Occupation Zone. Günther Mönch had been professor for applied physics at Königsberg between 1942 and 1945. Obviously they knew each other quite well. Kretschmann asked Mönch about the living conditions in Halle. Mönch who obviously had already recommended Kretschmann for the vacant position answered that the basic monthly income for a 58 year old full professor is 966.67 RM in addition to 114 RM for accommodation.

> The tax load is about 50%. The lectures are also paid depending on the number of participants but without guarantee. There is no pressure to be a member of a political party. In principle we can accept any position in another zone if it is managed by a German administration. Former liabilities, however, from other universities cannot be approved by a present state administration.

Furthermore Mönch wrote:

> The institute is completely intact and under development. The theoretical physicist has to his disposition an office for himself, one for an assistant, a further office room, and a library which is divided in two parts. Furthermore the Theoretical Institute has a position for a secretary and an assistant professor. The heating for the building has already been partly supplied in June. It amounts to 50% of what has usually been used before the war.

The letter also contains information concerning how Kretschmann would be informed if the faculty were to approve his application. Then Mönch's letter continues:

> The shortage of accommodation is also a problem here but negligible in comparison to the West. I myself obtained a few days after my appointment a beautiful five-room apartment. Immediately craftsmen were sent for renovation which was completed in only four weeks.

Note that this letter was written thirteen months after the end of the war.

Mönch proposed Kretschmann should come to Halle and present himself there to the faculty. But Kretschmann wrote in a letter dated September 8, 1946 that he was unable to obtain permission to travel. He furthermore explained why it would be impossible for him to try an illegal crossing over the "green border."[12]

What follows is one of the rare personal statements which I found in Kretschmann's file. It throws some light on the troubled, difficult, and deprived conditions in these first years after the war, conditions which one can hardly imagine today. I quote a longer passage from Kretschmann's letter:

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[12] Letter of E. Kretschmann to G. Mönch from September 8, 1946:

Sehr geehrter Herr Mönch,

Ihr Telegramm lautete hier "Anschließend an Dr. Hiller Lübeck Nienburg Gut Rothenhausen zwecks Berufungsbesprechungen.." Ich las "Anschließet statt Anschließend" und glaubte, ich sollte mich mit Herrn Hiller in Verbindung setzen, um ihm meine Berufungsbedingungen wenigstens im Groben zu vereinbaren. Demgemäß versuchte ich, zumindest in Rothenhausen anzurufen. Erfuhr nach langem Warten, dass dort kein Fernsprecher sei und sandte daraufhin einen eingeschriebenen Brief mit meinen Bedingungen und Wünschen dorthin. Statt der erwarteten Antwort kam Ihr 3. Telegramm, aus dem ich ersah, dass ich mit Herrn Hiller zusammen hätte nach Halle kommen sollen. Es hat also vermutlich nicht "Anschließet" statt "Anschließend" geheißen wie angenommen, sondern etwa Herkommt anschließend zu uns. Die Verstümmelung des Telegramms hat gerade das entscheidende Wort getroffen. Daraufhin versuchte ich mir Reisegenehmigung zu beschaffen und erfuhr, daß das ganz unmöglich sei und drahtete Ihnen dies nebst "Brief folgt." Zu einer Schwarzfahrt, zu der ich mir heute Mittag Auskunft holte, kann ich mich aus schwer wiegenden Gründen nicht entschließen. Erstens würde ich dabei von meinen Barmitteln, von denen ich z. Zt. leben muss, so viel verbrauchen, wie hier in mehreren Monaten. Zweitens würden die Strapazen und Entbehrungen der Schwarzfahrt meine Gesundheit und Arbeitsfähigkeit, die ich hier durch äußerst geregelte Lebensführung und genaueste Einteilung der für mich erreichbaren Lebensmittel noch so eben erhalte, auf lange Zeit und womöglich für den ganzen kommenden Winter untergraben. Ich könnte nämlich durch die langen Eisenbahnfahrten und den anstrengenden Nachtmarsch über die Grenze so gut wie keine Lebensmittel mitnehmen, da ich so gut wie alle meine (Lebensmittel-) Marken für ein 10-tägiges Mittagessen und ein 14-tägiges Abendessen fortgegeben habe, bei denen ich besser fahre als bei Entnahme von Einzelmahlzeiten. Und dann hätte ich noch immer nichts für den Aufenthalt in Halle und für die Rückfahrt, zu der ich schon meiner Sachen wegen genötigt wäre, die ich nicht alle mit mir mitschleppen könnte. Schlechtes und kaltes Wetter könnten, da ich keinen auch nur einigermaßen dicht haltenden Regenmantel besitze und meine nassen Sachen am Leibe trocknen lassen müsste, das Unternehmen geradezu lebensgefährlich für mich machen. – Ganz abgesehen von der Gefahr, von den Russen erwischt zu werden. Und das alles um mich übermüdet und halb verhungert zu Besprechungen zu sellen, bei denen es darauf ankommt frisch zu sein und zu erscheinen. …

I received some information today about the possibilities of an illegal journey. However, there are pressing reasons why I cannot make up my mind. Firstly I would have to spend as much cash as would otherwise cover my daily budget for several months. Secondly, the stress and strain of the illegal journey would undermine my health and my working capability. Up to now I have been able to maintain both, through a strictly regulated lifestyle and careful portioning out of the available food rations. I am not able to obtain a food supply on the long voyage by train. Or the stress of a nightly walk across the border, having spent all my food stamps in advance, which makes more sense to me than arranging single meals. After all I wouldn't have any supplies for my stay at Halle and the journey back. Cool and rainy weather would be another obstacle, since I do not possess a sufficiently waterproof coat. My wet things would have to dry as I wear them. All of this would make the venture far too risky for me. Last but not least I could get caught by the Russians.

In the same letter Kretschmann refers to some people who know him quite well[13] and expresses the hope that the colleagues at Halle might be able to get an impression of his

[13] The letter of E. Kretschmann to G. Mönch from September 8, 1946 continues: ... Andererseits bin ich persönlich ja nicht nur Ihnen bekannt, sondern auch Prof. Reinh. Hoffmann, der aber wohl nicht mehr in Halle ist, ferner dem früheren praktischen Physiker Prof. Gerh. Hoffmann und Frau, ferner (flüchtig) den Theoretiker Smekal und weiter Prof. Schütz und Dr. Cappeller schließlich Prof. Litscherich in Berlin. Man kann sich also in Halle, auch ohne daß ich mich vorstelle, ein Bild davon verschaffen, was von mir zu erwarten ist. Und was ich selbst zur Bedingung meines Kommens mache, ist wie mir scheint leicht zu erfüllen.

1) Die der Stellung eines o. Professors und meines anerkannten Dienstalters vom 30.IV.1930 entsprechende Gehalt nebst Altersversorgung für einen Ledigen, das jedenfalls zu anständiger Lebensführung ausreichen muß und dazu die übliche Kolleggeldgarantie.
2) Die Freiheit einem Angebot einer anderen Stelle auch außerhalb der russischen Zone jederzeit unbedingt zu folgen. Hierzu erkläre ich, daß ich gegenwärtig in keinerlei Verhandlung zu irgendeiner Stelle stehe.
3) Die Freiheit von jedem Zwang oder Druck sich einer politischen Partei oder Bewegung anzuschließen oder mich in irgend einer vorgegebenen Richtung zu bewegen.
4) Auszahlung oder mindestens Anerkennung meines Anspruchs auf Nachzahlung meines früheren Gehalts für die Zeit von 1.Juni 1945 – von dem ab die Zahlung eingestellt wurde - bis zum Beginn der neuen Gehaltszahlungen. – Was ich hatte ist bis auf ein (Spar-?) Buch in Königsberg geblieben. Meine weiteren Wünsche sind enthalten in dem einen mir vor allem am Herzen liegenden, möglichst ausgiebig und fruchtbar wissenschaftlich arbeiten zu können. Was ich dazu von der Universität an Hilfsmitteln, wie Bücher, geheiztes Arbeitszimmer, Schreibhilfe, Assistent etwa brauche oder haben kann, hängt von den örtlichen Gegebenheiten ab, sowie davon wieweit ich mit wissenschaftlich unfruchtbaren Verwaltungsarbeiten belastet werde. In diesen Punkten verzichte ich auf den Versuch, scharf umrissene Bedingungen aufzustellen, der sich ja bei meiner Unkenntnis der Verhältnisse kaum sachgemäß durchführen ließe, und verlasse mich darauf, daß eine vernünftige Regelung dieser Fragen ja auch den allgemeinen Zielen der Universität dient.

Kann ich der Erfüllung dieser–oder äquivalenter–Bedingungen gewiß sein, so komme ich gerne nach Halle und scheue auch keine Reisestrapazen.
Zum Schluß bitte ich noch darum, mich gütigst sogleich zu benachrichtigen, falls meine Berufung endgültig aufgegeben wird, andwernfalls bitte ich auch um Mitteilung der dortigen tatsächlich erhältlichen Lebensmittelzuteilungen und der Unterkunftsmöglichkeiten.
Wie mir eben einfällt, habe ich nach Empfang Ihres zweiten Telegramms, etwa am 28. August, einen uneingeschriebenen Brief an Sie gesandt, der Sie hoffentlich inzwischen erreicht und über meinen Irrtum aufgeklärt hat.

Mit herzlichen Grüßen verbleibe ich Ihr ergebener
Erich Kretschmann

thoughts without his personal presence. He mentioned conditions under which he would accept. His time of service should be recognized, as well the freedom of choice to accept another offer, and the guarantee of his freedom of—or abstinence from—political activity. Finally his claim to receive backpayments of his salary dating to June 1, 1945 should be recognized.

The appointment of Erich Kretschmann as full professor of theoretical physics at the Martin-Luther-Universität Halle is dated October 10, 1946.[14]

Erich Kretschmann—Full Professor of Theoretical Physics at the Martin-Luther-Universität Halle

Only traces of information about Kretschmann's professional life at Halle after 1947 can be found. In his file kept in the university archive, I came across several notes on his teaching, which was evaluated quite positively. Then there was a request from him for permission to travel to Berlin and stay there for several weeks. He mentioned the necessary study of physics journals as grounds for a visit. The scarcity of currency obviously forced the DDR to keep international physics journals centralized in Berlin and available for scientists on request. There was also a questionnaire he had to fill out, concerning his political past. He confesses never to have been a member of the NSDAP, but he had paid a membership fee for the NS-Lehrerverband (NSLB) from October 1933 onward (these declarations were confirmed by the Bundesarchiv in Berlin). He also indicated his membership in the Reichsbund für Leibesübungen NSV and the Luftschutzbund. Kretschmann denied being politically active in the Reich, and mentioned how he cunningly declined a personal invitation from Minister Bernhard Rust to participate in an NS training camp for lecturers. In his personal file at the

[14] Der Kurator der Martin-Luther-Universität Halle d. 10. Oktober 1946

Der Herr Präsident der Provinz Sachsen hat gemäß Erlass vom 1. Oktober 1946—Vb 5390—den außerplanmäßigen Professor Dr. phil. Erich Kretschmann zum ordentlichen Professor in der Naturwissenschaftlichen Fakultät der Martin-Luther-Universität Halle-Wittenberg ernannt mit der Verpflichtung, das Fachgebiet "Theoretische Physik" in Vorlesungen und Übungen zu vertreten.

Durchschlag der Ernennungsurkunde ist für Ihre Akten beigelegt. Ich bitte Herrn Prof. Kretschmann die Ernennungsurkunde nebst Glückwunschschreiben auszuhändigen und mir davon Mitteilung zu machen.

Unterschrift

An den Herrn Rektor Magnifizenz

Reichsministerium,[15] which is also kept at the Bundesarchiv, I found under the rubric "political activity" the entry "none."

I arrived at Halle in the fall of 1949 and enrolled in October to study physics and mathematics. After two terms of experimental physics accompanied by lab courses and mathematics courses for beginners (calculus and linear algebra), I encountered Erich Kretschmann in my third semester in his lectures on Theoretical Mechanics. We were about twenty students, and assembled in the so-called "Small Lecture Hall" of the Physics Institute at the Friedemann-Bach-Platz. Kretschmann entered the room, a large, slender, and white-haired man of impressive appearance. Some students mentioned he was an active tennis player. He always showed up carefully dressed, although always wearing the same suit, which he probably had saved from Königsberg. In the cold season he arrived in an elegant dark blue coat with a white scarf. There was a sink in the lecture hall at the right side of the blackboard and a water tap which allowed the professor to clean his hands after the lecture. To the right of the sink there was also a hook on the wall where Kretschmann hung his coat. On one occasion, paying close attention to the scarf he also hung up, we discovered that it was actually a white towel. Necessity is always the mother of invention.

Kretschmann's lecture was clear and easily understandable. Sometimes he stepped back from the blackboard and stopped delivering his lecture for a moment. Then he gave one or two short coughs—"ahem"—as people sometimes do when they put down a heavy load, before carrying on. Kretschmann's assistant Max Hieke, already a licensed lecturer, gave a supplementary course on the action principle and Hamiltonian mechanics for students who were especially interested in the topic. In the summer term of 1951 I went to his course Introduction to Atomic Physics. In this lecture he mainly discussed the basic experiments which led to Quantum Mechanics. Finally in the last lecture he wrote down the Schrödinger Equation in Cartesian coordinates. But disappointingly he ended the lecture by saying that this equation is too complex and not suitable to be discussed at the blackboard. My fellow students and I were frustrated and wished Kretschmann would have encouraged us to study quantum physics. However, Kretschmann was a teacher whose prudence always outbalanced any kind of enthusiasm.

[15] Kretschmanns Karteikarte aus dem Reichsministerium für Wissenschaft, Erziehung und Volksbildung (in Kopie aus dem Bundesarchiv Berlin) vermerkt unter Politische Betätigung: "keinerlei" (handschriftlicher Eintrag)

I remember some short philosophical remarks he made during the lectures. Once he tried to illustrate the difference between physics and mathematics, which he summed up in a short sentence: “Physics is a science of retrospective consolidation.” I remember another funny aphorism too: “It is even possible to jabber mathematically.”

In my fourth term I took examinations in undergraduate mathematics, experimental physics, and theoretical physics. The latter exam was given in Kretschmann’s office, along with Hieke, who assisted in writing the protocol. At one point however Kretschmann requested Hieke ask the questions—they changed places and Kretschmann wrote the record. After I passed the exams I left Halle for Jena to study astronomy.

Erich Kretschmann retired at the end of the summer term in August, 1952. He wrote his will in 1954 and decided his younger sister Herta Kretschmann should be his sole heir. He stayed at Halle, remaining at the same address until his death. The Dean of Faculty regularly congratulated him on his birthday on the tenth of July, also on behalf of their colleagues. Kretschmann usually expressed his gratitude with a handwritten postcard. Kretschmann’s last card is dated from July 1973 in clear handwriting and without any trace of jitter. There is no indication he would pass away half a year later. He died on December 30, 1973. The peaceful funeral was organized by Herta Kretschmann and took place without any official participation.

Kretschmann’s Heritage

There are three specific concepts which the community of General Relativity and Gravitation owes to Kretschmann:

1) the concept of general covariance (GC) was stated more precisely. Today GC is often replaced by “diffeomorphismus”

2) the “Kretschmann scalar” $K = R_{\alpha\beta\gamma\delta} \cdot R^{\alpha\beta\gamma\delta}$

3) the point coincidence argument which he shared with Einstein

Sources

This article on the professional life of Erich Kretschmann is based exclusively on documents that I found in his personal file kept by the Martin-Luther-Universität Halle. I also used information from the Bundesarchiv in Berlin concerning a possible commitment in the years 1933–1945. The biographical facts and dates are mainly taken from three autobiographical notes, two longer scripts from November 1938 and June 1946, and a shorter undated document, all available as copies. I was provided with the *Vorlesungsverzeichnisse der Albertina 1920–1943* by the university library.

Acknowledgments

Andreas Kleinert kindly introduced me at Halle to the archives of the university and the Leopoldina. I have to thank him for the time he spent with me during my visit, and for his useful advice. I am indebted to my colleague Klaus Richter at Regensburg who provided me with information about Paul Volkmann and with a copy of a letter from Arnold Sommerfeld cited. Thanks also to Gernot Deinzer and the university library, who helped me find the *Vorlesungsverzeichnisse der Albertina/Königsberg*.

Kretschmann's Publications

Kretschmann, Erich. 1914. Eine Theorie der Schwerkraft im Rahmen der ursprünglichen Einsteinschen Relativitätstheorie. (Dissertation, Berlin)

———. 1915. Über die prinzipielle Bestimmbarkeit berechtigter Bezugssysteme beliebiger Relativitätstheorien. *Annalen der Physik* 48: Part I: 907–942 and Part II: 943–993.

———. 1917. Über den physikalischen Sinn der Relativitätspostulate. Albert Einsteins neue und seine ursprüngliche Relativitätstheorie. *Annalen der Physik* 53: 575–614.

———. 1920. Der Liouvillesche Satz und die Relativitätstheorie. *Physikalische Zeitschrift*. 21: 484–487.

———. 1921. Über die Wirkung des Planckschen Oszillators auf die spektrale Energieverteilung des Strahlungsfeldes. *Annalen der Physik* 370: Book 12, 310–334.

———. 1922. Eine Bemerkung zu Hrn. A. Gullstrands Abhandlung: 'Allgemeine Lösung des statischen Einkörperproblemsin der Einsteinschen Gravitationstheorie'. *Arkiv för Matematik, Astronomi och Fysik*. 17: 2.

———. 1923. Das statische Einkörperproblem in der Einstein'schen Theorie. Antwort an Hrn. A. Gullstrand. *Arkiv för Matematik, Astronomi och Fysik*. 17: 25.

———. 1924. Das Maxwell-Boltzmannsche Geschwindigkeits- und Energieverteilungsgesetz in der Relativitätstheorie. *Physikalische Zeitschrift*. 25: 162–165.

———. 1925. Über die Ableitung der Helmholtzschen Wirbelsätze in der Lorentz-Einsteinschen Relativitätstheorie. *Schriften der Königsberger Gelehrten Gesellschaft*. Naturwissenschaftliche Klasse 5.

———. 1926. Zur Theorie der Dauerströme in Supraleitern. *Annalen der Physik* 4: 80, 109–136. Berichtigung. *Annalen der Physik* 4: 80, 532.

———. 1928. Die Supraleitfähigkeit nach Schrödingers Wellengleichung und Fermis Statistik. *Annalen der Physik* 4: 86, 914–928.

———. 1929. Atom und Welle. *Schriften der Königsberger Gelehrten Gesellschaft*. Naturwissenschaftliche Klasse 6: 5.

———. 1932. Beitrag zur Theorie des elektrischen Widerstandes und der Supraleitfähigkeit der Metalle. *Annalen der Physik* (5) 13: 564–598.

———. 1934. Beitrag zur Kritik der Blochschen Theorie der Elektrizitätsleitung. *Zeitschrift für Physik* 87: 518–534.

———. 1934. Über die Resonanzbedingung und über die Beschleunigung der Elektronen in der Blochschen Theorie der Elektrizitätsleistung. *Zeitschrift für Physik* 88: 792–799.

———. 1949. Über streng punktförmige Elementarladungen. Eine Bemerkung zur klassischen Elektronentheorie. *Zeitschrift für Physik* 439: 331–334.

A list of Kretschmann's publications can be found online on the Math Forum under the name Erich Kretschmann:

http://mathforum.org/kb/message.jspa?messageID=4927825. Accessed 12 April 2016.

Bibliography

Einstein, A. 1916. Die Grundlage der allgemeinen Relativitätstheorie. *Annalen der Physik* 49: 769–822.

———. 1918. Prinzipielles zur allgemeinen Relativitätstheorie. *Annalen der Physik* 55: 241–244.

Hoffman, D. and M. Walker. 2006. *Physiker zwischen Autonomie und Anpassung. Die DPG in Nationalsozialismus*. Weinheim: Wiley-VCH.

Janssen, M. 2005. Of Pots and Holes: Einstein's Bumpy Road to General Relativity. In *Annalen der Physik* 14, Issue Supplement 1: 58–85.

Jungnickel, C. and R. McCormmach. 1964. *Intellectual Mastery of Nature. Theoretical Physics from Ohm to Einstein*, Vol. 2, Chicago: Chicago University Press.

Kretschmann, Erich. 1915. Über die prinzipielle Bestimmbarkeit berechtigter Bezugssysteme beliebiger Relativitätstheorien. *Annalen der Physik* 48, I: 907–942; II: 943–993.

———. 1917. Über den physikalischen Sinn der Relativitätspostulate. Albert Einsteins neue und seine ursprüngliche Relativitätstheorie. *Annalen der Physik* 53, 575–614.

Rynasiewicz, R. 1999. Kretschmann's Analysis of Covariance and Relativity Principles. In *The Expanding Worlds of General Relativity*, Einstein Studies, Vol. 7. eds. H. Gönner, J. Renn, J. Ritter, T.Sauer, 431–462. Boston: Birkhäuser.

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