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Henryk Niewodniczański and Ernest Rutherford

Organon 28 30, 247-256

1999 2001

ORGANON 28-30:1999-2001

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HENRYK NIEWODNICZAŃSKI AND ERNEST RUTHERFORD*

Professor Niewodniczański, the founding father of the Kraków physics center, was born in Wilno a century ago. A graduate of physics at Wilno's Stefan Batory University, he stayed there to pursue his scientific career. His first subject was optical atomic spectroscopy. In 1933, he discovered forbidden lines in lead vapour spectrum and interpreted them as connected with

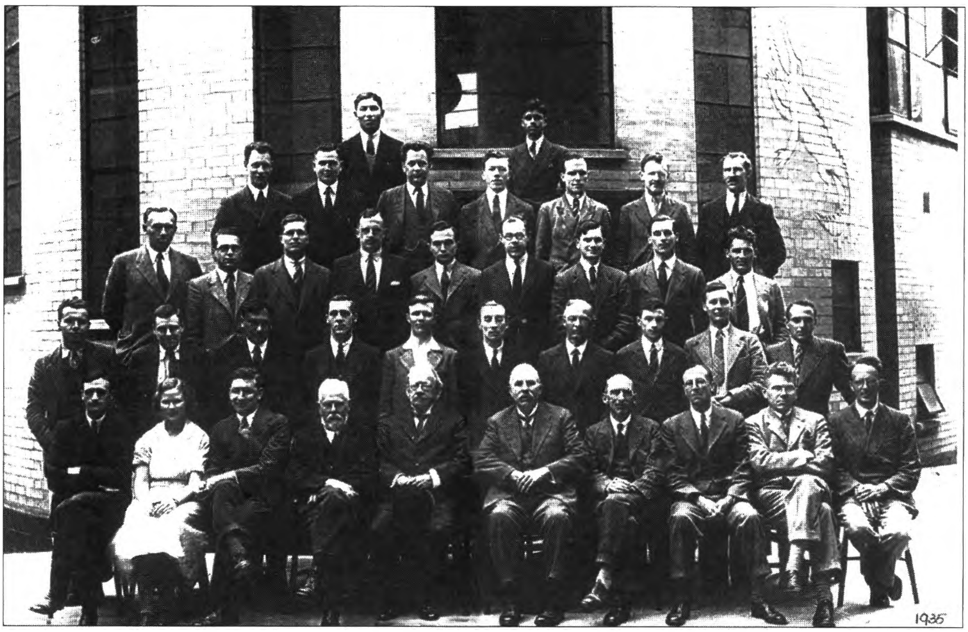

Fig. 1. Scientific Staff of Cevendish Laboratory in 1935.
Niewodniczański is standing on the far left in the third row.

*The original Polish version of this paper will appear in the volume of editorial series of Polish Academy of Arts and Sciences "W Służbie Nauki" to be published *in memoriam* of Professor Henryk Niewodniczański.

magnetic dipole transitions. That was certainly the most important discovery in Polish experimental physics of the inter-war period.

By the mid-1930s, Henryk Niewodniczański had had made the discovery of his lifetime, had been back from a longer scientific stay at Tübingen, got habilitated, got married, and seen his son Tomek born. He felt he had to do something to broaden his scientific scope from his previous concentration on nuclear spectroscopy and thought he could do that in a leading foreign research center. He chose Rutherford's Cambridge.

Cambridge was really an extraordinary scientific center, great not only in its own times but by today's standards as well [1]. A 1935 picture of the Cavendish Laboratory coworkers shows 38 scientists around J. J. Thomson and E. Rutherford (Fig. 1). And those were not all. J knew personally three Rutherford coworkers not shown in the picture who, I am sure, were in Cavendish at the time. And then there was also the Mond Laboratory. Among those shown in the picture there are three other Nobel prize winners, apart from Thomson and Rutherford.

Niewodniczański stands at the far left end in the third row from the bottom. He had arrived at Cambridge as a Rockefeller Foundation fellow the year before, in 1934, with his wife, Irena, and the one-year-old baby, Tomek.

Rutherford suggested to Niewodniczański to join the Mond Laboratory. That was a new research laboratory built close by the Cavendish Laboratory on funds the Royal Society received from a well-to-do British industrialist, the chemist L. Mond. The new laboratory was ruled by Peter Kapitza. Kapitza, since he came to England in 1921 to procure scientific apparatus for the Soviet Union, collaborated closely with Rutherford. In 1933, Kapitza was appointed Royal Society professor and allowed to establish a laboratory for his own work using the money donated by Mond. Unfortunately, when he went to Russia to attend the Mendeléeff conference in 1934 he was held back by the Soviet authorities so he could not come back to England. That was why Niewodniczański on his arrival did not meet Kapitza in Cambridge, even though the two became good friends in later years. When Rutherford became head of the Mond Laboratory after Kapitza's departure he asked J. D. Cockcroft, who built the laboratory together with Kapitza, to run it. Cockcroft then proposed that two Henrys: Nie-

Fig. 2. H. Niewodniczański, H. A. Borse and C. J. Milner in front of the Mond Laboratory (Photo D. Shoenberg)

wodniczański and a young American named Henry A. Boorse, should jointly start investigating resistance of metals in very low temperatures.

In a photo (Fig. 2) I have received by courtesy of Professor David Shoenberg, Niewodniczański is seen sitting beside Boorse and C. J. Milner. That was not the whole Mond Lab, for there was also David Shoenberg, yet he was the one taking the picture. Niewodniczański (Fig. 3) took pictures too, yet unfortunately those photos were burned during the war. A third picture (Fig. 4) shows Mrs. Irena, in Shoenberg's words "the charming wife of Niewodniczański", with little Tomek in a boat paddling with Shoenberg down the Cam.

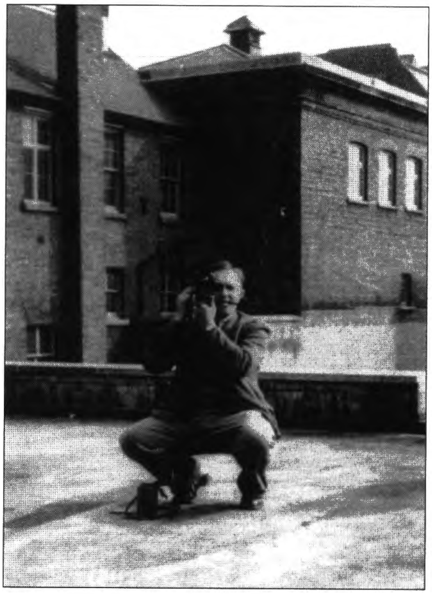

Fig. 3. H. Niewodniczański (Phot. D. Shoenberg)

I was able to get in thouch with many former colleagues of Professor Niewodniczański of his Cambridge days: Professors David Shoenberg in Cambridge, Bill Burcham in Birmingham, Maurice Goldhaber in Brookhaven National Laboratory [2], and Henry Boorse in Houston, Texas.

In Shoenberg's recollections from that time Niewodniczański appears as a very talkative gentelman and he remembers occasions when Boorse got rather irritated with Niewodniczański gossiping too much while the liquid hellium used in the measurements boiled away. And it was still a novelty in those days and something too precious to waste!

Fig. 4. Irene Niewodniczańska with son Thomas in boat on river Cam (Phot. D. Shoenberg)

Rutherford did not often visit the Mond Laboratory, yet Boorse did recall one such occasion. One morning the great Lord Rutherford popped in the Mond lab and the excited Boorse and Niewodniczański thought he would want to know about results of their work, if they had come across antyhing unex-

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The Electrical Resistance of Aluminium at Low Temperatures

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(*Communicated by Lord Rutherford, O.M., F.R.S.—Received August* 2, 1935)

1—Introduction

The electrical resistance of aluminium at low temperatures has been the subject of numerous investigations. The general results of the studies made previous to 1926 have been summarized by Tuyn and Kamerlingh Onnes.‡ Subsequent researches have been mainly concerned with measurements at liquid helium temperatures. These have been made by Tuyn and Kamerlingh Onnes,§ by Meissner and Voigt,‖ and by Keesom,¶ who discovered that aluminium becomes superconducting at about 1·14° K.

The data given by Meissner and Voigt for Al, as well as for several other metals (*e.g.*, Mo, Co, and Mg), appear to show that the resistance in the range 4·2° K to 1·3° K is not constant, but increases slightly with decreasing temperature. The measurements of Tuyn and Kamerlingh Onnes and of Keesom show no such phenomenon, the resistance of their aluminium specimens remaining constant, within the experimental error, between these temperatures. However, the resistance ratio $R_{4\cdot2^\circ K}/R_{0^\circ C}$ for the specimen used by Tuyn and Kamerlingh Onnes was 0·067 and for the specimens of Keesom 0·073 and 0·039, while the four specimens used by Meissner and Voigt show considerably smaller values, viz., 0·0197, 0·0148, 0·0079, and 0·0065, suggesting that their aluminium was of higher purity than that used by Tuyn and Kamerlingh Onnes and by Keesom.

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‡ 'Comm. Phys. Lab., Leiden,' Suppl., No. 58 (1926).

§ 'Comm. Phys. Lab., Leiden,' No. 181 (1926).

‖ 'Ann. Physik,' vol. 7, p. 761 (1930).

¶ 'Comm. Phys. Lab., Leiden,' No. 224c (1933).

Fig. 5. Front page of the Boorse and Niewodniczański paper

pected. Yet what caught Rutherford's attention was the measurement device, in particular the liquid helium pump, which was controlled by a solenoid connected to a timed electric circuit. Rutherford was a devoted experimental physicist throughout all his life.

What did Niewodniczański and Boorse busy themselves with? Kapitza's kingdom, the Mond Laboratory, was of course the realm of low temperatures. Researchers at the Kamerlingh-Onnes laboratory in Leyden, the Mecca of cryogenics at the time, had measured electrical resistance of metals in low temperatures and notices certain anomalies. For aluminum they found an unexpected increase of resistance with temprature falling below 4.2 K [3], and for gold they found a distinct minimum at 3.7 K [4]. Impurities of samples used in the experiments could not be ruled out a possible casue of those anomalies, so Niewodniczański and Boorse carried out their measurements using polycristalline aluminum of extraordinary purity of 99.995%, additionally checked by spectroscopic methods. Their measurements were done for 0^{o}C temperature and for liquid nitrogen, liquid hydrogen and liquid helium temperatures. They established that in the range of 4.2 K to 2.2 K, where the Leyden measurements disclosed anomalies, aluminum had constant resistance with the limits of experimental error, which had the record-low value 2.10^{-5} of resistance value at 273.16 K.

Lord Rutherford communicated the study to the Royal Society, whereupon it was published in the *Proceedings* [5] (Fig. 5), as well as in the *Nature* [6]. Niewodniczański reported the results at a metal physics conference organized by N. F. Mott in Bristol in 1935, which he attended together with David Shoenberg.

Rutherford suggested to Niewodniczański that he move his research work to the Cavendish Laboratory. That was a short time after Chadwick's 1932 discovery of neutron at the Laboratory [7]. Neutrons, particles without electric charge, are excellent projectiles to initiate nuclear reactions. Enrico Fermi with his *ragazzi di Via Panisperna* in Rome, Amaldi, D'Agostino, Pontecorvo, Rasetti and Segré, observed in their famous study [8] that efficiency of neutrons in producing nuclear transformations increased in the presence of large quantities of paraffin or water. They attributed that to a loss of energy of neutrons in result of repeated collisons with protons, the nuclei of hydrogen atoms. The number of those collisions was not known at the time, but T. Bjerge and C. H. Westcott [9] raised reasons for believing the collisions could reduce neutron velocities to the gas kinetic velocity corresponding to the temperature of the scattering hydrogenous body. That brought up the idea to study the neutrons slow-down factor in a function of temperature. Fermi had been unable to detect any change between room temperature and 200°C, however such effects were likely to appear as temperature was being lowered. Wetscott and Niewodniczański decided to attempt measurements at temperatures of liquid nitrogen (77 K) and liquid

[Extracted from the *Proceedings of the Cambridge Philosophical Society*,
Vol. XXXI. Pt. IV.]

SOME EXPERIMENTS WITH NEUTRONS SLOWED DOWN AT DIFFERENT TEMPERATURES

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[Communicated by Dr M. L. OLIPHANT]

[*Received* 7 October, *read* 28 October 1935]

I. INTRODUCTION

Fermi and his collaborators* have shown that the efficiency of neutrons in producing certain nuclear transformations is very much increased in the presence of large amounts of paraffin or water, and they attribute this to a loss of energy by the neutrons in repeated elastic collisions with hydrogen nuclei. The number of such collisions which a neutron might undergo before it is absorbed was not known, but Bjerge and Westcott† advanced reasons for believing that this number would be sufficient to reduce the velocity of the neutrons to the gas kinetic velocity corresponding to the temperature of the scattering hydrogenous body. In this case the effects observed might be expected to depend on that temperature, but Fermi‡ had been unable to detect any change between room temperature and 200° C. Later, however, Moon and Tillman§ announced a considerable increase in the radioactivity induced in several substances when the temperature of the paraffin wax through which the neutrons passed was lowered from ordinary temperatures to the temperature of liquid oxygen (90° K.). A similar effect was also found by Dunning, Pegram, Fink, and Mitchell‖, and recently Fermi¶ has also been able to obtain the effect, in addition to making a more direct estimation of the velocity of the neutrons, which agrees with the hypothesis of kinetic equilibrium.

The present paper describes some further experiments on neutrons slowed down at low temperatures. In view of the considerable increases in the effects obtained at liquid air temperature, we decided to attempt similar measurements not only at the temperature of liquid nitrogen (77° K.), but also at that of liquid hydrogen (20° K.), particularly as very large increases at the latter temperature were thought possible.

* Amaldi, D'Agostino, Fermi, Pontecorvo, Rasetti and Segrè, *Proc. Roy. Soc.* A, 149 (1935), 522.

† *Proc. Roy. Soc.* A, 150 (1935), 709. ‡ *Loc. cit.*

§ *Nature*, 135 (1935), 904.

‖ *Phys. Rev.* 47 (1935), 796 (Abst. 54) and 888; 48 (1935), 265.

¶ Amaldi, Fermi, and others, *La Ricerca Scientifica*, (6), 1 (1935), no. 11–12.

Fig. 6. Front page of the Westcott and Niewodniczański paper

hydrogen (20 K). Using radioactivity induced by the neutrons in several substances (copper, silver, rhodium) as detector, and studying also neutron absorption coefficient for the same substances (copper, silver), they tested the influence on those effects of the temperature of a paraffin block wherein the neutrons were slowed down. For liquid hydrogen temperature they found a substantial increase of absorption coefficient as compared with liquid nitrogen temperature. The effect on the induced radioactivity was less pronounced because of the effect of neutron absorption in the paraffin block. Measurements were also done using a boron chamber to detect neutrons and substituting liquid hydrogen for paraffin as the slow-down medium. Results of that study were presented by M. L. Oliphant, who supervised it directly, and published in the *Proceedings of the Cambridge Philosophical Society* [10] (Fig. 6).

His Cambrdige stay at Rutherford's Lab and the work he did there marked a breakthrough in Henryk Niewodniczański's scientific career. Above all, they opened a new perspective to him on nuclear physics, a new domain of physics that grew very fast then. Right upon his return to Wilno, and instantly after receiving a grant from Poland's National Heritage Fund, Niewodniczański committed himself to creating a nuclear physics laboratory. After World War II, while already in Cracow, he focused on nuclear physics as his mainstream effort. He plunged himself into work to build and install large experimental devices necessary for that research work, especially spectrometers and accelerators. He created a school of young enthusiastic co-workers and established new research center.

Niewodniczański's stay at Rutherford's Cambridge research center bore more fruit than just the burgeoning nuclear physics research in Cracow. His work in Cambridge on cold neutrons helped him realize the significance of such neutrons, even beyond nuclear physics. As he launched new directions of research work in Cracow Niewodniczański alerted his pupil Jerzy Janik to a possibility as well as potential significance of using the interaction of cold neutrons with matter for research in solid state physics. That opened up vistas of expansion into to a huge research area that eventually gave rise to a new school around Niewodniczański's disciple Jerzy Janik of research of condensed phase by methods of interaction with cold neutrons.

Rutherford's impact showed not only in the circumstance that Henryk Niewodniczański initiated new areas of research. Niewodniczański was fascinated by Rutherford, his personality, and acknowledged him as one of his Masters. The atmosphere at Rutherford's laboratories was truly extraordinary. People worked hard, with great devotion to physics research work, yet all those working there enjoyed an excellent friendly atmosphere at the place. Even Professor Niewodniczański's disciples, of whom I am one, were able to get a feel of that in our scientific careers. During my lifetime I met nine Rutherfordians, all of them the Professor's colleagues from Cambridge. Always I was received and treated as member of the family. Niewodniczański befriended many of Rutherford's pupils, who attained later top positions in world science, so he was able to help us, his own pupils, to stay at the best foreign physics research centers abroad and set up different contacts and international cooperations which continues to bear fruit even today.

Professor Niewodniczański inspired that excellent atmosphere of dedication to work and friendship to all research centers he headed. In fact, Cracow gained a proud reputation as a place with an excellent scientific climate among Polish scientific research centers. This continues to this day, 32 years after the Professor death.

Professor Niewodniczański's countenance had a striking if not extraordinary resemblance to Rutherford's own (Fig. 7). Niewodniczański even strengthened the impression by his hair style, the way he trimmed his moustache, his tweed jackets. At a jubilee conference in Manchester in 1960 to celebrate the 50th anniversary of Rutherford's discovery of the atomic nucleus, I was sitting beside the professor at a concert, and several rows below us there was another Rutherfordian, Professor Rudi Peierls with his wife. Many years later, already after the Professor's death, Mrs. Peierls told me that her most shocking experience at that jubilee occasion was when she turned to look around and saw Rutherford in person sitting a couple of rows behind her.

The two also passed away an amazingly similar manner. Both contracted hernia, and both decided to had it operated. Shortly before he went to hospital

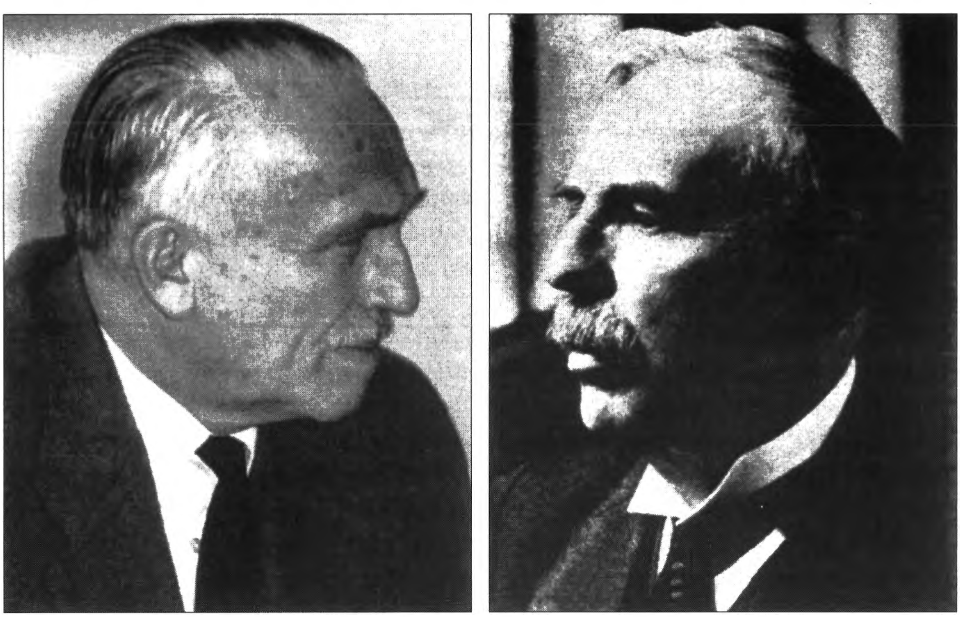

Fig. 7. Henryk Niewodniczański and Sir Ernest Rutherford Lord of Nelson

the Professor come up to our – Budzanowski's, Grotowski's and mine – room at the Institute in Cracow-Bronowice. He told us he was going to hospital, that his illness was very much like Rutherford's, and said, "Like Rutherford, I'am not going to survive the operation." Of course, we never took the Professor's pessimism seriously.

Mark Oliphant wrote in his recollections of Rutherford [11] that after the great Scientist's operation he went, not worrying, with John Cockcroft to Bologna to attend a conference to celebrate Galvani's 200th birthday. During the conference they obtained telegram of their Master's unexpected death on October 20, 1937.

In the morning of December 20, 1968, several days after his operation, I went to see Professor Niewodniczański at his clinic. He was already able to get up from his bed, although he was a bit thoughtful about the blood showing in his saliva, yet otherwise he was all right. Reassured about his condition we went to a performance of the *Piwnica pod Baranami* variety show that night at our Institute. As we were leaving I saw Mrs. Irena in the hall.

"Adam, Henryk is dead", she said.

In a volume of *Acta Physica Polonica* dedicated to the memory of Professor Niewodniczański, our friend and scientific partner of Oxford, Dr. Peter E. Hodgson wrote in his *Personal Appreciation* [12]:

"On the wall of his office in Cracow there is a picture of the young Niewodniczański in the company of Rutherford in Cambridge. We in England who know what he did to establish nuclear physics in Poland naturally think of him as the Rutherford of Poland. His work for nuclear physics was in a heroic scale and will endure into the future, but we will remember him first of all as a kindly and benevolent person."

I am sure no other words could be appreciated more by our Professor.

I wish to thank heartily Professor Niewodniczański's colleagues from time of his work at the Cavendish Laboratory: Professors W. E. Burcham, H. A. Boorse, M. Goldhaber, for sharing their recollections with me, and Professor D. Shoenberg also for sending me the photographs. My special thanks are due to Dr. P. E. Hodgson of Oxford University and Dr. G. I. Squires of the Cavendish Laboratory for their assistance in collecting the information on Rutherford's time in Cambridge.

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