Nagaoka to Rutherford, 22 February 1911

During 1910, the physicist Hantaro Nagaoka represented Japan at two international scientific congresses in Brussels and one in Vienna. This visit to Europe gave him an opportunity to observe the latest researches in the various centers of physics and to renew many acquaintances from his student days in Germany. He called at Manchester before continuing to the continent, and the letter he later wrote to Rutherford is both a description of the state of physics through the eyes of an acute observer and a "thank you" to Rutherford.

by Lawrence Badash

WHAT WAS PHYSICS LIKE slightly more than half a century ago? One readily thinks of such famous names as J. J. Thomson, Ernest Rutherford, Marie Curie, Max Planck, Niels Bohr, H. A. Lorentz, Albert Einstein, et al, but these are the *highlights* of hindsight. For the *background* of perhaps lesser, but nevertheless significant and interesting efforts, we usually must look to the contemporary literature, since histories of science rarely have room for elaborate descriptions of a period.

The letter printed below contains the impressions of an eminent physicist who visited a good many physical laboratories in Europe during the last quarter of 1910. Years earlier, its author, Hantaro Nagaoka (1865–1950), had studied in Berlin, Munich, and Vienna, and was, therefore, renewing old acquaintances as well as familiarizing himself with the latest continental research activities. Since 1906, he had been professor of theoretical physics at the Imperial University of Tokyo; and many years later he was to become the president of the Imperial University of Osaka.

The recipient of this letter, Ernest Rutherford (1871–1937), needs no identification in PHYSICS TODAY, other than to indicate that at this time he was professor of physics at the University of Manchester. Nagaoka had visited Rutherford's laboratory in September 1910, and now, happily, thought to describe his trip in this letter of thanks for his host's hospitality.

Still classical physics

In this letter it is interesting to note the widespread activity in "classical" physics, which had by no means entirely been superseded by the increasing amount of research in "modern" physics. This is a point we too often overlook. One final note of interest is that, coincidentally, Nagaoka's best known scientific contribution derives its fame from the work of Rutherford. When the latter published his concept of the nuclear atom in 1911, it was seen that Nagaoka's "Saturnian" atom of 1903–1904 was something of a precursor. Though there was no direct influence of this earlier work upon Rutherford, and in fact their atoms bear many dissimilarities, these constructs of Nagaoka and Rutherford frequently have been associated in popular literature. It is not impossible, however, that the two discussed the Saturnian atom in September 1910 and that the concept remained subconsciously in Rutherford's mind, bearing fruit in the next year.

February 22nd, 1911
Physical Institute,
Tokyo University

Dear Professor Rutherford,

I have completed my "Studienreise" in Europe and returned home a few weeks ago, and have the pleasure of writing you some of my impressions during the journey. In the first place, I have to thank you for the great kindness, which you have shown me during my visit to Manchester. I have been struck with the simpleness of the

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apparatus you employ and the brilliant results you obtain. Everybody engaged with the investigations on radioactivity seems to be impressed with the same fact and expresses admiration of the splendid results, which you obtain with extremely simple means.

Lowest temperature yet

The "Kältekongress" in Vienna was too technical for me; it was in fact a congress for the industry of refrigeration. The only scientific paper of importance was a report by Kamerlingh-Onnes on the lowest temperature hitherto attained. By boiling liquid helium in vacuum, he claims to have reached the temperature of 2.5° from absolute zero. Later on I visited his laboratory in Leyden and saw his cascade process of reducing the temperature. He tells me that the greatest difficulty lies in the purification of gases; a millionth part of hydrogen mixed with helium would deteriorate the process of liquefaction. It will be quite interesting to experiment on the radioactivity at the temperature of −270°, if such cold can be maintained for a sufficient length of time. I met Planck in Berlin and asked his opinion as to the change which would be wrought on radioactivity. His conjecture on the change of λ in the neighborhood of absolute zero is in the affirmative, based on several considerations depending on the theory of radiation.

At the time I visited Vienna, the radium institute was not yet completely built, but I met St. [efan] Meyer in the old laboratory of Boltzmann and Exner. In Graz, I was happy to see my old friend Benndorf, who studied with me in Berlin and Vienna about 16 years ago. He was occupied with the registration of the atmospheric electricity and seemed much interested in seismology, which has special charm for Japanese on account of the volcanic character of the Japanese islands. It was very curious that most of my opinions respecting earthquakes were in accord with those of Benndorf, although I am quite at variance from Japanese seismologists.

Righi in Bologna was much interest-

Cast of Characters—People Mentioned by Nagaoka

Hans Benndorf (1870–1953). Physics professor, University of Graz, after 1910.

Ludwig Boltzmann (1844–1904). Physics professor, University of Vienna, from 1902 to 1906. Earlier at Munich. Famous for his part in the introduction of statistical mechanics.

Alfred Bucherer (1863–1927). Privatdozent, University of Bonn, after 1899; later professor.

Peter Debye (1884–1966). Privatdozent, University of Munich, 1910–1911. Later professorial positions at Zuerich, Utrecht, Goettingen, Berlin and Cornell. Nobel Prize in chemistry in 1936 for his studies of molecular structure.

Hermann Ebert (1861–1913). Mathematics professor, Technische Hochschule, Munich, after 1898.

Felix Ehrenhaft (1879–1952). Assistant in Physical Institute, University of Vienna, 1904–1910; professor after 1911.

Franz Exner (1849–1926). Physics professor, University of Vienna, after 1891. Interested in spectroscopy, particularly the lines of the ultraviolet region.

Carl Friedrich Gauss (1777–1855). The "Prince of Mathematicians" was mathematics professor and director of the Goettingen astronomical observatory, after 1807. Concerned also with terrestrial magnetism.

Ernst Gehrcke (1878–1960). Physicist at the Physikalische-Technische Reichsanstalt, Berlin; later director.

Charles Guye (1866–1942). Physics professor, University of Geneva, after 1900.

Friedrich Harms (1876–1946). Assistant in the Physical Institute, University of Wuerzburg, after 1901; later professor.

Johannes Hartmann (1865–1936). Astronomy professor, University of Gottingen, after 1909. Spectroscopist interested in continuous spectra due to atoms.

Hermann von Helmholtz (1821–1894). Physics professor, University of Berlin, 1871–1894; president of the Physikalische-Technische Reichsanstalt, Charlottenburg, 1888–1894; Famous for his work in physiology, sound and conservation of energy.

Heinrich Hertz (1857–1894). Physics professor, University of Bonn, from 1889 to 1894. Famous for his discovery of the electromagnetic waves predicted by Maxwell.

Ludwig Janicki (1879–????). Physicist at the Physikalische-Technische Reichsanstalt, Charlottenburg.

Heike Kamerlingh-Onnes (1853–1926). Physics professor, University of Leiden, after 1882. Nobel Prize in 1913 for low-temperature investigations.

Heinrich Kayser (1853–1940). Physics professor, University of Bonn, after 1894. With C. Runge, he determined that the distribution of spectral lines has a regularity.

Suekichi Kinoshita (1877–1933). Physics instructor, University of Tokyo, after 1909. Later professor.

Peter Paul Koch (1879–1945). Privatdozent, University of Hamburg; later professor.

Friedrich Kohlrausch (1840–1910). Physics professor, University of Wuerzburg, from 1875 to 1888; University of Strassburg, 1888 to 1895; then president of the Physikalische-Technische Reichsanstalt, Charlottenburg, 1895 to 1905. Explained electrolytic conductivity by dissociation hypothesis.

August Kundt (1838–1894). Physics professor, University of Berlin, from 1888 to 1894. Studied anomalous dispersion in liquids, vapors and solids; devised method of comparing sound velocities in gases and in solids.

Otto Lehmann (1855–1922). Physics professor, Technische Hochschule, Karlsruhe, after 1889. Discovered the unexpected existence of crystalline arrangement in some liquids.

Philipp Lenard (1862–1947). Physics professor, University of Heidelberg, after 1907. Nobel Prize in 1905 for his work on cathode rays.

Hendrik Antoon Lorentz (1853–1928). Physics professor, University of Leiden, after 1878. Shared 1902 Nobel Prize with Zeeman for his study of the influence of magnetism on radiation.

Otto Lummer (1860–1925). Physics professor, University of Breslau, after 1905. Noted for his experimental study of black-body radiation.

Stefan Meyer (1872–1949). Physics professor, University of Vienna, after 1908. In charge of the Radium Institute, and a leader in the field of radioactivity.

Alexander Pflueger (1869–1945).

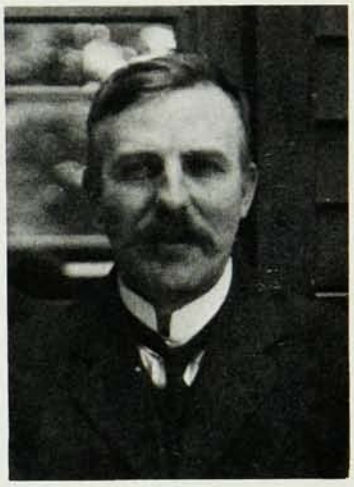
ed with my model of Saturnian atom published in 1904. He showed me his different apparatus on electric waves and the so-called magnetic rays. O. Lehmann in Karlsruhe seems to have made similar experiment with a colossal tube of several meter length and arrived at results similar to Righi. In Geneve, I met Guye and Sarasin. The latter gentleman has been kind enough to show me all the notorieties and fine sceneries of Geneve. He told me of your visit there and how you laughed "von ganzem Herzen," if I may be permitted to use Sarasin's language.

80 000-gauss magnets

The speciality of the physical institute in Zurich seems to be electromagnets. Weiss showed me one of 1000 Kilogrm. weight, with which he can get a field strength of 80 000 gauss in space of 2 mm., a somewhat extraordinary figure.

In Munich, I saw Ebert's apparatus for registering the quantity of emanation coming out of the soil. What seemed to me new and interesting was the section for technical physics. There are various investigations going on in connection with the applications of physics to technical purposes. Unfortunately I could not see Röntgen, as he was away from the city. Koch tells me that he could measure Zeeman effect in field of 3 gauss by photographing the lines and comparing the intensity by means of Hartmann's pho-

NAGAOKA



RUTHERFORD

DEBYE

Physics professor, University of Bonn, after 1905.

Max Planck (1858–1947). Physics professor, University of Berlin, after 1892. Nobel Prize in 1918 for discovery of energy quanta.

Erich Regener (1881–1955). Physics professor, agricultural Hochschule, Berlin, after 1914; later at Technische Hochschule, Stuttgart. Noted for method of counting alpha particles by scintillations.

Augusto Righi (1850–1920). Physics professor, University of Bologna, after 1889. Improved Hertz's vibrator, or wave-radiating apparatus.

Wilhelm C. Roentgen (1845–1923). Physics professor, University of Munich, after 1900. Nobel Prize in 1901, the first year it was awarded, for his discovery of x rays, made at the University of Wuerzburg.

Heinrich Rubens (1865–1922). Physics professor, University of Berlin, after 1906. Studied black-body radiation.

Jean E. C. Sarasin (1870–1933). [Identification not certain] Geology and paleontology professor, University of Geneva, after 1896.

Clemens Schaefer (1878–????). Physics professor, University of Breslau, after 1910.

Arthur Schuster (1851–1934). Physics professor, University of Manchester, from 1881 until he retired in 1907 to allow Rutherford to succeed him.

Arnold Sommerfeld (1868–1951). Physics professor, University of Munich, after 1906. Noted for his refinement of Bohr's original atom picture, by the introduction of orbital quantum numbers.

Johannes Stark (1874–1957). Physics professor, Technische Hochschule, Aachen, after 1909. Nobel Prize in 1919 for his discovery of the Doppler effect in canal rays and the splitting of spectral lines in electric fields.

Emil Take (1879–1925). Privatdozent, University of Marburg, after 1911; later professor.

Woldemar Voigt (1850–1919). Physics professor, University of Goettingen, after 1883. Explained Kerr effect using electron theory.

Wilhelm Weber (1804–1891). Physics professor, University of Goettingen, after 1849. Associated with Gauss in terrestrial magnetism, telegraphy, mathematical physics. Introduced absolute units in electricity.

Pierre Weiss (1865–1940). Physics professor, Polytechnicum, Zuerich, after 1903. Introduced the word "magneton" to represent an elementary magnet, in a theory of magnetism.

Johann Emil Wiechert (1861–1928). Geophysics professor, University of Goettingen, after 1898.

Wilhelm Wien (1864–1928). Physics professor, University of Wuerzburg, after 1900. Nobel Prize in 1911 for his study of black-body radiation.

Pieter Zeeman (1865–1943). Physics professor, University of Amsterdam, after 1900. Nobel Prize in 1902, shared with Lorentz, for discovery of magnetic broadening of spectral lines: Zeeman effect.

The Lincoln Laboratory, a research center of the Massachusetts Institute of Technology, is engaged in research and development in advanced electronics, with emphasis on applications to national defense and space exploration. The program of research extends from fundamental investigations in selected areas, through technological development of devices and components, to the design and development of complex systems. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin. Lincoln Laboratory, Massachusetts Institute of Technology, Box 15, Lexington, Massachusetts 02173.

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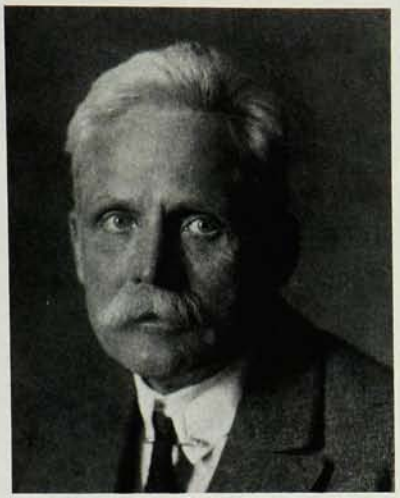
tometer. When I studied in Munich in 1894 under Boltzmann, the institute was very poor, but it is now rebuilt and there is also an institute for theoretical physics under Sommerfeld, who is working on the principle of relativity, and Debye expounded mathematical formulae for the pressure of light acting on a dielectric or metallic sphere.

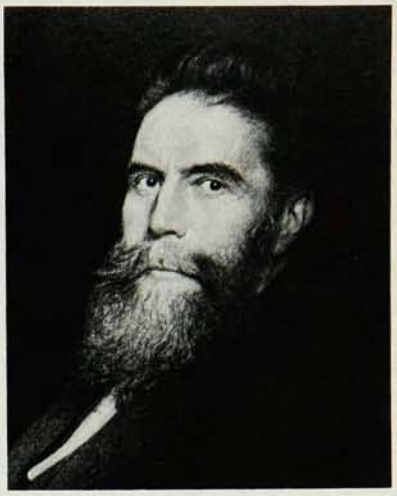
In Amsterdam I saw Zeeman investigating the effect bearing his name in various lines of research. In Leydon, Lorentz was discussing Ehrenhaft's curious result on the charge of electrons, but afterwards I learned in Berlin that the experiment was entirely wrong. Stark in Aix-la-Chapelle [Aachen] was propounding his "Lichtquantentheorie"; there is some doubt whether he will succeed in explaining the interference phenomena, or not. The Germans say that he is full of phantasies, which may be partly true. In Bonn I failed to see Bucherer, but his experiment on e/m is now repeated by C. Schäfer in Breslau, and I hope we shall be able to hear his result in the near future. Kayser's spectroscopic researches are worth seeing; instead of moving the grating and keeping the slit fixed, he uses the reversed method of turning the slit on a fixed circle while the grating is fixed on a stout pier. This will be sometimes advantageous in photographing the spectrum. Pflüger, with whom I worked in Kundt's laboratory in 1893, showed me a number of interesting apparatus. He has pasted thin quartz plates on a rocksalt prism and investigated the infrared as well as the ultraviolet rays with as much success as with fluorite or quartz prisms. A vacuum tube used by Hertz to demonstrate the passage of cathode rays through thin aluminum plate is one of the historical treasures of the physical institute of Bonn.

Discharges and x rays

The radiological institute in Heidelberg under Lenard is perhaps one of the most active in Germany. Professor Lenard and most of his pupils are working on the phosphorescence and photoelectric action. In Würzburg, I saw the room where X ray was discovered by Röntgen. Various researches on canal rays are going on under the direction of W. Wien. The famous

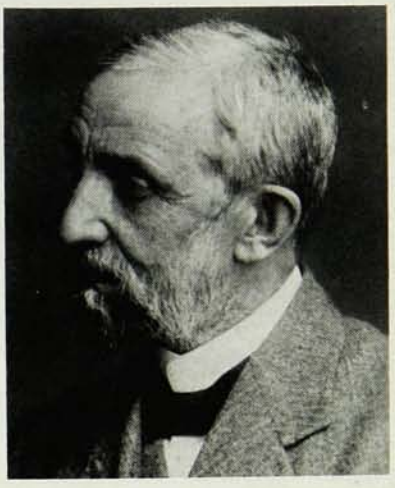


WIEN

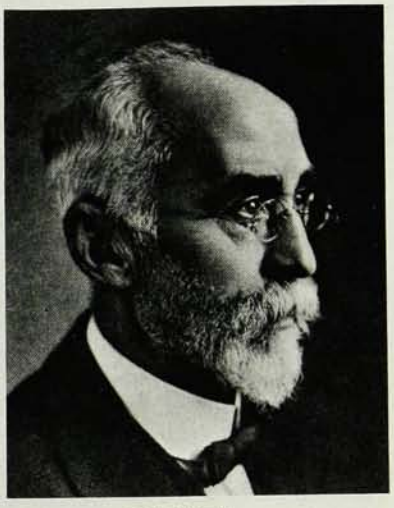


ROENTGEN

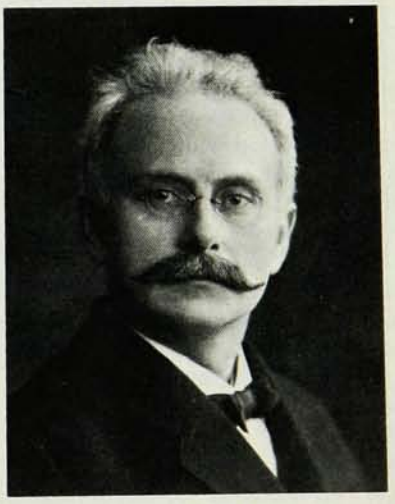
SOMMERFELD



LENARD



LORENTZ



STARK

magnetic observatory without iron, built by Kohlrausch, is now rotten; more important works on vacuum discharge have absorbed the attention of Würzburg physicists. In the colloquium, Harms gave a report of your paper on the calculation of α particles, which was in progress when I visited Manchester. All the members present expressed great admiration at the splendid result obtained with such a simple device. It seems to me that it is only a genius, who can work with simple apparatus and glean rich harvest far surpassing that attained with the most delicate and complex arrangements.

[In his reply to Nagaoka, 20 March 1911, Rutherford noted: "I very much appreciate your kind references to myself and to my work. I did not know that the simplicity of my experiments was so unusual. As a matter of fact I have always been a strong believer in attacking scientific problems in the simplest possible way, for I think that a large amount of time is wasted in building up complicated apparatus when a little forethought might have saved much time and much expense."]

Liquid crystals

In Karlsruhe, the original apparatus of Hertz for demonstrating electromagnetic waves were most attracting. They are as simple as are most of your apparatus. Lehmann is busily occupied with the investigation of the so-called liquid crystals. The appearance of several substances in polarised light is quite phantastic and accords with the illustrations given by him. The only point of doubt is that these crystals appear only in the neighbourhood of the melting point, and may be closely connected with the changes in the aggregate condition. It is quite certain that in the present stage different views are entertained as to the nature of the liquid crystals.

Strassburg was interesting to me as a centre of seismological association; great changes are going on in the staff of the central bureau, and it is to be congratulated for the science of seismology that the reorganisation will produce good effect on the international investigation of earthquakes. We have to thank Prof. Schuster for the lively interest he takes for the association, and the great effort he has made to strengthen the weak association, by recruiting it with personages, who can investigate earthquakes physically [better] than it has hitherto been examined statistically and with defective instruments.

Frankfurt, Leipzig, Breslau

Frankfurt has built a fine physical institute with rich equipments. It is curious that the city well known for its immense wealth has not yet established a university within its precinct. The magnetic properties of Heusler alloy is now being investigated by Take in Marburg; the artificial means of aging the alloy seems to effect interesting magnetic changes. Voigt's laboratory in Göttingen is justly celebrated for the numerous works, which are connected with the physics of crystals and the magneto- and electro-optics. There were more than 20 research students. The famous magnetic observatory of Gauss and Weber is now removed to the environs of Göttingen. Wiechert has installed an extremely sensitive seismometer, which records vibrations due to storm in the North Sea. He showed me traces of shocks due to dynamo engine in Göttingen.

The physical institute in Leipzig is perhaps the largest in Germany; but I find that the largest is not always the best. However poor the laboratory may be, it will flourish if it has earnest investigators and an able director. The size and the equipment of the laboratory seems to me to play a secondary part in the scientific investigations. The splendid institute in Breslau has been newly built by Lummer. The investigations are mostly optical; the different kinds of interferometers and the photometers are the essential equipments of the institute. Besides Lummer, C. Schäfer is working in electric waves and applications of integral equations to different problems of theoretical physics.

The works going on in the Physikalische Reichsanstalt in Berlin is somewhat akin to those in the National Physical Laboratory. Some measurements are nervously delicate that we can not help crying out *qui bono*. The [illegible]-rohr and Glimmlichtrohr of Gehrcke are very interesting, and the inventor claims to use the latter tube as an oscillograph for high frequency up to 100,000 cycles per second. The investigations of spectral lines by Janicki will form a good contribution to our knowledge on the nature of atomic vibrations.

In the physical institute of Berlin, I saw Rubens who showed me his arrangement of "Reststrahlen" for isolating light waves of 96 μ. Regener was repeating Ehrenhaft's experiment and announced that the result was entirely wrong, so that there can not exist a charge, which is a fraction of that of an electron. While visiting the institute, I chanced to enter the rooms where I heard the lectures by Helmholtz and where I worked under Kundt in 1893. They made me deeply impressed how swiftly time is gliding; and while thus writing it reminds me that 5 months has passed away since I saw you in Manchester.

Cold in Siberia

I returned by way of Siberia and experienced the low temperature of −44°C on the Chinese frontier. The car was comfortable, but the temperature difference of 60° in and out of the car was almost unbearable. The consequence was that I caught a severe cold and was confined to bed for about three weeks. I have as yet nothing to write you about the scientific investigations in Japan. Kinoshita is going to start radioactive works with the radium, which you have kindly procured for him.

Please remember me to Mrs. Rutherford and your daughter.

Wishing you much scientific success,

I remain

Yours faithfully

H. Nagaoka

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For access to this letter and permission to print it and for permission to quote Rutherford's reply, I am indebted to: the family of Professor Nagaoka, Mr. T. Kimura and Dr. E. Yagi of the Committee for the Publication of Nagaoka's Biography, the grandchildren of Lord Rutherford, the authorities of the Cavendish Laboratory, and the Cambridge University Library. Nagaoka's letter is preserved at the Cambridge University Library; Rutherford's reply is in the possession of the Committee for the Publication of Nagaoka's biography. A few spelling errors in Nagaoka's 14-page longhand original have been corrected in the editing. □