

Ernest Rutherford and the origins of nuclear physics

J.C. Hardy

At the invitation of the Canadian Association of Physicists I presented a talk at their annual congress in St. John's Newfoundland on the subject, "Ernest Rutherford and the Origins of Nuclear Physics." I was subsequently asked to write an article on the same subject for *Physics in Canada*, which will appear in volume 68, number 1 (Jan-Mar 2012). A brief synopsis follows.

Rutherford was born in 1871 under very humble and remote circumstances in pioneering country on New Zealand's South Island. With intelligence and spunk he won scholarships, first to college in nearby Nelson, then to university in Christchurch; and finally landed an 1851 Exhibition Scholarship to Cambridge, where he arrived in 1895 just after Roentgen had reported from Germany on the mysterious new X radiation and just before Becquerel in France announced that uranium spontaneously emitted radiation. Working with J.J. Thomson, Rutherford was soon studying the nature of the radiation emitted from uranium and was the first to report (and name) [1] the two different types of rays – α and β – that he observed.

By 1898, at the age of 27, Rutherford had been appointed Macdonald Professor of Experimental Physics at McGill University in Canada, where he spent 9 years. During this time, with a series of ingenious experiments, he cracked the puzzle of radioactivity and determined that "... the succession of chemical changes taking place in radioactive bodies is due to the succession of α rays, i.e. the projection of a heavy charged mass from the atom" [2]. For his work at McGill he received the 1908 Nobel Prize in Chemistry.

By the time he received the prize he had already moved on to Manchester University, where he continued the experiments that led to his discovery that the atom had a hard core. The famous alpha scattering experiment by Geiger and Marsden (proposed by Rutherford), which gave the crucial evidence, was published in 1909 [3] but not understood for nearly two years. It was in 1911, one hundred years ago, that Rutherford first stated [4] that, "The ... atom ... consists of a central electric charge concentrated at a point and surrounded by a uniform spherical distribution of opposite electricity equal in amount."

The first mention of the word "nucleus" did not come for two more years, during which time a young postdoc at Rutherford's lab had weighed in on the problem. That postdoc was Niels Bohr, and it was he who first used the word in a published paper [5] although he gave full credit to Rutherford for proposing the atomic model with a charged nucleus at its center.

Rutherford's accomplishments were by no means over. After the interruption of the First World War, he moved to Cambridge, where he and the young scientists he attracted to work with him were the first to initiate a nuclear reaction using alpha particles from a radioactive source. They were then the first to build an accelerator to produce a beam of high speed hydrogen nuclei, which were projected onto a lithium target causing a nuclear reaction that "split the atom." Along the way, it was Rutherford who suggested that a special name – "protons" – be given to hydrogen nuclei to acknowledge the wide role they played in the nuclear structure of all species. It was also he who proposed in 1920 the existence of

an atom of mass one and zero nuclear charge, and it was in his lab 12 years later that this particle, the neutron, was first observed.

Although technology has improved enormously since Rutherford's day, nuclear physics – and particle physics for that matter – still follows the path well begun by Ernest Rutherford.

[1] E. Rutherford, *Phil. Mag. Ser. 5*, xviii, 109 (1899).

[2] E. Rutherford, *Phil. Mag. Ser. 6*, v, 177 (1903).

[3] H. Geiger and E. Marsden, *Proc. Roy. Soc. A 82*, 485 (1909).

[4] E. Rutherford, *Proc. Manchester Literary and Philosophical Soc. IV*, 55, 18 (1911).

[5] Niels Bohr, *Phil. Mag. Ser 6*, xxvi, 1, 476, 857 (1913).