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Editorial

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Nuclear Physics

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Editorial

Nuclear physics is the field of physics that studies atomic nuclei and their constituents and interactions. Other forms of nuclear matter are also studied.

Nuclear physics should not be confused with atomic physics, which studies the atom as a whole, including its electrons.

Discoveries in nuclear physics have led to applications in many fields. This includes nuclear power, nuclear weapons, nuclear medicine and magnetic resonance imaging, industrial and agricultural isotopes, ion implantation in materials engineering, and radiocarbon dating in geology and archaeology. Such applications are studied in the field of nuclear engineering.

Particle physics evolved out of nuclear physics and the two fields are typically taught in close association. Nuclear astrophysics, the application of nuclear physics to astrophysics, is crucial in explaining the inner workings of stars and the origin of the chemical elements.

The history of nuclear physics as a discipline distinct from atomic physics starts with the discovery of radioactivity by Henri Becquerel in 1896 while investigating phosphorescence in uranium salts. The discovery of the electron by J. J. Thomson a year later was an indication that the atom had internal structure. At the beginning of the 20th century the accepted model of the atom was J. J. Thomson's "plum pudding" model in which the atom was a positively charged ball with smaller negatively charged electrons embedded inside it.

In the years that followed, radioactivity was extensively investigated, notably by Marie Curie, Pierre Curie, Ernest Rutherford and others. By the turn of the century, physicists had also discovered three types of radiation emanating from atoms, which they named alpha, beta, and gamma radiation. Experiments by Otto Hahn in 1911 and by James Chadwick in 1914 discovered that the beta decay spectrum was continuous rather than discrete. That is, electrons were ejected from the atom with a continuous range of energies, rather than the discrete amounts of energy that were observed in gamma and alpha decays. This was a problem for nuclear physics at the time, because it seemed to indicate that energy was not conserved in these decays.

The 1903 Nobel Prize in Physics was awarded jointly to Becquerel, for his discovery and to Marie and Pierre Curie for their subsequent research into radioactivity. Rutherford was awarded the Nobel Prize in Chemistry in 1908 for his "investigations into the disintegration of the elements and the chemistry of radioactive substances".

In 1905, Albert Einstein formulated the idea of mass–energy equivalence. While the work on radioactivity by Becquerel and Marie Curie predates this, an explanation of the source of the energy of radioactivity would have to wait for the discovery that the nucleus itself was composed of smaller constituents, the nucleons.

In 1906, Ernest Rutherford published "Retardation of the Particle from Radium in passing through matter." Hans Geiger expanded on this work in a communication to the Royal Society] with experiments he and Rutherford had done, passing alpha particles through air, aluminum foil and gold leaf. More work was published in 1909 by Geiger and Ernest Marsden, and further greatly expanded work was published in 1910 by Geiger. In 1911–1912 Rutherford went before the Royal Society to explain the experiments and propound the new theory of the atomic nucleus as we now understand it. The key experiment behind this announcement was performed in 1910, at the University of Manchester: Ernest Rutherford's team performed a remarkable experiment in which Geiger and Marsden under Rutherford's supervision fired alpha particles (helium nuclei) at a thin film of gold foil. The plum pudding model had predicted that the alpha particles should come out of the foil with their trajectories being at most slightly bent. But Rutherford instructed his team to look for something that shocked him to observe: a few particles were scattered through large angles, even completely backwards in some cases. He likened it to firing a bullet at tissue paper and having it bounce off