HISTORY OF SCIENCE

ONE HUNDRED YEARS SINCE THE DISCOVERY OF RADIOACTIVITY

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HISTORY OF THE DISCOVERY

In the history of mankind there certain several centuries, certain discoveries, which have in the most fundamental way influenced the succeeding development of mankind. Thus, in ancient times the most important event was the discovery of the wheel. In the nineteenth century the study of electricity was one of the principal directions of development of physical science. The German physicist Julius Plücker participated in investigations of electricity; he discovered that the glass of the tube in an electrical discharge began to fluoresce. In this way the first cathode rays were discovered (in 1859). The German scientist Johann Hittorf continued the investigations and also observed fluorescence, and in 1869 described the properties of the new sort of ray. Two years later the English physicist Cromwell Fleetwood Varley proposed that these rays consisted of small electrically charge particles emitted by the cathode. This idea was confirmed by the English physicist William Crookes (1879) and then by Philipp Lenard (1892). Decisive experiments were performed by the English physicist Joseph John Thomson who established that the particles composing the cathode rays carried an elementary electric charge and were lighter than the hydrogen atom by a factor of 1837. He called this particle the electron.

Thus, the investigation of cathode rays led to the discovery of the first elementary particle. Subsequent investigations led to the discovery of a new kind of electromagnetic radiation, and this led to a world sensation. This phenomenon was discovered by Wilhelm Röntgen.

Jules Henri Poincaré, the well-known French mathematician and physicist proposed checking whether or not Röntgen rays (x-rays) were emitted by a uranium salt. The glass of an x-ray tube fluoresced with a green light, which was reminiscent of the light emitted by uranium crystals after they had been held in sunlight.

The French physicist Antoine Henri Becquerel set about checking this hypothesis. The study of fluorescence had been a long tradition in his family. His grandfather Antoine César Becquerel, the well-known scientist and member of the Parisian Academy, had already performed experiments in this area. His father Alexandre Edmond Becquerel, also an academician and even the president of the Parisian Academy, was the author of fundamental works on phosphorescence and classified this phenomenon as it depended on various external influences.

The experiments of Henri Becquerel were extremely simple. He took a photographic plate, wrapped it in black paper, and placed uranium crystals on it. After exposing the plate to the sunlight for some time he then developed it and to his satisfaction discovered silhouettes of the crystals on it. At first glance this could be considered as conformation of the hypothesis that the uranium crystal, fluorescing under the action of the sunlight, had been emitting x-radiation. However Becquerel, being a highly qualified scientist, decided to set up a control experiment. He placed uranium crystals on the photographic plate without previously irradiating them with sunlight and established that, despite this, they were emitting and not fluorescing. Further experiments confirmed that this effect was caused by the uranium itself which was contained in the crystals. Becquerel discovered that the "uranium rays" ionized air and rendered it electrically conducting. This made it possible to study the rays using an electroscope.

Thus, in 1896 Antoine Henri Becquerel discovered the phenomenon known as natural radioactivity.

The discovery of natural radioactivity gave physicists the possibility of entering a new world. This eventually led to the concepts of the complexity of atomic structure and to the mastering of atomic energy. Henri Becquerel received the Nobel...
Prize for Physics in 1903 for the discovery of natural radioactivity. Two other investigators of natural radioactivity, the French physicists Pierre Curie and Marie Sklodowska-Curie, shared the prize with him.

Utilizing the fact that the radioactive radiation from uranium ionized the air, Marie Sklodowska-Curie used an electroscope in her research. She set herself the problem of finding out whether or not other substances possessed similar properties. In 1898 Sklodowska-Curie simultaneously with (and independently of) the German physicist Erhard Karl Schmidt established that the element thorium was also radioactive. In addition, she noted that certain uranium and thorium compounds emitted more strongly than one would predict on the basis of the percentage content of the named elements in them. This indicated the possibility of the existence of unknown radioactive substances.

Marie and Pierre Curie carried out a chemical analysis of certain minerals containing uranium and after having processed tonnes of ore discovered a new chemical element in 1898. It was named polonium, in honor of Poland the birthplace of Marie Sklodowska-Curie. In December of the same year yet another element was discovered which, on account of the strong radiation which it emitted, was given the name radium.

The Curies are rightly regarded as the pioneers of atomic physics. The very term radioactivity was proposed by Marie Sklodowska-Curie. In 1901 Pierre Curie discovered the biological action of radiation and in 1903 formulated the law on the decay of radioactivity and introduced the concept of a half-life. He proposed using the phenomenon of radioactivity in order to determine the absolute age of the Earth’s rocks. In the same year Pierre Curie jointly with A. Laborde discovered the spontaneous release of heat by radium salts, having established that 1 g of radium released 100 cal/h of heat. This indicated that an enormous amount of energy was concentrated in the atom. Unfortunately, Pierre Curie died in 1906 as a result of an accident, having scarcely reached the age of 47. The research was continued by Marie Sklodowska-Curie who in 1910, together with the French chemist A. Debierne, separated out metallic radium in pure form. She determined the atomic weight of radium and indicated its place in the periodic table of elements. She was awarded a second Nobel Prize for this in 1911, in this case the prize for chemistry.

STUDY OF RADIOACTIVITY IN THE FIRST YEARS FOLLOWING ITS DISCOVERY

Practically simultaneously with Becquerel, investigations of radioactivity were being carried out in France by the husband and wife Pierre and Marie Curie, and in England and Canada by Ernest Rutherford.

Thus, in 1899 Rutherford discovered that there were two components in radioactive radiation which were differently absorbed by materials: α particles having a short mean free path and β particles which were absorbed considerably more weakly. In 1903 Rutherford and Soddy explained the phenomenon of radioactivity as being due to the transmutation of the atoms of certain elements into others. This went against the current ideas on the immutability of the elements but formed the basis of scientific ideas on the phenomenon of radioactivity. Somewhat later Rutherford proved that the α particles are the nuclei of helium atoms. The planetary model which he created in 1911 replaced the previous ideas concerning the structure of the atom.

Ten years later Rutherford predicted the possibility of the existence of the neutron, which was discovered after only ten years in 1932 by J. Chadwick. The concept of a nucleus consisting of protons and neutrons has been retained to this day. Only at very high excitation energies of a nucleus is the quark structure of a nucleon manifested. This was elucidated as a result of work with high-energy particle beams.

An important stage in the physics of the nucleus was the discovery by Rutherford in 1919 of the artificial transmutation of the elements. On irradiating nitrogen with α particles he observed hydrogen nuclei. Subsequently, different nuclear reactions became a method for obtaining new isotopes of various elements and formed a method for investigating the structure of nuclei and the mechanism of the processes.

In 1908 the Nobel Prize for Chemistry was awarded to Rutherford for his investigations on the decay of the elements and the chemistry of radioactive substances.

In 1934 the American physicist Harold Urey was awarded the Nobel Prize for the discovery of deuterium. Heavy water became a necessary moderator of neutrons in subsequent work with nuclear reactors and on the atomic bomb. Deuterium, 2H, also became a powerful medium in chemical and biological research since it is relatively easy to distinguish it from the light hydrogen isotope 1H.

The next step in the study of radioactivity was the creation by Frédéric and Irène Joliot-Curie in 1934 of the artificial radioactive isotopes. They were obtained by irradiating various materials with α particles. In the first experiments the reaction