Fiftieth anniversary of the discovery of the neutron

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Usp. Fiz. Nauk 137, 3–4 (May 1982)

PACS numbers: 01.65. + g, 14.20.Dh, 28.20. – v

Fifty years have elapsed since the discovery of the neutron. Chadwick submitted for publication his celebrated paper entitled "The possible existence of a neutron" on February 17, 1932. This paper had many precursors. The discovery of the neutron was in fact the logical outcome of Rutherford's celebrated experiments on the splitting of light nuclei by alpha particles, which were performed in 1919. They led to the work of Bothe and Becker who discovered, in 1930, a penetrating radiation that appeared when beryllium was bombarded with alpha particles. A little later, Irene Curie and Frederic Jolliot showed that these "beryllium rays," which at the time were thought to be gamma rays, had the surprising ability to eject fast protons from hydrogen-containing materials (1932). The decisive step was taken by Chadwick who suggested, and then demonstrated by simple but convincing experiments, that this mysterious radiation was in fact a stream of neutral particles whose mass was very nearly the same as the mass of the proton. Chadwick's discovery of the neutron was, of course, facilitated by Rutherford's hypothesis of the existence of the neutron, which he put forward in 1920.

No one could have foreseen in 1932 the surprising and attractive possibilities that neutron physics was to offer to science and technology or, even more so, the fearful consequences that now threaten the very existence of mankind. Although none of this was appreciated in 1932, the discovery of the neutron was at once greeted by physicists as an event of primary importance. A particle that did not carry electrical charge presented a clear threat to the firmly established belief that the presence of electrically charged particles (electrons, protons, and nuclei consisting of them) was an inherent property of all matter. It was no accident that Rutherford imagined the neutron as an atom in which the electron was simply more tightly and more closely bound to the proton than in the hydrogen atom. This model of the neutron began to be doubted soon after Chadwick's discovery, and was eventually replaced by the neutron-proton model of the nucleus (put forward by Ivanenko and Heisenberg).

Physicists thus encountered particles of matter that did not have an electrical charge and were of a different nature than all those that had been known before. The immediate problem was to determine their properties. All was thrown into confusion, and it was not even clear whether, like the electron and the proton, the neutron exhibited the wave-particle duality. All this gave rise to the exceptional interest that the discovery of the neutron attracted among physicists. Nor was it an accident that eminent and far-sighted physicists such as S.I. Vavilov and A.F. Ioffe, who did not themselves work in nuclear physics, were able to guess the significance of these developments for the future of science and pressed for the development of nuclear physics in the Soviet Union in the early 1930s. I happen to know that the discovery of the neutron was an important stimulus to their endeavors to force such developments in our country.

The importance of neutron physics eventually exceeded all expectations. The work carried out in Fermi's laboratory over a period of only three years (1934–1936) is striking not only because of the sheer volume of the results but also because of their significance. With hindsight, one can readily appreciate that the foundations were being laid for future advances in neutron physics. All that was still to come was the discovery of fission, but even this was the outcome of Fermi's discovery of the neutron-induced radioactivity of uranium. Nuclear fission was discovered by Hahn and Strassman at the end of 1938, and the detection of neutrons emitted in the process of fission provided all the prerequisites for the attainment of the nuclear chain reaction. The first atomic reactor was built in the USA in 1942 under Fermi's direction, and the first European reactor was constructed in the USSR in 1946 under the direction of I.V. Kurchatov.

It is, of course, impossible to cover in a single review, or even in a series of papers, all the different branches (and even more so, all the results) of modern neutron physics. Only three review papers are published in this issue of Uspekhi. One of them is devoted to the fundamental properties of the neutron, and is historical in character. The other two are more akin to short monographs on certain current problems in neutron physics that have engaged the attention of their authors. These papers do not, therefore, pretend to provide a complete historical picture or a complete account of the present state of neutron physics. They merely illustrate the fact that the rapid advance of neutron physics is continuing.

Translated by S. Chomet

 0038-5670/82/050279-01$01.80