Pauli, Wolfgang (1900 - 1958)

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Austrian-born Swiss physicist who made a substantial contribution to quantum theory with the Pauli exclusion principle. For this achievement, Pauli was awarded the 1945 Nobel Prize for Physics. He also postulated the existence of the neutrino.

Pauli was born in Vienna on 25 April 1900. His father was professor of colloid chemistry at the University of Vienna and his godfather was the physicist Ernst Mach. Pauli made rapid progress in science while at school in Vienna and by the time he entered the University of Munich to study under Arnold Sommerfeld, he had already mastered both the special and general theories of relativity proposed by Albert Einstein. Recognizing his ability, Sommerfeld gave Pauli the task of preparing a comprehensive exposition of relativity, as Einstein had not done so. Pauli produced a monograph of extraordinary clarity, an amazing achievement for a student of 19.

Pauli obtained his doctorate in 1922 and then went to Göttingen as an assistant to Max Born. He soon moved to Copenhagen to study with Niels Bohr and then in 1923 went to Hamburg as a Privatdozent (unpaid lecturer). In 1928, Pauli was appointed professor of experimental physics at the Eidgenössische Technical University, Zürich. He retained this position until the end of his life, but spent World War II in the USA at the Institute for Advanced Study, Princeton. Pauli became a Swiss citizen on his return and died in Zürich on 15 December 1958.

In the early 1920s, the quantum model of the atom proposed by Bohr in 1913 and elaborated by Sommerfeld in 1916 was in some disarray. Observations of the magnetic anomaly in alkali metals and of the fine spectra of alkaline-earth metals did not accord with the Bohr-Sommerfeld model and it was suggested that the quantum numbers used to describe the energy levels of electrons in atoms in this model would have to be abandoned. Pauli realized that the situation could be explained if a fourth quantum number were added to the three already used (n, l, and m). This number, s, would represent the spin of the electron and would have two possible values. He further proposed that no two electrons in the same atom can have the same values for their four quantum numbers. This is the Pauli exclusion principle, which was announced in 1925.

The exclusion principle means that the energy state of each electron in an atom can be defined by giving a unique set of values to the four quantum numbers. It not only accounted for the unusual properties of the elements that had been observed, but also gave a means of determining the arrangement of electrons into shells around the nucleus that explained the classification of elements into related groups. The successive shells could contain a maximum of 2, 8, 18, 32, and 50 electrons, with most elements containing outer valence electrons and inner complete shells. This discovery was of great importance, for it gave an explanation of the similarities in the properties of elements and revealed the significance of ordering elements by their atomic number.

Pauli's other main contribution to physics was made in 1930. The production of beta radiation in a...
continuous spectrum had puzzled physicists as theory demanded that the spectrum should be discontinuous. It appeared to be caused by a loss of energy when beta particles (electrons) were emitted from atoms, but no explanation could be found for such a loss. It was suggested that the theory of conservation of energy would have to be abandoned, but Pauli proposed that the emission of an electron in beta decay is accompanied by the production of an unknown particle. This particle would have unusual properties, having no charge and zero mass at rest - hence the fact that it had not been observed. Pauli persisted in this opinion, and in 1934 Enrico Fermi confirmed Pauli's view and called the particle the neutrino. It was eventually detected in 1956.

Pauli made substantial advances in our understanding of the nature of the atom by adhering to accepted theories that he felt he could not abandon. He demonstrated exceptional insight, for such an approach usually blinds scientists to progress. Pauli summed up his life in a characteristically succinct fashion when he declared ‘In my youth I believed myself to be a revolutionary; now I see that I was a classicist.’

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