The discovery and properties of pentaquarks

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The pentaquarks are exotic baryons formed of four quarks and an antiquark. Their existence, as stable or quasistable particles against strong decays, has been discussed in the literature over the last 25 years, but experimentally they could not be identified until about a year ago, when the LEPS collaboration [1] observed a narrow S = + 1 resonance, called Θ^+, of mass around 1540 MeV. This observation has been motivated and oriented by Ref. [2]. The Θ^+ resonance has been confirmed by the CLAS Collaboration [3] and by many other laboratories. The ordinary baryonic resonances are described as three quark systems and their strangeness S can be either zero or negative. Due to its positive strangeness, Θ^+ cannot be a three-quark system and it has been interpreted as a pentaquark formed of two quarks u, two quarks d and an antiquark s, as its minimal content. The discovery of Θ^+ has been followed by the observation of two other narrow resonances at CERN [4], interpreted also as pentaquarks, all three belonging to the same antidecuplet of SU(3)-flavour. Since the discovery of Θ^+ there has been a very intense activity on pentaquarks both on the experimental and theoretical sides.

Here we shall mainly review the predictions of pentaquark properties in constituent quark models and the implications of their existence on baryon spectroscopy. Both in the light and heavy sector, of particular importance are the predictions for the spin and parity [5,6] and the mass splitting between the isomultiplets contained in an $SU(3)_F$ multiplet [7]. The predictions of the quark model of 1998 [5] are consistent with the recent observation [8] of the heavy analog of Θ, called presently Θ_c, where $\bar{s}$ is replaced by $\bar{c}$.

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