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Baryon Structure in the Low Energy Regime of QCD

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I review the key problem of light and strange baryon spectroscopy, which suggests a clue for our understanding of underlying dynamics. Then I discuss the spontaneous breaking of chiral symmetry in QCD. In the region of spontaneously broken chiral symmetry, where the Goldstone boson degree of freedom is important, the structure of the elementary excitation of the QCD vacuum can be approximately reproduced by absorption of the scalar interaction between bare (current) quarks into the mass of the quasi particles - i.e. constituent quarks. This implies that in the low-energy regime the proper chiral dynamics is due to the coupling of Goldstone bosons and constituent quarks and that the nucleon should be viewed as a system of confined constituent quarks that interact via the Goldstone boson exchange (GBE) [1]. The GBE interaction contains both the ultraviolet (short range) part, which is independent of pion mass, and the infrared (Yukawa) part. The latter one is important for the long-range nuclear force, but it does not produce any significant effect in baryons because of their small matter radius. The short-range part of the GBE interaction causes a flavor-spin dependent force between quarks and has a range Λ_χ^{-1}. While the infrared (Yukawa) part of the interaction vanishes in the chiral limt, the ultraviolet one - does not [2]. This means that the short-range part of the GBE interaction is "more fundamental" than its Yukawa part. This short-range part of the GBE interaction stems from the γ_5 structure of the vertex and hence is demanded by the Lorentz invariance. At the microscopical level this short range interaction comes from the t-channel iterations of that bare gluonic interaction between quarks that is responsible for chiral symmetry breaking [3]. This is a typical antiscreening behavior; the interaction is represented by a bare gluonic vertex at large momenta, but it blows up at small momenta in the GBE channel due to the (Landau) pole that occures at $q^2 = 0$. I show how this explicitly flavor-dependent short-range part of GBE interaction, when combined with the $SU(6)$ symmetry (that is demanded by large N_c limit in QCD), solves the key problem of baryon spectroscopy and present baryon spectra obtained in a simple analytical calculation [1] as well as in covariant three-body calculations [4]. Finally I show recent lattice results [5–8] and comment on their connection with the present physical picture.

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