UNSTABLE QUARKS AND THEIR DETECTION

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It is known that a baryon classification by multiplets, corresponding to SU(3), can be illustratively described under the assumption that the baryons consist of three fundamental particles - quarks, fermions with spin 1/2 and fractional electric charges (+2/3, -1/3).

In such a theory, free unit quarks can be transformed into one another, but at least one of them must be absolutely stable.[1)] Then the proton quark p (z = +2/3) would give a "quarkion atom" (p, e) and its chemical compounds; the neutron quark n (z = -1/3) would become attached to the ordinary nuclei. In exactly the same way, the proton antiquark $\bar{p}$ (z = -2/3) should become attached to the nuclei, and the neutron antiquark $\bar{n}$ (z = +1/3) binds the electron quite weakly (1.5 eV) and goes over easily to the free state.

However, searches for particles with fractional charge in accelerators and in cosmic rays produced negative results, while mass and optical spectroscopy gives no hints of the existence of nuclei with fractional charge. This makes more attractive the well-known scheme with a fourth object, in which all fundamental particles have integer charges. We assume that there exists a "protobaryon" (R^-), a boson with baryon number 1, charge 1, strangeness 0, and spin 0. In such a scheme, the quarks have a baryon number 0, spin 1/2, the charge of p is equal to +1, while n and Λ are neutral. The known weak interaction depends on the ($p\bar{n}$) and ($p\bar{\Lambda}$) terms in the weak current. Along with this, quarks can decay into leptons through currents of the type [2)] ($p\nu$), (ne), ($n\mu$), (Λe), and ($\Lambda\mu$).

In such a case it becomes possible in principle to observe the track of a p-quark and the decay of p, n, and Λ quarks with formation of e or μ leptons at a certain distance from the point of creation. If the intermediate $W^{\pm}$ boson of weak interaction exists and the mass of the quark exceeds the mass of W, then the decay of the quark occurs within a time shorter than 10^{-19} sec. In this case the existence and decay of the quarks can be deduced only from the appearance of the leptons e, μ, and ν in strong interactions at an energy exceeding the quark creation threshold. It will be necessary to distinguish these leptons in the experiment from the products of weak decay of particles with lifetime 10^{-8} - 10^{-10} sec (π, K, Λ, Σ, Ξ, Ω), and also from Dalitz pairs $\pi^0 \rightarrow \gamma + e^+ + e^-$, $\Sigma^0 \rightarrow \Lambda^0 + e^+ + e^-$, which are produced practically instantaneously (within $\sim 10^{-16}$ sec).

Nuclei with anomalous quark content (not equal to 3A), as well as R^{-1} itself, are unstable in such a scheme against transformations into ordinary nuclei and nucleons via the same interaction that insures the decay of the quarks. This makes their absence in nature logical. The purpose of this paper is opposite to the idea of Lee [1], who considers quarks with integer charge, but seeks principles that forbid their decay.

From the point of view of the theoretician, the shortcomings of the proposed scheme are the fact that it is uneconomical (an extra particle R^-) and it foregoes the known deductions concerning electromagnetic interactions in SU(6), including the impressive prediction concerning the ratio of the neutron and proton magnetic moments. The advantages of the R^- scheme are connected with the intuitive concepts of the meson and baryon structure.

In constructing mesons of quarks and antiquarks, we assume that the latter attract each other, and accordingly two quarks repel each other, at least at ultrashort distances. In the scheme with the R^- boson, it is natural to assume that the quarks are attracted to R^- and repel each other. Inasmuch as three quarks in $(p)^3$ state are fully antisymmetrical in the coordinates ($\ell_z = 1$, $\ell_z = 0$, $\ell_z = -1$, $L = 0$), we obtain a natural representation of a decuplet of baryons with $J^P = 3/2^+$ and an octet of baryons with $J^P = 1/2^+$. The identical orbital wave functions of the decuplet and the octet correspond precisely to the fact that the decuplet and the octet combine into a single representation with 56 elements in SU(6). This intuitive scheme is developed in a tutorial article by the author [2].

[1] T. D. Lee, Nuovo cimento 35, no. 3 (1965)
[2] Ya. B. Zel'dovich, UFN 86, no. 6 (1965), Soviet Phys. Uspekhi 8 (1965).

1) If the quark mass difference is smaller than the mass of the corresponding meson ($m_\Lambda < m_{p,n} + m_K$, $m_p < m_n + m_\pi$), then the transformation proceeds via weak interaction. If $|m_p - m_n| < m_e$, then two quarks, p and n, are stable in vacuum.

2) In this case we ascribe to the quarks a lepton decay, and the correspondence between the quarks and the leptons can be established, for example, from the Kiev symmetry of ($\Lambda\mu$), (ne), and ($p\nu$). However, the existence of neutral currents (pe), ($n\nu$), and ($\Lambda\nu$) is also possible.

AMPLIFICATION OF COHERENT RADIATION USING STIMULATED RAMAN SCATTERING

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We present preliminary results of an experiment on the amplification of an external signal by using stimulated Raman scattering (SRS). In the experiments performed to date [1, 6-8], in accord with theory [2-5], powerful radiation was observed at the frequency of self-exciting waves $\omega_s = \omega_0 - \Omega$, where ω_0 is the pump frequency and Ω one of the frequencies of the molecular oscillations active in the Raman scattering. However, there are no reports in the literature of the use of the SRS phenomenon for amplification of an external signal of Stokes frequency. At the same time, the problem of effective amplification of coherent radiation with wavelengths for which powerful sources are available is very timely. By using an amplifier for the Stokes