Unexplained Quantum Chromodynamics Data

The discussions presented elsewhere in this site contain theoretical arguments showing contradictions pertaining to several parts of contemporary physics. This approach is analogous to an analysis of errors in a mathematical theory. In addition it is pointed out in the Introductory part of this site that a physical theory should satisfy a second level of tests where compatibility of its predictions with experimental data is required. Now, QCD has been investigated for more than 30 years. Hence, one expects that its main properties are already included in textbooks. Below one finds a list of several experimental QCD data that have no adequate explanation in textbooks.

A. The Higgs Mesons.

   QCD is an element of a broader theory called the Standard Model. Here it is assumed that particles called Higgs mesons exist. In spite of a prolonged search, no evidence of these particles has been detected (see [4], p. 32).

B. The Photon-Hadron Interaction

   The data show that a hard photon (having energy greater than 1000MeV) interacts with a proton in a form which is very similar to that of a neutron [28]. Due to the difference between the electric charge of the proton's constituents and those of the neutron, this similarity cannot be explained as interactions of the photon with an electric charge. It turns out that VMD (see the corresponding part of this site) has been suggested in order to provide an explanation for this effect. Now, it is proved in [30] that VMD contains serious theoretical errors. Moreover, in the PACS classification it is regarded as just a model and in the xxx arXiv, VMD is relegated to the phenomenological category. Hence, QCD has no *theoretical* explanation for the interaction of a hard photon with hadrons.

C. Properties of Anti-Quarks in Hadrons

The structure functions of proton constituents show that the width of x values of antiquarks is much smaller than that of quarks (see [43], p. 281). (x is a dimensionless Lorentz scalar used in the analysis.) Henceforth, quarks and anti-quarks are denoted by q and $\bar{q}$, respectively. The width values indicate that, in the nucleon, the uncertainty of momentum of $\bar{q}$ is smaller than the corresponding value of q (see [43], pp. 270, 271). Therefore, due to the uncertainty principle, one concludes that in a nucleon, $\bar{q}$ occupies a volume which is *larger* than that of q. This property of nucleons lacks an adequate explanation.

In the literature, the $\bar{q}$ region is called "the $q - \bar{q}$ sea" (see [43] p. 281). This terminology does not aim to be a theoretical explanation and cannot be regarded as such. Indeed, a π meson is a bound state of $q\bar{q}$, both of which came from the Dirac sea of negative energy states. Now, in a π meson, the $\bar{q}$ is attracted just by one q. In spite of that, this force is strong enough for binding the system in a volume which is even smaller than the nucleon's volume (see [4], pp. 499, 854). Hence, it is not clear why 4 quarks (the 3 valence quarks and the $\bar{q}$'s companion) cannot do that. It is concluded that QCD has no explanation for the rather large volume of $\bar{q}$ in nucleons.

D. The Lack of Strongly Bound States of $qqqq\bar{q}$ (pentaquarks)

Consider the $qqqq\bar{q}$ system (a nucleon-meson system called pentaquark). The following properties of hadrons are relevant to an evaluation of this object. Data of strongly interacting systems show that gaps between energy states are measured by hundreds of MeV. On the other hand, the binding energy of a nucleon in a typical nucleus is about 8 MeV. These values can be used for making a clear distinction between true strong interactions and the nuclear force, which is regarded as a residual force.

Another property of hadrons can be learned from the data. The mass of a π meson is about 140MeV whereas the mass of a nucleon is about 940MeV. Therefore, one concludes that if QCD holds, then the $q\bar{q}$ binding energy is much larger then that of a qq pair (in a nucleon there are 3 such pairs of interactions).

Let us turn to the case of pentaquarks and examine a particle called Θ^+ having a mass of 1540MeV. Evidence of this object has been found in several experiments (see e.g. [4], p. 916). This object can be regarded as a union of a neutron and a K^+ meson. The sum of the masses of these particles is about 1435MeV. Therefore, the Θ^+ is an *unbound* state of the nK^+ system. On the other hand, a strongly bound state of nK^+ should have a mass which is smaller than 1400MeV. Hence, QCD still does not provide an explanation for the absence of *strongly* bound states of pentaquarks. Moreover, it does not explain why the deuteron (a 6-quark system) is a bound state whereas the nK^+ (which contain an antiquark) has no bound state.

E. The Uniform Density of Nuclear Matter

Consider nuclei that contain more than a very small number of nucleons. The data show that for these nuclei, the nucleon density is (very nearly) the same. QCD does not provide an explanation for these data.

Another aspect of this issue is that QCD does not provide an explanation for the striking similarity between the form of the van der Waals force and that of the nuclear force.

F. The EMC Effect

An examination of the mean volume occupied by quarks in nuclei shows that it increases with the increase of the number of nucleons of the nucleus [44,45]. This effect is analogous to the screening effect of electrons in molecules. QCD has not predicted this effect and provides no explanation for it.

G. The Idea of Strange Quark Matter

QCD proponents claim that a stable state of an aggregate of baryons, each of which consists of u,d,s quarks, can exist. This idea is discussed for more than two decades and attempts to find this kind of baryonic matter have been carried out. These attempts are continued persistently and, as of today, ten annual conferences dedicates to this subject have been organized. References to this idea can be found by searching the Internet for the words "Strange Quark Matter" (SQM).

The regular monopole theory predicts that a SQM does not exist. This conclusion relies on the similarity between electricity of charges and magnetism of magnetic monopoles. Now, a postulate of the regular monopole theory states that hadrons are like neutral nonionized atoms. Thus, bound states of hadrons are like atoms in a liquid drop. This conclusion explains the underlying structure of nuclei, which are bound states of nucleons. Here, the typical binding energy per nucleon is 8 MeV. This quantity is very far below s quark energies which are measured by hundreds of MeV. Hence, no stable SQM is expected to exist.

In principle, QCD allows the existence of SQM. The failure of attempts to detect this object provides another reason for questioning the validity of QCD.

In principle, one established experimental result which is inconsistent with a theory, casts doubt on the theory's validity. Here one can find several examples of experimental data which are unexplained by QCD.

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