QUARK-GLUON INTERPRETATION OF DIFFRACTIVE BUMPS

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It is conjectured that the enhancements observed in diffractive dissociation processes are gluonic excitations of the initial beam particles. Arguments in favour of this conjecture are collected.

A characteristic feature of diffractive dissociation at high energies is the production of the broad enhancements in the mass distribution of the diffractively produced systems [1]. These enhancements, called A-, Q- and B-bumps, are difficult to interpret theoretically. They do not show a clean resonant behaviour [2]. They cannot be explained by kinematic, e. g. Deck type [3] arguments, either [4, 5]. They are hardly produced at all in reactions other than diffraction dissociation.

It is therefore natural to accept that these diffractive enhancements form a new class of objects, different from ordinary resonances. Such suggestion was made first by Morrison [6] who called them D-resonances, to emphasize their relation to the diffractive processes.

In this paper we propose a specific interpretation of these D-resonances in the framework of the quark-gluon picture of hadrons. Our idea is that they are bound states of (*i*) a system of quarks with quantum numbers identical to those of the incident particle and (*ii*) a "glueball" i. e. a system of gluons.

We see two possibilities of coupling of a glueball to the quark system which give correct quantum numbers of D-resonances.

(*a*) The glueball is in 0^+ state but its orbital angular momentum with respect to quarks takes values 1, 2, 3...

(*b*) The glueball is excited into 1^-, 2^+, 3^-... states whereas its orbital angular momentum with respect to quarks vanishes[1].

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[1] One may remark that, in absence of any dynamical arguments, it is not clear why the internal excitations of glueballs should be dominantly 1^-, 2^+, 3^-... It is also difficult to understand why higher orbital angular momenta of a glueball with respect to quarks should be forbidden. Thus it seems that this version of the model predicts more states than actually observed. It is not impossible, however, that dynamical calculations can explain the absence of unwanted states and thus remove this objection.

To be more explicit, we interpret A-bumps as systems consisting of $q\bar{q}$ pair with π-meson quantum numbers and glueball with angular momentum 1, 2, 3... Q-bumps are analogous objects with $q\bar{q}$ pair having the quantum numbers of K-meson. Finally in B-bumps we have glueball and a system of three quarks with quantum numbers of the nucleon.

This picture seems to us a natural generalization of the standard model of hadrons made of quark and gluons. Indeed, the ordinary resonances can be understood as bound states of quarks and a glueball with angular momentum zero. We know that the quark system can be easily excited to higher angular momentum states. It is therefore natural to expect also appearance of excitations of higher angular momentum of the glueball.

Let us now collect the arguments in favour of our conjecture.

(*i*) One obtains a trivial explanation of the internal quantum numbers of the D-resonances: clearly they are the same as those of initial particles.

(*ii*) The Gribov-Morrison rule [7] is automatically satisfied for the dissociation of pseudoscalar particles.

(*iii*) For nucleon dissociation, in general violation of Gribov-Morrison rule is expected because the spin of the 3-quark system can couple in two ways to orbital angular momentum of the glueball. However, from the data on relative probabilities of excitation of different A- and Q-bumps [8, 9] it follows that probability of a gluonic excitation strongly decreases with increasing angular momentum. For nucleon dissociation this implies dominance of spin-parity combinations $3/2^-$, $5/2^+$, $7/2^-$... over $3/2^+$, $5/2^-$, $7/2^+$..., respectively. To illustrate this effect, we performed a simplified calculation where relative probabilities for gluonic excitations were taken in the ratios

$$1^- : 2^+ : 3^- = 8 : 3 : 1$$

suggested by the data [8] on excitation of A-bumps at 15 GeV. The results for the incident proton beam are shown in the table below, where the relative probabilities for small angle production of different spin-parity states are given.

TABLE

J^P	$\frac{3}{2}^-$	$\frac{5}{2}^+$	$\frac{7}{2}^-$	$\frac{3}{2}^+$	$\frac{5}{2}^-$
$\frac{\sigma(J^P)}{\sigma(\frac{1}{2}^-)}$	2	0.7	0.2	0.45	0.15

We see from this table that indeed, for given J, there is strong dominance of the waves consistent with Gribov-Morrison rule. Also rather strong production of $1/2^-$ wave is expected.

(*iv*) If one accepts the idea that the diffractive processes are generated by exchange [10] or interaction [11] of gluons, it is natural to expect gluonic excitations to dominate such processes. This would explain copious production of D-resonances in diffractive dissociation.

(*v*) The model predicts naturally the dominance of the non-spin-flip amplitude in forward direction, because it is not necessary to flip spin of neither quarks nor gluons in the interaction. This is different from situation in simple quark models [12], where the non-spin-flip amplitude is expected to vanish for forward production of A_1, contrary to experimental data [2].

(*vi*) Since the quark-gluon content of D-resonances in our model is the same as in ordinary resonances, a natural explanation is obtained for the small cross-sections of the D-resonances in nuclear matter [13, 14]. One thus avoids the problems of the Deck mechanism, where the expected cross-sections of diffractively produced systems in nuclear matter are expected to be much larger than experimentally observed [4].

To summarize, we propose that Morrison's D-resonances are gluonic excitations of the beam particles. We find that this hypothesis can naturally account for most of the observed phenomena in diffractive dissociation of mesons and baryons. It also fits nicely into the picture of diffraction being generated by gluon interactions. We thus feel that it deserves further investigation.

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