SOME THEORETICAL PROBLEMS RELATED WITH NON RESONANT ENHANCEMENTS

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1.- INTRODUCTION. - Knowing what is not a resonance is obviously necessary to know what is a resonance. The whole hadronic spectroscopy is thus affected by the possibility of existence of non resonant enhancements. As a consequence the whole understanding of hadrodynamics is also affected by this possibility. For instance, the classification of states according to symmetry schemes relies on the decision of giving such or such state the dignity of being a resonance. This is obviously true for SU(3) but also for instance for chiral symmetry; in this respect the possibility that A_1 is not a resonance puts a lot of troubles for the tenants of such a symmetry scheme. The separation of resonances from pseudo resonances is also crucial for testing some dynamical schemes like, say, duality. As we shall see at the end of this talk one does not know yet whether the two component duality conjectured by Harari and Freund in two body scattering is valid or not in diffractive productions.

It is rather difficult to decide in a very clear way what is a resonance. The french summer school of GIF sur YVETTE devoted a complete session in 1971 to this question. One of the proposed answers was that a resonance is a signal appearing in a given state independently of the production mechanism. A contrario a non resonant enhancement depends of the production amplitude. So, studying these pseudo resonances is not only important for hadron spectroscopy but also for the understanding of the production process itself. In this respect the explanation of the so called ABC effect, proposed in this conference is particularly interesting.

2.- THE DECK MECHANISM. - We shall first recall briefly how the so called Deck mechanism works in producing pseudo resonances. Consider the production amplitude $a + b \rightarrow c + d + e$ symbolised in fig. 1 on which the kinematics is defined.

Fig. 1

Originally the Deck effect is a kinematical enhancement produced by the presence of a pole in the t_{ac} variable, close to the physical region. Even if there is no rapid variation in the s_{cd} variable, the presence of nearby pole in t_{ac} favors the low cd invariant masses, as shown in fig. 2.

Fig. 2

One understands easily that the Deck effect disappears rapidly with increasing initial energy s . In fact when s increases the physical domain broadens and flattens near $t_{ac} = 0$ in such a way that the low mass enhancement vanishes. Curiously it is the development of Regge formalism in inclusive processes which has allowed to understand why the Deck mechanism may persist with increasing energy. Assume that particles c and d are a part of the missing mass in

the inclusive process $a + b \rightarrow e + x$. In the fragmentation region (s large, t_{be} small) the Regge behaviour is given by

$$\sigma \propto \frac{1}{s^2} \left(\frac{s}{s_{cd}}\right)^{2\alpha(t_{be})}$$

where α is the trajectory exchanged between b and e . The higher is this trajectory, the stronger is the cutoff in s_{cd} .

This explains why Deck enhancements are likely to occur when :

- pion can be exchanged between a and c (nearby pole)
- Pomeron can be exchanged between b and e (s_{cd}^{-2} cutoff).

3.- THE Q CROSS OVER PUZZLE.- The diffractively produced Q enhancement is considered as one of the best illustration of the Deck mechanism. The Deck diagram shown in fig. 3 allows to explain most of the observed features :

Fig. 3

- the shape of the Q enhancement
- the energy dependence of its production cross section
- the density matrix of K^* .

Unfortunately this mechanism does not explain the observed cross over of Q and $\bar{Q}$ differential cross sections : due to pion exchange one expects a π -Nucleon type cross over whereas one observes a K -Nucleon like one. The situation is even worse in neutral Q^0 and $\bar{Q}^0$ productions where the observed effect is the inverse of the one expected from naive pion exchange, (see fig. 4).

Fig. 4

In a paper submitted to this conference (1) G. Cohen Tannoudji, C. Gilain and A. Santoro propose a solution based on duality arguments to this puzzle. It is known that the cross over effect in K -Nucleon scattering is due to the interference between the Pomeron and the ω contributions. The cross over effect in π -Nucleon scattering is much weaker because the ω is not coupled to $\pi\pi$. In order to have a K -Nucleon like crossover in Q production one thus needs the exchange of the ω . The above mentioned authors show that this ω exchange is possible provided that the pion is not exchanged alone but in company with its exchange degenerate partner (which could be the B meson). Fig. 5 shows the duality diagrams contributing to ω exchange in $K^*\pi$ production

Fig. 5

Indeed this explanation of the Q cross over puzzle applies only to the $K^*\pi$ production.

When the Q bump is observed in the $K\rho$ system, there is no puzzle since it is the K which is exchanged. But the Q is mainly observed in the $K^*\pi$ system.

4.- DUALITY IN DIFFRACTIVE PRODUCTIONS.- As we have seen above the Deck effect is likely to occur in diffractive productions. In an inclusive point of view a diffractive process is of the type $a + b \rightarrow b + x$. In terms of the Regge-Mueller analysis the inclusive diffractive cross section is, in the fragmentation region related to the total cross section of the scattering of a virtual Pomeron on particle a : see fig. 6.

For large missing masses one expects this virtual reaction to be dominated by Pomeron and secondary Regge exchanges. For low missing masses one expects the occurrence of diffractive resonances and diffrac-

Fig. 6

tive background. It is of great theoretical interest to know whether the two component conjecture of Harari and Freund according to which resonances are dual to Regge poles and background to Pomeron is also valid in diffractive reactions. In particular, if one was able to separate diffractive resonances from diffractive background, one should be able to get through Finite Mass Sum Rules (the inclusive version of Finite Energy Sum Rules) an idea of the relative strength of Pomeron-Pomeron-Regge and Pomeron-Pomeron-Pomeron couplings. Unfortunately, as we have seen, the Deck mechanism is able to terribly complicate the situation in producing non resonance but resonance like enhancements. In other words the diffractive background shares with diffractive resonances many of their features. Due to the importance of questions related with triple Pomeron coupling, we think it would be interesting to improve detailed analyses of the diffractively produced missing mass (phase shift analysis, density matrix, phase variation...) in order to well separate resonances from background. Let us conclude this section by mentioning the paper submitted by Lubatti and Moriyasu (2) which could allow systematic studies of the implications of duality and quark model in diffractive dissociations.

5.- THE ABC EFFECT AND ITS EXPLANATION.- We conclude this brief survey of theoretical interpretations of non resonant enhancements by mentioning the elegant explanation of the so called ABC effect proposed in a submitted paper by J. Anjos, D. Levy and A. Santoro (3).

The ABC effect is a near threshold enhancement observed in the missing mass spectrum in the reaction $d + p \rightarrow \text{He}^3 + \pi\pi^0$. This effect was first observed a long time ago and did not receive any satisfactory explanation. A series of experiments (4), using the extracted deuteron beam from the synchrotron Saturne at Saclay has been recently performed by a Saclay, Caen and Frascati collaboration. L. Goldzahl has reported here the main features of the experimental data. In fig. 7 we show the approximate shape of the observed spectrum plotted versus the laboratory momentum of the out going He^3 . The three bumps are

called from left to right (increasing He^3 momentum) "forward ABC", "middle bump", "backward ABC".

Fig. 7

The proposed theoretical explanation relies on the treatment of the reaction as a real three body problem: two pions are produced in a two step reaction $N_1 + p \rightarrow d_1 + \pi_1$ followed by $d_1 + N_2 \rightarrow \pi_1 + \text{He}^3$, where N_1 and N_2 are the constituents of the deuteron and d_1 an intermediate deuteron. The kinematical configuration is such that the intermediate deuteron is almost on its mass shell, so the diagram of fig. 8 is dominant.

Fig. 8

The two processes I and II, with real deuteron have been experimentally studied. The differential cross sections show strong forward and backward peaks. Qualitatively one can understand that when both reactions take place in the forward direction one gets the forward ABC, when they take place in the backward direction one gets the backward ABC, and when one takes place in the forward direction and the other in the backward direction one gets the middle bump. More quantitative calculations taking into account the Fermi motion inside the deuteron lead to a satisfactory agreement with the data.

REFERENCES

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