Possibility of observing a cumulative dibaryon resonance

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A narrow peak with a mass between 1.92 and 1.93 GeV/c^2 has been detected in the spectra of the effective masses of two protons. These spectra were recorded in various pion-nucleus interactions. Experimental data show that a cumulative dibaryon resonance can be observed.

The dibaryon resonances have attracted increasing attention in view of the problem of multiquark states. In particular, experimental data on the low-lying narrow resonances in the spectra of the effective masses of two protons have been published.[1–5] On the other hand, no structural features have been observed in the cross section for

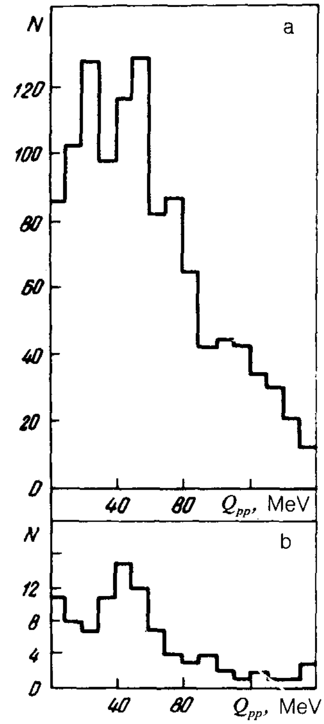

FIG. 1. The distribution based on $Q = (M_{\text{eff}\,2p} - 2M_p)c^2$: (a) for the $\pi^- A$ interactions with the production of strange particles and (b) for the $\pi^- Ne$ interactions with the emission of two protons.

pp interaction in the corresponding energy range. The hypothesis that narrow dibaryons have an isotopic spin equal to 2 is an attractive hypothesis in this case. The narrow width can then be explained by the fact that the rapid decay into $2p$ is forbidden by the law of conservation of the isospin. If, on the other hand, the decay into $2p$ is an electromagnetic decay, then the decay into $2p$ should proceed with comparable probability, a process which can be verified experimentally.

The new physical phenomenon—the dibaryon resonances—requires a comprehensive verification in various reactions and with use of various procedures.

We have studied the spectra of the effective masses of two protons in the reactions involving (1) the production of strange neutral particles by π^- mesons at 4 GeV/*c* in Freon (Fig. 1a), (2) the interaction of 4-GeV/*c* π^- mesons with Freon-mixture nuclei, in which two or more cumulative protons are emitted [i.e., in which fast protons with an emission angle of $> 90°$ with respect to the beam direction in the laboratory frame are emitted (Fig. 2), and (3) deep inelastic interaction of 6.2-GeV/*c* π^- mesons with neon nuclei, in which two fast protons are emitted (Fig. 1b).

The spectra were constructed on the basis of the variable $Q = (M_{\text{eff}\,pp} - 2M_p)c^2$, where M_p is the proton mass, and $M_{\text{eff}\,pp}$ is the effective mass of two protons. We used photographs taken in the 105-cm Freon bubble chamber of the Moscow Engineering Physics Institute and the 2-meter neon-hydrogen bubble chamber of the Institute of Theoretical and Experimental Physics. The measurement procedure and analysis of

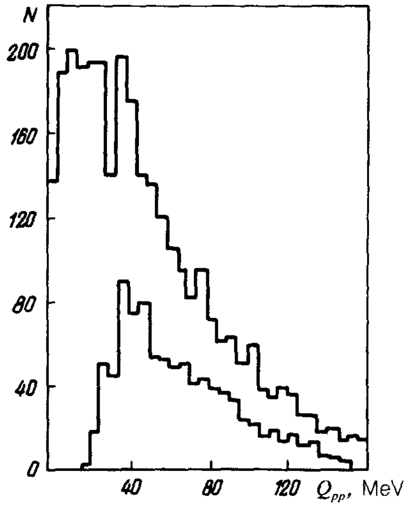

FIG. 2. The distribution based on $Q = (M_{\mathrm{eff}\,2p} - 2M_p)c^2$ for the cumulative protons. The lower histogram corresponds to $-0.4 < \cos\theta_{pp} < 0.2$.

the tracks were described elsewhere.[6,7] The reduced spectra of the effective masses include only the protons that were stopped in the active volume of the bubble chamber. The energies of protons were determined from their tracks. The mean error of the effective mass is ± 2 MeV/c^2.

All spectra presented here exhibit an intensification at $Q = 40$–50 MeV, which is consistent with one of the narrow resonances with a mass in the range 1.92–1.93 GeV/ c^2, which was observed elsewhere.

This intensification is seen in the events with two cumulative protons (1536 events) and in the events with three or more cumulative protons (1493 binary combinations).

Analysis of the distributions from the angle between two protons shows that the resonance region is best identified by the scatteirng of protons at an angle close to 90°. As an example, Fig. 2 shows a distribution basd on the variable Q for the events with $-0.4 < \cos\theta_{pp} < 0.2$ (the lower histogram).

The particles whose production is inconsistent with the kinematics of the collision of the incident particle with a free nucleon at rest are called cumulative particles. This definition applies to long-lived (stable) particles as well as to short-lived particles (resonances). In terms of this definition, the dibaryons observed in this experiment are cumulative dibaryons, since the incident particle is a meson. The mechanism responsible for their production cannot be reduced to the interaction of the incident meson with the correlated nucleon pair, since we observe a resonance even when both nucleons enter the back hemisphere. The dibaryon which goes to the back hemisphere in the laboratory frame corresponds to the most widespread understanding of heavy cumulative particles.

In summary, the experimental data obtained by us suggest that we may have detected a narrow cumulative dibaryon resonance. The cumulative dibaryon resonances may be used as additional information in our understanding of the mechanism of the interaction of elementary particles with atomic nuclei, in particular, the mechanism for the maximum nuclear fragmentation.

[1]S. A. Azimov, M. L. Allaberdin, S. O. Edgorov, *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. **40**, 316 (1984) [JETP Lett. **40**, 1109 (1984)].
[2]A. A. Baĭramov *et al.*, Yad. Fiz. **39**, 44 (1984) [Sov. J. Nucl. Phys. **39**, 26 (1984)].
[3]G. N. Agakishiev *et al.*, Preprint JINR 1-84-103, Dubna, 1984.
[4]K. Beshliu *et al.*, Preprint JINR D1-85-433, Dubna, 1985.
[5]K. N. Ermakov *et al.*, Preprint No. 1089, Leningrad Institute of Nuclear Physics, Leningrad, 1985.
[6]A. T. Bederkin *et al.*, Preprint JINR 13-6274, Dubna, 1972.
[7]Yu. A. Biryukov *et al.*, Preprint ITEP-107, Moscow, 1982.

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