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ABOUT THE COMMON FEATURES OF THE POSSIBLE EXOTIC STATES $K(1630)$, $N(3520)$, $\Sigma(3170)$ OBSERVED EXPERIMENTALLY

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Introduction

One of the important problems of particle physics is the question of existence of anomalous-narrow multiquark states predicted in a series of theoretical studies. For example, according to representations of a colour clusters' model a small width (the delay in a decay time) of multiquark states is stipulated by the existence inside the resonance structure of two colour quark clusters connected with each other by a colour exchange and spatially separated by a centrifugal barrier between them [1]. The possibility of forming anomalous-narrow states in processes with large momentum transfers ($t > M_p^2$) was considered [2]. This formation is explained by a more effective excitation of internal colour degrees of freedom in these processes where exotic quark systems are formed.

An experimental solution to the question about the existence of exotic hadrons and study of their internal properties as well as the character of the processes with formation of such hadrons are of particular importance for obtaining basic ideas about the nature of hadron matter.

The K(1630)-state observation

The analysis of experimental data taken with CERN 2m hydrogen bubble chamber concerning $\pi^- p$-interactions at 16 GeV/c shows up a narrow resonance structure K(1630) with $\Gamma = 16^{+19}_{-16}$ MeV/c^2 in the effective masses spectrum of the $K_s^0\pi^+\pi^-$ system. The width of the peak is comparable with the experimental resolution [3].

Slight enhancements in the region of 1630 MeV/c^2 were found in the effective masses spectra of the neutral systems $K^+\pi^+\pi^-\pi^-$, $K^-\pi^-\pi^+\pi^+$, $K_s^0\pi^+\pi^+\pi^-\pi^-$ and $K^+\pi^+\pi^-$, $K^+\pi^-\pi^-$ (exotic system) [3].

A new approach to analysis of peaks in masses spectra has been based [4]. This analysis distinguishes resonant state from statistical fluctuation by the kinematic features of its formation and decay.

An analysis of the structure $K(1630) \to K_s^0\pi^+\pi^-$ has revealed the kinematic features of its formation and decay. These features distinguish the group of events populating the peak's interval from the events in side intervals of the mass spectrum. The probability of a casual manifestation of these characteristics is less 10^{-7}. All these revealed features indicate the possible existence of a new state - strange $K(1630)$-meson [3-5].

Processes with formation of state K(1630) were selected. It was found that this new state $K(1630)$ (with about 8 standard deviations in the

peak region over the background in the mass spectrum of $K_s^0\pi^+\pi^-$) occurs in processes with large momentum transfers from primaries particles to secondaries: $< t' > \geq 3$ $(GeV/c)^2$, where $t' = |t - t_{\min}|$ and t - the square of the 4-momentum transfer.

The study of the angular correlations between the products of $K(1630) \rightarrow K_s^0\pi^+\pi^-$ decay has pointed out a space clusterization of decay products i.e. a clear angular separation in two parts: $K_s^0\pi^+$ and π^-. No indications for a cascade decay of the structure (which is usual for wide resonances) have been found. Possibly, the observable feature of the decay is a reflection of the colour clusters dynamics predicted by theoretical research [1].

Besides, for the events from the peak interval, other kinematic feature is observed which may be associated with manifestation of the spin ($J \geq 1$) of the contemplated exotic state [3].

An analysis of the published data on $K\pi\pi$-systems has shown that in other experiments the resonant states in $K\pi\pi$-systems were studied mainly in peripheral processes with small momentum transfers at rather small part of events with high transfers from primary particles.

In the combined effective masses spectra of various $K\pi\pi$ systems [3] involving data from different bubble chamber experiments for separate channels of reactions at the energies of 4-16 GeV, a prominent peak is observed in the area of well known wide resonance $K_2^*(1430)$ and a weak narrow enhancement near 1630 MeV/c^2.

The CERN experiment with the wide-aperture $OMEGA$-spectrometer studied the production of wide resonances in the reaction $K^-p \rightarrow \overline{K}^0\pi^+\pi^-n$ at the incident momentum of 10 GeV/c [6]. In the spectrum of masses of $\overline{K}^0\pi^+\pi^-$-system, besides the known wide resonances $K_2^*(1430)$, $K_3^*(1780)$, a clear narrow peak was observed at the mass of 1630 MeV/c^2 interpreted by the authors [6] as a statistical fluctuation. From the results presented in [6] it follows that of the registered events about 10 % have $t'(p \rightarrow n) > 0,8$ $(GeV/c)^2$.

In other electronic experiments [7] the system $\overline{K}^0\pi^+\pi^-$ was studied at $t'(p \rightarrow n) < 0{,}2$ and $0{,}3$ $(GeV/c)^2$. No enhancement in the region of 1630 MeV/c^2 has been observed.

The N(3520), Σ(3170) -states observations

It is worth mentioning that the anomalous-narrow resonance baryon states $N(3520)$ and $\Sigma(3170)$ observed earlier [8] are also formed in processes with large momentum transfers and decay into multiparticle

systems with strange particles.

The resonance state $N(3520)$ with $\Gamma = 6^{+21}_{-6}$ MeV/c^2 has been detected in $\pi^- p$-interactions at 16 GeV/c in a mass spectrum of $K^0_s K^+ p\pi^-\pi^-$ [9]. Indication is received, what this state is formed apparently in quasi-two-particle reactions with accompaniment of meson resonance state with $M \approx 1,9\ GeV/c^2$. The peculiar features of formation and decay distinguishing the group of events of the peak area from the events of other intervals of the mass spectrum have been found. The probability of a casual manifestation of these features is less 10^{-8}. For the most part of the events from the peak area (10 standard deviations), in c.m.s. of $\pi^- p$-interactions, the structure is directed to the hemisphere of primary π^--meson and is formed in the processes with large momentum transfers: $< t'(p_I \to K^0_s K^+ p\pi^-\pi^-) > \ = 6.3 \pm 0.6\ (GeV/c)^2$. The special feature of the decay points out a space clusterization of colourless decay products $N(3520)$, their angular separation in two parts: $K^+ p\pi^-\pi^-$ and K^0_s.

The resonance state $\Sigma(3170)$ with Γ<20 MeV/c^2 has been detected in two independent experiments of CERN and ANL (USA) ($K^- p$-interactions at 6.5 and 8.25 GeV/c) [10]. This state is formed in quasi-two-particle reactions with accompaniment of π^--meson and decays into $\Sigma K\overline{K} + (\geq)2\pi$, $\Lambda K\overline{K} + (\geq)2\pi$, $\Xi K + (\geq)3\pi$. In c.m.s. of $K^- p$-interactions $\Sigma(3170)$ is directed to the hemisphere of flying K^--meson; therefore, this state is also formed in the processes with large momentum transfers.

Conclusion

The $K(1630)$, $N(3520)$, $\Sigma(3170)$ -states are distinguished from the known hadron resonances with light quarks by anomalous-narrow width. These states are formed in processes with large 4-momentum transfers and decay into multiparticle systems with strange particles and pions. The space clusterization (angular separation on two parts) of decay products is observed for $K(1630)$ and $N(3520)$. Possibly, this feature is a reflection of the colour clusters dynamics predicted by theoretical research [1]. Such an analysis was not performed for $\Sigma(3170)$.

The similar peculiarities of the three states discussed above provide a way for assumption of the existence of a new group of hadron states with similar properties. To clarify the questions related with the interpretation of these states, it would be of interest to perform searches in processes with large 4-dimensional momentum transfers ($t > M_p^2$)

in other experiments at rather low energies. Studies of these processes could be possible at the installations with the area of particle registration close to a 4π-geometry.

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Карнаухов В.М., Мороз В.И., Кока К. Е1-2001-185
Общие особенности возможных экзотических состояний
$K(1630)$, $N(3520)$, $\Sigma(3170)$, обнаруженных экспериментально

Обсуждаются экспериментальные наблюдения аномально узких адронных структур $K(1630)$, $N(3520)$, $\Sigma(3170)$. Эти предполагаемые экзотические состояния образуются в процессах с большими четырехмерными переданными импульсами. Особенность распада указывает на пространственную кластеризацию бесцветных продуктов распада $K(1630)$ и $N(3520)$, их угловое разделение на две части.

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About the Common Features of the Possible Exotic States
$K(1630)$, $N(3520)$, $\Sigma(3170)$ Observed Experimentally

Experimental observations of the anomalous-narrow resonant hadronic structures $K(1630)$, $N(3520)$, $\Sigma(3170)$ are discussed. These supposed exotic states are produced in processes with large 4-momentum transfers. The special feature of the decay points out a space clusterization of colourless decay products of $K(1630)$ and $N(3520)$, their angular separation in two parts.

The investigation has been performed at the Laboratory of Information Technologies, JINR.

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