Status of 0^{-+} in $\omega\pi^-\pi^0$ and $\pi^+\pi^-\pi^-$ channels.

Dmitry Amelin, VES collaboration [1]

IHEP, Protvino

Abstract. Resonance-like behaviour of phase of the 0^{-+} $\rho\pi^-$ wave is found at $M \simeq 1.6 MeV$ at VES spectrometer in $\pi^+\pi^-\pi^-$ system. The results of the combined fit of 0^{-+} waves obtained from PWA of the $\omega\pi^0\pi^-$ and $\pi^+\pi^-\pi^-$ systems are presented.

In the last few years significant attention was given to the investigations of the $J^{PC} = 0^{-+}$ waves in the mass region $\simeq 1.8\,GeV$. This activity was partially stimulated by the progress in phenomenological models. For instance, the existence of a hybrid meson π_H with quantum numbers $J^{PC} = 0^{-+}$ and mass $\simeq 1.8\,GeV$ is predicted in flux tube model [1,2].On the other hand, the 0^{-+} $q\bar{q}$ state $\pi(1800)$ is predicted in the same mass region. Branching fractions of these states estimated in flux tube model [3,4] are shown in the Tab.1 (from [3]).

TABLE 1. Partial widths of 3S and hybrid $\pi(1800)$ states.

	$\rho\pi$	$\rho\omega$	$\rho(1465)\pi$	$f_0(1300)\pi$	$f_2\pi$	K*K	total
$\pi(1800)$	30	74	56	6	29	36	231
π_H	30	0	30	170	6	5	≈ 240

State $\pi(1800)$ was experimentally observed in various decay modes [5–10]. Its properties are very unusual, it has unexpectedly high decay rate into $f_0(980)\pi^-$ channel and very low probability of the decay into $\rho\pi^-$, its mass varies from $1.74\,GeV$ in $\omega\pi^0\pi^-$ system up to $1.84\,GeV$ in the $\eta\eta\pi^-$.

Wave 0^{-+} was observed at the VES setup on $37\,GeV$ π^- beam by PWA method in many final states: $f_0(980)\pi^-$, $f_0(1300)\pi^-$, $a_0(980)\eta$, $f_0(1500)\pi^-$, $\eta\eta\pi^-$,

[1] D. Amelin, E. Berdnikov, S. Bityukov, G. Borissov, Yu. Gouz, V. Dorofeev, R. Dzhelyadin, A. Ekimov, A. Karyukhin, I. Kachaev, Yu. Khokhlov, V. Konstantinov, S. Kopikov, M. Kostrikov, V. Kostyukhin, S. Likhoded, V. Matveev, A. Ostankov, B. Polyakov, D. Ryabchikov, O. Soloviyanov, A. Solodkov, E. Starchenko, N. Vishnevski, E. Vlassov, A. Zaitsev, **IHEP, Protvino**, G. Sekhniaidze, E. Tskhadadze, **IPh, Tbilisi**

$K_0^*(1430)K^-$, $K^*(892)K^-$, $\rho\pi^-$, $\eta\eta\prime(958)\pi^-$. Some of these results are shown in Fig.1a.

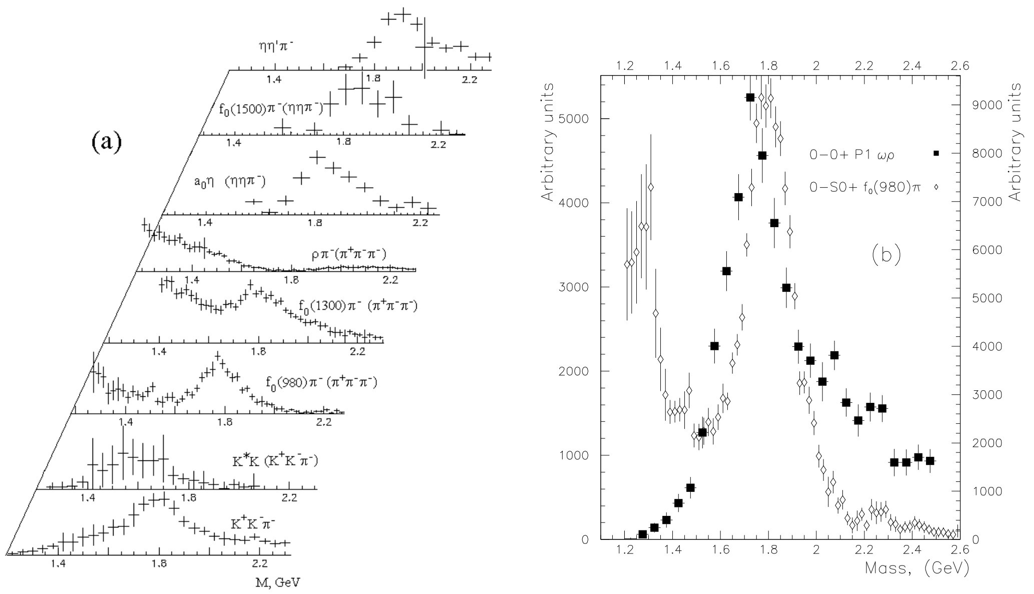

FIGURE 1. a) Some of the 0^{-+} waves seen at VES. b) Variation of the 0^{-+} resonance parameters in $f_0(980)\pi$ and $\omega\rho$ channels.

Fig.2 represents 0^{-+} waves obtained by the PWA of the $\pi^+\pi^-\pi^-$ and $\omega\pi^0\pi^-$ systems. The resonance $\pi(1800)$ is clearly seen in the waves $0^-Sf_0(980)$ and $0^-S\,f_0(1300)$ (Fig.2(a,b)). There is no any significant structure in the $\rho\pi^-$ wave at the $\pi(1800)$ mass region (Fig.2(c)). The relative phases of the $0^-S\,f_0(980)$ and $0^-S\,f_0(1300)$ waves show resonance behaviour and increase by $\sim 100^0$ with respect to $1^+S\,\rho\pi^-$ and $2^-S\,f_2(1270)\pi^-$ in the mass region $1.7 \div 1.9\,GeV$. Nevertheless the phase of $0^-S\,f_0(980)$ also rises relatively to $0^-S\,f_0(1300)$ (Fig.2e). This fact can be attributed to the existence of background under $\pi(1800)$ signal. Although there is no visible structure in the intensity of the $\rho\pi^-$ wave, its relative phase with respect to $0^-S\,f_0(980)\pi$, $0^-S\,f_0(1300)\pi$, $1^+S\,\rho\pi$ shows the significant rise by $\sim 100^0$ at $M \simeq 1.6\,GeV$ (Fig.2f).

A structure with maximum at $M \simeq 1.75\,GeV$ is clearly seen in the wave $0^-P\,\omega\rho$ (Fig.2d). It should be pointed out that the mass of this object differs from $\pi(1800)$ in the $\pi^+\pi^-\pi^-$ decay modes (see Fig.1(b)). In addition, there is some shoulder to the right of the peak. Mentioned above variation of the mass in different decay channels may arise from the interference of $\pi(1800)$ with background.

In order to describe the phase motion of the wave $0^-S\,\rho\pi^-$ and variation of the position of $\pi(1800)$ peak in different channels, combined fit of the following data set was performed:

— $0^-S\,f_0(1300)\pi^-$, $0^-S\,f_0(980)\pi^-$, $0^-P\,\rho\pi^-$ amplitudes in the $\pi^+\pi^-\pi^-$ system;

— $0^- P\, \omega\rho^-$ amplitude in the $\omega\pi^-\pi^0$ system;
— relative phases:
$\varphi(0^- S\, f_0(980)\pi^-) - \varphi(0^- S\, f_0(1300)\pi^-)$ and $\varphi(0^- P\, \rho\pi^-) - \varphi(0^- S\, f_0(1300)\pi^-)$.

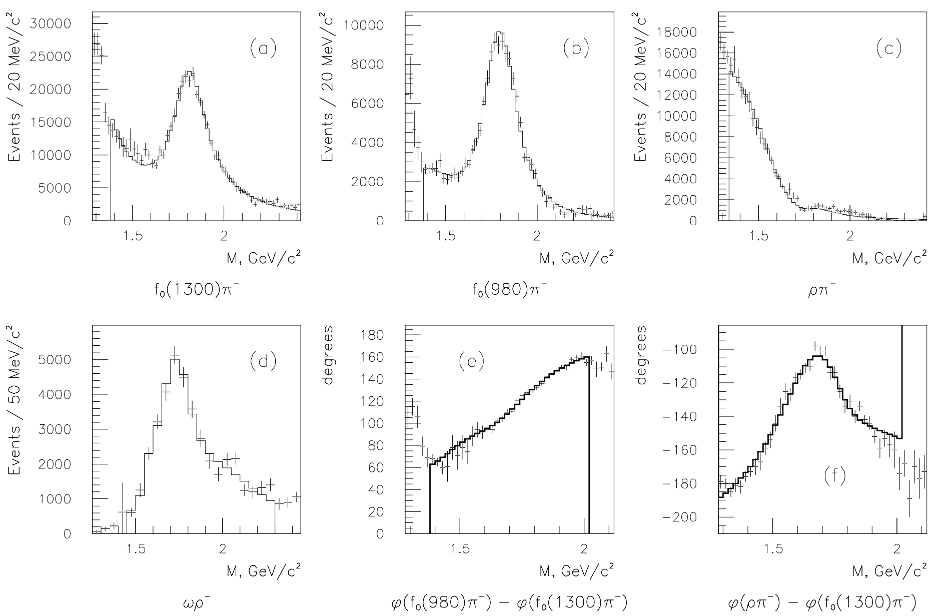

FIGURE 2. Intensity of 0^{-+} waves in $\pi^+\pi^-\pi^-$ and $\omega\rho$ channels. Description of the experimental data by the model described in the text is shown by solid line.

Fit was performed in the following model. A relativistic (or non-relativistic) Breit-Wigner resonance with free parameters or Deck-type background was introduced in all 3π amplitudes to describe the bump in the low mass region at $M \simeq 1.3\, GeV$. The $\pi(1800)$ was represented by BW resonance (relativistic or non-relativistic) in all four waves. Experimental data were fitted by the coherent sum of these two amplitudes. No satisfactory description was obtained in this model. The major reason of the bad description is resonance-like phase motion in the $\rho\pi^-$ wave (Fig.2f). This phase motion can not be described by the model with only one resonance with mass more than $\sim 1.4\, GeV$. Coherent adding of the supplementary BW amplitude in all four channels gives a good description of all experimental data (Fig.2). The resulting parameters of $\pi(1800)$ are stable under variation of the model. The following parameters of the resonances are obtained from the fit:

$\pi(1800)$	$M = 1790 \pm 6 \pm 12\, MeV$		$\Gamma = 225 \pm 9 \pm 15\, MeV$
$\Gamma(f_0(980)(\pi^+\pi^-)\pi)$	$: \Gamma(f_0(1300)(\pi^+\pi^-)\pi)$	$: \Gamma(\rho\pi)$	$: \Gamma(\omega\rho^-) =$
1	$: 1.0 \pm 0.2$	$:< 0.1\, at\, 90\% C.L.$	$: 1.4 \pm 0.7$

$\pi(1600)$ $\quad$ $M = 1580 \pm 43 \pm 75\, MeV$ $\quad$ $\Gamma = 450 \pm 50 \pm 100\, MeV$

These results may be considered as an indication on the existence of a new broad resonance at $M \simeq 1.6\, GeV$.

The fit describes the intensity of the $0^{-+} P\, \omega\rho$ wave as a superposition of $\pi(1800)$ and $\pi(1600)$ resonances. It should be noted that $\pi(1800)$ has high decay rate into $\omega\rho$ channel. Branching fractions of the $\pi(1600)$ are model dependent but the $\rho\pi$ and $\omega\rho$ are dominate decay modes.

Parameters of the $\pi(1600)$ and $\pi(1800)$ obtained from the fit do not correspond to predictions of the flux tube model for the pure hybrid and $q\bar{q}$ states and therefore these states should be considered as mixtures of $\pi(1600)$ and $\pi(1800)$.

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CONCLUSION

Combined fit of 0^{-+} waves in $f_0(980)\pi$, $f_0(1300)$, $\rho\pi$ and $\omega\rho$ decay channels gives an indication on the existence of a broad resonance at $m \simeq 1.6\, GeV$, in addition to $\pi(1800)$.

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