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Resonant phenomena in E852 experimental data
(Status of Light Exotic Mesons)

V. L. Korotkikh

In this note we pay attention on the observation of the interfering effect in the experimental data. Its concentrate image is the relative phase of two interfering waves $\Delta(m)$.

Let's consider two waves which give contribution to experimental measured intensity

$$|f(m)|^2 = |D_+(m) + P_+(m)|^2; \tag{1}$$
$$= |D_+(m)|^2 + |P_+(m)|^2 + 2Re(|D_+(m)||P_+(m)|\ e^{i\Delta(m)}); \tag{2}$$
$$\Delta(m) = \delta_1(m) - \delta_2(m) + \delta_{pr}; \tag{3}$$

It's known if one wave is small then the interfering member in (1) may be large and comparable with sum of two intensities. In our E852 data an exotic effect for $\eta\pi^-$ is $|P_+(m)|^2/|D_+(m)|^2 \approx 0.05$ and for $\eta\pi^0 \approx 0.40$. So the contribution of interfering member may change from zero to 30%, depending on phase value. Remark, if the resonances in both wave have close masses and widths then the relative phase is flat. The result of KEK analysis of $\eta\pi^-$ system shew a flat mass dependence of relative phase.

There are two groups of physical community, studying Exotic mesons, which are debating the present experimental data. One group (I) claim the Exotic effect yes, other group (II) say no. Discussion is on $\pi_1(1400)$ and $\pi_1(1600)$. Let's move aside the theoretical interpretation and discuss only the experimental effect.

Not clear expressive bump is observed in mass distribution of $P+$ wave of $\eta\pi^-$ and $\eta\pi^0$ systems at mass region 1200-1400 MeV in $\pi^- p \to Xp(n)$ (KEK, E852, GAMS, IHEP). Crystal Barrel experiment need the resonant state in $P+$ wave of $\eta\pi^\pm$ system to describe Dalitz plot in $\bar{p}n$ and $\bar{p}p$ annihilation.

A bump near mass 1600 MeV of $\rho\pi$ system is observed in P wave with low-wave set (20 waves) of PWA and disappeared with high-wave set (40 waves).

Let's underline some details of results.

I $\eta\pi^0$ SYSTEM

Main objection of group II is based on an argument of very small Exotic effect on level of intensity exotic wave. But Exotic effect is not small because the interfering term is large. IU group analyzed $\eta\pi^0$ system with decay $\eta \to 2\gamma$ with relative large statistic (45K events). It was found out that the resonant parameters of Exotic state in P_+ wave depend on t'- transfer momentum squared. It's a second argument against the resonant nature of P_+ bump. Remark, that for the whole and low - t' - region the IU resonant parameters and parameters of MSU analysis of $\eta\pi^0$ system (with decay $\eta \to \pi^+\pi^-\pi^+$, 22K events) are close

$$IU: \quad m = 1271 \pm 17 MeV/c^2, \quad \Gamma = 660 \pm 48 MeV/c^2,$$
$$MSU: \quad m = 1257 \pm 20 \pm 25 MeV/c^2, \quad \Gamma = 354 \pm 64 \pm 60 MeV/c^2,$$

and for low-t'

$$IU: \quad m = 1301 \pm 14 MeV/c^2, \quad \Gamma = 190 \pm 32 MeV/c^2,$$

For two pseudo-scalar systems there is a problem with ambiguous solutions. This problem was not resolved exactly in IU analysis. They select a physical solution by the curve of $a_0(980)$ and $a_2(1320)$ resonances, described by BW amplitudes. S. Sadovsky (Soviet Physics Doklady **36**, 537 (1991)) shew that the physical solution may be select using D_0 and D_+ waves as the more sensitive waves to ambiguous solutions. It is necessary to have large statistic for this aim. Perhaps, IU group failed to use this method.

MSU group failed also to select exact physical solution (small statistic) and used two additional methods to prove truthfulness of resonant parameters and calculate systematical errors.

So, MSU group has the next arguments of the experimental measurement of resonant state in P_+ wave:

1.The relative phase can't be described by present only resonant in D_+ wave (compare solid and dotted lines in fig. 1 c)).

2.Non resonant hypothesis in P_+ wave gives worse fit of the main waves in $\eta\pi^0$ system ($\chi^2_{res}/DoF = 32/28, \quad \chi^2_{nonres}/DoF = 84/28$)

3. Multifit of many sets of ambiguous solutions gives more probability hypothesis as the resonant state with the same parameters as in fit of average solutions.

4. Mass-dependent fit, which doesn't dependent on problem ambiguous solutions gives the same resonant parameters.

Main argument is the mass movement of relative phase.

II $\rho\pi$ SYSTEM

Here are only some comments on IU analysis of $\rho\pi$ system in paper A.R. Dzierba *et al.*, Phys. Rev. D **67**, 094015 (2003). You see from fig. (2) a bump near $1600 MeV$ disappiars, but the relative phase doesn't changes when the analysis is done with high-wave set. The same is for neutral mode $\pi^-\pi^0\pi^0$ system.

It is difficult to agree that there is no Exotic phenomena in $\rho\pi$ system near mass 1600 MeV. There is some intrinsic property of PWA which smears a bump of seperate wave with increasing of wave numbers. Let me remind one old methodical result in R. Lindenbucsh's thesis (1997). He takes a bump of $a_0(980)$ in only S_0 wave, simulates events and make PWA with 7 waves. Then in all waves there are bumps near 980 MeV.

So, the mass movement of relative phase in $\rho\pi$ system and its difference from expressive resonant form of $a_2(1700)$ gives an argument in favour of resonant $\pi_1(1600)$.

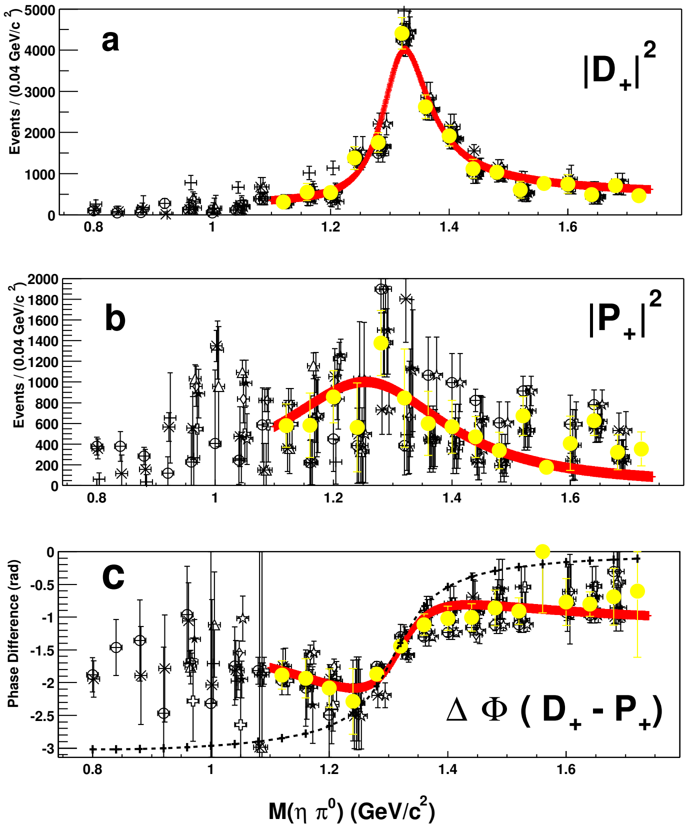

FIGURE 1. The Partial Wave Analysis (PWA) and Mass-Dependent Fit (MDF) results for $\eta\pi^0$ system. The points shown in each mass bin are the eight ambiguous PWA solutions. a) the D_+ wave intensity; b) the P_+ wave intensity; and c) the relative phase between the P_+ and D_+ waves. The lines show the MDF results. The average PWA solution in each mass bin is plotted using grey points. The dotted line in (c) is the phase difference if the P_+ phase is constant.

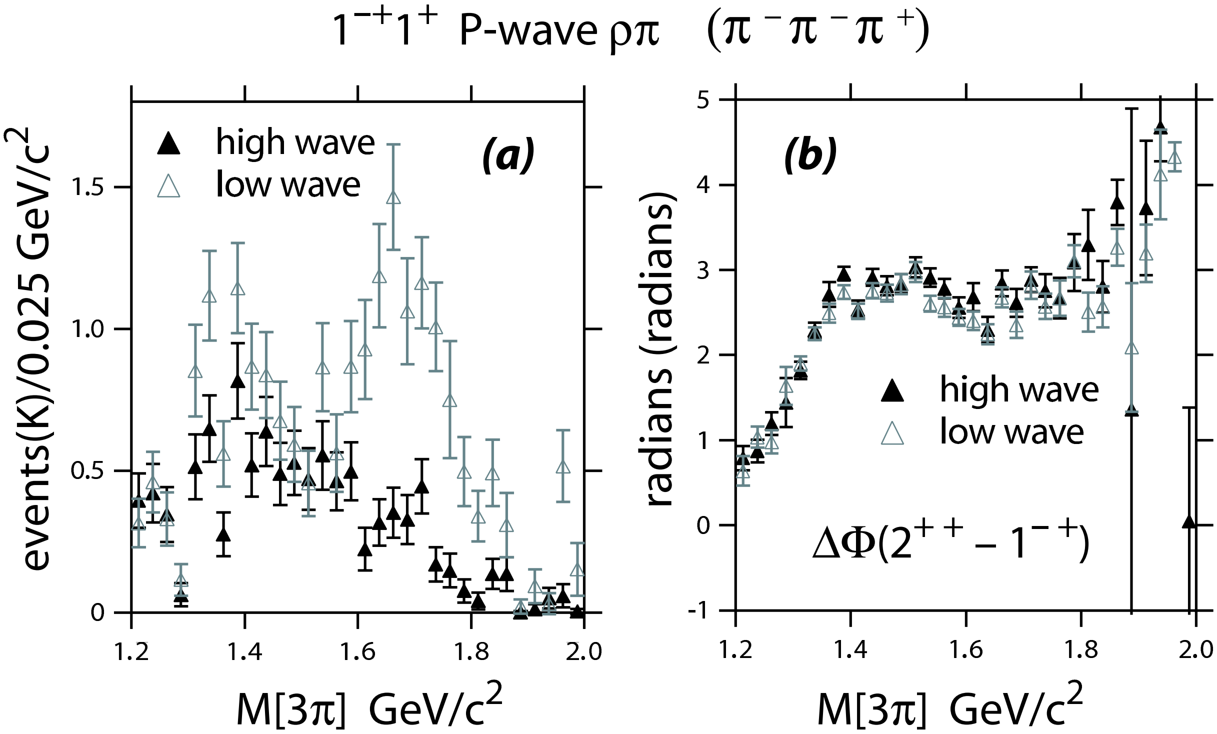

FIGURE 2. The Partial Wave Analysis (PWA) of $\rho^0\pi^-$ system of IU group. Comparison for high-wave set and low-wave set PWA. a) The intensity of P_- wave, b) the relative phase D_+ and P_- waves.