PROCEEDINGS OF SCIENCE

Light meson decays at BESIII

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At present the world's largest sample of 1.3 billion J/psi decay has been collected by the BESIII detector, which provides a unique opportunity to investigate light meson decays. The η and $\eta\prime$ hadronic decays are sensitive tools for the investigations of π-π and η-π interactions, symmetry breaking, and for testing the Chiral Perturbation Theory. In this article, BESIII presents new results on amplitude analyses of the Dalitz decays $\eta\prime \to 3\pi$, $\eta\prime \to \eta\pi\pi$, $\eta\prime \to \gamma\pi\pi$ and $\eta\prime \to \gamma\gamma\pi^0$, on the observation of new decay modes and on searches for rare or forbidden decays. The $a_0(980)$-$f_0(980)$ mixing is an important probe to the nature of these two light scalars. The first observation of $a_0(980)$-$f_0(980)$ mixing will be presented.

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1. Introduction

BESIII started data taking for physics since 2009, up to now, the world largest data samples at J/ψ, ψ', $\psi(3770)$, $\psi(4040)$, $Y(4260)$,..., are already collected. The results reported in this talk are based on the 1310M J/ψ data sample.

2. $\eta\prime \to \pi^{+(0)}\pi^{-(0)}\pi^0$ [1]

Within the framework of chiral effective field theory combined with a relativistic coupled-channel approach, Ref. [2] predicts that the $\eta\prime \to \rho^{\pm}\pi^{\mp}$ P-wave contribution should be larger than $\eta\prime \to \pi^+\pi^-\pi^0$.

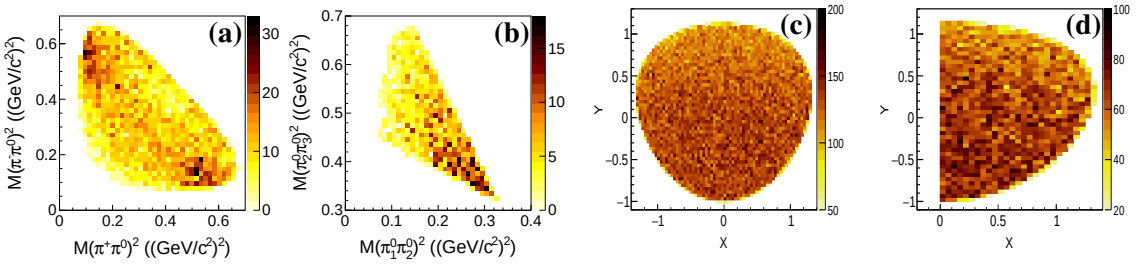

Figure 1: Dalitz plots for candidate events selected from data (a) $\eta\prime \to \pi^+\pi^-\pi^0$. (b) $\eta\prime \to \pi^0\pi^0\pi^0$. (c) $\eta\prime \to \eta\pi^+\pi^-$ and (d) $\eta\prime \to \eta\pi^0\pi^0$

A Dalitz plot analysis based on the formalism of the isobar model is performed for both the $\eta\prime \to \pi^+\pi^-\pi^0$ (Fig. 1 (a)) and $\eta\prime \to \pi^0\pi^0\pi^0$ (Fig. 1 (b)) events. The data are well described by three components: P-wave $(\rho^{\pm}\pi^{\mp})$, resonant S-wave $(\sigma\pi^0)$, and phase-space S-wave $(\pi\pi\pi)$. The fit results are presented in Table 1, the P-wave contribution from $\rho^{\pm}$ is observed for the first time with high statistical significance.

Table 1: Yields with statistical errors, detection efficiencies, and branching fractions for the studied $\eta\prime$ decay modes, where the first errors are statistical, the second systematic, and the third model dependent.

Decay mode	Yield	ε (%)	$\mathscr{B}$ (10^{-4})
$\pi^+\pi^-\pi^0$	6067 ± 91	25.3	$35.91 \pm 0.54 \pm 1.74$
$\pi^0\pi^0\pi^0$	2015 ± 47	8.8	$35.22 \pm 0.82 \pm 2.54$
$\rho^{\pm}\pi^{\mp}$	1231 ± 98	24.8	$7.44 \pm 0.60 \pm 1.26 \pm 1.84$
$(\pi^+\pi^-\pi^0)_S$	6580 ± 134	26.2	$37.63 \pm 0.77 \pm 2.22 \pm 4.48$

3. $\eta\prime \to \pi^{+(0)}\pi^{-(0)}\eta$ [3]

The two dominant hadronic decays, $\eta' \to \eta\pi^+\pi^-$ and $\eta' \to \eta\pi^0\pi^0$, are believed to be an ideal place to study $\pi\pi$ and $\eta\pi$ scattering [4], which may lead to a variation in the density of the Dalitz plot.

In experimental analyses, the decay amplitude squared is parametrized as $|M(X,Y)|^2 = N(1 + aY + bY^2 + cX + dX^2 + \ldots)$, which is the so-called general representation. A second parametrization for the decay amplitude squared used by previous experiments as $|M(X,Y)|^2 = N(|1+\alpha Y|^2 + cX + dX^2 + \ldots)$, the so-called linear representation. Unbinned maximum likelihood fits to the data (Fig. 1(c) and (d)) are performed to determine the free parameters in the decay amplitude squared.

In case of the linear representation, the results are in agreement with previous measurements and also provide a reasonable description on the X projection for both decay modes. However, the goodness of fit on the Y projections are worse than the general one.

4. $\eta\prime \to \gamma\pi^+\pi^-$ [5]

In our analysis, binned maximum likelihood fits are performed to the $M(\pi^+\pi^-)$ distribution between 0.34 and 0.90 GeV/c^2 with different scenarios (Fig. 2). For the first time, the ω contribution is observed in the dipion mass spectrum in the decays $\eta\prime \to \gamma\pi^+\pi^-$. The model-dependent fit indicates that only the components of ρ^0 and ω as well as the corresponding interference fail to describe the data, and an extra significant contribution, *i.e.* the box anomaly or $\rho(1450)$, is found to be necessary for the first time.

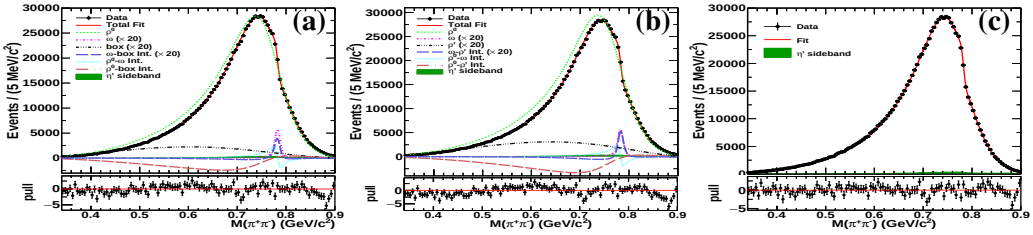

Figure 2: Model-dependent fit results in case (a) ρ^0-ω-box anomaly and (b) ρ^0-ω-$\rho\prime$. To be visible, the small contributions of ω, the box anomaly ($\rho\prime$) and the interference between ω and the box anomaly ($\rho\prime$) are scaled by a factor of 20. (c) Model-independent fit results with ω interference.

As suggested by Ref. [8], a model independent approach is also implemented to investigate the decay dynamics. In contrast to the conclusion in Ref. [8] based on the limited statistics from the Crystal Barrel experiment [9], our result indicates that the quadratic term and the ω contribution in $P(s)$, corresponding to statistical significances of 13σ and 34σ, respectively, are necessary.

5. $\eta\prime \to \gamma\gamma\pi^0$ [10]

In this article, the branching fraction of the inclusive decay is measured for the first time to be $\mathscr{B}(\eta\prime \to \gamma\gamma\pi^0)_{Incl.} = (3.20 \pm 0.07(\text{stat}) \pm 0.23(\text{sys})) \times 10^{-3}$. The $M^2_{\gamma\gamma}$ dependent partial decay widths are also determined. In addition, the branching fraction for the nonresonant decay is determined to be $\mathscr{B}(\eta\prime \to \gamma\gamma\pi^0)_{NR} = (6.16 \pm 0.64(\text{stat}) \pm 0.67(\text{sys})) \times 10^{-4}$. As a validation of the fit, the product branching fraction with the ω intermediate state involved is obtained to be $\mathscr{B}(\eta\prime \to \gamma\omega) \cdot \mathscr{B}(\omega \to \gamma\pi^0) = (2.37 \pm 0.14(\text{stat}) \pm 0.18(\text{sys})) \times 10^{-3}$, which is consistent with the PDG value.

6. $a_0^0(980)$-$f_0(980)$ Mixing [11]

The mixing mechanism in the system of $a_0^0(980)$-$f_0(980)$, which was first proposed in the late 1970s [12], is thought to be an essential approach to clarify the nature of these two mesons. Inspired by Refs. [13, 14], a first quantitative calculation was carried out to examine the $a_0^0(980) \leftrightarrow f_0(980)$ mixing with the isospin-violating processes of $J/\psi \to \phi f_0(980) \to \phi a_0^0(980) \to \phi\eta\pi^0$ and $\chi_{c1} \to \pi^0 a_0^0(980) \to \pi^0 f_0(980) \to \pi^0\pi^+\pi^-$ [15, 16].

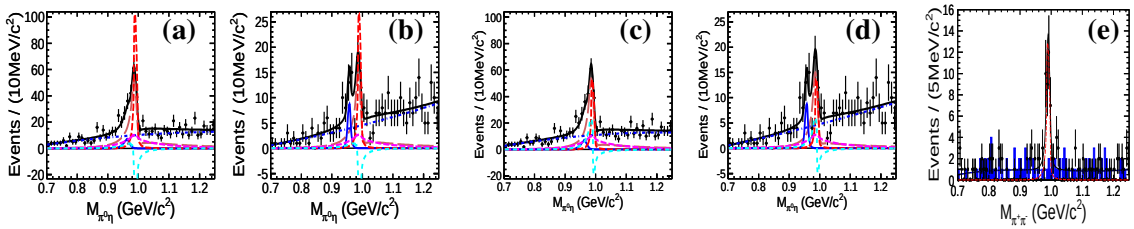

Figure 3: Fits to the $M_{\eta\pi^0}$ spectra of the $J/\psi \to \phi\eta\pi^0$ for destructive ((a),(b)) and constructive ((c),(d))) interference in the decay $\eta \to \gamma\gamma$ ((a),(c)) and $\eta \to \pi^+\pi^-\pi^0$ ((b),(d)), respectively. And fit to $M_{\pi^+\pi^-}$ spectrum for the $\chi_{c1} \to \pi^+\pi^-\pi^0$ in the χ_{c1} signal region (e).

Based on the input parameters of $a_0^0(980)$ and $f_0(980)$ in Refs. [15], the signals of $f_0(980) \to a_0^0(980)$ and $a_0^0(980) \to f_0(980)$ are observed for the first time with statistical significances of 7.4σ and 5.5σ, respectively. The corresponding branching fractions of the mixing signal and the mixing intensities as well as the EM process of $J/\psi \to \phi a_0^0(980) \to \phi\eta\pi^0$ are also measured.

References

[1] M. Ablikim *et al.* (BESIII Collaboration), Phys. Rev. Lett. 118, 012001 (2017).

[2] B. Borasoy and R. NiÃ§ler, Eur. Phys. J. A 26, 383 (2005).

[3] M. Ablikim *et al.* (BESIII Collaboration), Phys. Rev. D 97, 012003 (2018).

[4] A. H. Fariborz and J. Schechter, S. Zarepour, and S. M. Zebarjad, Phys. Rev. D 90, 033009 (2014).

[5] M. Ablikim *et al.* (BESIII Collaboration), Phys. Rev. Lett. 120, 242003 (2018).

[6] M. Benayoun *et al.*, Z. Phys. C 58, 31 (1993); M. Benayoun, P. David, L. DelBuono, O. Leitner, Eur. Phys. J. C 65, 211 (2010).

[7] J. P. Lees *et al.* (BABAR Collaboration), Phys. Rev. D 86, 032013 (2012).

[8] F. Stollenwerk *et al.*, Phys. Lett. B 707, 184 (2012).

[9] A. Abele *et al.* (Crystal Barrel Collaboration), Phys. Lett. B 402, 195 (1997).

[10] M. Ablikim *et al.* (BESIII Collaboration), Phys. Rev. D 96, 012005 (2017).

[11] M. Ablikim *et al.* (BESIII Collaboration), Phys. Rev. Lett. 121, 022001 (2018).

[12] N. N. Achasov, S. A. Devyanin, and G. N. Shestakov, Phys. Lett. B 88, 367 (1979).

[13] F. E. Close and A. Kirk, Phys. Lett. B 515, 13 (2001).

[14] C. Hanhart, B. Kubis, and J. R. Pelaez, Phys. Rev. D 76, 074028 (2007).

[15] J. J. Wu and B. S. Zou, Phys. Rev. D 78, 074017 (2008).

[16] M. Bayar, V. R. Debastiani, Phys. Lett. B 775, 94 (2017).