

spectroscopy at besin

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• Peak luminosity: 1.1×10³³ cm⁻²s⁻¹ From 2009: BESIII physics runs



Unique dataset: high statistics and clean environment



Rich BESIII Physics Program



Hadron Spectroscopy



A lot of exotic states observed, but their nature is far from being understood!

Hadron Spectroscopy: BESIII Contribution



J/Ψ Radiative Decays

A gluon rich environment

Glueballs and Hybrids



- Glueballs with ordinary J^{PC} mix with $q\overline{q}$ mesons
- $B(J/\Psi \rightarrow \gamma f_0(1710)) \times 10$ larger then $f_0(1500)$
- f₀(1710) largely overlaps with scalar glueball

- Hybrid $J^{PC} = 1^{-+}$ nonet is predicted to be the lightest
- Only isovector candidates observed so far: π₁(1400), π₁(1600), π₁(2015)
- Isoscalar 1⁻⁺ hybrids can decay to ηη' in P-wave (PRD 83,014021, PRD 83, 014006, Eur.Phys.J.Plus 135, 945)





Further Checks on η_1 (1855)

The distribution of $cos(\theta_{\eta})$ in a region of $M(\eta\eta')$ can be expressed as a model independent expansion in Legendre polynomials.

The coefficient are the unnormalized moment of the expansion.

$$\langle Y_l^0 \rangle \equiv \sum_{i=1}^{N_k} W_i Y_l^0(\cos \theta_{\eta}^i)$$

Narrow structure in $\langle Y_1^0 \rangle$

Cannot be described without a 1-+ component $\eta_1(1855) \rightarrow \eta\eta'$ is needed



Comments on $f_0(1500)$ and $f_0(1710)$ from PWA of J/ $\Psi \rightarrow \gamma \eta' \eta$

Decay mode	Resonance	$M ({\rm MeV}/c^2)$	Γ (MeV)	$M_{\rm PDG}~({\rm MeV}/c^2)$	Γ_{PDG} (MeV)	B.F. (×10 ⁻⁵)	Sig.
	$f_0(1500)$	1506	112	1506	112	$1.81 \pm 0.11^{+0.19}_{-0.13}$	$\gg 30\sigma$
	$f_0(1810)$	1795	95	1795	95	$0.11\pm0.01^{+0.04}_{-0.03}$	11.1 <i>σ</i>
	$f_0(2020)$	$2010\pm6^{+6}_{-4}$	$203\pm9^{+13}_{-11}$	1992	442	$2.28 \pm 0.12^{+0.29}_{-0.20}$	24.6 <i>o</i>
$J/\psi \rightarrow \gamma X \rightarrow \gamma \eta \eta'$	$f_0(2330)$	$2312\pm7^{+7}_{-3}$	$65\pm 10^{+3}_{-12}$	2314	144	$0.10\pm0.02^{+0.01}_{-0.02}$	13.2 <i>σ</i>
	$\eta_1(1855)$	$1855\pm9^{+6}_{-1}$	$188 \pm 18^{+3}_{-8}$		• • •	$0.27\pm0.04^{+0.02}_{-0.04}$	21.4 <i>o</i>
	$f_2(1565)$	1542	122	1542	122	$0.32\pm0.05^{+0.12}_{-0.02}$	8.7σ
	$f_2(2010)$	$2062\pm6^{+10}_{-7}$	$165\pm17^{+10}_{-5}$	2011	202	$0.71 \pm 0.06^{+0.10}_{-0.06}$	13.4 <i>σ</i>
	$f_4(2050)$	2018	237	2018	237	$0.06\pm0.01^{+0.03}_{-0.01}$	4.6σ
	0 ⁺⁺ PHSP				•••	$1.44\pm0.15^{+0.10}_{-0.20}$	15.7 <i>σ</i>
$J/\psi \rightarrow \eta' X \rightarrow \gamma \eta \eta'$	$h_1(1415)$	1416	90	1416	90	$0.08\pm0.01^{+0.01}_{-0.02}$	10.2 <i>σ</i>
	$h_1(1595)$	1584	384	1584	384	$0.16\pm0.02^{+0.03}_{-0.01}$	9.9 <i>o</i>

Significant f₀(1500) contribution: $\mathcal{B}(f_0(1500) \to \eta \eta') / \mathcal{B}(f_0(1500) \to \pi \pi) = (1.66^{+0.42}_{-0.40}) \times 10^{-1}$. Absence of f₀(1710): $\mathcal{B}(f_0(1710) \to \eta \eta') / \mathcal{B}(f_0(1710) \to \pi \pi) < (2.87) \times 10^{-3}$

Support the hypotesis that $f_0(1710)$ largely overlaps with scalar glueball Expectation is that $B(G \rightarrow \eta \eta^2)/B(G \rightarrow \pi \pi) < 0.04$





Observation of X(1835), X(2120), X(2370) in J/ψ EM Dalitz Decays PRL 129, 022002















Confirmation of Y(4500) and evidence for Y(4710)



Y(4230) observed in J/ $\Psi \pi^+\pi^-$, Ψ (2S) $\pi^+\pi^-$, J/ Ψ K⁺K⁻, J/ Ψ K_SK_S, D^{*0}D^{*-} π^+

Y(4500) observed in J/ Ψ K⁺K⁻, D^{*0}D^{*-} π ⁺

Y(4660) observed in Ψ (2S) $\pi^{+}\pi^{-}$, D*⁰D*⁻ π^{+}

Evidence of Y(4710) in J/ Ψ K_sK_s

A new vector charmoniumlike state Y(4790) in $e^+e^- \rightarrow D_s^{*+} D_s^{*-}$?







BEPCII Upgrade in 2024

	BEPCII	BEPCII-U
Lum [10 ³² cm ⁻² s ⁻¹]	3.5	11
$eta_{\mathcal{Y}}^{*}$ [cm]	1.5	1.3
Bunch Current [mA]	7.1	7.5
Bunch Num	56	120
SR Power [kW]	110	250
$\xi_{y,\mathrm{lum}}$	0.029	0.036
Emittance [nmrad]	147	152
Coupling [%]	0.53	0.35
Bucket Height	0.0069	0.011
$\sigma_{\!_{Z,0}}$ [cm]	1.54	1.04
$\sigma_{\! Z} $ [cm]	1.69	1.3
RF Voltage	1.6 MV	3.3 MV



- Luminosity is increased by a factor 3
 @ 2.35 GeV
- Maximun beam energy is increased up to 2.8 GeV

Summary

- Unprecedented statistics collected by BESIII provides great opportunities to study QCD exotics
- Exciting results from J/Ψ radiative and Dalitz decays:
 - Observation of $\eta_1(1855)$, exotic spin state, possible hybrid candidate
 - f₀(1710) can possibly be a superposition with a ground state scalar glueball
 - Observation of new state X(2600)
- Improved understanding of XYZ states:
 - New production mechanism of X(3872)
 - Mapping of fine structure of Y states
 - Further studies of the Z_{CS} state family
- Many more BESIII results have not been discussed here...
- ... And many more will come:
 - Upgrade of BEPCII (2024)
 - Upgrade of the inner tracker of the BESIII detector with 3 layers of Cylindrical GEM detectors (2024)
 - Data taking will continue at least until 2030