Charged charmonium-like states as rescattering from conventional B decays

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MEPhI

Z(4430) discovery: history

$>5\sigma$

“no significant signal is observed”

PRL 100 142001 (2008)

PRD 79 112001 (2009)
Z(4430) discovery: history

$\sigma > 5\sigma$

PRD 80 031104 (2009)

$\sigma > 12\sigma$

PRL 112, 222002 (2014)
Z(4430): possible interpretations

Models for \textit{XYZ} Mesons

**Quarkonium Tetraquarks**

- compact tetraquark
- meson molecule
- diquark-onium
- hadro-quarkonium
- quarkonium adjoint meson

**Rescattering**

\[ B \to D^* \ D_1(2420) \ K \]

\[ \psi(2S)\pi \]

\[ \text{PRD 76, 114002 (2007)} \]
When we talk about rescattering?

- Large overlap of the wave-functions
- $(c\bar{c})$ pair with low momenta at small distance

→ Charmonium decays, B-meson decays, ISR, $\gamma\gamma$-physics
Rescattering in $B \rightarrow D_{sJ}D$ decay

- $\tau(D_{sJ}) \ll \tau(D^*)$
- $\beta(c) \sim (0.2-0.5)$

$M(DD^*)=M(\psi'\pi)$
\( Z^+(4430) \) in \( B \rightarrow D_{sJ}D \) channel

Assumptions:

- \( DD^* \rightarrow \psi'\pi \) decay goes is s-wave
- On-shell approximation works for this diagramm
- \( DD^* \rightarrow \psi'\pi \) amplitude does not change drastically in the region of 4-4.8 GeV

\quad \text{M}(\psi'\pi) \text{ spectrum lineshape for } J^P=1^+ \text{quantum numbers is similar to } Z^+(4430)
Full rescattering amplitude

\[ A \sim BW(Ds' \rightarrow D^*K) \times A(\text{rescattering}) \times A(Ds' \text{ decay}) \times A \left( D^* \text{ spin rotation} \right) \times A \left( Z \text{ formation} \right) \]

\[ A \sim \int \Psi_{D}(c) \Psi_{D^*}(\bar{c}) \Psi(\bar{c}c) \ d^3p_c \ d^3p_{\bar{c}} \]

\[ \sim 1 \]

\[ \sim d^1_{00}(\theta') \]

$\theta'$ is angle btw. $Ds'$ and $Z$ in $D^*$ frame

\[ d^1_{00}(\theta'') \]

$\theta''$ is $D^*$ helicity in $Z$ frame
LHCb results

- Z(4430) quantum numbers: $1^+$
- ~5σ structure at ~4200 MeV
- Underestimation of the signal at higher mass region
- Breit-Wigner-like phase change
  Z(4430)

PRL 112, 222002 (2014)
LHCb mass spectrum with rescattering

LHCb data after incoherent background subtraction

- ✔ Z(4430) quantum numbers: 1+
- ✔ Broad structure at ~ 4200 MeV
- ✔ Bump at the end of the spectrum

Predicted well before the first measurement of Z(4430) quantum numbers by Belle and LHCb

PLB 702, 139 (2011)

BW-like phase movement (in opposite direction, though)
Ds' parameters estimation

- Perform a fit with various values of Ds' mass and width
- Find best fit quality

\[ M = (2614 \pm 4^{+20}_{-13}) \text{ MeV}, \quad \Gamma = (92 \pm 10 \pm 10) \text{ MeV} \]
Conclusions

✔ $\Psi'\pi$ spectrum from $B\rightarrow K\Psi'\pi$ could be described without exotic states introduction

✔ Model reproduces all main features:
  ✔ $Z(4430)^+$ quantum numbers
  ✔ Bump at the end of the spectrum
  ✔ Broad structure at 4200 MeV
  ✔ Resonance-like phase change

BACKUP
Why rescattering results in a peak?

**M**(DD*) distribution from B → Scalar Scalar is flat. cos(\text{angle rotation } D^* \text{ spin}) correlates with M(DD*).

$$N/10 \text{ MeV}/c^2$$

$$\cos(\theta')$$

M(DD*) - 4.6 GeV suppressed.

M(DD*) - 4.8 GeV suppressed.