Observation of $D_{sJ}(2460)$ and Confirmation of $D^*_{sJ}(2317)$ at CLEO

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Introduction & Background

We need to interpret fundamental properties of quarks as revealed in CKM angle determinations, rare decay studies and CP violation measurements. Often we need to use QCD to extract the vital information from the data. Thus incisive studies of QCD are crucial to our fundamental understanding.

Prior to April 2003:

- The known $c\bar{s}$ mesons were $D_s(1969)$, $D_s^*(2112)$, $D_{s1}(2536)$, $D_{sJ}(2573)$.
- Theoretical expectations were that the remaining two $c\bar{s}$ states 0^+ and 1^+ were above DK threshold and had large widths.

After April 2003:

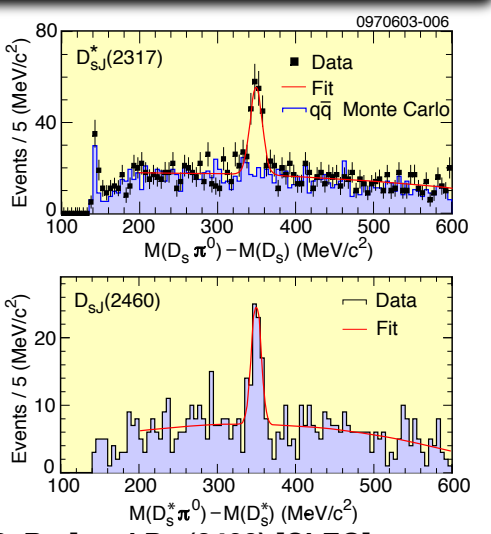
- BaBar observed the narrow state $D_s^*(2317)$ decaying to $D_s\pi^0$ consistent with $J^P=0^+$ [PRL 90, 242001 (2003)].
- CLEO confirmed this new state and observed a second peak at 2460 MeV.

The $D^*_{sJ}(2317)$ and $D_{sJ}(2460)$ Signals at CLEO

Reconstructing the decay chains:

$D^*_{sJ}(2317) \to D_s\pi^0$, $\pi^0 \to \gamma\gamma$; $D_s \to \phi\pi$, $\phi \to K^+K^-$

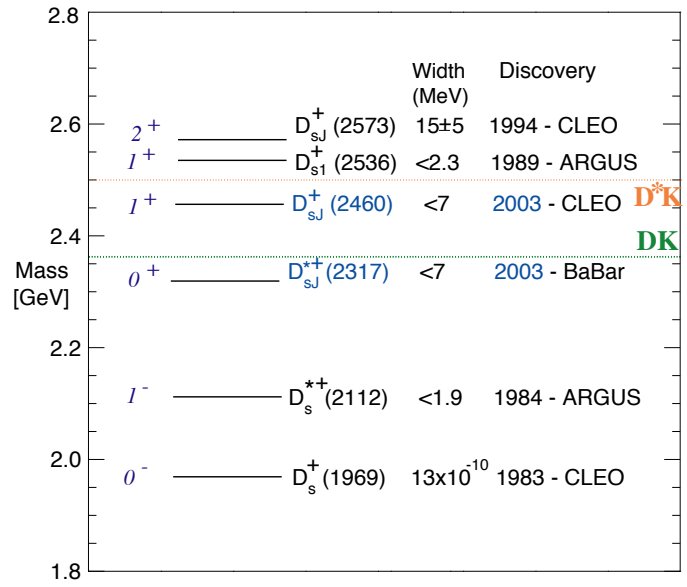
$D_{sJ}(2460) \to D_s^*\pi^0$, $\pi^0 \to \gamma\gamma$; $D_s^* \to D_s\gamma$; $D_s \to \phi\pi$, $\phi \to K^+K^-$



The observations of the $D^*_{sJ}(2317)$ [BaBar] and $D_{sJ}(2460)$ [CLEO] states were surprising because they are:

- narrow resonances (intrinsic width < 7 MeV);
- observed in the isospin-violating $D_s^{(*)}\pi^0$ channel;
- less massive than most theoretical predictions for a 0^+ or 1^+ $c\bar{s}$ state that could decay via these channels.

Spectroscopy of the $c\bar{s}$ Mesons

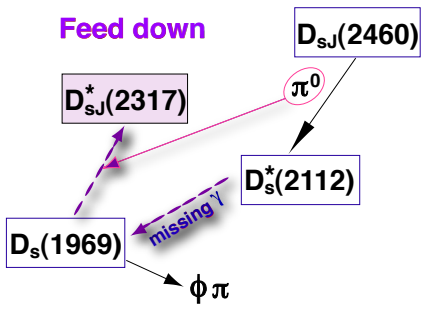


Theoretical Explanations

- DK molecule [Close & Lipkin, hep-ph/0305025]
- Ordinary excited $c\bar{s}$ states:
  - D_{sJ} are narrow because isospin is violated in the decay (only way for hadronic decay to occur since they are below DK threshold) [Cho & Wise, PRD 1994].
  - HQET + chiral symmetry explain the mass difference [Bardeen, Eichten & Hill, hep-ph/0305049].
  - Look for radiative decays [Colangelo & De Fazio, hep-ph/0305140 and Godfrey, hep-ph/0305122].
- Contradictory lattice results [Bali, hep-ph/0305209 & UKQCD collaboration, hep-lat/0307001]
- Unitarized meson model [Beveren & Rupp, hep-ph/0305035]
- Mass obtained using QCD sum rules [Dai, Huang & Zhu, hep-ph/0306274]
- Mixture of 4-quark states $|c\bar{s}\rangle$ + $|DK\rangle$ above $D^{(*)}K$ threshold [Browder et al., hep-ph/0307054]

Cross Feed between $D_s\pi^0$ and $D_s^*\pi^0$

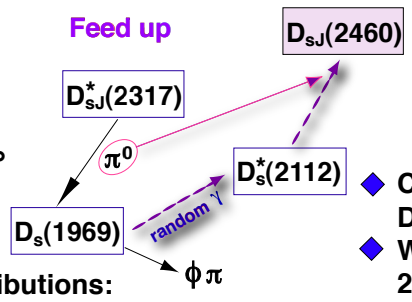
Feed down



The state at 2460 MeV will generate a peak at 2317 if the photon from the D_S decay is not observed! The probability of feeding down is (84±4±10)% and results in smearing of the width according to Monte Carlo simulations.

The state at 2317 MeV will generate a peak at 2460 if a random photon makes a D_s^* ! This happens (9.1±0.7±1.5)% of the time, and also results in smearing.

Feed up



Three approaches to untangle these contributions:

- Use Monte Carlo simulations as basis for "unfolding"
- Use sidebands from the data to estimate background
- Study lineshapes of peaks

All lead to consistent results.

This analysis uses 13.5 fb^{-1} of data collected with the CLEO II detector in symmetric e^+e^- collisions at the Cornell Electron Storage Ring, at center-of-mass energies $\sqrt{s} \approx 10.6$ GeV.

Searching in Other Final States

We have searched for $D^*_{sJ}(2317)$ and $D_{sJ}(2460)$ in other decay channels: $D_s\pi^+\pi^-$, $D_s\gamma$, $D_s^*\gamma$; however, there is no sign of any structure in the mass difference spectrum in the region where a signal from $D^*_{sJ}(2317)$ or $D_{sJ}(2460)$ decay would be expected.

Summary & Conclusions

- CLEO has observed a new state at mass of 2460 MeV decaying to $D_s^*\pi^0$, as expected for $J^P = 1^+$; $M(D_s^*\pi^0) - M(D_s^*) = 351.2 \pm 1.7 \pm 1.0$ MeV.
- We have also confirmed the BaBar discovery of the state at 2317 MeV decaying to $D_s\pi^0$, as expected for $J^P = 0^+$; $M(D_s\pi^0) - M(D_s) = 350.0 \pm 1.2 \pm 1.0$ MeV.
- Results are compatible with models based on HQET and chiral symmetry, that predict 1^+ and 0^+ are the chiral partners of the 1^- and 0^- states, with the same mass splitting [Bardeen et al.].
- Results are reported in hep-ex/0305100, [PRD 68, 032002 (2003)].
- Both states are also confirmed by Belle in continuum e^+e^- collisions [hep-ex/0307052] and $B \to DD_{sJ}$ decays [hep-ex/0308019].