DETERMINING THE QUANTUM NUMBERS OF HEAVY EXCITED MESONS

It is appropriate to subtitle the above with:

PRODUCTION OF DALITZ PAIRS:

$$X^* \to X e^+ e^-$$

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Thanks to Frank Krauss, my collaborator in:
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Outline

- א : Introduction: Why did we study $X^* \to X e^+ e^-$?
  Or: What is the motivation?

- ב : Model and results.

- ג : Summary and conclusions.

$\aleph$: Introduction: Why did we study $X^* \to X e^+ e^-$?
Or: What is the motivation?
Here we consider:
D^{*0}, D_s^{*+}, B^{*0} and B_s^{*0}.

- The quantum numbers J^P of X^*s are assumed by PDG to be 1^-. It would be nice to confirm experimentally such basic predictions of the quark model.

- The quantum numbers of even heavier mesons depend on the X^*s they decay into.

- In PDG the central values of Br($D^{*0} \to D^0 \gamma$) and Br($D^{*0} \to D^0 \pi$) sum up to exactly 100 %.
  Closer look at the experimental papers: This was one of the assumptions in the experimental analyses!
  Similarly,
  Br($D_s^{*+} \to D_s^+ \gamma$) + Br($D_s^{*+} \to D_s^+ \pi^0$) = 100%
  was assumed by exp. and by PDG. Current errors on Br's are higher than the Br($D^* \to D + e^+ e^-$).

Who cares if there is less than a % Br that has not been measured?

Future experiments in the B sector require tracking of all outgoing D's i.e.: We have to know the identity and size of the leading decays to better than a % in Br.

Define:

$$R \equiv \frac{\Gamma(X^* \to X e^+ e^-)}{\Gamma(X^* \to X\gamma)}.$$

More than 50 years ago:

R is a good measure of the quantum numbers of baryons.

Results were close to ours: $R \approx 0.5 \times 10^{-2}$

More recently, R for $X = D$, was calculated to be 5 time smaller than that.

ℶ : Model and results.

Here $X = D,\ B$. Parametrize:

$\mathcal{M}(X^* \to X\gamma) = g_{X^*X\gamma} \cdot \mathcal{F}(q^2)$.

Assume: $\mathcal{F}$ is independent of q^2.

Justified by:

$m_{X^*} - m_X \lesssim 150\text{MeV} << m_\rho$.

$$
\begin{aligned}
\mathcal{M}_{1^-0^-\gamma} &= g_{X^*X\gamma} \cdot \mathcal{F} \cdot \epsilon^{\alpha\beta\mu\nu} \epsilon_\alpha(\gamma) \epsilon^*_\beta(X^*) P_\mu(X^*) q_\nu(\gamma) \\
\mathcal{M}_{2^+0^-\gamma} &= g_{X^*X\gamma} \cdot \mathcal{F} \cdot \epsilon^{\alpha\beta\mu\nu} \epsilon_\alpha(\gamma) P_\beta(X^*) \epsilon^*_{\mu\rho}(X^*) \\
&\quad \cdot q_\nu(\gamma) q_\rho(\gamma) .
\end{aligned}
$$

We then calculate:

$\sum \overline{|\mathcal{M}|^2}$ for $J^P(B^*) = 1^-, 2^+$. Obtaining:

X	$R\ (1^-)$	$R\ (2^+)$	$\mathcal{B}(X^* \to X\gamma)$	$m_{X^*} - m_X$
B_s^0	$4.65\ \times10^{-3}$	$4.34\ \times10^{-3}$	dominant	45.78 ± 0.35
B^0	$4.69\ \times10^{-3}$	$4.38\ \times10^{-3}$	dominant	45.78 ± 0.35
$D_s^\pm$	$6.45\ \times10^{-3}$	$6.14\ \times10^{-3}$	0.942 ± 0.025	143.8 ± 0.4
D^0	$6.44\ \times10^{-3}$	$6.13\ \times10^{-3}$	0.381 ± 0.029	142.12 ± 0.07
$D^\pm$	$6.42\ \times10^{-3}$	$6.11\ \times10^{-3}$	$0.011\ ^{+0.021}_{-0.007}$	140.64 ± 0.10
K^0	$7.99\ \times10^{-3}$	$(7.68\ \times10^{-3})$	0.0023 ± 0.0002	398.42 ± 0.28

COMMENTS:

1 $R = \Gamma(X^* \to Xe^+e^-)/\Gamma(X^* \to X\gamma)$.

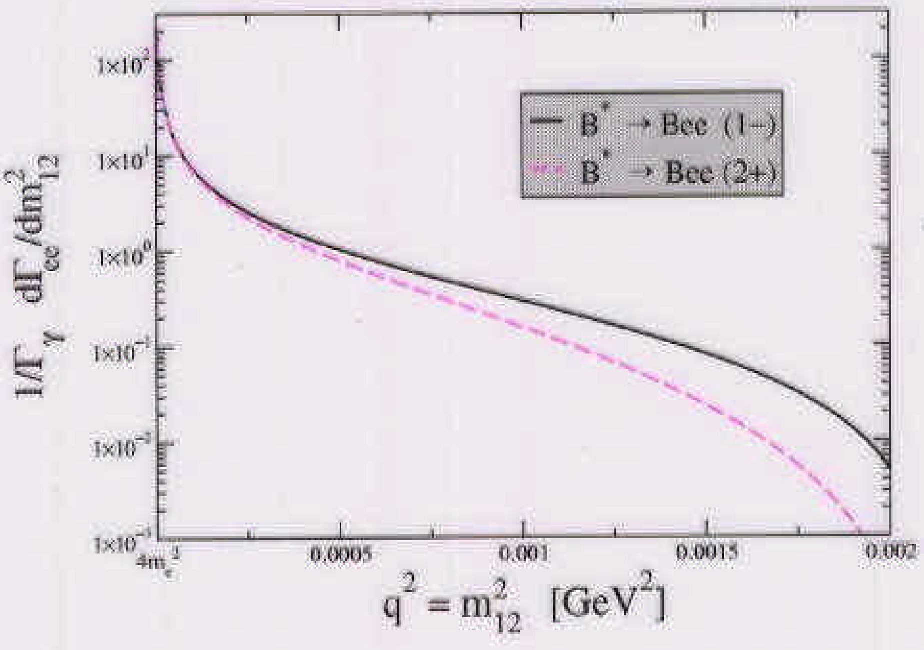
2 $m_{X^*} - m_X$ in MeV.

3 Assumed: $m_{B_s^*} - m_{B_s} = m_{B_d^*} - m_{B_d}$.

4 $K^*(892)$ for completeness.

5 Only: $R = (4.7 \pm 1.1 \pm 0.9) \times 10^{-3}$ observed.

Better: $q^2 = m_{ee}^2$ distributions:



COMMENTS:

1 Similar results for $X = D$.

2 The tail of the distribution is affected by J^P of X^*.

] : Summary and conclusions.

The ratio between the widths $X^* \to Xe^+e^-$ and $X^* \to X\gamma$, has a role in determining the quantum numbers of X^* for $X = D, B$ and may become essential with new precision B experiments.