

B_c mesons, Theoretical Overview

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Content

1 Introduction

2 Spectroscopy, Production

3 Decays

- Semileptonic Decays
- Two-particle Hadronic Decays
- Light Meson Production
- Annihilation Decays
- Exotics

4 Conclusion

Introduction

$$B_c = c\bar{b}$$

- Heavy quarkonium with open flavour
- $(c\bar{c}) — (c\bar{b}) — (b\bar{b})$
- Spectroscopy, Production \Rightarrow see A. Berezhnoy's talk
- Decays

Spectroscopy and Production

- Spectroscopy
 - Mass spectrum look like usual for heavy quarkonia
 - Some modifications due to open flavour
- Production
 - Can be explained using NRQCD
 - Can be used to understand physics of B_c and gluonic showering
- For more detailed description see upcomming talk by A. Berezhnoy

Decays, General Picture

B_c meson decays can proceed via

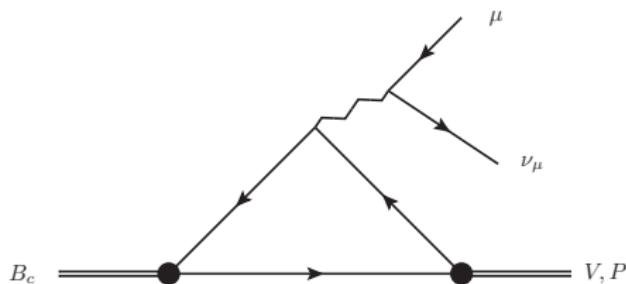
- b -quark decays (spectator c): $\sim 45\%$
- c -quark decays (spectator b): $\sim 35\%$
- Weak annihilation decays: $\sim 10\%$

Can be classified:

- Semileptonic Decays
- Two-body Hadronic Decays
- Light Meson Production
- Exotics
- etc

Semileptonic Decays - I

- Hard to observe
- Most clean theoretically



- Form-factors
 - $B_c \rightarrow P + \mu\nu$: $f_+(q^2), f_-(q^2)$
 - $B_c \rightarrow V + \mu\nu$: $A_{0,1,2}(q^2), V(q^2)$

Semileptonic Decays - II

Theoretical models for form factors

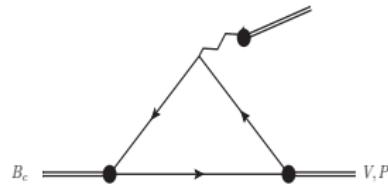
- Potential models
- QCD SR
- LC
- Lattice
- etc

Theoretical predictions for

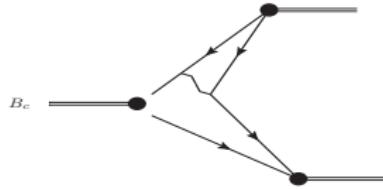
$$B_c \rightarrow [\eta_c, J/\psi, \eta_c(2S), J/\psi(2S), B_s, B_s^*] + e\nu$$

Only $B_c \rightarrow J/\psi\mu\nu$ observed in experiment

Two-particle Hadronic Decays



$$B_c \rightarrow \psi \rho$$
$$|a_1|^2$$



$$B_c \rightarrow D_s D$$
$$|a_2|^2$$

Both

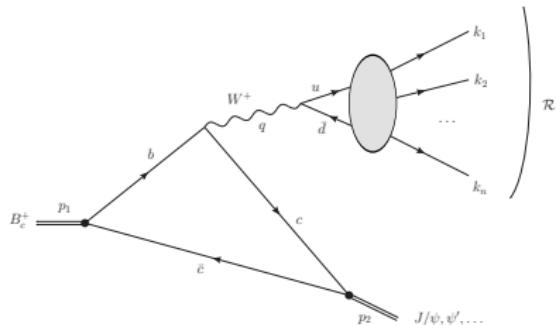
$$B_c \rightarrow \eta_c D$$
$$a_{1,2}$$

Observed experimentally:

	$\eta_c^{(')}$	$\psi^{(')}$	$\chi_c^{(')}$	$h_c^{(')}$	$B_s^{(*)}$	$B^{(*)}$	$D_s^{(*)}$
π	✓	✓	✓	✓	✓	✓	—
ρ	✓	✓	✓	✓	✓	✓	—
ϕ	—	—	—	—	—	✓	✓
$K^{(*)}$	✓	✓	✓	✓	✓	✓	✓
$D^{(*)}$	—	✓	—	—	—	—	✓

Ratios in good agreement with theory

Light Meson Production — I

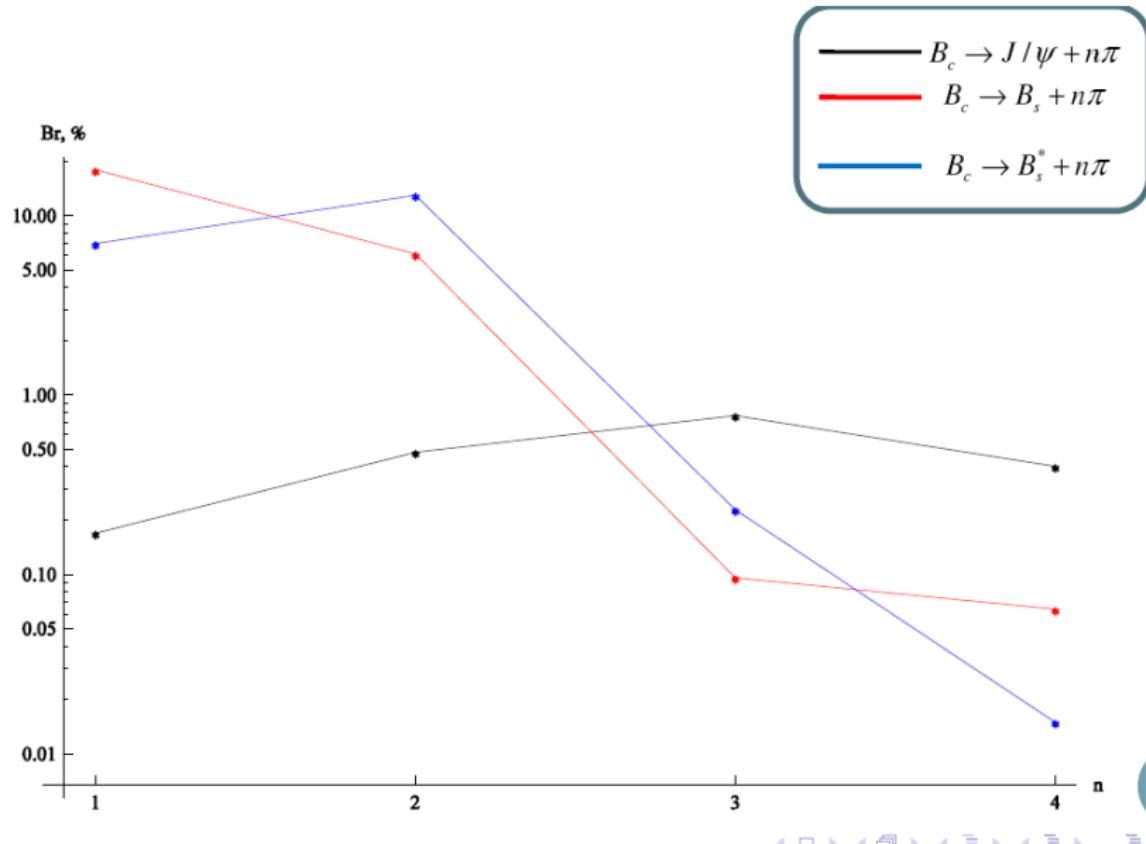


$$\mathcal{M} \sim \mathcal{H}_\mu \epsilon_\mu^{\mathcal{R}}$$

$$\frac{d\Gamma[B_c \rightarrow \psi^{(\prime)} \mathcal{R}]}{dq^2} = \frac{d\Gamma[B_c \rightarrow \psi^{(\prime)} \mu\nu]}{dq^2} \frac{d\Gamma[\tau \rightarrow \nu_\tau \mathcal{R}]/dq^2}{d\Gamma[\tau \rightarrow \nu_\tau \mu\nu]/dq^2}$$

	2π	3π	4π	5π	$KK\pi$	$K\pi\pi$
J/ψ	✓	✗	✓	✗	✓	✓
$\psi(2S)$	✓	✓	✓	✓	✓	✓
B_s	✓	✓	✓	—	—	—
B_s^*	✓	✓	✓	—	—	—

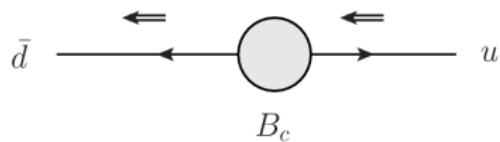
Light Meson Product — II



Annihilation Decays — I

- Helicity conservation \Rightarrow
- Spin flip \Rightarrow
- Helicity suppression

$$\text{Br} \sim \left(\frac{m_q}{M_{B_c}} \right)^2$$

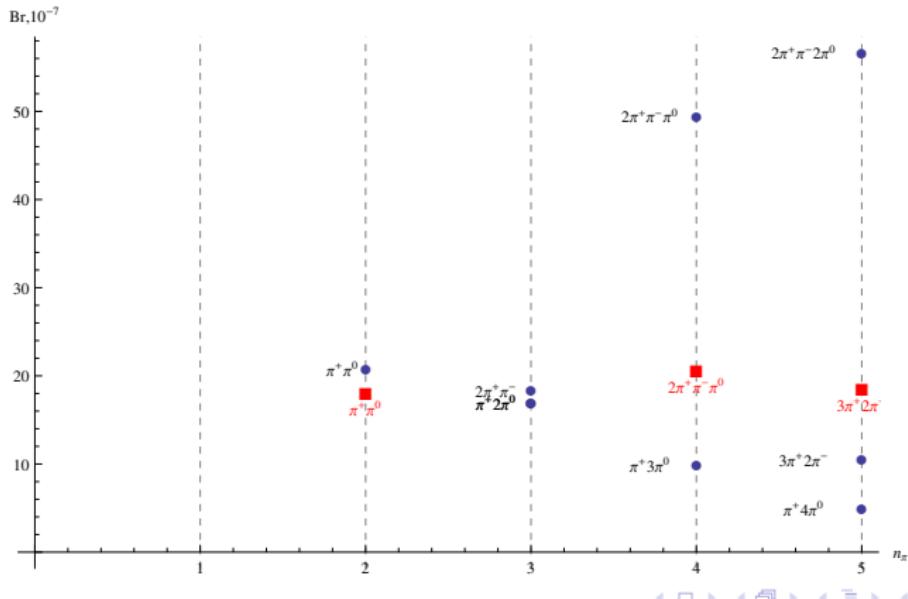


- $B_c \rightarrow \tau \nu_\tau$: 1.6%
- $B_c \rightarrow c \bar{s}$: 4.9%
- $B_c \rightarrow u \bar{d}$: $\sim 10^{-8}$

Annihilation Decays — II

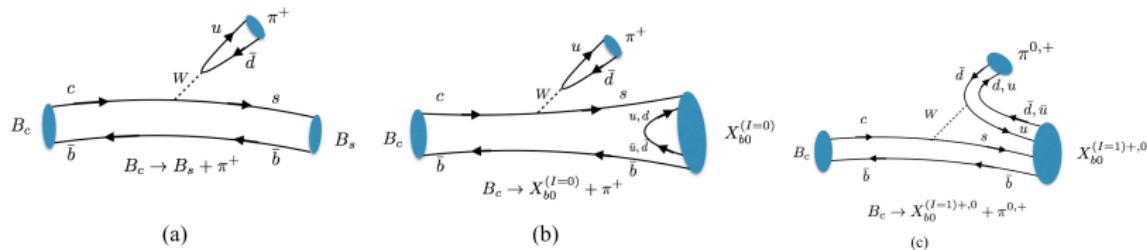
$$B_c \rightarrow u\bar{d}\gamma$$

- No helicity suppression
- $\alpha \gg (m_{u,d}/M_{B_c})^2 \Rightarrow$ enhancement for light quarks



Exotics

- $X(3872)$ production cross sections comparable with $c\bar{c}$
- B_c decays into $c\bar{c}$
- search for tetraquark production in B_c decays



- $\text{Br}(B_c \rightarrow X(3872)\pi) \sim 1.7 \times 10^{-4}$
- $\text{Br}(B_c \rightarrow X(3872)\rho) \sim 1.3 \times 10^{-5}$

Conclusion

- B_c meson is a very interesting particle with exiting production and decay patterns
- There are several theoretical models for description of the decays they give results agreeable with existing experimental data
- Additional experimental study could help to select the best model
- ⇒ Clarify the structure of B_c , charmonia, light mesons, $X(3872)$, etc

Thank you for your attention!

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