Weak decays of doubly charmed baryons

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Within a nonrelativistic quark model, we evaluate exclusive semileptonic decays of ground-state spin-1/2 doubly heavy charmed baryons driven by a quark $c \to s, d$ transition.

We shall only present final results for the decay widths. For the interested reader, Ref. [1] gives a full account of our work. In particular, a discussion on heavy quark spin symmetry constraints on form factors and the level to which those constraints are satisfied for the actual c-quark mass can be found there.

The quantum numbers of the baryons involved in our study are shown in Table 1. Quark model masses have been taken from our previous works in Refs. [2, 3]. Experimental masses are the ones given by the PDG [4] and in the table we quote the average over the different charge states. With the exception of the Ξ_{cc}, the agreement is fairly good. In the calculation we use experimental masses. For the Ξ_{cc} which is not well established, and for the Ω_{cc}, for which there is no experimental information, we take our model predictions of $M_{\Xi_{cc}} = 3613\,\text{MeV}$ and $M_{\Omega_{cc}} = 3712\,\text{MeV}$.

In Table 2 we give our results. To the best of our knowledge there are just a few other calculations of exclusive semileptonic decays of ground-state spin-1/2 doubly charmed baryons. Those are also shown in Table 2 for comparison. In Ref. [5] only the $\Xi_{cc} \to \Xi'_c e^+ \nu_e$ decay was evaluated using the relativistic three-quark model. In Ref. [6], the authors use heavy quark effective theory and non-relativistic QCD sum rules to evaluate both the lifetime of the Ξ_{cc} baryon and the branching ratio for the combined decay $\Xi_{cc} \to \Xi_c e^+ \nu_e + \Xi'_c e^+ \nu_e + \Xi^*_c e^+ \nu_e$ from which we have obtained the semileptonic decay widths shown in the table. We find a fair agreement of our predictions with both calculations. We also give results for exclusive semileptonic $c \to s$ decays of the Ω^+_{cc} baryon and for sub dominant $c \to d$ decays of both the Ξ^{++}_{cc}, Ξ^+_{cc} and Ω_{cc} baryons.

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Baryon	J^π	S^π	Quark content	Mass [MeV]	
				Quark model [2,3]	Experiment [4]
Ξ_{cc}	$\frac{1}{2}^+$	1^+	ccn	3613	3518.9
Ω_{cc}	$\frac{1}{2}^+$	1^+	ccs	3712	–
Λ_c	$\frac{1}{2}^+$	0^+	udc	2295	2286.5
Σ_c	$\frac{1}{2}^+$	1^+	nnc	2469	2453.6
Σ_c^*	$\frac{3}{2}^+$	1^+	nnc	2548	2518.0
Ξ_c	$\frac{1}{2}^+$	0^+	nsc	2474	2469.3
Ξ_c'	$\frac{1}{2}^+$	1^+	nsc	2578	2576.8
Ξ_c^*	$\frac{3}{2}^+$	1^+	nsc	2655	2645.9
Ω_c	$\frac{1}{2}^+$	1^+	ssc	2681	2695.2
Ω_c^*	$\frac{3}{2}^+$	1^+	ssc	2755	2765.9

Table 1: Quantum numbers of the baryons involved in this study. J^π is the spin-parity of the baryon, while S^π is the spin-parity of the two heavy or the two light quark subsystem. n denotes a u or d quark.

		This work	[5]	[6]
$\Gamma(\Xi_{cc}^{++} \to \Xi_c^+ e^+ \nu_e)$	$(c \to s)$	8.75×10^{-2}		
$\Gamma(\Xi_{cc}^{+} \to \Xi_c^0 e^+ \nu_e)$	$(c \to s)$	8.68×10^{-2}		
$\Gamma(\Xi_{cc}^{++} \to \Xi_c'^+ e^+ \nu_e)$	$(c \to s)$	0.146	$0.208 \div 0.258$	
$\Gamma(\Xi_{cc}^{+} \to \Xi_c'^0 e^+ \nu_e)$	$(c \to s)$	0.145	$0.208 \div 0.258$	
$\Gamma(\Xi_{cc}^{++} \to \Xi_c^{*+} e^+ \nu_e)$	$(c \to s)$	3.20×10^{-2}		
$\Gamma(\Xi_{cc}^{+} \to \Xi_c^{*0} e^+ \nu_e)$	$(c \to s)$	3.20×10^{-2}		
$\Gamma(\Xi_{cc}^{++} \to (\Xi_c^+ + \Xi_c'^+ + \Xi^{*+}) e^+ \nu_e)$	$(c \to s)$	0.266		$0.37 \pm 0.04^{(*)}$
$\Gamma(\Xi_{cc}^{+} \to (\Xi_c^0 + \Xi_c'^0 + \Xi_c^{*0}) e^+ \nu_e)$	$(c \to s)$	0.264		$0.47 \pm 0.15^{(*)}$
$\Gamma(\Xi_{cc}^{++} \to \Lambda_c^+ e^+ \nu_e)$	$(c \to d)$	4.86×10^{-3}		
$\Gamma(\Xi_{cc}^{++} \to \Sigma_c^+ e^+ \nu_e)$	$(c \to d)$	7.94×10^{-3}		
$\Gamma(\Xi_{cc}^{+} \to \Sigma_c^0 e^+ \nu_e)$	$(c \to d)$	1.58×10^{-2}		
$\Gamma(\Xi_{cc}^{++} \to \Sigma_c^{*+} e^+ \nu_e)$	$(c \to d)$	1.77×10^{-3}		
$\Gamma(\Xi_{cc}^{+} \to \Sigma_c^{*0} e^+ \nu_e)$	$(c \to d)$	3.54×10^{-3}		
$\Gamma(\Omega_{cc}^{+} \to \Omega_c^0 e^+ \nu_e)$	$(c \to s)$	0.282		
$\Gamma(\Omega_{cc}^{+} \to \Omega_c^{*0} e^+ \nu_e)$	$(c \to s)$	5.77×10^{-2}		
$\Gamma(\Omega_{cc}^{+} \to \Xi_c^0 e^+ \nu_e)$	$(c \to d)$	4.11×10^{-3}		
$\Gamma(\Omega_{cc}^{+} \to \Xi_c'^0 e^+ \nu_e)$	$(c \to d)$	7.44×10^{-3}		
$\Gamma(\Omega_{cc}^{+} \to \Xi_c^{*0} e^+ \nu_e)$	$(c \to d)$	1.72×10^{-3}		

Table 2: Decay widths in units of ps^{-1}. We use $|V_{cs}| = 0.97345$ and $|V_{cd}| = 0.2252$ taken from Ref. [4]. Results with an $(*)$, our estimates from the total decay widths and branching ratios in [6]. Similar results are obtained for $\mu^+\nu_\mu$ leptons in the final state.

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References

[1] C. Albertus, E. Hernandez and J. Nieves, Phys. Lett. B **704**, 499 (2011).

[2] C. Albertus, J. E. Amaro, E. Hernandez and J. Nieves, Nucl. Phys. A **740**, 333 (2004).

[3] C. Albertus, E. Hernandez and J. Nieves, Phys. Lett. B **683**, 21 (2010).

[4] K. Nakamura et al. (Particle Data Group), J. Phys. G 37, 075021 (2010).

[5] A. Faessler, T. Gutsche, M. A. Ivanov, J. G. Korner and V. E. Lyubovitskij, Phys. Lett. B **518**, 55 (2001).

[6] V. V. Kiselev and A. K. Likhoded, Phys. Usp. **45**, 455 (2002) [Usp. Fiz. Nauk **172**, 497 (2002)] [arXiv:hep-ph/0103169]. See also A.I. Onishchenko, hep-ph/9912425; A.I. Onishchenko, hep-ph/0006271; A.I. Onishchenko, hep-ph/0006295.