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Favored B_{c} decay modes to search for Majorana neutrino

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First we give the formalism for heavy neutrino mixing with light neutrinos where we extend the SM to include n right-handed SM singlets along with the three generation of left-handed SM SU(2) doublets. We give the calculation of the four body decay $B_c^- \to J/\psi \ell_1^- \ell_2^- \pi^+$ and $B_c \to B_s^0 \ell_1^- \ell_2^- \pi^+$. Explicit form of four monemta is given in the appendix. We calculate the decay width of N in our interested mass range. We define the quantity $B\left(B_c^- \to \overline{B}_s^0 e^- e^- \pi^+\right) = G_{ee}\left(m_N\right) \frac{|V_{eN}|^4}{\Gamma_N}$ and similarly for $\mu\mu$ and $e\mu$ channels. where, G_{ee} , $G_{\mu\mu}$ and $G_{e\mu}$ are functions of the Majorana mass and depend on the explicit matrix element and phase space for each of the processes. Further we define $F_{ee} \equiv \frac{B^{exp}\left(B_c^- \to \overline{B}_s^0 e^- e^- \pi^+\right)}{G_{ee}(m_N)}$ and similarly for other channels. where B^{exp} are the experimental branching ratio. Upper limits on branching ratio is simply translated to upper limits on mixnig as $\frac{|V_{eN}|^4}{\Gamma_N} < F_{ee}$, $\frac{|V_{\mu N}|^4}{\Gamma_N} < F_{\mu\mu}$, $\frac{|V_{eN}|^2|V_{\mu N}|^2}{\Gamma_N} < F_{e\mu}/F_{\mu e}$. We calculate the expected number of B_c in LHCb with$\sqrt{s} = 14TeV$ which is around $10^8 - 10^9$ per year. We use this information to set the upperlimit on branching ratio.

Summary

Recently, the LHCb collaboration reported the observation of the decay mode $B_c^- \to \overline{B}_s^0 \pi^-$ with
the largest exclusive branching fraction amongst the known decay modes of all the B mesons. Here we propose a search for a few lepton-number violating ($\Delta L = 2$) decay modes of B_c which can only be induced by Majorana neutrinos. Distinguishing between Dirac and Majorana nature of neutrinos is an outstanding problem and hence, all possible searches for Majorana neutrinos need to be carried out. Since the lepton number violating modes are expected to be rare, when using meson decay modes for these searches one expects CKM favoured modes to be the preferred ones; $B_c \to B_s$ is one such transition. With a resonance enhancement of the Majorana neutrino mediating the $B_c^- \to \overline{B}_s^0 \ell_1^- \ell_2^- \pi^+$ modes, one can hope to observe these rare modes or even their non-observation can be used to obtain tight constraints on the mixing angles of the heavy Majorana singlet with the light flavour neutrinos from upper limits of the branching fractions. Using
these modes we obtain exclusion curves for the mixing angles which are tighter or compatible with results from earlier studies. However, we find that the relatively suppressed mode $B_c^- \to J/\psi \ell_1^- \ell_2^- \pi^+$ can provide even tighter constraints on $\mid V_{eN} \mid^2$, $\mid V_{\mu N} \mid^2$, $\mid V_{eN} V_{\mu N} \mid$, and in a larger range of the heavy neutrino mass. Further, exclusion regions for $\mid V_{eN} V_{\tau N} \mid$, $\mid V_{\mu N} V_{\tau N} \mid$ can also be obtained for masses larger than those accessible in tau decays. Upper limits on $B\left(B_c^- \to \pi^+ \ell_1^- \ell_2^-\right)$ can also result in stringent exclusion curves for all the mixing elements, including that for $\mid V_{\tau N} \mid^2$ in a mass range where it is unconstrained thus far.

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