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Exploiting a future galactic supernova to probe neutrino magnetic moments

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A core-collapse supernova (SN) offers an excellent astrophysical laboratory to test non-zero neutrino magnetic moments. In particular, the neutronization burst phase, which lasts for few tens of milliseconds post-bounce, is dominated by electron neutrinos and can offer exceptional discovery potential for transition magnetic moments. We simulate the neutrino spectra from the burst phase in forthcoming neutrino experiments like the Deep Underground Neutrino Experiment (DUNE), and the Hyper-Kamiokande (HK), by taking into account spin-flavour conversions of SN neutrinos, caused by interactions with ambient magnetic fields. We find that the neutrino transition magnetic moments which can be explored by these experiments for a galactic SN are an order to several orders of magnitude better than the current terrestrial and astrophysical limits. Additionally, we also discuss how this realization might shed light on three important neutrino properties: (a) the Dirac/Majorana nature, (b) the neutrino mass ordering, and (c) the neutrino mass-generation mechanism.

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