Contribution ID: **50** Type: **Poster**

Neutron star cooling with lepton-flavor-violating axions

Friday, 31 May 2024 18:40 (5 minutes)

The cores of dense stars are a powerful laboratory for studying feebly-coupled particles such as axions. Some of the strongest constraints on axionlike particles and their couplings to ordinary matter derive from considerations of stellar axion emission. In this work we study the radiation of axionlike particles from degenerate neutron star matter via a lepton-flavor-violating coupling that leads to muon-electron conversion when an axion is emitted. We calculate the axion emission rate per unit volume (emissivity) and by comparing with the rate of neutrino emission, we infer upper limits on the lepton-flavor-violating coupling $|g_{ae\mu}|$ that are at the level of 10^{-6}. For the hotter environment of a supernova, such as SN 1987A, the axion emission rate is enhanced and the limit is stronger, at the level of 10^{-11}, competitive with laboratory limits. Interestingly, our derivation of the axion emissivity reveals that axion emission via the lepton-flavor-violating coupling is suppressed relative to the familiar lepton-flavor-preserving channels by the square of the plasma temperature to muon mass ratio, which is responsible for the relatively weaker limits.

Paper info

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Session Classification: Poster session and dinner