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Exploring dark sector parameters in light of neutron star temperatures

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Neutron star (NS) as the dark matter (DM) probe has gained a broad attention recently, either from heating due to DM annihilation or its stability under the presence of DM. In this work, we investigate spin-$1/2$ fermionic DM χ charged under the $U(1)_X$ in the dark sector. The massive gauge boson V of $U(1)_X$ gauge group can be produced in NS via DM annihilation. The produced gauge boson can decay into Standard Model (SM) particles before it exits NS, despite its tiny couplings to SM particles. Thus, we perform a systematic study on $\chi\bar{\chi} \to 2V \to 4\mathrm{SM}$ as a new heating mechanism for NS in addition to $\chi\bar{\chi} \to 2\mathrm{SM}$ and kinetic heating from DM-baryon scattering. The self-trapping due to χV scattering is also considered.
We assume the general framework that both kinetic and mass mixing terms between V and SM gauge bosons are present. This allows both vector and axial-vector couplings between V and SM fermions even for $m_V \ll m_Z$.
Notably, the contribution from axial-vector coupling is not negligible when particles scatter relativistically.
We point out that the above approaches to DM-induced NS heating are not yet adopted in recent analyses. Detectabilities of the aforementioned effects to the NS surface temperature by the future telescopes are discussed as well.

In-person participation

Yes

Primary authors: Prof. LIN, Guey-Lin (Institute of Physics, National Yang Ming Chiao Tung University, Taiwan); Dr LIN, Yen-Hsun (Physics Division, National Center for Theoretical Sciences, Taipei 106, Taiwan and Institute of Physics, Academia Sinica, Taipei 11529, Taiwan)

Presenter: Prof. LIN, Guey-Lin (Institute of Physics, National Yang Ming Chiao Tung University, Taiwan)

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