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Featured X-ray signal from axion conversion at neutron stars

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Neutron stars (NS's) with their strong magnetic fields and hot dense cores could be powerful probes of axions, a classic benchmark of feebly-coupled new particles, through abundant production of axions with the axion-nucleon coupling and subsequent conversion into X-rays due to the axion-photon coupling. In this article, we point out that the pulsation structures in both the intensity and polarization of X-rays from NS's could provide us additional information about axions and their couplings. We develop new analytical formalisms of pulsation-polarization structure applicable to a wide range of NS's in the axion scenario and argue that they hold in complicated astrophysical environments. As a case study, we apply our formalism to a representative X-ray Dim Isolated Neutron Star, RX J1856.6-3754, with an unexpected hard X-ray excess which might be axion-induced. We show with an updated fit that the axion explanation is compatible with both the intensity and pulsation data available, and combining the pulsation data does not shift the posterior by more than $1\,\sigma$. Yet, the preferred parameter space is close to being excluded by other astrophysical constraints. With a 75\% reduction of the uncertainties in the pulsation data, we could potentially draw a definite conclusion on the axion-induced X-rays at more than $3\,\sigma$ level.

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