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Fast cooling from young and cold isolated neutron stars constraining dense matter EoS

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The quest to constrain the equation of state (EoS) of ultra-dense matter and thereby probe the behaviour of matter inside neutron stars core is one of the main goals of modern astrophysics. A promising method involves investigating the long-term cooling of neutron stars, comparing theoretical predictions with various sources at different ages. However, limited observational data and uncertainties in source ages and distances have hindered this approach. In this talk, I will share results from an extensive study on dozens of thermally emitting isolated neutron stars. By re-analyzing XMM-Newton and Chandra data and taking advantage of updated ages and distances, we identified three sources with unexpectedly cold surface temperatures for their young ages. To investigate these anomalies, we conducted magneto-thermal simulations across diverse mass and initial magnetic field ranges, considering three different EoSs. We found that the "minimal" cooling model failed to explain the observations, regardless of mass or magnetic field, as validated by a machine learning classification method. The existence of these young cold neutron stars suggests that any dense matter EoS must be compatible with a fast neutrino cooling process, eliminating a significant portion of current EoS options according to recent meta-modelling analysis.

session

H. Equation of State and Neutron Stars

Primary authors: Dr DEHMAN, Clara (University of Alicante); Dr MARINO, Alessio (ICE-CSIC); Dr KOVLAKAS, Konstantinos (ICE-CSIC); Prof. REA, Nanda (ICE-CSIC)

Co-authors: Prof. PONS, Jose (University of Alicante); Dr VIGANÒ, Daniele (ICE-CSIC)

Presenter: Dr DEHMAN, Clara (University of Alicante)

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