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Contrasting neutron star heating mechanisms with *Hubble Space Telescope* observations

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Introducción

Passively cooling neutron stars are expected to reach undetectably low surface temperatures $T_s < 10^4$K within less than 10^7 yr. However, likely thermal ultraviolet emission was detected from the Gyr-old MSPs PSR J0437−4715 and PSR J2124−3358 and the $\sim 10^7$ yr-old CPs PSR B0950+08 and PSR J0108−1431, implying temperatures $T_s \sim 10^5$ K. This discrepancy could be explained by various heating mechanisms proposed in the literature. Therefore, we computed thermal evolution curves considering different heating mechanisms, contrasting them with the observations.

We found that for millisecond pulsars, the dominant heating mechanism is rotochemical heating with superfluid neutrons in the core. This mechanism consists of non-equilibrium beta reactions induced by the continuous spin-down of the star. The released energy depends exclusively on the energy gap of the superfluid neutrons, disregarding the energy gap of superconducting protons as a consequence of the effect of magnetic flux tubes in the core. For classical pulsars, it is vortex creep, where the heat is produced by the friction of the quantum vortices when they move through the neutron star crust.

Consequently, the whole set of observations can be explained by considering a mixing of vortex creep with $J \sim 3 \times 10^{43}$ erg s and rotochemical heating with an energy gap $\Delta_n = 1{,}5$ MeV for neutrons.