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White dwarfs with finite temperature: consequences of general relativity and nuclear reactions in their structure and stability

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We investigate the structure of massive white dwarfs with finite temperature and their stability against radial oscillations, pycnonuclear reactions, and the inverse β-decay. Regarding the stellar fluid, we consider that it is composed of nucleons and electrons confined in a Wigner-Seitz cell surrounded by free photons. The star is considered with an isothermal core and a non-degenerate envelope in which a temperature distribution dependent on the mass density is implemented. We obtain stable equilibrium configuration sequences that are compared with some white dwarfs from Ultraviolet Explorer Survey (EUVE) and Sloan Digital Sky Survey (SDSS). We note that some high surface gravity white dwarfs observed are well described by our curves with higher central temperatures, which motivated us to investigate them. We select some of them to obtain mass and radius according to their observed effective temperature and gravity in our model. We found results in a similar range compared to those in the literature, except those that present masses $M \geq 1.37 M_{\odot}$, which is a range affected by general relativity. For a few central temperatures and surface gravity above $2.5 \times 10^4 g_{\odot}$ considering general relativity, we derive a relation between mass and surface gravity that can be useful for astronomers to obtain white dwarf masses through their observed surface gravity values and effective temperature [1]. We obtain that the maximum mass point and the zero eigenfrequencies of the fundamental mode are determined at the same central energy density; thus, indicating that the maximum total mass marks the beginning of radial instability in a sequence of equilibrium configurations with fixed temperature. Furthermore, regarding low-temperature stars, we show that pycnonuclear reactions occur in almost similar central energy densities, and the central energy density threshold for inverse β-decay is not modified. For central temperatures, $T_c \geq 10^8$ [K], the onset of the radial instability is attained before the pycnonuclear reaction and the inverse β-decay.

[1] Síilvia P. Nunes, José D. V. Arbañil and M. Malheiro, "The structure and stability of massive hot white dwarfs", to be published in ApJ; http://arxiv.org/abs/2108.08238

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