Deep crustal heating in accreting neutron stars

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Heating associated with non-equilibrium nuclear reactions in accreting neutron-star crusts is reconsidered [1]. We take into account a suppression of neutrino energy losses demonstrated recently in [2]. Two initial compositions of the nuclear burning ashes, $A_{\rm i} = 56$ and $A_{\rm i} = 106$, are considered. The dependence of the integrated crustal heating on uncertainties plaguing pycnonuclear reaction models is studied. One-component plasma approximation is used, with compressible liquid-drop model of Mackie and Baym, to describe the nuclei in a neutron star crust. The evolution of a crust shell is followed from the density of 10^8 g cm^{-3} to $10^{13.6}$ g cm^{-3}. The integrated heating in the outer crust agrees nicely with the results of self-consistent multi-component plasma simulations, with large network of nuclear reactions, reported in [2]. The results of [2] fall between our curves obtained for $A_{\rm i} = 56$ and $A_{\rm i} = 106$. The total crustal heat per one accreted nucleon ranges between 1.5 MeV to 1.9 MeV for $A_{\rm i} = 106$ and $A_{\rm i} = 56$, respectively. The value of $Q_{\rm tot}$ depends weakly on the presence of pycnonuclear reactions at $10^{12} - 10^{13}$ g cm^{-3}. A remarkable insensitivity of $Q_{\rm tot}$ on the details of the distribution of nuclear processes in the accreted crust is discussed. Our results are relevant for modeling of soft X-ray transients, X-ray superbursts, and thermal relaxation observed in persistent soft X-ray transients KS 1731–260 and MXB 1659–29.

References

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