Heat blanketing envelopes and neutron stars cooling

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Interpretation of observations of isolated neutron stars is a difficult task. One of the problems is our poor knowledge of chemical composition of outer neutron star envelopes. The uncertainties in the chemical composition lead to the uncertainties in our theoretical inference of the internal temperature and, thus, the internal structure of a neutron star.

We have studied the impact of different chemical compositions of heat blanketing envelopes on thermal states and thermal evolution of isolated neutron stars. Although such studies were conducted in the past, they often relied on simplified "onion"-like models of the envelopes which consist of different shells of pure chemical species with abrupt boundaries between the shells. A well known and widely used example of such a model is a model by Potekhin et al. [1]. In contrast, we have investigated the heat blanketing envelopes with proper treatment of diffusion. To do this, we have extended our previous work on diffusion in isothermal dense stellar plasmas [2] to handle non-isothermal systems and have constructed models of diffusively-equilibrated and non-equilibrated heat blanketing envelopes composed of binary ionic mixtures (H–He, He–C, C–Fe) with different amounts of lighter ion species [3].

Using these envelopes and taking the Vela pulsar as an example, we have demonstrated that the uncertainties in the chemical composition of the heat blanketing envelopes can cause up to ~ 2.5 times variation in the internal temperature of the Vela pulsar for a fixed surface temperature inferred from observations. In turn, the uncertainty in the internal temperature causes up to ~ 200 times variation of the neutrino cooling function. We have also studied the effect of variations of chemical composition on cooling curves of isolated neutron stars [4].

References

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