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Non-LTE effects in neutron star atmospheres

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Abstract. We present the first non-LTE model atmospheres for neutron stars (NS). We study their structure and NLTE effects on the emergent thermal radiation of old isolated NS.

Our models assume plane-parallel geometry, hydrostatic and radiative equilibrium. The radiation transfer equations are solved simultaneously with the NLTE rate equations by using an Accelerated Lambda Iteration technique (Werner & Dreizler 1999). Blanketing by millions of iron lines is considered with an Opacity Sampling method. The models neglect magnetic fields, which is a good approximation as long as B< 10^8–10^{10} G, depending on $T_{\rm eff}$ and chemical composition (Zavlin et al. 1996). Iron opacities are calculated from Kurucz line lists, and bound-free cross-sections from Opacity Project data.

We have computed a set of three models with different chemical composition: pure H, He, and Fe models. We chose $T_{\rm eff}$=200 000 K, $\log g$ =14.39, corresponding to a NS with M=1.4 $M_\odot$ and R=10 km. Fig. 1 shows their emergent fluxes. They display distinctly harder high energy tails than a blackbody. Fig. 2 shows details of the model structures. Due to NLTE effects, temperatures show a slight increase in the surface layers. Departures from LTE are most pronounced in the iron model. They affect the line formation regions and hence fluxes in the strongest Fe line cores, typically of the order 10%. The general spectral shape is unaffected. NLTE effects might be even more important at higher $T_{\rm eff}$.

Werner K., Dreizler S. 1999, Journal of Computational and Applied Math., in press
Zavlin V.E., Pavlov G.G., Shibanov Y.A. 1996, A&A 315, 141

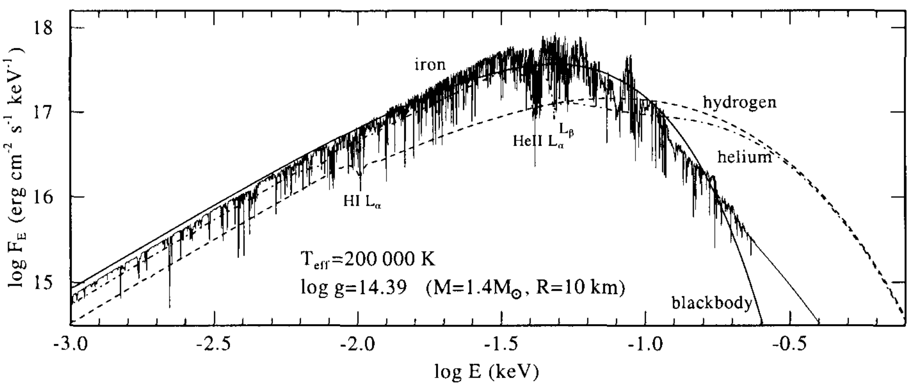

Figure 1. Emergent fluxes of NLTE neutron star model atmospheres

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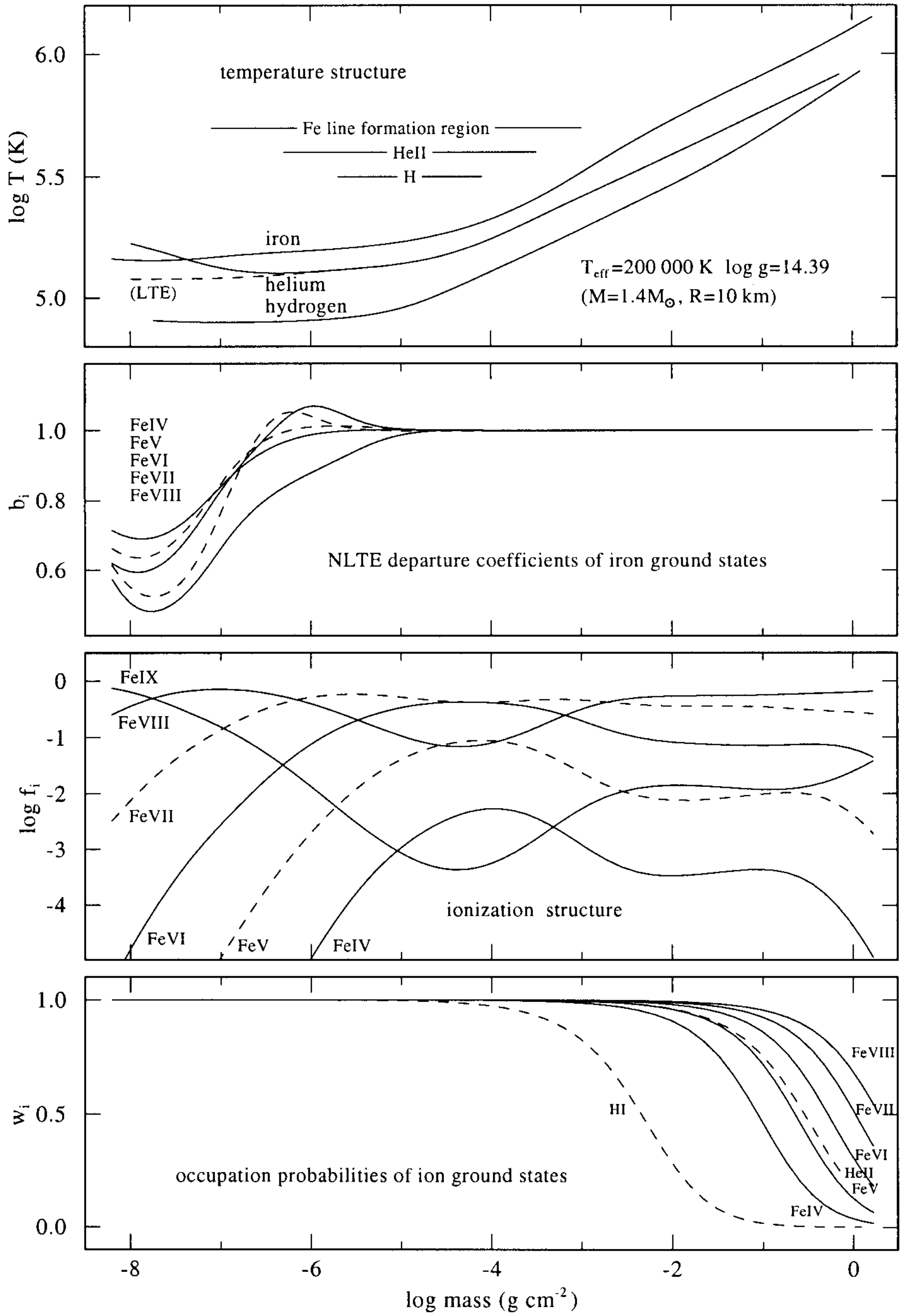

Figure 2. Structures of the NLTE neutron star model atmospheres. Departures from LTE occur in the iron line formation region.

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