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# Models of neutron star atmospheres enriched with nuclear burning ashes

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## Abstract

© ESO, 2015. Context. Low-mass X-ray binaries hosting neutron stars (NS) exhibit thermonuclear (type-I) X-ray bursts, which are powered by unstable nuclear burning of helium and/or hydrogen into heavier elements deep in the NS "ocean". In some cases the burning ashes may rise from the burning depths up to the NS photosphere by convection, leading to the appearance of the metal absorption edges in the spectra, which then force the emergent X-ray burst spectra to shift toward lower energies. Aims. These effects may have a substantial impact on the color correction factor fc and the dilution factor w, the parameters of the diluted blackbody model FE wBE(fcTeff) that is commonly used to describe the emergent spectra from NSs. The aim of this paper is to quantify how much the metal enrichment can change these factors. Methods. We have developed a new NS atmosphere modeling code, which has a few important improvements compared to our previous code required by inclusion of the metals. The opacities and the internal partition functions (used in the ionization fraction calculations) are now taken into account for all atomic species. In addition, the code is now parallelized to counter the increased computational load. Results. We compute a detailed grid of atmosphere models with different exotic chemical compositions that mimic the presence of the burning ashes. From the emerging model spectra we compute the color correction factors fc and the dilution factors w that can then be compared to the observations. We find that the metals may change fc by up to about 40%, which is enough to explain the scatter seen in the blackbody radius measurements. Conclusions. The presented models open up the possibility of determining NS mass and radii more accurately, and may also act as a tool to probe the nuclear burning mechanisms of X-ray bursts.

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## Keywords

Methods: numerical, Radiative transfer, Stars: atmospheres, Stars: neutron, X-rays: bursts, X-rays: stars