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Constraining neutron star EoS from cooling stages of X-ray bursts

Juri Poutanen[1] and Valery Suleimanov[2]

[1]University of Oulu, Finland, Finland
email: juri.poutanen@oulu.fi

[2]Tuebingen University, Germany
email: suleimanov@astro.uni-tuebingen.de

Abstract. Thermal emission during X-ray bursts is a powerful tool to determine neutron star masses and radii, if the Eddington flux and the apparent radius in the cooling tail can be measured accurately, and distances to the sources are known. We propose here an improved method of determining the basic stellar parameters using the data from the cooling phase of long, photospheric radius expansion bursts covering a large range of luminosities. For this purpose, we computed a large set of atmosphere models for burst luminosities varying by two orders of magnitude and for various chemical compositions and surface gravities. We show that the variation of the inverse square root of the apparent blackbody radius with the flux, observed during the photospheric radius expansion bursts from a number of sources at low accretion rate is entirely consistent with the theoretical expectations of the color-correction factor evolution. However, for bursts happening at higher accretion rates the observed evolution is inconsistent with theory, implying that accretion strongly disturbs the neutron star atmosphere. These findings have profound implications for the recent claims on determination of the neutron star radii and masses from such bursts. Our method allows us to determine both the Eddington flux and the ratio of the stellar apparent radius to the distance much more reliably. For 4U 1724-307, we find a lower limit on the neutron star radius of 13 km, independently of the chemical composition. These results suggest that the matter inside neutron stars is characterized by a stiff equation of state.