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Vertical structure of the outer accretion disk in persistent low-mass X-ray binaries

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Abstract

We have investigated the influence of X-ray irradiation on the vertical structure of the outer accretion disk in low-mass X-ray binaries by performing a self-consistent calculation of the vertical structure and X-ray radiation transfer in the disk. Penetrating deep into the disk, the field of scattered X-ray photons with energy $E \gtrsim 10$ keV exerts a significant influence on the vertical structure of the accretion disk at a distance $R \gtrsim 10^{10}$ cm from the neutron star. At a distance $R \sim 10^{11}$ cm, where the total surface density in the disk reaches $\Sigma_0 \sim 20$ g cm $^{-2}$, X-ray heating affects all layers of an optically thick disk. The X-ray heating effect is enhanced significantly in the presence of an extended atmospheric layer with a temperature $T_{\text{atm}} \approx (2-3) \times 10^6$ K above the accretion disk. We have derived simple analytic formulas for the disk heating by scattered X-ray photons using an approximate solution of the transfer equation by the Sobolev method. This approximation has a $\lesssim 10\%$ accuracy in the range of X-ray photon energies $E < 20$ keV. © 2011 Pleiades Publishing, Ltd.

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Keywords

accretion disks, low-mass X-ray binaries