A QUANTITATIVE STUDY OF LIMB DARKENING IN ACCRETION DISKS

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Abstract. The UV emission of accretion disks was synthesized for a grid of optically thick models that cover the high-$\dot{M}$ nova-like regime, aiming to quantify the effect of limb darkening in the integrated and radially resolved spectrum of the disk.

1. Introduction

The method described by Hubeny (1990) is employed to compute the disk properties. The steady-state disk is assumed geometrically thin and its structure is solved for a set of concentric rings where a plane-parallel atmosphere calculation is performed. Such an atmosphere is in hydrostatic equilibrium with the depth-dependent gravity. The mass surface density is given by the standard model and $\bar{w}$, the depth-averaged viscosity, is parameterized in terms of the Reynolds number of the flow. The viscosity $w(z)$ varies as a power law of the mass column density above depth z. The 'disk' equations and the radiative transfer equation are solved iteratively in LTE by the complete linearization method using the code TLUSDISK (Kriz & Hubeny 1986). Once the temperature and density are self-consistently modeled, the radiative transfer equation is solved by the general spectral synthesis program SYNSPEC (Hubeny, Lanz & Jefferys 1994). Several continuum opacity sources are included and the lines of elements up to $Z = 30$ (Kurucz 1990) were considered. The local line profile has the form of a Voigt function which includes Stark and thermal broadening. The integrated disk spectrum is obtained by coadding the specific intensities in the observed wavelength scale defined by the inclination and the local Keplerian velocity. In addition, the partial occultation of the inner disk by the white dwarf is considered.

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2. Results

A comparison between the limb darkening effect in disk models with 'gravity equivalent' model atmospheres indicates that the local behavior of limb darkening in disks is not too different from the same process in stellar atmospheres (cf. Wade & Rucinski 1985). The continuum limb darkening effect as a function of the disk radius was measured by defining a 'line-free' passband at 1448 Å. The limb darkening correction factors for the integrated disk were then interpolated in $\dot{M}$, M_1 coordinates. It can be seen from our results that the limb darkening effect is larger at outer disk radii and for low white dwarf masses, reflecting the temperature and gravity variations in the disk. It also increases at low mass transfer rates up to a typical value of 2.5 mag for $i = 83°$. However, at high mass transfer rates onto massive white dwarfs, negligible effects are expected over *most* of the disk, even for an inclination of 72°. The disk emissivity at 1448 Å is largest close to the canonical maximum temperature radius and its radial decline is flatter for low-mass white dwarfs, as expected from the standard theory with a simple blackbody emissivity. Gross systematic trends in the Lyman line profiles can be seen. The line width obviously increases with i while the core depth increases as the white dwarf mass decreases. Another sequence is seen in the Lyman line width as a function of the mass transfer rate; the larger, the narrower the lines. The continuum shape appears steeper as the disk temperature ($\dot{M}$ or M_1) increases. In general, the level of the continuum adjacent to the blue wing of Lyγ is a good indicator of the mass transfer rate for the whole mass range. This simulation shows that the limb darkening is an important effect, especially in the UV, and should be taken into account when the overall or local emission of accretion disks in CV's is modeled and compared with observations. Limb darkening corrections such as those computed in this work should be considered in the luminosity and/or distance estimations made on the basis of observed color–magnitude diagrams and radial continuum emissivity distributions. These quantities have been measured for several nova-like systems using eclipse mapping techniques. A detailed discussion of the results summarized here will be published elsewhere.

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