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Accretion Disks

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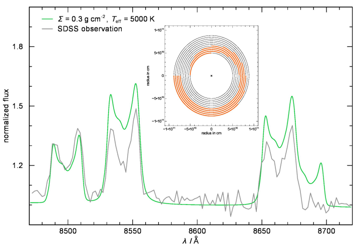
Introduction

AcDc is a NLTE code based on the Tübingen stellar atmosphere package TMAP. It computes self-consistently the vertical structure and emergent spectrum of accretion disks. We have applied it to the quantitative spectral analysis of accretion disks in rather different environments: disks in cataclysmic variables and AM CVn stars, around neutron stars in ultra-compact low-mass X-ray binaries, supernova fallback disks, and gaseous debris disks around single white dwarfs.

Metal Disks around White Dwarfs

Recently, signatures of gaseous disks were discovered around single white dwarfs (WD). They are thought to develop from disrupted planetary bodies. We focus on one of these, namely SDSS J1228+1040. The spectra display double-peaked emission lines of calcium. Hydrogen and helium are not discovered. It is concluded that the Ca lines stem from a metal-rich Keplerian disk. They can be modeled with a geometrically thin, viscous gas disk from 0.64 to 1.5$R_\odot$ from the WD, with T_{eff} = 6000K and a surface mass density of 0.3g/cm^3. Assuming a uniform surface density, its total mass would be about 4•10^{21}g. A rocky asteroid with this mass would have a diameter of ~135km (Hartmann et al., 2011).

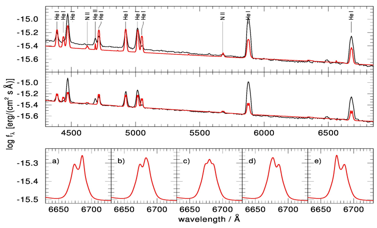


Modeling the spectrum for a non-axisymmetric geometry is reproducing the asymmetry of the Ca II IRT line profiles.

AM CVn Stars

AM CVn stars are close, interacting binary systems with very short orbital periods of 5–65 minutes, forming a subgroup of cataclysmic variables. Their spectra are dominated by helium lines. The accretor is a WD, whereas the nature of the Roche lobe filling low-mass donor is still discussed. It might be a helium WD, a helium star, or the helium-rich core of an evolved secondary. As the disk represents the chemical composition of the donor's atmosphere, the analysis of the disk will help to understand the donor star and the formation of these systems.

We find emission-line spectra for low and absorption-line spectra for high mass-accretion rates. Comparing an observed spectrum of CE 315 with our models we find the qualitatively best match for a 0.8$M_\odot$ primary and a mass-accretion rate of $10^{-11} M_\odot yr^{-1}$. The disk shows a strong silicon underabundance confirming the hypothesis that it is a Population II object (Nagel et al., 2009).

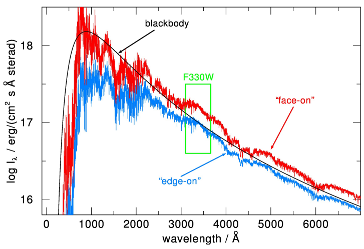


Comparison of an observered spectrum of CE 315 (black) with models: disk, boundary layer and hotspot (top); disk and WD (middle); modulation of a He I line caused by the orbiting hotspot (lower).

Supernova Fallback Disks

The existence of supernova fallback disks, e.g. in AXPs, is a widely discussed topic. The non-detection of a point source in SN1987A imposes an upper limit for the optical luminosity. This limits the size of a possible fallback disk around the stellar remnant. Assuming a steady-state thin disk with blackbody emission requires a disk smaller than 100,000km if the accretion rate is at 30% of the Eddington rate.

With AcDc we have modeled the disk spectrum more realistically. The chemical composition is assumed to be pure Fe or that of a Si-burning ash. It turns out that the observational limit on the disk extension becomes even tighter, namely 70,000km (Werner et al., 2007).



Specific intensity of the fallback disk at a distance 40,000km from the central compact object and a blackbody spectrum for T_{eff} of 33,000K. The rectangle indicates the passband of the HST/ACS filter F330W: The blackbody spectrum systematically under-estimates the flux for inter-mediate inclinations.

References
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