Effect of Dust Obscuration on the Emission Lines of RR Tel

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Abstract. We continue our investigation of the emitting region of the symbiotic nova RR Telescopii by analyzing the emission line fluxes from high quality AAT optical spectra obtained in 2000, and comparing these with previous observations. The fading found in the recent spectra suggests increased circumstellar dust absorption in the stellar wind of the mira. Differing absorption of lines formed in different regions provides information on the geometry of the dust regions.

1. Introduction

This work is a follow up of our previous works dealing with investigation of the emitting regions of the symbiotic nova RR Tel by use of analysis of the Fe II emission line fluxes in the optical spectra of RR Tel taken in the years 1996 (Kotnik-Karuza et al. 2002) and 2000 (Kotnik-Karuza et al. 2003). A fading of both, permitted and forbidden lines was found, which suggested a possible dust obscuration event taking place between the two observations.

The size of the emitting region determined by use of the Fe II lines on both dates, which proved to be too small on the later date, might be taken as another sign for the additional dust obscuration. Such obscuration events have been observed in other symbiotic binary systems containing a mira as the cool component (Mikolajewska et al. 1999; Whitelock 2003).

There were still earlier observations of RR Tel in 1993 (McKenna et al. 1997). Comparison of the emission line fluxes from these spectra with the same lines from 1996 (Crawford et al. 1999; Selvelli & Bonifacio 2000) and 2000 suggests very little or no dust obscuration in 1993, a start of a dust obscuration event in 1996 and fair dust obscuration in 2000.

In order to understand the physics behind the fading we have studied the behaviour of lines of different ionization potential which implied the measure-
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The behaviour of flux ratios implying the values from the observations in 2000 and 1996 should help us to obtain information on the geometry of dust obscuration knowing that a cooling of the hot component would especially affect lines of highly ionized states and that dust absorption would differentially affect lines, depending on which line of sight it was strongest.

2. Observations and methods

The line fluxes were measured from the RR Tel spectra taken at the Anglo-Australian Telescope (AAT) on 2000 July 13-14 with UCLES in the wavelength range 2800-10450 Å. The calibration and measurement procedure have been described in our previous work (Kotnik-Karuza et al. 2003).

From a total number of 420 measured lines of wavelengths between 3180 and 9230 Å belonging to ions of different degrees of ionization other than Fe II which were measured also in the 1996 spectra, lines in the far red and far violet have been left out because of greater measurement errors. After elimination of blends and misidentifications in the remaining set, 360 lines were accepted for further analysis.

In order to obtain information on the geometry of dust obscuration, ratios of fluxes from spectra taken on different dates, i.e., 2000 (F) and 1996 (Fc), were determined for each line. Their behaviour with wavelength and ionization potential was examined.

The same procedure has been done separately for the permitted and the forbidden lines since they are not formed in the same region and a different behaviour might be expected.

3. Results and discussion

The results are given in the form of a flux ratio-wavelength correlation for different ionization potential ranges (Figure 1). They are mainly empirical. The slopes of linear fits, being usually positive, indicate a decrease of absorption with wavelength. Negative slopes seem unimportant, the correlation coefficient in such cases being too small to be significant.

This behaviour is better seen from the graph in Figure 2 in which the intercept of the linear fit solution (plot in Figure 1) at fixed wavelengths is given. The results for the permitted and forbidden lines have been presented separately as they are not expected to be formed in the same region.

There is no doubt on general fading of all lines in 2000 with respect to 1996. Forbidden lines appear to have faded by about the same amount as the permitted ones. Previously we found that [Fe II] lines faded less than Fe II which suggests the [Fe II] line formation further away from the dust.

There is a week dependence on excitation potential, the flux ratios being usually higher for higher ionization potentials. This suggests stratification of the ions and a different absorption on lines of sight to highly ionized and little ionized lines.
Figure 1. Log(flux ratio)-wavelength correlation for the (a) permitted and (b) forbidden lines. The contributing fluxes are from the 2000 (F) and 1996 (Fc) spectra respectively. The linear fits 1 indexed in ascending order correspond to increasing values of the IP ranges.
Thus the regions towards the hot component, with the most ionized stages near it prove to be less obscured by dust. (No significant decrease of the hot component temperature is expected). However other effects occur, especially for permitted lines (self absorption, etc....).

Comparison with the results for Fe\textsubscript{II} shows that most lines of other ions are not formed in the same region as Fe\textsubscript{II}.

A large scatter of the log flux ratios of little ionized atoms, especially of those with log flux ratios above zero, is observed. There are at least two explanations for this effect. It can be a result of unreliable fluxes which refer particularly to weak lines, as well as because of complicated radiative transfer effects in the presence of dust.

The permitted lines have more scatter because of self absorption effects contrary to the forbidden lines which are optically thin. It might be useful to analyze the lines with a rather low excitation potential of their upper level (less than 7–8 eV) separately from the others according to different excitation mechanisms. Namely, forbidden lines, usually collisionally excited in the less dense regions, as well as permitted lines of neutral and some singly ionized atoms appear to be usually excited by a process starting at the ground level. On the contrary, the optical lines of well ionized atoms with a high excitation potential are often excited by recombinations.
4. Conclusion

In our search for differences in dust absorption of lines due to atoms of different ionization potential, there are indications of more dust absorption of neutral and weakly ionized atoms. This agrees with the conception that such lines are formed closer to the cool component, where there is more dust. Fluxes of such lines should decrease more during dust obscuration events. However other effects are probably present, producing the large scatter particularly for permitted lines of not very ionized atoms. They might include the effects of radiative transfer in the presence of dust.

In order to improve this work and so get to the bottom of the obscuration we intend to compare the flux ratios with the IR data on dust obscuration and to expand the wavelength limits of the studied lines in the far red and far violet. A further rigorous check for blends and misidentifications might reduce the scatter.

References

Whitelock P.A. 2003, ASP Conf. Ser., in press