Eclipse observations of active binary systems

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Abstract. We present and discuss some new data obtained in our study of the atmospheres and environments of active binary systems (RS CVns). High spectral and time resolution observations of the spectral lines Ca II H & K and Hα have been obtained for several systems.

1. Introduction

Recent observations have provided unexpected evidence of cool coronal structures surrounding active stars. Mullan et al. (1989) observed cool coronal condensations being ejected from V471 Tauri at line-of-sight velocities up to 800 kms^{-1}. Houdebine et al. (1990) reported a coronal mass ejection (CME) event during a flare on AD Leo (dM4.5e). On active binaries such structures have been reported by Hall & Ramsey (1992).

Observations have established that short rotation periods and therefore high levels of dynamo-related activity are a prominent feature of stellar youth. Questions raised by these observations include: (i) is magnetic activity, through mass loss,a key parameter in determining the future of main sequence stars, (ii) what is the main sequence star contribution to the interstellar medium, and (iii) do coronal formations play a major role in the mass loss process?

Detailed observations of stars of differing mass and spectral type are essential for an understanding of the angular momentum loss mechanism and its dependence on convective zone depth and rotation rate. The RS CVn-type binaries are a powerful tool in the investigation of the coronal and chromopheric properties of active stars as a function of rotation period, mass and spectral type. We have recently begun an observing campaign to investigate coronal phenomena by imaging the stellar emission during RS CVn eclipses.

2. Observational results

The observations were made from 28th July to 1st August 1993 with the 4.2-m William Herschel Telescope equipped with the cross-dispersing Utrecht Echelle Spectrograph. The targets observed are summarized in Table 1. A 1180$\times$ 1280 EEV6 charge-coupled device images 51 spectral orders from about 4900 Å to 8700 Å with a resolution of approximately 60,000. Integration times were varied according to the target brightness but did not exceed 10 minutes in the blue region and 3 minutes in the red.

Target	P_{orb} (days)	Eclipse Type	Spectral Types (hot/cool)		Observed Eclipses (Julian Date + 2440000)	Phase Coverage
V772 Her	0.879	P	G0V/[M1V]	G5V	9197.5388	0.13
SZ Psc	3.966	P	F8IV	K1IV	9197.6552	0.04
RT And	0.629	T	F8V	K0V	9198.4795 9200.6808	0.23 0.15
ER Vul	0.698	P	G0V	G5V	9199.5537	0.11
EZ Peg	11.660	N	G5V-IV	K0IV	9199.6256	0.02
BD-00 4234	3.757	N	K3Ve	K7Ve	9200.5293	0.09

Table 1. *Observations with the WHT in July-August 1993. For each object we list the orbital period, the eclipse type of the system (P = partial, T = total and N = none eclipsing), the spectral type of the hot and cool components, the Julian date of the eclipses which were observed and the total phase coverage for each observation.*

The data were reduced using the IRAF[1] software package. Each image was corrected with bias and flat-field frames and the dispersion axis CCD response calibrated out with a normalization technique. The orders were extracted optimally and the average sky count subracted. Wavelength calibration was done by reference to Th-Ar arc spectrum images. The signal-to-noise ratio was estimated from the continuum noise in line free regions and was about 50 for our observations of RT And in the red region.

3. Discussion

In Figure 1 we present the entire series of spectra spanning the secondary eclipse of RT And at 04:20 UT on 1st August 1992. The Hα absorption line clearly varies with orbital phase and appears to be most symmetric during the mid-eclipse spectrum. Each spectrum consists of a composite formed from both members of the binary system and are therefore effected by radial velocity variations. Several methods are available to resolve the intrinsic radiative processes from the complex variation in component radial velocities. The cross-correlation of a spectrum consisting of two highly rotationally broadened binary components with that of a standard non-active slow-rotating single star produces a power spectrum which unambiguously resolves the component radial velocities relative

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Figure 1. *A series of spectra spanning the 180° phase eclipse of the RS CVn system RT And. The 04:20 UT spectrum was taken across mid-eclipse.*

to the standard. The series of observed spectra can then be aligned on the radial velocity curve of one of the components. We are analyzing these data with cross-correlation techniques and the spectral subtraction technique used extensively by Hall & Ramsey (1992) and others.

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