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The long-term phenomenon in U Mon

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Abstract. The nature and origin of the long-term variability in U Mon has been investigated using multicolour photometry and high-resolution echelle spectroscopy. The photometry shows long-term dimming, damping and reddening of the system, as well as the extremely variable nature of this modulation. The new spectroscopic observations show enhanced Hα emission during long-term light minimum. Our radial velocities were combined with those from the literature to determine orbital parameters for the U Mon system (P$\sim$2600 d, e=0.43). Obscuration by dust at certain orbital phases explains the light decrease and reddening, while the enhanced H-alpha emission and damping of the light and colour curves may indicate that mass loss or interaction is occurring at (or close to) periastron passage in the U Mon system.

Key words. Stars: variable – Stars: Population II – stars: individual: U Mon

1. Introduction

U Mon is the second brightest RV Tauri star (after R Sct) and the brightest of the RVb subclass. The RVb subclass possess a long-term ($\sim$600-3000 d) variation of the mean V magnitude superimposed on the short-term ($\sim$50-150 d) light variations due to radial pulsations. In addition, members of this subclass (as well as some RVa stars, eg. AC Her) exhibit long-term radial velocity variations. Although it is well established that the short-term variations are due to radial pulsational motion, the long-term variations are not well understood.

Recent RV Tauri research has investigated their binarity, the origin of the long-term modulation and the possible link between these two phenomena (Pollard & Cottrell 1995, Pollard et al. 1996, Van Winckel et al. 1998, 1999, Maas et al. 2002).

2. Observations and analysis

BVRI photometry of selected RVb stars was obtained with 0.61-m telescopes at the Mt John University Observatory (MJUO) from 1990 onwards. High-resolution echelle spectra using the 1.0-m telescope were obtained from 1991 onwards. The V and $(V - I)$ curves (Figure 1(a) and (b)) show the long-term modulation, with the reddest colours occurring slightly after the long-term V minimum. The short-term light and colour variations are damped at the long-term minimum.

The strength of the Hα emission is dependent on both the short-term and the long-term phase (Figure 1(c)). Short-term variations in Hα emission are related to the propagation of two shock waves through the stellar atmosphere during each 92.92 d luminosity cycle. Long-term enhanced Hα emission is seen just

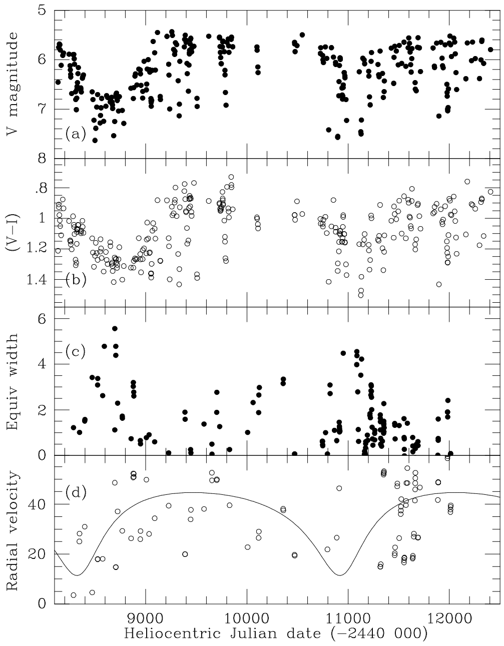

Fig. 1. MJUO observations of U Mon: (a) the V light curve; (b) $(V-I)$ colour curve; (c) Hα equivalent width; (d) radial velocities (circles) and orbital solution (solid line).

after the long-term light minimum when the colours are reddest.

Figure 1 (d) shows both short-term (radial pulsations) and long-term radial velocity variations of comparable amplitude. The most likely explanation for the long-term radial velocity variations is orbital motion. Previously published radial velocities for U Mon were analysed together with the new MJUO data in order to obtain an orbital solution, giving a period of 2597 d and an eccentricity of 0.43. The orbital period is in reasonable agreement with the value (2475 d) obtained from analysis of visual and photographic estimates (Percy et al. 1991).

3. Discussion

The explanation for the long-term (light, colour, radial velocity and Hα emission) variability in the RVb stars is uncertain, though a leading model involves a binary system surrounded by a dust torus which periodically eclipses the RV Tauri star (see Figure 2).

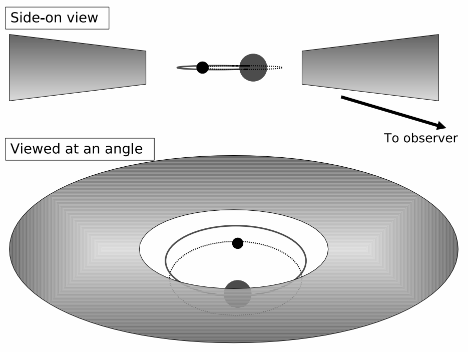

Fig. 2. The dust obscuration model where the RV Tauri star (large star) may be periodically eclipsed by a circumbinary dust torus depending on the observer's perspective.

An effect seen in U Mon (and reported in many members of the RVb subclass) which is difficult to explain by the dust-eclipse model is the decrease in amplitude or "damping" of the light and colour variations at the long-term minimum. A possible explanation for this damping, as well as the enhanced Hα emission at the same time, is that the binary system is interacting at some orbital phase. The interaction could involve mass loss or mass transfer between the components of the binary. The orbital analysis for U Mon did indicate that the binary components may be close enough to interact at periastron as a consequence of the large radius changes that occur during the pulsation cycles.

Finally, it is quite possible in a system where circumstellar or circumbinary material is known to exist, that a combination of obscuration and interaction mechanisms is present.

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