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The UXOR-type Star RY Ori

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EXPORT

Abstract. We present the observations of the UXOR-type star RY Ori carried out by EXPORT. A first analysis of the simultaneous optical and near-infrared data suggests that the optical and near-IR variabilities of pre-main sequence stars can follow different trends when observed at the same time.

1. Introduction

RY Ori (HBC 436) is a young highly variable PMS star of the Orion population classified as a F6/F8 star. It was studied by Bibo & Thé (1991) in the ubvy system who found a Δy variability of 1.85 mag in the range 11.15 - 13.00. They observed a colour-reversal in the colour-magnitude diagram similar to that observed in UX Ori and noticed that the star remain most of the time at mean brightness and shows rapid activity. The star has been studied at near-IR wavelenghts by Cohen (1973) and by Glass & Penston (1974). IRAS 05296-0251 is associated with RY Ori in the SPC catalogue. Recently Yudin & Evans (1998) have carried out polarimetric observations and reported a large polarization in the range $p \approx 4\% - 6\%$ when the star was near minimum, V$\approx$ 13.7 mag.

During the EXPORT observing runs RY Ori showed spectroscopic and very prominent photometric and polarimetric variability. In particular, the optical and near-IR variabilities follow different patterns. This contribution presents a first analysis of the photopolarimetry results.

2. OBSERVATIONS AND RESULTS

RY Ori was observed with the INT during the nights 25-28 October 98 and 29-31 January 99. Details of the observations are given in other EXPORT con-

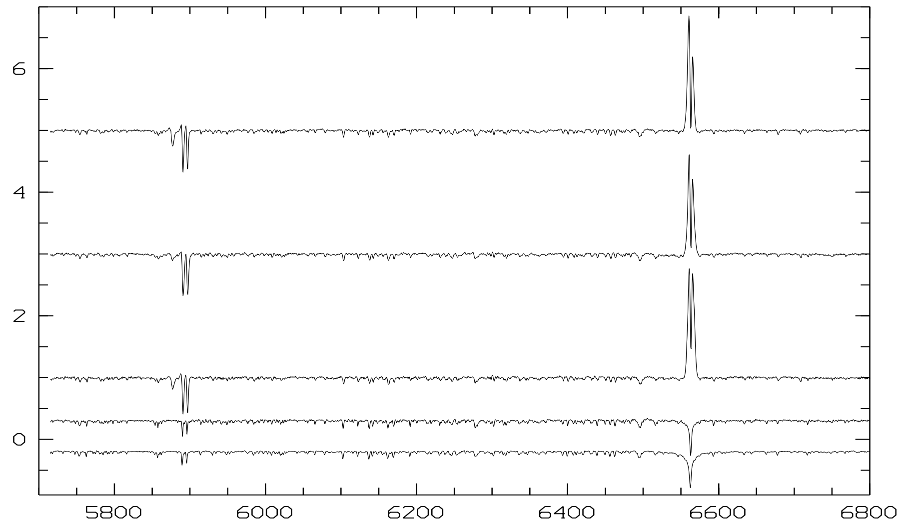

Figure 1. January 99 INT spectra of RY Ori. From top to bottom the spectra corrrespond to JD(+2400000) 51208.50, 51209.51, 51210.52. The fourth spectrum from the top corresponds to a F6V standard star and the spectrum at the very bottom is a F6IV star.

tribution in this wolume. Figure 1 shows the INT January spectra. The spectra correspond very well to a F6V/IV star. In addition to the photospheric spectrum, RY Ori shows variability in some lines. HeI 5875 and NaI D 5890 appear relatively strong in absorption and they also show a blueshifted emission in some of the spectra. Hα is a strong double-peaked emission; the red component is always the faintest one. Figure 2 shows HeI, NaI D and Hα with some detail (October 98 and January 99).

One spectrum was taken with the WHT in the night 30/31 January 99 (JD 2451209.50). Figure 3 shows the CaII H and K and the NaI D lines as observed with the WHT. Procyon (F5V) is also shown for comparison. The CaII and NaI lines are very different in both stars. In particular, NaI redshifted absorption components are observed in the RY Ori spectrum. These components are not distinguished in the lower resolution INT spectrum taken simultaneously (Figure 2). These components are similar to those observed in other UXORs and β Pic/Vega-type systems and probably are transient, although this requires further confirmation - we only have one high-resolution spectra.

Optical photopolarimetry (NOT) and near-IR photometry (CST) were carried out in October 98 and January 99. In particular, the October 98 run was very good in terms of photometric quality. The star showed a strong variability in October 98 while it remained at mean brightness level and practically constant in January 99. Figure 4 show the observed photometric and polarimetric light curves corresponding to the October 98 data.

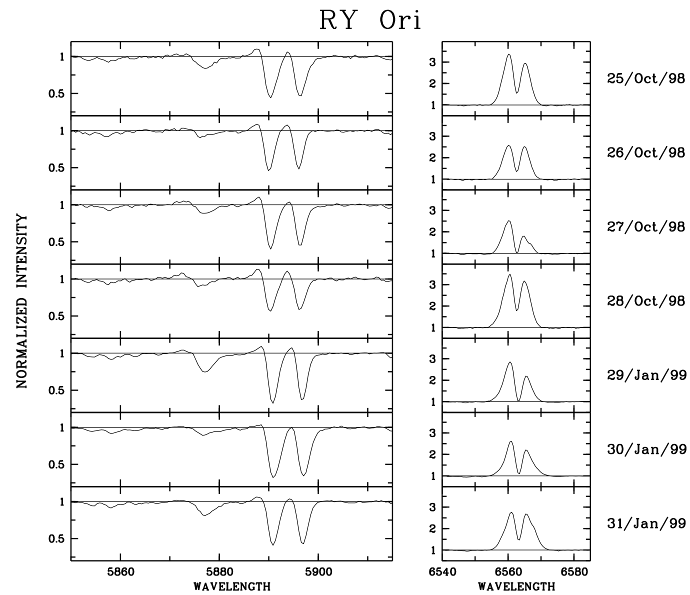

Figure 2. INT spectra of RY Ori around the HeI, NaII and Hα lines.

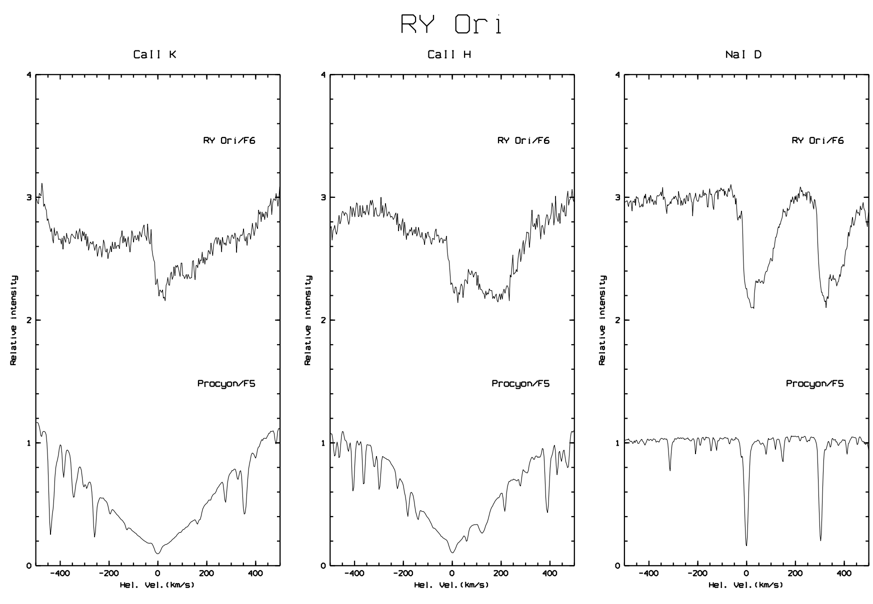

Figure 3. WHT high-resolution CaII H, K and NaI D lines from RY Ori (JD 2451209.50). The spectrum of Procyon is also shown for comparison.

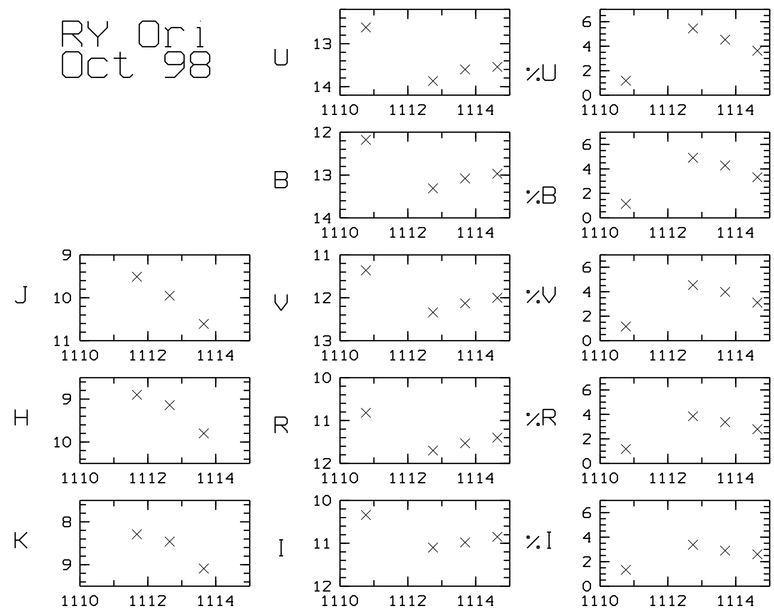

Figure 4. October 98 photometric and polarimetric light curves of RY Ori. The figure plots magnitudes and polarization degree versus Julian Date (+2450000.0). Note the lack of correlation between the optical and near-IR photometric variabilities.

3. DISCUSSION

RY Ori fits into the commonly accepted scheme of a PMS star surrounded by a circumstellar disk. The star shows a photosperic spectrum plus some variable emission and absorption lines originated in the circumstellar gas and a stellar wind. Optical colours are consistent with a F type star reddened by an extinction $A_V \sim 1$ mag, while the IR colours indicate a noticeable near-IR excess. The data indicate a noticeable photometric and polarimetric variability. However, *the optical and near-IR variability are not correlated* (Figure 4).

RY Ori shows the largest and rapid near-IR variability of the EXPORT sample: ΔJ =1.10, ΔH = 0.90 ΔK = 0.80 within 48 hours during October 98; at optical wavelengths the star also varies significantly. From JD 2451110.76 to JD 2451112.74 the star fades at optical wavelengths (UBVRI), V changes from 11.36 mag to 12.34 mag, while the polarization increases, from 1.2 to 4.5 %. The amplitude of the variations decreases from U to I. From JD 2451112.74 to JD 2451114.64 the star brightens up again and the polarization disminishes; now the amplitude of the variability is similar at all wavelengths while the polarization decreases less with the wavelength. This anticorrelation between optical brightness and polarization degree has previously been observed towards many young stars. The near-IR behaviour, however, is very different and the star remains fading from JD 2451111.67 to JD 2451113.65 all the way. Note that although the near-IR and optical light curves do not exactly overlap in time, the critical points are those from JD 2451112.7 to JD 2451113.7, when the star fades in the near-IR but it brightens in the optical.

In principle, we would expect the same fading/brightening trend in the optical and near-IR bands. To be sure that the data are real, we have revised very carefully all the October 98 photometric data. The run was excellent in terms of optical and near-IR photometry. Errors of the standard star fits and/or errors of the individual measurements of RY Ori (as well as of the observed standard stars) are low, normally well below 0.05 magnitudes. Thus, there is nothing indicating that the RY measurements could be wrong. We have analysed the light curves of other variable stars observed in the same run and found many different behaviours. In particular, DK Tau, a T Tauri star of spectral type K7, presents light curves similar to RY Ori, i.e. the optical and near-IR variabilities do not correlate. Taken independently, the variability in both spectral ranges follows usual trends observed in pre-main sequence stars. Thus, we conclude that the simultaneity of the observations in the optical and in the near-IR is the fact revealing that the variability in both wavelengths regimes does not necessarily follow the same trend at the same time.

Photometric variability of PMS stars is normally atributed to one or several of the following scenarios: 1. Cool stellar spots which rotationally modulate the stellar light. 2. Hot spots caused by a magnetically channeled accretion flow onto the stellar surface. 3. Variable obscuration by dust clumps in the circumstellar environement. 4. Changes in the temperature profile and structure of the circumstellar dust disk. The first three scenarios can produce large amplitude variations, up to several magnitudes, with the amplitude of the variability disminishing with increasing wavelength (although variability larger that ~ 0.2 - 0.3 mag is difficult to explain in terms of cool spots because it would require a very large coverage of the stellar surface). The fourth one would produce a larger variability in the near-IR than in the optical, since typical dust disk temperatures ($T_D^{max} \sim 2000K$) radiate relatively few in the optical. It seems plausible to think that the origin of the observed optical and near-IR variability in RY Ori is a combination of hot stellar spots and/or variable obscuration plus some changes in the disk structure, each mechanism acting with different weights in both optical and near-IR ranges. A detailed comparison of the observational data with PMS variability models is beyond the scope of this paper but it is planned for the near future.

4. CONCLUSIONS

Further simultaneous near-IR and optical pohotometric observations are required to reconfirm and to characterize much better the observed variability in RY Ori (and also in the case of DK Tau). In our opinion, the relevant outcome of the data presented here is the real need of simultaneous optical and near-IR observations to provide plausible scenarios in order to explain the variability of pre-main sequence stars.

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