# LU Vel (GJ 375): a dM3.5Ve Flare and Double-lined Spectroscopic Binary


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Close Binaries in the 21st Century
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## Abstract

High resolution echelle spectroscopic observations taken with the FEROS spectrograph at the 2.2m telescope ESO confirm the binary nature of the flare M3.5V star LU Vel (GJ 375, RE J0958-462) previously reported by Christian & Mathioudakis (2002). Emission of similar intensity from both components is detected in the Balmer, NaI D1&D2, HeI D3, CaII H&K, and CaII IRT lines. We have determined precise radial velocities by cross correlation with radial velocity standard stars, which have allowed us to obtain for the first time the orbital solution of the system. The binary consist of two near-equal dM3.5V components with an orbital period of 1.875 days. We have analyzed the behaviour of the chromospheric activity indicators (variability and possible flares). In addition, we have determined its rotational velocity and kinematics.


## Observations

The spectroscopic observations (high resolution echelle spectra) of this star were obtained during one observing run from 18 to 22 February 2005 using 2.2 m telescope at the European Southern Observatory, ESO (La Silla, Chile). We have used the FEROS (Fiber-fed Extended Range Optical Spectrograph) linked to the Cassegrain focus of the 2.2m telescope, in unique fiber modus, with CCD (2048X4096, 0.15 μm/pixel). This configuration give a resolution of 48000 and a spectral range from 3500 to 9000 Å, from Ca II H & K (3933, 3968 Å) to Ca II IRT (8498, 8542, 8662 Å), in a total of 39 orders.
A total of 12 spectra of LU Vel has been taken during the 5 nights of observations. Reference stars of similar spectral type and radial velocity standards stars are also observed with the same configuration.

## LU Vel

LU Vel (GJ 375, BD-45 5627), is a nearby (d=16 pc) M3.5 dwarf (V=11.3) with Balmer and CaII H&K lines in emission (see Fig. 1) and know to have a high level of flare activity (Doyle et al. 1990, A&AS 86, 403). It is a EUV source (RE J0958-462) detected by the ROSAT Wide Field Camera all-sky survey (Pounds et al. 1993 MNRAS, 260, 77). Recently, two high resolution spectra reported by Christian & Mathioudakis (2002, AJ, 123, 2796) identified it as a double-lined spectroscopic binary (SB2) with strong Balmer emission from both components (see Fig. 2). But the orbital solution has not been obtained until now. These authors also determined a rotational velocity (vsini = 10 km s$^{-1}$) , and no detected the lithium line (6708 A) in their spectra.

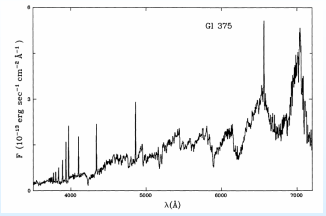


**Fig. 1:** Low resolution spectrum of LU Vel (GJ 375) from Doyle et al. (1990). Note the strong Balmer and CaII H&K lines in emission.

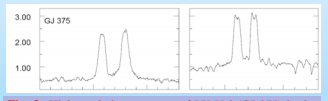


**Fig. 2:** High resolution spectrum of LU Vel (GJ 375) in the Hβ and Hα lines from Christian & Mathioudakis (2002). Note the strong emission from both components.

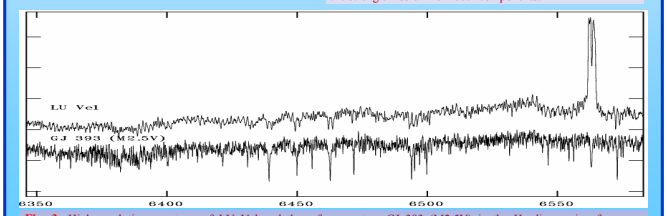


**Fig. 3:** High resolution spectrum of LU Vel and the reference stars GJ 393 (M2.5V) in the Hα line region from our observations. Note the SB2 nature of the system.

## Orbital Solution

Heliocentric radial velocities of both components of LU Vel have been determined by using the cross-correlation technique. The spectra of LU Vel were cross-correlated order by order, using the routine **FXCOR** in IRAF, against spectra of radial velocity standards of similar spectral types. The velocity is derived from the position of the cross-correlation peak. Uncertainties in the derived velocities have been estimated from the width of the cross-correlation peak and the inter-order agreement in the derived velocities.

Orbital solution of LU Vel

| Element | Value | Uncertainty | Units |
|---|---|---|---|
| $P$ | 1.8752 | 0.0021 | days |
| $T_0$(peri) | 2453418.0898 | 0.1110 | HJD |
| $\omega$ | 215.2045 | 21.5762 | degrees |
| $e$ | 0.0113 | 0.0069 | |
| $K_1$ | 75.2714 | 1.0829 | km s$^{-1}$ |
| $K_2$ | 76.4120 | 1.5824 | km s$^{-1}$ |
| $\gamma$ | 17.3916 | 0.2632 | km s$^{-1}$ |
| $q = M_1/M_2$ | 1.0152 | 0.0151 | |
| $a_1 \sin i$ | 1.9408 | 0.0280 | $10^6$ km |
| $a_2 \sin i$ | 1.9702 | 0.0409 | $10^6$ km |
| $a \sin i$ | 3.9110 | 0.0495 | $10^6$ km |
| " | 0.02614 | | AU |
| " | 5.6193 | | $R_\odot$ |
| $M_1 \sin^3 i$ | 0.3415 | 0.0137 | $M_\odot$ |
| $M_2 \sin^3 i$ | 0.3364 | 0.0165 | $M_\odot$ |
| f($M$) | 0.0828431 | 0.0035909 | $M_\odot$ |

Using 11 radial velocities determined by us we have determined the orbital solution of LU Vel (see Fig. 4). We have obtained a near circular orbit ($e$ = 0.01) with an orbital period of 1.8752 days. The resulting minimum masses ($M\sin^3 i$) ≈ 0.3 M\ are compatible with two near-equal dM3.5V components.

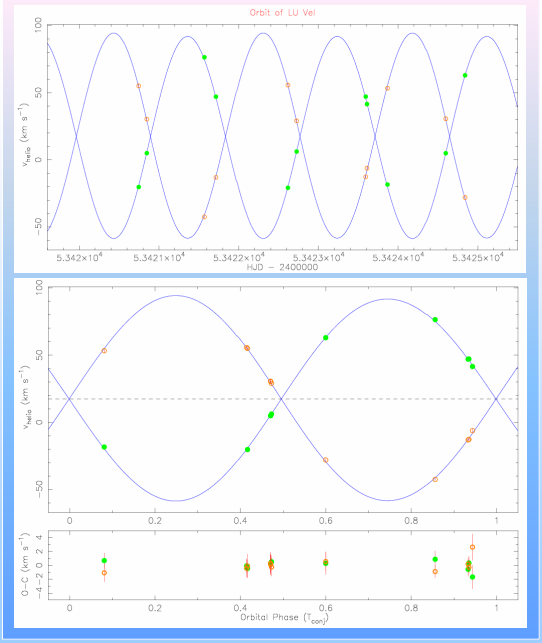


**Fig. 4:** Heliocentric radial velocity determined by us vs. HJD (upper panel) and vs. orbital phase (lower panel). Our observations cover 3 orbital periods. Solid circles represent the primary (the component with large chromospheric emission) and open circles the secondary. Blue solid line is the obtained orbital solution..

## Chromospheric activity

The echelle spectra analysed in this work allow us to study the behaviour of the different optical chromospheric activity indicators from the Ca II H & K to the Ca II IRT lines, formed at different atmospheric heights. Strong emission from both components is observed in the Ca II H & K lines (see Fig. 5), all the Balmer lines (see Hα and Hβ in Figs. 6, 7 and Hε in Fig. 5), the Ca II IRT lines (Fig. 8), as well as the NaI $D_1$, $D_2$ and the HeI $D_3$ lines (Fig. 8). The emission lines of both components have similar intensities, but the primary component have a slightly large intensity in all the orbital phases except the last night of our observations where an enhancement of the emission of the secondary is observed. The Hα line of both components exhibit a central self-absorption (see Fig. 6).

Although flares have been detected in this star (Doyle et al. 1990, A&AS 86, 403), during ours observations covering 5 nights (with 2 or 3 spectra per night) we have not found evidences of strong flares (only small variations of the emission lines has been detected).

Both component of this BY Dra binary system are very active stars since even in the quiescent (or pseudo-quiescent) state show strong emission in all the chromospheric activity indicators. High temporal resolution is needed to analyse the possible flares of both components of this binary.

Fig. 6

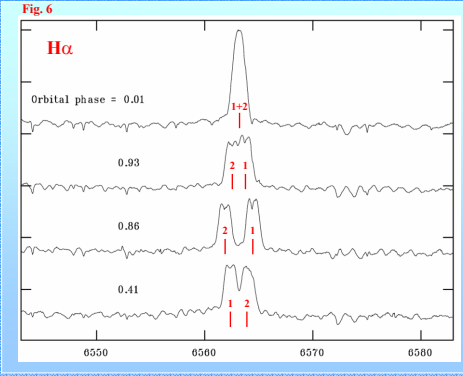


Fig. 5

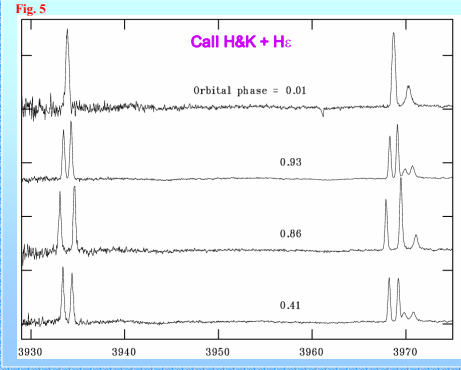


Fig. 7

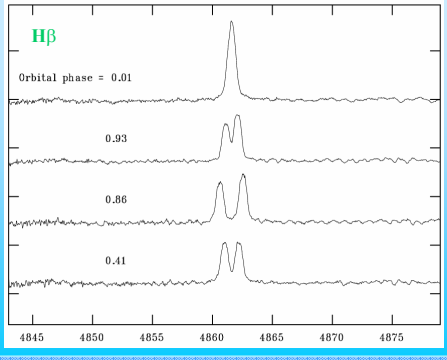


Fig. 9

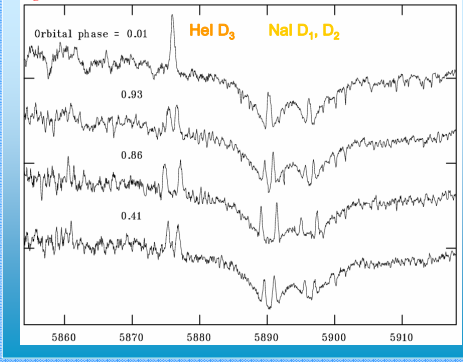


Fig. 8