High Resolution Spectroscopy of the Semi-regular Variable LR Sco

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Abstract. A detailed spectroscopic investigation of LR Sco which was earlier misclassified as R CrB star is made. Atmospheric parameters and elemental abundances are determined using detailed depth-dependent model atmospheres and line synthesis technique. Most of the elements show near solar abundances.

The strength of circumstellar components seen in Na D lines are used to derive the mass loss rate. Another independent estimate of mass loss rate is made using the observed infrared flux from 1–100μm. These two approaches lead to nearly the same value of mass loss rate when $M_v$ is assumed to be −4.5 for this star.

Key words: Semi-regular variables—abundances—infrared flux—mass loss

1. Introduction

LR Sco has been listed as an SR variable in the General Catalogue of Variable Stars by Kukarkin et al. (1969). This classification is based on photometric observations of Shapley & Swope (1934) who estimated a period of 104.4 days using 202 observations covering 145 epochs. Stephenson (1978) examined a low dispersion (580 Å mm$^{-1}$) objective prism spectrum of this star in the blue spectral region and remarked that the spectrum resembled that of R CrB stars at light minimum. His remarks appear to have persuaded Bidelman (1979) to list this star with other R CrB stars.

Feast (1979) showed that the observed infrared excess of LR Sco is very similar to that of other R CrB stars i.e. the location of LR Sco in (J–H) vs (H–K), and (H–K) vs (K–L) diagrams is similar to that of other R CrB stars; J, H, K and L photometry of LR Sco was published by Carter, Roberts & Feast (1979). Later IRAS observations showed the infrared excess as prominent at 12, 25, 60 and 100 μm indicating that cold dust surrounds the star (Table 1). The infrared photometry lent further support to the classification of LR Sco as R CrB type star (Walker 1986). Drilling & Hill (1986) included this star in their list of cool hydrogen deficient stars. However, our high resolution spectra reveals that LR Sco is not a R CrB type star but a normal yellow supergiant of spectral type near G0Ib (Giridhar et al. 1991).

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Table 1. Basic observational data for LR Sco.

| J   | 8.20 |
| H   | 7.48 |
| K   | 6.52 |
| L   | 4.73 |
| Jy  |      |
| 12 μm | 10.72 |
| 25 μm | 7.75  |
| 60 μm | 3.41  |
| 100 μm | 7.06  |

J, H, K, L magnitudes are from Carter et al. (1979)
The IRAS fluxes are from Walker (1986)
Radial velocity from Giridhar et al., (1990)

2. Observation and data analysis

High resolution spectra with a GEC CCD detector were obtained using the cassegrain echelle spectrometer of the 4-m reflector of the Cerro-Tololo-Inter-American-Observatory. The spectral regions covered are 4200–4900 Å and 5450–6850 Å. The instrumental profile in the adopted configuration has a width (FWHM) of 0.34 Å in red and 0.32 Å in the blue spectral region. Three exposures were taken for each region to get better S/N ratio and identify cosmic ray hits. The exposure times were 20 minutes both in the red and in the blue. A xenon lamp was used for the flatfield images.

Our spectra were reduced using the spectroscopic data reduction package RESPECT (Prabhu, Anupama & Giridhar 1987) in its upgraded version (Prabhu & Anupama 1991). The extraction of the echelle spectrum follows the algorithm of Home (1986, 1988). The background level due to thermal noise and mean scattered light in the spectrograph is estimated using the counts in interorder rows after removing the effect of cosmic ray hits. Flatfielding was done using a normalized flatfield image. A Th + A hollow cathode lamp was used for wavelength calibration. The extracted spectrum orders were linearized in wavelength using a third degree polynomial for wavelength as a function of position. The standard error of the fit was around 0.02 Å. The pseudocontinuum for each order was determined using the highest points in spectrum known to be free of stellar lines. The spectra were then reduced to normalized continuum using spline interpolated values between these points. The accuracy of equivalent widths measured here are of the order of 10% for weak lines in equivalent width range 10–30 mÅ, 5–10% for lines in 50–200 mÅ range and 5% for lines in 200–350 mÅ range. The S/N ratio was in the range of 60–80.

3. Description of the spectrum

LR Sco was observed alongwith 12 R CrB type stars and 5 Hdc stars during an observing run from 17–18 July, 1989. When the spectrum of LR Sco was compared