IS LR SCO AN RCB STAR?

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The variable star LR Sco has been classified previously as an R Coronae Borealis variable. A high-resolution spectrum shows that the star has been misclassified: it is a yellow supergiant.

LR Sco is one of 29 entries in the latest catalogue of cool hydrogen-deficient stars[1]; *i.e.*, RCB variables and cool hydrogen deficient (HdC) carbon stars. LR Sco's membership among these rare stars is traceable to Stephenson[2], whose examination of objective prism plates led to the remarks "The 580 Å/mm spectrum seems identical to that of RCrB at maximum. This is remarkable, since the variability type has been considered to be SR on the basis of magnitude determinations at more than a hundred epochs."

High-resolution spectra of LR Sco in the intervals 5500–6800 Å and 4200–4900 Å were obtained in 1989 July with the cassegrain echelle spectrometer at the 4-m reflector of the Cerro-Tololo-Inter-American Observatory (CTIO). Spectra of 12 certain RCBs and 5 HdCs were obtained during the observing run. Comparison of the spectra of LR Sco and the RCBs shows that LR Sco is not a member of this class of peculiar stars.

Strong lines of *C* I are a primary spectral characteristic of RCB stars. In Figure 1, we compare spectra of LR Sco and two RCB stars: RY Sgr and NSV 6708. Several, but not all, of the *C* I lines in this interval are identified and

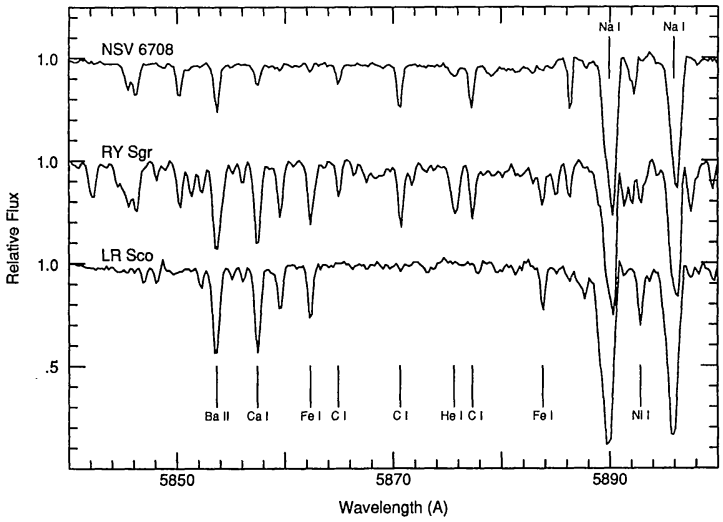

FIG. 1

Spectra of LR Sco, RY Sgr, and NSV 6708 in the range 5840–5900 Å. Selected lines of *C* I and other species are identified. Note that the *He* I 5876 Å and the *C* I lines are present in RY Sgr and NSV 6708, but not in LR Sco.

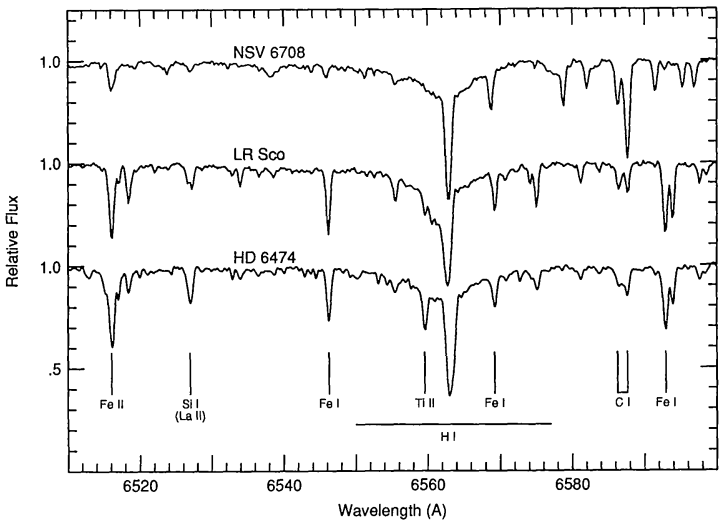

FIG. 2

Spectra of LR Sco, HD 6474 (Go Ia), and NSV 6708 near *Hα*. Selected lines are identified.

are obviously present in the spectra of the RCB stars, but absent from the spectrum of LR Sco. The *He* I D_3 5876 Å feature, which is present in the spectrum of RY Sgr and which is a common feature of spectra of RCBs, is absent from the spectra of LR Sco. Lines of other elements from *Na* to *Ba* are identified and are of similar strength in LR Sco and RY Sgr. This similarity suggests that LR Sco (for which we measure a radial velocity of -12 ± 3 km s^{-1}) is a normal supergiant at an effective temperature about equal to that of RY Sgr. The metal lines are very weak in NSV 6708, which is a recently discovered RCB star not listed in Drilling and Hill's catalogue — see Kilkenny and Marang[3], who provided spectroscopic confirmation of the classification.

The Balmer lines of hydrogen are weaker in RCB spectra than in spectra of normal supergiants of the same effective temperature. Examination of our CTIO spectra shows that the Balmer lines in RCB spectra range from undetectable to nearly normal strength. NSV 6708 shows a well-developed *Hα* profile, as noted by Lawson and Cottrell[4]. In Figure 2 we show a region around *Hα* for LR Sco, NSV 6708, and the normal Go Ia star HD 6474. (The last star was observed with the McDonald Observatory's 2·1-m Struve reflector by Y. Sheffer.) The three *Hα* profiles have a similar sharp core and broad wings. The core of LR Sco is slightly blue-shifted and a P Cygni component appears to be superimposed on the photospheric line. LR Sco is clearly similar to HD 6474. The *C* I lines again show LR Sco is not an RCB star. Examination of the line intensities, and especially the high excitation *Si* I lines, indicates that LR Sco is an F rather than an early G supergiant. The $B-V$ colour suggests a spectral type of F8.

Our spectra clearly show that LR Sco must be withdrawn from the catalogue of cool hydrogen-deficient stars. At our request, Dr. Bruce Stephenson re-examined the objective-prism spectrum of LR Sco and confirmed that the spectrum is unusual, but remarked that the star could be either a very luminous but otherwise normal supergiant or an RCB star. The former classification is consistent with our high resolution spectra and also with the star's classification as a SRd variable. Stephenson in his initial note[2] on LR Sco remarked upon the inconsistency between his spectral classification of RCB and the variability class

of SR. LR Sco is worthy of more detailed study. Its striking infrared excess[5] suggests that it has experienced mass loss. Such mass loss may be fed by the pulsations in the envelope of this supergiant, and may have resulted in changes of the surface abundances of the light elements C, N, and O.

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References

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A REMARKABLE COINCIDENCE CONCERNING THE JETS OF SS433

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The extraordinary radio, optical, and X-ray source SS433, at distance 5 kpc, consists of a compact system expelling in opposite directions two highly collimated jets of low-temperature gas moving at 0·26 times the speed of light and precessing with a 164-day period[1–6]. The evidence indicates that SS433 is a binary system containing a massive early-type star transferring mass at a rate 10^{-6}–$10^{-4} M_{\odot}\,\mathrm{yr}^{-1}$ to a thick accretion disc around a compact companion that may be a neutron star. The kinetic power in the jets, of order 10^{40} erg s^{-1}, exceeds the luminosity of any known star in the Galaxy, and no compelling theory of the accelerating mechanism has yet emerged. Most proposed models (see reviews[6–9]) assume that the accretion disc is directly involved in the acceleration and collimation of the high-speed jets. Here I consider the novel possibility that the jets originate at the surface or perhaps in the interior of an accreting neutron star.

Milgrom[10] showed that the speed of the jets of SS433, $0{\cdot}26c$, is close to the value of $0{\cdot}28c$ needed to Doppler shift the Lyman-α wavelength to the Lyman continuum limit, and suggested that the jets are accelerated to terminal speed by line-locking in a radiation field having a spectral cut-off at the Lyman limit. This initially promising mechanism, which requires[11] an extremely clumpy geometry and an intense ultraviolet radiation field in order to accelerate the jets to terminal speed in a distance 10^{14}–10^{15} cm, encounters severe difficulties because the iron X-ray lines exhibit similarly varying Doppler shifts and show that the jets attain their terminal speed in a distance perhaps less than 10^{12} cm from the central source[12].