The visual companion Rs1 137B merits further study. If, as appears to be the case, the stars are truly associated then this may provide further clues to the nature of HD 36705. Rst 137B may be of interest in its own right, as it may also be a young star, possibly pre-main sequence. There is also the chance that it may be similar to the spotted BY Dra stars, thus making this a very interesting system, but the presence of the brighter HD 36705 at such a small angular distance will make this difficult to check.

We intend to continue our study of HD 36705, including an investigation of the LiI6708 line. If HD 36705 is in fact a very young star, it would be on the brightest objects of its type known, and thus well suited to a variety of observational studies.

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An Optical and Radio Investigation of the Active RS CVn Star HD 127535

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Abstract: We present some preliminary results of an optical and radio study of the very active RS CVn binary HD 127535. Photometric measurements show the presence of a large amplitude wave which exhibits marked changes in shape and range on time scales as short as a few months. This photometric variation is almost certainly due to large cool starspots on the cooler, more luminous component. As part of a survey of southern active-chromosphere stars with the Parkes radio telescope, HD 127535 has been observed at 5, 8.4 and 22 GHz. No detection was made at 5 GHz, possibly because of confusion due to the angular proximity of the star to the galactic plane. However, it is one of the strongest sources detected in the 8.4 GHz survey, and is one of only two stars detected at 22 GHz. Photometry obtained two cycles before the 8.4 GHz observations suggest a possible correlation between the radio emission and the photometric variation, i.e. spot visibility, but more data are needed.

Introduction
RS CVn stars are detached binary systems with periods between one day and two weeks. The components are typically F-GV and K0 IV. The cooler secondary is characterized by strong Ca II H and K émission and by rotational modulation of brightness attributed to the presence of large star spots. These spots are typically 1000 K cooler than the surrounding photosphere, cover up to 30% of the visible hemisphere and migrate in latitude and longitude.

Such photospheric and chromospheric phenomena also occur on binaries with both longer and shorter periods than RS CVn stars and on some classes of single stars. The important property that distinguishes all of these classes of objects is the existence of strong photospheric magnetic fields associated with the star spots. These fields are responsible for the existence of magnetically contained coronae and a range of flare phenomena in many ways similar to those on the Sun.

An important manifestation of flare activity is the production of non-thermal radio émission. Such émission has indeed been detected from a large number of RS CVn and related objects at microwave énergies. The émission is usually strongly circularly polarized (~30%) and is believed to be gyrosynchrotron radiation from mildly relativistic électrons spiralling in the extended coronal magnetic fields. Sources of such émission have recently been mapped with VLBI arrays featuring
(Mutel et al. 1985). The radio source size is about that of the star or the orbital separation of the binary system. The observed brightness temperatures ($10^8$ to $10^{10}$ K) are consistent with the emission being gyrosynchrotron radiation.

A large number of southern RS CVn and related objects have now been observed at both optical and radio wavelengths (Collier 1982a; Collier et al. 1982; Slee et al. 1984). Of these HD 127535 has been selected for special study because of the large amplitude and rapid variability of its photometric wave. At times more than 40% of the visible disk is covered by star spots. In addition, it is one of only two southern RS CVn stars so far detected at 22 GHz. This compares with about 23 detected at 5 and 8.4 GHz.

Optical Observations
HD 127535 was known to be a K type star with strong Ca II H and K emission (Houk and Cowley 1975) and thus a likely RS CVn star. The first extensive spectroscopic study was in 1981, by Collier (1982a). In addition to the Ca II emission he also found H\alpha emission. His radial velocity study showed the star to be a single-lined binary with an amplitude of ~ 40 km s\(^{-1}\) and a six-day orbital period.

We obtained further radial velocity measurements with the 1.0-m telescope at Siding Spring in 1985 and have refined the orbital period to $6.015 \pm 0.001$ days (Fig. 1). We have used this period and the base epoch HJD 2444653.737 in all of the following phase plots.

The star was first extensively observed photometrically in 1981 by Collier (1982b), who found it to be a variable with a V range of $\sim 0.07$ mag and a quasi-sinusoidal light curve with a six-day period (Fig. 2).

Udalski and Geyer (1984) obtained further photometric observations in 1984 April and found that the V range had significantly increased to $\sim 0.25$ mag, while maximum light was essentially unchanged (Fig. 3). In addition, the phase of the light curve had almost reversed. This large change in the light curve was almost certainly due to the changing star spot distribution on the K star.

We have obtained photometric light curves for 1984 August and 1985 February-April (Figs. 4 and 5) with the 0.4 and 0.6 m telescopes at Siding Spring. These data show that the comparison stars, HD 128277 and HD 127724, exhibited no variation above observational scatter during our measurements. Once more it is seen that the light curve of HD 127535 is remarkably changeable, firstly in the 20 or so orbital cycles from 1984 April (Udalski and Geyer 1984) to 1984 August, when maximum light faded by $\sim 0.1$ mag, and then from 1984 August to 1985 February-April, when minimum light decreased by $\sim 0.07$ mag. It also seems that the curve changed during the 1985 February-April observations, as seen when comparing observations made at the same phase early and late in this run.

The long-term behaviour of HD 127535 in V is summarized in Figure 6, where the length of the bar represents the observed range at that epoch.

Radio Observations
Early observations at 5 GHz with the Parkes 64-m radio telescope failed to detect HD 127535 because of confusion. To minimize this problem the two subsequent observations were made at 8.4 and 22 GHz. The star was unambiguously detected at both frequencies.

In our survey of southern RS CVn type stars at 8.4 GHz 64
Figure 4 — V photometry of HD 127535 relative to a reference star HD 128277. The phases relate to the orbital phase defined in Figure 1. Note the variability in shape, phase and amplitude with epoch. This variability implies more rapid restructuring of photospheric and coronal magnetic fields on this star than perhaps on any other RS CVn.

Figure 5 — V photometry of HD 127535 relative to a reference star HD 128277. The phases relate to the orbital phase defined in Figure 1. Note the variability in shape, phase and amplitude with epoch. This variability implies more rapid restructuring of photospheric and coronal magnetic fields on this star than perhaps on any other RS CVn.

Figure 6 — The range of the light curves of Figures 2-5 are plotted against epoch. The decay in minimum light is −0.07 mag per year. The decay in maximum light indicates that no hemisphere is ever completely free of starspots.

Observations of 18 objects resulted in 33 detections of nine different objects. Eight of these detections, shown in Figure 7, were of HD 127535. The negative fluxes on August 14 are due to confusion. We have assumed that the confusion contribution is the same at the same hour angles on the following days. The August 14 values have therefore been used as upper-limit estimates of the baseline.

At 22 GHz 33 observations of 22 objects detected only 2 objects, HR 1099 and HD 127535. HR 1099 is the most active RS CVn known at radio wavelengths and has been extensively studied from the Northern Hemisphere. The observations of HD 127535 plotted in Figure 8 show the temporal variations of the 22 GHz flux. At this frequency confusion is negligible (<5 mJy). The variation, although slow compared with that of solar or flare star microwave bursts, is much faster than normally observed on RS CVn stars. Time scales of days are more typical. For example, the 8.4 GHz flux in Figure 7 is relatively stable throughout an observing period of several hours but does change significantly from day to day.

Discussion

The photometric light curves in Figures 2-5 and the summary in Figure 6 reveal considerable variability in the area of the visible hemisphere covered by star spots. If we assume that the peak brightness observed in 1981 is from an unspotted hemisphere then we can make a lower-limit estimate of the area covered by spots at the time of minimum brightness in 1985. The darkening due to spots is 0.35 mag. If the spot emitted no light then at least 28% of the disk would need to be covered by spots. In fact, the spot will be ~30% as luminous as the photosphere if it is 1000 K cooler. Thus at least 40% of the visible disk must have been covered by spots in early 1985. Six months earlier the area was only 30%.

Larger spot areas than these have been reported for other...
RS CVn stars (Catalano 1983). However, the rate of change of spot area on HD 127535 is probably only matched by one other RS CVn object, II Peg. The long-term rate of change of the light curve minimum is $\sim 0.07$ mag per year for HD 127535, compared with 0.05 mag per year for II Peg (Rodono et al. 1983).

It is not surprising that such large and rapid restructuring of the photospheric magnetic fields leads to observable coronal phenomena. Flares on the Sun are attributed to restructuring of the coronal magnetic fields, although the detailed mechanisms responsible for electron acceleration and heating are not well understood. Once accelerated however the electrons may be trapped in the extended coronal magnetic fields for long periods of time. On RS CVn stars the extensive areas of photospheric fields are capable of supporting very large and intense magnetic structures in the corona. These may even form links between the synchronously rotating binary components (Uchida and Sakurai 1983). The large scale of these field structures no doubt accounts for the long-lived nature of the microwave emission emanating from accelerated electrons trapped in the fields.

Other properties of the coronal fields may also be deduced from the observed microwave emission. Nelson and Stewart (1979) presented a model of gyrosynchrotron emission from regions of inhomogeneous magnetic field on the Sun. Features of the model are applicable in any situation where the magnetic field strength decreases outwards in the source, such as in the corona of an RS CVn object. The model shows that the microwave spectrum of such a source increases with frequency until the source becomes optically thin. At frequencies above this the emission falls off rapidly. It is clear from the fact that so few objects were detected at 22 GHz that in most cases the turnover frequency is below 22 GHz. Nelson and Stewart (1979) show that the frequency of peak emission depends mostly on the maximum magnetic field in the source and only very weakly on other parameters, such as electron density and the scale size of the source. For a turnover frequency of 10 GHz, which may be typical of emission from most RS CVn stars, the maximum magnetic field in the source is about 500 G. For the few objects where the emission extends up to 22 GHz electrons must populate regions with magnetic fields as high as 1500 G. Fields of this magnitude will occur only relatively low in the corona, where collisions between the radiating electrons and the thermal plasma are frequent. It is not surprising then that the 22 GHz emission from HD 127535 on 1984 March 11 shows such a rapid decay following a large flare (Fig. 8) and that lower-frequency emissions from electrons populating weaker fields at greater heights persist very much longer.

If, as would be expected, the location of the intense coronal magnetic fields and the regions of electron acceleration are closely related to the photospheric star spots then a correlation should exist between the occurrence of non-thermal microwave emission and minimum light. This indeed seems to be the case in Figure 9, where the 8.4 GHz flux and V magnitude of HD 127535 are compared. On other occasions however, especially at low microwave frequencies, the source may be so large that it is not completely occulted by the star. It would then be at least partly visible at any phase. Such a model may be checked best, we believe, at high microwave frequencies (e.g. 22 GHz). The small radio source expected at these frequencies would be more likely to suffer occultation as the starspot region, together with its associated coronal fields, rotates in and out of the field of view.

Figure 8 — 22 GHz observations of HD 127535 made at the same hour angle on three successive nights with the Parkes 64-m radio telescope. The error bar shown is representative of the error due to noise. It does not take into account errors due to confusion.

Figure 9 — The 8.4 GHz flux (corrected for confusion) and the V magnitude relative to that of the reference star HD 128277 are shown during a six-day orbital period of HD 127535. The radio emission is larger when the spotted hemisphere is visible.
Interstellar NaI Absorption Towards the Stellar Association Ara OB1

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Abstract: Observations have been made of the interstellar D-line absorption of NaI towards a loose grouping of OB stars (containing the association Ara OB1 and probably the Hα emission regions RCW 107 and 108) centred at $l = 337^\circ.5$ and $b = -1^\circ.5$. The individual absorption spectra contain several velocity components which show well-defined groupings at $-37$, $-18$ and $0$ km s$^{-1}$. The corresponding median optical depths are 2, 7 and 6. The evidence indicates that both the $-37$ and $-18$ km s$^{-1}$ NaI clouds are located in the Carina-Sagittarius spiral arm. Several HII regions are located at similar longitudes, but most are close to zero latitude and are more distant than the arm.

The association contains the galactic cluster NGC 6193. The results suggest that the turbulence seen optically towards this cluster has been caused by the interaction between two cloud groups moving towards each other at velocities of 10 to 15 km s$^{-1}$.

Introduction

The study of interstellar absorption lines in the optical spectra of early-type stars could be regarded as a potentially powerful tool in the investigation of the kinematics of interstellar clouds (see e.g. Whiteoak and Gardner 1980). A prominent nearby molecular-cloud/HII-region complex at $l = 336^\circ$, $b = -1^\circ.5$ is contained within the stellar association Ara OB1. As part of an extensive investigation of the dynamics of southern molecular clouds, using both microwave and optical spectral lines that arise in the clouds, we have obtained high-resolution NaI spectra towards a selection of OB stars in the direction of the association.

Ara OB1 is located within a loose grouping of OB stars between $l = 335^\circ$ and $340^\circ$, and $b = -2^\circ$ and $+1^\circ$ (Whiteoak 1963). Whiteoak found that the stellar distances varied considerably but that there was a well-defined grouping (Ara OB1) at 1.4 kpc. More recent photometry of the members has been carried out by Herbst and Havlen (1977), who derived a revised distance of 1.32 kpc. The stars observed in the present study are shown in Fig. 1, a composite of prints produced from the SRC Southern 'J' Survey. The association contains the galactic cluster NGC 6193; it is hidden in the figure by the prominent Hα emission region RCW 108 which surrounds the cluster. Some or all of neighbouring clusters NGC 6167, 6200 and 6204 may also be related to the association, although distance estimates for these groups vary widely (Whiteoak 1963; Becker and Fenkart 1971; Moffatt and Vogt 1973, 1975; Fitzgerald et al. 1977; Fenkart and Binggeli 1979; Dachs et al. 1982). The complex of ionized gas, neutral gas and dust around NGC 6193 may also contain the small peculiar Hα emission region RCW 107 (seen associated with star 26 in the figure), although there is some evidence that this region is more distant (Westerlund 1960; Catchpole and Feast 1970). The presence of numerous sharp dust edges in the complex is indicative of extensive dynamic interaction between the gas and dust. The field contains another Hα emission region, RCW 109. It is too faint to be visible in the figure but is centred at a position about one-third of the way along a line from star 4 to star 1.

At radio wavelengths considerable HII continuum emission is present in the same longitude range. Figure 2 shows the distribution of 5 GHz emission (Haynes et al. 1978). Table 1 lists the brighter maxima (Haynes et al. 1979), together with associated hydrogen recombination-line velocities and the velocities of 4.8 GHz H$_2$CO absorption observed against the continuum emission (Whiteoak and Gardner 1974; Gardner and Whiteoak 1984). The velocities listed in the previous publications were corrected by $-3$ km s$^{-1}$ to convert them from l.s.r. to heliocentric values. The regions 336.375-0.131, 336.514-1.477 and 339.128-0.408 appear to be associated with RCW 107, 108 and 109 respectively.

Observations and Results

The observations of the two D lines of NaI (with rest wavelengths of 588.9949 and 589.5922 nm) were obtained with the coudé spectrograph on the Mount Stromlo 1.9-m telescope, using the 32-inch camera, cross-disperser grating, and a 1-D photon-counting array (PCA) as a detector. The final spectral resolution was 0.008 nm, equivalent to a radial velocity of 4 km s$^{-1}$. Depending on star brightness, the integration times were either 1000 or 2000 s. Figure 3 shows the average absorption...