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SOME CARBON STARS WITH UNUSUAL LIGHT VARIATION

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Photometric long-term monitoring of carbon stars has revealed several objects which show characteristics of light variation non-typical for this class of stars. Observed peculiarities of light variation are reported for the stars RW LMi, V366 Lac and DY Per.

KEY WORDS Stars: carbon – stars: individual: RW LMi, V366 Lac, DY Per

1 INTRODUCTION

Since the late 1940s when J. Ikaunieks, following a suggestion by professor P. P. Parenago started to study carbon stars, this class of cool giant stars has been the object of particular interest to stellar astronomers at the Latvian Academy of Sciences. When at the end of 1966 the 0.8-m Schmidt telescope of the Radioastrophysical Observatory (then the Astrophysical Laboratory) was installed on the Riekstukalns hill (Mount Nut) near the town of Baldone one of the main observing programmes became the photometric monitoring of carbon stars. Observations were made, of course, photographically in several passbands: red, visual, blue, infrared and ultraviolet (in order of frequency of respective observations).

The centres of the separate fields studied (equal to the field of view of the Schmidt telescope — 5° diameter) were chosen in the Galactic belt near open clusters with photoelectric magnitude sequences. Larger fields were centred on the Galactic anticentre region and on the Galactic equator near longitude 90° in Cygnus. The most extensive was the study of 240 square degree field in Cygnus, where 140 carbon stars then identified in this field were monitored over 10–14 years (Alksnis and Alksne, 1988). Some individual carbon stars were also selected for the monitoring, mainly the optically brighter infrared carbon stars and some known long-period carbon stars with very long periods.

The results have been published mainly in editions of the Radioastrophysical Observatory Series of *Issledovanie Solntsa i Krasnykh Zvezd (Investigations of the*

Sun and Red Stars) and some books. Many of the results are summarized in the book by Alksne *et al.* (1993, in Russian; 1991, in English).

Forty-five of the 140 carbon stars in the Cygnus field were found to have a periodic component in their light variations. Light variation of the long-period variable carbon stars (similarly to M- and S-type stars) are more or less far from regular. Usually a secondary variation or a variation in mean brightness is superimposed on the long-period variation. Sometimes this secondary variation is interpreted as periodic. So Houk (1963) found that there is a period in the secondary variation of 22 carbon stars, on average 12.4 times longer than the main period. Observations of 45 long-period carbon stars in the Cygnus field revealed very different secondary variations, for part of the stars, however, cycles in the secondary variations could be found and their lengths were between 2 and 10 main periods of the respective stars (Alksnis and Alksne, 1988). For seven carbon stars in the Cygnus field the amplitude of the secondary variation exceeds the amplitude of the long-period variations, but not by more 1.5 times.

The carbon star V Hya, however, has an amplitude of the secondary period of 3.5 mag compared with an amplitude of 1.1 mag for the main period (Mayall, 1965). Evidently, this is an exceptional case.

In the course of study of variable carbon stars with the Baldone Schmidt telescope some objects were found which in one or other respect of their light or colour variation seemed to be exceptional. I would like to direct your attention to three such carbon stars with unusual light variation. Two of them at first became known as infrared objects CIT 6 and AFGL 2881 the third was long ago named as variable star DY Per.

2 RW LMi, CIT 6, IRG+30219, AFGL 1403, IRAS 10132+3049

For this star the red light variation had a periodic component with a mean cycle length of 605 d before 1987 which changed to 628 d later. The main peculiarity of light (and also colour) variation of this star is the absence of, or very weak, correlation between variation in the red and the blue at the long-period pulsational frequencies (see Figure 1 in Alksnis, 1995). In fact, the long-period variation with the range of 1.5 mag in red light could not be detected for this star in blue light. The secondary, very slow variation, however, is similar in both these passbands (Alksne *et al.*, 1991), as are short time fluctuations (Alksnis and Eglītis, 1977).

It must be noted, however, that for a relatively short period, not a long time after the beginning of our monitoring of this star, when RW LMi was exeptionally bright in blue light (it was at the maximum of the component of the secondary variation), there existed a correlation between brightness variation in both passbands: red and blue. What has changed since then? What is the cause of light variation in the blue? Possibly, the model of a carbon star surrounded by a toroid of dust, based on spectropolarometric observations and suggested by Cohen and Schmidt (1982) for RW LMi might help to answer these questions.

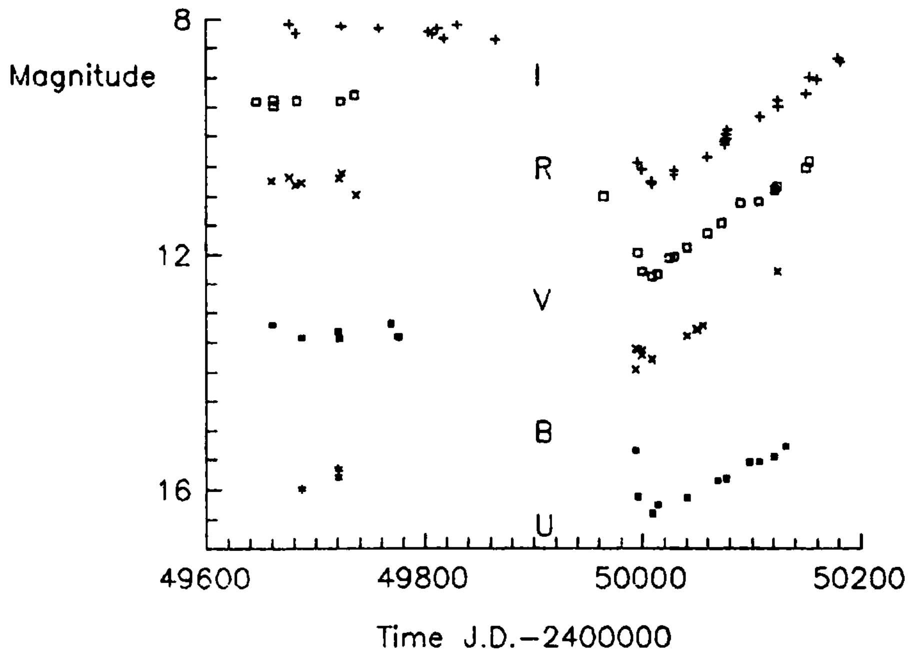

Figure 1 The 1995–1996 decline event of DY Per according to observations with the Baldone Schmidt telescope. Crosses, infrared; open squares, red; Andrew crosses, visual; filled squares, blue; asterisks, ultraviolet magnitudes.

3 V366 Lac, AFGL 2881

Classified as a carbon star by Blanco (1958) this star raised more interest later on as an infrared star. Our observations in the red light since 1975 and in the infrared since 1983 provide evidence of a long-period variation with an average cycle length of 562.5 d. The unusual photometric behaviour of V366 Lac started in 1979, when its mean brightness in a time period of one cycle of long-period variation faded by about 3 mag, and the star continued to fade during the next three cycles, declining a magnitude more, at the same time still pulsating with the previous frequency (Alksnis *et al.*, 1988).

Our further observations show that the long-period variation of V366 Lac is continuing as previously. However, up to now V366 Lac in the red light has not returned to the early high light level of secondary variation and its mean light level is still 3–4 mag below that stated in our early observations. In the photographic infrared passband in which the observations of the star were started only after its light drop in the red occurred, secondary variation seems to be similar to that in the red. The amplitude of the secondary variation in the infrared has been about 3 mag with a cycle length of not less than 7 cycles of long-period variation (Alksnis *et al.*, 1996).

Thus, in the red light the star V366 Lac during the last 10 cycles of long-period variation (1980–1995) has not returned to its previous high light level. Was the high level an exceptional state of this star? Evidently not, because two earlier accidental observations provide evidence that the star has been as bright as during the years 1975–1978. The one observation is the estimate of the infrared magnitude 9.1 of the star by Blanco (1958). The other – the Palomar Observatory Sky Survey red plate E 580, taken August 26/27, 1952– on which the star is as bright (10.5 mag) as at the maximum of long-period variation during the high light level. Therefore, light variation of V366 Lac can be interpreted as long-period variation with a mean period of 562.5 d superimposed on secondary variation of exceptionally large (4 mag) amplitude.

4 DY PER

This star was included in our observing programme because of its very long (900 d) period (Kholopov *et al.*, 1987) of semiregular variation. The brightness of the star in photovisual light based on the Sonneberg Observatory Sky Patrol plates taken during the years 1963–1980 indicated a periodic component of 792 d in the light variations of the star. Monitoring with the Schmidt telescope revealed some deep minima, and the shape of the decline and recovery curve was reminiscent of an R Coronae Borealis (RCB) type variable (Alksnis and Jumike, 1990). Later on two more declines were observed: the decline 1991–1992 is the deepest (decline range 4.6 mag in the red) registered for this star (Alksnis, 1994). A furthes decline started in 1995 and the light recovery is finishing now (Figure 1).

If indeed DY Per is a variable of RCB type, it is nothing unusual, because nine of the believed or suspected RCB stars have been classified as carbon (R-type) stars (Zhilyaev *et al.*, 1978; Clayton, 1996). A peculiarity in this case seems to be in the existence of both long-period variation (P = 792 d) and RCB-type light declines. Still more, time gaps between the minima of RCB-type light declines for DY Per seem to be connected to the mean cycle length of the long-period variation: the first time gap 3122 d is nearly equal, for cycle lengths, to 3168 d, the average value of the next three time gaps is 810 d. The moments of minima of the first and the fifth light declines observed during the monitoring of DY Per are separated by seven intervals of 793 d (Alksnis, 1994). Is it only a coincidence?

Typical pulsation periods of RCB stars are several 10 s of days. Is the cycle length of DY Per (792 d) an exceptionally large pulsation period of an RCB-type star of exceptionally late spectral type? If so, the onsets of the last four declines have occurred on successive cycles. Is the star DY Per both a long-period variable star and an RCB-type variable? In any case it is a carbon star with unusual light variation.

Undoubtedly, the three stars discussed deserve further monitoring, photometry of higher precision and polarimetry and also in other bandpasses, as well as other more sophisticated observations at least at the crucial times of their photometric behaviour.

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