

ON THE SPOTTEDNESS OF RED DWARF STARS

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ABSTRACT. A new approach for analysis of the spottedness of red dwarfs based on their multicolor photometry is shortly described and main results of such an analysis are presented.

Key words: Stars: spots.

The usually used algorithm for starspot parameters estimations from a photometry of a star gives a hierarchical model of its spottedness: firstly, parameters of "a main spot" are defined, and then parameters of one or two less essential starspots are calculated in consecutive order. However, this algorithm gives often large circumpolar starspots and is apparently not adequate for a task of a surface heterogeneity study of red dwarfs with the activity of the solar type, since sunspots occur only within rather narrow low latitude intervals.

Within the framework of a general approach to calculate theoretical light curves of spotted stars, the simplest model of a stellar zonal spottedness with the least number of free parameters is proposed: a totality of starspots are approximated by two spotty belts that are symmetrical relatively to the stellar equator and have variable filling factors along longitudes. Such a model is described by 4 free parameters: distances of spotty belts from the stellar equator, their widths, a parameter of a filling factor variation along the stellar longitudes and a ratio between brightnesses of spotted areas and of the quiet stellar photosphere. An algorithm for estimation of these parameters from *BVRI* photometry is developed. Application of the methodics developed to 19 epoches of observations of the flare spotted star EV Lac has shown a possibility to represent observational data successfully within the framework of the model proposed.

This new approach to analysis of periodic brightness variations of BY Dra-type dwarfs, where in the first time general features of spotted stellar areas are considered instead of traditional estimations of parameters of individual starspots, has been realized to analyze the all available long-term *BVRI* observations of such stars – 174 epoches of 17 red dwarfs. The analysis carried out allows to make the following conclusions.

1. The simplest model of a zonal spottedness permits to represent main parameters of observable *BVRI* light curves of each star with a high accuracy.

2. The proposed model represents observations without a hypothesis on existence of large cool circumpolar starspots, their existence is often suggested in the hierarchical model of stellar spottedness but it contradicts to the known picture of the solar spottedness and meets difficulties from the point of view of the stellar magnetism theory.

3. Within the framework of the model of a zonal spottedness an increase of a mean brightness of a star from a season to another season may be accompanied both by an increase and by decrease of an amplitude of a rotational modulation of its brightness – as it is observed in reality – while within the framework of traditional models one should expect a decrease of this amplitude only unless one suggests essential reconstruction of a large circumpolar starspot.

4. The whole observed variety of main parameters of light curves of spotted red dwarf stars – mean season brightnesses, amplitudes of brightness rotational modulation and ratios of amplitudes in the *BVRI* bands – succeeds in representing within the framework of the simplest 4-parameters model of a zonal spottedness with distances from stellar equators to spotty belts from 0 to 21° , with widths of the belts from 1.6° to 33° , with the least filling factors within the belts from 0.00 to 0.93, and with ratios between brightness of spots and brightness of quiet photospheres in the *V* band from 0.03 to 0.62. As a result, models considered give the total spottedness from 1.9 to 42% of the whole stellar surfaces.

5. The combined consideration of all calculated models permits to note some statistical regularities.

For cool stars of our sample – $V - I > 1.5$ – calculations give a merging of two suggested symmetrical to an equator belts into one structure. For a half of warmer stars calculations give two separated belts, as we see in the solar case. Among the warmest stars of our sample, which have the spectral class G, the same as the Sun has, we find objects with the largest rotational periods, with the least spottednesses and with the least extension of spotty belts along their latitudes. In other words, a tendency to merging of the solar spottedness characteristics and parameters of our calculated models is outlined. The same tendency appears in consideration of temperature features of starspots: if one constructs a dependence between the stellar colour indices

$V - I$ and starspot temperatures, the sunspots meet this dependence as well. These results give a ground to suggest that the found models of zonal spottedness of stars have essential features of surface heterogeneities of red dwarfs indeed.

This study is described in four papers by authors: in *Astron.Zhurn.* v.73, N 4, 1996 (two papers), in *Astrofizika*, v.39, N 1, P.67, 1996 and in *Astron.Zhurn.* v.74, N 1, 1997 (in press).

TWO NEW VARIABLES (MIRAS?) IN OPHIUCHI

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ABSTRACT. Two new variables, possible Mira-type stars, are discovered in Ophiuchi constellation in 1995 year.

Key words: Stars: Mira

Observations

During the monitoring of the X-ray Nova Oph 1993 = V 2293 Oph ($\alpha = 17^h 16^m$, $\delta = -24^\circ 58'$, Eq. 1950), two new variable stars were discovered. The first variable is localized at 2 arc minutes to the west (star "a") and the second one – at 2.5 arcminutes to the north (star "b") from Nova Oph. Observations have been carried out at TV complex MTM-500 of the Crimean astrophysical observatory in 1995-1996 years. The rough brightness estimates were made in R and V standard colour system using the secondary

photometric standards around RT Ser (Bochkov et al., 1994). They are given in Table 1.

Table 1. V and R magnitudes for two new variables.

JD	V ("a")	R ("a")	V ("b")	R ("b")
2449981.23	17.5	12	> 19	16 :
2450213.43	18.5 :	12.5	18 :	11
2450220.49	19 :	13	> 19	11
2450274.33	> 19	16.5	> 19	13

The large amplitude of brightness variations in R, very red colours together with space localisation of variables define that variables could be the Mira-type stars.

References

Bochkov V.V., Pavlenko E.P., Vasiljanovskaya O.P.: 1994, *Odessa Astron.Publ.*, **7**, 98.