NUMERICAL CRITERIA OF THE VARIABILITY OF THE INDIVIDUAL PULSATING CYCLES IN THE LPVs

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ABSTRACT. Some numerical parameters of long term changes of light curves in LPVs are obtained. Results of analysis of the sample of 53 LPVs and classification of these stars are discussed.

Key words: Stars: long-periodic variables, Mira-type stars, semi-regular variables.

1. Introduction

The long period variables (LPVs) is characterized by significant changes of their light curves from cycle to cycle. So the parameters of light curves are unstable and can not be used as reliable classification criteria. One of the way is to use types long term changes of light curves as criteria for classification.

The sample of 53 LPVs, which are actively observed by amateur astronomers, has been studied. Most of them (43) are Mira-type stars, according to GCVS (Kholopov et al., 1985), others are semiregular (SR) variables.

2. Data analysis

To study cycle-to-cycle changes in these variables, the dense series of data during long time interval are needed. We use the AFOEV and VSOLJ data-bases for this research. We have obtained the following characteristics of each individual cycle: moments and magnitudes of extrema and hump at the ascending branch, periods between maxima and minima, amplitudes of both branches, asymmetry, slopes of the ascending and descending branches, mean brightness of the branches. Analysis of variations of these characteristics with time and correlation analysis of them have been made. We also applied the periodogram, Fourier and wavelet analysis to study the periodicities and its stability. Parameters of the mean light curves such as period, amplitude, asymmetry has been obtained by using the trigonometrical polynomial fit. (Below these characteristics are mentioned as "mean period", "mean amplitude", etc.) The example of our analysis has been described by Marsakova and Andronov (1998).

3. Results

Also we have analyzed the relations between numerical characteristics of the cycle-to-cycle changes and the parameters of the mean light curves (including the degree of trigonometrical polynomial fit) and the spectral class. For spectral class we have used conditional scale from -5 (spectral class K5) to 29 (C9), where interval 0-9 corresponds to spectral classes M0-M9, 10-19 corresponds to S0-S9, 20-29 corresponds to C0-C9. For the cycle-to-cycle changes we have used the following characteristics:
– relative quantity of humps at the ascending branch;
– scatter the of mean brightness;
– scatter the of amplitudes;
– scatter the of asymmetry;
– scatter ot the individual periods between maxima;
– scatter ot the individual periods between minima.
Four last characteristics also have been used as arbitrary to mean light curves characteristics.

We have obtained a sequence of diagrams, such as spectral class – arbitrary amplitude scatter, spectral class – arbitrary mean brightness scatter, arbitrary period scatter – arbitrary amplitude scatter, etc.

Several diagrams show that all values differ for different spectral classes in sequence C–M–S. They show no changes between Miras and semiregular variables in the sample. But diagram spectral class – arbitrary scatter the of amplitudes shows that three stars (RU Cyg, V Boo, V CVn, all of them were classified as semiregular in GCVS) significantly differ by the value of arbitrary scatter the of amplitudes from other stars in group of spectral class M. Y Per (classified as Mira, but with significant irregularity in last decade) also differ from other stars in group of spectral class C.

Almost all stars of spectral class C have amplitudes smaller than 2 magnitudes mentioned in GCVS as the limit for discerning Miras and SR variables. And there is a subgroup of stars where Mira-type and semiregular variability exchange each other in the different time intervals. Diagram mean amplitude – scatter of the individual periods between maxima shows that the transition between small amplitude and large amplitude

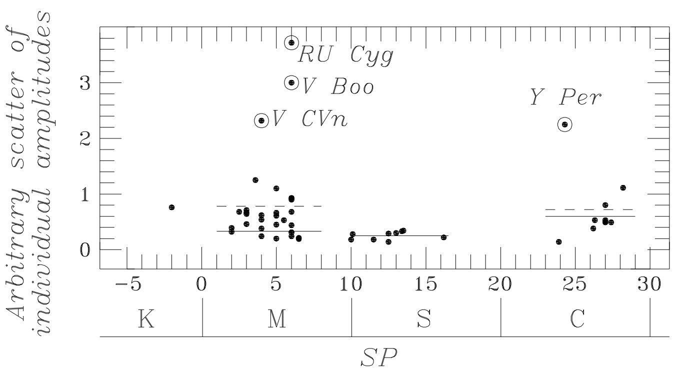

Figure 1: Dependence of arbitrary scatter the of amplitudes on spectral class. Horizontal lines show mean values for spectral classes M, C, S. Solid lines correspond to mean value of scatter the of amplitudes for spectral classes M and C without the stars marked by double circles. Dashed lines – with these stars.

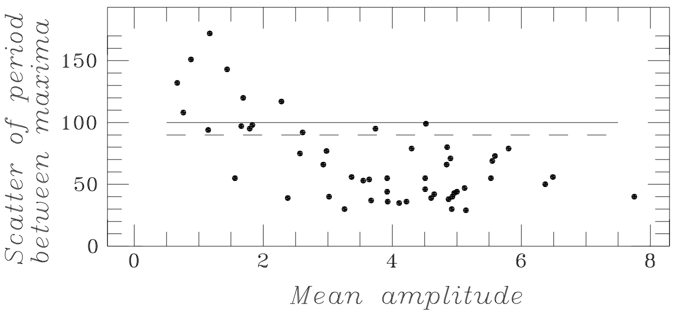

Figure 2: Dependence of period between maxima on mean amplitude. Solid line corresponds to 100^d.

stars is very fluent. So the majority of stars in our sample of spectral class C may be classified as periodic carbon LPVs. There are no significant differences between Miras and SR variables.

Other diagrams also show that limited quantity of stars (both SR and Miras) differ from majority by values of characteristics of the cycle-to-cycle changes.

Stars RU Cyg, V Boo, V CVn lie separately at the majority of diagrams. So these stars may be classified as semiregular variables confidently.

In stars wit progressive period changes were pointed out two types of light curve transformation: in R Aql and R Hya period decrease is followed by very strong amplitude decreasing, in T UMi fast period decreasing is followed by significant changes of curve sharpness. In some papers (Wood and Zarro, 1980; Gal and Szatmary, 1995) it is suggested, that T UMi is in the beginning of helium shall flash, but R Aql and R Hya are in the more later stages of it.

The secular amplitude increase or decrease (except the stars on the stage of helium shell flash) probably also may serve to classification. Also for 5 stars (4 Miras and SS Vir which was classified as SR in GCVS) the amplitude increase has been obtained. For V Boo, RU Cyg we have obtain amplitude decrease.

In three Miras: R LMi, R Dra and V CrB we also have found the decrease of mean brightness.

In some Miras were found period and amplitude changes which like cyclic ones in the observational interval. But there are some difficulties: characteristic times of this cyclicity is about 15000-23000 days, so we can't study more than 2-3 long cycles.

The group of periodic carbon LPVs shows different types of amplitude variations (cyclic, irregular, parabolic trend).

So analysis of the long-term light curve changes allows to introduce the new criteria of the classification of LPVs into Miras and semiregular variables.

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