INVITED PAPERS

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Multiple Periodic Variable Stars
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ON DOUBLE PERIODICITY IN THE LIGHT VARIATION OF VARIABLE STARS

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Double periodicity of light variations is shown in different ways in stars of different types. So the light curves of μ Cephei of RV Tauri-type giant stars are composed of more or less fast waves superposed on slow ones, such that between the duration of the short and long cycles there is a correlation.

Convincing evidences have been recently given as to the existence of superpositions of rapid fluctuations of eruptive character upon the slow ones; this makes light variations similar to solar activity manifestations.

Double periodicity of another type - interference of radius fluctuations occurring with similar periods which produces more or less long beat cycles - is inherent to the stars of β CMa-type, to dwarf cepheids and RR Lyrae-type stars.

Periods of RR Lyrae-type stars and of cepheids suffer slow secular changes. True, a view-point is common according to which the diagram of O-C residuals plotted against E represents a random phenomenon. One can hardly believe, however, that the O-C diagram of Z CVn or RZ Cep could be accounted for by the summation of cumulative errors. But variations of a period during "critical" moments can be fortuitous indeed and may result from abrupt stellar structure change.

Convinced we are in this due to the following items:

As shown in AP Her the O-C residual fluctuations are nearly of periodic character with the cycle about 800P. It is impossible to attribute these periodic fluctuations to fortuitous accumulation of errors. Neither is it possible to attribute them to evolutionary variation of stellar structure - they proceed

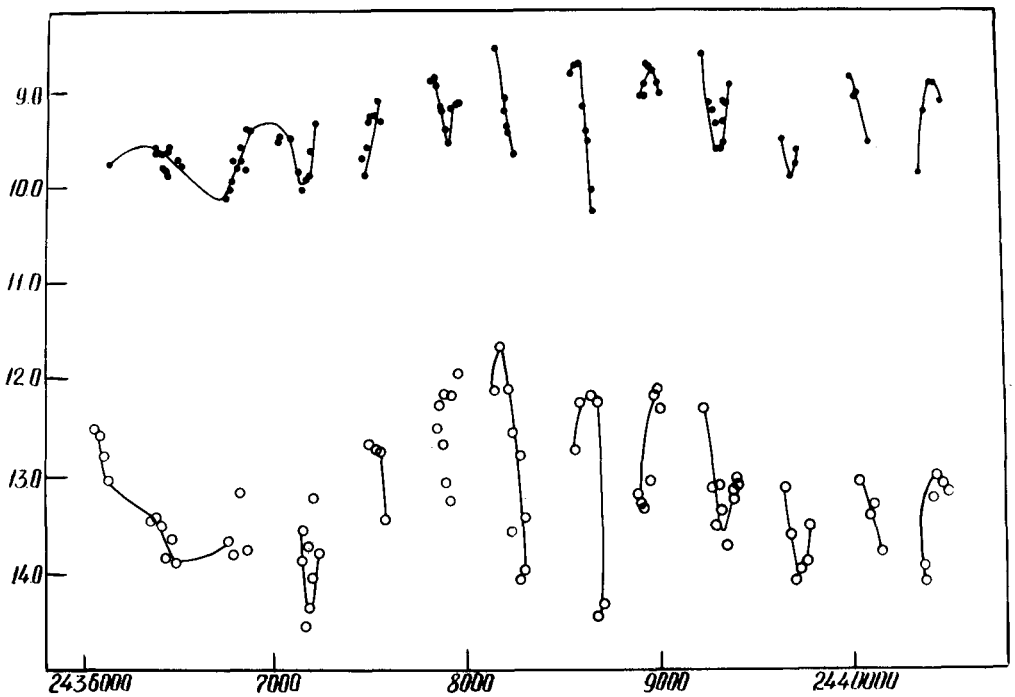

Fig.1. Two light curves of red giant EP Vul. Upper curve - photovisual, lower-photographic one. On slow variations short ones are superposed.

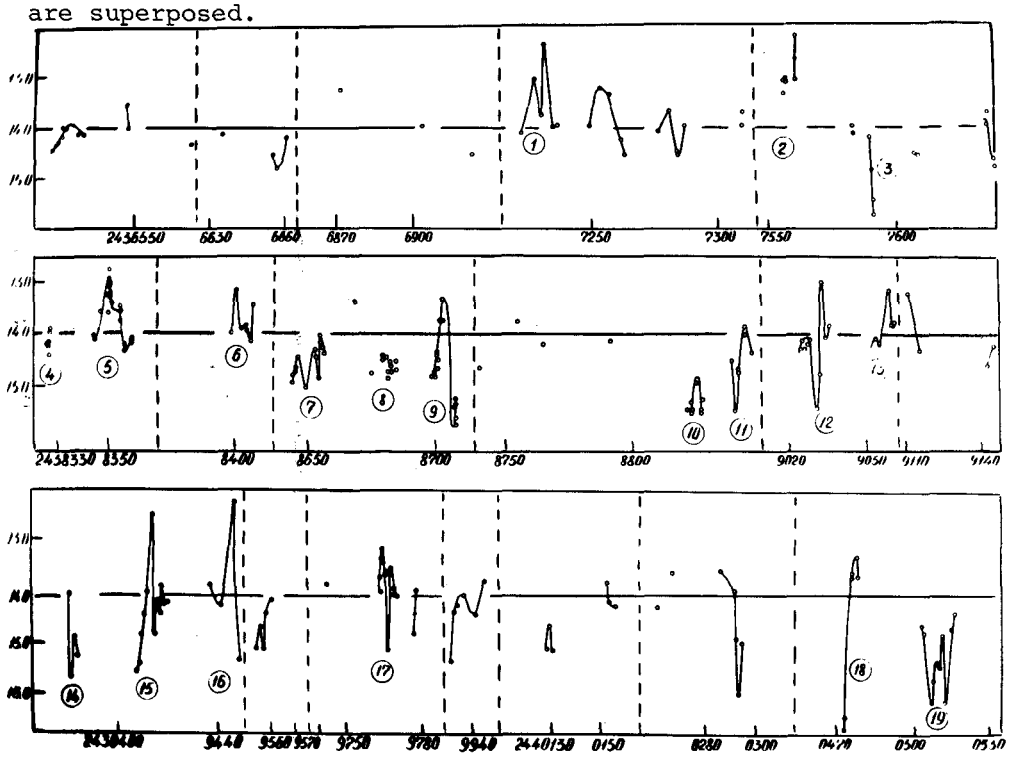

Fig.2. Fragments of light curve RW Aur-type star - AA Tau. There are flares superposed on slow variations of mean brightness.

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too rapidly. The evolutionary track is also conspicuous in the diagram, with a slow secular increase accompanying the cyclic O-C behaviour.

Furthermore, the following phenomena have been observed repeatedly in RR Lyrae-type stars. After the second variation of the period the former value of period (or nearly the previous) was resumed. This suggests that a pulsating star shows two extreme states between which a real one is fluctuating.This conclusion is confirmed by the Blazhko-effect as well.

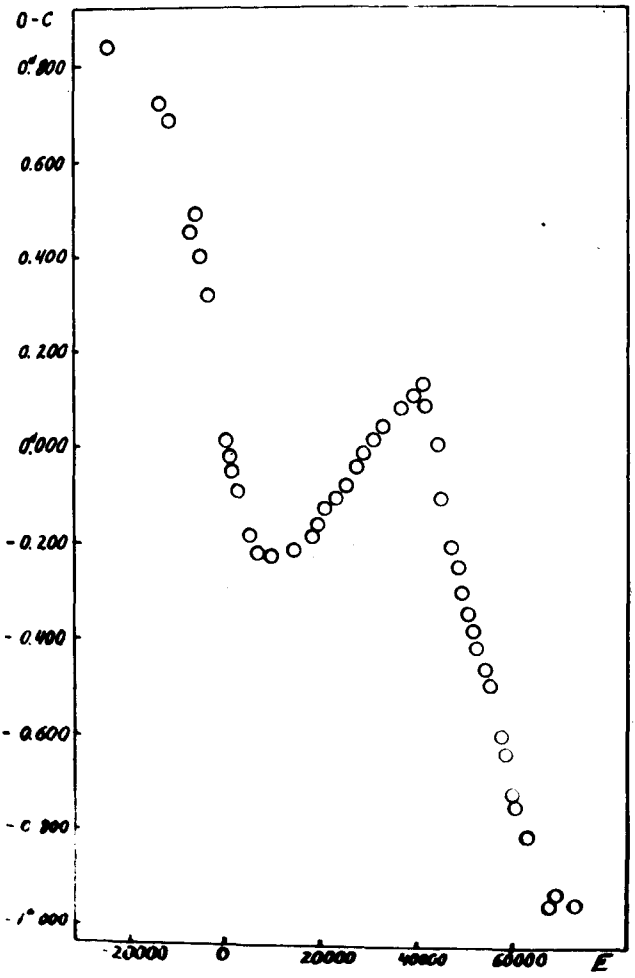

Fig.3. RZ Cep: residuals O-C plotted against number E.

The attempts of "summing" the Blazhko-effect of two interfering light fluctuations have failed. However, the star lumino-

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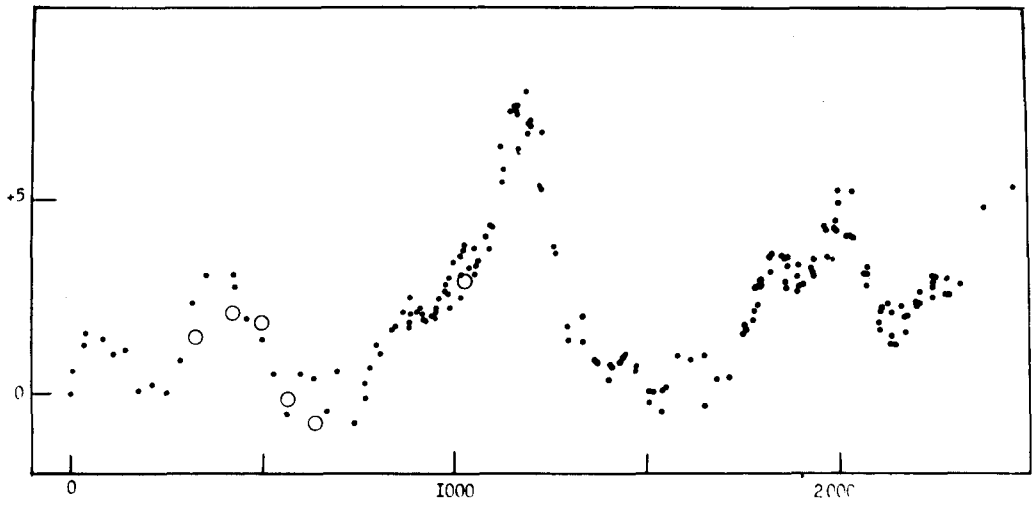

Fig.4. AP Her:star of CW-subtype. Periodical fluctuations of O-C residuals.

sity is not a primary value though composed of two primary values - radius and effective temperature. The most primary value in a pulsating star is its variable radius. The integration of curves of radial velocities has enabled us to find two oscillations of radius, the primary one with a large amplitude and the secondary one with a smaller amplitude. The addition of these two oscillations - primary and perturbing - brings about radius variation of a variable amplitude and the latter causes different type variations in luminosity.

Investigations of Blazhko-effect made it possible to divide it into some subtypes. Normal Blazhko-effect occurs with periodic variations both in the light curve and in the shift of the moment of maximum relative to the linear formula $M=M_o+PE$.

Anomalous Blazhko-effect involves amplitude variations without any shift of the moment of maximum or of variations in phase of maximum light without any variations in amplitude. Recently I have detected an anomalous Blazhko-effect in AR Ser. The Blazhko-effect period in this star varies irregularly from 90 to 120 days.

The O-C residuals are computed with respect to formula

$$\text{Max.hel. JD} = 2430472.469 + 0.57514215\ E.$$

The O-D residuals of moments of maximum amplitudes are computed with respect to formula

$$T_{Max,Amp.} = 243969.5 + 113.02\ E.$$

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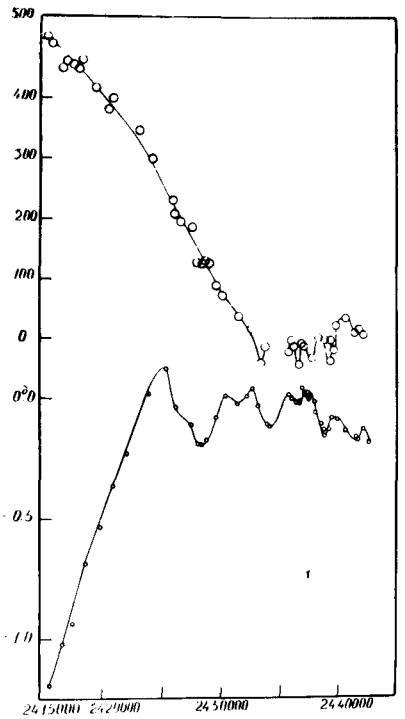

Fig.5. AR Ser: Residuals O-C and O-D plotted against JD (for details see text).

The light curve shape variations are distinctly shown in observations by Fitch, Wisniewski and Johnson.

It is stated that the period Π of Blazhko-effect changes essentially with the variation of period P of principal light variation. These variations are correlated which testifies to the fact of nonaccidental character of O-C graphs.

Thus Blazhko-effect indicates fortuitous reconstructions of internal stellar structure to occur, the cause of which is still to be found out. We have to assume, however, that variations in RR Lyrae-type stars are caused by fluctuations in the star's envelope, the suggestion being consistent with the present viewpoint of Zhevakin, Christy, et al.

These problems can be solved successfully if a sufficient number of observations are gained. Naturally, ample photoelectric observations of numerous objects are particularly urgent. At present, however, it seems next to impossible to realize all that. Therefore a considerable increase in visual observations

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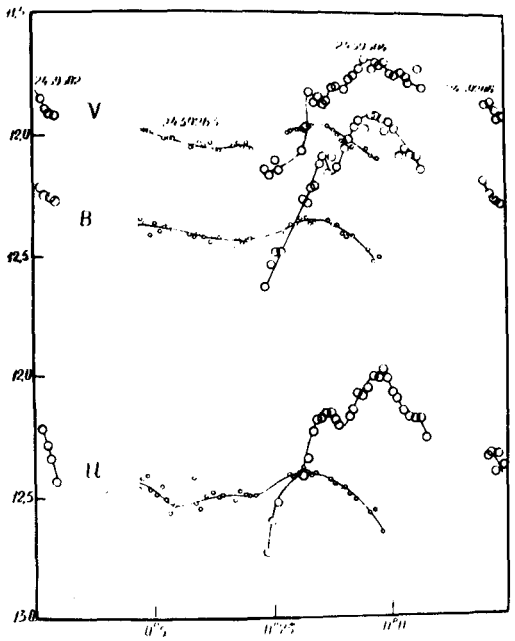

Fig.6. AR Ser: UBV light curves according to the observations by Fitch, Wisniewski, Johnson for two different phases of Blazhko-effect.

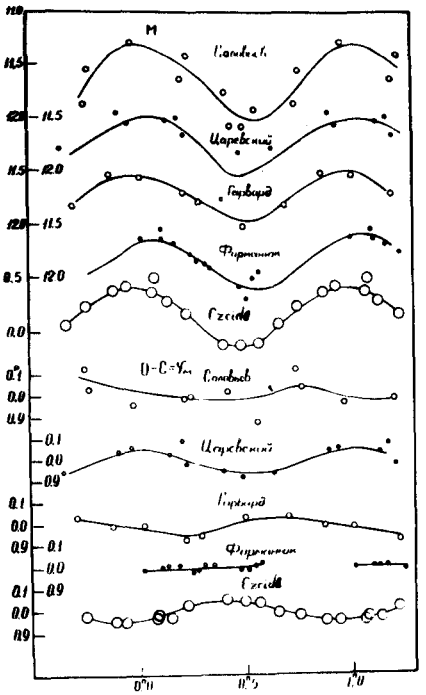

Fig.7. AR Ser: change of elements M and O-C during cycle of Blazhko-effect.

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of many objects will be urgent too. At present, ample material is available due to the realization of IAU resolution suggested by L. Detre in 1957. The revised Catalogue is regularly published in Cracow as well as ephemerides' data calculated on its basis. This work has been carried out for more than 15 years. At first several observers used to send their observations to the yearly Catalogue revision which proved to be of great importance. Now the lot has fallen upon the Odessa Astronomical Observatory to participate in the activities, for many thousands of visual observations of over 200 objects are available here.

It is too extensive a problem to be solved by the colleagues of one observatory only. More and more groups of amateurs should be attracted for the purpose of collecting observations.

However, progressive collection of maximum moments will give us information only on periodicity of a phenomenon and its variations, it will not suffice. To solve the problem of Blazhko-effect and related problems, synchronous photoelectric multicoloured observations are ncessary as well as determinations of radial velocities. Only large instruments can solve these problems.

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