POLARIMETRIC AND PHOTOMETRIC OBSERVATIONS
OF LONG-PERIOD VARIABLES

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Observations of 35 long-period variables have been done mainly at the Byurakan Astrophysical Observatory during the last years. A polarimetric monitoring of 34 stars has been carried out with simultaneous photometric measurements for some of them. Photometric data in the UBVR bands have been obtained for the star Y Ori, which is the faintest one. The results show that the degree of light polarization is correlated with the period and brightness of these stars. This indicates that the degree of light polarization is connected with the mass loss as well. Finally the photoelectric observations of the stars Y Ori, T Cep, R Gem, and R Boo show a short-term increase of their brightness in the decreasing branch of their light curves. The measured (U - B) or (B - V) colors of detected rapid variations are bluer than the colors of the star measured before these events. It is supposed that the change of polarization with time, the relatively blue colors of miras near their minimum brightness, and the colors of detected rapid variations may be explained by the influence of an invisible blue companion, as in the case of the star R Aqr.

1. Introduction.

The Asymptotic Giant Branch (AGB) is a critical stage of the stellar evolution. As is well known, a major class of the oxygen-rich stars of the AGB is constituted by the long-period variables (or Mira Ceti type stars) and located at the top of the AGB. They are late type red giants characterized by the presence of hydrogen emission lines and TiO absorption bands showing complex intensity changes along the period, and by the large rates of mass loss. The General Catalogue of Variable Stars (GCVS) contains about 5800 long-period variables [1].

The investigation of the red giants and supergiants in the Byurakan Observatory began with the discovery of the changes in the stellar light polarization of the red supergiant $\mu$ Cep by Grigoryan [2]. Since 1995 a systematic photoelectric and polarimetric monitoring has been carried out for the selected Mira Ceti variables within the framework of the French-Armenian astronomical cooperation (PICS).

The early polarimetric observations [2,3] of red variable stars were limited to objects situated near the galactic equator, and the wavelength dependence of the polarization was not studied. The intrinsic polarization was mixed with the interstellar polarization and little could be said about its properties. In 1966 large degrees of polarization increasing steeply towards the ultraviolet were found for several high galactic latitude miras and semi-regular variables. Variations of the polarization with time were detected for some of these stars [4]. Later this result was confirmed by Vardanian [5,6]. For the stars o Ceti and R Hya the largest degree of polarization is usually observed halfway between the minimum and maximum brightness [7].

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If the light polarization is produced by Rayleigh scattering on gas molecules or other particles in the stellar atmosphere, as first suggested by Shakhovskoj [3], then the characteristics of the intrinsic polarization, especially the variability, should be closely connected with the physical processes taking place in the outer layers of the atmosphere. In particular the results of Shakhovskoj [3] for the double stars and of Vitrichenko and Efimov [8] for the single stars suggest that the variations of the degree of polarization with time can be connected with mass loss. Since the mass loss phenomenon is observed in many stars on the AGB, polarimetric observations can help to understand the mechanisms taking place in this stage of evolution of the long-period variables.

Important information about the miras can be obtained from their colorimetric observations and the study of the fine structure of their light curves. In this respect the observations of 67 long-period variables by Mendoza [9] are especially useful. The stars have been observed in the spectral range 0.36-10.2 mm. Some of them show an ultraviolet excess near the minimum of brightness.

On the basis of classification of about 400 light curves of miras observed during 76 years, Boughaleb et al. [10] have shown interesting relationships between the characteristics of the light curves and the physical properties of the stars. Some miras show changes of their period from one cycle to another; as is well known, this is direct evidence of the existence of thermal pulsations [11].

The detection of rapid variations – with time scale smaller than 30 days – is of particular importance. Historically the first detection of such variations has been done by Hetzler [12,13] in the red band of the spectrum. On the basis of photographic observations during 30 years in the near infrared, Maffei and Tosti [14] also detected rapid variations of brightness and suggested that such variations are typical for some long-period variables.

In this paper the results of polarimetric and photoelectric observations obtained for 35 long-period variables in the Byurakan Observatory are presented.

2. Observations.

Most of the photoelectric and polarimetric observations have been carried out in the Byurakan observatory with the use of a photopolarimeter attached to the 50-cm telescope. During the polarimetric observations of 1988, the 2.6-m telescope has also been used with the same apparatus. The monitoring of the program stars has been performed in the $UBVR$ bands of the spectrum, and sometimes without filter.

The photopolarimeter works in the regime of amplification of the direct current and can serve as a photoelectric photometer when the polaroid is removed. An FEU 79 photomultiplier was used with maximum sensitivity in the spectral range 4000-4400Å. A comparison star and background star have been measured for every program star. The accuracy of the photoelectric observations in the $UBVR$ bands is about $0^m.02 - 0^m.07$. The uncertainties of the polarimetric measurements are of the order of $0.2-0.4\%$. The position of the polarization angle is determined with an accuracy of 2-5 degrees. A detailed description of the method and apparatus has been given earlier [15].

The photoelectric monitoring of Y Ori in the $UBVR$ bands has been carried out with the 60-cm telescope of the Maydanak station of the Tashkent Astronomical Institute (Uzbekistan) in autumn 1989. More details about these observations have already been described by Melikian and Jakubov [16].

3. Polarimetric observations.

The data of polarimetric observations for 34 stars are presented in Table 1, which gives in the successive columns the name of the star as found in the General Catalogue of Variable Stars (GCVS), the minimum $P_{\text{min}}$ and maximum $P_{\text{max}}$ values of the detected light polarization in the $U$ band, the telescope on which the observations were made, and the number of polarimetric measurements ($n$).