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LINEAR POLARIZATION OF THE LATE-TYPE VARIABLE STARS μ Cep AND MIRA IN YEAR 1981

Linear polarization observations of the late-type variable stars μ Cep (M2 Ia, SRc) and Mira (o Cet: M5e-M9e) were carried out in the late summer and autumn of the year 1981. The polarization of both these stars at earlier epochs has already been extensively chronicled by many observers. Data from the past, present and future epochs should ultimately form one of the bases for generating definitive models of the atmospheres in these and similar stars. A more immediate motivation was to compare the results being reported here with those obtained about one year earlier.

All observations were carried out at the Cassegrain focus of the 61 cm telescope at Columbia University's Harriman Observatory. The same wide-band (B) filter, polarimeter, ancillary equipment and observing procedures were used as in previous surveys of this type made by the author [vide Hayes (1981b) and references contained therein for further details regarding instrumentation and observing procedures.] The results of this survey appear in Table I, with the amount (P) and direction (θ) of polarization being expressed in percentages and in the equatorial coordinate system, respectively. Each observation of the amount of μ Cep's and Mira's polarization had a Poisson photon-count standard deviation of 0.025% and 0.020%, respectively. The polarization position angle standard deviation is given by $28^\circ\!.7$ (σ_p/P). The same photon-count errors applied for the 1980 measurements of these stars reported by Hayes (1981a) and Hayes and Russo (1981).

I. Discussion of the μ Cep Observations.

Comparison of the 1981 observations of μ Cep being presented here with the 1980 observations of Arsenijevic et al. (1980) and Hayes (1981a) reveals a drastic change in polarization. For the autumn 1980 data Hayes (1981a) reported a historic polarization maximum of $\overline{P} = 4.15\pm0.05\%$ (here and henceforth the cited errors are the standard deviations of the data). The current observations ($\overline{P} = 2.09\pm0.20\%$) indicate that a remarkable decrease in polarization has occurred in the course of about one year. But the polarization position angles have not changed markedly in the interim - going from a value of $\bar{\theta}$ = 41.3±0.8° in 1980 to $\bar{\theta}$ = 38.4±1.9° in 1981. (The eight measurements carried out in 1981 spanned an interval of about three months, while the seven measurements made in 1980 spanned about two months.) It should be noted that large-scale polarization changes are not unknown in this star [vide the earlier results summarized by Coyne and Kruszewski (1968)]. Perusal of Table I suggests that μ Cep may now be entering into an interval of polarization quiescence.

Table I

Journal of Polarization Amount and Position Angle

Star	Date (UT)	P (%)	θ (deg.)
μ Cep	1981 Aug. 25.16	2.47	36.7
	1981 Sep. 21.09	2.24	37.9
	1981 Sep. 26.06	2.14	38.2
	1981 Sep. 29.16	2.13	35.4
	1981 Oct. 18.02	2.01	38.7
	1981 Oct. 25.15	1.99	37.9
	1981 Nov. 03.02	1.91	40.6
	1981 Dec. 01.01	1.85	41.4
o Cet	1981 Sep. 09.39	1.19	42.7
	1981 Sep. 10.26	1.17	43.6
	1981 Sep. 11.36	1.20	46.1
	1981 Sep. 21.27	1.19	44.9
	1981 Sep. 25.31	1.24	46.4
	1981 Sep. 29.35	1.28	45.2
	1981 Oct. 05.28	1.34	46.3
	1981 Oct. 09.29	1.39	45.6

Consideration was given to the possibility that these polarization changes are the manifestation of a mass loss event as it traversed the extended (circumstellar) envelope. If one assigns μ Cep a radius of 1030 solar radii (Sanner 1976), it would take some 1.8 years for matter traveling at a representative velocity of 13 km sec^{-1} (Deutsch 1960) to traverse even one stellar radius [which is only a very small portion of this star's extended envelope]. As apparent from Table I, appreciable polarization changes can occur over an interval of less than a week. Thus the comparatively rapid polarization changes being reported here are inconsistent with such a mass loss event. The observed time-scales of variability suggest that the polarization is ultimately seated in the lower atmosphere - either being directly produced in the photosphere itself, or indirectly through photospheric processes which control temporal variations in the anisotropic illumination of circumstellar polarization-producing material. The first scenario (i.e., photospheric production) is very attractive despite some potential pitfalls. The primary problem with such an explanation lies in the fact that μ Cep's polarization arises from grains (Coyne and McLean, 1979), and current prevailing wisdom indicates that these particles would not survive in the lower atmosphere of such a star. But the existence of grains in such an environment may not be as vexing as once thought, since Schmid-Burgk and Scholz (1981) have recently advanced tentative theoretical arguments to account for their survival at such atmospheric depths. Complementary observational evidence may also be at hand since Hagen (1978) has suggested that the presence of grains near the stellar surface may be responsible for μ Cep's lack of chromospheric emission.

II. Discussion of the Mira Measurements.

The eight polarization measurements of Mira being reported here were carried out over a one month interval which commenced about three weeks after the 1981 light maximum. (Janet A. Mattei of the A.A.V.S.O. kindly provided a provisional estimate of the date of maximum.) Hayes and Russo (1981) have reported on four polarization measurements of this star which commenced about six weeks after the 1980 light maximum and extended over a one week interval. The amount of polarization in 1981 ($\overline{P}$ = 1.25±0.08%) was appreciably greater than in 1980 ($\overline{P}$ = 0.84±0.02%). The polarization position angles were $\overline{\theta}$ = 45.1±1.3° in 1981 and $\overline{\theta}$ = 39.7±0.7° in 1980. Shawl (1975) has reviewed arguments which suggest that nonradial pulsations are ultimately responsible for this star's polarization variations.

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