N91-14986

MULTICOLOR OPTICAL POLARIMETRY OF REDDENED STARS IN THE SMALL MAGELLANIC CLOUD

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SUMMARY

First results of an on-going program to determine the wavelength dependence of the interstellar optical polarization of reddened stars in the Small Magellanic Cloud are presented.

I. INTRODUCTION

IUE observations of reddened stars in the Small Magellanic Cloud (SMC) (Bouchet et al. 1985) generally show marked differences in the extinction law as compared to both the Galaxy and the Large Magellanic Cloud. Our aim is to determine the wavelength dependence of the optical linear polarization in the direction of several such stars in the SMC in order to further constrain the dust composition and size distribution in that galaxy.

II. INSTRUMENTATION

The observations reported here were mostly gathered with the VATPOL polarimeter (Magalhães et al. 1984) of the Vatican Observatory at the 2.15m argentinan national telescope in San Juan and with the MINIPOL polarimeter (Frecker and Serkowski 1976) at CTIO. A few observations were also obtained with PISCO polarimeter (Stahl et al. 1986) at ESO/La Silla. Later in this season, observations are scheduled with both VATPOL and the University of São Paulo IAGPOL polarimeter (Magalhães and Velloso 1988) at the 1.60m brazilian national telescope.

III. FOREGROUND GALACTIC POLARIZATION

The observed optical linear polarization in the SMC in our sample is typically fairly small (section IV below), which makes the correction due to foreground galactic dust fairly critical, despite the low ($0^{m}_{.}02$) foreground reddening (McNamara and Feltz 1980). Schmidt (1976) presents a rather detailed study of the foreground polarization in the SMC direction, dividing it into five fields and suggesting the necessary foreground corrections in each section.

We also considered separately, from Schmidt's sample, stars in each field at distances larger than 400 pc; most of the foreground reddening occurs within this distance (McNamara and Feltz 1980). We also considered averages of SMC stars from the sample of Magalhães et al. (1987) and from the present sample with visual polarization smaller than 0.4%.

These estimates are compared in Table 1 below. We then corrected the SMC observation in each filter employing Serkowski's (Coyne et al. 1974) relation for the galactic interstellar polarization,

$$P(\lambda) = P_{max} * \exp\{-K \ln^2(\lambda_{max}/\lambda)\},$$

chosing to use for P_{max} the P value from galactic stars with r > 400pc and the relation between K and λ_{max} as given by Wilking et al. (1982). We used 0.55um for λ_{max}, consistent with own multicolor observations of foreground stars.

IV. RESULTS

With one exception, our sample contains stars which have been observed for ultraviolet extinction by Bouchet et al (1985) and we refer to them according to their number in the catalogue of Azzopardi and Vigneau (1982). The exception is AV 211 which (as far as we know) has not had its UV extinction determined. We employ colour excesses from Bouchet et al. For AV 211, we have estimated the colour excess using photometric and spectroscopic data in Azzopardi and Vigneau and the calibration by Brunet (1975).

Fig. 1 presents the correlation we obtain between P_{max} and E_{B-V}. P_{max} was obtained by fitting the data with Serkowski's relation, using the galactic relation between K and λ_{max}. As can be seen, the intrinsic polarization for most of the stars is fairly small, albeit consistent with their colour excesses. The galactic envelope is also indicated for comparison.

For the three more polarized objects, AV 211, AV 398 and AV 456, we present details of the fits in Figs. 2 through 4 and in Table 2. The derived values of P_{max} and λ_{max} stay the same within the errors even if a allowing the fit to include the parameter K as a free parameter as well as rather insensitive to the foreground polarization choice. We include in Table 2 the ratio between R ($=A_V/E_{B-V}$) and λ_{max}, assuming R=2.7 ± 0.2 for the SMC as given by Bouchet et al. (1985). These values should be compared to the galactic one of about 6.7 (Clayton and Mathis 1988) and are meant to be taken as indicative only, since many more stars will have to be studied. More observations should allow us to check more closely the relation between K and λ_{max} for the SMC.

AV 456 has an extinction law (Lequeux et al. 1982) and gas-to-dust ratio (Bouchet et al. 1985) close to galactic values and its λ_{max} (Table 2) seems to reflect that the grains responsible for the optical interstellar polarization in that direction are indeed similar to those in the Galaxy. AV 398, the most heavily reddened object, is also the most polarized one and presents UV extinction law typical of the SMC (Bouchet et al. 1985), with a steep rise into the UV and absence of a strong 2200 Å peak. Its λ_{max}, although somewhat smaller, is still quite comparable to galactic values. AV 211 presents the smaller λ_{max} of the three objects.

Even values of λ_{max} close to "normal" should have an important bearing on grain modelling for the SMC. For instance, if the details mentioned above in the SMC extinction law are interpreted, in the context of the Mathis et al. (1977) model, as the result of a smaller role of graphite grains in the visible, the size distribution of silicate grains would have to be shifted in the direction of larger grains (Bouchet et al. 1985) in order to account properly for the visual extinction. If, as expected, variations in λ_{max} reflect distinct size distributions of dust particles (as for the Galaxy - Clayton and Mathis 1988), the preliminary results of Table 2 point either against that conclusion or to a size distribution of aligned grains (probably still silicates) in the SMC distinct from the one producing the extinction. Clearly, the forthcoming observations of this program will be of importance regarding the grain population in the SMC.

Finally, Table 2 shows a comparison between the optical (this work) and radio polarization position angles (from Loiseau et al. 1987). Since the latter is of non-thermal origin and would indicate a magnetic field direction orthogonal to that of a similarly oriented optical polarization vector, it is quite probable that the radio and optical polarixations originate from distinct regions in and around the SMC (Loiseau et al. 1987; Magalhães et al 1987).

ACKNOWLEDGEMENTS

A.M.M. and C.V.R. would like to acknowledge support from Fundação de Amparo à pesquisa do Estado de São Paulo (FAPESP) for this project. A.M.M. also acknowledges support for his travel from FAPESP through grant nº 88/1415-4 and the IAU through the Local Organizing Committee.

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TABLE 1. FOREGROUND POLARIZATION IN THE DIRECTION OF THE SMC

Field	Schmidt (1976)		r > 400 pc		SMC stars*	
	P ± σ (%)	θ (°)	P ± σ (%)	θ (°)	P ± σ (%)	θ (°)
I	.37 ± .15	111	.36 ± .05	110	.22 ± .01	129
II	.27 ± .15	123	.27 ± .03	125	.32 ± .01	118
III	.06 ± .09	139	.18 ± .03	132	.09 ± .01	139
IV	.14 ± .12	125	.25 ± .02	127	.09 ± .03	159
V	.16 ± .12	93	.35 ± .04	102	.16 ± .04	117

* $w/P_V < 0.4\%$

TABLE 2. FITTED PARAMETERS FOR THE MORE HIGHLY POLARIZED OBJECTS

Star	P_{max} (%)	λ_{max} (A)	R/λ_{max}	θ opt (°)	θrad (°)
AV 211	1.01 ± .05	.41 ± .05	6.6 ± .9	128	135
AV 398	1.70 ± .05	.49 ± .04	5.5 ± .6	135	135
AV 456	1.19 ± .05	.55 ± .05	4.9 ± .6	166	140

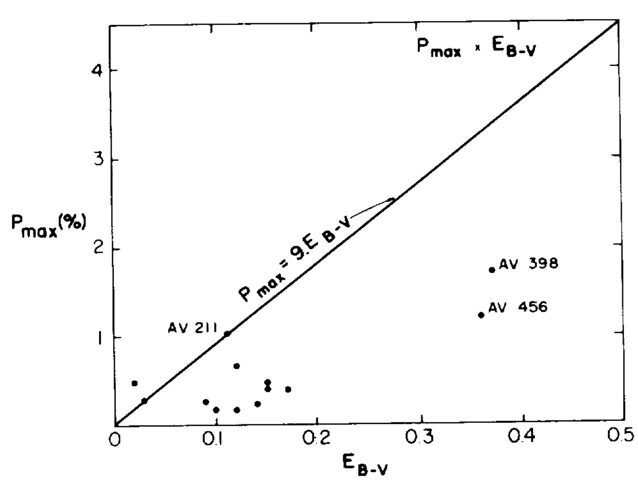

Fig. 1 - Maximum polarization as a function of colour excess for the observed SMC stars.

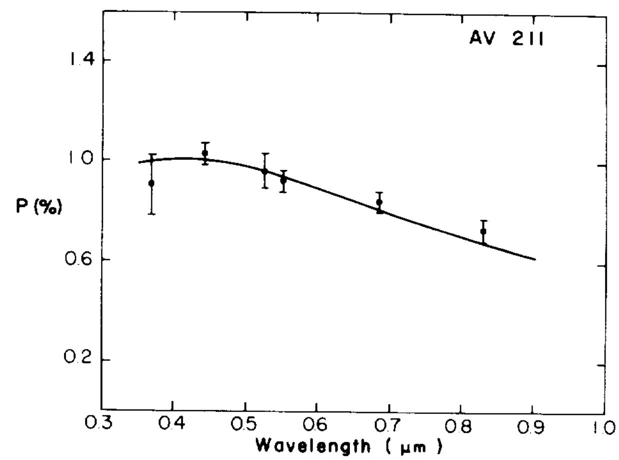

Fig. 2 - Wavelength dependence of the linear polarization for the SMC star AV 211.

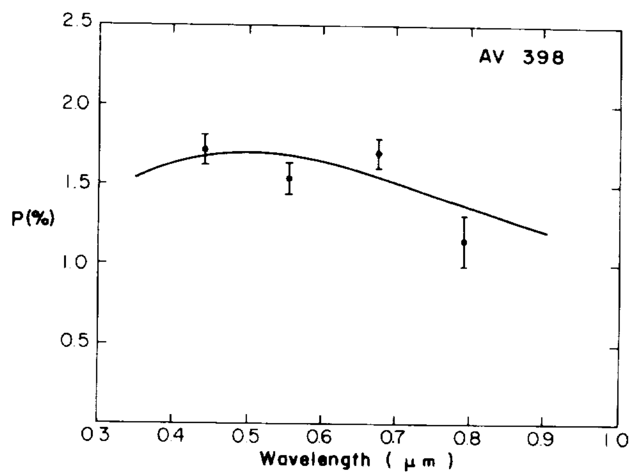

Fig. 3 - Same as Fig.2 for AV 398.

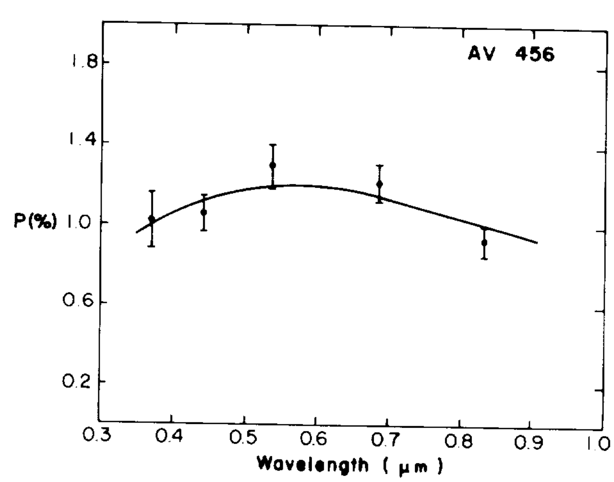

Fig. 4 - Same as Fig.2 for AV 456.