The Astronomical Journal, 120:1906–1912, 2000 October

THE HIGHLY POLARIZED OPEN CLUSTER TRUMPLER 27[1]

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Received 2000 April 19; accepted 2000 June 21

ABSTRACT

We have carried out multicolor linear polarimetry (*UBVRI*) of the brightest stars in the area of the open cluster Trumpler 27. Our data show a high level of polarization in the stellar light with a considerable dispersion, from $P = 4\%$ to $P = 9.5\%$. The polarization vectors of the cluster members appear to be aligned. Foreground polarization was estimated from the data of some nonmember objects, for which two different components were resolved: the first one associated with a dust cloud close to the Sun producing $P_{\lambda max} = 1.3\%$ and $\theta = 146°$, and a second component, the main source of polarization for the cluster members, originating in another dust cloud, which polarizes the light in the direction of $\theta = 29.5°$. From a detailed analysis, we found that the two components have associated values $E_{B-V} < 0.45$ for the first one and $E_{B-V} > 0.75$ for the other. Due the difference in the orientation of both polarization vectors, almost 90° (180° at the Stokes representation), the first cloud ($\theta \sim 146°$) depolarizes the light strongly polarized by the second one ($\theta \sim 29.5°$).
Key words: dust, extinction — open clusters and associations: individual (Trumpler 27)

1. INTRODUCTION

Trumpler 27 ($l = 355$, $b = -0.7$), also known as C1732-334, is a heavily reddened open cluster located approximately in the direction to the Galactic center. This cluster deserved a major attention in the past because some of its brightest members are stars that play a dominant role in attempts to interpret the different evolutionary phases of the brightest massive stars. Tr 27-102 is a long-period Cepheid (van Genderen & Thé 1978; Bakker & van Genderen 1981). Tr 27-28 and Tr 27-105 are two known Wolf-Rayet stars (WR 95 and WR 98, respectively) in the catalog of Galactic WR stars (van der Hucht et al. 1981). The first of them has a very large infrared excess due to thermal reemission of the stellar UV radiation by dust grains (Thé, Tjin A Djie, & Wamsteker 1980).

The literature reports three previous studies of the stellar population in Tr 27, with the main interest being to determine the distance to the cluster, namely, Thé & Stokes (1970); Moffat, FitzGerald, & Jackson (1977, hereafter MFJ77); Bakker & Thé (1983, hereafter BT83). This last study determined a distance of 1.65 ± 0.25 kpc using five-color (*WULBV*) Walraven photometry, locating the Tr 27 cluster in the Sagittarius arm. MFJ77 found Tr 27 to be a 6×10^6 year old cluster containing eight supergiant stars; six are blue (stars 2, 8, 23, 43, 46, 46a), one is yellow (star 102), and one is red (star 1).

MFJ77 also argued, based on the lack of detected Hα emission or a reflection nebula, that the layer of dust causing the strong reddening of the cluster ($E_{(B-V)} \sim 1.25$) is in front, but not associated with Tr 27. BT83 also found a normal extinction law analyzing three stars observed in several wavelengths and suggested that the radiation of these stars is already diluted when it reaches the dark cloud.

In order to understand the physical properties of the interstellar medium (ISM) towards Trumpler 27, we have carried out linear polarization observations of its brightest stars. In the next sections we will discuss the observational procedures, the data calibration, and the results in terms of both individual stars and the whole cluster.

2. OBSERVATIONS AND DATA REDUCTION

Data of linear polarimetry were obtained during three observing runs at the Complejo Astronómico El Leoncito (CASLEO), San Juan, Argentina, using two different photopolarimeters attached to the 2.15 m telescope. The first observations were performed using the Vatican polarimeter (VATPOL) during 1991 June 11–15, while the rest were carried out with the Torino five-channel photopolarimeter from 1995 May 30 to June 3 and on 1997 June 30. Most of the stars were observed through the Johnson broadband *UBVRI* filters ($\lambda_{U\mathrm{eff}} = 0.360$ μm, $\lambda_{B\mathrm{eff}} = 0.440$ μm, $\lambda_{V\mathrm{eff}} = 0.530$ μm, $\lambda_{R\mathrm{eff}} = 0.690$ μm, $\lambda_{I\mathrm{eff}} = 0.830$ μm), but a few fainter ones were observed in white light, i.e., without any filter (VATPOL run only). Several polarization standard stars (for angle and zero point) were also measured for calibration purposes. In order to verify the lack of systematic differences between the observations performed with both instruments, we show in Figure 1 the results obtained for a set of stars observed with both polarimeters. Notice that the straight lines in this figure are not least-square fits, but the 45° slopes drawn as a reference. No systematic difference was detected between the VATPOL and the Torino five-channel polarimeter data, as can be seen from the excellent agreement, as well for the values of the polarization vectors, as for their respective angles.

Our results are listed in Table 1, which shows in self-explanatory format the stellar identification as given by

[1] Based on observations obtanined at Complejo Astronómico El Leoncito (CASLEO), operated under agreement between CONICET and the National Universities of La Plata, Córdoba, and San Juan, Argentina.

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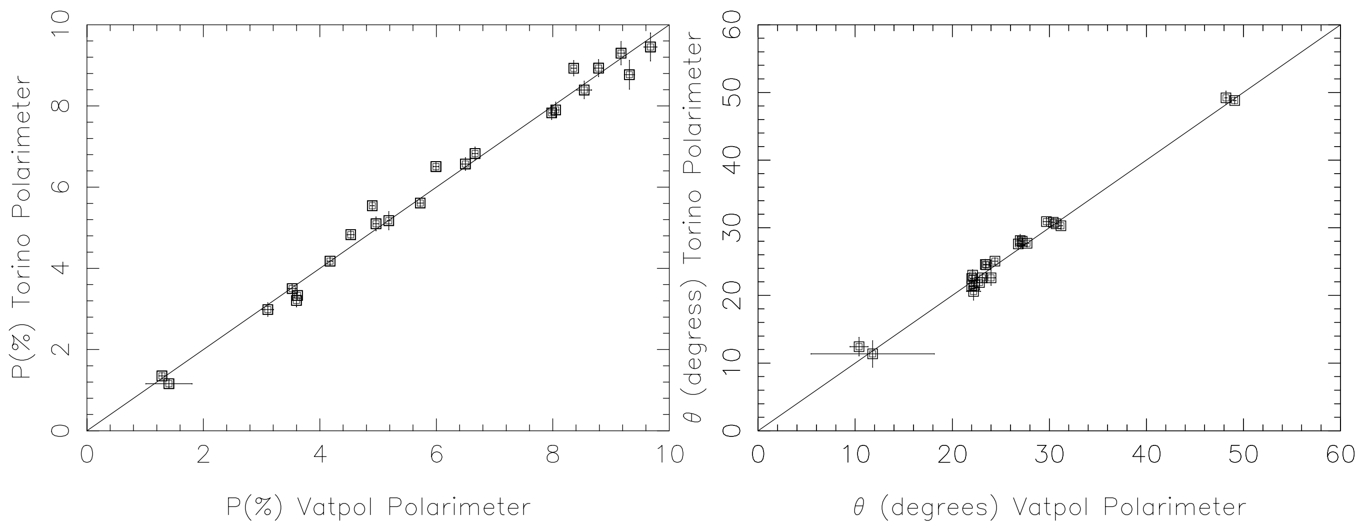

FIG. 1.—Comparison of the data for the stars observed with both polarimeters

MFJ77, the average of the percentage of polarization (P), and the position angle of the electric vector (θ) observed through each filter, with their respective mean errors.

Several stars in the area have been observed by the *Hipparcos* astrometric satellite and are included in the *Hipparcos*/Tycho catalog data (stars 1, 2, 16, 23, 24, 43, 102, 103, and 104). However, all these stars are so far away from the Sun that no useful parallax measures could be obtained. Although star 24 is a nonmember star in front of the cluster, it too has a meaningless parallax in *Hipparcos* data.

3. RESULTS

We want to emphasize, as seen from data in Table 1, the presence of cluster stars having linear polarization values reaching 9%. As far as we know, such values are not very often measured in an open cluster. The only case reported in the literature having measurements of polarization greater than Tr 27 is M17, where Schultz et al. (1981) found values in excess of 20% for some stars.

In Figure 2 we show the sky projection of the V-band polarization for the observed stars in Tr 27. As a reference, the dashed line is the Galactic parallel $b = -0\overset{\circ}{.}8$. Note the alignment of the polarization vectors with the Galactic plane. An evident feature in this figure is also that some stars with low polarization (near $\sim$1%) do not follow the general trend shown by most of the stars in Tr 27. These stars (4, 6, 22, 24, and 26) were considered nonmembers in earlier investigations, and they are very probably located in front of the cluster and the dark cloud near the cluster (MFJ77; BT83).

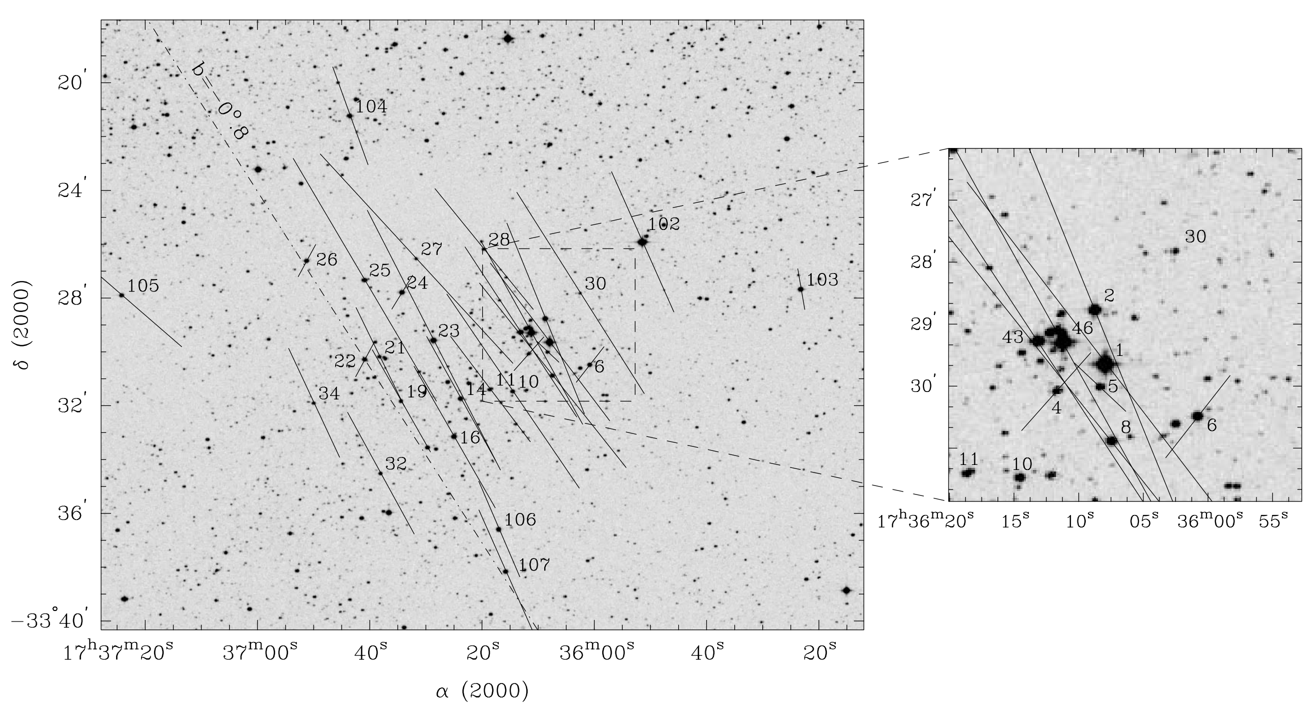

FIG. 2.—Projection of the polarization vectors (Johnson V filter) over the sky. The dotted line is the Galactic parallel $b = -0\overset{\circ}{.}8$.

TABLE 1

Polarimetric Observations of Stars in Trumpler 27

Filter	$P_\lambda \pm \epsilon_P$ (percent)	$\theta_\lambda \pm \epsilon_\theta$ (deg)
Star 1:		
B	6.65 ± 0.09	32.0 ± 0.4
V	6.47 ± 0.08	37.2 ± 0.4
R	5.63 ± 0.03	43.8 ± 0.1
I	5.37 ± 0.07	40.2 ± 0.4
Star 2:		
U	5.65 ± 0.15	24.1 ± 0.8
B	6.53 ± 0.02	21.7 ± 0.1
V	6.75 ± 0.02	22.2 ± 0.1
R	6.25 ± 0.01	21.9 ± 0.1
I	5.67 ± 0.01	22.4 ± 0.1
Star 4:		
B	1.04 ± 0.26	146.4 ± 6.9
V	1.48 ± 0.20	138.5 ± 3.8
R	1.47 ± 0.15	140.1 ± 2.9
I	1.55 ± 0.29	125.5 ± 5.4
Star 5:		
U	4.18 ± 0.62	38.8 ± 4.2
B	1.63 ± 0.66	60.8 ± 11.1
V	1.00 ± 0.76	46.8 ± 18.7
Star 6:		
B	1.80 ± 0.28	140.3 ± 4.3
V	1.48 ± 0.08	142.1 ± 1.6
R	1.51 ± 0.08	142.2 ± 1.4
I	1.18 ± 0.13	140.9 ± 3.1
Star 8:		
U	7.32 ± 0.57	37.3 ± 2.2
B	6.74 ± 0.40	38.3 ± 1.7
V	7.72 ± 0.26	38.5 ± 1.0
R	7.16 ± 0.18	41.2 ± 0.7
I	6.32 ± 0.17	41.6 ± 0.8
Star 10:		
U	7.28 ± 0.65	30.3 ± 2.5
B	8.05 ± 0.44	32.7 ± 1.6
V	7.70 ± 0.29	34.4 ± 1.1
R	6.79 ± 0.17	33.8 ± 0.7
I	5.85 ± 0.15	35.5 ± 0.7
Star 11:		
U	3.06 ± 0.35	33.5 ± 3.3
B	3.73 ± 0.29	36.2 ± 2.2
V	4.32 ± 0.29	37.2 ± 1.9
R	4.58 ± 0.15	37.6 ± 0.9
I	4.21 ± 0.16	40.3 ± 1.1
Star 14:		
V	4.64 ± 0.04	29.1 ± 0.3
R	4.24 ± 0.05	29.3 ± 0.4
I	4.05 ± 0.05	29.7 ± 0.4
Star 16:		
U	4.10 ± 0.19	26.9 ± 1.3
B	5.06 ± 0.01	28.7 ± 0.1
V	5.35 ± 0.02	29.9 ± 0.1
R	5.22 ± 0.02	31.4 ± 0.1
I	4.72 ± 0.01	31.3 ± 0.1
Star 19:		
U	3.28 ± 0.48	26.7 ± 4.1
B	3.51 ± 0.37	27.9 ± 3.0
V	3.85 ± 0.32	29.7 ± 2.4
R	3.44 ± 0.18	30.2 ± 1.5
I	2.62 ± 0.21	33.9 ± 2.3
Star 21:		
U	3.47 ± 0.65	26.0 ± 5.3
B	3.40 ± 0.48	25.3 ± 4.1
V	3.58 ± 0.38	26.6 ± 3.0
R	3.77 ± 0.16	26.2 ± 1.2

TABLE 1—*Continued*

Filter	$P_\lambda \pm \epsilon_P$ (percent)	$\theta_\lambda \pm \epsilon_\theta$ (deg)
I	3.00 ± 0.23	25.6 ± 2.2
Star 22:		
U	1.94 ± 0.55	150.7 ± 7.8
B	1.23 ± 0.28	143.7 ± 6.3
V	1.30 ± 0.08	151.9 ± 1.6
R	1.31 ± 0.07	150.1 ± 1.6
I	1.02 ± 0.15	144.4 ± 4.1
Star 23:		
U	8.03 ± 0.64	26.5 ± 2.3
B	9.04 ± 0.10	27.5 ± 0.3
V	9.56 ± 0.09	27.2 ± 0.3
R	8.86 ± 0.03	27.7 ± 0.1
I	7.91 ± 0.02	27.6 ± 0.1
Star 24:		
U	1.10 ± 0.16	152.0 ± 4.1
B	1.21 ± 0.11	147.9 ± 2.6
V	1.32 ± 0.10	148.5 ± 2.1
R	1.32 ± 0.07	150.4 ± 1.5
I	1.15 ± 0.09	148.7 ± 2.2
Star 25:		
U	7.74 ± 0.19	31.6 ± 0.7
B	8.38 ± 0.03	30.8 ± 0.1
V	9.24 ± 0.06	30.6 ± 0.2
R	8.64 ± 0.03	30.1 ± 0.1
I	7.98 ± 0.03	30.8 ± 0.1
Star 26:		
V	1.20 ± 0.07	151.5 ± 1.7
Star 27:		
B	7.71 ± 0.95	45.4 ± 3.5
V	9.32 ± 0.41	42.7 ± 1.3
R	9.31 ± 0.18	42.8 ± 0.6
I	8.07 ± 0.24	42.6 ± 0.8
Star 28:		
U	4.06 ± 1.54	68.4 ± 10.4
B	4.24 ± 1.01	29.5 ± 6.7
V	5.10 ± 0.76	39.2 ± 4.3
R	5.39 ± 0.24	35.3 ± 1.3
I	4.84 ± 0.17	35.2 ± 1.0
Star 30:		
U	6.92 ± 1.35	24.4 ± 5.5
B	7.77 ± 0.80	33.3 ± 2.9
V	7.80 ± 0.55	32.4 ± 2.0
R	7.23 ± 0.22	34.6 ± 0.9
I	6.50 ± 0.34	35.3 ± 1.5
Star 32:		
U	4.26 ± 0.36	27.0 ± 2.4
B	4.53 ± 0.38	28.0 ± 2.4
V	4.54 ± 0.30	28.8 ± 1.9
R	4.63 ± 0.12	29.2 ± 0.7
I	3.64 ± 0.19	28.8 ± 1.5
Star 34:		
U	3.21 ± 0.41	23.8 ± 3.6
B	4.09 ± 0.47	27.7 ± 3.2
V	3.94 ± 0.30	25.2 ± 2.2
R	4.07 ± 0.14	25.0 ± 1.0
I	3.70 ± 0.27	25.0 ± 2.1
Star 43:		
U	5.79 ± 0.31	36.2 ± 1.5
B	6.55 ± 0.15	34.0 ± 0.6
V	6.67 ± 0.16	33.4 ± 0.7
R	6.21 ± 0.15	35.3 ± 0.7
I	5.47 ± 0.13	35.1 ± 0.7
Star 46:		
B	6.59 ± 0.05	28.9 ± 0.2
V	6.88 ± 0.06	29.1 ± 0.2
R	6.23 ± 0.05	29.8 ± 0.2

TABLE 1—*Continued*

Filter	$P_\lambda \pm \epsilon_P$ (percent)	$\theta_\lambda \pm \epsilon_\theta$ (deg)
Star 102:		
U	5.51 ± 0.59	26.5 ± 3.1
B	5.00 ± 0.29	23.0 ± 1.7
V	5.03 ± 0.02	24.0 ± 0.1
R	4.68 ± 0.01	24.0 ± 0.1
I	4.18 ± 0.01	24.7 ± 0.1
Star 103:		
U	1.06 ± 0.22	11.9 ± 5.9
B	1.181 ± 0.08	11.3 ± 0.1
V	1.36 ± 0.06	9.9 ± 1.2
R	1.82 ± 0.00	11.4 ± 0.1
I	1.28 ± 0.11	11.6 ± 2.5
Star 104:		
U	2.86 ± 0.12	20.4 ± 1.2
B	3.33 ± 0.12	18.1 ± 1.0
V	3.40 ± 0.09	19.9 ± 0.7
R	3.51 ± 0.08	19.1 ± 0.6
I	3.13 ± 0.07	19.8 ± 0.6
Star 105:		
U	4.50 ± 0.47	53.5 ± 3.0
B	4.82 ± 0.04	51.2 ± 0.3
V	5.20 ± 0.04	49.1 ± 0.2
R	5.20 ± 0.01	48.9 ± 0.1
I	4.88 ± 0.02	48.4 ± 0.1
Star 106:		
U	2.97 ± 0.19	23.6 ± 1.8
B	3.05 ± 0.03	21.4 ± 0.3
V	3.40 ± 0.03	23.3 ± 0.3
R	3.51 ± 0.01	22.9 ± 0.1
I	3.47 ± 0.02	22.5 ± 0.2
Star 107:		
U	3.71 ± 0.19	24.2 ± 1.5
B	3.98 ± 0.18	23.4 ± 1.3
V	4.39 ± 0.20	24.0 ± 1.3
R	4.24 ± 0.13	24.1 ± 0.9
I	3.75 ± 0.18	23.7 ± 1.4

Figure 3 (*top*) presents the histogram of the angle distribution of the polarization vectors for the observed stars. The nonmember stars are easily detected because of their different angle, appearing as an isolated group at ~146°. These objects can be used to estimate the interstellar polarization component (IP) in front of Tr 27 and to subtract its contribution from the measures of the cluster stars. Averaging the value for nonmember stars, we find that the IP component is $P_V = 1.32 \pm 0.02\%$ and $\theta_V = 146\overset{\circ}{.}6 \pm 5°$. This angle is not aligned with the Galactic plane, but appears almost perpendicular, showing a perturbation in the local magnetic field of the Galaxy on the line of sight to the Tr 27 cluster. As we do not know the distances to these foreground stars we cannot estimate the extent over which the dust is aligned in this angle. From the data in the catalog of linear polarization of Axon & Ellis (1976), the angle of the polarization vector in this direction seems to show a complex pattern not associated with the direction of the Galactic plane in a large range of distances. In the photometry of MFJ77, most of these nonmember objects have colors compatible with low mass main sequence stars.

Figure 3 (*bottom*) shows the plot of the observed linear polarization vector P_V versus the polarization angle. In this figure the segregation between the members of Tr 27 and nonmembers becomes more obvious, as the cluster stars appear much more polarized. It is interesting to note that the nonmember stars 4 and 6 (~2′.5 to the west from stars 22, 24, and 26) are ~0.2% more polarized than the other nonmembers (also the angle is 10° lower), which means that the IP component is probably not fixed at the field and probably has a gradient (Fig. 3, *bottom*) like the one found in the Carina Nebula by Marraco, Vega, & Vrba (1993). However, with only a few objects to determine the IP, a selection in distance cannot be ruled out.

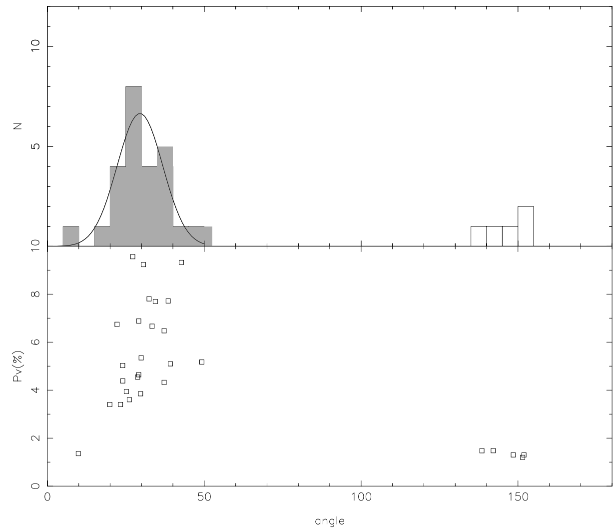

FIG. 3.—*Top*: Histogram of the polarization angle (θ) for the observed stars. Shadowed bars are for the Tr 27 cluster stars and white bars are for the foreground stars. The continuous line is the Gaussian fit to the data for members of Tr 27. *Bottom*: Polarization percentage of the stellar flux versus the polarization angle for each star. Note how the cluster stars and the nonmember objects are segregated.

In Figure 3 (*top*), the stars observed in Tr 27 cluster appear very close to ~30° in polarization angle, and the data can be easily fitted with a Gaussian distribution. The dispersion of this fit is ~10°, which is in the range of the values found by Waldhausen, Martínez, & Feinstein (1999) for the open clusters NGC 6167, NGC 6193, and NGC 6204 in Ara OB1. One star in Tr 27 (star 103) seems to be less polarized than the others. Star 103 is an isolated object located 1′ to the west, where the ISM has different properties. This star was not considered for the fitting of the Gaussian distribution.

We note that the direction of pointing of the foreground component (IP) is 146°.6, which is at near 90° to the cluster component (~29°.5), so that the total effect is to depolarize the light crossing through the ISM that produces the IP. Thus, the polarization percentages corrected for IP would be even larger than the observed ones.

BT83 suggested that the star 105 (WR 98) is a background object. However, our data indicate that the light of this star has polarimetric properties ($P_V = 5.2 \pm 0.04\%$, $\theta = 49.1 \pm 0\overset{\circ}{.}2$) similar to the cluster members, because of the high polarization and the polarization angle average ($\theta \sim 30 \pm 10°$). As this star is a Wolf-Rayet–type binary system (Niemela 1991), an intrinsic polarization component may be expected, but it would be hard to distinguish from the high value of the polarization of the ISM. We consider WR 98 to be a probable member of the Tr 27 cluster.

4. ANALYSIS AND DISCUSSION

To analyze the data, the polarimetric observations were fitted using the Serkowski law of interstellar polarization (Serkowski 1973). This is

$$P_{\lambda}/P_{\lambda \max} = e^{-K \ln^2(\lambda_{\max}/\lambda)} . \quad (1)$$

If the polarization is produced by aligned interstellar dust particles, the observed data (in terms of wavelength, *UBVRI*) will follow equation (1), where each star is characterized by a $P_{\lambda\max}$ and a $\lambda_{\max}$.

Adopting $K = 1.66\lambda_{\max} + 0.01$ (Whittet et al. 1992), we fitted our observations and computed the σ_1 parameter (the unit weight error of the fit) in order to quantify the departure of our data from the "theoretical curve" of Serkowski's law. A σ_1 larger than 1.5 is considered to be an indication of the presence of a component of intrinsic stellar polarization. Another criterion of intrinsic stellar polarization is to compute the dispersion of position angle for each star normalized by the average of the position angle errors ($\bar{\epsilon}$).

The $\lambda_{\max}$-values can also be used to test the origin of the polarization. In fact, since the average value of $\lambda_{\max}$ for the interstellar medium is 0.545 μm (Serkowski, Matthewson, & Ford 1975), objects showing $\lambda_{\max}$ rather lower than this value are also candidates for having an intrinsic component of polarization (e.g., Orsatti, Vega, & Marraco 1998). The values that we have obtained for P, the σ_1 parameter, $\lambda_{\max}$, and $\bar{\epsilon}$ together with the identification of stars are listed in Table 2.

Figure 4 shows the observed P and θ of those stars which are the candidates for having an intrinsic component of polarization. For purposes of comparison, the best fit to Serkowski's law of these observations is also plotted (*continuous line*). Stars 1 and 2 (spectral types M0Ia and O9Ia, respectively; MFJ77) have a large departure of the Serkowski relation for the data at the wavelengths of the I filter. Star 1 also shows a significant rotation in the position angle of the polarization vector. Both cases are noticeable despite the high polarization vector component added by the dust, meaning a considerable intrinsic component of polarization. Stars 25 and 106 do not fit the Serkowski curve at U- and I-filter wavelengths.

The histogram of all the observed $\lambda_{\max}$ shown in Figure 5 confirms that the most probable value of $\lambda_{\max}$ for stars in Tr 27 is around 0.55 μm, which is the same value found by Serkowski et al. (1975) as the average value for the ISM.

The observed polarization P (%) and θ of the nonmember stars show that there exist dust particles in a different alignment than those observed in the highly polarized light of the Tr 27 cluster stars. We will try to estimate the effect of this layer of dust particles, characterizing its properties (P [%], θ, E_{B-V}, etc.). The polarization vector and the angle of orientation can be obtained from the nonmembers stars 4, 6, 20, 22, and 24, which give by fitting a Serkowski law to each one of these stars an average of $P_{\lambda\max} = 1.35$ and $\theta = 146.6$.

Figure 6 is the plot of the $P_{\lambda\max}$ (corrected by the IP vector) versus E_{B-V} (data from MFJ77), but not corrected for E_{B-V} of the IP, because the value is unknown. The dashed line is the empirical upper limit relation for the interstellar polarization, $P_{\lambda\max} = RA_v \sim 9E_{B-V}$ (for normal

TABLE 2

Parameters of the Serkowski Fit to the Linear Polarization Data for Stars in Trumpler 27

Stellar Identification	$P_{\max} \pm \epsilon_P$ (percent)	σ_1	$\lambda_{\max} \pm \epsilon_{\lambda_{\max}}$ (μm)	$\bar{\epsilon}$
1	6.417 ± 0.367	5.862	0.487 ± 0.044	48.08
2	6.702 ± 0.058	5.078	0.536 ± 0.007	0.30
4	1.529 ± 0.108	0.570	0.727 ± 0.098	6.53
6	1.551 ± 0.102	1.257	0.518 ± 0.070	0.11
8	7.605 ± 0.194	1.186	0.529 ± 0.023	1.71
10	7.883 ± 0.115	0.433	0.441 ± 0.009	1.01
11	4.528 ± 0.057	0.326	0.656 ± 0.018	1.55
14	4.608 ± 0.133	3.448	0.551 ± 0.036	0.17
16	5.372 ± 0.012	1.278	0.570 ± 0.002	4.44
19	3.725 ± 0.194	0.874	0.470 ± 0.034	1.51
21	3.821 ± 0.196	0.980	0.530 ± 0.048	0.04
22	1.343 ± 0.069	1.057	0.524 ± 0.062	1.09
23	9.417 ± 0.047	1.038	0.534 ± 0.004	0.02
24	1.336 ± 0.017	0.335	0.579 ± 0.013	0.54
25	9.038 ± 0.075	3.961	0.576 ± 0.009	0.40
27	9.430 ± 0.351	1.327	0.567 ± 0.045	0.07
28	5.347 ± 0.102	0.453	0.620 ± 0.022	1.49
30	7.799 ± 0.073	0.213	0.522 ± 0.008	0.86
32	4.814 ± 0.204	1.334	0.512 ± 0.036	0.19
34	4.122 ± 0.057	0.470	0.595 ± 0.019	0.21
43	6.673 ± 0.026	0.289	0.519 ± 0.004	0.83
46	6.777 ± 0.066	2.158	0.513 ± 0.013	0.73
102	4.999 ± 0.030	1.749	0.530 ± 0.005	0.13
103	1.844 ± 0.170	3.265	0.776 ± 0.078	0.01
104	3.520 ± 0.036	0.880	0.585 ± 0.012	0.47
105	5.269 ± 0.014	1.337	0.612 ± 0.006	0.12
106	3.578 ± 0.046	3.826	0.655 ± 0.020	0.41
107	4.354 ± 0.047	0.570	0.562 ± 0.012	0.06

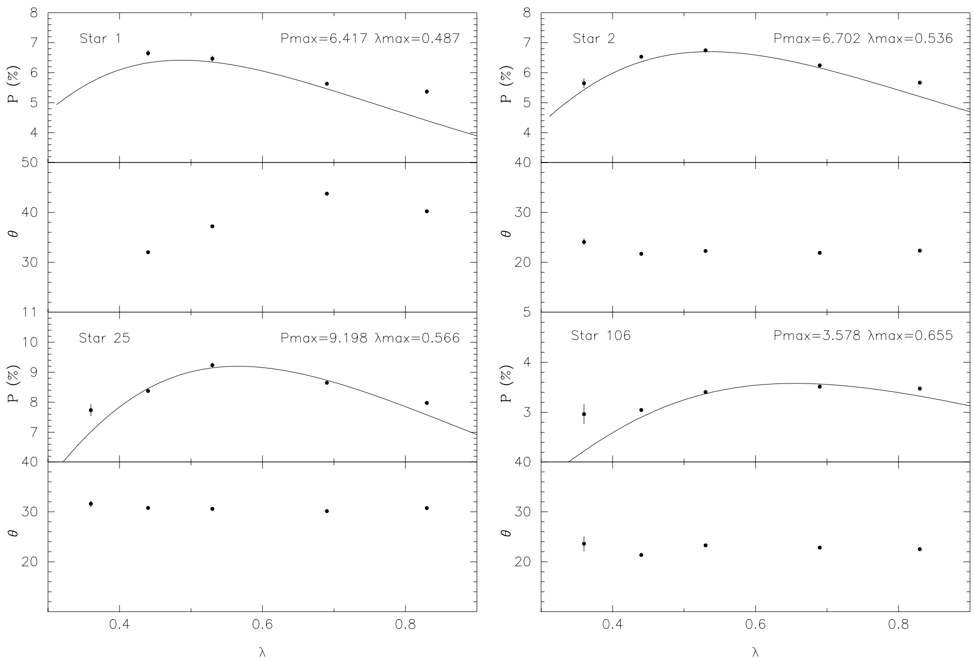

FIG. 4.—Plot of the observed data for objects showing large departures from the Serkowski law. The solid line is the best fit.

dust, $R = 3.2$), Serkowski et al. (1975). If we consider that star 23 is nearly the case of the maximum observed efficiency for the dust to polarize light, we can shift the dashed line over the E_{B-V} axis up to the location of star 23 (Fig. 6, *solid line*). This displacement ($\Delta E_{B-V} = 0.45$) then represents the maximum E_{B-V} allowed for the IP component ($E_{B-V\ \mathrm{IP}}$). Note that if the slope of the relation $P_{\lambda\mathrm{max}}$ versus E_{B-V} is less than 9, as it probably is, the maximum value of E_{B-V} for the IP component will decrease. Therefore, we can conclude that the IP component at least must have an $E_{B-V\ \mathrm{IP}} \leq 0.45$.

MFJ77 and BT83 have confirmed that the total mean color excess towards Trumpler 27 is $E_{B-V} = 1.2$. As we found that $E_{B-V\ \mathrm{IP}} \leq 0.45$, the cloud that causes the high polarization must be associated with $E_{B-V} > 0.75$ (second component). Also both above mentioned papers argue that this last layer of dust (the second component) must be in front but not associated with the Tr 27 cluster due to the lack of Hα emission or a reflection nebula (MFJ77); and since the extinction law appears normal for three luminous stars, the radiation of these stars is already diluted when it reaches the dark cloud (BT83). On the other hand, in both papers their two-color plots show a wide dispersion and not a sharp sequence, implying that some of this dust may be intracluster or just in front of the cluster, but with a density distribution that appears very nonhomogeneous.

Using the MFJ77 data for the nonmember stars and considering the value $E_{B-V\ \mathrm{IP}} < 0.45$, we find that some of these objects are consistent with solar-type main-sequence stars. To achieve the average polarization $P_{\lambda\mathrm{max}} = 1.35$ for normal efficiency of the polarizing properties of the dust ($P_{\lambda\mathrm{max}}/E_{B-V} \sim 5$, Serkowski et al. 1975) the $E_{B-V\ \mathrm{IP}}$ cannot be larger than $E_{B-V\ \mathrm{IP}} \sim 0.3$, which is still in the range of $E_{B-V\ \mathrm{IP}} \leq 0.45$.

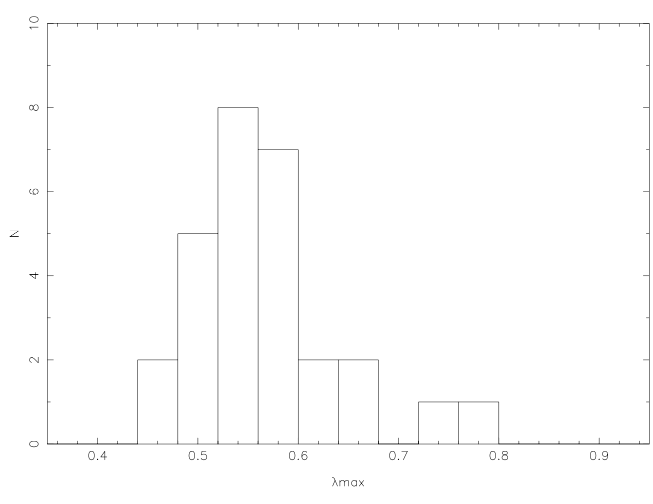

FIG. 5.—Histogram of the parameter λ_{max} obtained fitting the Serkowski law to the observations.

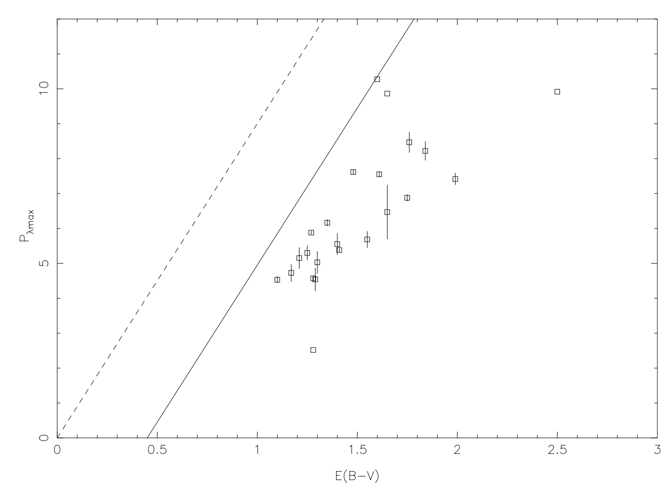

FIG. 6.—$P_{\lambda\mathrm{max}}$ vs. E_{B-V}. The dashed line is $P_{\lambda\mathrm{max}} = 9E_{B-V}$, and the solid line is a parallel for an IP component of $E_{B-V} = 0.45$.

Excluding the cluster stars with the highest polarization percentage, namely, stars 23, 25, and 27, and also star 103, with the lower polarization, the rest of the Tr 27 stars seems to be aligned in Figure 6. The slope of this alignment is the polarization efficiency of the ISM. The fit for these stars gives $P_{\lambda \max}/E_{B-V} = 4.6 \pm 0.12$, which is similar to the value of $P_{\lambda \max}/E_{B-V} = 5$ mentioned above as the canonical value for ISM.

This picture of two dust components agrees with the behavior of the interstellar absorption in this direction of the Galaxy according the study of the spatial distribution of the interstellar dust by Neckel & Klare (1980). Their work shows a strong jump in absorption from 1 to 4 mag at about 1 kpc.

5. CONCLUSIONS

We have observed linear polarization (P and θ) for a sample of stars in the open cluster Trumpler 27 and also for a few nonmember objects. Our observations indicate that the cluster members show a percentage of polarization up to 9%, an unusually high value for an open cluster. The dispersion of polarization values goes from 4% to 9%, while the average orientation of polarization is 29°.5, with a dispersion of 10°, approximately.

Using the nonmember stars located in front of the cluster, we could identify a first component of interstellar polarization (IP), which is characterized by $P_V = 1.32 \pm 0.02$ and a mean polarization angle of $\theta_V = 146°.6 \pm 5°$. The second component, which accounts for the bulk of the high polarization properties in Trumpler 27, has a mean polarization angle of $\theta_V = 29°.5$, oriented along the Galactic plane.

From the analysis of the relation between extinction and polarization it is possible to estimate the extinction related with each dust cloud component. For the group of nonmember stars, we found $E_{B-V} < 0.45$, a value that is in good agreement with previous photometric values. The second component must have an $E_{B-V} > 0.8$ to account for the previous photometry (MFJ77; BT83).

We wish to acknowledge the technical support of CASLEO during our observing runs. We thank the Vatican Observatory for the loan of their polarimeter. Also we want to acknowledge useful discussions with Ana M. Orsatti, Nidia Morrell, and Hugo Marraco, which are greatly appreciated.

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