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MULTICOLOR POLARIMETRY OF STARS IN THE OPEN CLUSTER TRUMPLER 27

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RESUMEN

Se han realizado observaciones de polarimetría multicolor de las estrellas de la región del cúmulo abierto Trumpler 27 en CASLEO, San Juan, Argentina. Estos datos muestran valores de polarización sumamente altos pero con considerable dispersión (P $\sim$ 4% a 9.5 %). A su vez, los ángulos de los vectores de polarización muestreados parecen ser constantes. Para analizar los datos usamos un nuevo algoritmo numérico que determina las distintas componentes de los vectores de polarización observados. Estimamos el valor de la polarización delante del cúmulo a partir de observaciones de algunas estrellas no miembros en la región. Nuestros datos sugieren que hay una estructura de manchas de polvo presente dentro del cúmulo.

ABSTRACT

Observations of multicolor polarimetry of the stars in the region of the open cluster Trumpler 27 have been obtained at CASLEO, San Juan, Argentina. These data show rather high values of polarization but with a considerable scatter (P $\sim$ 4% to 9.5%). On the other hand, the angle of the polarimetric vectors appears to be constant in the sample. A new numerical algorithm is used to study the different components of the observed polarization vectors. We estimate the foreground polarization vector of the cluster from observations of a few foreground, non-member stars seen in the region. Our data suggest that a patchy dust structure is present across the cluster surface.

Key words: **ISM: DUST, EXTINCTION — OPEN CLUSTERS AND ASSOCIATIONS: INDIVIDUAL (TRUMPLER 27) — POLARIMETRY**

1. INTRODUCTION

Trumpler 27 is a young open cluster located in the direction to the galactic center ($l = 355°$, $b = -0.^{\circ}7$). It appears strongly dimmed by foreground dark clouds, with visual absorption values A_V ranging from ~ 2 to 7 magnitudes. In the last years Tr 27 has received attention due to the fact that it contains several interesting members including a couple of Wolf-Rayet (WR) type stars, a Cepheid and a red supergiant along with OB stars. In the literature, there are three somewhat discrepant distance estimates for Tr 27. Thé & Stokes (1970) estimated a distance of 1.08 kpc from photographic photometry; Moffat, FitzGerald, & Jackson (1977) (hereafter MFJ) gave one of 2.1 kpc, based on photoelectric *UBV* photometry of 39 stars; and Bakker & Thé (1983) found a value of 1.65 ± 0.25 kpc using five color *WULBV* Walraven photometry. This last distance estimate locates Tr 27 in the Sagittarius spiral arm. Bakker & Thé have also found that the extinction law appears normal from observations of 3 stars at several wavelengths.

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We present here preliminary results of multicolor polarimetric observations in the region of Tr 27 aimed to investigate the behavior of interstellar material along the line of sight to this cluster.

2. OBSERVATIONS AND DATA REDUCTION

Multicolor polarimetry of stars in the region of Tr 27 was obtained during two observing runs with different polarimeters attached to the 2.15-m telescope of the Complejo Astronómico El Leoncito (CASLEO[4]), San Juan, Argentina. The first observing run was in June 1991, using the Vatican Polarimeter (VATPOL) with *UBVRI* filters. The second observing run took place in May 1996, with the Torino five channel photopolarimeter, which allows simultaneous observations through 5 filters, in this case *UBVRI*. Several polarization angle and zero polarization standard stars were measured each night for calibration purposes. Some stars were observed with both instruments and no systematic deviations appeared between the values obtained with them.

3. RESULTS AND DISCUSSION

The open cluster Tr 27 is seen projected close to the galactic center. Therefore, when we measure the polarization of the light of its members we are looking through several dust clouds. It is not easy to isolate the contribution of each cloud component in our observations, because the polarization angle is probably the same due to the particular line of sight.

We fitted our data using the Serkowski's (1971) law given by

$$P(\lambda)/P_{\max} = \exp[-K \ln^2(\lambda_{\max}/\lambda)] \ .$$

A standard value of $K = 1.15$ proved to give a good fit for stars with polarization values between 4% and 7%. However, we had to adopt the Whittet et al. (1992) dependency of K with $\lambda_{\max}$, ($K = 1.66\lambda_{\max} + 0.01$), for those stars with high polarization values of 8% and 9%, as shown in Table 1. The necessity to use different K-values is interpreted in the following way: the higher polarization values are produced by dust with uniform properties (same $\lambda_{\max}$), and lower polarization values are produced by different dust clouds located along the line of sight with different $\lambda_{\max}$.

TABLE 1

SERKOWSKI FIT TO THE OBSERVATIONS

Star Number	$\lambda_{\max}$(Å)	$P_{\max}$(%)	Θ
8	5536	7.8	40.5
10	4626	7.8	34.4
11	6665	4.6	37.2
19	5153	9.8	29.7
21	5432	3.9	25.4
23	5596	9.4	30.3
25	5740	9.5	30.4
27	5986	9.5	43.1
28	5818	5.0	33.2
30	5298	7.9	32.4
32	5406	4.6	27.1
34	5948	4.2	25.8
43	5350	6.7	33.3
102	5616	5.2	24.0
103	6057	1.4	11.0

We have also observed 4 stars indicated as foreground stars of Tr 27 by Thé & Stokes (1970) and MFJ; these are #4, #6, #22, and #24 (numbers are from those authors). For these objects we have obtained, on the average, a polarization value of 1.4% and a polarization angle of 145°, values which are very similar to those of

[4]Operated under agreement between CONICET, SeCyT, and the Universities of La Plata, Córdoba, and San Juan, Argentina.

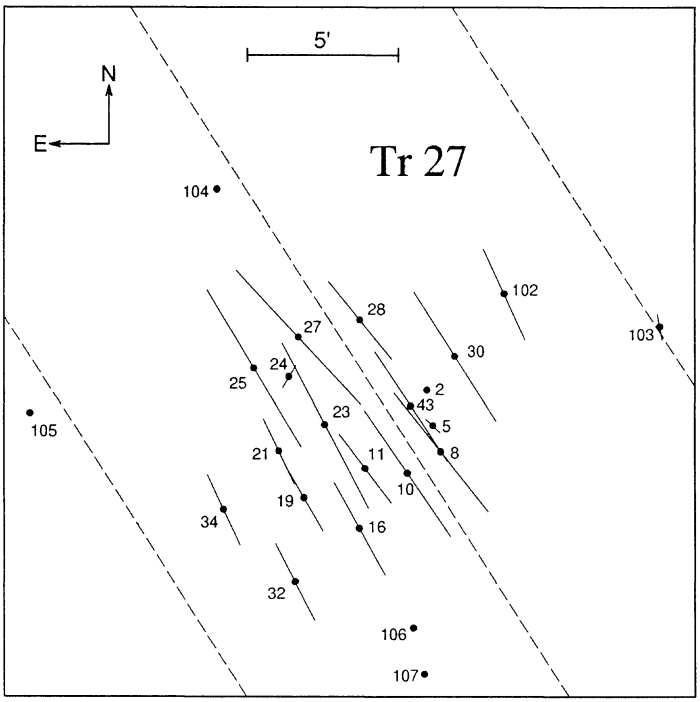

Fig. 1. Polarization vectors on the sky for stars in Trumpler 27.

the Star #103, a peripheral member having a reddening of $E_{B-V} = 1.28$ from previous photometry. This value of reddening is similar to the minimum found in Tr 27 ($E_{B-V} = 1.25$) according to recent CCD photometry carried out by Baume, Feinstein, & Vázquez (1999). Star #103 is the only member we have observed not being obscured by dust related to the cluster itself. The main difference between this star and those deemed to be foreground, is the value of the polarization angle. Therefore, as the object #103 is far from the cluster center it may not represent the exact foreground polarization of Tr 27.

We have used a numerical method to determine the foreground polarization. Assuming that the observed polarization is produced by several layers of dust, the observed multicolor polarization curve would be wider. Also, there would be differences in the polarization angles observed through each filter, as for each wavelength the added component would be of different size due to the different λ_{max} of each layer of dust. We performed a numerical algorithm that subtracts certain P_{max}, θ and λ_{max} values (as if they correspond to a foreground polarization vector), and then calculates the correlation of the angles of the vectors in the *BVRI* bands of each star. This estimate would be maximum for the real foreground correction. Several numerical experiments were done, mixing real data with artificial star data as a check of our procedure. As λ_{max} is adopted from some of the foreground stars, the method is able to find the correct value of the foreground polarization.

From this numerical approach we found a first dust component having $P_{max} = 1.43\%$ and a polarization angle of 145° (similar to the value discussed above), and also a second one having $P_{max} = 3.2\%$ and a polarization angle of 46°, which is comparable to the observed data of the less polarized stars in the cluster (Figure 1).

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