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MULTICOLOR POLARIZATION STUDY OF ARA OB1

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RESUMEN

Presentamos los primeros resultados de nuestro estudio polarimétrico multicolor de estrellas en la asociación Ara OB1. Estrellas pertenecientes a los cúmulos abiertos NGC 6204, NGC 6193, NGC 6167 y al campo local fueron observadas como parte de un estudio global de la región. La polarimetría de estrellas miembros muestra que la orientación de los vectores (su ángulo de polarización = P.A.) es muy parecida dentro de cada cúmulo. En NGC 6204 y NGC 6193 el promedio de los valores del P.A. de las estrellas miembros es de 36.2 ± 9.5, y 51.6 ± 13 respectivamente, y en NGC 6167 es de 108.3 ± 8.5 grados. Los primeros dos valores son compatibles con polvo alineado con la dirección del plano galáctico, a diferencia del valor hallado para NGC 6167. Este cúmulo parece estar en el centro de una estructura de gas en expansión, posiblemente originado en vientos estelares y/o explosiones de supernovas. Se discuten también las propiedades del polvo en la region y la hipótesis de formación estelar secuencial en la asociación OB.

ABSTRACT

We present the first results of our multicolor polarimetric study of stars in the association Ara OB1. Stars belonging to the clusters NGC 6204, NGC 6193, NGC 6167, and the local field were observed as part of a global study of the region. The polarimetry shows that the orientation of the polarimetric vectors of member stars are very close in each cluster. For NGC 6204 and NGC 6193 the average values are 36.2 ± 9.5, 51.6 ± 13 respectively, and for NGC 6167 108.3 ± 8.5 degrees. The first two values are compatible with dust aligned with the direction of the galactic plane, while the value for NGC 6167 is not. This cluster appears to be at the center of an expanding gas structure, possibly originated by stellar winds or supernova explosions. The properties of the dust in the region, and the possibility of sequential star formation in the OB association are also discussed.

Key words: **ISM: DUST — OPEN CLUSTERS: INDIVIDUAL (NGC 6167, NGC 6197, NGC 6204) — POLARIMERY — OPEN CLUSTERS AND ASSOCIATIONS: INDIVIDUAL (ARA OB1)**

1. INTRODUCTION

Ara OB1 is a well defined, rather compact association covering an area of A color excess $E(B-V)$ of 0.44 mag and a distance of 1360 pc were derived for the group by Moffat & Vogt (1973). Similar values were obtained by Herbst & Havlen (1977) who made an extensive photometric study of the region obtaining a distance of 1320 pc and color excess $E(B-V) = 0.46$ mag. These authors also suggested, that the star formation in the region may have been triggered by a supernova explosion. Later, Arnal et al. (1987) noted that NGC 6193 is seen in projection onto the border of an expanding neutral hydrogen structure. This feature has a diameter of 95 pc and its heliocentric radial velocity is -9 km s^{-1}. Also a relation between Ara OB1, the HI structure and a CO molecular complex found in the region, has been suggested by Arnal et al. (1987), in the sense that the thick HI shell was possibly originated by stellar winds from massive stars in the nearby cluster NGC 6167, which would be thus genetically linked to Ara OB1. From an infrared study of the RCW 108 region Straw et al. (1987) proposed a scenario where the star formation is propagating in this region, induced by the compression of the local molecular cloud by the hot stars in the clusters, as proposed in the theory of sequential star formation by Elmegreen & Lada (1977).

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Some of the clusters in Ara OB1 have been studied individually. NGC 6193 has been considered having an excess of close binary stars (Arnal et al. 1988). NGC 6167 was studied by Whiteoak (1963), who found little evidence of a main sequence, his data being more compatible with either an isolated stellar group or the effects of absorption produced by an irregular distribution of interstellar matter. Later, a study by Brück & Smyth (1967) suggested that if NGC 6167 is accepted as a genuine cluster, it would have an age of 4 10^7 yrs, and it would be located at a distance of 1200 pc.

Here we present the first results of a multicolor polarimetric study of the Ara OB1 region.

2. OBSERVATIONS

The observations were made during June and August, 1996, and June 1997, using the Torino Five Channel Photopolarimeter attached to the 2.15-m telescope at the Complejo Astronómico El Leoncito (CASLEO[3]), San Juan, Argentina. Polarimetry in the *UBVRI* filters was obtained for 108 stars in the clusters NGC 6167, NGC 6193, and NGC 6204, and also for 17 field stars. The total integration time was genearlly 240 sec for each star, but for some fainter objects, longer integrations were used. Several polarimetric standard stars were also measured each night.

3. RESULTS AND DISCUSSION

Table 1 lists the average polarization angles (P.A.) and their dispersions for each cluster. The rather small values of the dispersion of P.A. in this table mean that the angle of the polarization vector is nearly constant for each cluster.

TABLE 1

AVERAGE AND DISPERSION OF P.A.
FOR ARA OB1 CLUSTERS

Cluster	Average P.A.	Dispersion of P.A.
NGC 6167	108	8
NGC 6193	51	13
NGC 6204	36	9.5

It is clear from this result that stars in each cluster are behind the same dust structure, and we believe that each cluster is a real physical system because it is very unlikely that a group of stars at different distances, and thus with different layers of dust in the line a sight, could have almost the same angle of the polarization vector. This is more conspicuous in the case of NGC 6167 whose P.A. is not in the direction of the galactic plane. We suggest that the orientation of the polarization vector angle for this cluster is due to the dust surrounding the cluster being pushed by the stellar winds.

Several stars between NGC 6167, NGC 6193, and NGC 6204 (basically non members) were observed, in order to look for possible polarimetric connections between them and the clusters. These observations are listed in Table 2. None of those stars show a polarimetric behavior which could be associated with any of the clusters.

In general, the multicolor polarimetric properties of each star are supposed to follow a Serkowski (1971) law (with the Whittet et al. [1992] correction). However, this seems not to be the case for the Ara OB1 clusters, where few stars were found that could be fitted by a Serkowski law. We believe that a large number of the observed stars are binaries (as found by Arnal et al. [1988] for NGC 6193). If this were the case, a minor (periodic) component is added to the polarization vector. This component is not large enough to produce an appreciable change in the vector angle, but noticeable at the different observed wavelengths, like the U, B, and I filters, were the Serkowski law has lower values. A more detailed discussion of the number of binaries and individual properties of these stars (including spectroscopic data) will be presented in a forthcoming paper.

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TABLE 2

POLARIMETRIC DATA FOR FIELD STARS

Stars Lying between NGC 6204 and NGC 6193

Star Number[a]	Pv(%)	Error Pv(%)	P.A.	Error P.A.
62	0.711	0.037	26.1	1.5
74	2.638	0.050	51.5	0.5
77	0.922	0.045	20.4	1.4
81	4.152	0.025	163.5	0.2
87	1.310	0.029	56.2	0.6

Stars Lying between NGC 6193 and NGC 6167

Star Number[a]	Pv(%)	Error Pv(%)	P.A.	Error P.A.
18	1.020	0.077	154.4	2.2
19	0.941	0.061	8.2	1.9
24	0.990	0.088	167.7	2.5
30	0.903	0.038	60.4	1.2
33	1.780	0.065	23.7	1.0
37	0.258	0.044	120.4	4.8
40	0.457	0.067	177.1	4.2
I1	1.234	0.077	27.9	1.8
I2	0.590	0.061	27.3	3.0
I3	0.049	0.078	80.8	29.0
I4	0.821	0.065	6.0	2.2
I5	0.783	0.078	17.6	2.8

[a] Star Numbers are from Whiteoak (1963) and Herbst & Havlen (1977).

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