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POLARIMETRY OF THE HIGHLY REDDENED OPEN CLUSTERS HOGG 15 AND LYNGÅ 14[1]

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ABSTRACT

We present *UBVRI* polarimetric observations of stars belonging to the highly reddened open clusters Hogg 15 and Lyngå 14. The wavelength of maximum polarization is computed and then analyzed in the context of its relation to the optical properties and characteristic particle size distribution of the grains responsible for the polarization in each case. The amount and direction of the linear polarization are also computed. Results indicate that the polarization efficiency is relatively low in both cases, compared with the values attributed to the interstellar medium, and probably due to depolarization effects. Only one out of the 12 observed members in Hogg 15, and none in Lyngå 14, presents indications of intrinsic polarization in its measures. There exists some "intracluster" dust in association with Hogg 15, with a slightly different grain size distribution when compared with the Coalsack dust itself. For Lyngå 14, we conclude that the polarization detected in this case possibly comes from dust present in a nearby cloud located along the line of sight to the cluster, with some dust related to the cluster itself. The magnetic field in the direction to Hogg 15 follows the general trend of the polarization directions in the region, but this is not true for Lyngå 14, where differences seem to exist.

Key words: dust, extinction — open clusters and associations: individual (Hogg 15, Lyngå 14)

1. INTRODUCTION

As part of an investigation dealing with the characteristics of interstellar dust in association with different astronomical objects (e.g., H II regions, H II regions in connection with dark clouds, R associations), we have selected two young open clusters, Hogg 15 and Lyngå 14, which stand out because of the heavy absorption suffered by the light coming from their respective members. To study the material responsible for the dimming of the light, and assuming that the dust causing the reddening is also a source of polarization, we present multicolor polarimetric measures for stars belonging to both groupings to determine the amount and direction of the linear polarization toward them. By observing the amount of the interstellar polarization in the *UBVRI* bandpasses, the wavelength of maximum polarization is computed and then analyzed in relation to the optical properties and characteristic particle size distribution of the grains responsible for the polarization in each cluster.

Hogg 15 (C1240−628) is a young object of small size (3′ in diameter), located at $l = 302^\circ.4$, $b = -0^\circ.24$, behind the Coalsack region. It has been investigated by Moffat (1974), who found for this cluster an approximate age of 8×10^6 yr and a large interstellar mean reddening, which amounts to $\bar{E}_{B-V} = 1.16 \pm 0.03$ mag. Adopting the value of R (the relation between total and selective absorption) as 3.2, he derives a distance of 4.2 ± 0.6 kpc (maximum error), which locates it in the inner arm −II.

On the other hand, Lyngå 14 (C1651−452) is another young open cluster, with Galactic coordinates $l = 340^\circ.9$ and $b = -1^\circ.2$, sharing with Hogg 15 both characteristics of small size and high reddening: about 2′ in diameter and $\bar{E}_{B-V} = 1.48 \pm 0.04$, respectively, according to Moffat & Vogt (1975). They also derived for the cluster a distance of 2.34 kpc and a young age, through the presence of an O9 object still on the main sequence.

2. OBSERVATIONS

We have selected for observation in Hogg 15, 15 members and eight nonmembers according to Moffat (1974); and in the case of Lyngå 14, 10 members and five nonmembers according to Moffat & Vogt (1975). Observations in the *UBVRI* bands ($\lambda_{U_{\rm eff}} = 0.360$ μm, $\lambda_{B_{\rm eff}} = 0.440$ μm, $\lambda_{V_{\rm eff}} = 0.53$ μm, $\lambda_{R_{\rm eff}} = 0.690$ μm, $\lambda_{I_{\rm eff}} = 0.830$ μm) were carried out using the five-channel photopolarimeter of the Torino Astronomial Observatory, attached to the 2.15 m telescope at the Complejo Astronómico El Leoncito (San Juan, Argentina). They were performed on different nights during 1997 May; standard stars for null polarization and for the zero point of the polarization position angle were taken from Clochiatti & Marraco (1988).

Table 1 lists, for the 23 observed stars in the direction of Hogg 15, the percentage polarization (P_λ), the position angle of the electric vector (θ_λ) in the equatorial coordinate system, and their respective mean errors for each filter. We indicate also the number of 60 s integrations with each filter.

[1] Based on observations at the Complejo Astronómico El Leoncito, operated under agreement among the Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina, Secretaría de Ciencia y Tecnología de la Nación, and the National Universities of La Plata, Córdoba, and San Juan.

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TABLE 1

POLARIMETRIC OBSERVATIONS OF STARS IN HOGG 15

Bandpass	P_λ (%)	θ_λ (deg)
Star 1 ($n = 4$):		
U	3.15 ± 0.12	79.6 ± 1.1
B	3.99 ± 0.12	81.4 ± 0.9
V	3.58 ± 0.05	79.1 ± 0.4
R	3.73 ± 0.08	80.2 ± 0.6
I	3.33 ± 0.06	82.4 ± 0.5
Star 2 ($n = 4$):		
U	1.68 ± 0.28	72.1 ± 4.7
B	2.60 ± 0.18	71.8 ± 1.9
V	3.02 ± 0.18	73.7 ± 1.7
R	3.12 ± 0.14	75.8 ± 1.3
I	2.23 ± 0.15	78.0 ± 1.9
Star 3 ($n = 10$):		
U	3.38 ± 0.15	64.2 ± 1.3
B	3.94 ± 0.11	68.8 ± 0.8
V	3.99 ± 0.06	68.5 ± 0.4
R	4.09 ± 0.04	68.6 ± 0.3
I	3.59 ± 0.06	68.9 ± 0.5
Star 4[a] ($n = 8$):		
U	3.24 ± 0.17	63.4 ± 1.5
B	3.68 ± 0.12	62.4 ± 0.9
V	3.61 ± 0.04	63.0 ± 0.3
R	3.90 ± 0.04	63.8 ± 0.3
I	3.32 ± 0.05	64.3 ± 0.5
Star 5 ($n = 7$):		
U	2.41 ± 0.43	87.6 ± 5.1
B	2.70 ± 0.20	74.5 ± 2.1
V	3.13 ± 0.11	77.4 ± 1.0
R	3.03 ± 0.12	77.9 ± 1.2
I	2.61 ± 0.24	78.4 ± 2.6
Star 6 ($n = 7$):		
U	2.14 ± 0.42	70.3 ± 5.5
B	2.88 ± 0.27	79.7 ± 2.7
V	2.20 ± 0.23	78.7 ± 2.9
R	2.64 ± 0.23	77.7 ± 2.5
I	1.93 ± 0.35	79.0 ± 5.1
Star 7[a] ($n = 10$):		
U	2.63 ± 1.62	78.7 ± 15.8
B	3.58 ± 1.14	63.2 ± 8.8
V	1.25 ± 0.13	70.2 ± 3.0
R	1.45 ± 0.13	72.7 ± 2.6
I	1.21 ± 0.17	73.7 ± 3.9
Star 8[a] ($n = 8$):		
U	5.67 ± 2.57	47.7 ± 12.2
B	3.10 ± 1.58	76.3 ± 13.5
V	2.05 ± 0.20	72.6 ± 2.8
R	1.86 ± 0.36	65.9 ± 5.5
I	2.67 ± 0.37	70.4 ± 4.0
Star 9 ($n = 16$):		
U	1.13 ± 1.04	125.1 ± 21.3
B	2.84 ± 0.73	86.9 ± 7.2
V	1.04 ± 0.33	90.1 ± 8.7
R	1.81 ± 0.33	93.5 ± 5.1
I	1.56 ± 0.41	89.4 ± 7.4
Star 10:		
U	3.95 ± 1.69	92.8 ± 11.6
B	4.17 ± 1.03	92.6 ± 6.9
V	3.08 ± 0.16	72.4 ± 1.5
R	3.19 ± 0.13	71.7 ± 1.2
I	3.23 ± 0.29	72.9 ± 2.6
Star 11 ($n = 6$):		
U	7.24 ± 2.34	69.2 ± 9.0
B	3.05 ± 1.52	115.7 ± 13.2
V	1.87 ± 0.42	81.0 ± 6.3
R	1.78 ± 0.33	86.4 ± 5.2
I	3.45 ± 1.01	68.5 ± 8.2
Star 12 ($n = 6$):		
U	4.21 ± 1.90	81.9 ± 12.1
B	4.98 ± 1.98	67.8 ± 10.9
V	2.70 ± 0.22	61.0 ± 2.3
R	3.00 ± 0.15	70.7 ± 1.5
I	2.83 ± 0.53	70.6 ± 5.3
Star 13 ($n = 6$):		
U	4.56 ± 1.31	74.5 ± 8.0
B	2.15 ± 1.96	146.7 ± 21.2
V	2.19 ± 0.33	77.0 ± 4.3
R	2.83 ± 0.27	74.7 ± 2.8
I	4.73 ± 0.77	65.0 ± 4.6
Star 14 ($n = 6$):		
U	3.64 ± 1.19	92.9 ± 9.0
B	2.68 ± 1.33	89.8 ± 13.2
V	1.79 ± 0.17	78.5 ± 2.8
R	1.84 ± 0.27	77.9 ± 4.1
I	1.38 ± 0.25	82.5 ± 5.2
Star 15[a] ($n = 8$):		
U	17.05 ± 4.10	67.1 ± 6.8
B	6.33 ± 2.01	93.8 ± 8.8
V	2.67 ± 0.34	69.8 ± 3.6
R	2.74 ± 0.46	76.6 ± 4.7
I	2.72 ± 0.50	75.4 ± 5.2
Star 16[a] ($n = 8$):		
U	2.49 ± 0.69	67.1 ± 7.7
B	1.20 ± 0.34	75.1 ± 7.9
V	1.61 ± 0.12	63.6 ± 2.2
R	1.80 ± 0.09	70.0 ± 1.4
I	1.73 ± 0.27	81.2 ± 4.4
Star 17[a] ($n = 6$):		
U	3.24 ± 1.76	92.2 ± 14.2
B	3.66 ± 0.97	93.3 ± 7.4
V	2.09 ± 0.21	71.8 ± 2.9
R	2.32 ± 0.18	77.0 ± 2.2
I	3.05 ± 0.60	75.2 ± 5.6
Star 18[a] ($n = 8$):		
U	11.56 ± 6.75	40.8 ± 15.1
B	5.18 ± 1.99	71.3 ± 10.5
V	2.13 ± 0.10	59.9 ± 1.3
R	2.20 ± 0.09	63.3 ± 1.2
I	2.00 ± 0.19	61.6 ± 2.7
Star 19 ($n = 19$):		
U	1.90 ± 0.85	70.0 ± 12.1
B	4.10 ± 0.60	78.4 ± 4.2
V	2.65 ± 0.11	72.2 ± 1.2
R	2.85 ± 0.11	73.0 ± 1.1
I	2.31 ± 0.35	74.0 ± 4.3
Star 20 ($n = 17$):		
U	3.69 ± 1.43	80.1 ± 10.6
B	3.13 ± 0.9	60.5 ± 8.0
V	3.31 ± 0.15	65.3 ± 1.3
R	3.58 ± 0.11	68.0 ± 0.9
I	2.85 ± 0.29	63.9 ± 2.9
Star 21 ($n = 18$):		
U	4.37 ± 0.98	71.2 ± 6.3
B	0.98 ± 0.85	59.0 ± 20.4
V	3.08 ± 0.22	64.9 ± 2.1
R	3.13 ± 0.22	65.6 ± 2.0
I	2.98 ± 0.39	70.6 ± 3.7
Star 22[a] ($n = 8$):		
U	3.17 ± 0.98	75.4 ± 8.6
B	4.58 ± 1.06	53.4 ± 6.5
V	2.92 ± 0.18	84.7 ± 1.7
R	2.52 ± 0.13	85.1 ± 1.5
I	3.40 ± 0.38	87.4 ± 3.2
Star 23 ($n = 14$):		
U	2.22 ± 0.56	76.5 ± 7.1
B	2.76 ± 0.55	80.3 ± 5.7
V	2.62 ± 0.13	81.6 ± 1.4
R	2.78 ± 0.11	85.3 ± 1.1
I	1.75 ± 0.22	83.5 ± 3.5

NOTES.—Identification from Moffat 1974; *n* is the number of integrations. Position angles are in equatorial coordinates.

[a] Nonmember.

Star identifications are taken from the work of Moffat (1974); nonmembers according to that work are noted in this table and also in Table 3 below. Table 2 has the same structure, but now for the 15 observed stars in the direction of the cluster Lyngå 14. Star identifications are taken from the work of Moffat & Vogt (1975), and nonmembers according to them are noted in this table and also in Table 4 below.

3. RESULTS

By observing the amount of interstellar polarization in several bandpasses, the wavelength at which maximum polarization P_{max} occurs can be computed. This wavelength λ_{max} is a function of the optical properties and characteristic particle size distribution of the aligned grains (McMillan 1978; Wilking et al. 1980). The maximum polarization (in microns) at which P_{max} (in percentage) occurs have been calculated by fitting the observed interstellar polarization in the *UBVRI* bandpasses to the standard Serkowski polarization law,

$$P_\lambda/P_{max} = \exp\left[-k \ln^2(\lambda_{max}/\lambda)\right]$$

(Serkowski 1973), and adopting $k = 1.15$. If the polarization is well represented by the Serkowski relation, σ_1 (the unit weight error of the fit) should not be higher than 1.5, because of the weighting scheme; a higher value could indicate the presence of intrinsic polarization.

Tables 3 and 4 present P_{max}, λ_{max}, and the σ_1 values for those stars in each cluster with relative errors in their P_{max} values under 15%. Excesses in the last column of each table have been calculated according to Feinstein & Marraco (1971), using *UBV* colors from Moffat (1974) in the case of

TABLE 2

Polarimetric Observations of Stars in Lyngå 14

Bandpass	P_λ (%)	θ_λ (deg)	Bandpass	P_λ (%)	θ_λ (deg)	Bandpass	P_λ (%)	θ_λ (deg)
Star 1[a] ($n = 4$):			Star 6 ($n = 8$):			Star 11 ($n = 6$):		
U	0.21 ± 0.15	145.8 ± 17.2	U	0.36 ± 0.59	162.2 ± 29.3	U	0.43 ± 0.86	148.5 ± 31.7
B	0.21 ± 0.08	28.4 ± 10.5	B	1.71 ± 0.40	148.1 ± 6.5	B	0.84 ± 0.47	14.8 ± 14.5
V	0.38 ± 0.03	37.0 ± 2.2	V	2.01 ± 0.12	139.7 ± 1.7	V	1.75 ± 0.09	150.1 ± 1.5
R	0.33 ± 0.03	39.0 ± 2.9	R	1.96 ± 0.10	138.0 ± 1.5	R	2.06 ± 0.11	150.0 ± 1.5
I	0.31 ± 0.05	43.5 ± 4.3	I	1.81 ± 0.14	138.1 ± 2.3	I	1.93 ± 0.15	148.6 ± 2.3
Star 2 ($n = 6$):			Star 7[a]:			Star 12[a] ($n = 9$):		
U	2.10 ± 0.18	140.3 ± 2.5	U	2.14 ± 2.13	8.5 ± 22.4	U	15.25 ± 7.52	170.3 ± 13.1
B	1.97 ± 0.14	144.6 ± 2.1	B	1.84 ± 0.56	9.0 ± 8.4	B	1.27 ± 0.55	157.0 ± 11.7
V	1.77 ± 0.07	147.8 ± 1.2	V	1.64 ± 0.10	5.1 ± 1.7	V	1.40 ± 0.07	157.4 ± 1.4
R	2.00 ± 0.05	146.9 ± 0.7	R	1.53 ± 0.08	5.8 ± 1.4	R	1.36 ± 0.04	158.6 ± 0.8
I	1.61 ± 0.12	153.0 ± 2.1	I	1.56 ± 0.09	4.5 ± 1.7	I	1.22 ± 0.07	157.9 ± 1.7
Star 3 ($n = 10$):			Star 8[a] ($n = 4$):			Star 13[a] ($n = 4$):		
U	2.13 ± 0.21	158.9 ± 2.8	U	1.04 ± 0.20	167.1 ± 7.7	U	0.97 ± 0.67	142.8 ± 17.3
B	2.01 ± 0.09	150.6 ± 1.3	B	0.25 ± 0.14	29.2 ± 14.2	B	2.06 ± 0.61	139.3 ± 8.2
V	2.27 ± 0.07	152.1 ± 0.9	V	1.06 ± 0.29	23.1 ± 7.7	V	1.87 ± 0.08	148.9 ± 1.2
R	2.39 ± 0.05	153.9 ± 0.6	R	0.68 ± 0.36	17.1 ± 13.9	R	1.97 ± 0.10	148.5 ± 1.5
I	2.22 ± 0.09	153.0 ± 1.2	I	1.65 ± 0.46	11.9 ± 7.8	I	1.69 ± 0.16	154.3 ± 2.7
Star 4 ($n = 9$):			Star 9 ($n = 14$):			Star 15 ($n = 4$):		
U	1.21 ± 0.18	136.1 ± 4.2	U	0.99 ± 0.65	26.5 ± 16.7	U	12.35 ± 3.17	165.0 ± 7.2
B	1.48 ± 0.14	130.2 ± 2.7	B	0.51 ± 0.64	25.1 ± 25.8	B	2.20 ± 1.54	124.2 ± 17.5
V	1.45 ± 0.04	130.5 ± 0.8	V	1.71 ± 0.19	146.8 ± 3.2	V	1.39 ± 0.48	152.3 ± 9.5
R	1.46 ± 0.03	129.8 ± 0.7	R	1.38 ± 0.27	141.7 ± 5.5	R	1.62 ± 0.35	160.7 ± 6.1
I	1.22 ± 0.09	130.7 ± 2.0	I	1.79 ± 0.32	144.4 ± 5.0	I	1.69 ± 0.56	163.6 ± 9.2
Star 5 ($n = 2$):			Star 10 ($n = 8$):			Star 16 ($n = 4$):		
U	0.14 ± 0.10	127.9 ± 18.0	U	1.40 ± 1.17	19.5 ± 19.9	U	7.53 ± 2.92	17.5 ± 10.6
B	0.08 ± 0.10	150.4 ± 25.0	B	1.87 ± 0.55	9.2 ± 8.2	B	3.55 ± 1.66	121.6 ± 12.5
V	0.25 ± 0.04	149.5 ± 4.2	V	0.39 ± 0.17	26.6 ± 12.0	V	1.20 ± 0.24	171.2 ± 5.6
R	0.31 ± 0.04	154.9 ± 3.5	R	0.88 ± 0.29	52.2 ± 9.0	R	2.09 ± 0.40	2.0 ± 5.4
I	0.45 ± 0.07	161.3 ± 4.7	I	0.88 ± 0.24	42.9 ± 7.6	I	0.39 ± 0.58	51.2 ± 28.8

Notes.—Identifications from Moffat & Vogt 1975; n is the number of integrations. Position angles are in equatorial coordinates.

[a] Nonmember.

Hogg 15 and from Moffat & Vogt (1975) for Lyngå 14.

None of the observed stars in Table 3 (Hogg 15) have values of the unit weight error of the fit above the limiting value of 1.5. That is, in principle, interstellar dust alone appears to be responsible for the observed polarization, but in fact, a situation in which a standard Serkowski curve gives a good fit to the observations of a particular star does not exclude the possibility of another origin for the polarization. This is so because circumstellar shells could follow an abnormal wavelength dependency on polarization, which could resemble the interstellar law in a limited range of wavelength. For member stars 6, 14, and 23, and nonmember 22, P_λ and θ_λ versus λ curves are shown in Figure 1. These stars were selected because the fitted λ_{max} is shorter

TABLE 3

Polarization Results for Hogg 15 Stars

Star	P_{max} (%)	σ_1	λ_{max} (μm)	P_{vis} (μm)	θ_{vis} (deg)	E_{B-V}
1	3.814 ± 0.119	0.957	0.576 ± 0.030	3.579 ± 0.05	79.1 ± 0.4	1.24
2	2.855 ± 0.186	0.873	0.599 ± 0.063	3.024 ± 0.18	73.7 ± 1.7	1.12
3	4.179 ± 0.061	0.478	0.581 ± 0.016	3.991 ± 0.06	68.5 ± 0.4	1.11
4[a]	3.824 ± 0.100	1.014	0.599 ± 0.032	3.605 ± 0.04	63.0 ± 0.3	1.36
5	3.109 ± 0.041	0.183	0.584 ± 0.016	3.125 ± 0.11	77.4 ± 1.0	1.24
6	2.601 ± 0.194	0.589	0.526 ± 0.066	2.201 ± 0.23	78.7 ± 2.9	1.13:
7[a]	1.370 ± 0.088	0.784	0.630 ± 0.096	1.246 ± 0.13	70.2 ± 3.0	1.91:
8[a]	2.299 ± 0.294	0.579	0.722 ± 0.156	2.054 ± 0.20	72.6 ± 2.8	1.42
10	3.255 ± 0.107	0.343	0.640 ± 0.057	3.079 ± 0.16	72.4 ± 1.5	1.19
12	2.979 ± 0.124	0.332	0.664 ± 0.082	2.701 ± 0.22	61.0 ± 2.3	1.26
14	1.904 ± 0.175	0.485	0.495 ± 0.065	1.794 ± 0.17	78.5 ± 2.8	1.12
15[a]	2.877 ± 0.288	0.411	0.600 ± 0.133	2.669 ± 0.34	69.8 ± 3.6	1.33:
16[a]	1.779 ± 0.101	0.748	0.684 ± 0.092	1.612 ± 0.12	63.6 ± 2.2	0.70
17[a]	2.366 ± 0.206	0.571	0.679 ± 0.144	2.091 ± 0.21	71.8 ± 2.9	0.67
18[a]	2.212 ± 0.047	0.340	0.623 ± 0.036	2.132 ± 0.10	59.9 ± 1.3	2.10
19	2.819 ± 0.120	0.558	0.613 ± 0.072	2.654 ± 0.11	72.2 ± 1.2	1.09
20	3.517 ± 0.104	0.339	0.619 ± 0.051	3.312 ± 0.15	65.3 ± 1.3	1.09
21	3.147 ± 0.367	0.802	0.652 ± 0.170	3.076 ± 0.22	64.9 ± 2.1	1.25
22[a]	2.889 ± 0.305	0.714	0.537 ± 0.108	2.919 ± 0.18	84.7 ± 1.7	0.99
23	2.747 ± 0.227	0.787	0.528 ± 0.076	2.617 ± 0.13	81.6 ± 1.4	1.05

[a] Nonmember.

TABLE 4

POLARIZATION RESULTS FOR STARS IN LYNGÅ 14

Star	P_{max} (%)	σ_1	λ_{max} (μm)	P_{vis} (μm)	θ_{vis} (deg)	E_{B-V}
1[a]......	0.372 ± 0.015	1.456	0.538 ± 0.039	0.376 ± 0.03	37.0 ± 2.2	1.17
2	2.017 ± 0.122	1.409	0.554 ± 0.062	1.768 ± 0.07	147.8 ± 1.2	1.43
3	2.401 ± 0.060	0.716	0.625 ± 0.031	2.268 ± 0.07	152.1 ± 0.9	1.53
4	1.493 ± 0.023	0.683	0.583 ± 0.020	1.454 ± 0.04	130.5 ± 0.8	1.25
6	1.982 ± 0.176	1.293	0.681 ± 0.133	2.009 ± 0.12	139.7 ± 1.7	1.50
7[a]......	1.645 ± 0.060	0.633	0.614 ± 0.049	1.644 ± 0.10	5.1 ± 1.7	1.54
9	1.680 ± 0.252	1.015	0.740 ± 0.203	1.710 ± 0.19	146.8 ± 3.2	1.47
11	2.020 ± 0.065	0.349	0.749 ± 0.041	1.748 ± 0.09	150.1 ± 1.5	1.47
12[a]......	1.411 ± 0.013	0.205	0.577 ± 0.011	1.401 ± 0.07	157.4 ± 1.4	2.16
13[a]......	1.940 ± 0.048	0.415	0.627 ± 0.037	1.873 ± 0.08	148.9 ± 1.2	0.90
15	1.661 ± 0.214	0.514	0.628 ± 0.195	1.389 ± 0.48	152.3 ± 9.5	1.69

[a] Nonmember.

than the average general value for the interstellar medium (0.545 μm). As can be seen for stars 6 and 23, the values fit the Serkowski curve quite well, but for the other two stars the presence of abnormal curves is clear. In particular, for star 14 there are indications of polarization originating in the diffuse interstellar medium plus the contribution of an intrinsic polarization from a scattering process.

The mean polarization for members of Hogg 15, excluding star 14, yields $\bar{P}_{max} = 3.069$ (over 11 stars); the mean λ_{max} value for the maximum polarization is $\bar{\lambda}_{max} = 0.598 \pm 0.04$ μm (over the same stars). As λ_{max} is proportional to grain radius (Greenberg 1968), this result shows that the grains associated with Hogg 15 are larger than those in the general interstellar medium (0.545 μm), and with about the same dispersion (± 0.04 μm).

Star 3 is HDE 311884 (=WR 47), a Wolf-Rayet star observed by Roberts (1962) and Feinstein & Marraco (1971) that is considered a probable member of the cluster (Moffat

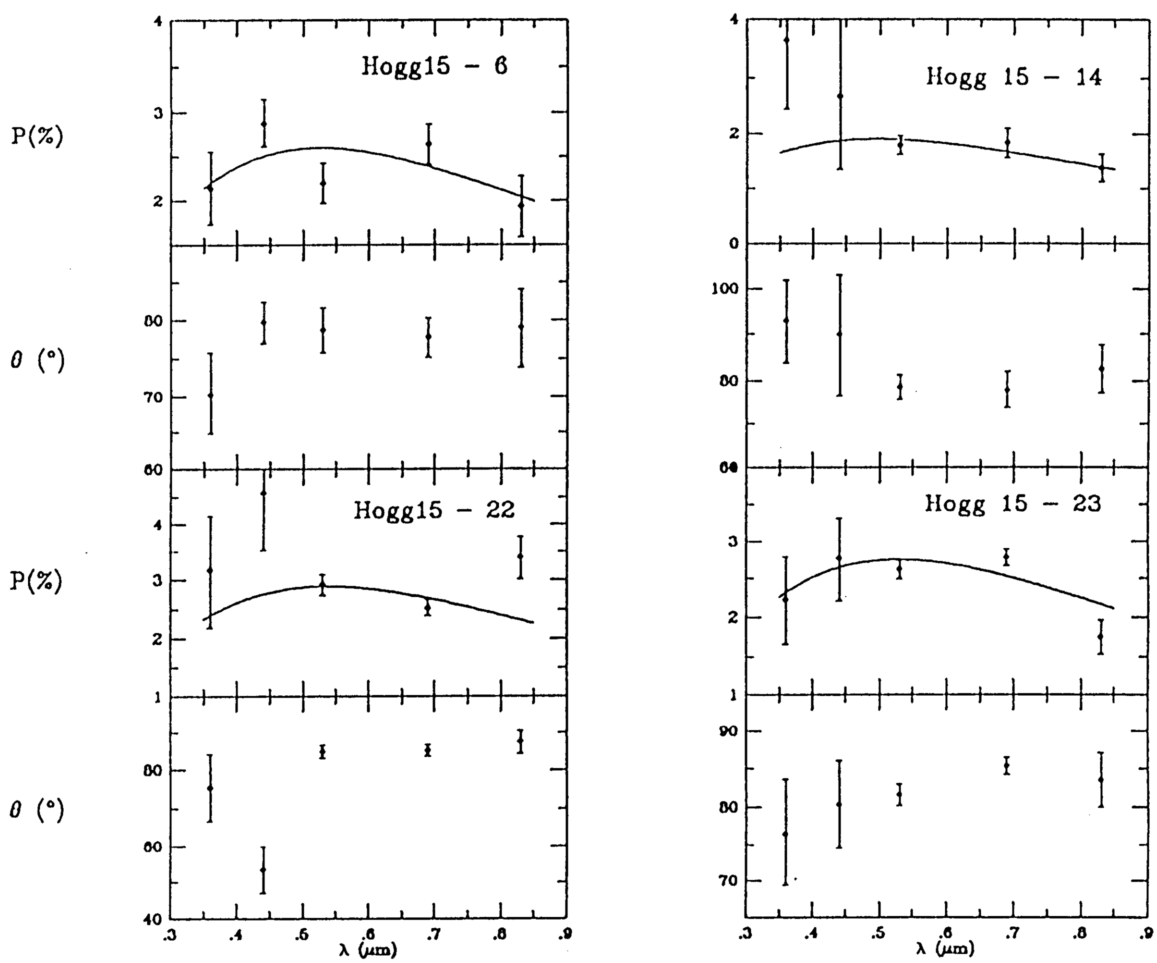

FIG. 1.—Polarization and position angle dependence with wavelength for stars with λ_{max} shorter than the interstellar medium value, in both open clusters

1974). It has the highest polarization ($P_{max} = 4.179\% \pm 0.06\%$) in Table 3, which is clearly intrinsic since it is actually a short-period W-R + O binary, with strongly time-variable polarization, modulated by the orbit (Moffat et al. 1990).

The mean polarization for seven members in Lyngå 14 yields $\bar{P}_{max} = 1.967\%$. The wavelength of maximum polarization for the same stars amounts to $\bar{\lambda}_{max} = 0.651 \pm 0.07$ μm. This value indicates, as in the case of Hogg 15, the presence of dust grains of larger size than those associated with the interstellar medium.

It is known that for the diffuse interstellar medium the polarization efficiency (ratio of the maximum amount of polarization to visual extinction) cannot exceed the empirical upper limit,

$$P_{max} < 3A_V \simeq 3R_V E_{B-V} ,$$

obtained for interstellar dust particles (Hiltner 1956). The ratio P_{max}/E_{B-V} depends mainly on the alignment efficiency and the magnetic field strength, and also on the amount of depolarization due to radiation traversing more than one cloud with different field directions. For the interstellar medium average, Serkowski, Mathewson, & Ford (1975) found $P_{max} = 5.03E_{B-V}$, but there are other regions where the value found is smaller, like in the case of Cygnus OB2, with a value of 1.7 (McMillan & Tapia 1977), or R Coronae Australis, with a value of about 2 (Vrba, Coyne, & Tapia 1981); this is thought to be the consequence of polarization and reddening from more than one source. Figure 2 depicts for both clusters the relation that exists between P_{max} for each star and its excess E_{B-V}. As can be seen in this plot, no star from either group lies to the left of the interstellar maximum line as given by Serkowski et al., a situation that indicates that the observed polarization is most likely due to the diffuse interstellar material. Some nonmember stars on the right side of Figure 2 are probably either supergiants (Hogg 15-18) or late-type stars (Hogg 15-8, -15 and Ly 14-7, -12), the excesses of which may be overestimated. These stars are marked in the figure using an arrow that points to smaller values of the excesses.

4. CONCLUSIONS

Only one out of the 12 observed members in Hogg 15 presents indications of intrinsic polarization in its measures, and none in Lyngå 14. As a comparison, in IC 2944 (Vega, Orsatti, & Marraco 1994) and NGC 6611 (Orsatti, Vega, & Marraco 1998), two open clusters associated with H II regions, we have found 50% and 30%, respectively, of members with intrinsic polarization.

The polarization efficiency, as indicated by the ratio P_{max}/E_{B-V}, is relatively low in both cases, when compared with the mean value of about 5 attributed to the interstellar medium. This low value could be due to depolarization effects, as a result of polarization and reddening from more than one source (e.g., the combination of intracluster and interstellar material).

The "foreground" polarization for Hogg 15, exluding nonmember No. 22, yields $\bar{P}_{max} = 2.311$ (mean of seven stars); the mean wavelength of maximum polarization for the foreground dust yields $\bar{\lambda}_{max} = 0.648 \pm 0.05$ μm. Comparing the "foreground" results with those of the members, we conclude that there exists some "intracluster" dust in Hogg 15, which is responsible for the excess in the mean polarization of its members (3.069%, compared with a mean value of 2.311% for the foreground stars). Also, the intracluster dust has a slightly different grain size distribution when compared with that of the foreground (mostly associated with the Coalsack dust) itself ($\bar{\lambda}_{max} = 0.598 \pm 0.04$ μm

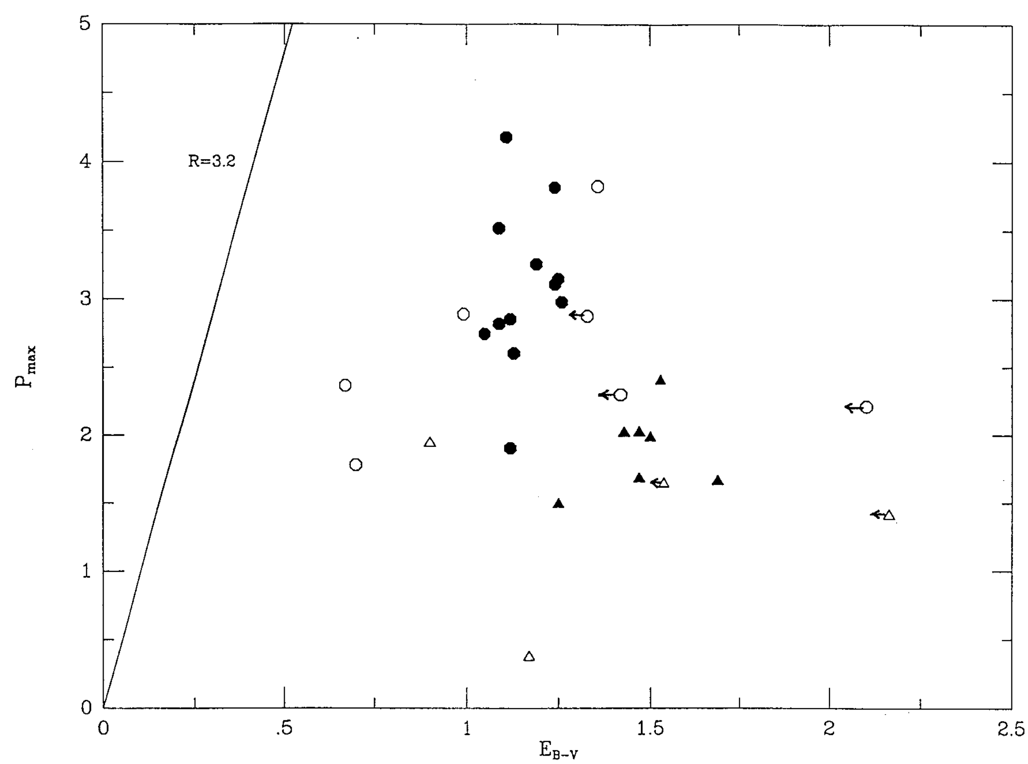

FIG. 2.—Polarization efficiency diagram for the observed dust. Using $R_V = 3.2$, the line of maximum efficiency is drawn. Filled and open circles are used for members and nonmembers of Hogg 15, respectively; filled and open triangles are for members and nonmembers in Lyngå 14. See the text for the arrows.

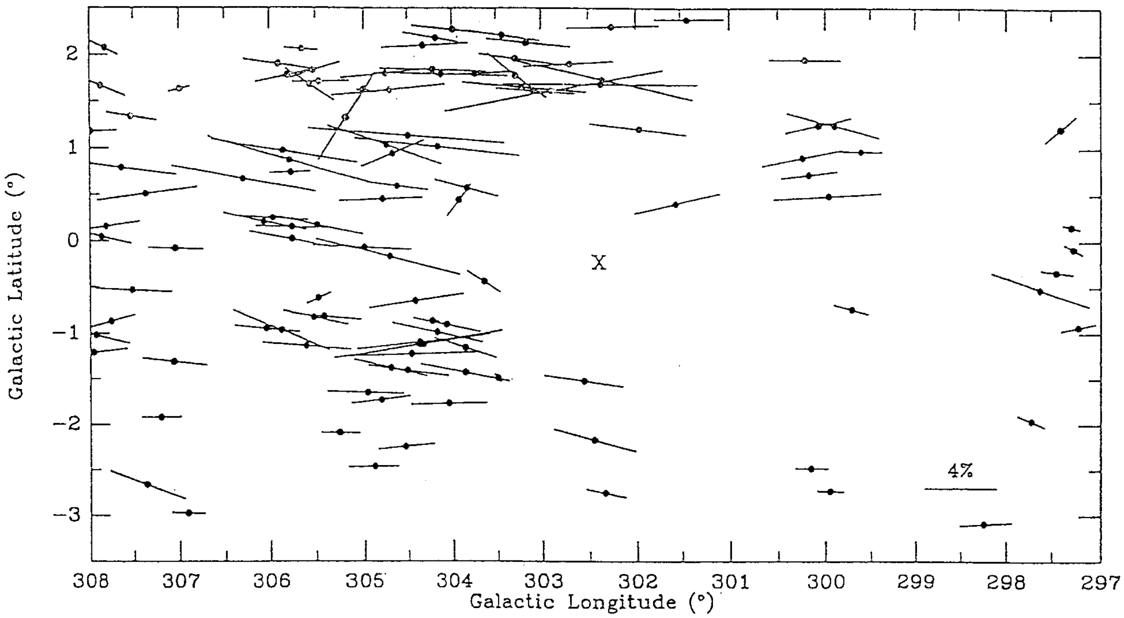

FIG. 3*a*

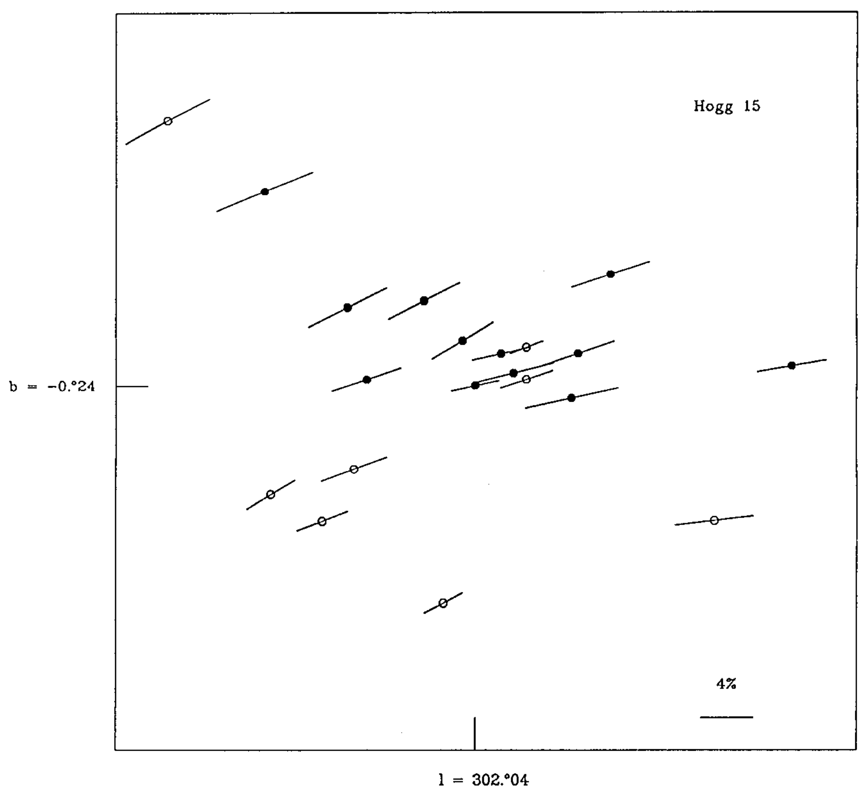

FIG. 3*b*

FIG. 3.—Polarization vectors and their orientations for stars from the catalog of Klare & Neckel (1977) in the neigborhood of Hogg 15. The length of each vector is proportional to the percentage polarization. The approximate position of the cluster in the region is indicated with a cross. (*b*) Observed polarization vectors and their orientations for stars belonging to Hogg 15. The length of each vector is proportional to the percentage polarization. Symbols are as in Fig. 2.

for members vs. $\bar{\lambda}_{max} = 0.648 \pm 0.05$ μm for the foreground dust).

For Lyngå 14, we find a mean "foreground" polarization of $\bar{P}_{max} = 1.651\%$ (mean of three stars), in comparison with the value of 1.967% for members in the cluster. The mean λ_{max} value for the foreground dust amounts to 0.606 ± 0.03 μm, similar to that of the members in this cluster. We conclude that the polarization detected in Lyngå 14 possibly comes from dust present in a nearby cloud located along the line of sight to the cluster, and also that there is some dust related to the cluster itself, as indicated by the different mean polarizations for members and foreground nonmembers.

The polarization vectors and their orientations in the

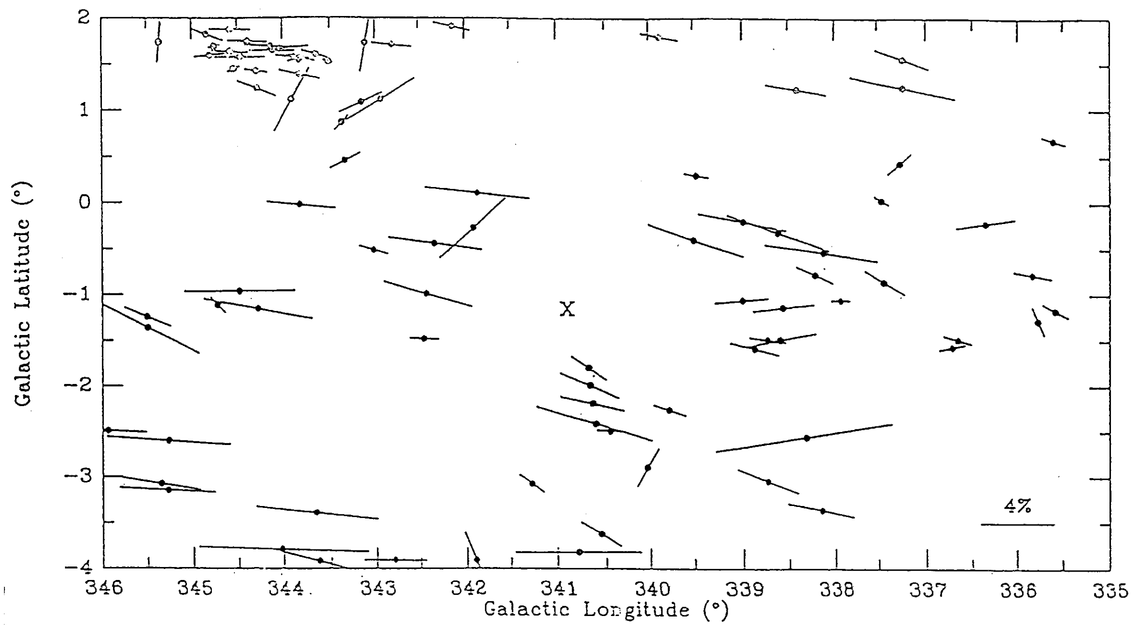

FIG. 4*a*

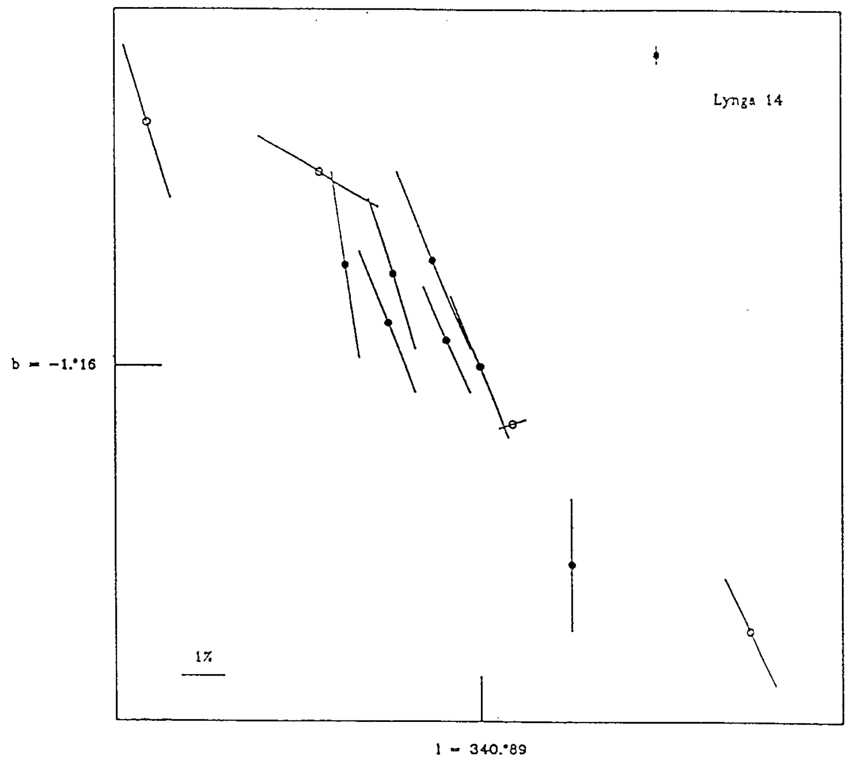

FIG. 4*b*

FIG. 4.—Same as Fig. 3, but for Lyngå 14

neighborhood of Hogg 15 (Fig. 3*a*) and for stars in the cluster (Fig. 3*b*) indicate that the magnetic field in the direction to the cluster follows the general trend of the polarization (projected magnetic field) directions in the region. The polarization in the cluster has an average direction in Galactic coordinates given by $\bar{\theta}_{vis} = 68.^{\circ}7 \pm 6.^{\circ}0$ ($70.^{\circ}5$ in equatorial coordinates). For Lyngå 14, we find that the mean direction of the magnetic field in the region (Fig. 4*b*) is $\bar{\theta}_{vis} = 196.^{\circ}3 \pm 7.^{\circ}9$ in Galactic coordinates ($145.^{\circ}6$ in equatorial coordinates), slightly different from what happens in the surroundings, as can be seen in Figure 4*a*.

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