Interstellar Matter and Star Formation:
A Multi-wavelength Perspective
ASI Conference Series, 2010, Vol. 1, pp 123–126
Edited by D. K. Ojha

Broad-band optical polarimetric studies of NGC1893

C. Eswaraiah[1]*, A. K. Pandey[1], G. Maheswar[1], B. J. Medhi[1], J. C. Pandey[1] and D. K. Ojha[2]
[1] *Aryabhatta Research Institute of Observational Sciences, Nainital 263 129, India*
[2] *Tata Institute of Fundamental Research, Mumbai 400 005, India*

Abstract. We present the results obtained through new optical broad-band (BV(RI)c) polarimetric observations carried out towards NGC 1893. In this study we found at least two foreground dust layers present towards NGC 1893. One at 170 pc and another at 350 pc. Second dust layer was found to be mainly responsible for the observed polarization towards the cluster. The polarization efficiency toward NGC 1893 is found to be higher than mean value for the general diffuse interstellar medium, thereby indicating that the dust grains are aligned well with respect to the Galactic magnetic field. The weighted mean in the λ_{max} (0.55 ± 0.01 μm), and the estimated Rv, the total-to-selective extinction (3.08 ± 0.05) are quite similar to the values corresponding to the general interstellar medium (ISM).

Keywords : Polarization: dust, magnetic field, individual: NGC 1893.

1. Introduction

Polarimetric studies are valuable tools to study the properties of interstellar as well as intracluster dust particles such as size, shape, composition and the magnetic field structure in the galaxy. Dust properties and their alignment efficiencies can be studied using Serkowski parameters P_{max} and λ_{max}. P_{max} is the maximum polarization that occurs at the wavelength λ_{max}. P_{max} is related

*email: eswar@aries.ernet.in

not only to dust properties but also to column density, degree of alignment and the orientation of the magnetic field with respect to the observer, and λ_{max} is related to the average size of the polarizing grains (Carrasco, Strom & Strom, 1973). As a part of the ongoing project to investigate dust properties at various Galactic environments, we obtained polarimetric observations of the stars towards the young open cluster NGC 1893. NGC 1893 (age $\sim$ 4 Myr) is located at a distance of 3.25 ± 0.02 kpc at the center of the Aur OB2 association (Sharma et al. 2007, hereafter, S07). Stars in the cluster shows a differential color excess in the range 0.4 - 0.6 mag (S07).

2. Observation and data reduction

Observations in B, V, R_c & I_c photometric bands were carried out on the nights of November 8 and 9, 2008 using ARIES Imaging Polarimeter (AIMPOL) (Rautela, Joshi & Pandey, 2004) coupled with TK 1024 $\times$ 1024 pixel CCD camera. The values of polarization and position angles for the programmed stars have been calculated by the standard reduction procedures mentioned in Ramaprakash et al. (1998) and Medhi et al. (2007). All the measurements were corrected for null polarization (instrumental polarization $\sim$ 0.1%) and the zero-point polarization angle by observing several unpolarized and polarized standard stars from Schmidt, Elston & Lupie (1992).

3. Results and discussion

The sky projection of V-band polarization vectors for the 44 stars towards NGC 1893 region are drawn on R band DSS image as shown in Fig. 1(a). The length of the polarization vector is proportional to the degree of polarization. A vector with a polarization of 2% is drawn for reference. The dash-dotted line superimposed on Fig. 1(a) is the Galactic parallel b=-1.53° showing a close alignment of the polarization vectors with the projection of the Galactic plane. The average polarization and polarization angles in V filter for total 44 stars are found to be $2.6 \pm 0.7\%$ and $162 \pm 5°$, respectively.

In order to understand the contribution of foreground dust layer(s) to the observed polarization measurements, we selected stars from the stellar polarization catalog agglomeration (Heiles 2000), with V band polarimetric values in a region of 10° around the cluster. The distances to these stars are estimated using the Hipparcos parallax measurements (van Leeuwen 2007). The polarization (P_V) and polarization angle (θ_V) versus distance plots are given in Fig. 1(b) and 1(c). Foreground stars are shown with open squares and cluster members stars are shown with filled circles. Presence of at least two dust layers, one at 170 pc and the other at 350 pc is evident. The polarization and position angles measured for the cluster stars are also shown using filled circles. The large range ($\sim$0.8 to 3.5%) in the observed polarization values (Fig. 1(b)) for the cluster stars (filled circles) could be due to a) some of the stars

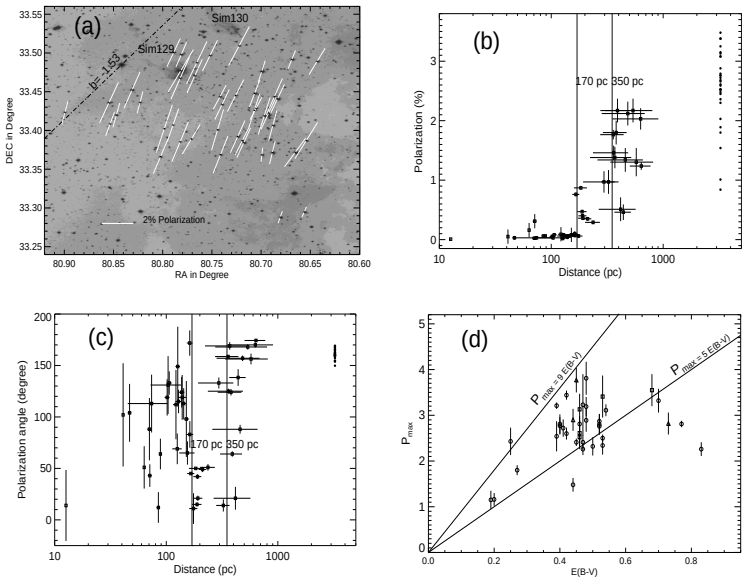

Figure 1. (*a)*: Projection of the polarization vectors on DSS R band image. North is up and east is to the left. (*b)*: Distance versus polarization for the foreground stars (open squares) and cluster members (filled circles at a distance of 3.2 kpc) (*c)*: Same as fig (1b) but for polarization angles. (*d)*: Polarization efficiency diagram. Open circles: Members with membership probability $\geq$ 50% (Dias et al. 2006). Open squares: Non-members. Triangles: Stars without membership data.

being considered as cluster members could be foreground stars, b) non-uniform distribution of dust component in the foreground, and c) differential reddening within the cluster (S07).

The mean and standard deviation of θ_V for the observed stars, $162 \pm 5°$, is found to be similar to that of the stars from Heiles catalogue lying beyond 350 pc (7 stars with $\theta_V > 150°$). Moreover the mean and standard deviation in P_V and θ_V for 32 members was found to be 2.51±0.64% and 161±5° respectively, whereas for 8 non-members 2.63±0.99% and 163±6° respectively. This implies that most of the contribution to our observed polarization values come from the dust component located very close to the Sun, most likely from the layer at $\sim$ 350 pc.

The P_{max} and λ_{max} were obtained using the weighted non-linear least square fit to the measured polarization in four (BV(RI)$_c$) bands to the Serkowski's relation ($P_\lambda = P_{max} \exp[-Kln^2(\lambda_{max}/\lambda)]$, Serkowski, 1973) by adopting $K = 1.15$. The data were weighted as per their associated errors. The least square fit was carried out for the two degrees of freedom. We found a weighted mean for P_{max} as 2.59 ± 0.02%. For the entire observed region,

the weighted mean in λ_{max} is found to be 0.55 $\pm$ 0.01 μm, which is quite similar to the value corresponding to the general interstellar medium. We estimated Rv, total-to-selective extinction, as 3.08 $\pm$ 0.05 using the relation $R_V = (5.6 \pm 0.3)\lambda_{max}$ (Whittet & Van Breda 1978). Our estimated value of Rv is found to be close to the average value for the Milky Way Galaxy.

Fig. 1(d) shows polarization efficiency diagram for the stars in NGC 1893 region. The reddening $E(B-V)$ of individual mainsequence sources with spectral type earlier than A0, have been calculated using Q method (Johnson & Morgan 1953). Majority of the possible members (open circles) of the cluster have polarization efficiency between 5 and 9.0 percent mag^{-1} correspond to mean ($P_{max}/E(B-V)$=5) and maximum ($P_{max}/E(B-V)$) polarization efficiency relations (Serkowski et al. 1975), respectively. It indicates that the region towards NGC 1893 has higher polarization efficiency as compared to the general diffuse interstellar medium.

4. Conclusions

In this study we found at least two foreground dust layers, one at 170 pc and another at 350 pc towards NGC 1893. From our analysis it is clear that the dust component that we sample through our present observations, seems to be the *second dust layer*. The dust layer existing beyond 350 pc could be characterized by the magnetic field with uniform orientation. The polarization efficiency toward NGC 1893 is found to be higher than the mean value for the general diffuse interstellar medium, thereby indicating that the dust grains are aligned well with respect to the Galactic magnetic field. The weighted mean in λ_{max}, and the estimated Rv are quite similar to the values corresponding to the general interstellar medium.

References

Carrasco L., Strom S.E., & Strom K.M., 1973, ApJ, 182, 95
Heiles C., 2000, AJ, 119, 923
Johnson H.L., & Morgan W.W., 1953, ApJ, 117, 313
Medhi B.J., Maheswar G., Brijesh K., et al., 2007, MNRAS, 378, 881
Ramaprakash A.N., Gupta R., Sen A.K., & Tandon S.N., 1998, A&AS, 128, 369
Rautela B.S., Joshi G.C., & Pandey J.C., 2004, BASI, 32, 159
Schmidt G.D., Elston R., & Lupie O.L., 1992, AJ, 104, 1563
Serkowski K., 1973, IAUS, 52, 145.
Serkowski K., Mathewson D.S., & Ford V.L., 1975, ApJ, 196, 261
Sharma S., Pandey A.K., Ojha D.K., et al., 2007, MNRAS, 380, 1141
van Leeuwen F., 2007, A&A, 474, 653
Whittet D.C.B., & Van Breda I.G., 1978, A&A, 66, 57