Chapter 6

DISCUSSION AND CONCLUSIONS

This chapter deals with the discussions on observed extinction of background starlight of different field stars for each of the clouds under consideration and conclusions are drawn from the present study.

The present work has been started with the expectation that there is some relation between extinction and polarization inside the CB clouds. With this aim, three clouds CB3, CB25 and CB39 have been observed in photometric mode. The raw images were calibrated by making master bias and master flat from a set of bias frames and flat-field frames taken for the present purpose within IRAF environment running under Fedora 5. Performing aperture photometry ("apphot" in IRAF), instrumental magnitudes of each of the field stars were obtained for the three CB clouds. After normalization to 1 sec. exposure time and air mass correction, finally calibrated magnitudes were obtained after further reduction of data and colour-excess determined extinctions were estimated for each field star of the three clouds. The extinction values measured from the present study have been compared with the polarization values from Sen et.al (2000).

For the cloud CB3 (Table 4.11), the mean value of the computed E (B−V) is found to be = 0.24 and 0.28 for R_V=3.1 and 4 respectively. It is seen that among the 31 stars, star no.s 18, 30 and 31 show a reddening significantly higher than the average. These may be non-main sequence star. Excluding these stars, the average E (B−V) values are 0.21 and 0.24 respectively for the above two R_V values. It is interesting to note from the colour-colour diagram (Figure 4.2) that apart from these stars with very strong colour excess (E (B−V) = 0.53 and 0.60, 0.51 and 0.59, 0.46 and 0.53), all other stars fit a single main sequence. So, it is logical to suppose that this star is a non-main sequence star. It is found (in Table 4.12) that, the correlation coefficients for the cloud CB3 are 0.14 and 0.13. It is also observed from the plots of 'p' vs E (B−V) (Figure 4.5, 4.6) as well as from the values of the correlation coefficient that, there is very low dependence of polarization on extinction values for the cloud CB3.

For the cloud CB25 (Table 4.11), the mean value of the computed E (B−V) is found to be =0.32 and 0.35 for R_V = 3.1 and 4 respectively. It is seen that star no.s 6 and 8 show very low reddening (0.11, 0.16 and 0.12, 0.18) with respect to the average value, thus these two may be the stars foreground to the cloud. Also these two stars do not fall in the main sequence (Figure 4.3) and were thus excluded from the plot of colour excess vs polarization values (Figure 4.7, 4.8). With the rest nineteen stars, the average values of E

(B−V) are 0.33 and 0.36, for the above two R_V values respectively. It is noticed that, the star no.s 7, 9 and 15 show very large colour excess (E (B−V) = 0.50, 0.58, 0.50 and 0.56, 0.65, 0.56) as compared to the average. Excluding these 3 stars, the average values of E (B−V) are 0.30 and 0.34. It is noticed from colour-colour diagram (Figure 4.3) that, except star nos. 7, 9 and 15, all stars belong to a single main sequence. So these stars may be non-main sequence stars or peculiar stars. The correlation coefficients for the cloud CB25 are 0.25 and 0.25(Table 4.12). From the plots of 'p' vs E (B−V) for nineteen stars (Figure 4.7, 4.8.), it is observed that the polarization may be linearly related to extinction, but the dependence is not so strong.

The mean values of the computed E (B−V) (Table 4.11), for the cloud CB39, is 0.58 and 0.67 for R_V = 3.1 and 4 respectively. It is noticed that the star no.s 3, 9, 12 and 19 show much higher reddening (compared to the average), with E (B−V) values (0.78, 0.71, 0.75, 0.82) and (0.89, 0.81, 0.85, 0.94) respectively for above two R_V values. These four stars also do not belong to main sequence as observed in the colour-colour diagram (Figure 4.4). Excluding these four stars, the average E (B−V) values are 0.54 and 0.62. Figure 4.9, 4.10 represent the plot of polarization 'p' vs colour excess E (B−V) for the cloud CB39 for R_V =3.1 and 4. It is seen from the plot as well as from the values of the coefficient of correlation (Table 4.12) that, the polarization increases linearly with extinction. Here the values of the coefficient of correlation are 0.68 and 0.73, which are relatively high.

Thus, in the present case, it is seen for the cloud CB3 that there is very low dependence of polarization on extinction; for the cloud CB25 also dependence is not so high. However, for CB39 the dependence seems to be relatively higher. Explanations for the lack of strong correlation between the observed polarization 'p' and extinctions E (B−V) for the stars background to the above clouds, may be provided in a number of ways. One may think of these clouds containing grains that do not get aligned (Lazarian et al. 1997) and are so-called bad grains (Creese and Jones 1995). There may be high amount of turbulence present in the clouds disturbing the grain alignment (Sen et al. 2005). Whether all cold dark clouds, including CB3, CB25 and CB39, will contain bad grains in their interiors is unknown. The physical conditions of the three clouds described by Clemens et al. (1991) tell us that, the cloud CB3 belong to group C with the gas temperature T< 8.5K and turbulent gas motions, characterized by ^{12}CO line widths, > 2.5 kms^{-1}. The clouds CB25 and CB39 are from group A with the gas temperatures T< 8.5K and turbulence < 2.5 kms^{-1}. The values of turbulence of the three clouds are listed in the Table 4.12. As the cloud CB3 has high turbulence with unusual dynamical activities, such a low correlation is expected for CB3. The cloud CB39 has less turbulence as compared to CB3, which may be responsible for higher correlation between p and E (B−V) in this cloud. As the cloud CB25 has lowest turbulence among the others, it should have better correlation value (*r*) according to this conjecture. However, it does not show high dependence of polarization on extinction. What causes the reduced correlation in this cloud is a matter of further analysis. The surveys of Clemens & Barvainis(1988) and Yun & Clemens(1990) reveal the presence of YSO and IRAS point source in the cloud CB39. But the cloud CB25 is quiescent (Stecklum 2004) with no YSOs and IRAS point sources detected and this may be the reason for this cloud to behave differently. Further, the alignment of the grains is an important factor that could be responsible for polarization-extinction relationship. As suggested by Sen et al. (2005), polarization should depend on the degree of Davis-Greenstein alignment. Under the present circumstances, Sen et al. (2005), quantified the degree of alignment by the parameter ~ T_d/T_m where $T_m = (T_d + T_g)/2$, is the average of the dust (T_d) and gas (T_g) temperatures. Therefore, one expects p ~ (T_d/ T_g + T_d). The values of (T_d/ T_g + T_d) (denoted by T_2) are reproduced in the Table 4.12, along with the values of turbulence and correlation coefficient (*r*).

To understand the present situation further, *r* is plotted against T_2 (in figure 4.11). This plot shows a trend where *r* increases with T_2, giving an explanation that better correlation coefficient can be expected, when there is better grain alignment.

However, just with three data points, it is difficult to draw a general conclusion. A larger number of such clouds should be investigated along these lines. However, it can be at least said that, the grain alignment may be one of the important reasons why the cloud CB39 is showing better p vs E (B−V) correlation as compared to the other two clouds CB3 and CB25. It will be important to study these clouds in further detail in future, to find the more specific reasons why the different clouds show different degree of dependence of polarization on extinction. A more precise way of doing this could be by determining the individual spectral types of the stars, so that E (B−V) can be estimated with less uncertainty.

CONCLUSIONS

Based on the above analysis it can be concluded that:

1. The three clouds under observation show different degree of dependence of polarization on extinction. The cloud CB3 shows very low dependence of polarization on extinction, for the cloud CB25, the polarization may be linearly related to extinction, but the dependence is not so strong and the cloud CB39 shows relatively higher dependence of polarization on extinction.

2. The coefficient of correlation between the observed polarization p and extinctions E (B−V) for the stars background to the above clouds, do not appear to be related to the turbulence in the clouds.

3. The correlation coefficient between the observed polarization p and extinctions E (B−V) seem to be dependent on the degree of grain alignment in the clouds. Thus it can be concluded that the grain alignment may be one of the important reasons of the observation that the cloud CB39 is showing better p vs E (B−V) correlation as compared to the other two clouds CB3 and CB25.