Chapter 5

DISCUSSION, RESULT AND CONCLUSION

The fifth chapter contains discussion, result and conclusion of the work.

5.1 Discussion

The negative polarization behaviour of comet is one of the important features observed in comets. Several comets show negative polarization beyond $157^\circ$ scattering angle (Kikuchi et al., 1987; Chernova et al., 1993; Ganesh et al., 1998 etc). The negative branch has an approximately symmetric shape and a minimum of $\sim -2\%$ near $170^\circ$. In the present work, it is interesting to observe that the used dust aggregate model reproduce the negative polarization
5.1.1: Comet Levy 1990XX

behavior which seems to be an observational constant for comets (Levasseur-Regourd & Hadamcik, 2001).

5.1.1 Comet Levy 1990XX

Das and Sen (2006) studied the light-scattering properties of comet Levy 1990XX using the T-matrix theory. They found that compact prolate grains as compared to spherical grains can better explain the observed linear polarization data. The $\chi^2_{\text{min}}$ value emerging from their analysis was 5.22. The value from the present work is found to be 4.2. Thus, it is clear that the result with aggregates gives still better fit to the observed polarization data. In Fig 5.1, the expected polarization curves are plotted against the observed data points for both compact prolate grains (Das & Sen, 2006) and fractal aggregates.

The best-fitting refractive indices coming out from the present analysis show silicate behaviour as the values are close to the optical constants of amorphous olivine. It is to be noted that olivine grains have been detected in comet Levy 1990XX (Lynch et al., 1992). It has been also studied that comet Levy 1990XX shows high silicate feature strength with a value close to 1.8 (Harker et al., 1999). The strong silicate feature indicates high abundance of silicates in the dust. Thus, our model calculations represent the more realistic type of grains which may be considered as a mixture of silicates. It is important to mention that the presence of negative polarization in the backscatter domain
has been commonly attributed to silicates or dirty ice grains (Kimura et al., 2006).

Actually, the fit refers the polarization curve which is obtained integrating the polarization values over the entire coma. In other words, the fit deals with integrated properties of dust in the coma and provides information about a sort of average scattering behaviour of the dust in all the coma, while the presence of structures in the coma of comets, like jets or arclets (characterized by higher polarization with respect to the background coma) generally indicates that the scattering properties of the dust are not uniform in the entire coma.
5.1.1: Comet Levy 1990XX

Figure 5.1: Comparison of the results obtained using fractal aggregates and compact prolate grains for comet Levy 1990XX. The observed polarimetric data of comet Levy 1990XX is taken from Chernova et al. (1993). The dotted curve represents the best fit polarization curve taken from Das & Sen (2006) for compact prolate grains whereas the solid curve represents the result for fractal aggregates.
5.1.2 Comet Hale-Bopp

Comet Hale-Bopp shows the highest silicate feature strength with a value close to 2.16 (Sitko et al., 2004). The strong silicate feature indicates high abundance of silicates in the dust. The best-fitting refractive indices coming out from this analysis are also close to the refractive index of amorphous olivine. Thus, it is clear from our analysis that the silicate composition can well match the observed data.

It is also noted that Comet Hale-Bopp shows a satisfactory result at \( x = 1.56 \). The simulated polarization curves for these two comets are drawn in Fig 5.2. It can be seen that a different set of refractive index parameter can match the observed data of these two comets at \( x = 1.56 \). Though the \((n, k)\) values in the two cases are close to each other but the effect of \( n \) and \( k \) in the third place after decimal is very important here. Even third place after decimal is sensitive to the shift of polarization curve. The simulated negative polarization curves are nearly similar for the two comets when \( \theta \geq 165^0 \). Thus, the polarization differences in two comets are prominent when \( \theta < 165^0 \).
Figure 5.2: Comparison of polarization characteristics of two comets at $\lambda = 0.485 \, \mu m$. The observed polarization data of comet Hale-Bopp is taken from Ganesh et al. (1998) and Manset & Bastien (2000) whereas the data for comet Levy 1990XX is taken from Chernova et al. (1993). The solid curve represents the best fit polarization curve obtained for BCCA particles with 128 monomers from the present work for comet Hale-Bopp where $n = 1.778$, $k = 0.059$ and $a_m = 0.12 \, \mu m$. The dotted curve represents the best fit curve for comet Levy 1990XX taken from Das et al. (2008a) for BCCA particles with 128 monomers where $n = 1.783$, $k = 0.052$ and $a_m = 0.12 \, \mu m$. 
5.2 Result and conclusion

5.2.1 Comet Levy 1990XX

- The observed polarization data fits well for BCCA aggregates with $a_m = 0.12 \mu m$ ($x = 1.555$).

- The particles comparable in size to the wavelength of incident light give better fit to the observed polarization data.

- The $\chi^2_{min}$ value for the aggregates is 4.2 whereas, the value obtained by Das and Sen (2006) for compact prolate grains is 5.22. Thus, it is clear that aggregate particles can best fit the observed data as compared to other shapes of particles.

- The best-fitting refractive indices coming out from the present analysis are $n = 1.783$ and $k = 0.052$ for $N = 128$. These values resemble the silicate mixture of dust grains.

5.2.2 Comet Hale-Bopp

- The observed polarization data fit well for BCCAs with $a_m = 0.12 \mu m$ for $\lambda = 0.485 \mu m$ and $a_m = 0.17 \mu m$ for $\lambda = 0.684 \mu m$. The size parameter, $x \approx 1.56$, is same at $\lambda = 0.485 \mu m$, $0.684 \mu m$.

- The particles comparable in size to the wavelength of incident light give
better fit to the observed polarization data.

- The best-fitting refractive indices coming out from this analysis are $n = 1.778$ and $k = 0.059$ for $N = 128$ at $\lambda = 0.485 \, \mu m$ and $n = 1.755$ and $k = 0.080$ for $N = 100$ at $\lambda = 0.684 \, \mu m$. These values resemble the silicate mixture of dust grains.

- The comparison with Comet Levy 1990XX shows that the polarization difference in Comet Hale-Bopp is due to the change in refractive index of the dust grains. Though the values are close to each other but they are even sensitive to the third place after decimal.