Chapter 6

DISCUSSION AND CONCLUSIONS

In this chapter, discussion and conclusions are made based on the simulations already done in Chapter 4 and Chapter 5.

6.1 Comet Hyakutake:

6.1.1 Discussion:

The negative polarization behaviour of comet is one of the major 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
6.1.1: **Discussion:**

etc.). Interestingly, all comets show very similar characteristics of negative polarization (minimum value of polarization $\sim -2\%$ near $170^\circ$ and inversion angle at $20-22^\circ$). Comet Hyakutake was observed over a wide scattering angle range ($68.6^\circ - 143.1^\circ$), but there was no observation recorded beyond $143.1^\circ$ (Joshi et al. 1997; Kiselev & Velichko 1998 and Manset & Bastien 2000).

In the present work, it is interesting to observe that the used dust aggregate model reproduce the negative polarization behaviour beyond $157^\circ$.

The strength of the silicate feature is defined as the ratio of the flux between 10 and 11 $\mu m$ to that of the underlying continuum (Lisse 2002; Sitko et al. 2004; Kolokolova et al. 2007). The silicate feature strength of Comet Hyakutake is $> 1.5$ (Lisse 2002) whereas the values for Comet Levy 1990XX and Comet Hale-Bopp are given by 1.8 (Harker et al. 1999) and 2.16 (Sitko et al. 2004). Comet Hale-Bopp is an intrinsically bright comet, with polarization values much higher than those of other comets. It has been found that Comet Hale-Bopp shows the highest silicate feature strength. The strong silicate feature indicates high abundance of silicates in the dust. It can be seen that the refractive indices coming out from the present calculation is closed to the refractive indices of silicates and organics. Again the *in situ* measurements of comet Halley (Lamy et al. 1987) and the ‘Stardust’ returned samples of comet Wild 2 (Zolensky et al. 2006) showed the presence of a mixture of silicates and organic refractory in cometary dust. Thus, our model calculations repre-
sent the more realistic type of grains which may be considered as a mixture of silicates and carbonaceous materials. It is to be noted that the presence of negative polarization in the backscatter domain has been commonly attributed to silicates or dirty ice grains (Kimura et al. 2006).

It has been investigated that the aggregate dust model can well fit the observed polarization data of comet Hyakutake when the size parameter of the monomer, \( x \sim 1.56 - 1.70 \). Thus the size ranges of the monomer differ for three wavelengths which is unlikely. The proposed model can be further developed if we take a mixture of compact spheroidal grains and aggregates over a wide size range which Lasue et al. (2009) used in their paper. They studied comet Halley and comet Hale-Bopp using a mixture of fluffy aggregates and compact solid grains and successfully explained the observed polarization characteristics of two comets.

### 6.1.2 Conclusions:

- The size parameter of the monomer, \( x \sim 1.56 - 1.70 \), turned out to be most suitable which provides the best fits to the observed polarization data of comet Hyakutake at three wavelengths \( \lambda = 0.365 \mu m, 0.485 \mu m \) and \( 0.684 \mu m \). This correspond to \( 0.090 \mu m \leq a_m \leq 0.098 \mu m \) at \( \lambda = 0.365 \mu m \); \( 0.120 \mu m \leq a_m \leq 0.131 \mu m \) at \( \lambda = 0.485 \mu m \) and \( 0.174 \mu m \leq a_m \leq 0.186 \mu m \) at \( \lambda = 0.684 \mu m \).
6.1.2: Conclusions:

- The best fit refractive indices coming out from the present analysis are $n = 1.745$ and $k = 0.095$ for $N = 128$ at $\lambda = 0.365 \mu m$; $n = 1.743$ and $k = 0.100$ for $N = 128$ at $\lambda = 0.485 \mu m$ and $n = 1.695$ and $k = 0.100$ for $N = 128$ at $\lambda = 0.684 \mu m$. These values resemble the mixture of silicates and carbonaceous compounds.

- The negative polarization values have been successfully generated for $\theta > 157^0$ at three wavelengths.
6.2 Comet Levy 1990XX:

6.2.1 Discussion:

The best fit effective refractive indices coming out from the simulation correspond to both silicates and carbonaceous materials. These values are comparable to the optical constants obtained from laboratory analysis of silicates (Dorschner et al. 1995) and amorphous carbon (Rouleau & Martin 1991). It is to be noted that the in situ measurements of comet Halley (Lamy et al. 1987) and the 'Stardust' returned samples of comet Wild 2 (Zolensky et al. 2006) showed the presence of a mixture of silicates and organic refractory in the cometary dust. Thus, our model calculations represent the more realistic type of cometary grains which may be considered as a mixture of silicates and carbonaceous materials.

The negative polarization nature of a comet is one of the interesting features observed in comets. All comets show almost similar characteristics of negative polarization (minimum value of polarization $\sim -2\%$ and inversion angle at $158^\circ - 160^\circ$). Our model calculation successfully reproduced the positive as well as the negative polarization behavior (beyond $157^\circ$) for comet Levy 1990XX. Though the average polarization curve obtained from the simulation fitted well to the observed polarization data, but the negative branch of polarization is not deep enough. The minimum value of polarization coming out
from the simulation is $\sim -0.8\%$ at $165^\circ$. Also, there is no observed polarization data beyond $161^\circ$, so it is not possible to guess what would be the minimum negative polarization for comet Levy 1990XX. However, the situation may be modified if we can consider larger aggregates (which is now limited due to computational constraint) and the mixture of aggregates (e.g. BCCA with BAM1 or BAM2).

6.2.2 Conclusions:

- The simulated average polarization curve obtained from our model fits well to the observed polarization data of non periodic comet 19900XX at $\lambda = 0.485 \mu m$. The size range of the compact particles is taken as $0.1 \leq a \leq 20\mu m$ whereas the range for aggregates is $0.40 \leq a \leq 1\mu m$. The mixing ratio between compact and aggregate particles is taken as 1:1.

- The best fitting refractive index indices coming out from the present analysis are $n = 1.600$, $k = 0.034$ (for compact particles) and $n = 1.960$, $k = 0.030$ (for aggregate particles). Thus our model calculations represent the more realistic type of grains which may be considered as a mixture of silicates and carbonaceous materials which are consistent with the in situ observation of comets and ‘Stardust’ mission.
6.2.2: Conclusions:

- The negative polarization branch of comet Levy 1990XX at $\lambda = 0.485 \mu m$ has been successfully generated beyond 157°.

- This model is also used to study the observed polarization characteristics of comet Halley at $\lambda = 0.365, 0.485, 0.670$ and $0.684 \mu m$. This work has been published in Das et al. (2011) (which is not a part of this Thesis).

- Thus it is concluded that the Combined Dust Model can be successfully used to study the polarimetric behavior of comets (periodic or non periodic).