CHAPTER 7

CONCLUSIONS

"Absence of evidence is not evidence of absence."
– Carl Sagan (aphorism)

In this thesis work, we have studied the characteristics of dust grains found in the Milky Way and nearby galaxies, with a special interest towards dust in the Magellanic clouds. The first half of the thesis has been focussed towards multi-wavelength correlation studies which have been used to identify the particular grain population responsible for the observed emissions at our observed locations. The second half of the thesis reports the use of various dust grain models to study the extinction in our local universe. The important findings of this thesis work are presented below.

7.1 KEY RESULTS OF CORRELATION STUDIES

Dust origins in the Milky Way

In Chapter 2, we have studied the FUV-IR correlations separately for low and high latitude locations in the Milky Way and we find that:

- The 8 μm intensity shows higher rank correlation value with the N(H) or 100 μm intensity as compared to 24 μm with N(H) at lower latitude locations. This supports the theory that PAH emission around 8 μm is from cold dust environments and the VSG emission around 24 μm is from hot dust, i.e. both belong to different dust populations.
- The FUV intensity shows a good negative correlation with the 24 μm emission at low latitudes which implies that the FUV gets absorbed and then re-emitted as IR by the dust and that FUV emission is complementary to the 24 μm emission. The negative correlation shows that the FUV absorption is predominantly due to hot dust grains. This is also evident in the lack of correlation between the N(H) and 24 μm emission for locations where the FUV vs. 24 μm correlation is significant, i.e. with cutoff on N(H).

- The correlations are significantly better in low latitude locations as compared to high latitude locations which indicate a decreasing abundance of interstellar PAHs and VSGs at high latitudes. Earlier studies have not found any correlation among the FUV and 100 μm emission which can be attributed to two reasons: high latitude and VSG dominance; since we did find a good correlation between 24 μm intensity and N(H), i.e. emission at 100 μm.

- The DIRBE maps seem to indicate a remote origin for the observed FUV intensities at high galactic latitudes and hence support the claim for an extragalactic contribution at locations which are far from the ecliptic plane.

Diffuse dust emission in the Large Magellanic Cloud

In Chapter 3, we present the IR data for two HII regions in the Large Magellanic Cloud (LMC), namely N11 and 30 Doradus. The results of the FUV-IR correlation studies at the observed dust locations are as follows:

- We compare the diffuse dust emission in two HII regions of the LMC, namely N11 and 30 Doradus, and we observe better FUV vs. IR correlations for N11 ($\sim$0.8) as compared to the lower correlations ($\sim$0.5) with high p-values for 30 Doradus.

- We observe higher FUV/IR(90 μm) ratio for 30 Doradus in comparison to N11, which may indicate low extinction and/or more number of stars being unaffected by interstellar dust.

- 30 Doradus is a very complex region with a high density of stars and therefore more starlight, as FUV can be contributed by unresolved stars.

- There is also a possibility of destruction of VSGs by highly energetic radiation in 30 Doradus leading to lower emissions around the 24 μm band.

Abundance of PAHs in the Small Magellanic Cloud

In Chapter 4, we investigate the PAH abundance in the Small Magellanic Cloud (SMC) which seems to be associated with the 2175 Å feature in the interstellar extinction curve. The findings of our correlation studies are as follows:

- We have studied the FUV-IR correlations for 24 diffuse locations in the SMC and we find the FIR (65 μm, 90 μm) dust emissions to be better correlated to the FUV intensities as compared to the MIR (8 μm, 22 μm, 24 μm) emissions.

- The absence of 8 μm vs. FUV correlation, coupled with the weakness of emission seen near 8 μm, indicates a lack or absence of PAHs at our observed diffuse locations due to their possible destruction by high energetic radiation fields in the vicinity.

- The FIR vs. FUV correlations indicate a strong contribution towards heating of the larger dust grains showing emission at our locations by UV photons predominantly scattered around 1250 Å. The very good correlation between the 65 μm and 90 μm intensities indicates that the grains responsible for both these emissions belong to similar dust environments.

- A comparison between the absence of MIR vs. FUV correlations for the SMC and the very good correlations obtained for the LMC (in Chapter 3) seems to support the theory that PAHs are shielded from destruction in high-metallicity galaxies as opposed to the low-metallicity SMC.

7.2 Key results of Dust Modelling

Dust scattering in the Galaxy: a case study of Orion

In Chapter 5, we first check the FUV-IR correlations in the surroundings of the Orion nebula. We then proceed to model the FUV scattering by dust grains around Orion to constrain the dust optical properties and the nature of dust species as we move away from the center of the nebula. The important findings of this work are as follows:

- We find the dust grains contributing to the extinction in our locations to be associated with colder environments as compared to the central Orion region (with the Trapezium star cluster) which agrees with earlier observations, where Orion's veil is seen to be responsible for the scattering and not the HII region dust. We also see better correlation values at longer wavelengths indicating the origin of the emission to be from larger sized dust grains.

- The FUV light scattering observed by us is predominantly from the foreground dust which provides for at least 84% of the scattered radiation.

Almost all of our dust locations lie within the 100-400 pc range and hence we are less concerned with the negligible background dust contaminating our observed results.

- We find the median values of dust optical properties from our model parameters to be α=0.7, g=0.6, which are same for all the four groups of dust observed by us irrespective of distance or location. This might be attributed to the presence of larger sized dust grains at our locations leading to high extinction values.

- We have determined the distances to individual dust locations observed between us and the Orion central region in a 100-400 pc range, which allowed us to construct a 3D distribution of dust around Orion using our dust model.

Dust grain composition and properties around Young Stars

In Chapter 6, we compare the observed polarimetric data for two Herbig Be stars (MWC 1080A, MWC 297) and one T-Tauri star (HL Tau) with the calculated linear polarization from our composite EMA and DDA based dust grain models in the MIR between 8-13 μm. The main findings of this work are as follows:

- The composite dust grain models comprising of silicate as host with inclusions of SiC (30% by volume) fit the observed MWC 1080A polarimetric data reasonably well for both DDA and EMA based models. The silicate/graphite mixture shows best fit to the observed MWC 297 polarization in both cases while showing a good fit to HL Tau only in case of the DDA based model. The porous silicate model shows a better fit to the HL Tau polarization when computed using the EMA method. The DDA approach is more reliable since it is rigorous and incorporates particle inhomogeneities which EMA fails to do.

- For all three young stars, we find elongated spheroidal shaped grains (axial ratio = 2) with an effective radius of 0.5 μm to best fit the observations. Earlier work has found that dust grain growth from submicron to micron size takes place slowly over the course of a few million years and since MWC 297 and HL Tau are around 1 Myr in age with MWC 1080A at only 0.22 Myr, it can be safely assumed that the typical dust grains in their envelope are still sub-micron sized.

- The observed polarization in the three stars seems to arise from the envelope rather than the disk surface/midplane with material flowing in from the ISM which might explain the similarity in dust grain properties to typical interstellar dust grains.

- The possible detection of SiC in the envelope of MWC 1080A here is very interesting due to the fact that there has only been one evidence of SiC detection while studying the MIR polarization in absorption (for SVS13). The dust grains accountable for the crystalline silicate features in absorption seem to originate in outer regions which are cold. This agrees very well with the MIR polarization in absorption originating from the outer envelope around MWC 1080A.