On the Evolution of the Mass Distribution of Interstellar Dust Grains

Sang-Hee Kim
Korea Astronomy Observatory

Mass distributions of interstellar dust grains have been determined using the objective maximum entropy method based on modeling the wavelength dependence of interstellar extinction and polarization in various environments. For the extinction analysis, we adopted bare spherical silicate and graphite grains. The mass distributions found are qualitatively similar to a widely used power-law distribution, however they depart significantly to achieve a good fit to the data (the detailed structure depends on the chemical composition). We also show how the mass distribution falls off smoothly toward large sizes (radii > 0.3 μm). At small sizes (< 0.02 μm) only the total mass of grains can be constrained. Most of the analysis for the polarization is based on bare silicate grains. Infinite cylinders as well as spheroids are considered. The aligned grain mass distributions found bear little resemblance to a power law. Compared to the mass distribution based on extinction, there is a close similarity for large grains, but it is not necessary to have nearly as many small grains. An oblate shape is preferred to prolate. Among materials explored, silicate is the most satisfactory. An interesting problem arises in explaining the wavelength dependence of ultraviolet interstellar polarization, if the refractive index of "astronomical silicate" is adopted, but the problem is much reduced if the rise of electronic absorption is simply shifted by about 1 μm^{-1} to higher frequencies. While this is not unlike obsidian, a volcanic glass, laboratory measurements for many more amorphous silicates are needed. There is a systematic reduction in the relative number of small grains with a < 0.1 μm in the more dense regions. On the other hand, there is not any noticeable variation for large grains. This suggests that aggregation plays a major role in the variation of the mass distribution as the medium becomes more dense (with shattering operating in reverse). Theoretical studies of aggregation support this point of view.