A Statistical View of the Evolution of Grain Size Distribution and Extinction Curve in Galaxies

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The evolution of dust in galaxies is characterized by two aspects; dust abundance and grain size distribution, both of which are important in determining the radiative properties of galaxies through dust extinction and emission. Recently we have been developing a theoretical framework that treats these two aspects consistently. In this presentation, we introduce our model of dust enrichment in a galaxy with a simplified treatment of grain size distribution [1].

We include in the model dust supply from stellar ejecta, destruction in supernova shocks, dust growth by the accretion of gas-phase metals, grain growth by coagulation and grain disruption by shattering, and consider how these processes work on the small and large grains. In spite of its simplicity, the model correctly catches the same features of dust evolution as is shown by a full treatment of grain size distribution [2]: Dust enrichment starts with a supply of large grains from stars. At a metallicity level, referred to as the critical metallicity of accretion, the abundance of small grains formed by shattering becomes large enough to increase grain abundance rapidly by accretion. Associated with this epoch, the abundance ratio of small grains to large grains reaches a maximum. Afterwards, this ratio converges to the value determined by the balance between shattering and coagulation, and the dust-to-metal ratio is determined by the balance between accretion and shock destruction.

Using a Monte Carlo simulation, we demonstrate that the simplicity of our model has an advantage in predicting statistical properties of galaxies. We also present some applications for predicting observational dust properties such as extinction curves. In particular, our models are computationally light; thus, they are suitable for parameter survey studies, which are indeed useful in finding a dust evolution scenario that reproduces the variety of extinction curves observed in nearby galaxies [3].

References

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