Modeling Interstellar Dust Emission Based on the Physical Properties of Amorphous Materials Evolving the TLS Model

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Since most interstellar dust is composed of amorphous material, dust emission modeling based on amorphous properties is essential to constrain the chemical composition and atomic structure of amorphous dust compared with observations.

The two-level systems (TLS) model has been proposed for amorphous dust emission at long wavelengths, considering the low-energy transition between the lowest two levels caused by the disordered crystalline structure of atoms composing amorphous dust [1]. Thermal emission from amorphous dust estimated by the TLS model is one possibility of the origin for sub-millimeter/millimeter excess and anomalous microwave emission observed in interstellar space [2, 3]. The TLS model explains long wavelength observations, but there are some problems. First, the TLS model is derived based on the assumption that the energy difference between the two levels is widely distributed in amorphous dust. However, it is not a self-consistent model, assuming a local distribution in the formulation. In addition, our previous study implies that observations support a local distribution of the energy difference [4, 5]. Second, model parameters do not directly link amorphous dust properties. Therefore, deducing the dust properties is challenging even if one estimates the parameters from observations.

In this study, we estimate spectral energy distributions (SEDs) of amorphous dust by calculating absorption coefficients based on a soft-potential (SP) model, which describes low-temperature amorphous properties more universally while encompassing the TLS model [6]. The SP model assumes that atoms constituting amorphous dust are trapped in a double-well potential described by a quartic function. We calculate the polarizability of amorphous dust by solving the interaction with the electric field to obtain the absorption coefficient. Since this model calculates absorption coefficients from the first principles, it is self-consistent and connects model parameters with fundamental physical quantities of amorphous dust.

We developed a scheme to estimate dust SEDs by computing the SP model. As a result, we found that the SP model has the potential to reproduce observations more redundantly. In contrast, the conventional TLS model requires fine-tuning for model parameters to explain observed SEDs. This talk will explain the detail and differences in the dust spectra estimated from the SP and TLS models and discuss the expected impact of future studies comparing our model and observation.

References

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