The Role of Amorphous Physics in Radio Dust Emission

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Most interstellar dust is known to be composed of amorphous material, not crystalline. Constructing a dust emission model that considers the amorphous properties is imperative to understand dust emission better and extract information on the physical properties of dust from observations.

Some previous studies have proposed a model of interstellar amorphous dust radio emission [1, 2], which applies the two-level systems (TLS) model introduced to explain the universality of the low-temperature dependence of the heat capacity and thermal conductivity of amorphous materials to the optical properties of interstellar dust. It is shown that the amorphous dust radio emission model can explain observed features such as the anti-correlation between the spectral index and dust temperature and the anomalous microwave emission (AME) with a peak around 30 GHz [3, 4]. On the other hand, the TLS model has the following problems. First, the TLS model can explain the temperature dependence of physical quantities in amorphous materials below 1 K but not around 10 K. Second, the assumption in the TLS model that the TLS eigenenergies and transition energies are independent parameters is not self-evident. These two problems indicate there is room for theoretical improvement in the TLS model.

We propose a new amorphous dust emission model adapted from a physical model that extends the TLS model, called a soft potential (SP) model [5, 6], and verify whether the characteristics of amorphous dust emission expected from the TLS model are reasonable. The SP model explains the temperature dependence of the thermal properties of amorphous materials over a wider temperature range than the TLS model by simultaneously considering two effects derived by assuming that the atoms comprising the amorphous material are trapped in a fourth-order potential: the TLS originating from the double-well potential, and the anharmonicity given by higher order terms. In this study, based on the SP model, we have developed a scheme to calculate absorption cross-sections of amorphous dust by solving the ab initio of the interaction between atoms and electric fields in amorphous dust.

We showed that the SP model can reproduce observed trends such as AME and the temperature dependence of the spectral index, like the TLS model. On the other hand, we showed that the absorption coefficient of amorphous dust is not equal between the two models, even when the same physical properties are set. We performed SED fitting for some objects with pronounced AME to validate the model further. We showed that the amorphous dust emission based on the SP model reproduces the observations with comparable or slightly better accuracy than the TLS model. In this presentation, we are going to discuss the impact of applying the SP model and the physical properties of amorphous dust expected from the SP model.

References

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