Extension of dust radiation evolution model considering dust number density in distant galaxies

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In the context of galaxy evolution, dust in galaxies has a significant effect on physical quantities such as the spectral energy distribution (SED) and star formation efficiency of galaxies. We have developed a model which includes dust in the theory of galaxy evolution, accounts for the dust evolution of galaxies by considering chemical evolution (Asano et al. 2013a,b; 2014; Nozawa et al. 2015). Furthermore, a galaxy SED model has been constructed which employs this model to compute the SED of galaxies (Nishida et al. 2022). These models reproduce the observational properties of nearby dusty galaxies and the Milky Way.

However, when we try to apply our SED model to distant galaxies (e.g., Tamura et al. 2019), some modification is necessary to reproduce their observational properties. In this work, we try to resolve the problems of current SED model and reproduce the observed SEDs of very high-redshift galaxies.

The computational cost would be enormous if the radiation per dust grain is considered. Our SED model solved this problem by adopting the mega-grain approximation for the treatment of dust scattering calculation. The molecular cloud around a young star is called a clump, which is considered to be a sphere. Since distant galaxies are considered to be compact, the density in the clumps should be higher than that of nearby galaxies. Therefore, we made the clump radius have a different dependence from the entire galaxy dependence, and by increasing the number density of dust in a clump, we were able to obtain high dust emission, the same as the observed value. This approach allows for more highly reproducible simulations.

The results suggest that distant galaxies have a higher dust number density than nearby galaxies and therefore emit more dust radiation. In the future, we will examine whether we can reproduce the observations by compacting distant galaxies into a spherical rather than a one-dimensional plane approximation.