A Dust Evolution Model Based on the Chemical Evolution with Gas Infall

Tsutomu T. Takeuchi[1,2], Ryusei R. Kano[1], Ryosuke S. Asano[1], Tom J. L. C. Bakx[1], Akio Taniguchi[1], Erina R. Kawamoto[1], and Sayaka K. Nagasaki[1]

[1]*Division of Particle and Astrophysical Science, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan*

[2]*The Research Center for Statistical Machine Learning, the Institute of Statistical Mathematics, 10–3 Midori-cho, Tachikawa, Tokyo 190–8562, Japan*

Dust influences the physical properties of galaxies, depending on the quantity and its size distribution. Therefore, a proper understanding of dust evolution is crucial to understand the formation and evolution of galaxies. Recently, a large amount of dust has been discovered in galaxies at very high redshifts. Surprisingly, the dust-to-stellar mass ratio of such galaxies is as large as that of nearby galaxies. This is not easy to explain by current theories of dust production and evolution in galaxies, leading to a problem known as "the dust budget crisis". To explain the dust amount in these galaxies, it is necessary to supply a tremendous amount of dust at a very early stage of the galaxy. In the series of previous studies, we established a model of dust formation and evolution based on the chemical evolution of galaxies, with a closed-box assumption. With this model, we discovered that the dust accretion in the dense interstellar matter is crucial for the dust evolution. However, as we mentioned above, there remain some unsolved problems such as the origin of huge dust amount at high redshifts. In this work, we developed an extension of the previous dust evolution model, implementing an inflow of gas from the intergalactic medium. Recently, gas infall is regarded as one of the fundamental processes in galaxy evolution. We found that even if the gas is significantly consumed to form stars, dust can grow in the interstellar matter infalling from outside of a galaxy. In such a case, the dust mass compared with the stellar mass becomes larger than that predicted from a closed-box model. Therefore, a galaxy can have a sufficient amount of dust at a young galaxy age when the stellar mass is quite small. We consider the new framework to be able to explain a broader range of physical properties and observations. We present to what could be explained and what could not by this new theoretical model compared with recent observations of high-z galaxies.