Simulating the life cycle of dust in star-forming galaxies

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Previous numerical simulations of galaxy formation and evolution did not incorporate self-consistently dust growth and destruction in ISM of galaxies at all. I show some results of my original simulations of galaxy formation and evolution which include, for the first time, dust growth and destruction in ISM, formation of molecular hydrogen on dust grains, and star formation in molecular hydrogen. I mainly discuss spatial and temporal variations of interstellar dust (e.g., dust-to-gas-ratios and dust depletion levels) and other galaxy properties in a self-consistent manner. The preliminary results are as follows. The star formation histories of disk galaxies are regulated by dust, mainly because the formation efficiency of molecular hydrogen is controlled by dust. The observed correlation between dust-to-gas-ratio and gas-phase oxygen abundance can be reproduced by the present simulations, though strong supernova feedback effects and density-dependent dust accretion model need to be adopted. The simulated disk galaxies can have extended dusty gaseous halo (>20 kpc) and the mass fraction of such dusty halo is significant (up to 50%). The galaxies show negative radial gradients (i.e., larger in inner regions) of dust-to-gas-ratio and molecular gas fraction. The surface mass densities of dust in disk galaxies are correlated more strongly with the total gas densities than with molecular hydrogen densities. More massive disk galaxies are more likely to show higher dust-to-gas ratios and higher molecular hydrogen fraction. Galaxy merging between disk galaxies can significantly reduce the dust mass fraction owing to consumption of dust in active star formation during merging. I briefly discuss how galaxy-scale star formation and chemo-dynamical evolution of forming galaxies depends on modeling of interstellar dust.