R12b Molecular line radiative transfer in a Monte Carlo radiative transfer SKIRT

Kosei Matsumoto, Peter Camps, Maarten Baes (Ghent University), Kentaro Nagamine (Osaka University), Leonard E. C. Romano (Max Planck Institute), Hiroyuki Hirashita (Academia Sinica)

Understanding the star formation (SF) in molecular clouds in galaxies is fundamental but complex because the local SF efficiency depends on the galactic environment, SF, and active galactic nuclei feedback. Recently, cosmological hydrodynamical simulations have become powerful tools in this quest, and our simulation code, GADGET4-Osaka, has succeeded in modeling molecular gas and star formation with sub-grid recipes (Romano et al. 2022). To understand the validity of the sub-grid recipes, we have to make synthetic images of molecular gas, dust, and stellar emission and compare them with actual observations. However, there have been no radiative transfer codes to calculate spectral energy distribution and molecular lines self-consistently, because previous codes used ray-tracing methods and could not handle the photons in a wide wavelength range. Therefore, we have developed a non-LTE atomic-and-molecular radiative transfer module in the Monte-Carlo radiative transfer code, SKIRT9 (Camps et al. 2018). In this presentation, first, we demonstrate the validity of our code by performing the test problems of Van Zadelhoff et al. (2002). We achieved the accuracy of $\lesssim 10\,\%$ even in the optically thick regime. Second, we show the comparison between observations and the results of CO and dust radiative transfer in a Milky-way-like galaxy simulation, and discuss implications on the CO-to-H_2 conversion factor and SF efficiency.