Spiral Structure and Mass Inflows in Spiral Galaxies

Yonghwi Kim[1], and Woong-Tae Kim[1]

[1] Center for the Exploration of the Origin of the Universe (CEOU),
Astronomy Program, Department of Physics & Astronomy, Seoul National University,
Seoul 151-742, Republic of Korea

We use hydrodynamic simulations to investigate nonlinear gas responses to imposed a stellar spiral potential in disk galaxies. The gaseous medium is assumed to be infinitesimally thin, isothermal, and unmagnetized. We consider various spiral-arm models with differing strength and pattern speed. We find that the extent and shapes of gaseous arms as well as the related mass drift rate depend rather sensitively on the arm pattern speed. In models where the arm pattern is rotating slow, the gaseous arms extend all the way to the outer boundary, with a pitch angle slightly smaller than that of the stellar counterpart. The arms drive mass inflows at a rate of ~ 0.2–$3.0\,\mathrm{M_\odot\,yr^{-1}}$ to the central region, with larger values corresponding to stronger arms. The contribution of the shock dissipation, external torque, and self-gravitational torque to the mass inflow is roughly 50%, 40%, and 10%, respectively. On the other hand, models with a fast rotating potential exhibit mass outflows, rather than inflows, over most of the arm regions. In these fast-arm models, spiral shocks are much more tightly wound than the stellar arms and cease to exist in the region where $\mathcal{M}_\perp/\sin p_* \gtrsim 30$–45, with $\mathcal{M}_\perp$ denoting the Mach number of a rotating gas perpendicular to the arms with pitch angle p_*. We demonstrate that the distributions of line-of-sight velocities and spiral-arm densities can be a useful diagnostic tool to distinguish if the spiral pattern is rotating fast or slow.