CLOUD-PARTICLE DYNAMICS AND STAR FORMATION IN SPIRAL GALAXIES

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We study the gas in a spiral galaxy with a cloud-dominated "stellar association-perturbed" interstellar medium from the standpoint of a cloud-particle model. Through N-body computational simulations, we follow the time evolution of the system of gas clouds and the corresponding system of young stellar associations forming from the clouds. Basic physical processes are modeled in a three-step cyclic procedure: (1) dynamical propagation of the clouds and young stellar associations, (2) simulation of cloud-cloud collisions, and (3) formation of new associations of protostars that are triggered by the local mechanisms of cloud-cloud collisions and cloud interactions with existing young stellar associations.

From its initially-uniform distribution, the cloud system evolves in time, driven by the prescribed spiral gravitational field of the model galaxy. Figure 1 shows a photographic color-intensity display of the distribution of 20,000 clouds in one representative disk of 25 kpc diameter at a representative time of 250 Myr after approximate "steady state" has been reached. The light blue regions have the highest concentrations of clouds. The gaseous spiral structure on the global scale exhibits characteristics of a global density wave, galactic shock wave manifestation. The local, small-scale disorder is a consequence of the turbulent nature of both the collisional and supernova processes. We are continuing to investigate to what extent the local, turbulent state might be associated with the corresponding raggedness and degree of disorder on the small scale that are often observed as characteristics permeating the global spiral structures of many galaxies.

Figure 2 illustrates the nature of the computed distribution of gas clouds and flow characteristics. Plotted versus phase of the spiral field are the components of flow velocity, the normalized number density distribution, and the velocity dispersion for clouds in a representative annulus at a radius of 10 kpc. Each plus (+) represents about 10 clouds on the average. The galactic shock, characterized by the rapid decline in the normal component of flow velocity (bottom panel), occurs over a width of the order of several mean free paths. The density enhancement measured from maximum to mean is of the order of 3:1.

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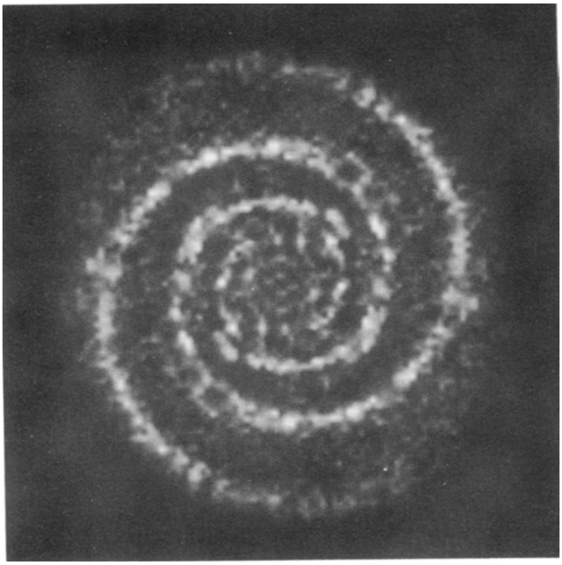

Figure 1.

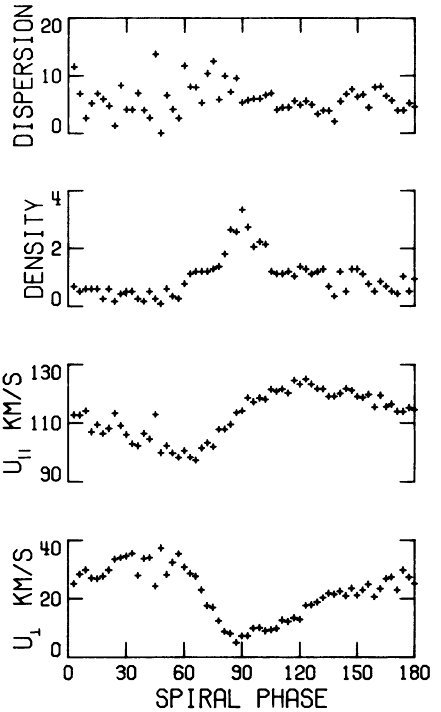

Figure 2.

In order to determine characteristics with respect to the z dimension, we are studying special three-dimensional flows within the context of this cloud-particle picture. Figure 3 provides a photographic intensity display of the computed distribution of clouds (projected in the x-z plane) for a case of three-dimensional flow (in x, from left to right) in the presence of a sinusoidal gravitational field. The regions near zero z height contain the highest concentrations of clouds. A shock occurs about midway in x along the flow; there, the compression to higher density cloud conglomerations takes place, as those clouds entering with super-sonic velocities (from the left) are decelerated and exit subsonically.

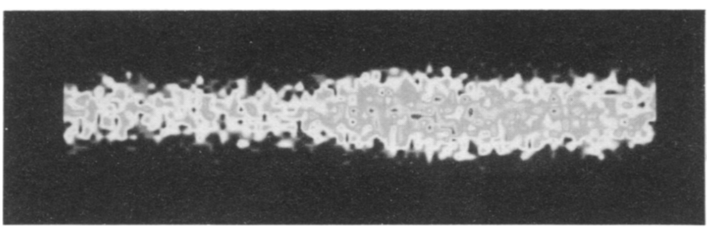

Figure 3.

It is possible to complement these N-body numerical computations with quasi-analytical theory. We are currently in the process of doing so.

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