SPIRAL TRACERS AND PRESTELLAR INCUBATION PERIODS IN A CLOUDY INTERSTELLAR MEDIUM

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We present further results of our model of the interstellar medium in spiral galaxies (Roberts and Hausman, 1983; Hausman and Roberts, 1983). The ISM is simulated by a system of particles, representing gas clouds, which orbit ballistically in a spiral-perturbed galactic gravitational field, collide inelastically with one another, and receive velocity impulses from expanding supernova remnants. Star formation may be triggered in the clouds by either collisions or SNR interactions.

The global morphology of bright, young stellar associations is influenced by our choice of delay times, i.e. the time between the star-birth triggering event and the period of high luminosity or SN explosions, after which associations are assumed to dim and lose their identity as spiral tracers. Short maximum-delay times (20 Myr or less) result in the young stellar associations appearing in coherent spiral arms. Longer maximum-delay times (50-100 Myr) wash out spiral patterns: the interarm regions become more substantially populated by young associations while the arms are less continuous, being formed by high-luminosity segments separated by gaps of low bright-star density. These long delay times allow the associations, whose birthsites are still concentrated in spiral arms, to drift long distances before they dim significantly. Such long delay times might be realistic if the most common bright stars in associations have long main-sequence lifetimes, or if the associations require long incubation periods between the star-birth triggering event and the time of peak luminosity.

The possibility that clouds may be sites of sequential star formation to different degrees is examined by varying our model clouds' refractory times, i.e. the period a cloud, which forms stars, must wait before it is again susceptible to further star formation. A short refractory time allows clouds the opportunity of forming stars repeatedly, whereas a very long refractory time more closely simulates the complete disruption of a cloud and the reconstitution of the same amount of gas into another cloud at an uncorrelated position elsewhere in the galaxy. We find that shortening the mean refractory time, although it increases the overall star-formation rate, has relatively little effect on the

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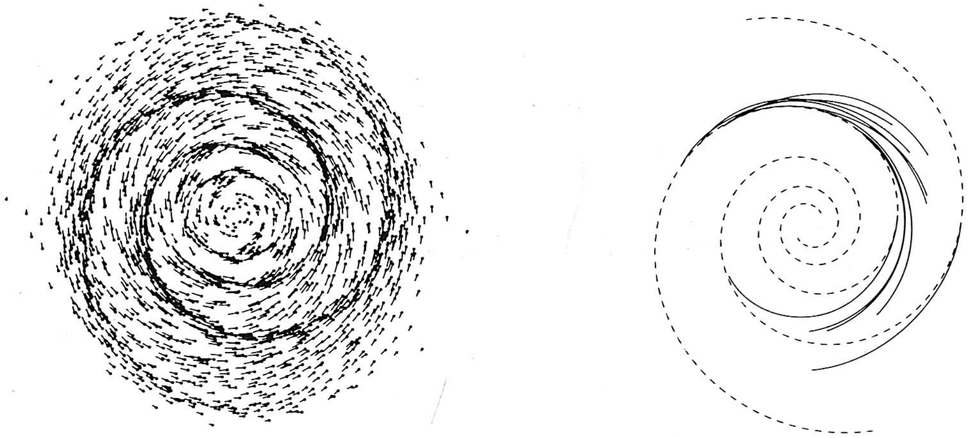

Figure 1. Left panel - Instantaneous-velocity vectors of 1000 representative clouds (dots). Vector lengths are the distances the clouds travel in 4 Myr (in the corotating frame). Right panel - Orbits, from age 0 to 100 Myr, of 10 stellar associations formed in the spiral arms.

coherence of spiral structure, slightly increasing the frequency of interarm spurs. Short refractory times slightly favor SNR-sparked over collisionally-induced star formation, which may explain the greater frequency of spurs.

The mean velocity field of clouds (Figure 1, left panel) shows oval streamlines, very similar to continuum gas-dynamical calculations, although individual orbit-segments are ballistic. Newly formed stellar associations leave the cloud-density peak at higher than post-shock velocities and do not recross the "shock" region. This result is illustrated in the right panel of Figure 1; ten representative associations which are formed in the arms are followed over 100 Myr orbits. This result is in contrast to earlier ballistic-particle models.

By varying choices of delay times, refractory times, and cloud mean free paths within physically plausible limits, we may reproduce spiral galaxies with a wide range of morphological appearances.

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