formation at the spiral potential wells. Though the spiral pattern is sometimes distorted due to small-scale and short-lived fluctuations, the grand design is stable for a long run.

As many observations show, GMCs are the active star forming sites. If star formation in a GMC is a spontaneous phenomenon, the global pattern of star forming regions is similar to that of GMC gas given in Figure 1. If the star forming activity on the other hand is influenced by the neighboring clouds (e.g. cloud-cloud collisions), the spiral patterns of active star forming regions are more prominent than those given in Figure 1.

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FORMATION OF GIANT MOLECULAR CLOUDS BY COAGULATION OF SMALL MOLECULAR CLOUDS IN A SPIRAL GRAVITATIONAL POTENTIAL

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ABSTRACT. The formation process of giant molecular clouds (GMCs) is investigated from the standpoint of the coagulation theory of molecular clouds. Small clouds collide with each other and grow to become massive ones. Ultimately they form GMCs with a finite lifetime. The occurrence of star formation in a GMC destroys it and consequently small clouds are formed again. We study the time evolution of the clouds which move through a spiral gravitational potential by an N-body simulation. Then the ensemble of clouds responds to the spiral potential and forms a spiral structure similar to that produced by hydrodynamical galactic shock. It is shown that GMCs are formed in the spiral arm region by collisions between clouds. The distribution of GMCs indicates their short lifetime, of the order of a few times 10^7 years.

1. INTRODUCTION. Many molecular clouds consist of giant molecular

clouds(GMCs) or molecular cloud complexes. On the formation mechanism of GMCs, two distinctly different theories have been proposed: the Parker instability theory and the coagulation theory.

In the present paper, we focussed on the coagulation theory; the idea is that small clouds collide and merge to form massive ones(GMCs) and GMCs are destroyed by active events associated with star formation.

2. MODEL AND METHOD. We assume that the mass circulation in the ensemble of clouds is as shown in Fig. 1. We integrate the evolution of the ensemble of clouds (about 70,000 clouds), by tracing each cloud moving in the spiral gravitational potential. For more detail, refer to Papers I and II.

3. RESULTS. We show the results of Case A (the cloud internal density, n_{cl}=40 H_2 cm^{-3}, the lifetime of GMCs, τ_{cl}=4x10^7 yr, and the limiting mass, m_{GMC}=1.6x10^5 $M_\odot$) in Fig. 2. By 2x10^8 yr, the clouds respond sensitively to the spiral gravitational potential and form spiral arms similar to those produced by the hydrodynamical galactic shock. GMCs are formed in the "post-shock" region by rapid collisional growth of small clouds due to the high density. It is shown that at the outer part of the disk (r>8kpc) GMCs are well concentrated on spiral arms. However, in the inner parts ($r \lesssim 5$kpc) the distribution of GMCs is more uniform. The small molecular clouds are distributed more uniformly than GMCs.

3. DISCUSSION. The l-v diagram of the distribution of warm molecular clouds (T_{kin}>10 K; Solomon et al. 1985), which are considered to be GMCs, shows several clear spiral arms. We compare it with the results of our simulation. Our model indicates that the lifetime of GMCs is as short as $\sim$4x10^7 yr not exceeding 10^8 yr.

We present the mass fraction of clouds falling into a unit logarithmic mass interval Δln m, g(m) in Fig. 3. The observed g(m) (Sanders et al. 1985) is characterized by: (1)a power law ($\propto m^{0.5}$) below the peak and (2)a sharp cutoff beyond the peak. We illustrate the g(m) of our results also in Fig. 3. It is shown that the characteristic power law is well reproduced by the coagulation model. It is also shown that the limiting mass, m_{GMC}, should be as large as 5x$10^5 M_\odot$(Case B) to fit the mass at the peak.

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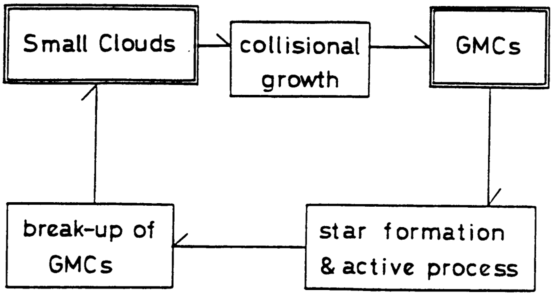


Fig.1. Mass circulation model.

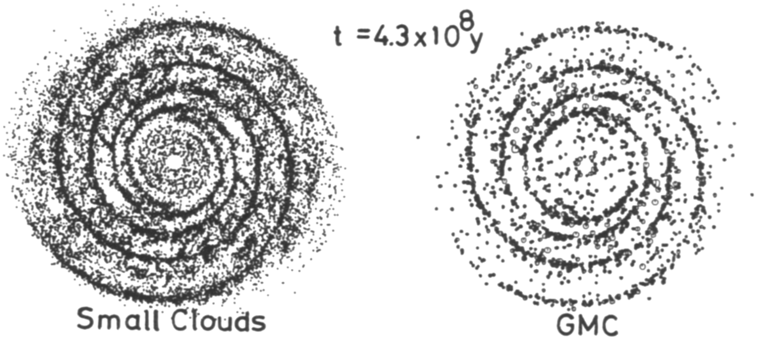
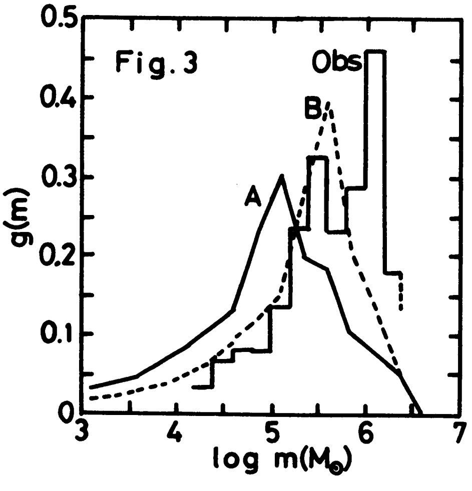


Fig.2. The distribution of molecular clouds.



The mass fraction of clouds, g(m).