GRAVITATIONAL INSTABILITY INDUCED BY COLLISIONS BETWEEN NON-IDENTICAL CLOUDS

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ABSTRACT. In order to investigate gravitational instability induced by supersonic collisions between small, dense clouds and large, diffuse clouds, we perform the numerical hydrodynamic calculation by SPH code. We show that the large cloud is disrupted by the bow shock induced by the small cloud, and the small cloud is compressed. Final fates of the small cloud are divided into two cases. The first case is that the small cloud is ablated by the ram-pressure of the large cloud and is finally destroyed. The second case is that the central part of the small cloud left from the ablation gravitationally collapses. We discuss the condition dividing these two cases. Our condition show that even if the Mach number of collision velocity is very high, the small cloud can collapse.

1. Introduction

Recently, cloud-cloud collision is proposed to be effective for triggering process of star formation in OB star formation region of our Galaxy (Scoville *et al.* 1986) and in star burst galaxeis (Olson and Kwan 1990).

Cloud-cloud collisions are mainly studied the case of collisions between clouds with same size (e.g. Gilden, 1984, Nagasawa and Miyama, 1987). In this case the gravitational instability condition of colliding clouds is shown. However, since interstellar clouds with various sizes and densities are observed, the case of identical cloud-cloud collision is very rare and collisions between clouds with different sizes and densities are more frequent. The latter case should be investgated. We perform the numerical hydrodynamic calculation of this case.

2. Model and Numerical Results

We assume two clouds with different size, R, and density, ρ. These values are chosen according to the empirical relation obtained by Larson (1981) from the observational results of many molecular clouds. His relation is $\rho \propto R^{-1}$ and $\sigma^2 \propto R$, where σ is the velocity dispersion of gas in clouds. We assume that initial clouds are stable in the meaning of the gravitational stability. These clouds are assumed to collide supersonically each other in head on. Since the shock structures in colliding clouds are well approximated as the isothermal shock, we adopt the isothermal state equations with different temperature

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for gases of these clouds. We use the smoothed particles hydrodynamic code (SPH) for calculation of self-gravitating gas motion in the axially-symmetric 2-dimension. Since our SPH code is the axially-symmetric 2-dimension, the particle number of 4300 is well enough to calculate the strong isothermal shock with high Mach numbers.

The model parameters and numerical results are shown in Fig.1. The mass ratio of the small cloud and the large cloud is 1:4. The large cloud is disrupted by the strong bow shock induced by the small cloud. We find that our numerical results are divided into two cases for the final fates of small clouds. The first case is that, although the strong shock wave compresses the small cloud and a dense gas layer is formed, the small cloud is finally dispersed by ablation prosess by the ram-pressure of large cloud. The second case is that, the strong shock wave compresses the small cloud, and finally the central part of the small cloud left from the ablation becomes gravitationally unstable, after the shock wave has passed through the small cloud. As a result it gravitationally collapses and its central density becomes higher than hundred thousand of initial cloud density.

3. Discussion

Numerical results indicate that the residual part of small cloud from the ablatin can collapse. We estimate this mass, m_{com}, and size of this region by a similar discussion to Gilden (1984) and give the gravitational condition of this part of cloud, $m_{com}/M_{com,J} > 1$, as shown the line in Fig. 1, where $M_{com,J}$ is the Jeanse mass of this part. Figure 1 shows that this criterion well agrees with our numerical results.

We show that even if the Mach number of collision velocity is very high, the small cloud can collapse in the non-identical cloud-cloud collisions. Olsen and Kwan (1990) insisted that in order to explain the high infrared luminosity of interacting galaxies, disruptive collisions must lead to star formation. In this paper, we have shown the case that the disruptive collision can lead to the gravitational collapse of clouds.

References

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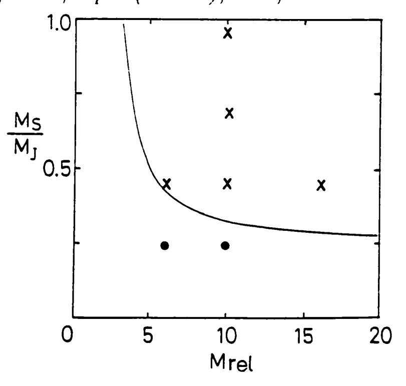

Figure 1. The model parameter and numerical results. Crosses denote the collapse case of small clouds. Filled circles denote the dispersed case of small clouds. The curve denotes the condition given in the text.

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