ON THE STRUCTURE AND EVOLUTION OF MASSIVE INTERSTELLAR CLOUDS

H. Kimura and Liu Cai-pin
Purple Mountain Observatory, Academia Sinica,
Nanking, China

The evolution of massive clouds is discussed with emphasis on inhomogeneous and heterogeneous nature of the system. We start from the two-phase model of interstellar medium and choose initial conditions of the clouds as being in the vicinity of critical state for gravitational instability. The equilibrium and stability problem for clouds is formulated in terms of polytropic models. Combining this with the thermal and chemical balance problem, we find that, even before the commencement of gravitational collapse, the fragmentation due to thermal instability can occur. The system begins to contract at a rate much slower than free fall, and thereafter, its evolution is governed mainly by collisions between fragments. The collision dynamics of the N-fragment system should be examined carefully by numerical experiments. The general trend to be expected is that the system tends to develop into a core-halo structure, accompanying by sporadic local events of star formation. The core or a clustering of massive fragments near the center could grow up into a favourable formation site of star clusters.

DISCUSSION

Hasegawa: What is the typical size of the fragments? In what range of mass and density do thermal instabilities occur?

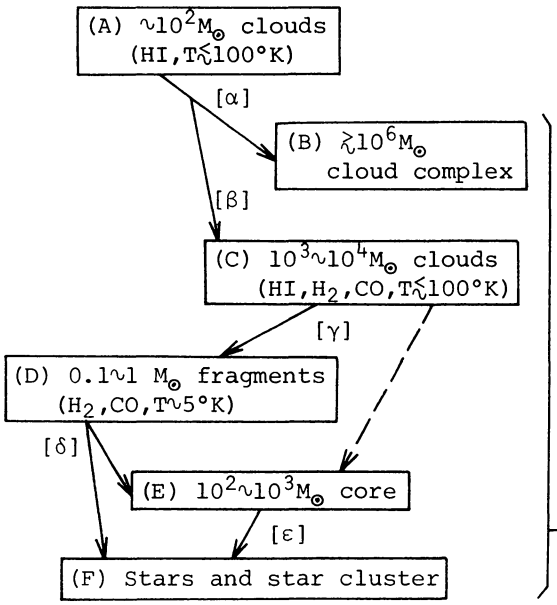
Kimura: The mean size of fragments can be roughly estimated by diameter $d = (\rho_0/\rho_1)^{1/3} c_s \tau_c$, where c_s denotes the sound speed and τ_c the timescale of CO cooling. The degree of compression, (ρ_1/ρ_0), may be ~5. Adopting typical values of $c_s \lesssim 1$ km/s and $\tau_c = 10^5 \sim 10^6$ years, we have $d = 0.07 \sim 0.7$ pc. With regard to your second question, it seems better to show the minimum values of local density n and effective column density N_H from the surface that are required; the answer is $N_H \gtrsim 10^{21}$ cm^{-2} and $n \gtrsim 10^2$ cm^{-3}, if the instability is due to CO cooling.

Hasegawa: Recent analyses of the 21-cm line of HI show the existence of cold gas fragments with a total particle density of ~100 cm^{-3} and a typical size of 20 pc in diameter. The formation of molecular clouds may occur via such a stage.

D. Sugimoto, D. Q. Lamb, and D. N. Schramm (eds.), Fundamental Problems in the Theory of Stellar Evolution, 70–71.

Kimura: A scenario that we would like to propose is shown below. It seems to me that the comment by Hasegawa refers to clouds of level (C) as components of (B). In my opinion, these clouds are formed not through fragmentation but by coalescence due to inelastic cloud-cloud collisions. We have discussed the possible occurrence of fragmentation in such clouds [level (C)], and the uniqueness of the heterogeneous system thus obtained.

A senario for the earliest stage of star formation



Physical processes

[α] Gravitational clustering or Parker instability.
[β] Collision dynamics of clouds.
[γ] Fragmentation due to thermal instability.
[δ] Collision dynamics of fragments and onset of gravitational collapse.
[ε] Fragmentation due to gravitational instability.

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