Introduction

Filaments in gaseous molecular clouds act as an initial phase that gives rise to star formation, and are the main structural unit of the ISM. They are the main stage of star formation, and the birthplace of new stars. The dynamics of the filamentary structure is of great interest for understanding the process of star formation (reviewed in [1, 2]).

We study the dissipationless collapse of a self-gravitating gaseous filament, and the effects of an external potential. The filamentary structure is assumed to be a self-similar and axisymmetric structure with a power-law index of n = 0.5, and a small external potential. The filamentary structure is assumed to be a self-similar and axisymmetric structure with a power-law index of n = 0.5, and a small external potential.

Numerical methods

To begin with, we performed direct N-body simulations of the system (2). In order to effectively explore different initial conditions, we varied the number of particles, N, from 10^5 to 10^11. The simulations were run for different numbers of particles, N, from 10^5 to 10^11.

Dissipationless collapses

We study the dissipationless collapse [6] of initially cold (i.e. 2K/|W| << 1), cylindrical overdensities with Gaussian radial density profile with different mean-square-radius α (i.e. units of mass radius).

Monitoring the virial ratio, it appears that the systems undergo a violent relaxation. The density and temperature profiles of the final states of PIC-MPC, PIC and HMF+kick:N=10^7,T=0.4244,kick h=10 for unit time are shown in Fig. 3. For the orca states, we have a range of n = 1/3 for 2K/|W| = 0 to n = 0.3 for 0.7.

Changing the concentration of the initial condition (i.e. varying the scale radius r, or fixed mass) yields different results for fixed initial virial ratio (see Fig. 2). As a general trend, more concentrated systems (with or without collisions) have steeper density profiles and stronger temperature gradients from core to outer regions.

Perturbed isothermal states

As an additional case, and in the same line of our previous investigation on long-range systems [3, 4, 15], we also studied the evolution of perturbed filamentary shapes [7] undergoing strong radial perturbations.

For all cases subjected to a radial compression (or expansion) with a typical velocity larger than n = 0:2, there is a density depression at equilibrium, the final states are non-thermal with manifest temperature-density anticorrelation. Both PIC-MPC and direct N-body simulations yield qualitatively similar results.

Conclusions

Dissipationless collapse produces dynamically supported non-thermal states that look very similar to those observed in filaments, without the need to invoke other mechanisms for their support.

Non-thermal long-lived states with temperature inversion may occur in any long-range-interacting system after the damping of collective oscillations.

Both collisions and interactions between perturber and perturbed object are important to enhance the temperature inversion.

Our model might be too simple yet to allow quantitative comparison with observations; the next step is the inclusion of magnetic fields.

References