Photoevaporation of Externally Irradiated Protoplanetary Disks in a Young Star Cluster

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Abstract

The gas dispersal of protoplanetary disks has great influence on the formation of planetesimals and giant planets. The dominant mechanisms of the dispersal are accretion onto the central star and photoevaporation. In particular, protoplanetary disks are considered to photoevaporate rapidly when the surface density evolution of the disks with considering photoevaporation due to the nearby massive star and accretion onto the central star and (2) performed hydrodynamical simulations of the photoevaporating flow from the disks, and obtained the radii of the ionization fronts around the proplyds by calculating the flux of the ionizing photons from the nearby massive star.

As a result, the outer disk rapidly evaporates and the disks shrink to several tens AU in 10⁸ yr. The correlations between the ionization front radii/disks and the distances from the massive star observed in the Trapezium cluster are well reproduced by our model calculation.

Introduction

Gas dispersal of protoplanetary disk

Gas dispersal has significant impacts on planet formation processes in protoplanetary disks – for example, planetesimal formation, gaseous planetesimals, planet migration, and so on.

Disk evolution in a star cluster

Since many stars are born in young star clusters, studying environmental effects in clusters is essential for general understanding of planet formation process.

Protoplanetary disks in the Trapezium cluster

Protoplanetary disks in the Trapezium cluster are photoevaporating due to UV irradiation from the nearby massive star 8 Ori C. The disks are surrounded by tear-drop-shaped ionization fronts.

Surface Density Evolution of Protoplanetary Disks

The surface density evolution due to photoevaporation and accretion.

Accretion

The gas in the disks accretes to the central star due to the turbulent viscosity.

Photoevaporation

The gas escapes from the disks due to the heating by UV irradiation.

Results

Without irradiation, the disks are surrounded by tear-drop-shaped ionization fronts.

With irradiation, the disks shrink rapidly when it is close enough to the massive star.