EPSC Abstracts
Vol. 13, EPSC-DPS2019-1684-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Influence of cloud collapse on the fragmentation of protoplanetary discs

Oliver Schib (1,2), Christoph Mordasini (1), Ravit Helled (2)
(1) University of Bern, Switzerland (oliver.schib@space.unibe.ch), (2) University of Zurich, Switzerland

Abstract

We study the formation and evolution of a large number of protoplanetary discs, focussing on the conditions in the discs when these fragment due to their own gravity. To this end we perform, for the first time, a large parameter study where we self-consistently model the formation of the star-disc system, including the effects of autogravitation and fragmentation on the disc's surface density. We present the distribution of initial mass and initial semi-major axis of fragments, as well as the evolution of disc mass and stellar mass.

1. Introduction

Planets form in discs around young stars. Many of these discs are expected to experience a phase of gravitational instability at early times. If they are sufficiently cold and massive, they may fragment to form bound clumps.

Depending on the conditions in the discs during and after fragmentation, as well as a number of physical processes governing the behaviour of the clumps, these may contract and become giant planets. This mechanism, called disc instability, may present a formation pathway for some observed giant planets at large separation, as the ones in the HR8799 system.

2 Goal

In order to assess the feasibility of this formation mechanism, we are working on a disc instability population synthesis model (DIPSY).

3 Model

We use a 1D, vertically integrated disc model to study the evolution of surface density and temperature in the protoplanetary disc. A number of physical processes are included. Among these are: infall from the parent molecular cloud core, formation and (viscous) evolution of the disc, autogravitation, transport of angular momentum through spiral arms and photoevaporation.

3.1 Initial conditions

We base our calculations on data taken from a radiation hydrodynamical simulation of star cluster formation [1]. Our model allows to evolve a large number of discs for several million years.

3.2 Temperature model

The model used to determine the disc's vertical temperature profile includes: shock heating through the infalling cloud material, viscous heating from the accretion, irradiation from the central star as well as from the envelope.

4 Results

We find that the evolution of the simulated discs is governed by the collapse of the molecular cloud core during the first $\sim 10^5 yr$. Fragmentation is responsible for a significant fraction of the mass transport in the discs. Figure 1 shows the surface density of a $0.025\,M_\odot$ disc when it undergoes fragmentation at $\sim 8kyr$, leading to the formation of a gap at $25AU$.

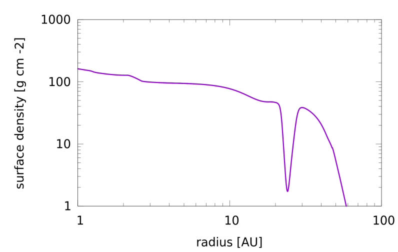

Figure 1: Surface density of a massive protoplanetary disc at $\sim 8kyr$

5. Summary and Conclusions

For the first time we perform a large parameter study where we self-consistently model the formation of the star-disc system, including the effects of autogravitation and fragmentation on the disc's surface density. We find that the influence of the infalling material from the collapsing molecular cloud core are very important for the disc instability paradigm since it determines when and where the disc fragments as well as how much mass is available. Future work will detail on the structure and evolution of the bound clumps formed in our simulations.

References

[1] Bate M. R., MNRAS, 475, 561, 2018