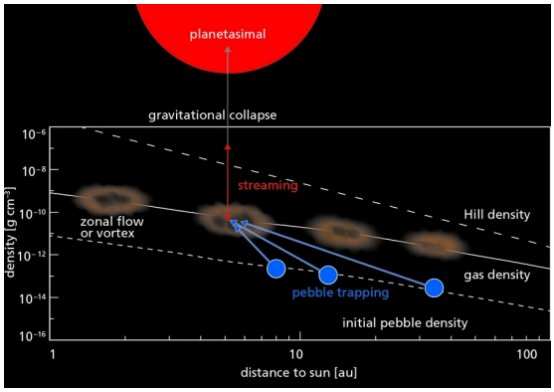
How does water influence planetesimal formation?



SUMMARY.
Protoplanetary discs consist of gas and small dust grains. These micro meter sized dust grains grow via coagulation and condensation to mm-cm sized pebbles. Large accumulations of these pebbles allow the formation of planetesimals - objects of 10s of km in size. While the process itself is studied in detail, it is unclear how the chemical composition of the particles themselves might influence the process of planetesimal formation in the first place. To this end, the student will perform numerical simulations of planetesimal formation to study how the water content influences planetesimal formation.

OBJECTIVES

- The main objective of this METEOR project is to train the student to analyse self-generated data and to identify key processes that influence the outcome of the simulations in respect to planetesimal formation (e.g. Drazkowska et al. 2023).
- The student will learn to run and modify the already existing planet formation code CHEMCOMP (Schneider & Bitsch 2021a), written in Python.
- The student will then compare the outcomes of the simulations to observations of stellar abundances to understand which stars are more likely to form planetesimals.

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THEORY

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- Protoplanetary disc structures and evolution
- Pebble growth and drift
- Planetesimal formation
- Stellar abundances and their implications to planet formation

APPLICATIONS

by Bertram Bitsch

The student will perform 1D simulations of dust growth and drift in protoplanetary discs and add a recipe that allows the formation of planetesimals (e.g. Drazkowska & Alibert 2017). The student will then investigate how the water content in the disc influences the formation of planetesimals. The student will do so by using the scaling of the elemental abundances of close-by stars. The student will then study how the formation of planetesimals is influenced by different stellar types (e.g. M-dwarfs are suspected to have smaller and less massive protoplanetary discs, eventually resulting in less efficient planetesimal formation) and metallicity/composition (see figure). The student will then identify the most important parameters that allow the formation of planetesimals around different types of stars.

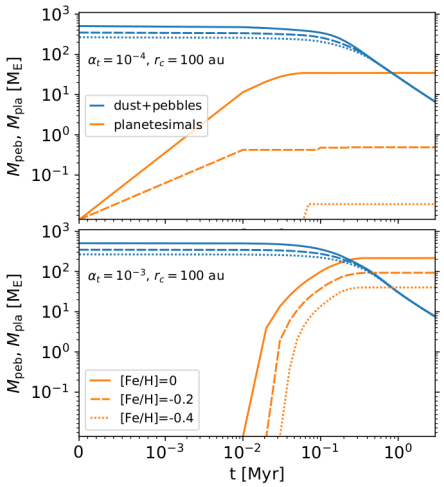

Figure: Time evolution of dust and planetesimal mass in the simulations of Andama et al. 2024.

MAIN PROGRESSION STEPS

- `Week 1-2`: Introduction, initial setup, model tests
- `Week 1-4`: study of theory
- `Week 3-7`: running of simulations with different parameters (water content, stellar mass) and analysis of the results
- `Week 8-9`: Report writing and final presentation

EVALUATION

- `Theory grade [30%]`
  - Written report
- `Practice grade [30%]`
  - Oral presentation
  - Initiative, progress, analysis
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

- Schneider & Bitsch 2021a
- Drazkowska et al. 2023
- Drazkowska & Alibert 2017
- Andama et al. 2024
- Chemcomp git repository

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