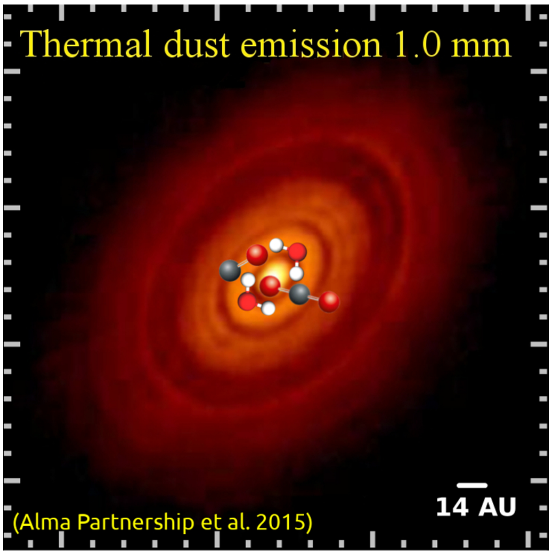
METEOR-Where does the water come from?



SUMMARY.
Observations with the James-Webb-Space-Telescope (JWST) have shown that protoplanetary discs around solar-like stars show (mostly) large water contents, while lower mass stars harbor carbon rich discs. A promising way to achieve this is by inward drifting and evaporating mm-cm sized grains - so called pebbles. As the pebbles move into hotter disc regions closer to the central star, they heat up and release their volatiles (e.g. water) into the disc, explaining the different disc compositions (Mah et al. 2023). However, observations with the Atacama-Large-Millimeter-Array (ALMA) have shown that many discs harbor substructures, e.g. gaps and rings. These rings are accumulations of pebbles, which can thus not move inwards. However, it is unclear how gaps and rings influence exactly the inward drift of pebbles and thus the water content of inner discs. The student will use the publicly available code `chemcomp` *(Schneider & Bitsch 2021a) and include a new method for pebble drift to understand how gaps influence the inward motion of pebbles.*

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 disc composition
- 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 protoplanetary discs to constrain the parameter space of the simulations.

INSTITUTE

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THEORY

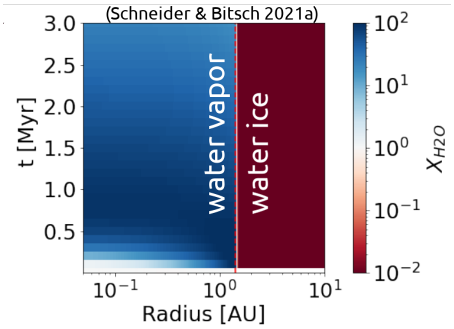
by Bertram Bitsch

- Protoplanetary disc structures and evolution
- Pebble growth and drift
- Evaporation of pebbles
- Comparison to observations

APPLICATIONS

by Bertram Bitsch

The student will perform 1D simulations of dust growth and drift in protoplanetary discs and add a new recipe for dust drift into the code (Pfeil et al. 2024). The student will then investigate how pebble drift is altered by comparing the two different recipes for different disc setups featuring different gap depths and locations. The student will then investigate how dust can diffuse through gaps and how this will influence the chemical composition of the inner disc regions in respect to water, but also other molecules. The student will then identify what conditions are needed to explain the observations of water rich/water poor inner disc in respect to outer disc substructures (aka gaps/rings). This will allow to make a connection between ALMA and JWST observations of discs.



Water evolution of the inner disc as function of time for a disc without outer gaps.

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 (gap depths, 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
- Pfeil et al. 2024
- Mah et al. 2023
- Chemcomp git repository

CONTACT

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