How does accretion of planet-forming disks influence stellar abundances?

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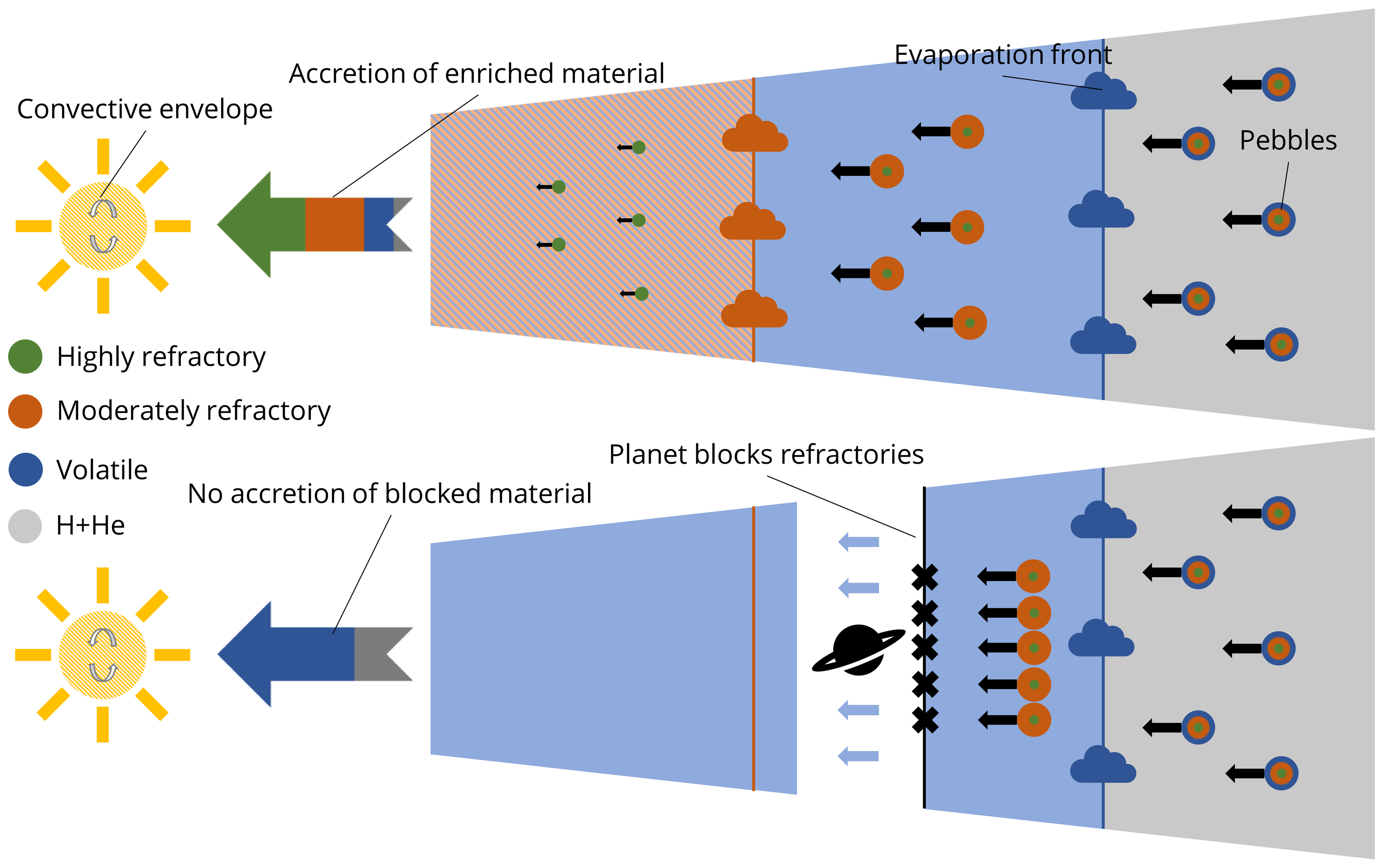
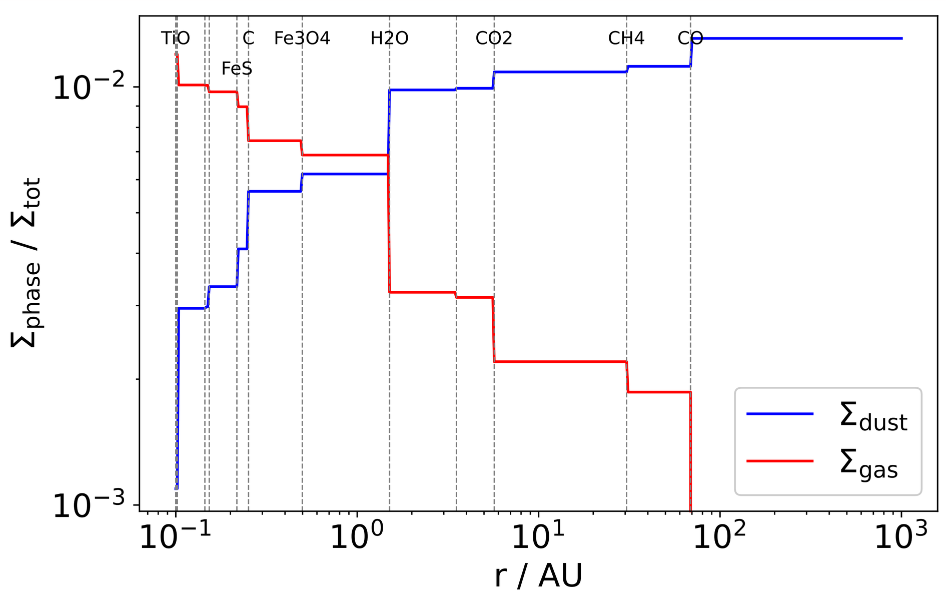
Motivation

- Fast drift of large dust causes enrichment at chemical species' evaporation fronts
- Refractories evaporate closer to the star than volatiles
  → Greater enrichment and earlier accretion
- **Dust and gas is accreted onto the stellar convective envelope**
  - Affects stellar abundances, accreted material is initially refractory-rich
  - Convective envelope shrinks over time
    → Faster adaptation to accreted composition
- Pressure bump created by a massive, gap-opening **planet prevents accretion** of large solids outside its orbit
  - Significantly diminishes their enrichment in the stellar envelope
  - Species gaseous at the planet's location can still be accreted onto the star
- Observations of the HD106515 wide binary system of solar like stars reveal: Unexpected abundance differences between the constituents
  - HD106515A host a confirmed giant planet, HD106515B has no confirmed planets

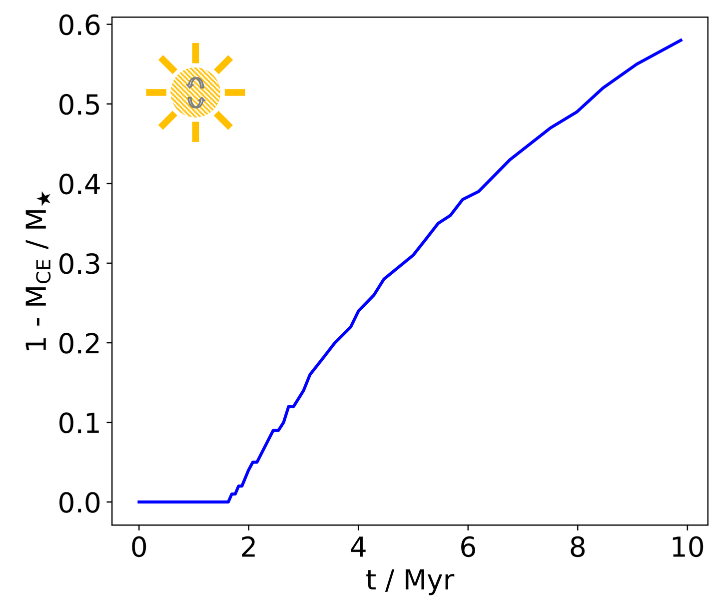
Can the HD106515 abundance differences be the result of planet formation?



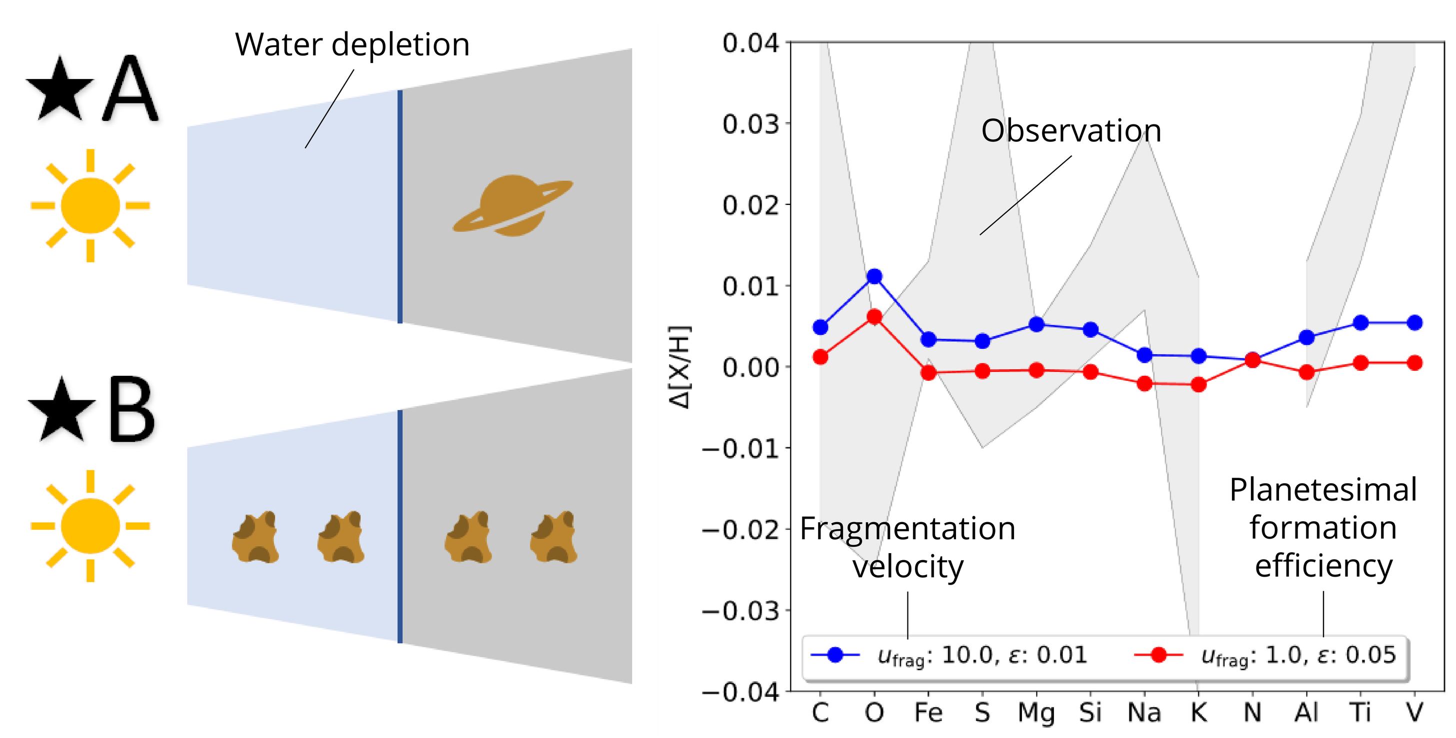
Methods



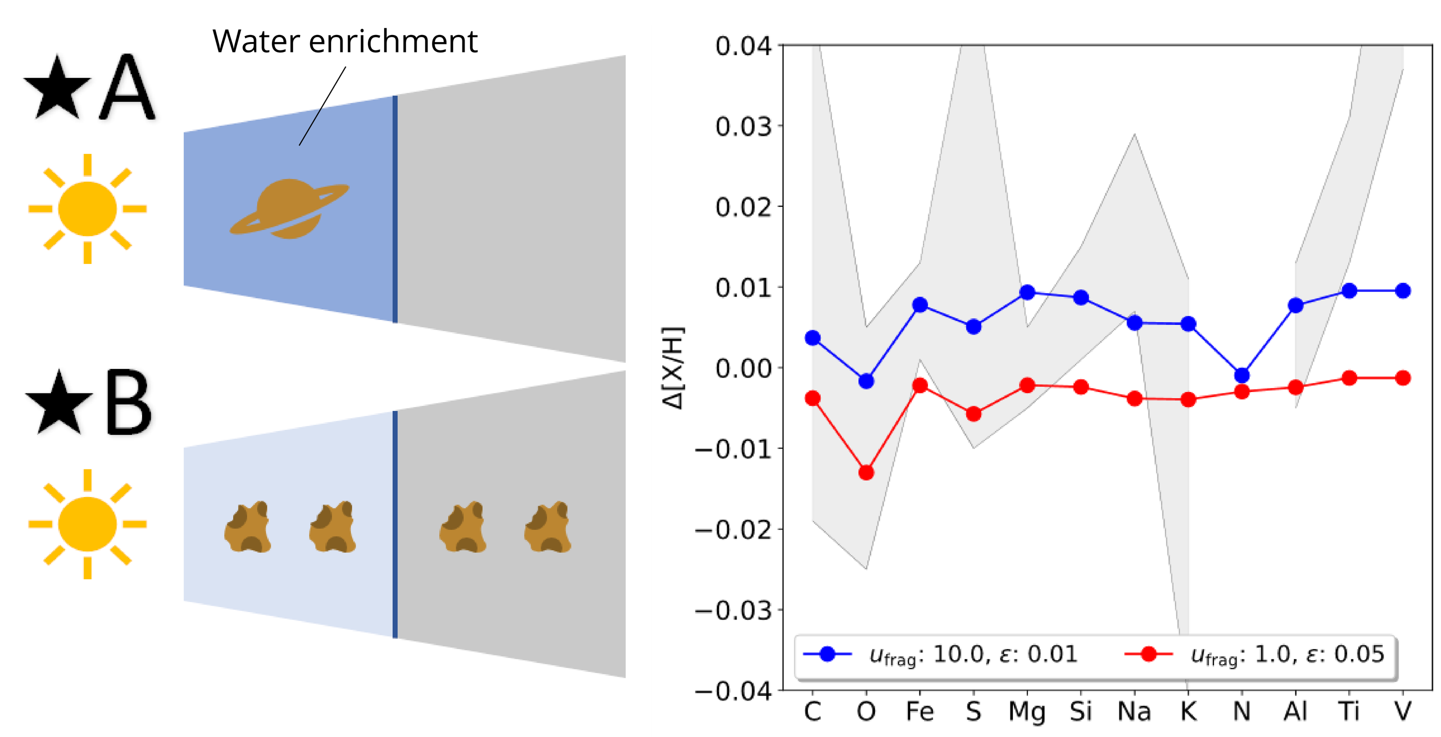
- 1D log-radial **simulations** integrating disk advection-diffusion equation
- Dust: Two-component model[1], implementing fragmentation and drift limits
- Planetesimal formation model[2] based on local pebble flux
- Planetary seed grows by pebble accretion, gap opening by artificial viscosity
- Partitioning model[3] for chemical species (*left*: initial condition), with possible evaporation and condensation during runtime. *More details*: [3]
- Precomputed stellar convective zone evolution models[4] (*right*: solar-like star)



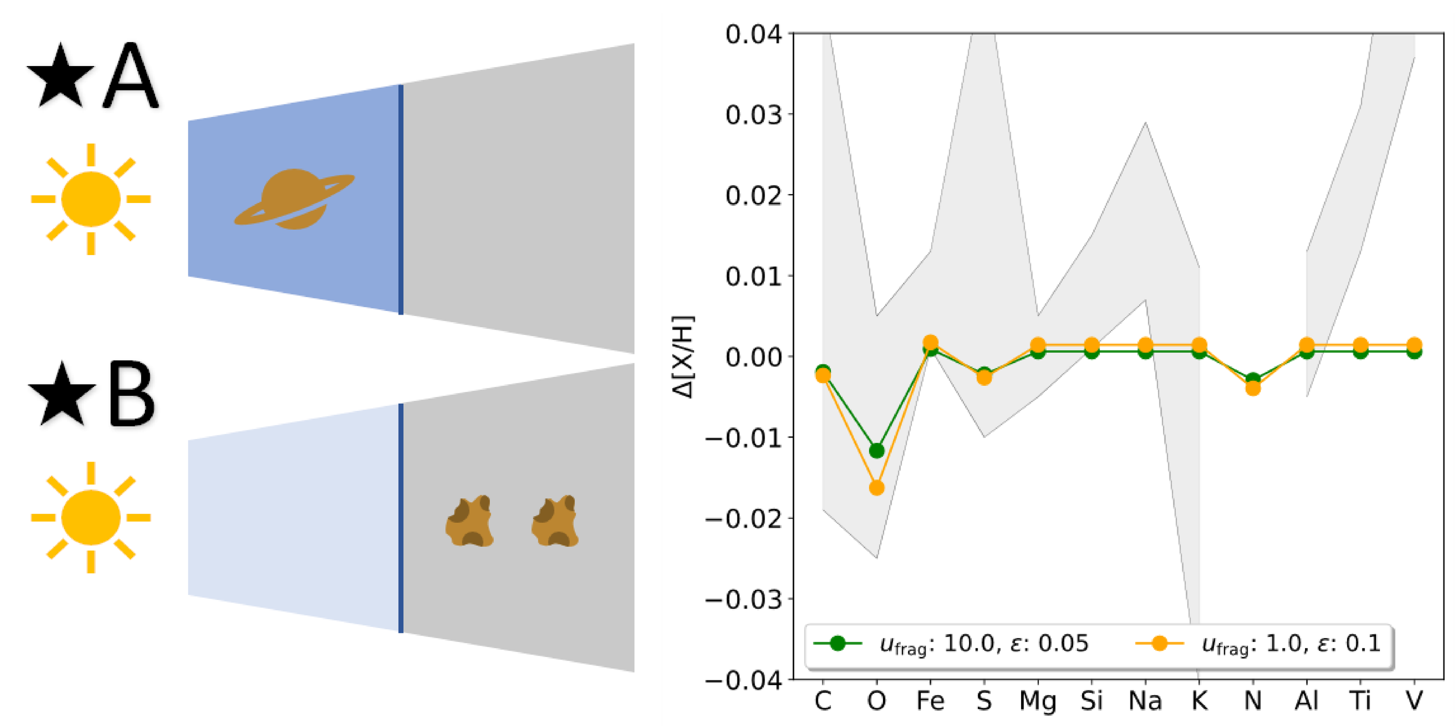
Results



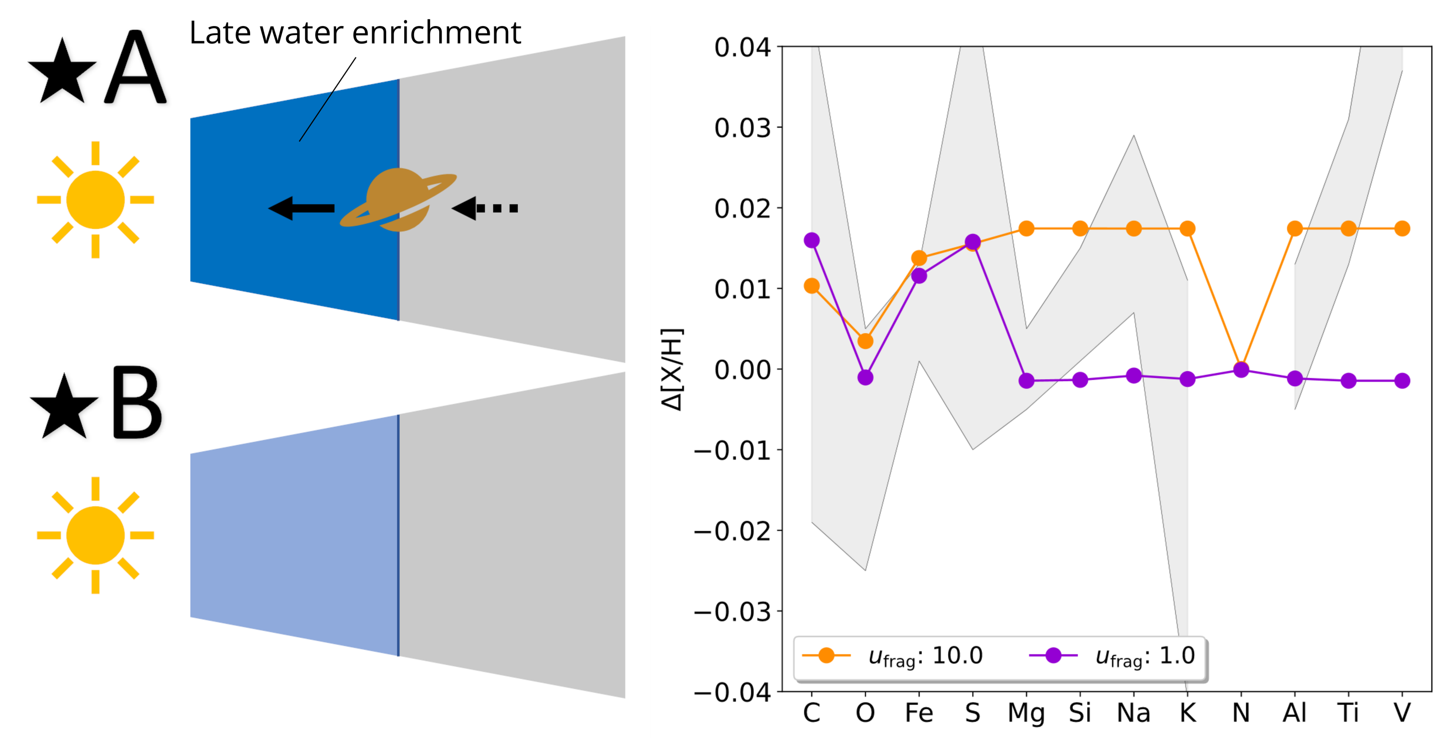
Bad model: Planet forms outside water ice line, oxygen not matched



Better model: Planet forms inside water ice line, better fit for oxygen



Best model: Planetesimals only form outside water ice line



Alternative: Inward migrating planet, no planetesimal formation

Conclusions

- A massive planet influences chemical abundances of the host star by trapping solids outside its orbit, most significantly for ice
- Observed HD106515 abundance differences **can be explained with planet formation**
- Detailed observations of stellar binaries can give clues about formation location
- Here: **Formation inside water ice line, more efficient planetesimal formation around star without planet**
- Models suggest that efficient planetesimal formation in the outer disk might hinder giant planet formation

https://huehn.page.link/ppvii

[1] Birnstiel et al. 2012, A&A, 539, A148 [2] Lenz et al. 2019, ApJ, 874, 36 [3] Schneider & Bitsch 2021, A&A, 654, A71 [4] Hoppe et al. 2020, A&A, 641, A73