Influence of internal photoevaporation on the chemical evolution of protoplanetary disks

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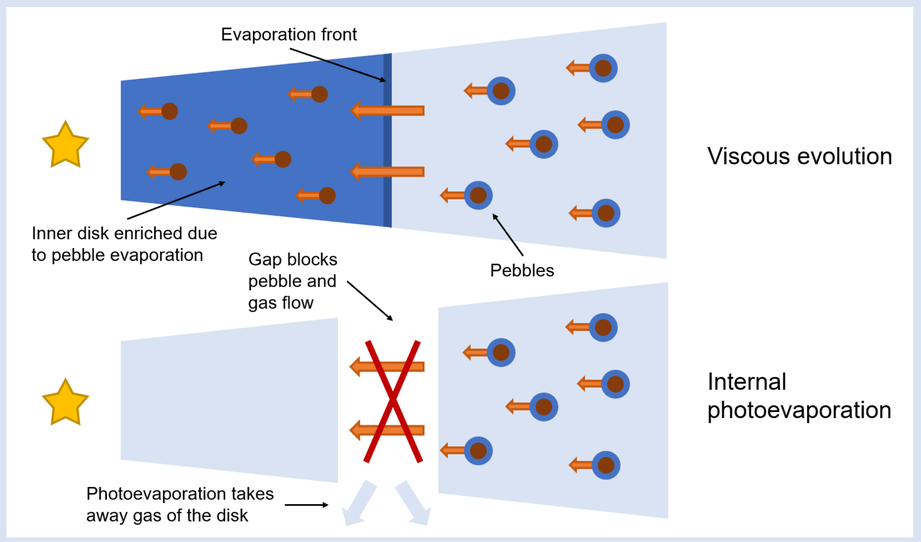
Abstract

Case 1: only viscous evolution + pebble evaporation[a,b]:
- Pebbles drift through disk
- Evaporation of volatile material at evaporation lines

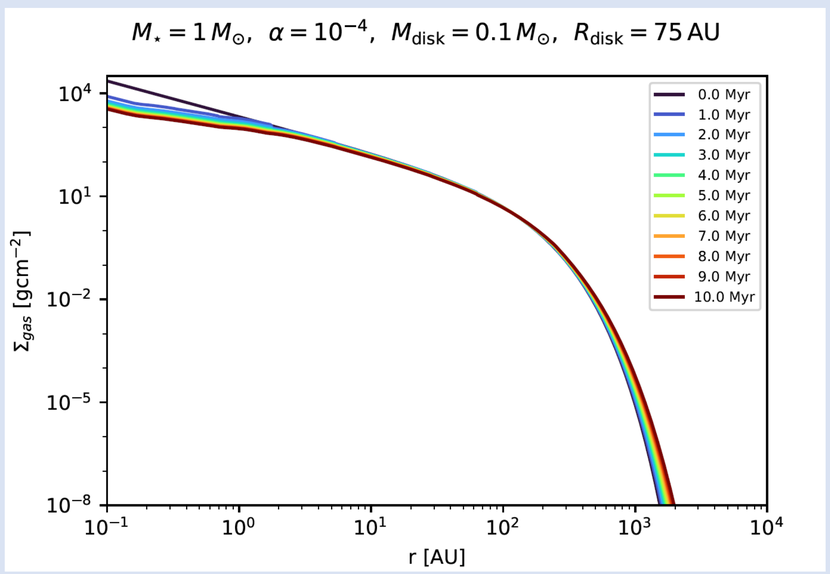
➢ Enrichment of inner disk with volatiles

Case 2: internal photoevaporation[c] + pebble evaporation:
- Gas of disk taken away → gap opens
- Pebbles are blocked

➢ No enrichment of inner disk

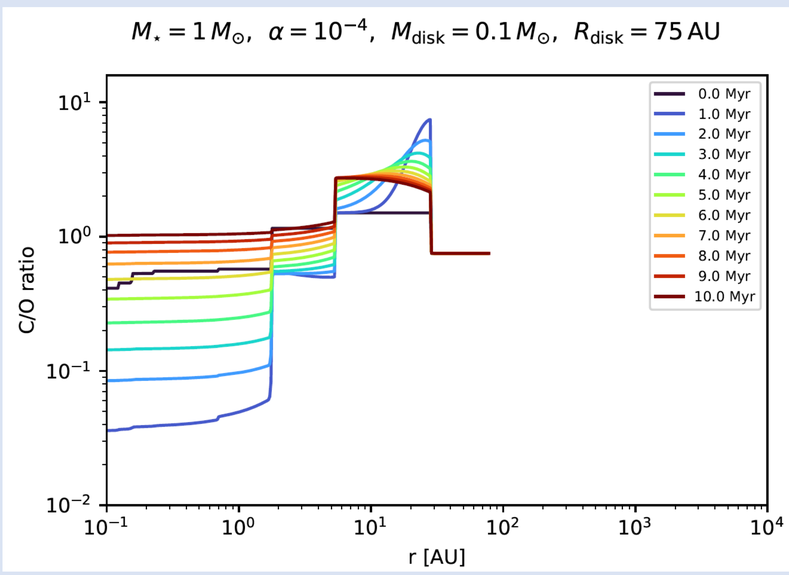


Without photoevaporation



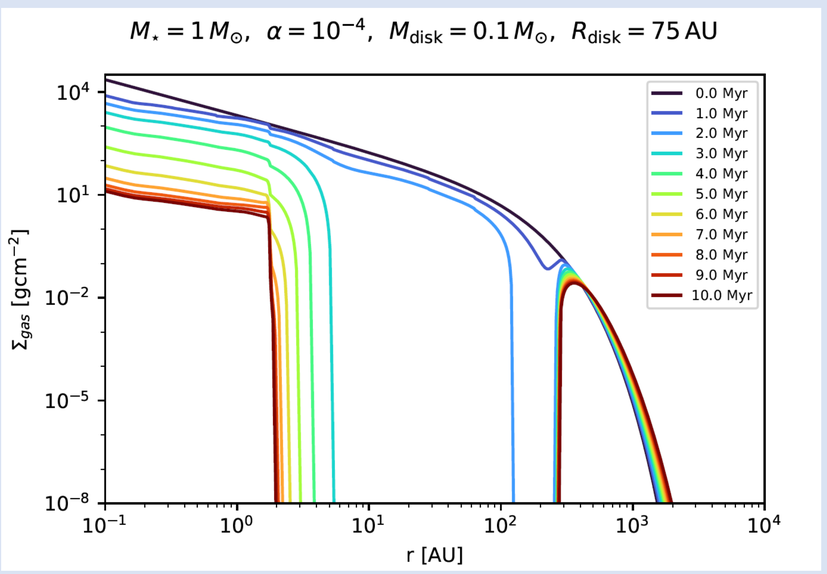
Gas surface density vs. disk radius:
- Viscous evolution leads to accretion onto host star + viscous spreading in outer disk

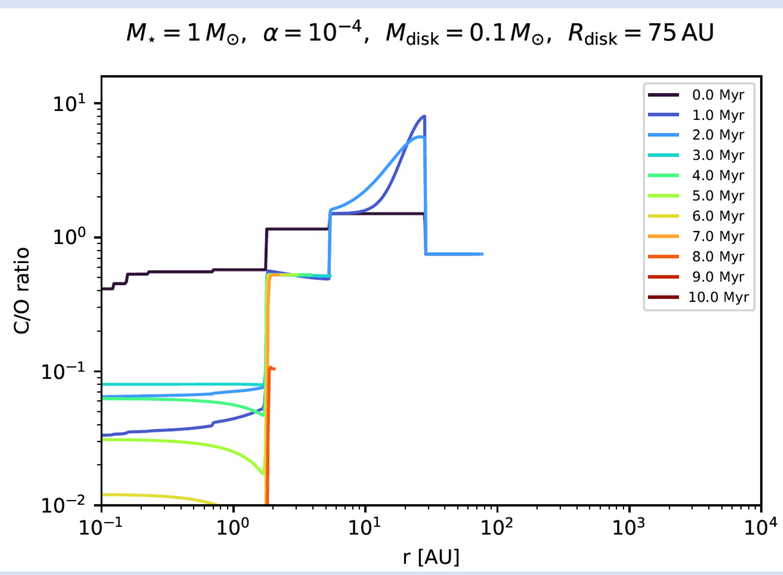
C/O ratio vs. disk radius:
- We show gas phase C/O ratio
- C/O in inner disk quite low after 1 Myr (due to water ice evaporation) → increases over time (since carbon-rich gas arrives)



With photoevaporation

Gas surface density vs. disk radius:
- Internal ph. opens gap after 2 Myr
- Material from outer disk is blocked
- Inner disk is accreted onto host star



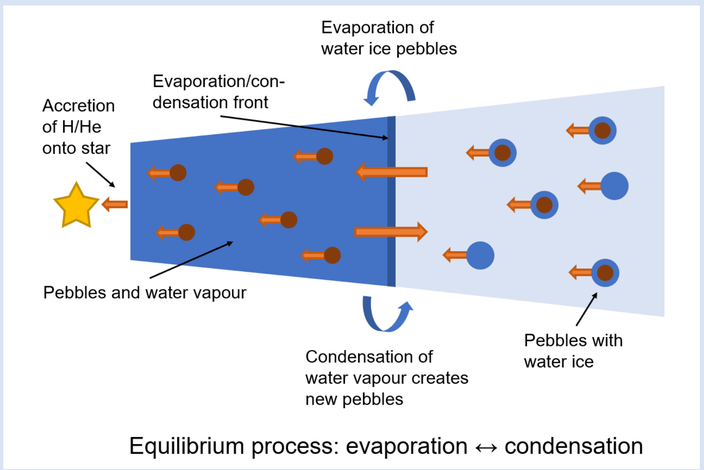


C/O ratio vs. disk radius:
- We show gas phase C/O ratio
- C/O in inner disk quite low after 1 Myr (due to water ice evapora-tion) → stays low (carbon-rich gas cannot pass ph. gap)

Explanation

Behaviour of C/O ratio:
- 0-1 Myr: water ice evaporates in the inner disk → C/O decreases
- 1-3 Myr: carbon-rich gas is transported inwards → C/O increases
- ~ 2.5 Myr: photoevaporation opens gap
- > 3 Myr: carbon gas is accreted onto star + no new supply due to gap → C/O decreases

More details:
- Evaporation lines of carbon-rich species are in the outer disk, while the water-ice line is in the inner disk – not affected by photoevaporation.
- Equilibrium process between evaporation and condensation holds water vapour in the inner disk for long periods of time, while other gases are accreted onto the star



Equilibrium process: evaporation ↔ condensation

References

a) Schneider, A., Bitsch, B., 2021a, Astronomy & Astrophysics, Volume 654, A71
b) Schneider, A., Bitsch, B., 2021b, Astronomy & Astrophysics, Volume 654, A72
c) Picogna, G., Ercolano, B., Espaillat, C. C., 2021, MNRAS, Volume 504, Issue 3

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See also: posters by B. Bitsch, S. Savvidou, L. Huehn