Compositions of Atmospheres from Pebble Accretion: Hydrodynamic Approach

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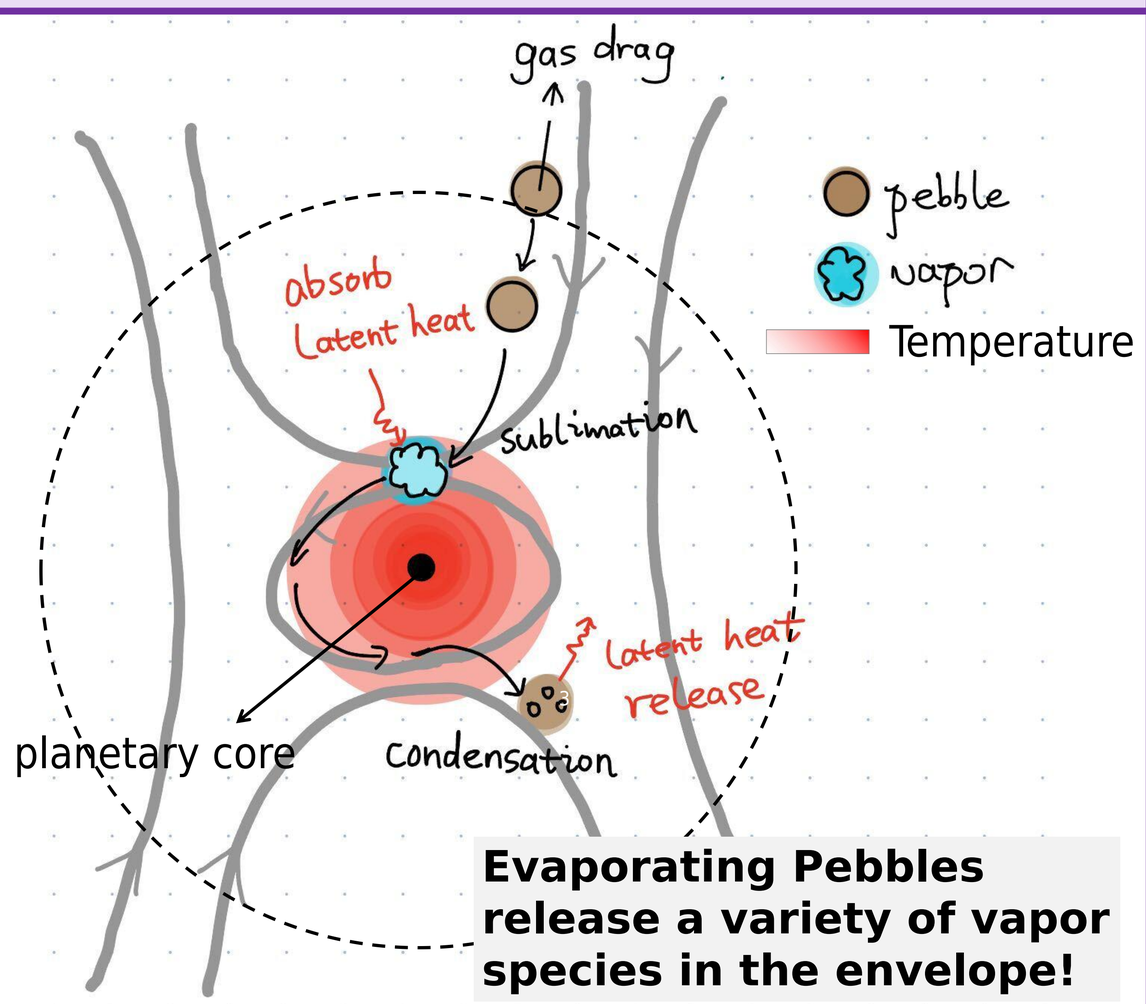
Accreting Embedded Planet (local frame)

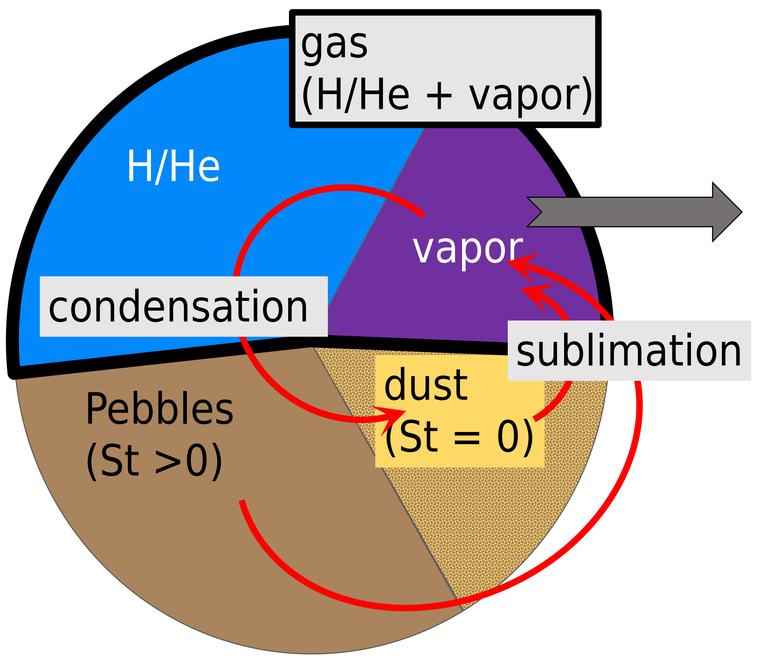


Evaporating Pebbles release a variety of vapor species in the envelope!

Q I. How is the **recycling mechanism** influenced by pebble evaporation?
II. What are the implications for the **composition of planets**, like (super) earth's dry water content?

"A" We implement **phase change** process in **Athena++**.

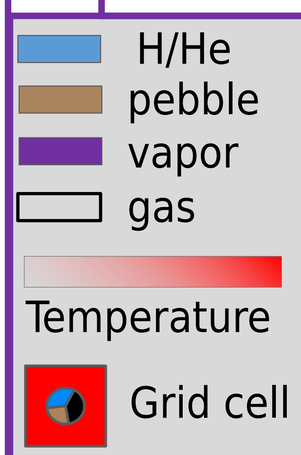
Hydrodynamic set-up



Vapor fraction in gas is followed through **tracer particle** approach

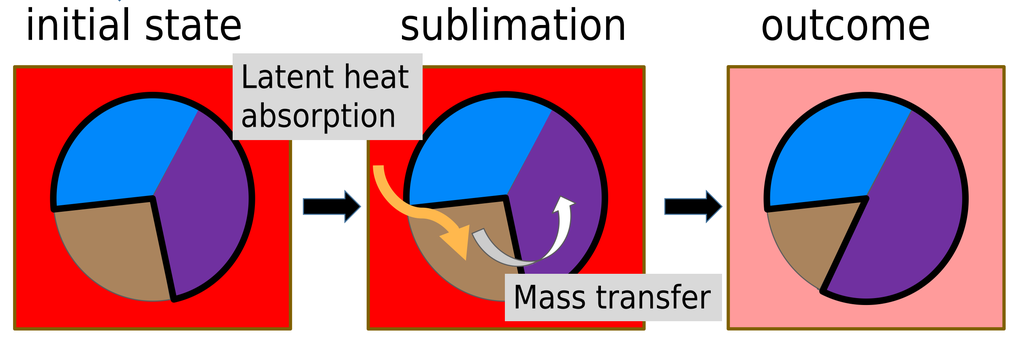
When sublimation happens, mass is transfered from pebble to **gas fluid** as well as **vapor tracers**.

The multi-species set-up is based on newly developed **Athena++ Multi-Fluid Dust module** (*https://arxiv.org/abs/2206.01023*)



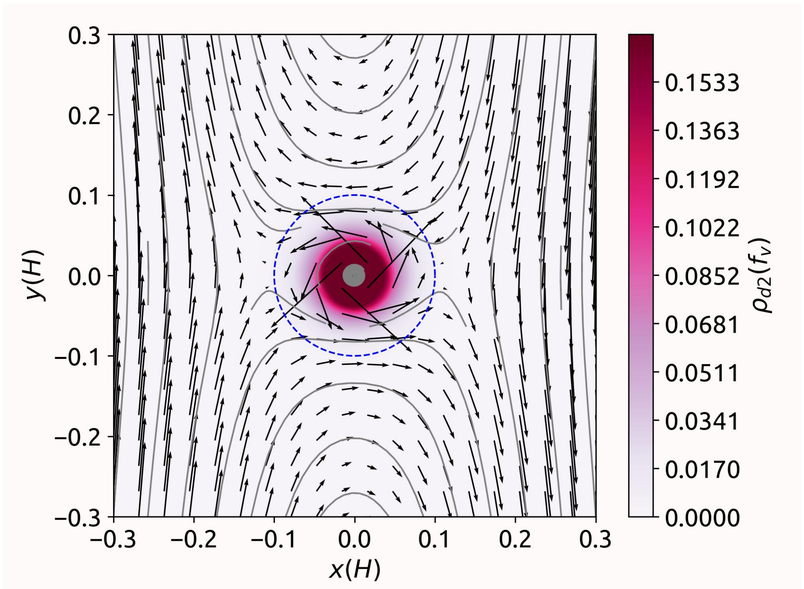
after one hydro step

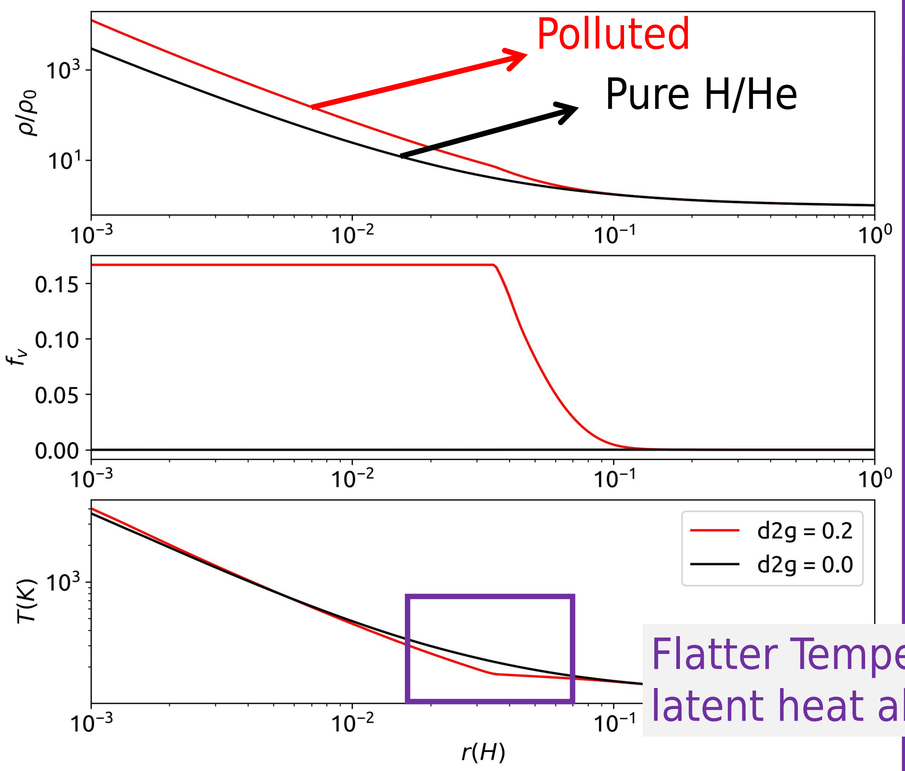
sublimation of pebbles e.g.



Mass and Energy conservation in a local cell

Preliminary Simulation Results



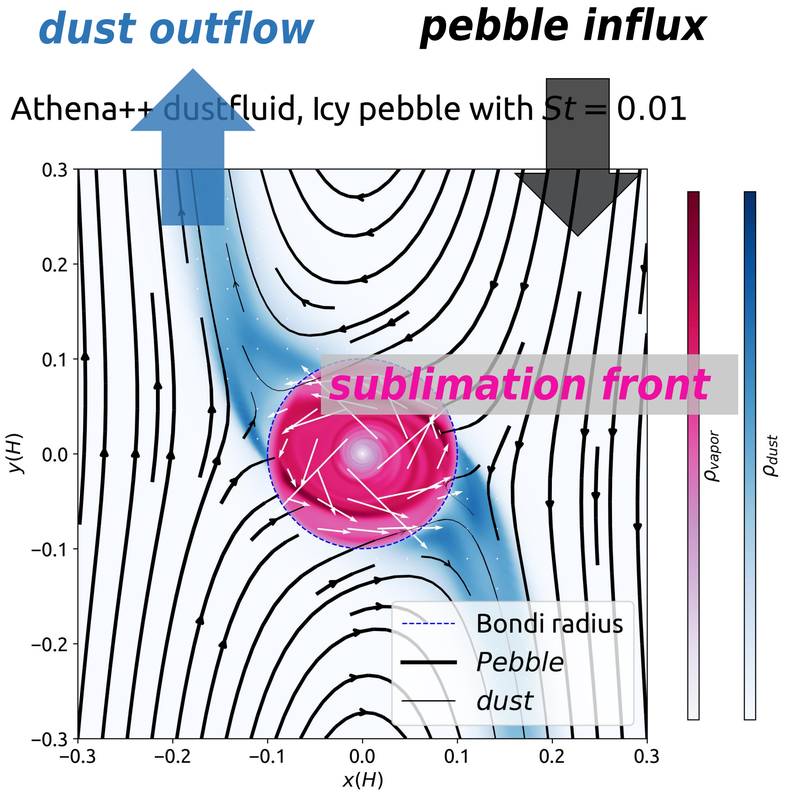


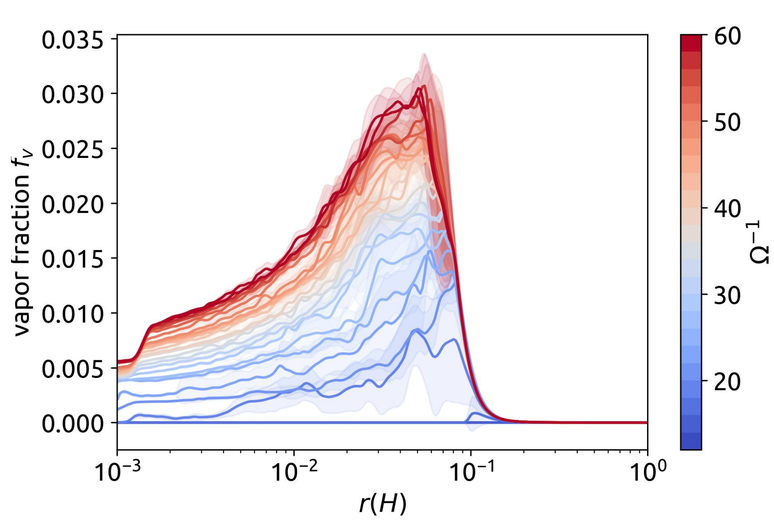
Flatter Temperature profile due to latent heat absorption

1. Comparison of cases with **Well-coupled** icy dusts (St = 0) & Pure H/He gas.
Top: Steady state flow pattern.
Bottom: Radial profile of gas density, vapor fraction and temperature.

Scan for movie and detailed descriptions on them!

2. H_2O-Ice pebbles (St = 0.01) accreted onto hot H/He envelope.
Top: Incoming sublimating pebbles reaches **quasi-steady** state with the outflux of condensing dusts.
Bottom: Time evolution of vapor fraction profile.





Future work: Investigate pebbles of different St & composition; Understand vapor transport process (possible instabilities triggered e.g.); Simulation of different initial conditions (vapor planet e.g.); Multi-species simulation (silicate pebbles e.g.).