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Water transfer and loss in (hit-and-run) collisions

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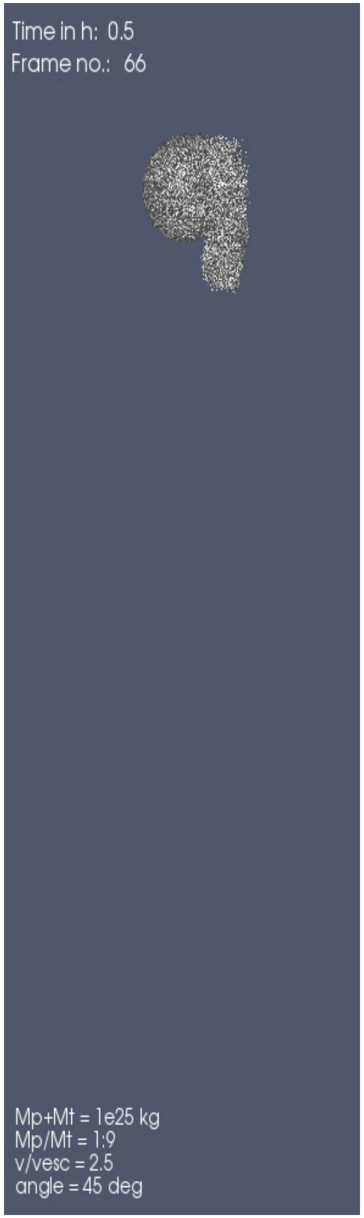
Image credit: NASA/JPL-Caltech



WHAT WE DO …

- *Collision physics during late stage planet formation* (giant impact phase) focusing on volatiles (water)
- ***SPH simulations of embryo-sized bodies***, including self-gravity and partly solid-body physics

WHY WE DO IT …

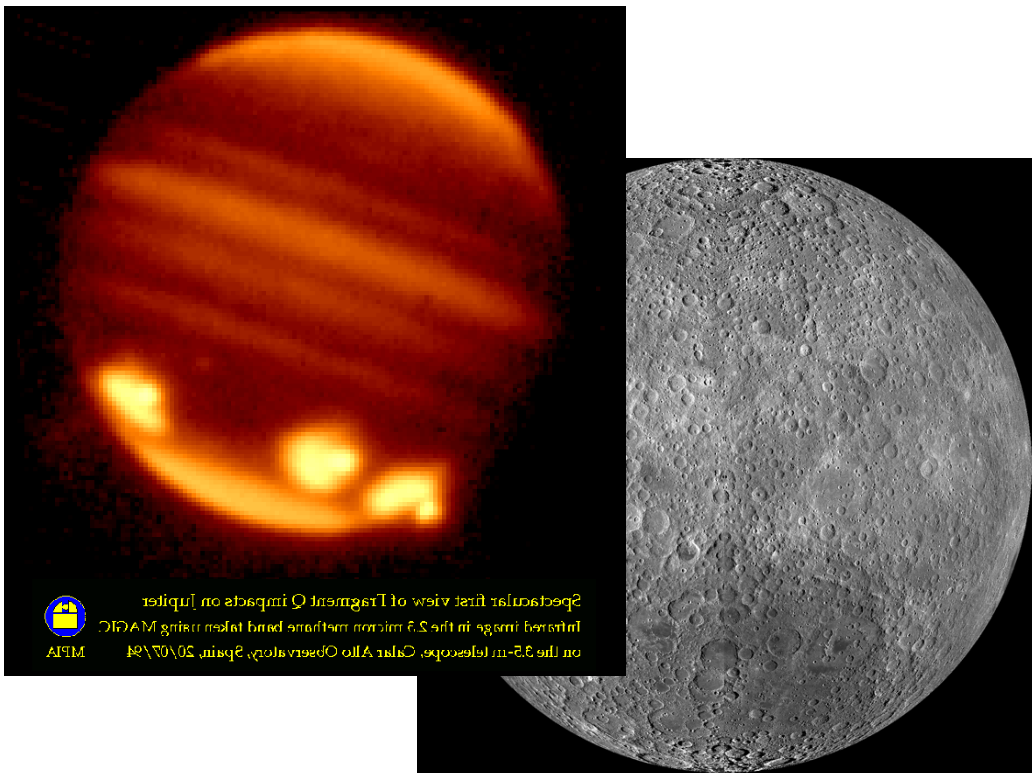
- Volatile material (water) is prone to collisional transfer and loss processes
- *Almost all current models (n-body codes) do not treat volatile material beyond perfect merging*

WHAT WE DO NOT DO …

- Include environmental (radiation, …) and long-term effects (sublimation, …)

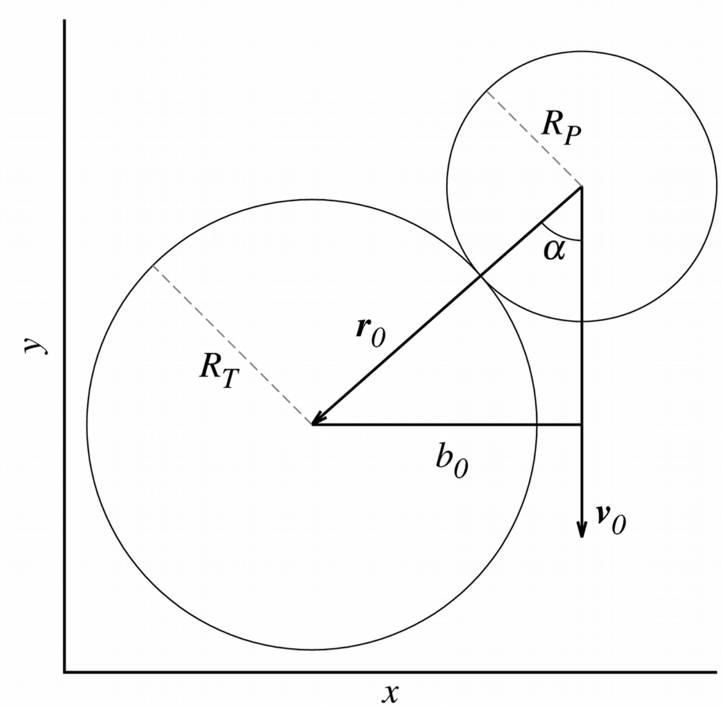
(RELATIVE) SIZE MATTERS

Small bodies impacting large ones are “hit or miss”



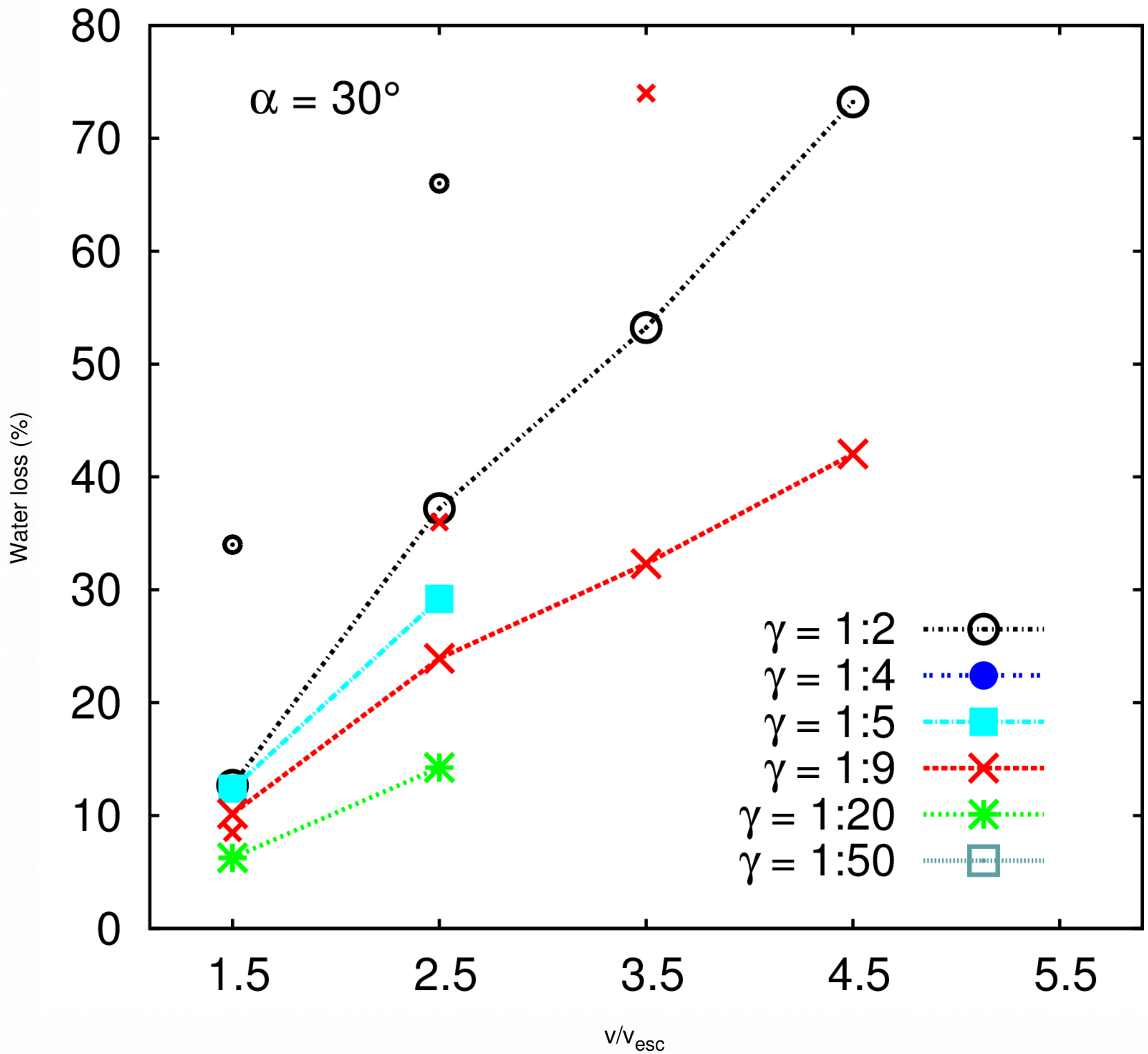
Credit: NASA/Goddard/Arizona State University

In ***collisions between similar-sized bodies*** there is accretion, erosion, hit-and-run, ...



Similar physics: Mechanical and gravitational stresses, shocks and pressure unloading – leading to fragmentation but also melting/vaporization

RESULTS: COMBINED VOLATILE LOSSES

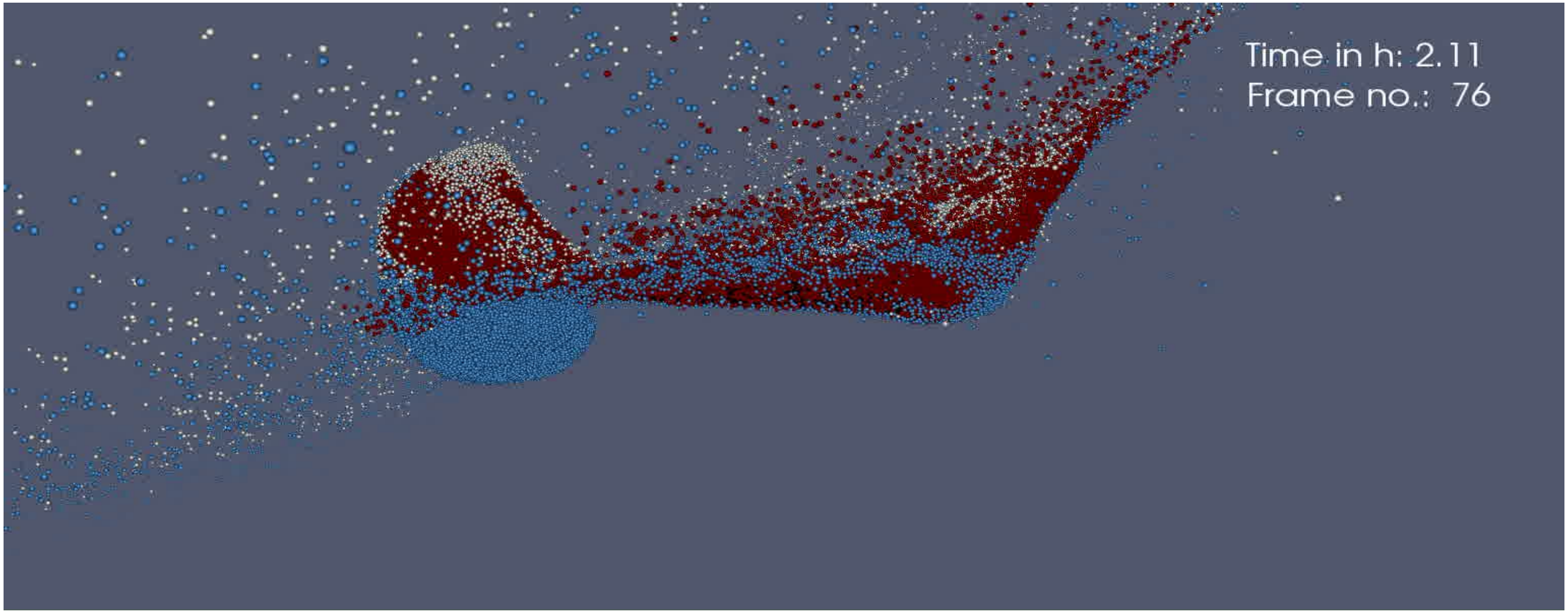


Burger et al. (2017)

- *Volatile losses depend on impact velocity, angle, mass-ratio, and also total mass*
- **Losses up to 75%** in a single hit-and-run collision
- ***Efficient stripping of volatiles*** *by several events*

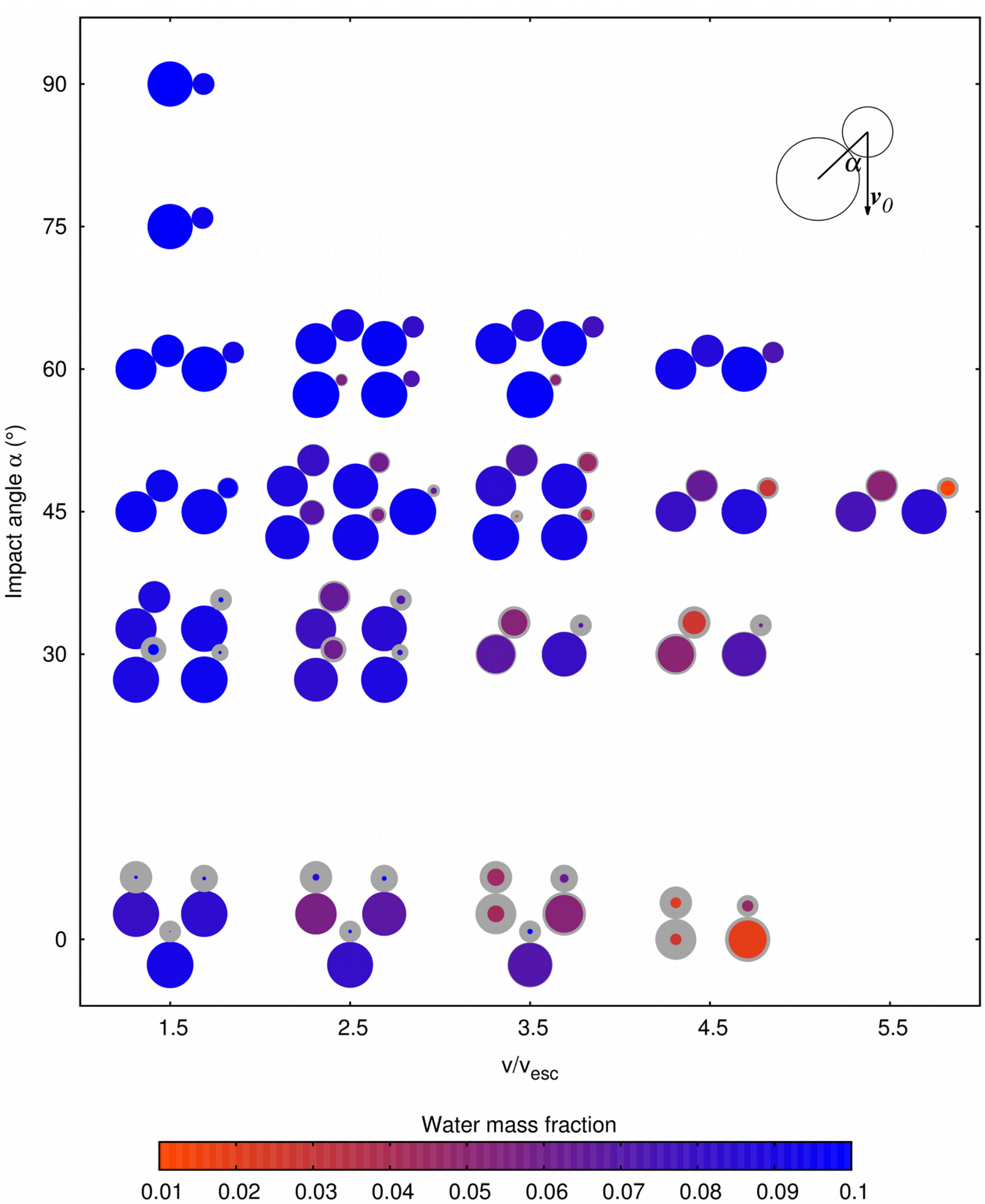
RESULTS: WATER TRANSFER PROJECTILE ↔ TARGET

- *Water transfer projectile ↔ target is often inefficient*, i.e. final water content is determined rather by volatile losses (than transfer)
- *Projectile is more affected the smaller it is*



Fate of projectile/target water (white/blue) for $\alpha = 30°$, $\gamma = 1/2$ and $v/v_{esc} = 1.5$

RESULTS: WATER TRANSFER AND LOSS



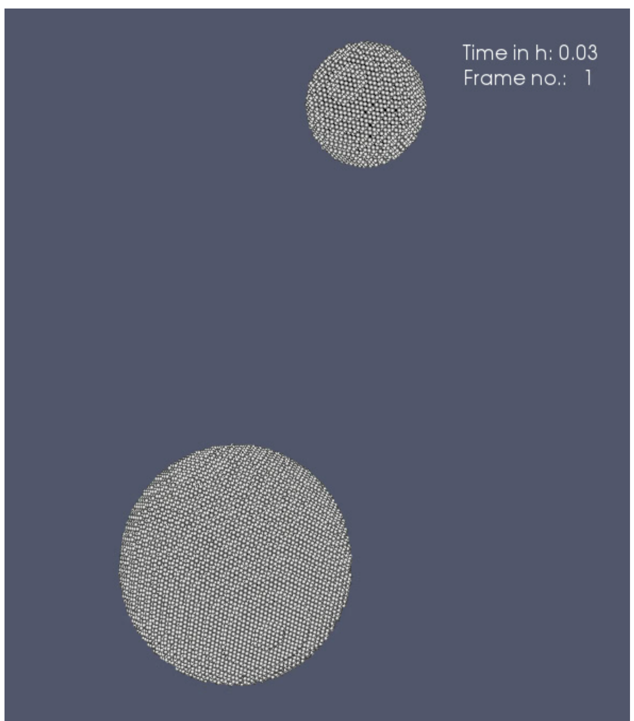
Burger et al. (2017)

- *Water fractions* practically never increase, but *always decrease* (for both bodies)
- *The smaller the projectile the more efficient is it stripped of volatiles*

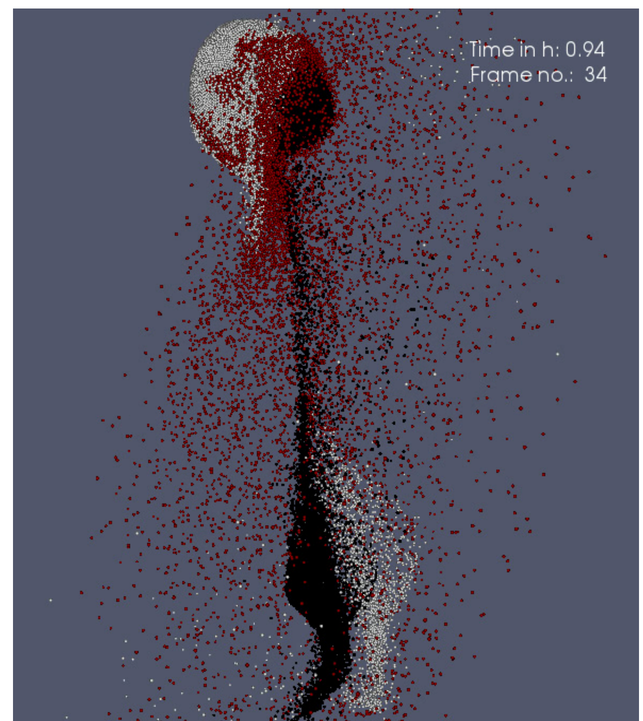
RESULTS: VAPORIZATION OF VOLATILES

- *The fraction of vaporized water strongly increases with M_{tot}*
- Especially in intermediate-mass collisions the vaporization fraction is already significant, but gravity (to hold this atmosphere) is still weak – additional losses up to ~40%

M_{tot} = 1e23 kg (~Moon-mass)



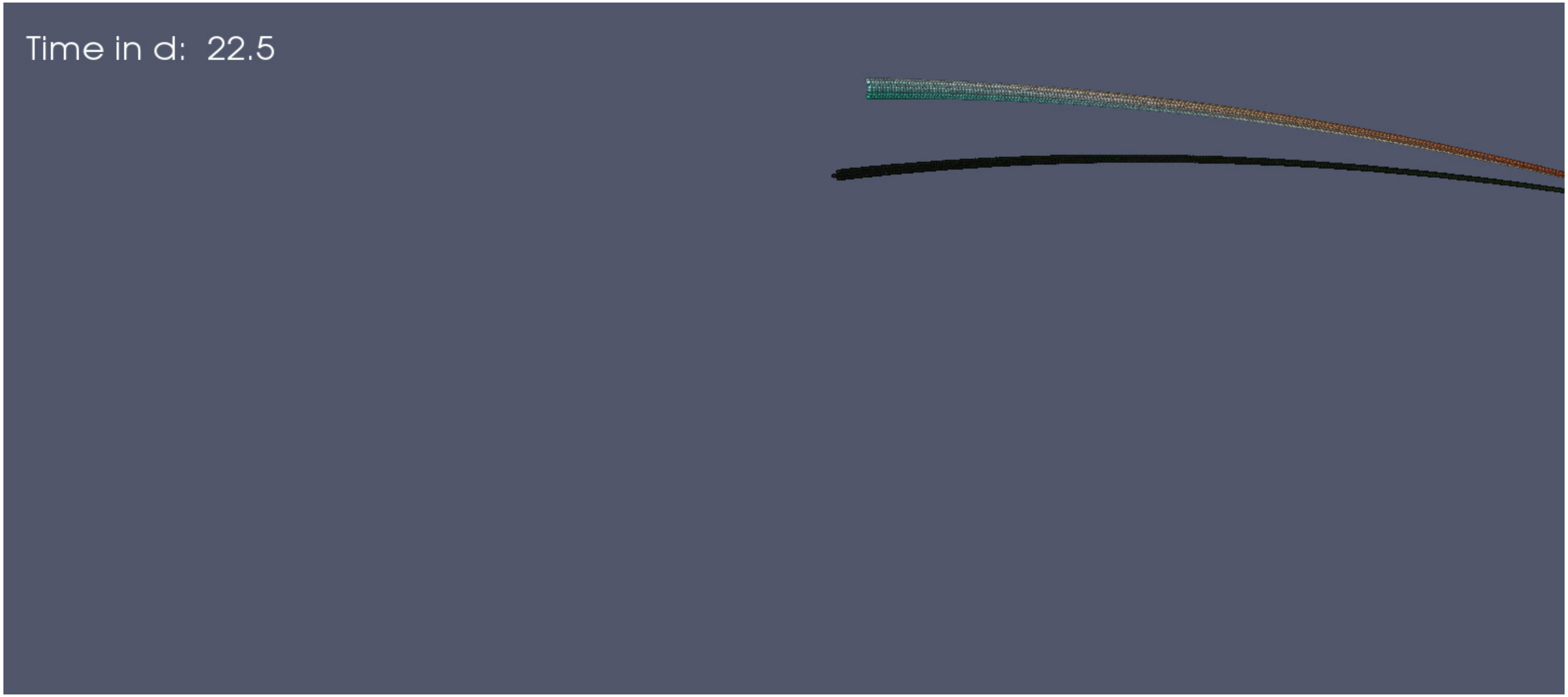
M_{tot} = 1e25 kg (~Earth-mass)



WHERE TO GO FROM HERE?

The goal is to consistently model water transfer and loss during (terrestrial) planet formation

→ Include results in n-body planet formation simulations




Thank you for your attention!