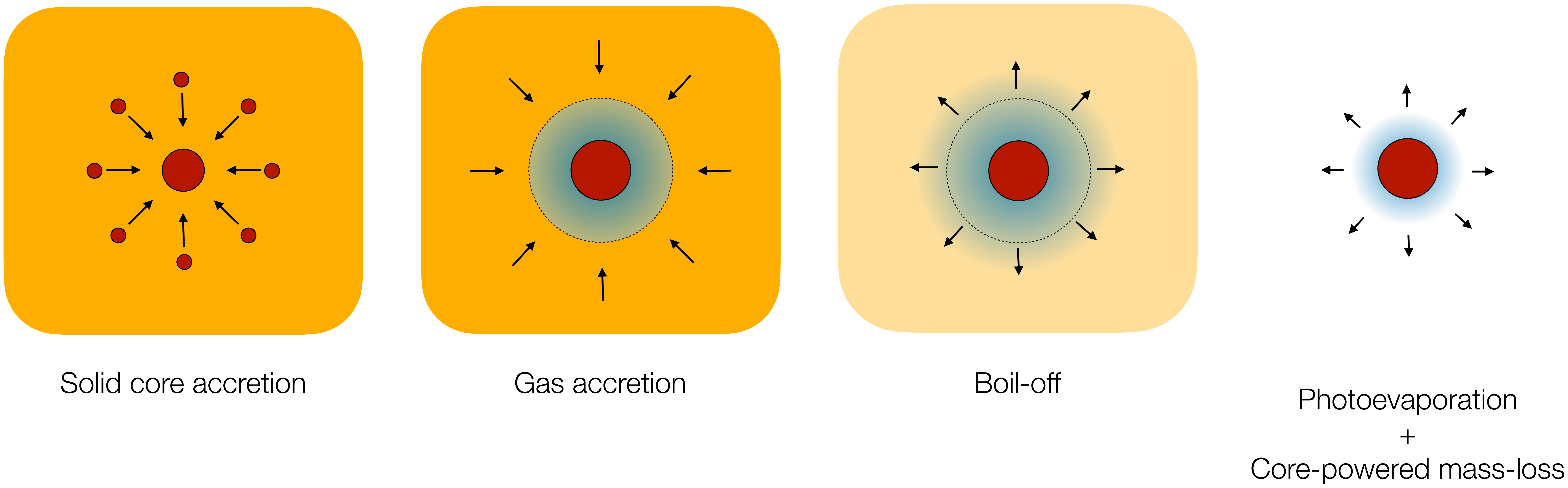
The Impact of Escaping Hydrogen Atmospheres on super-Earth Interiors

James Rogers

11th December 2023

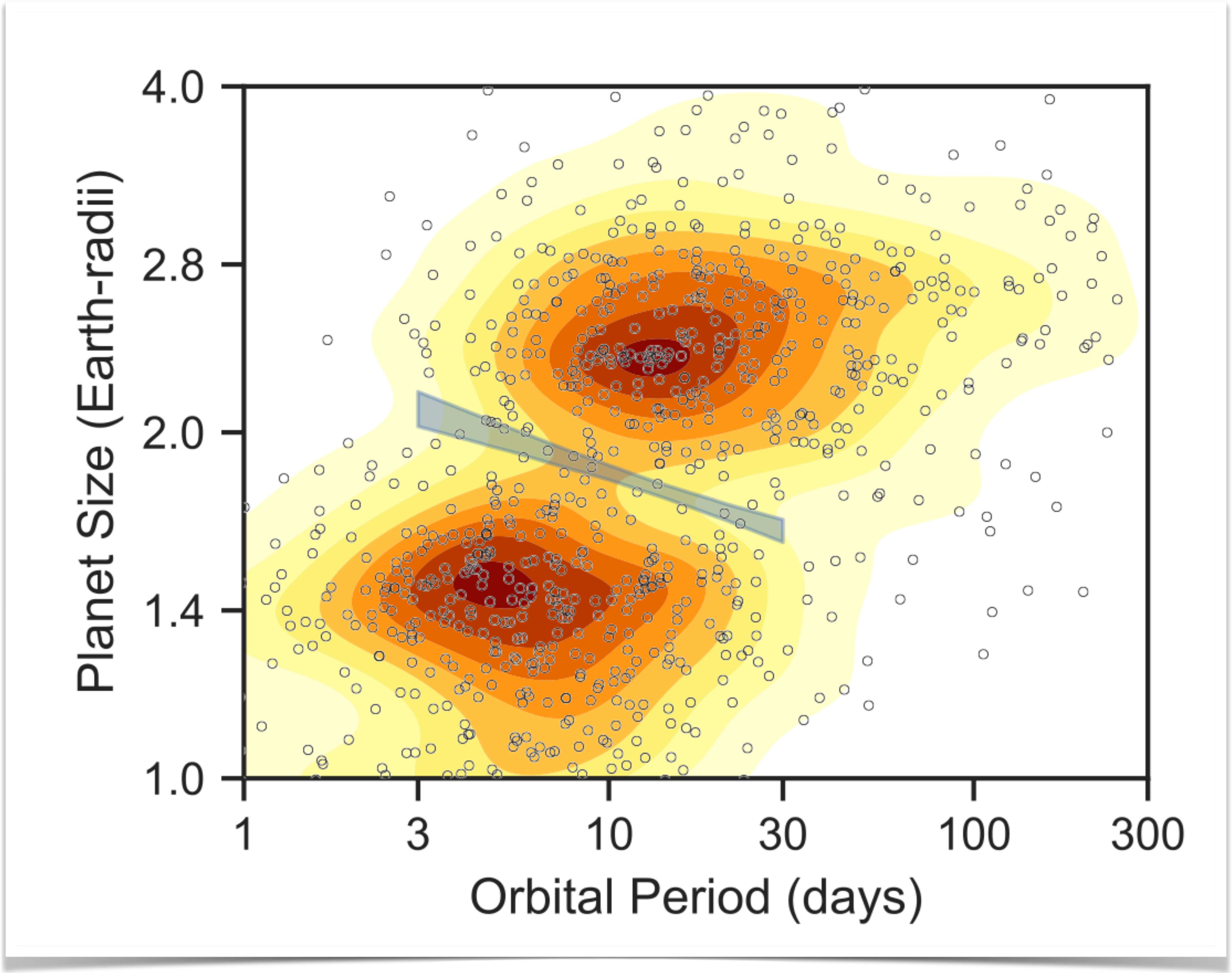
ExSoCal 2023

The tale of hydrogen…

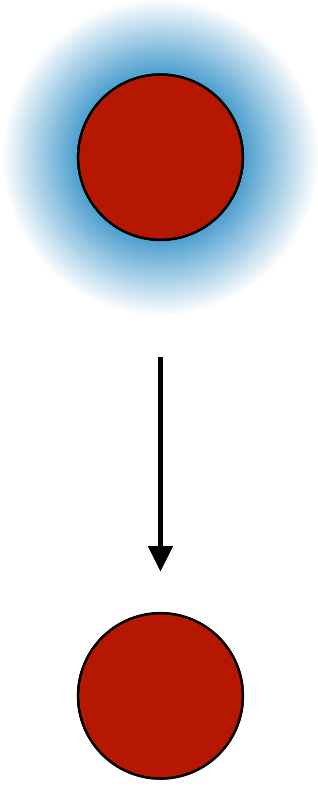


Rogers, Owen & Schlichting (2023)

The tale of hydrogen…



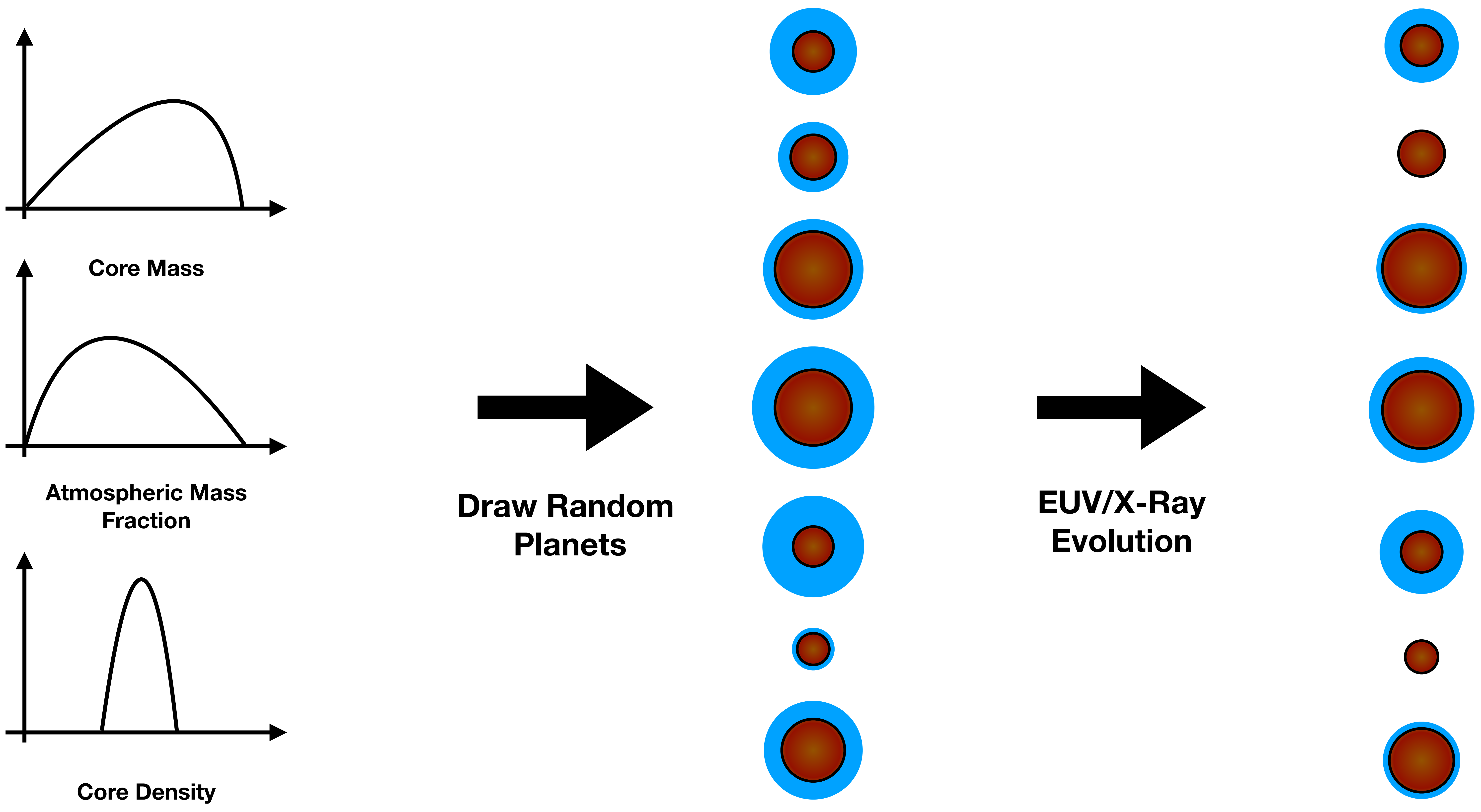
Petigura, Rogers et al. (2022)



Sub-Neptunes

Super-Earths

The tale of hydrogen…



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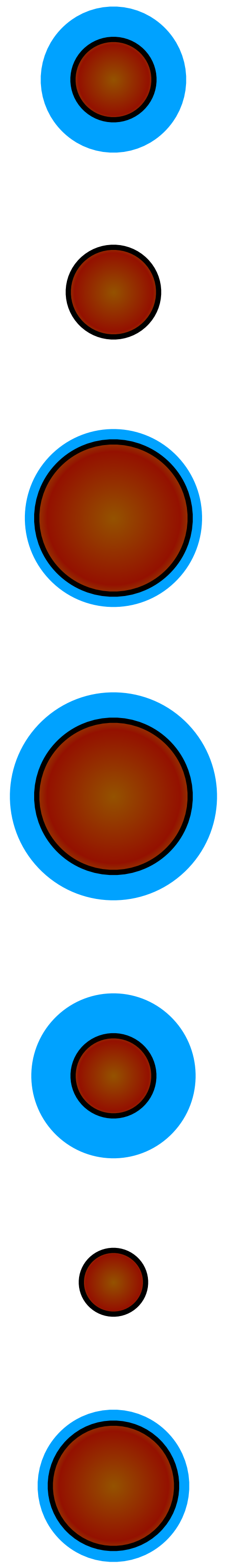
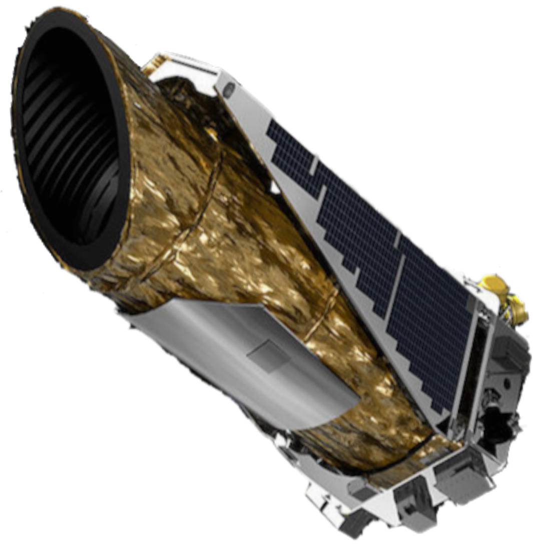
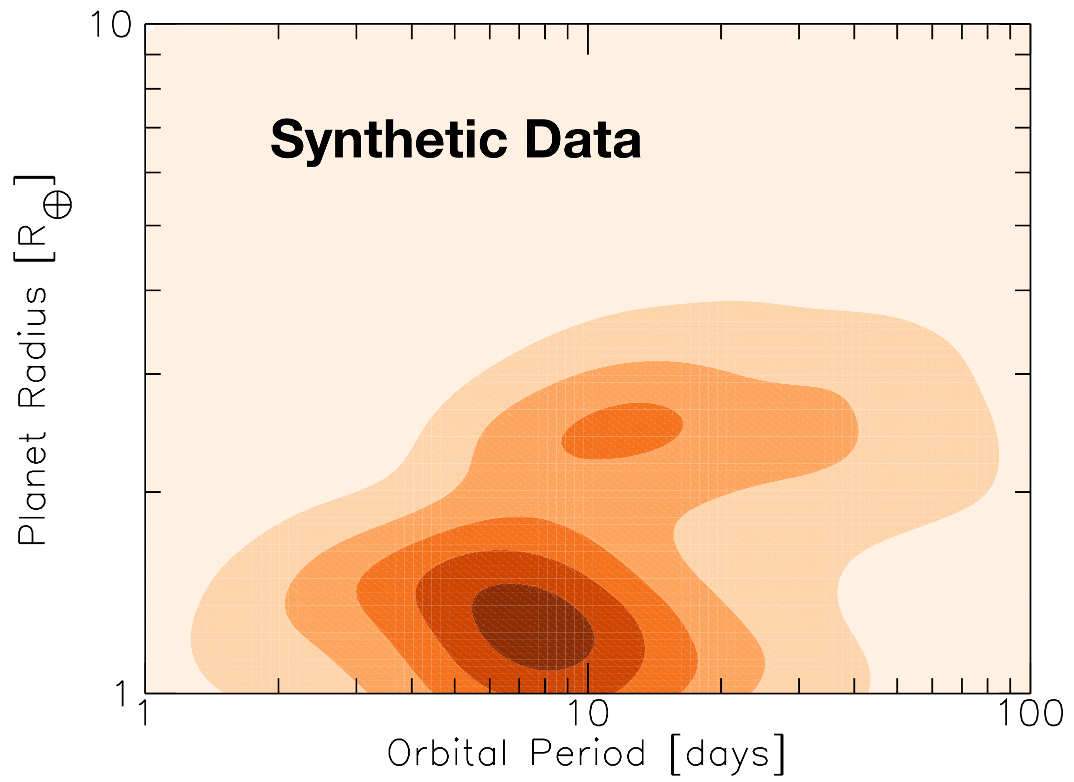
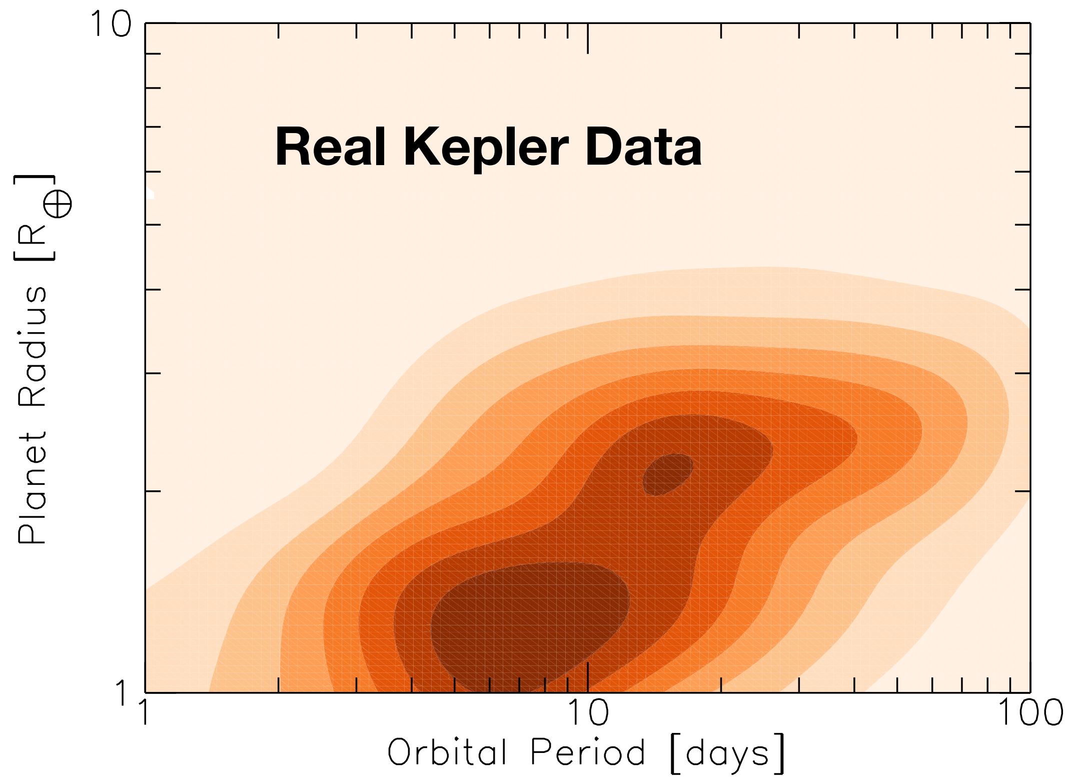




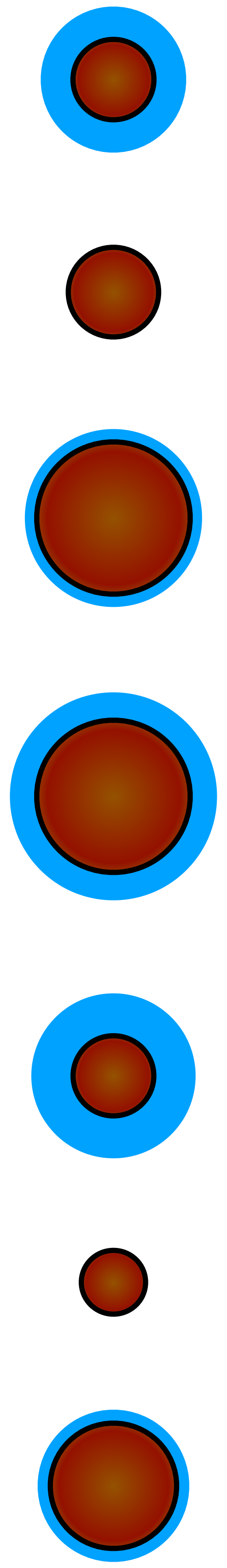
"Observe" Planets
with Kepler

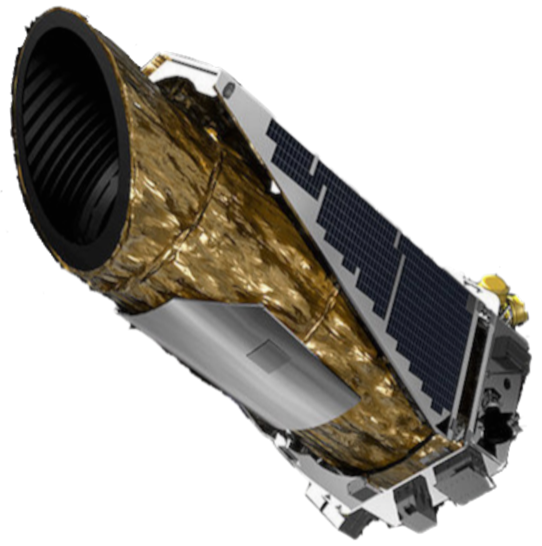




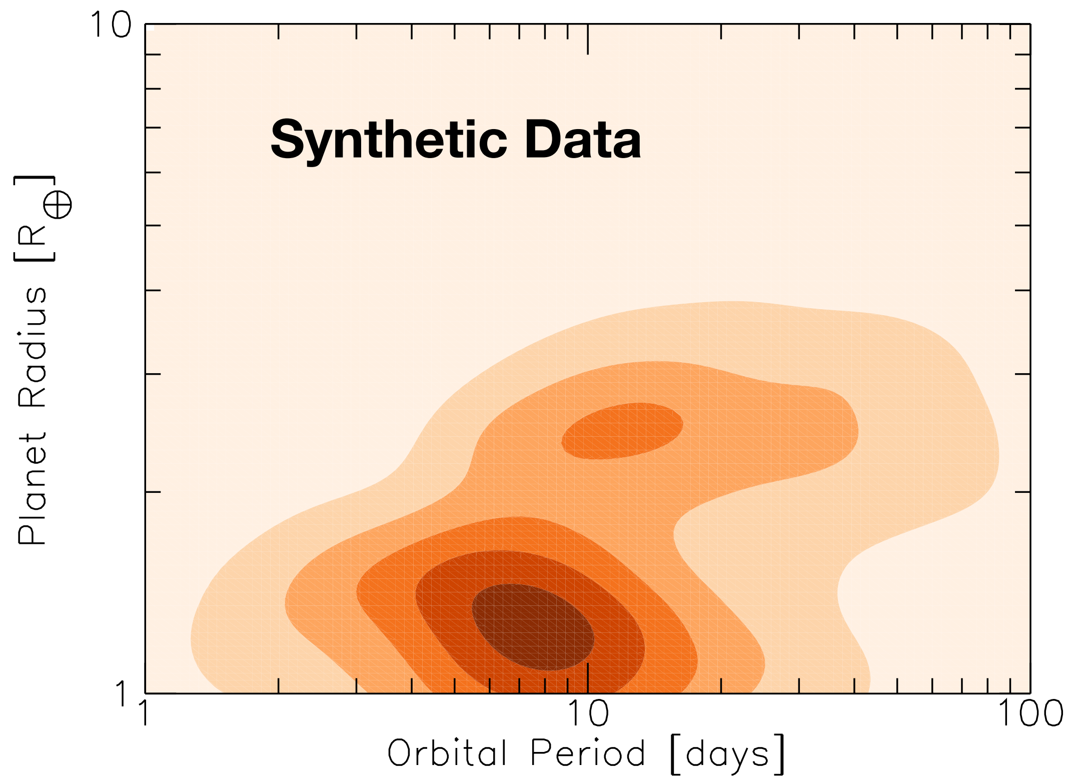
Compare with real Kepler
data

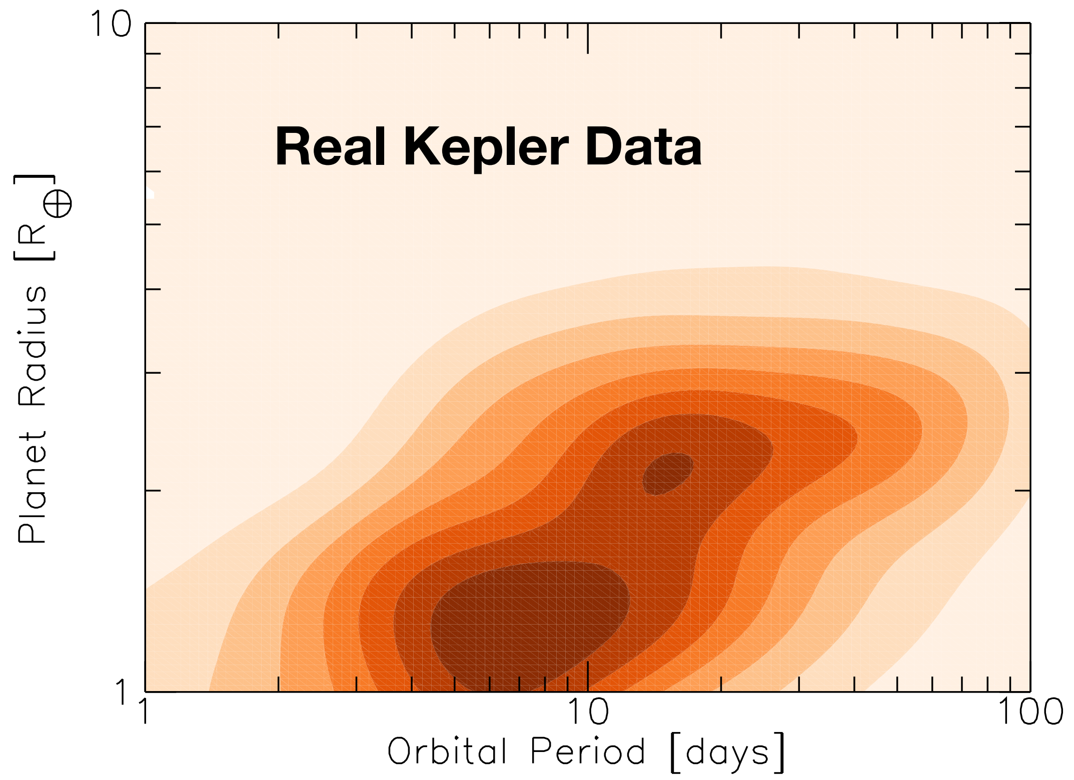
The tale of hydrogen…





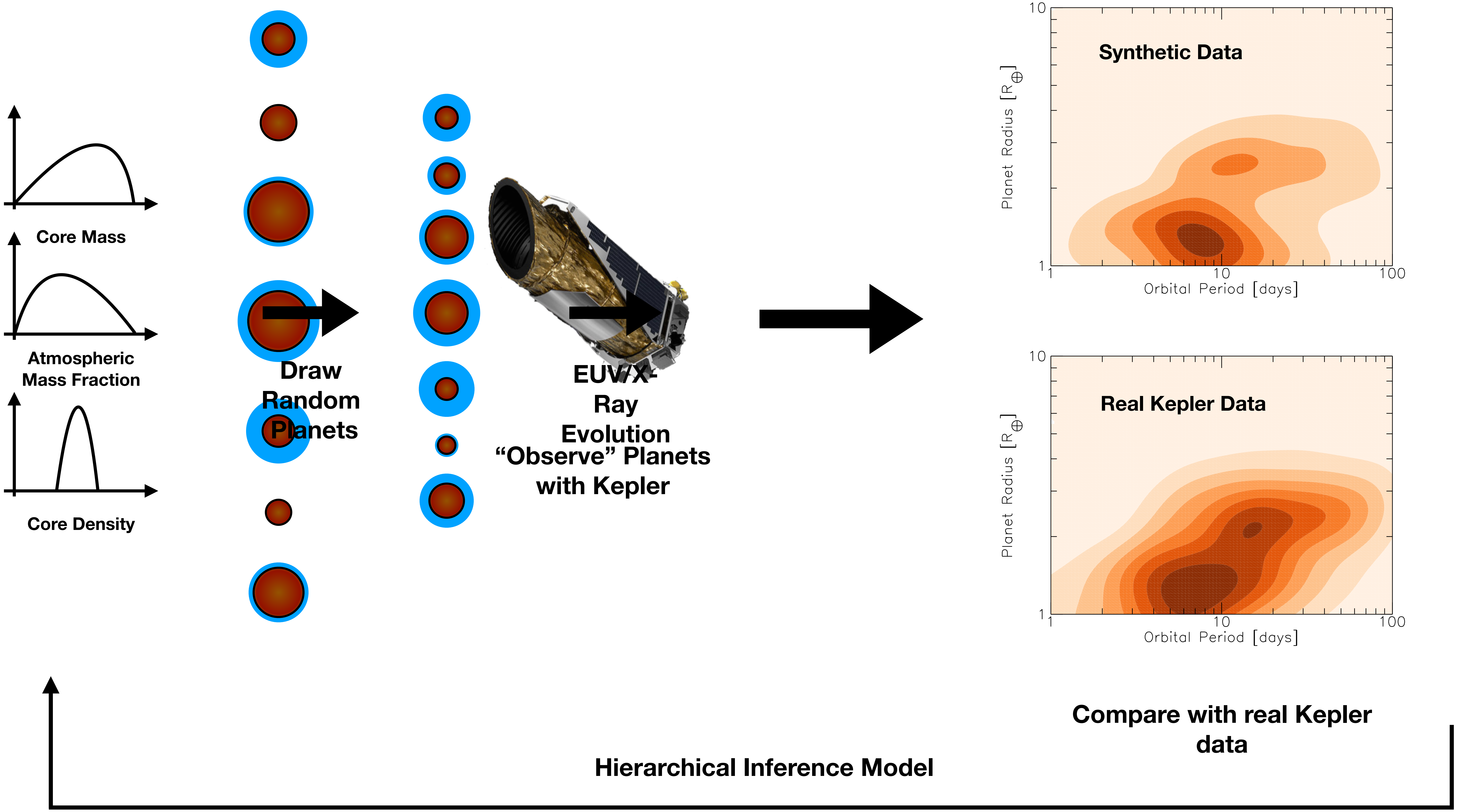
“Observe” Planets with Kepler





Compare with real Kepler data

The tale of hydrogen…



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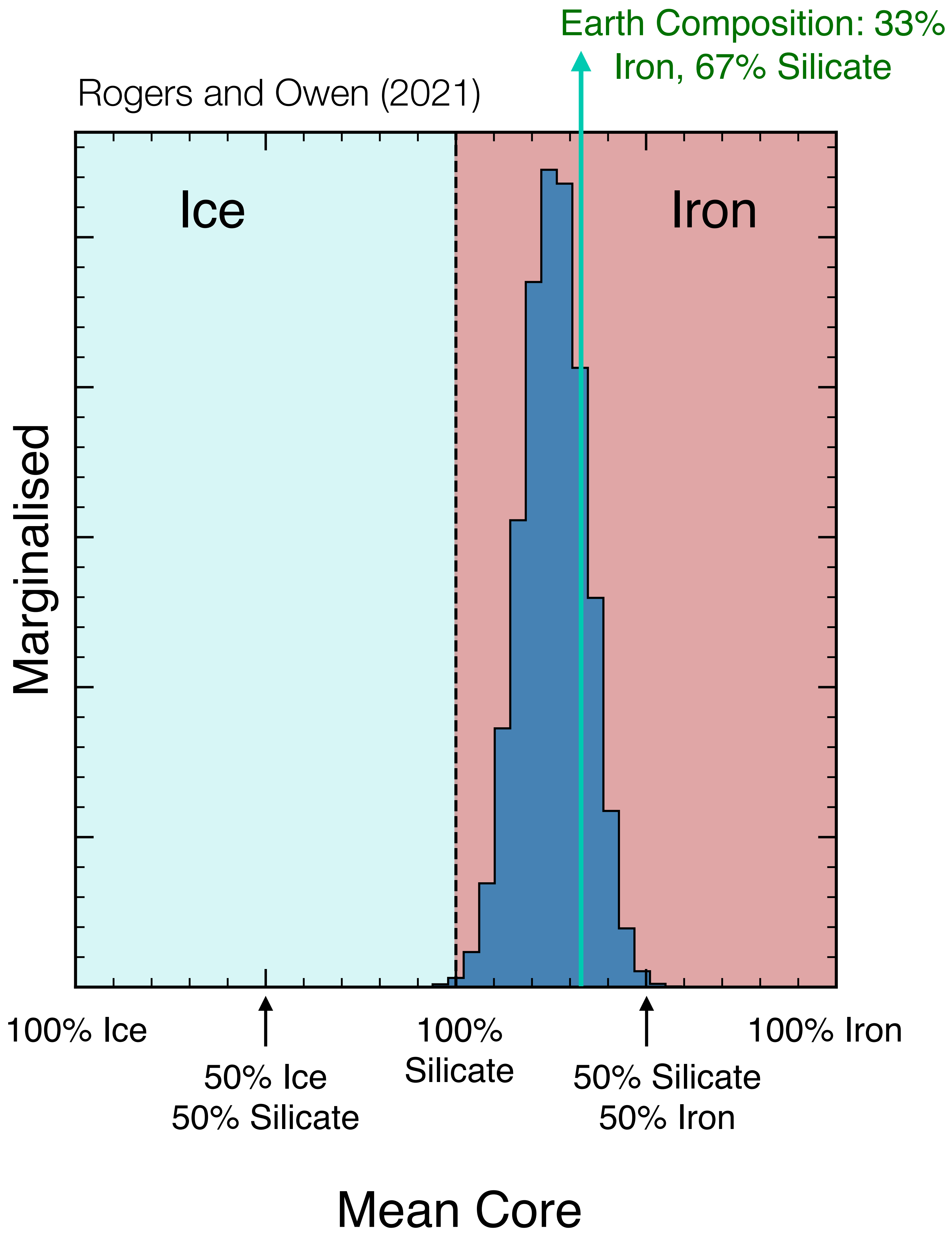

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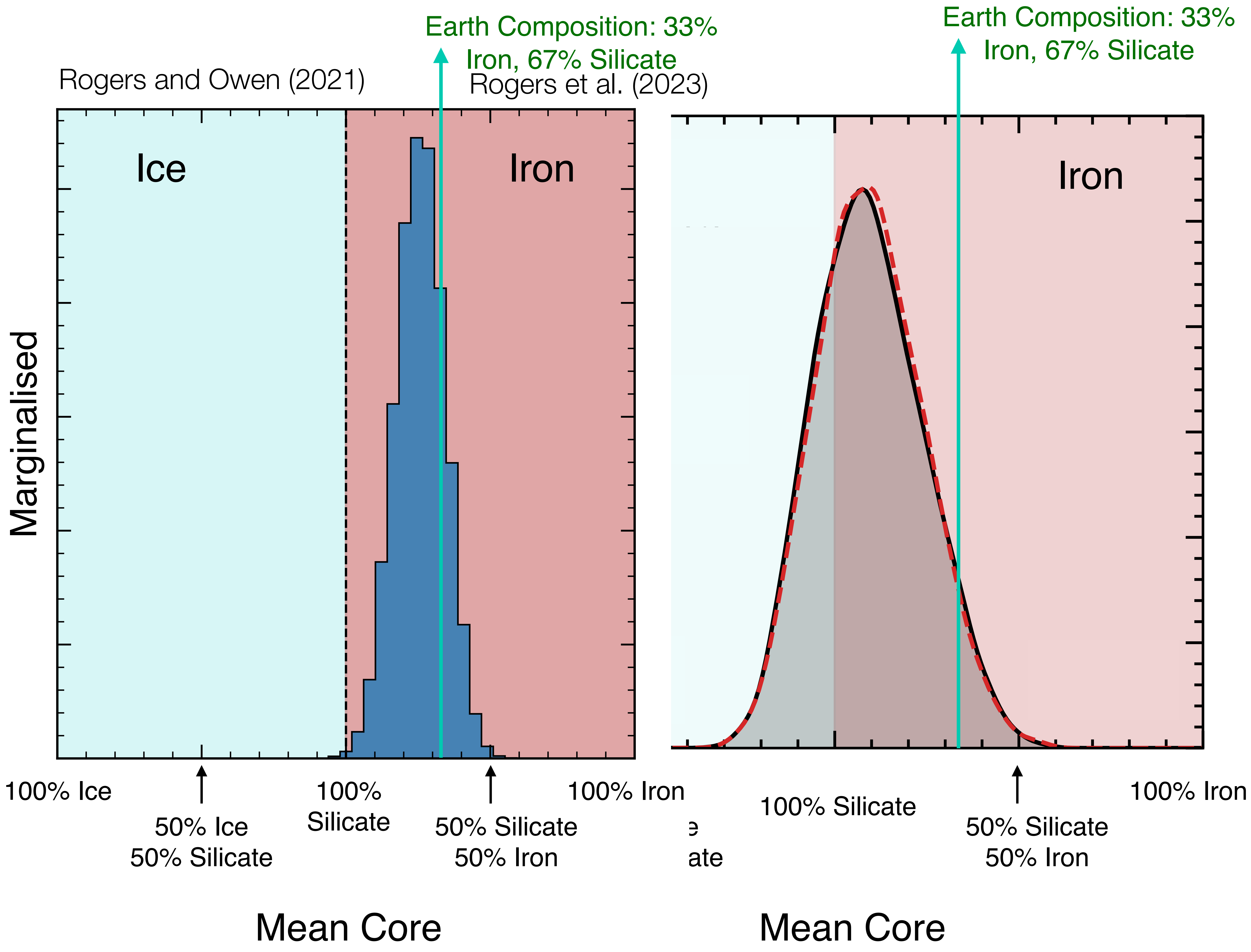


The tale of hydrogen…

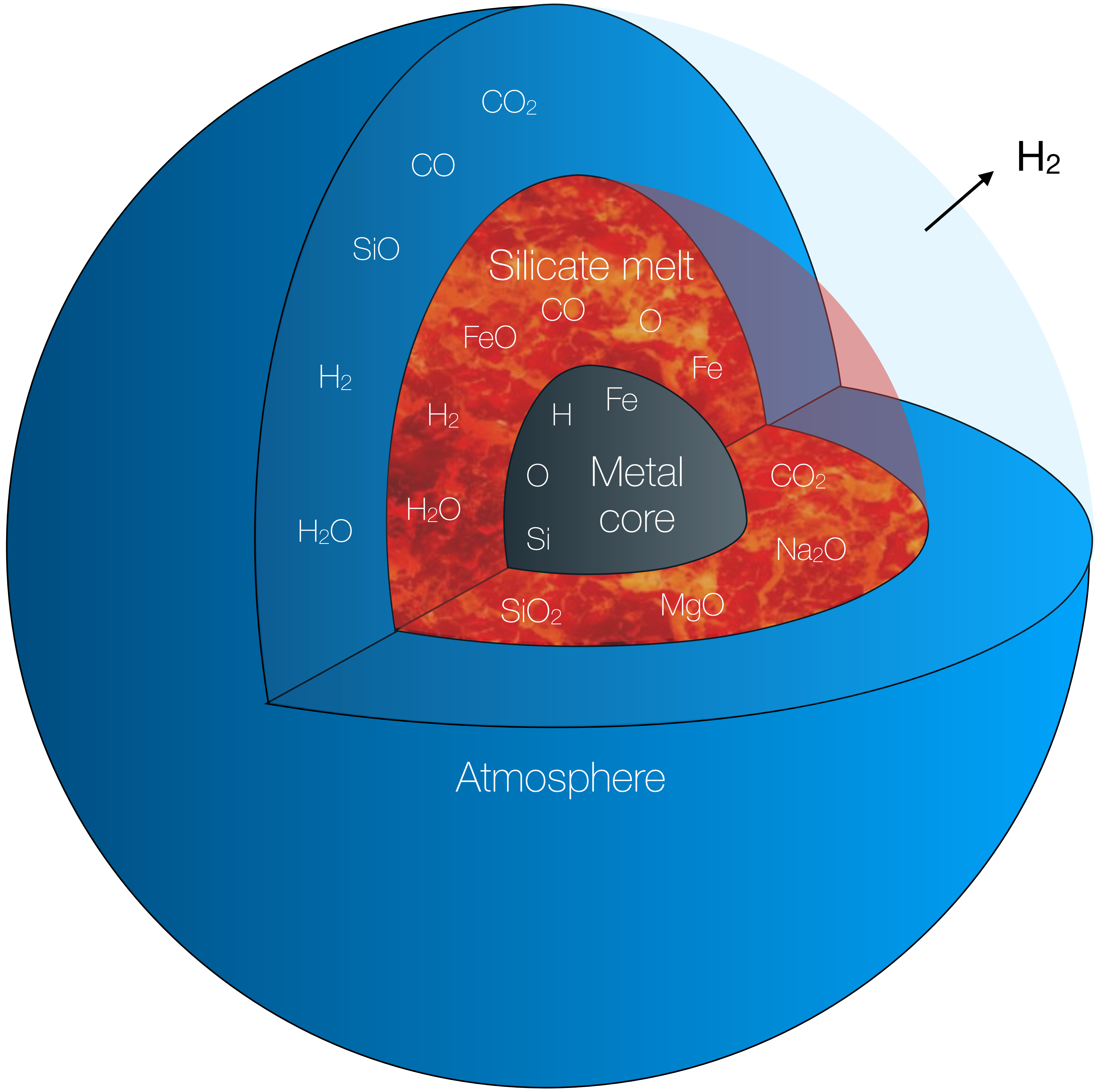
suggests that small planet interiors are slightly under-dense when compared to Earth

(A good example: TRAPPIST-1)

Why?

Can hydrogen *itself* explain this?

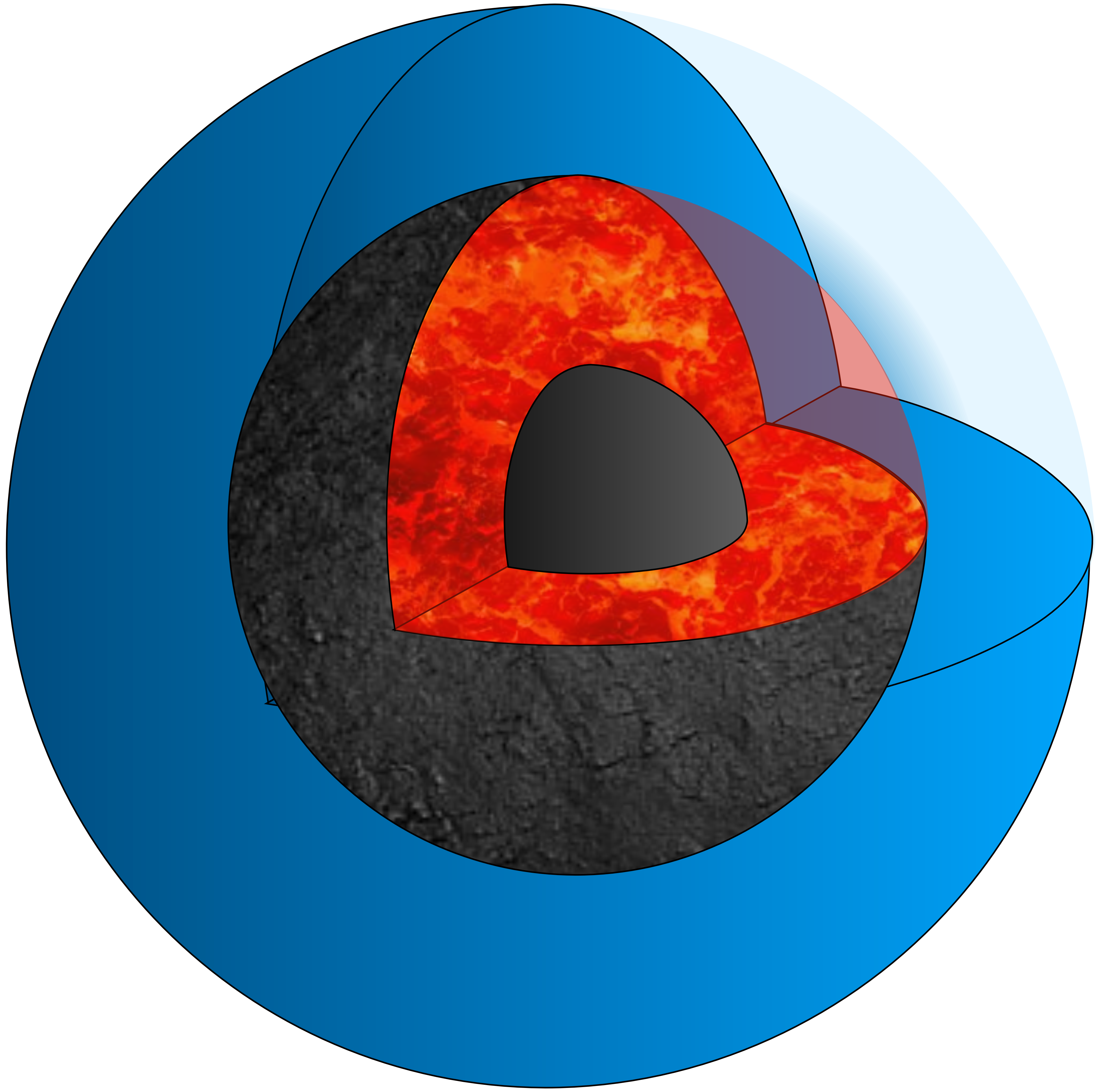
Can global chemical equilibrium explain under-dense super-Earths?



Rogers, Schlichting and Young (in prep.)

See Schlichting and Young (2021), Young et al. (2023)

Can global chemical equilibrium explain under-dense super-Earths?



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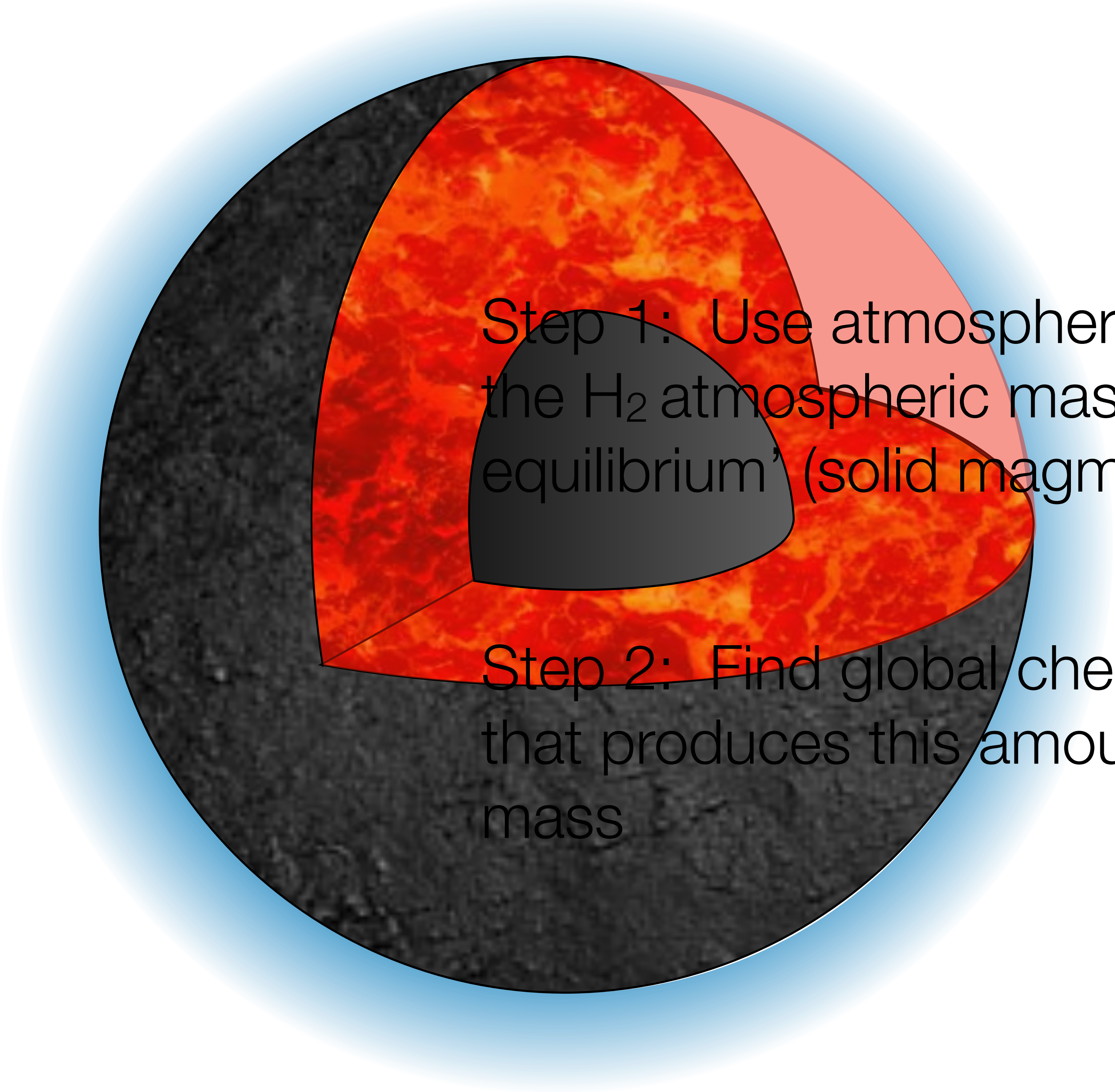

Step 1: Use atmospheric evolution models to determine the H_2 atmospheric mass at the 'time of final global equilibrium' (solid magma ocean surface)

Step 2: Find global chemical equilibrium state that produces this amount of H_2 atmospheric mass

Rogers, Schlichting and Young (in prep.)

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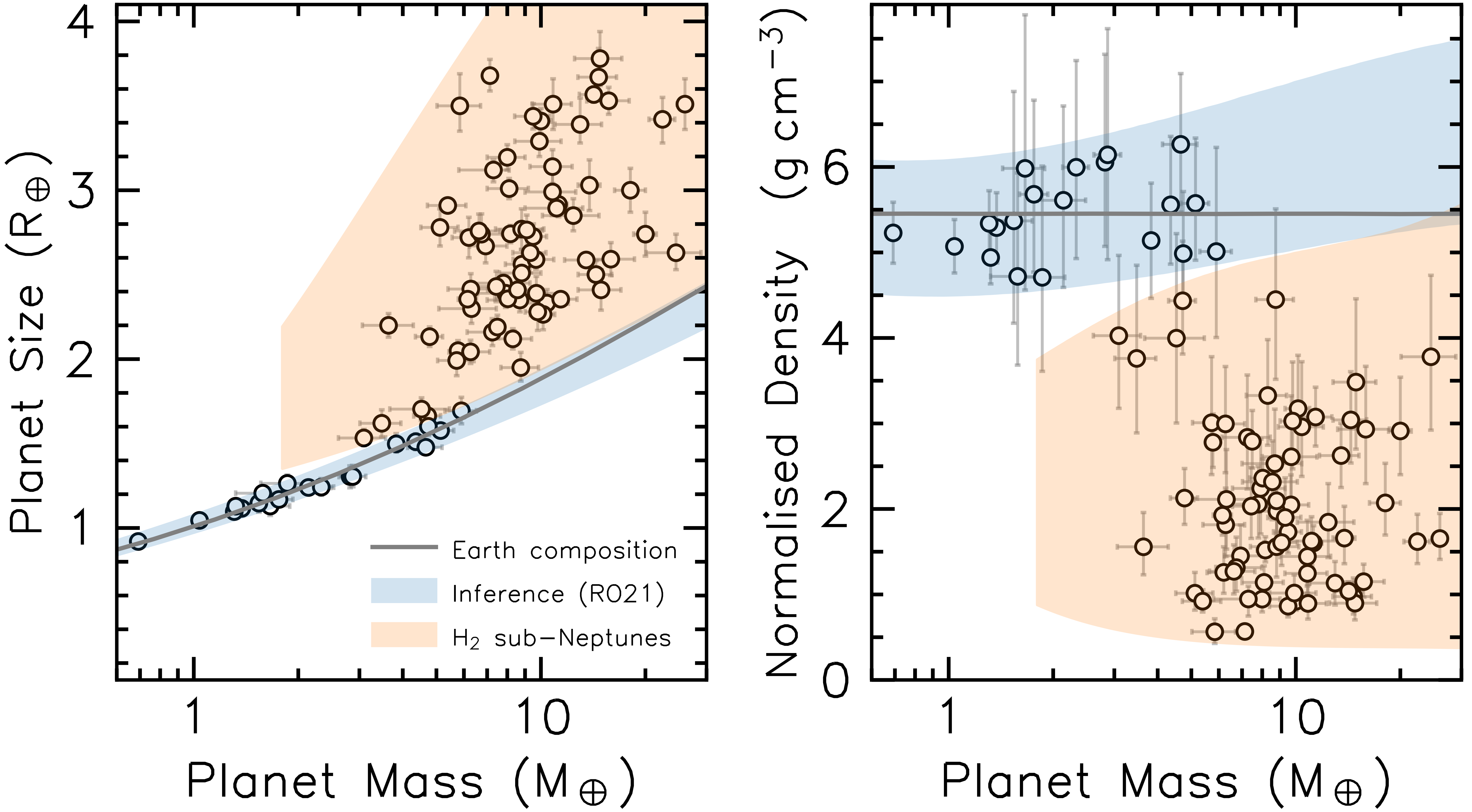

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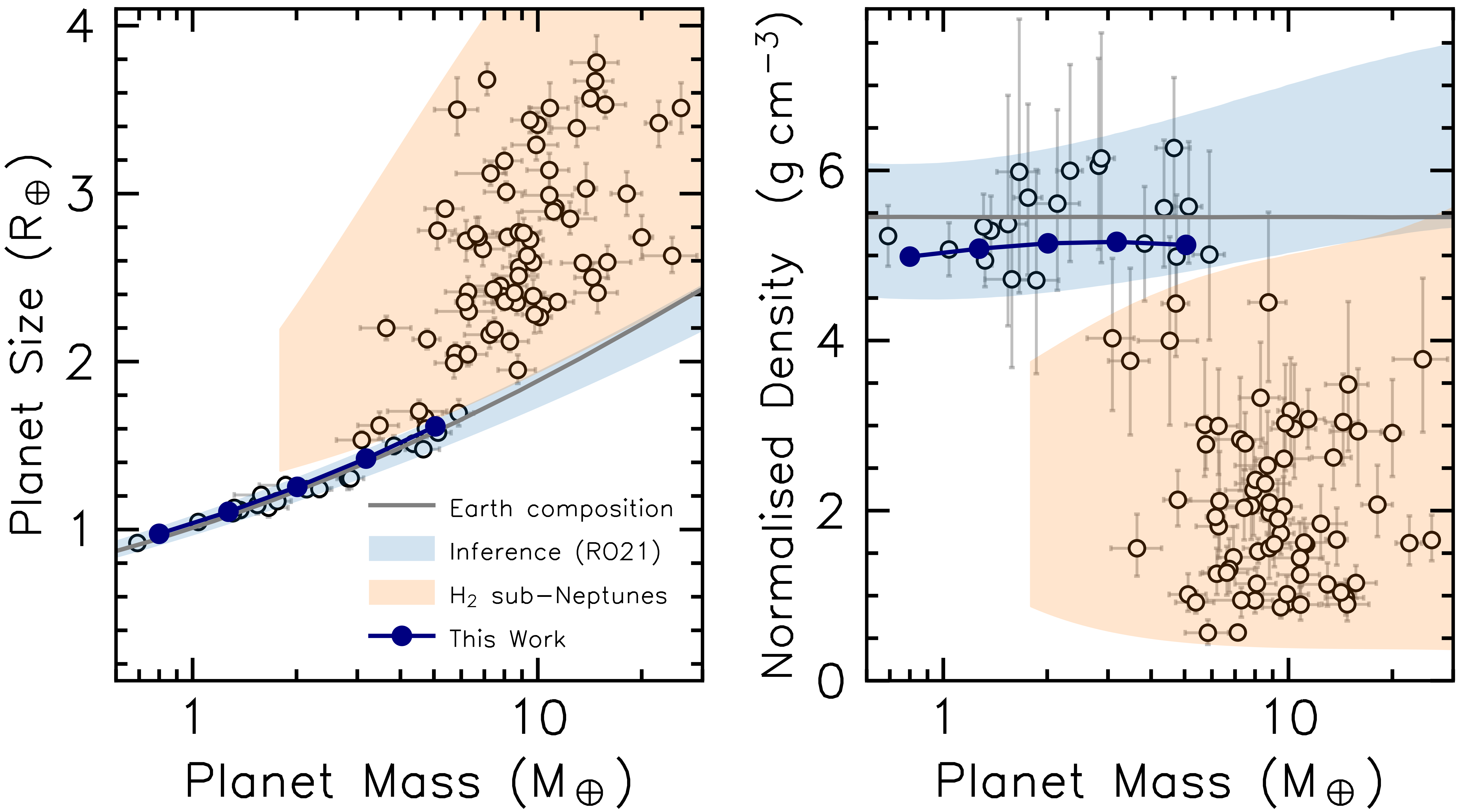

Rogers, Schlichting and Young (in prep.)

What is left behind?

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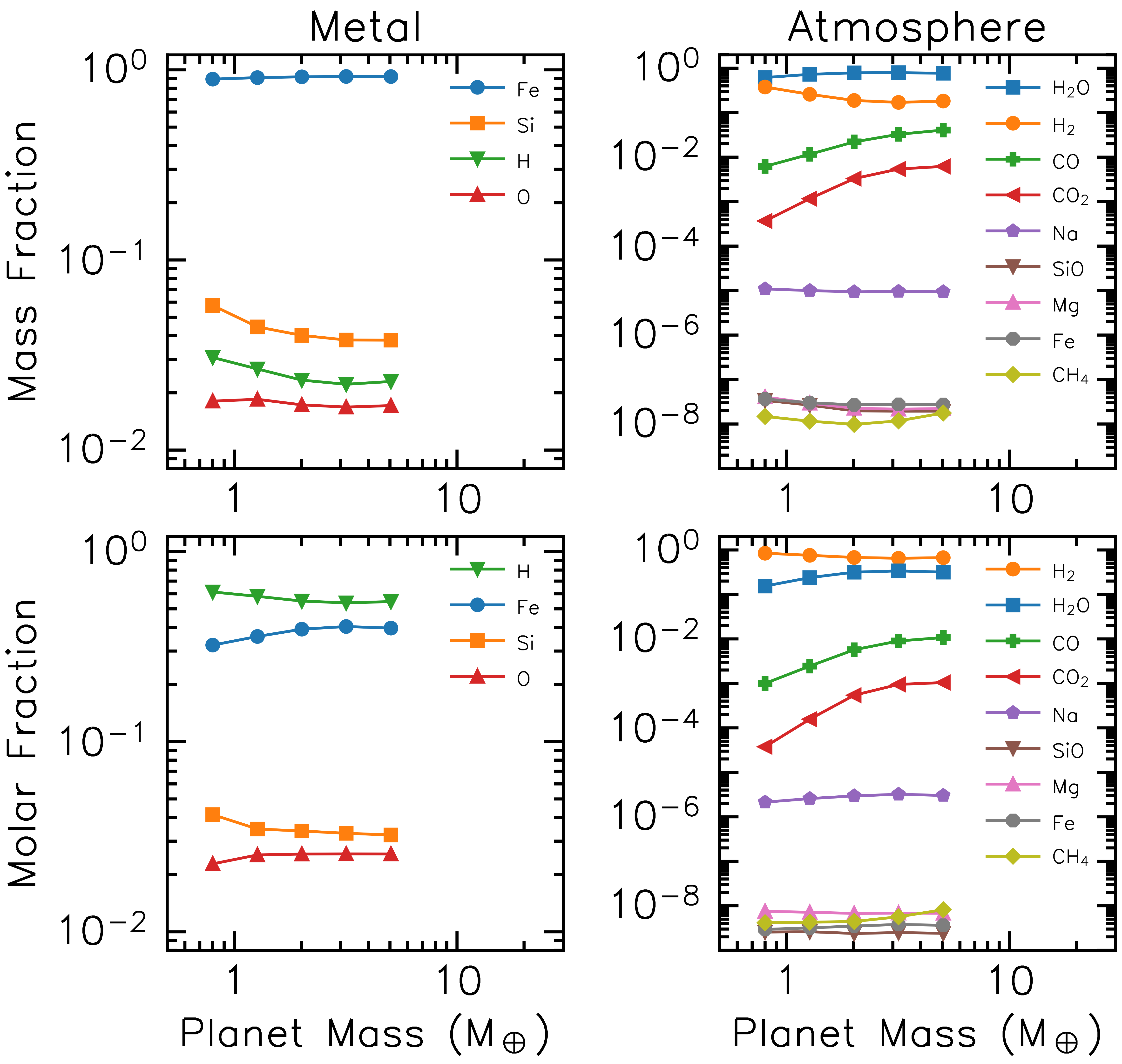

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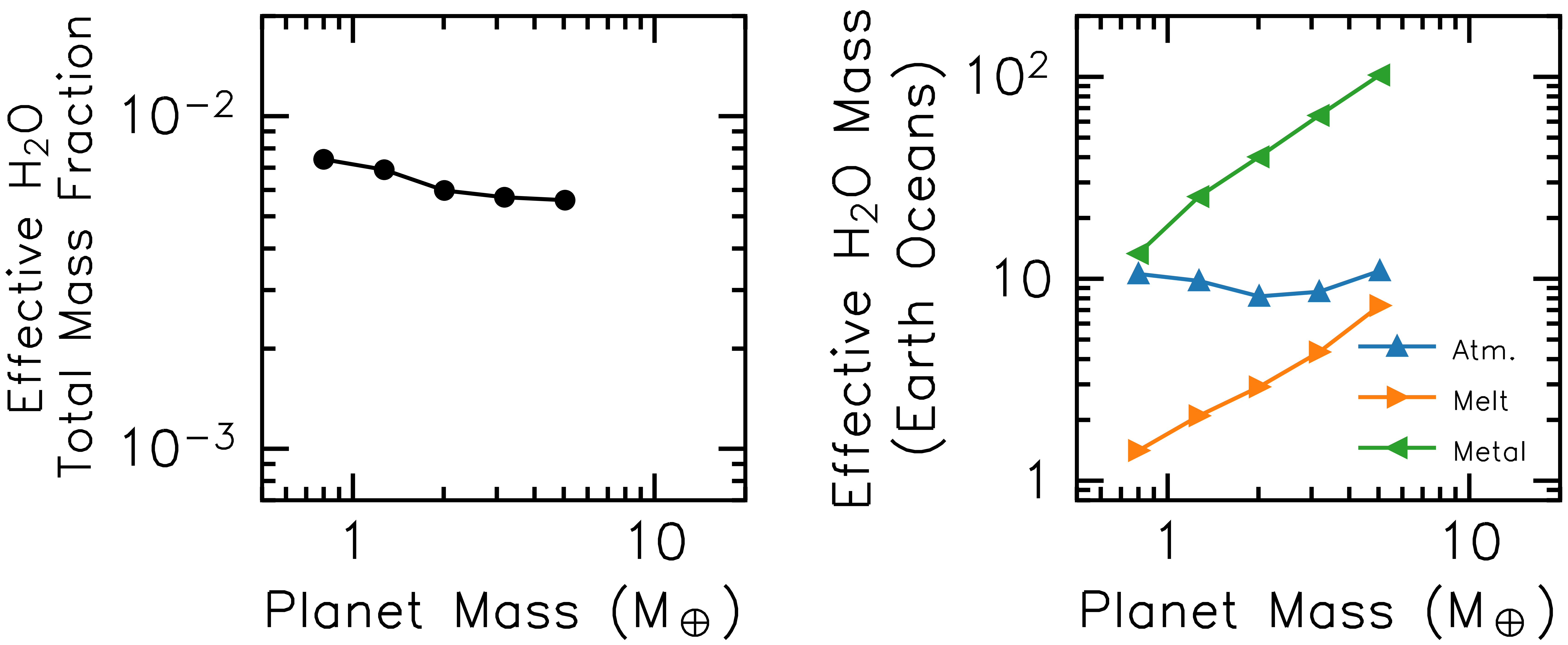
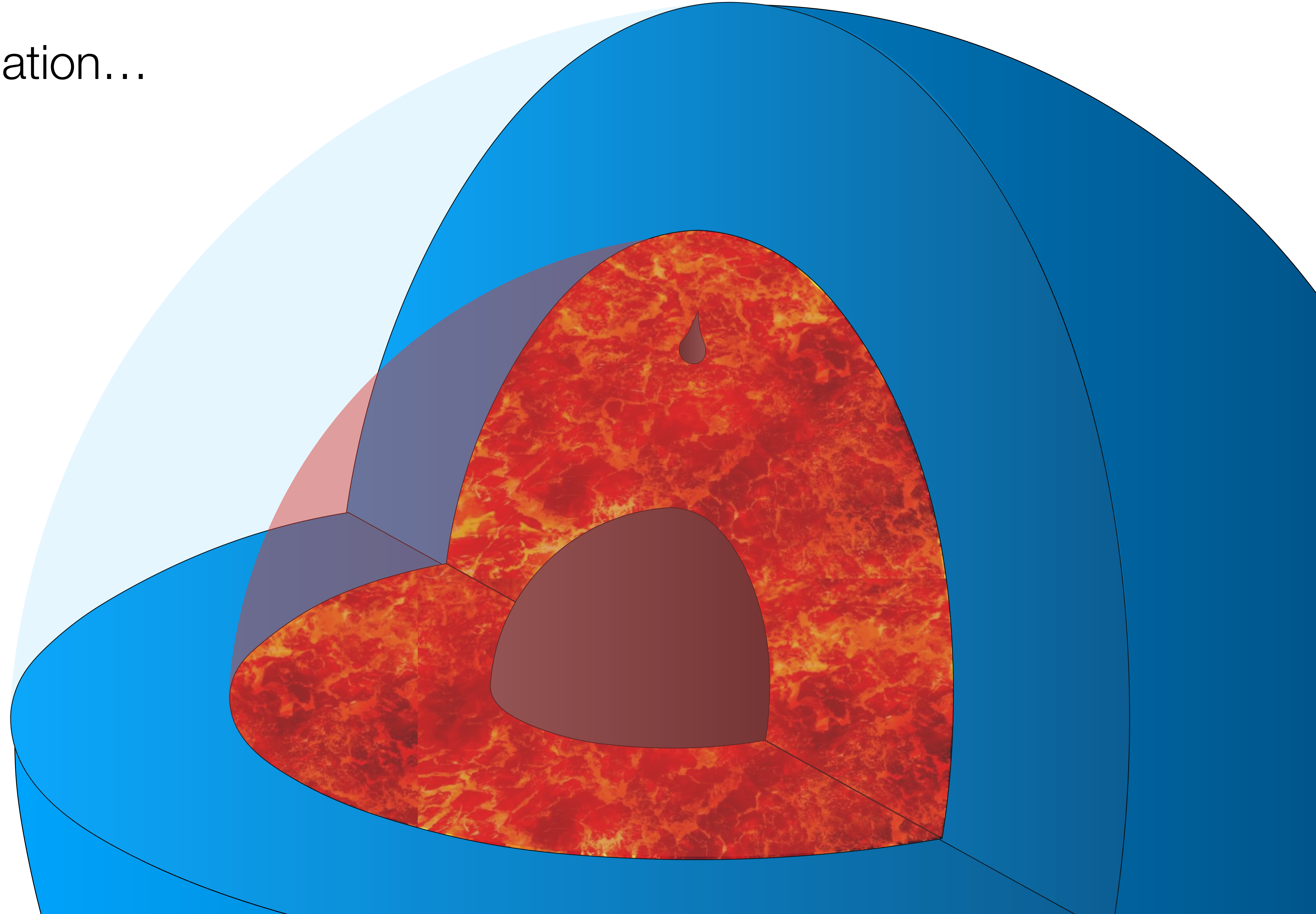


Rogers, Schlichting and Young (in prep.)

Some speculation…



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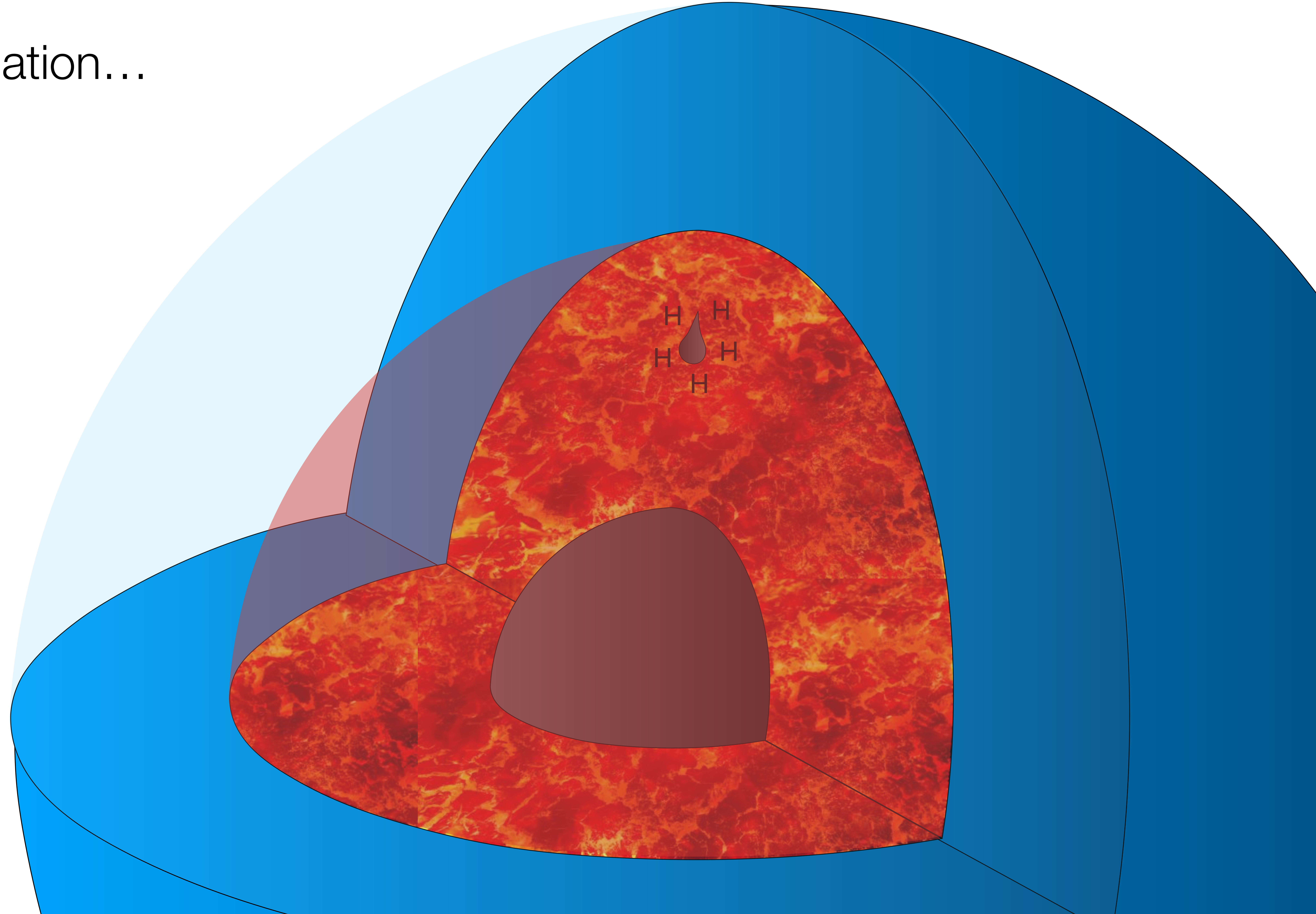
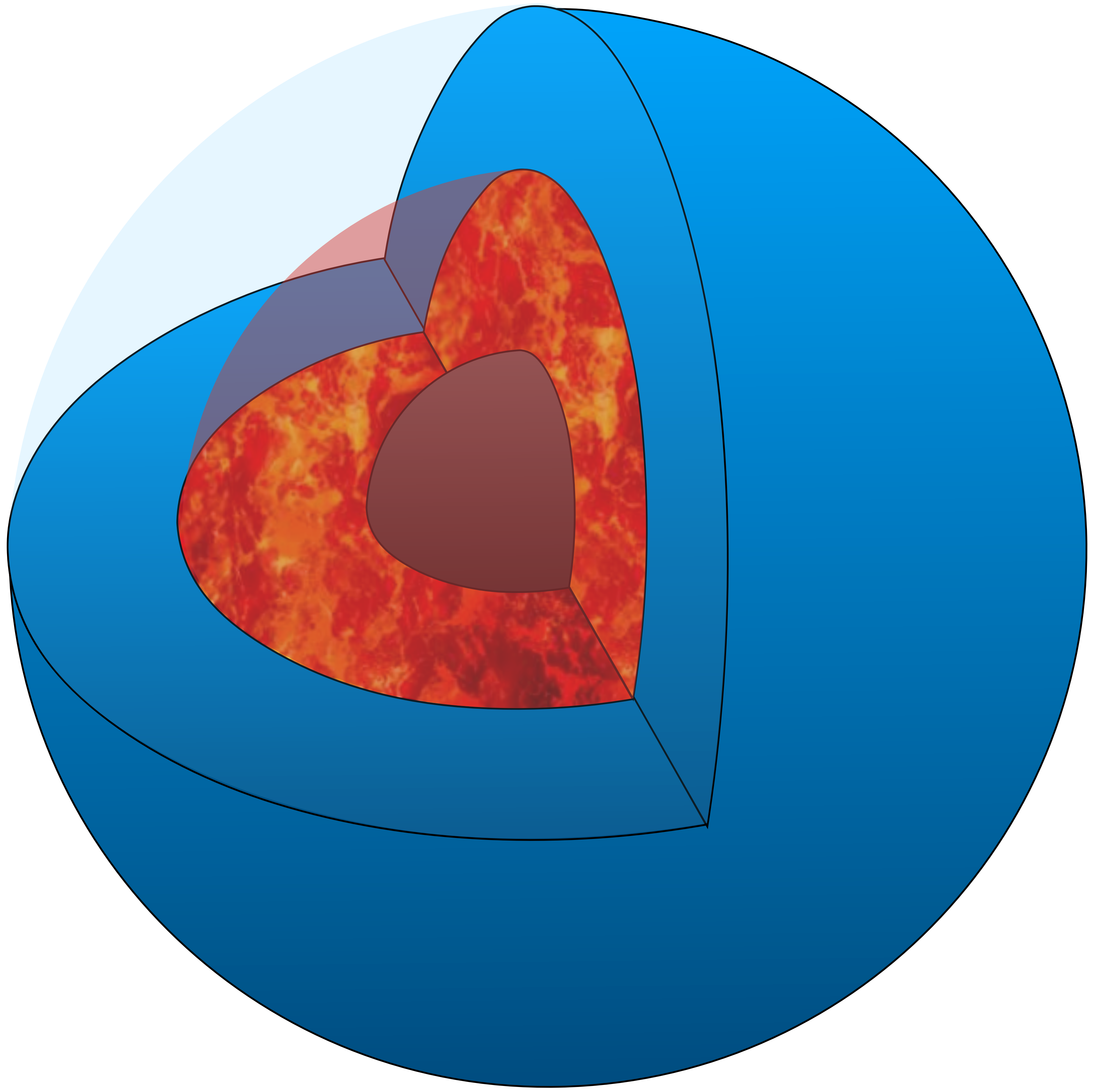


Conclusions

- Super-Earth interiors can be slightly under-dense when compared to Earth.
- As H_2 escapes, it is also sequestered into the interior, reducing overall bulk density.
- This produces abundant H_2O, and steam-dominated atmospheres.



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