The Impact of Escaping Hydrogen Atmospheres on super-Earth Interiors

James Rogers
The tale of hydrogen…

Solid core accretion

Gas accretion

Boil-off

Photoevaporation + Core-powered mass-loss

Rogers, Owen & Schlichting (2023)
The tale of hydrogen...
The tale of hydrogen…

- Core Mass
- Atmospheric Mass Fraction
- Core Density

Draw Random Planets

EUV/X-Ray Evolution
The tale of hydrogen…

“Observe” Planets with Kepler

Compare with real Kepler data
The tale of hydrogen…

“Observe” Planets with Kepler

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The tale of hydrogen…

Hierarchical Inference Model

“Observe” Planets with Kepler

Compare with real Kepler data

Synthetic Data

Real Kepler Data
The tale of hydrogen…

Rogers and Owen (2021)

Mean Core Composition ($\mu \Omega$)

Marginalised Posterior

Core Composition Standard Deviation ($\sigma \Omega$)

Mass Loss Index ($\xi \¥$)

$\xi \¥ < 1.36$

Ice

Iron

100% Ice

50% Ice

50% Silicate

100% Silicate

50% Silicate

50% Iron

100% Iron

Earth Composition: 33% Iron, 67% Silicate

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Iron, 67% Silicate

The tale of hydrogen…
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Rogers et al. (2023) Earth Composition: 33% Iron, 67% Silicate

Rogers and Owen (2021)
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)
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What is left behind?

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Some speculation…

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Some speculation…
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$_2$O, and steam-dominated atmospheres.