Understanding the origins of the radius valley

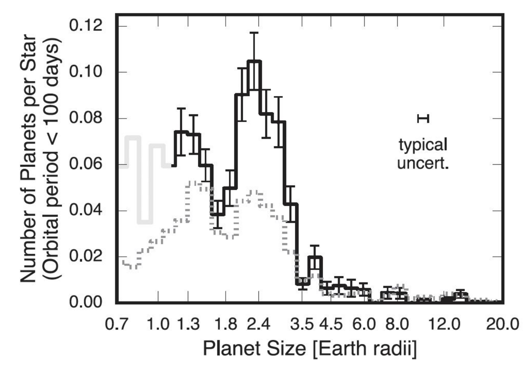
Jesper Nielsen[1], Anders Johansen[1,2]

[1]Center for Star and Planet Formation, Globe Institute, University of Copenhagen, Øster Voldgade 5-7, 1350 Copenhagen, Denmark
[2]Lund Observatory, Department of Physics, Lund University, Box 43, 22100 Lund, Sweden

Previous work

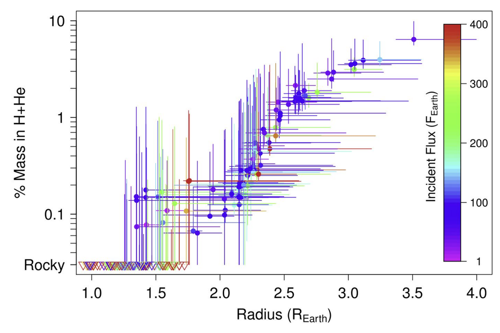
Context

- A radius valley has been observed for close-in planets



Fulton & Petigura (2018)

- Planets smaller than the valley are generally thought to be bare while those larger are thought to host an atmosphere



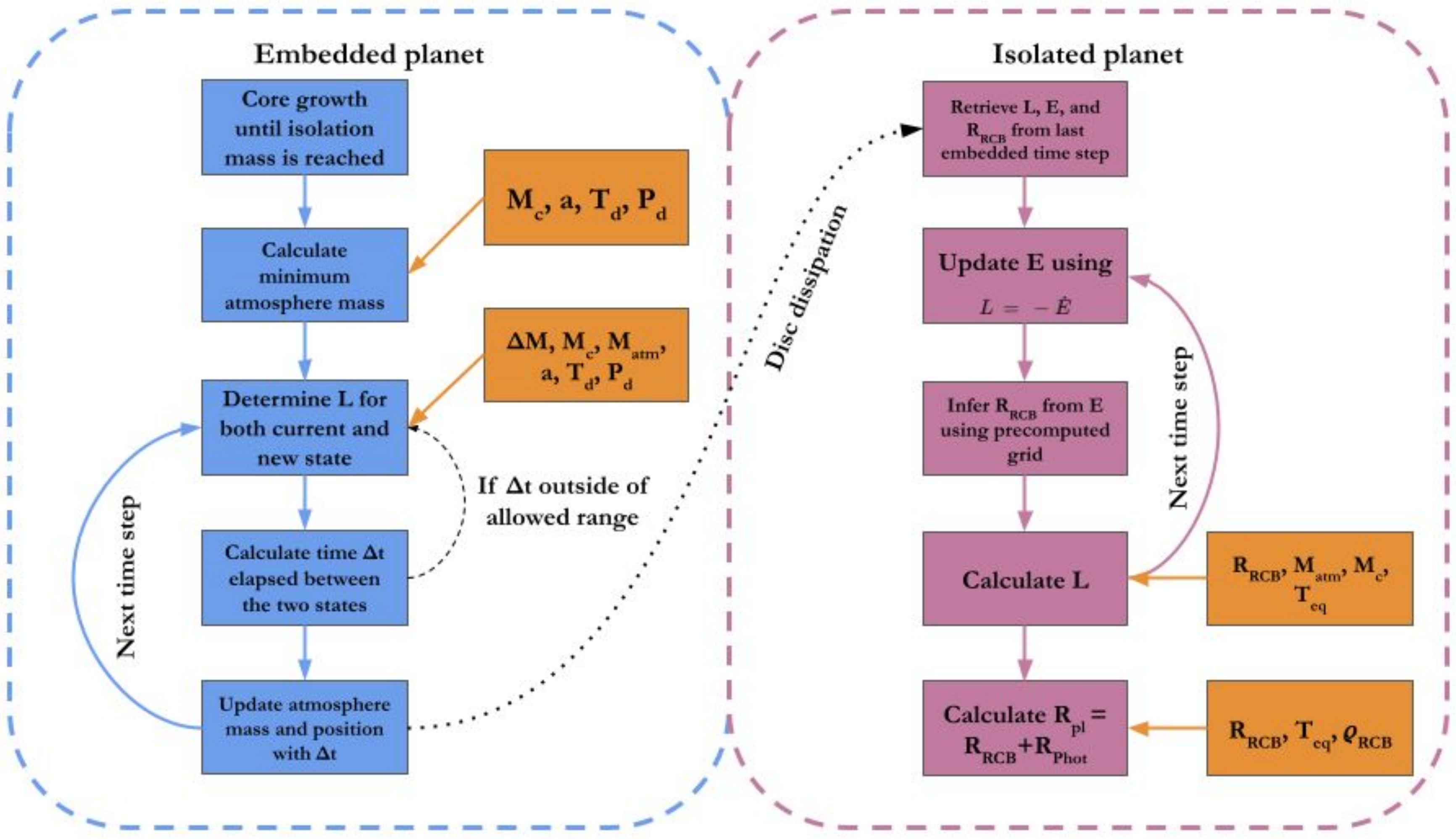
Wolfgang & Lopez (2015)

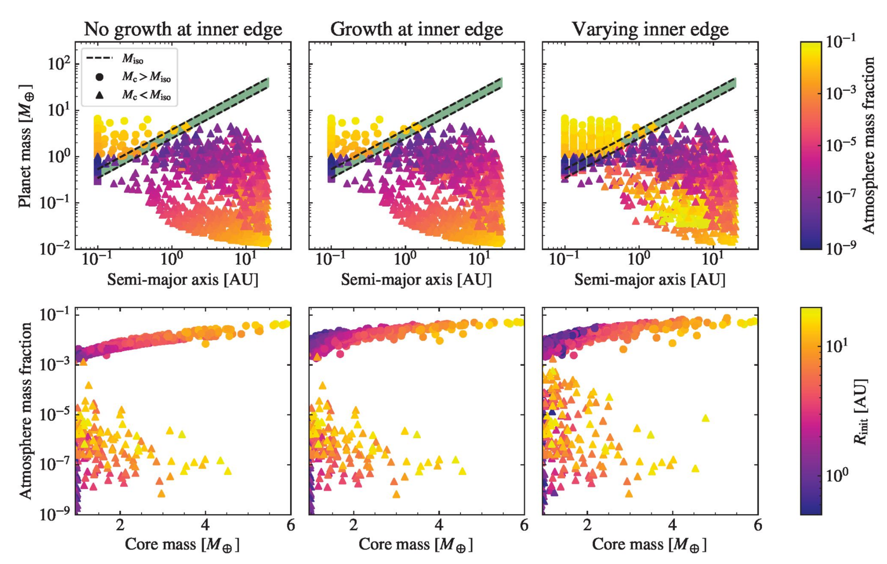
Hypothesis

- Previous work (e.g. Owen & Wu, 2017; Ginzburg et al. 2018) have mostly focused on explaining how planets *lose* their atmospheres
- Recent work (Lee et al. 2022) however, suggests that the radius valley might be a primordial feature
- Planet formation from pebble accretion naturally explains a division between planets without an atmosphere and planets with an accreted atmosphere through the pebble isolation mass M_{iso}
- We therefore want to test whether the radius valley emerges from planet formation models without any need for mass loss

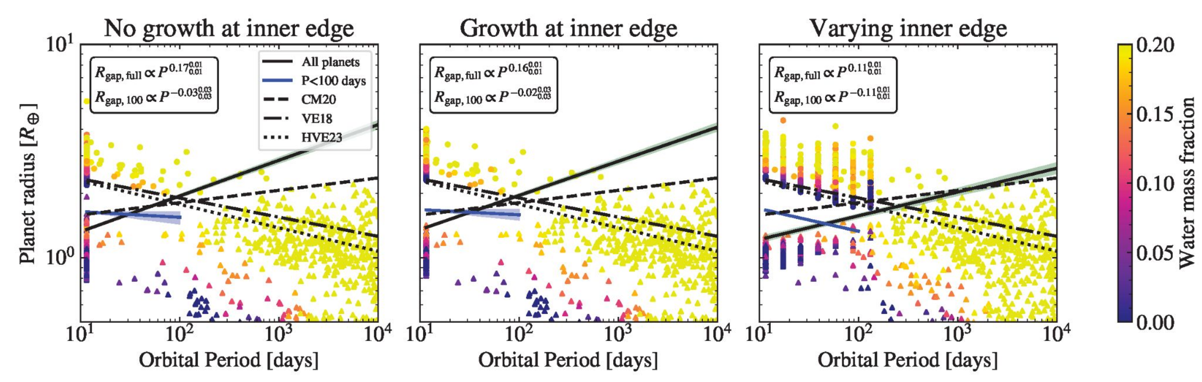
Method

- Grow planets through pebble accretion taking into account:
  - Inwards migration (type I and II)
  - Sublimation of pebbles across ice lines
  - …and more! (see Nielsen et al. (2023) for details)
- Once M_{iso} is reached: start gas accretion according to Piso & Youdin (2014)
- Integrate atmosphere inwards in order to find luminosity, which sets gas accretion rate
  - Use opacities from Bell & Lin (1994)
- Consider 3 different models:
  - Fixed inner edge, no growth at inner edge
  - Fixed inner edge, growth at inner edge
  - Varying inner edge, growth at inner edge
- After disc dissipation: calculate luminosity and energy and evolve the radius over time



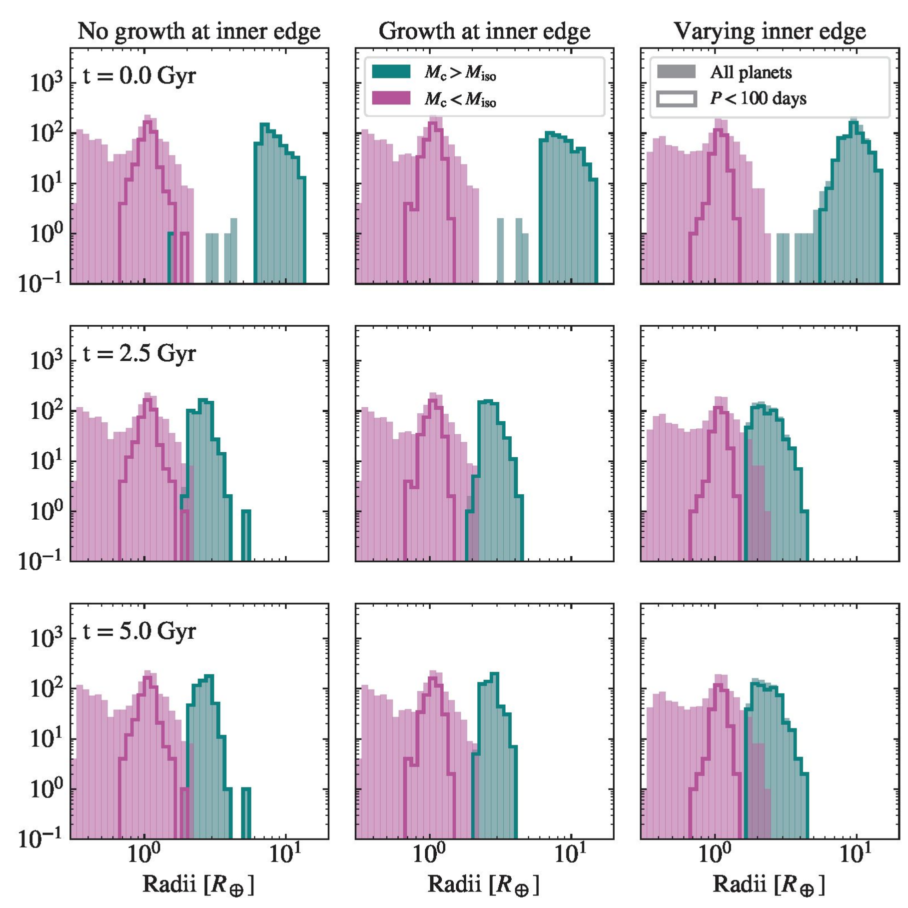


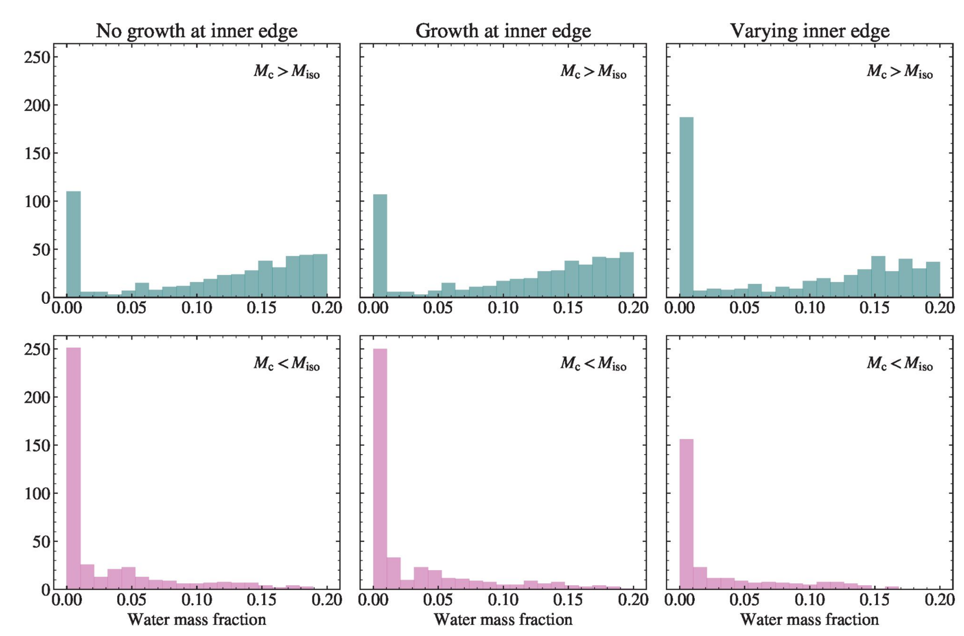
- Migration limits atmosphere growth
- Halting migration further out allows for more efficient growth
- Overall low atmosphere mass fractions, in line with observations



- Fitting the slope in the full population nearly recovers pebble isolation mass scaling
- Limiting the data to close-in planets changes the direction of the slope

- Initially, all planets are highly inflated, but contract quickly
- The final planet radius distribution show a clear gap, in the same location as observations
- Radius valley shallower for full population
- When the inner edge is varied, we don't retrieve the sharp decline for planets larger than ~2.4 $R_\oplus$ as their atmospheres are too massive to contract significantly
  - Might point towards mass loss being needed





- Bare planets: mostly rocky
- Planets with atmospheres can be both rocky and water-rich

Conclusions

- Radius valley emerges without the need for mass loss - although mass loss is still expected
- Migration plays a significant role in shaping the planet population
- The observed radius valley slope might simply be a detection bias due to the lack of observations of wide orbit planets
- Small, bare planets are generally rocky while planets with atmospheres can be both rocky and water rich

References

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For further information

Please don't hesitate to come up and talk to me if you see me!

Also e-mail: jesper.nielsen@sund.ku.dk
UNIVERSITY OF COPENHAGEN
Center for Star and Planet formation, Globe Institute

Thank you for reading all the way to the end!
Here's a bonus picture of my dog