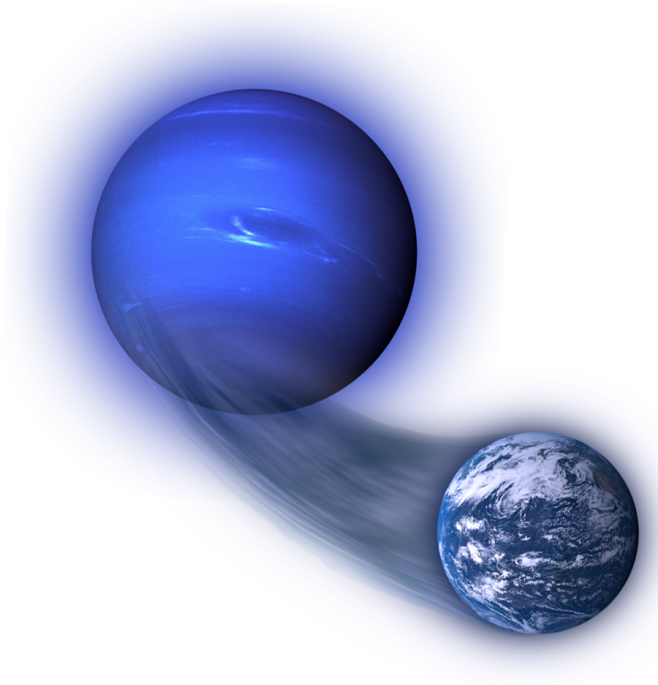

Habitable Evaporated Cores

*Converting **Mini-Neptunes** into **Super-Earths** in the Habitable Zone of M Dwarfs*

223rd AAS — January 8, 2014

Rodrigo Luger, Rory Barnes, Eric Lopez, Jonathan Fortney, Brian Jackson, *and* Victoria Meadows

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The Big Picture

M dwarfs: the best targets — Terrestrial planets are easiest to detect around low-mass stars

In situ formation unlikely — Rocky planets in the HZ could be small and volatile-poor

Raymond et al. (2007), Lissauer et al. (2007)

Planets can migrate — Gas-rich, volatile-rich planets can migrate into the HZ

Planets can lose mass — Roche lobe overflow and XUV-driven hydrodynamic escape

Erkaev et al. (2007), Lopez et al. (2012)

TESS — Observations of these planets are just around the corner

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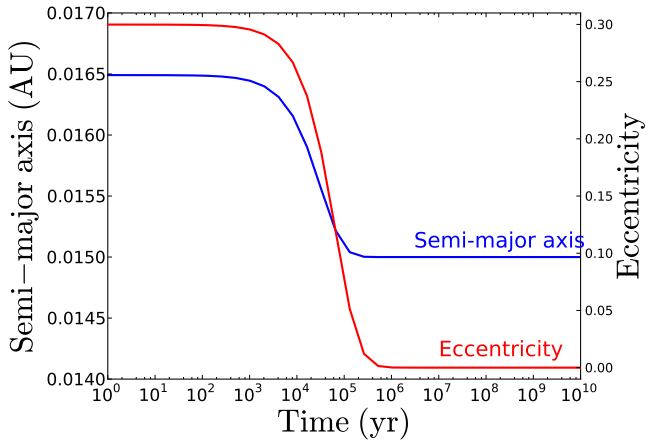
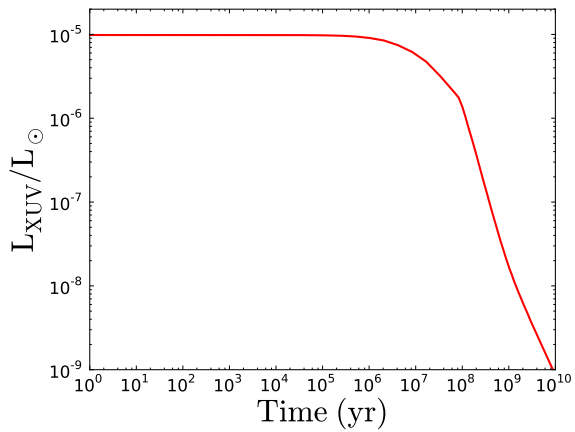
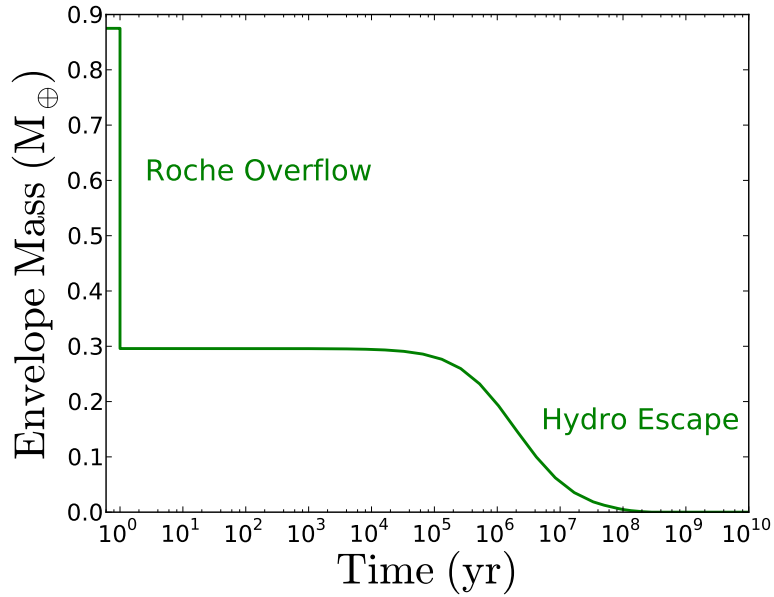
The Model







Parameters

$M_p = 3.5 M_\oplus$ $\quad f_{H_0} = 0.25$

$a_0 = 0.0165$ AU $\quad e_0 = 0.3$

$M_* = 0.08 M_\odot$ $\quad \tau_{CTL} = 1$ s

$L_{sat} = 10^{-3} L_*$ $\quad \epsilon_{XUV} = 0.3$

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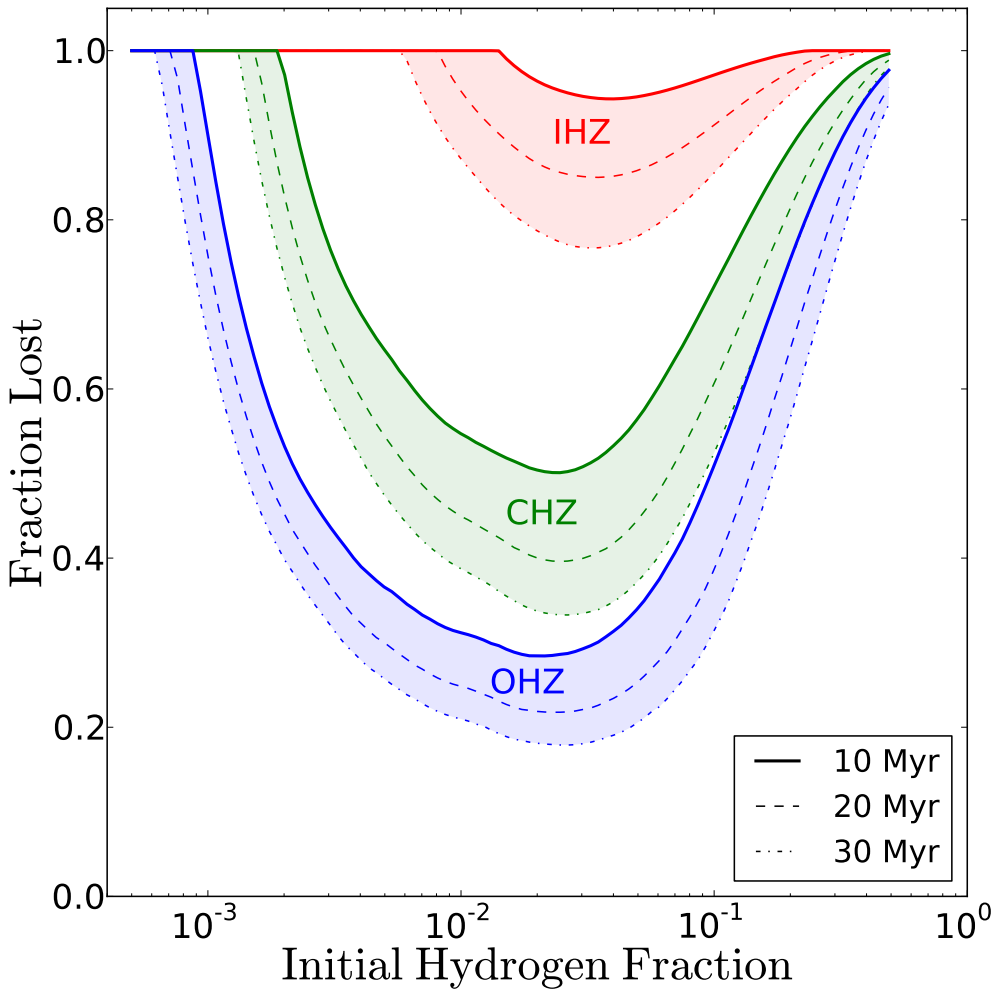
Forming a Habitable Planet



$M_p = 3.5 M_\oplus$ $\quad e_0 = 0$

$M_* = 0.08 M_\odot$ $\quad \tau_{CTL} = 1\,s$

$L_{sat} = 10^{-3} L_*$ $\quad \epsilon_{XUV} = 0.3$

Gas-rich mini-Neptunes that migrate **early** into the IHZ form super-Earths.

Let's take a closer look...

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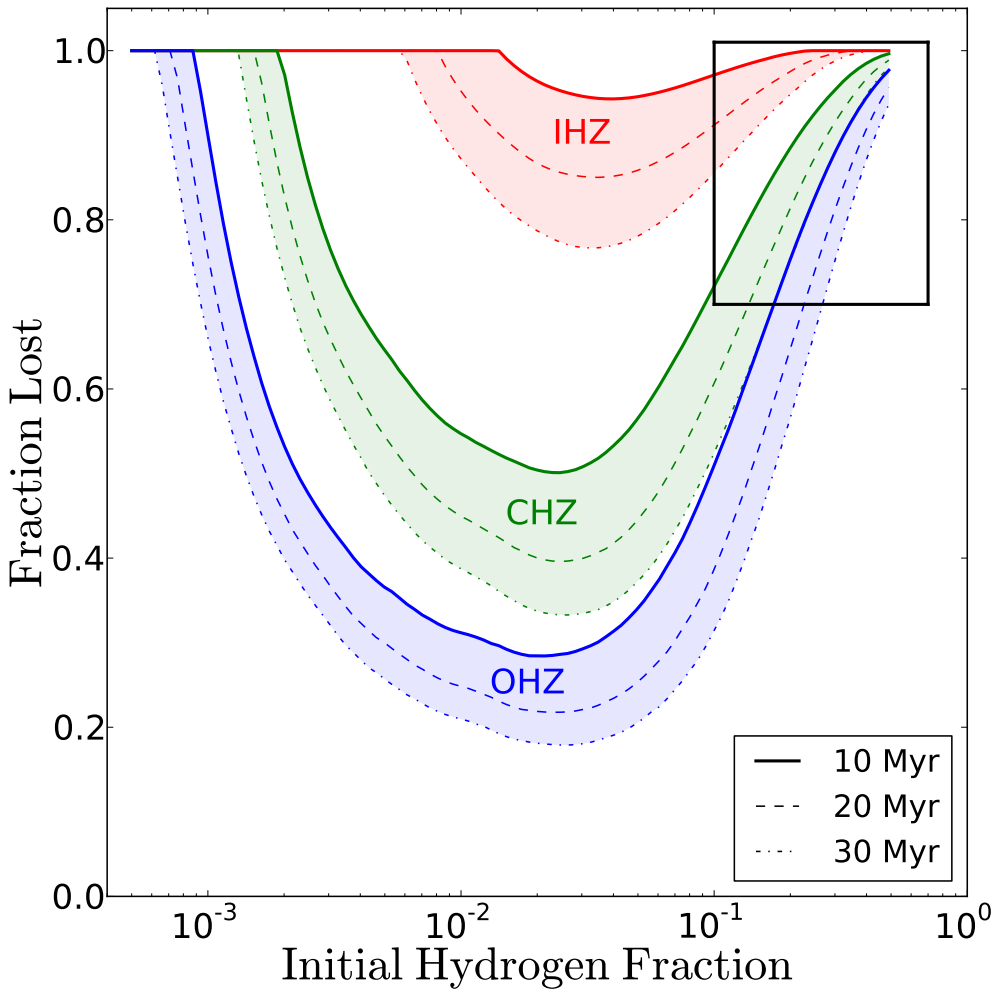
Forming a Habitable Planet



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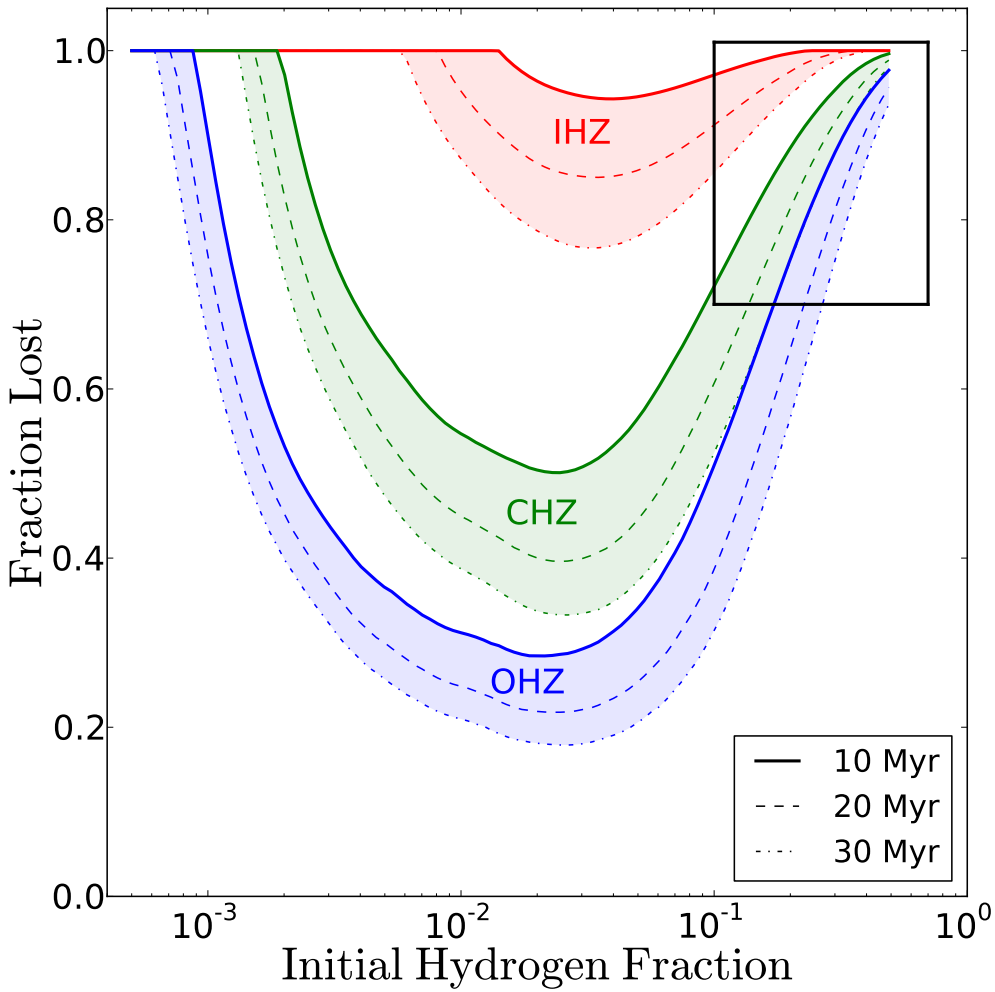

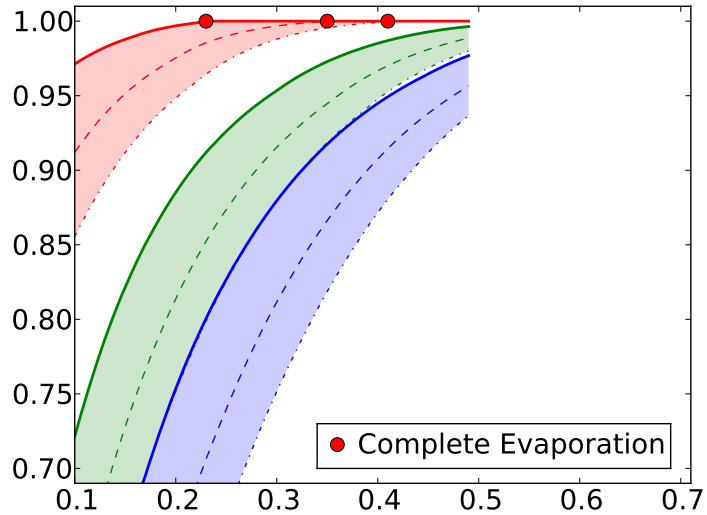

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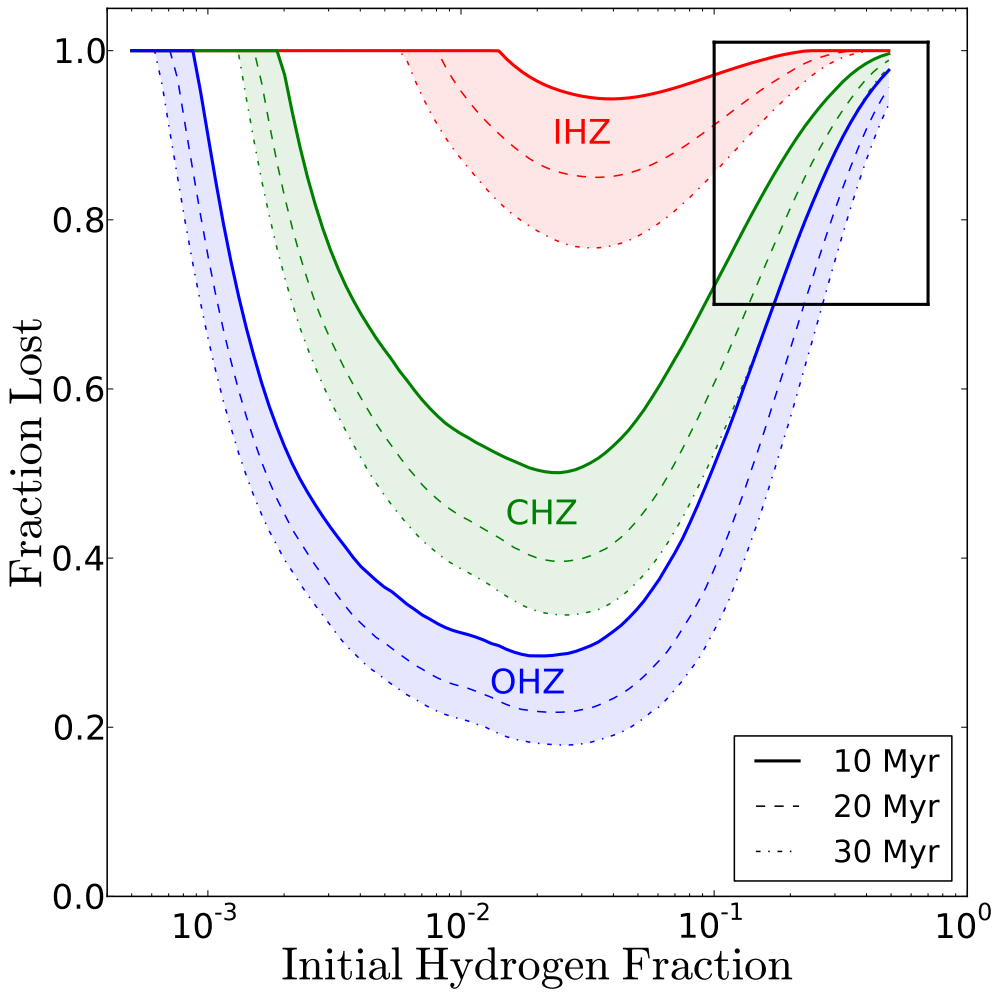
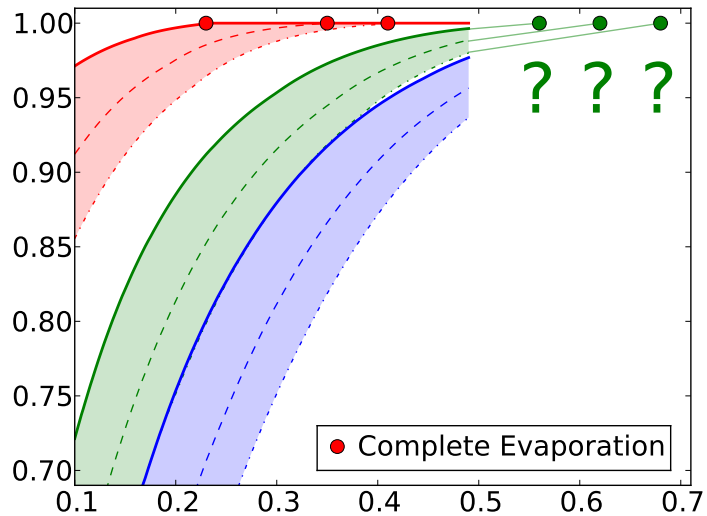
Forming a Habitable Planet





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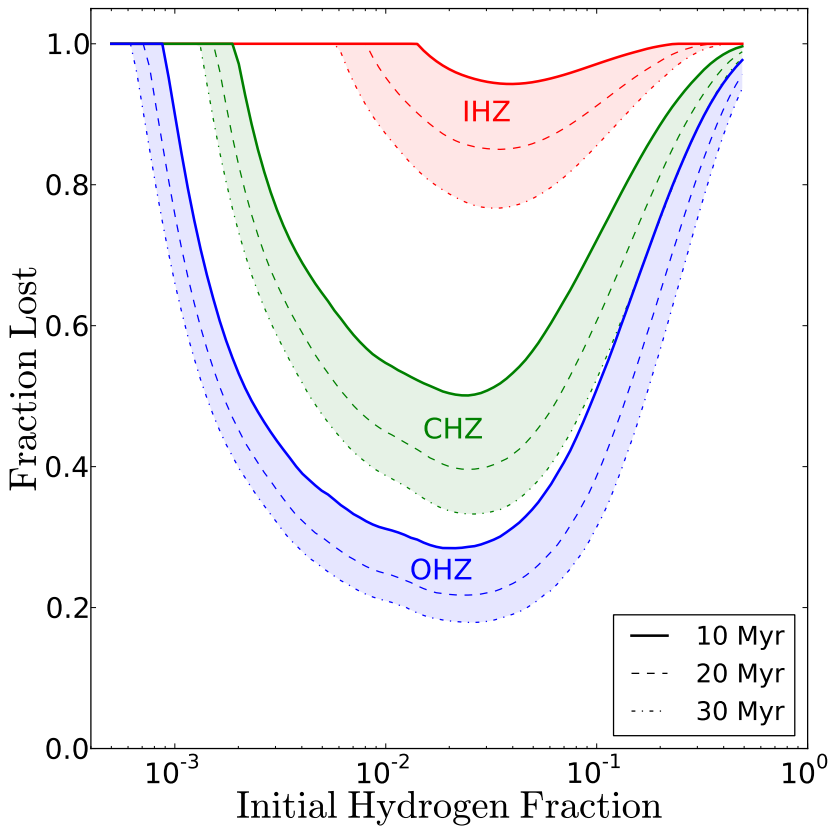
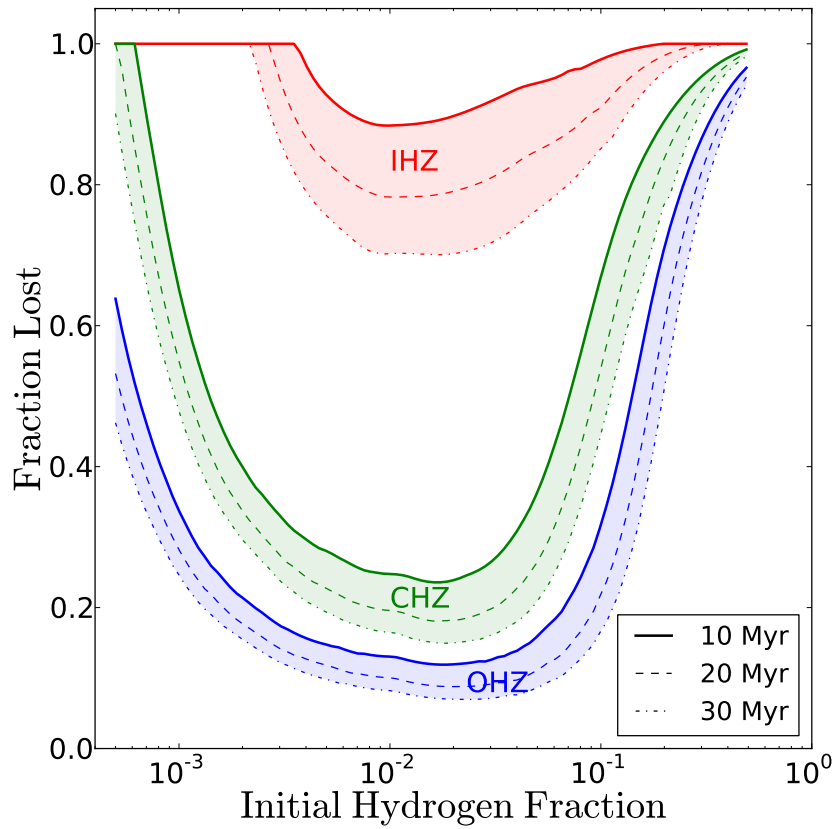
The Effect of Eccentricity

$e = 0$



$e = 0.7$



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Conclusions

- HECs can form from mini-Neptunes with $f_{H_0} \gtrsim 0.25$ **scattered** into the HZ of $M \lesssim 0.2 M_\odot$ M dwarfs
- HECs more likely for **high** f_{H_0}
- HECs form **early** ($t \lesssim 50$ Myr)
- Hydrodynamic escape, Roche lobe overflow, tidal evolution and thermal evolution all play a **critical** role in forming HECs
- This process may be the primary mechanism for the formation of **habitable planets** around M dwarfs.
- HECs may be observed in the **next few years**

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