A compositional link between rocky exoplanets and their host stars

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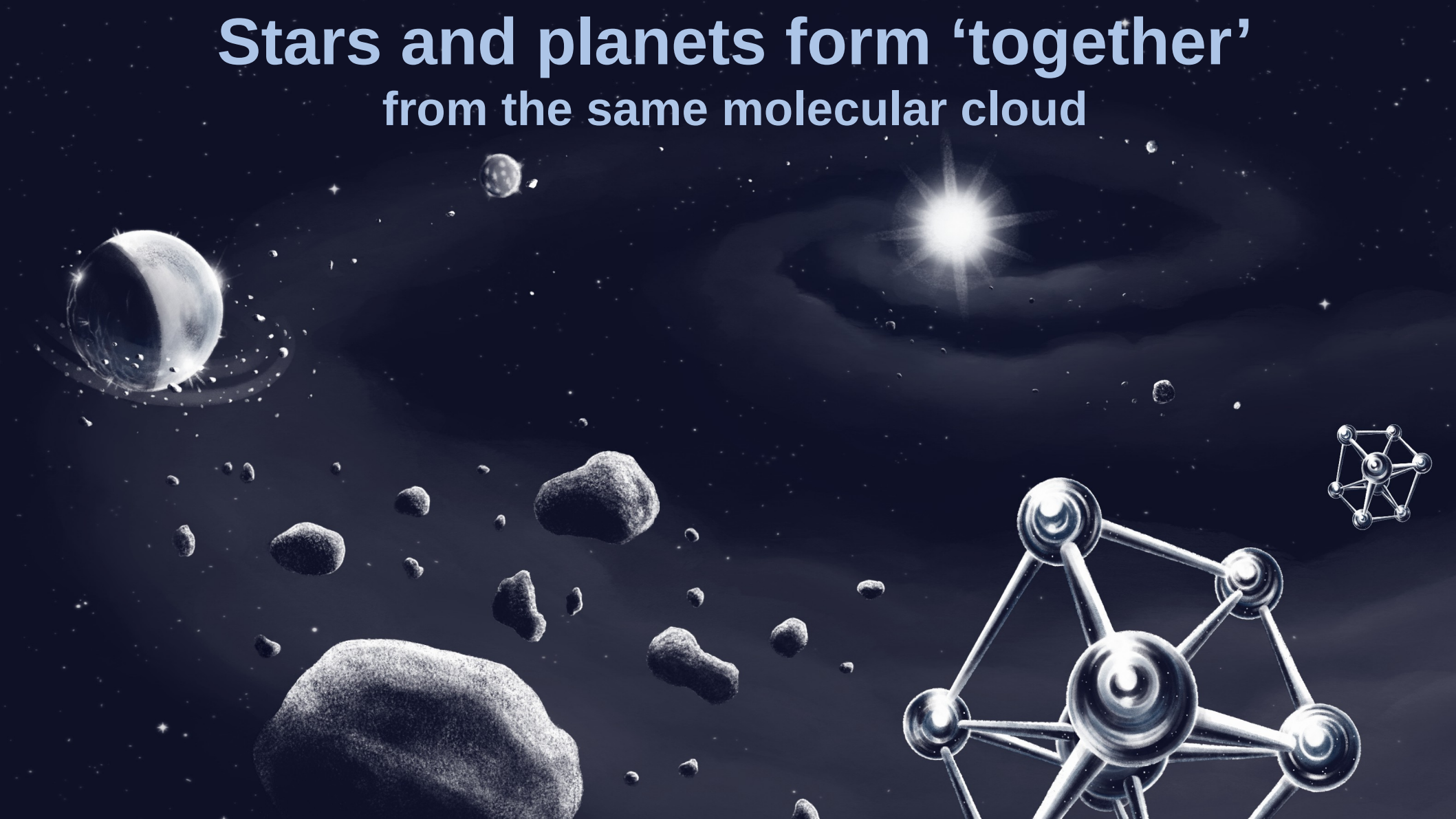
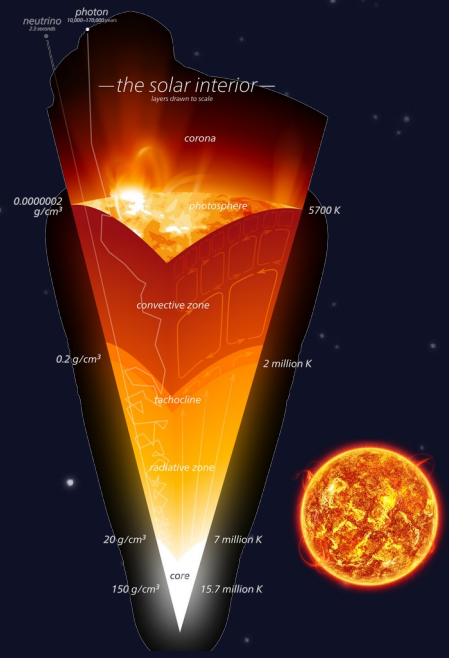
Stars and planets form ‘together’

from the same molecular cloud



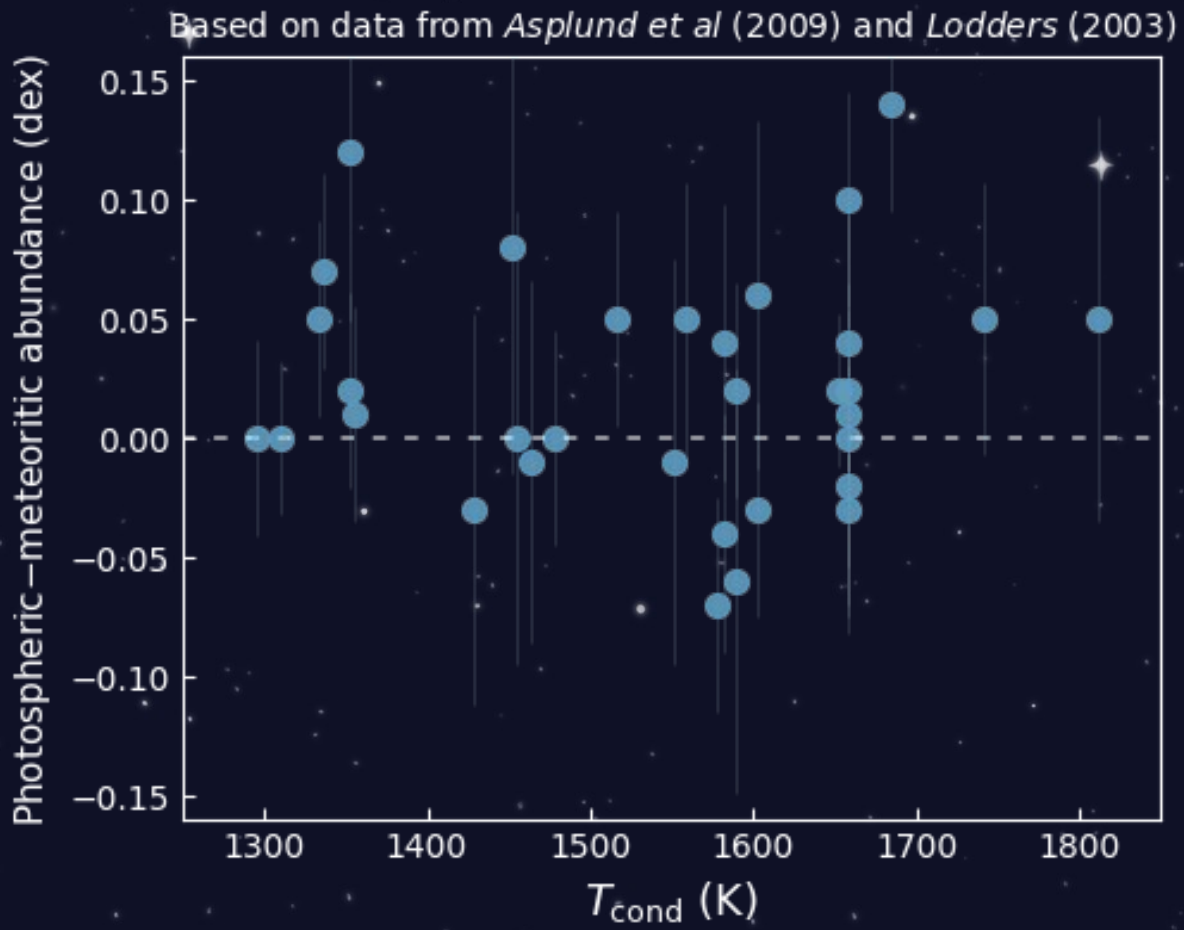
Bulk composition of the Sun and Earth

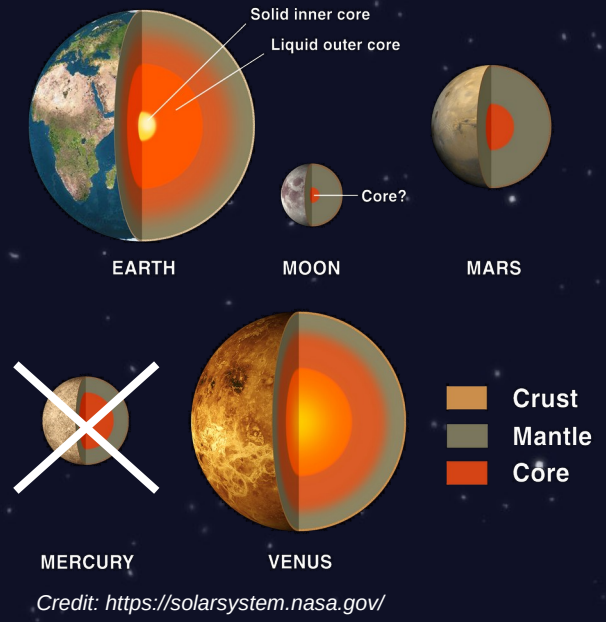


H: ~73.8 %
He: ~24.8 %
Metals: ~1.3 %

Fe: ~32 %
O: ~29 %
Si: ~15 %

The composition of Solar System objects

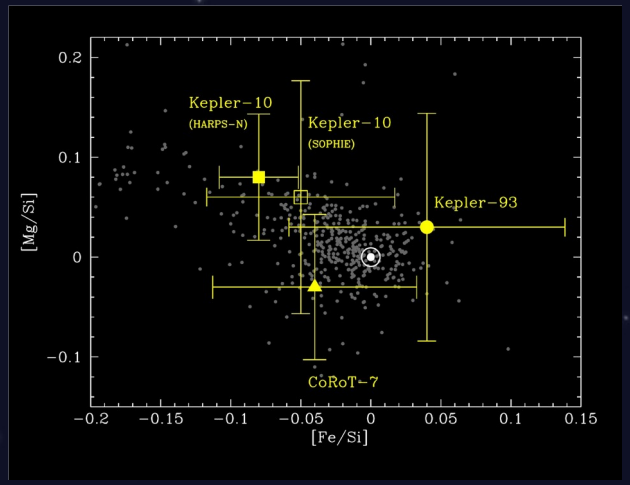




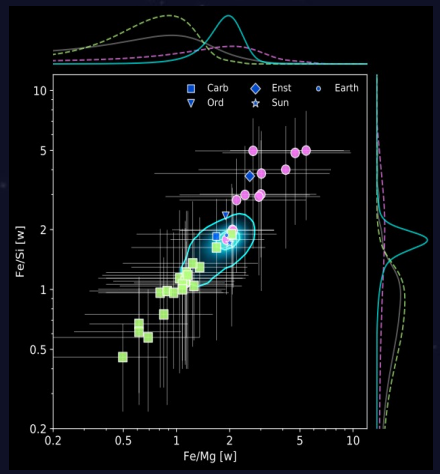
Credit: https://solarsystem.nasa.gov/

Mg/Si and Fe/Si ratios similar to the Sun

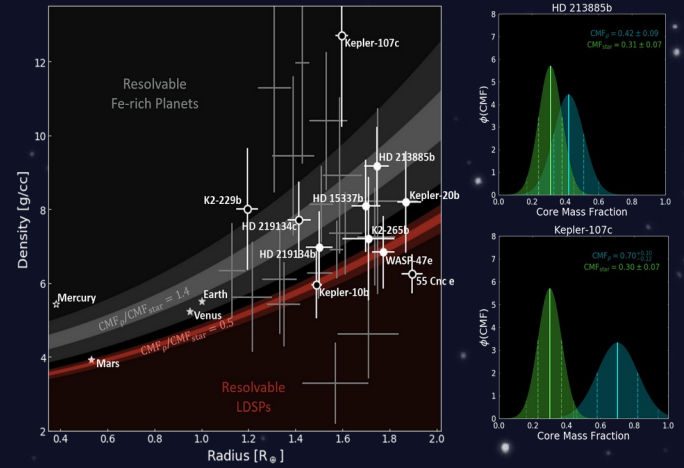
Previous works



Santos, Adibekyan et al (2015)

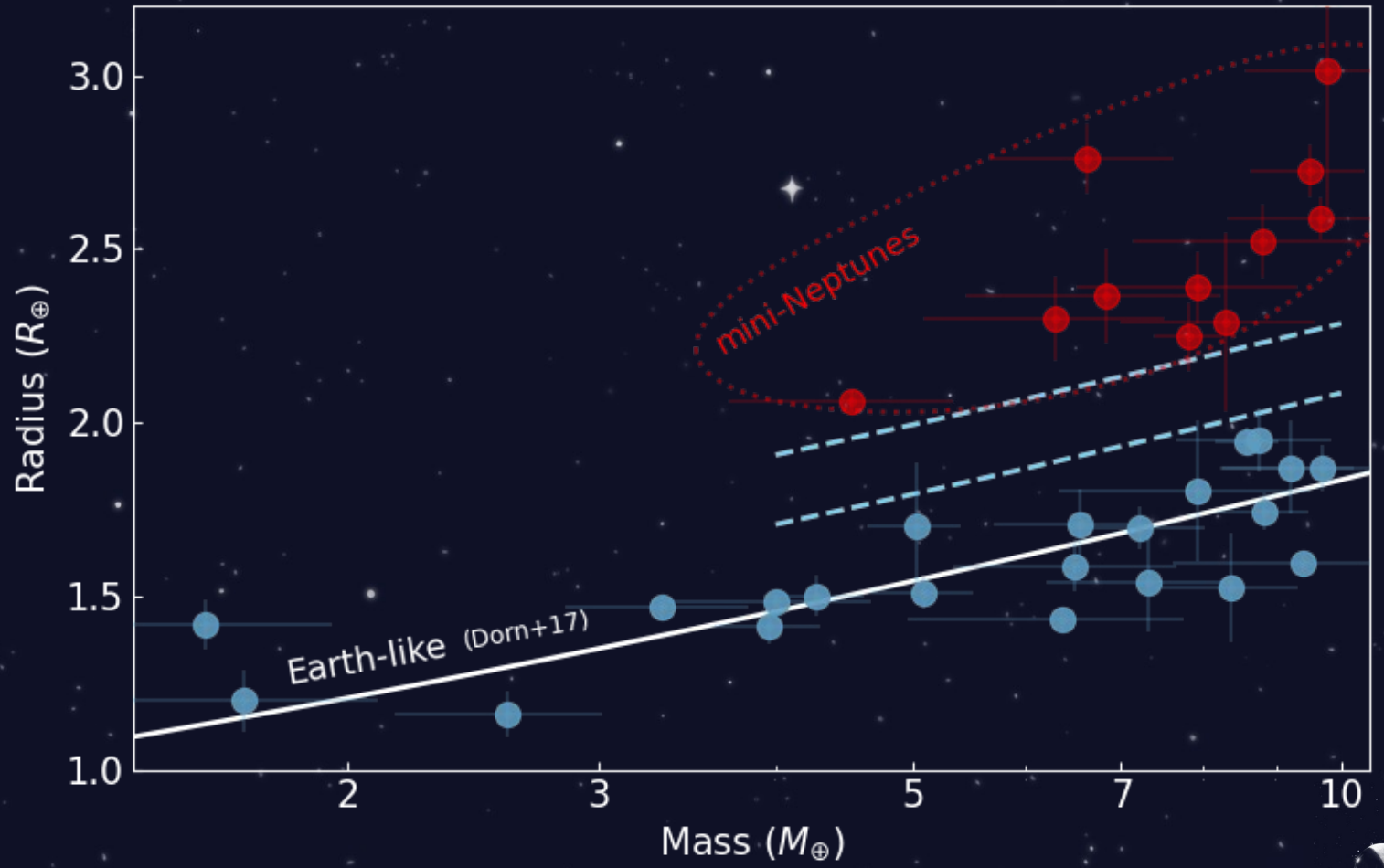


Plotnykov&Valencia (2020)

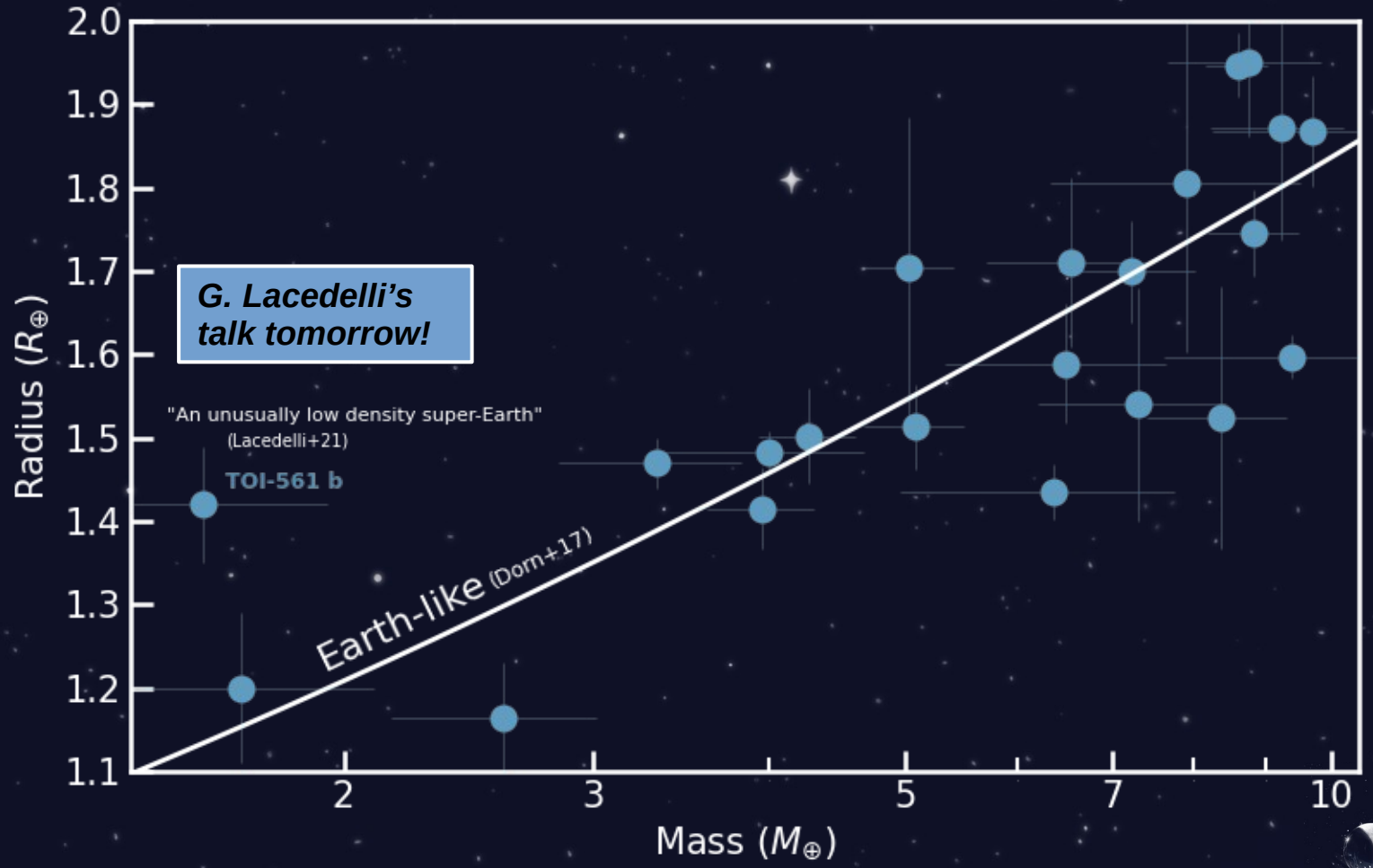


Schulze et al (2021)

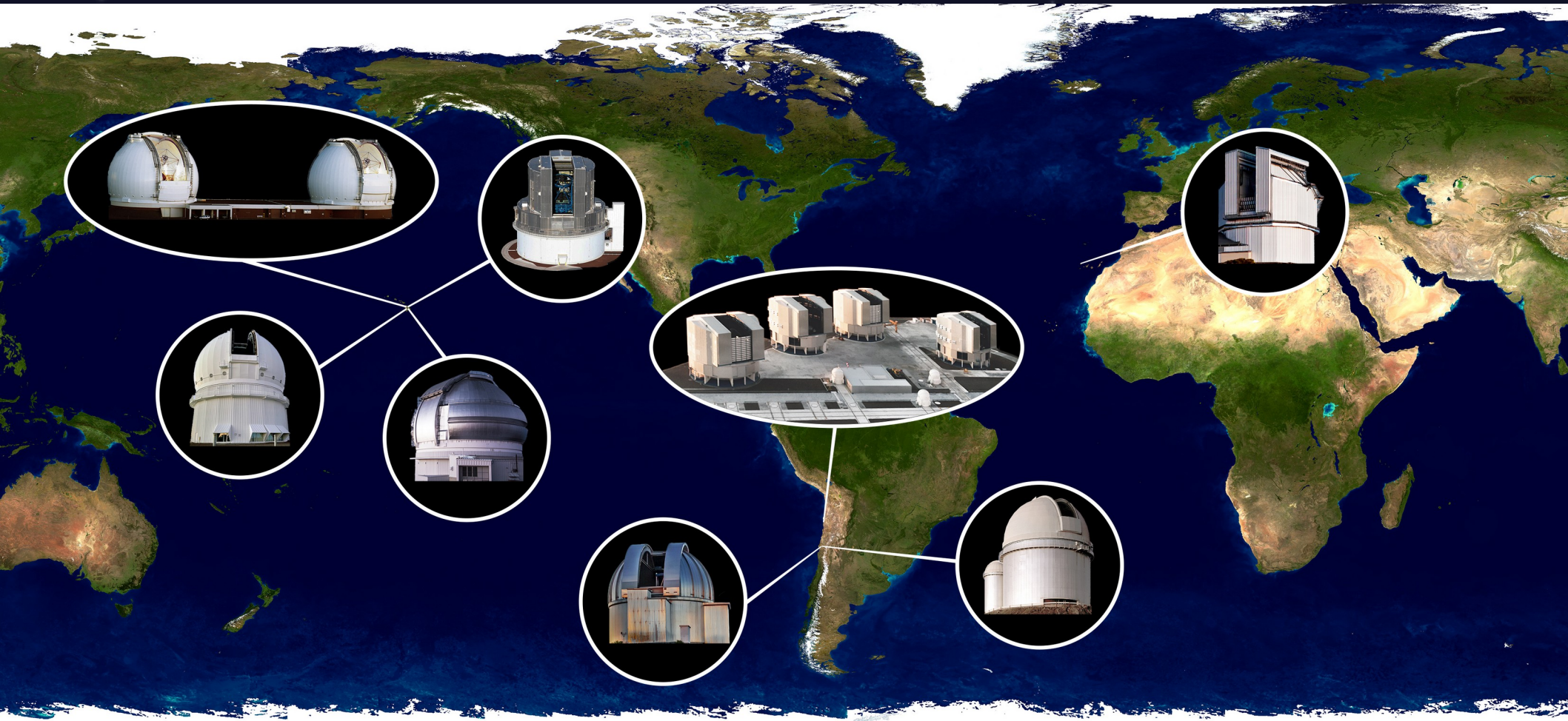
R-M diagram of the rocky planets



R-M diagram of the rocky planets

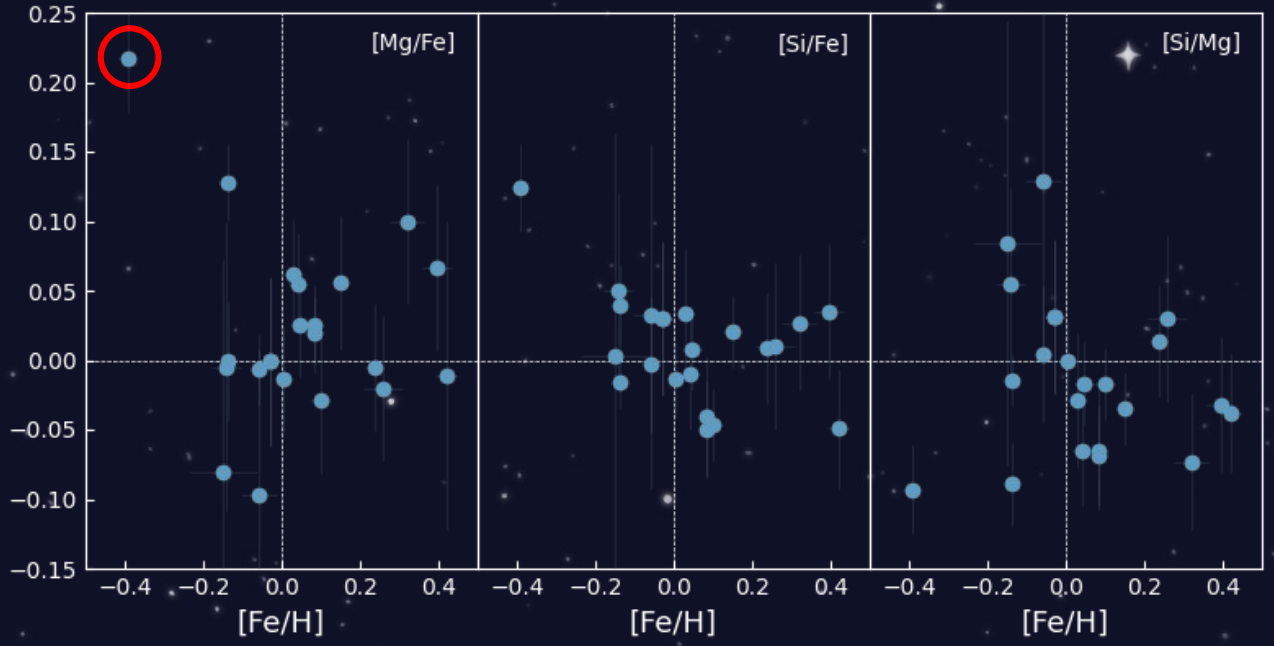


HR spectra for the host stars



Iron mass fraction of ‘planet building blocks’

Homogeneously derived abundances of Mg, Si, and Fe



$$N_{\rm O} = N_{\rm H_2O} + 3N_{\rm MgSiO_3} + 4N_{\rm Mg_2SiO_4}$$
$$N_{\rm Mg} = N_{\rm MgSiO_3} + 2N_{\rm Mg_2SiO_4}$$
$$N_{\rm Si} = N_{\rm MgSiO_3} + N_{\rm Mg_2SiO_4}$$
$$N_{\rm C} = N_{\rm CH_4},$$

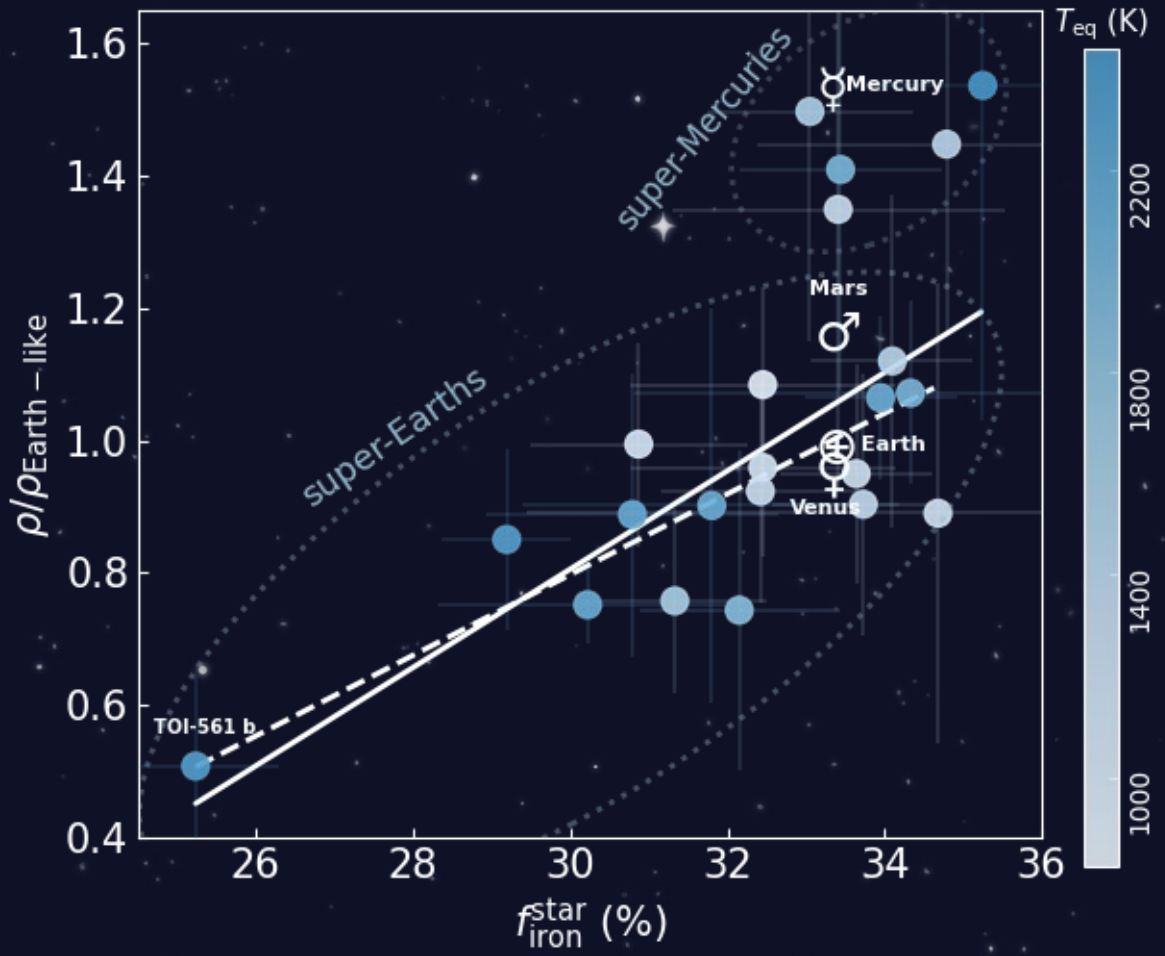
otherwise, when $N_{\rm Mg} \leq N_{\rm Si}$,

$$N_{\rm O} = N_{\rm H_2O} + 3N_{\rm MgSiO_3} + 2N_{\rm SiO_2}$$
$$N_{\rm Mg} = N_{\rm MgSiO_3}$$
$$N_{\rm Si} = N_{\rm MgSiO_3} + N_{\rm SiO_2}$$
$$N_{\rm C} = N_{\rm CH_4}.$$

$$f_{\rm iron} = m_{\rm Fe}/(m_{\rm Fe} + m_{\rm MgSiO3} + m_{\rm Mg2SiO4} + m_{\rm SiO2})$$

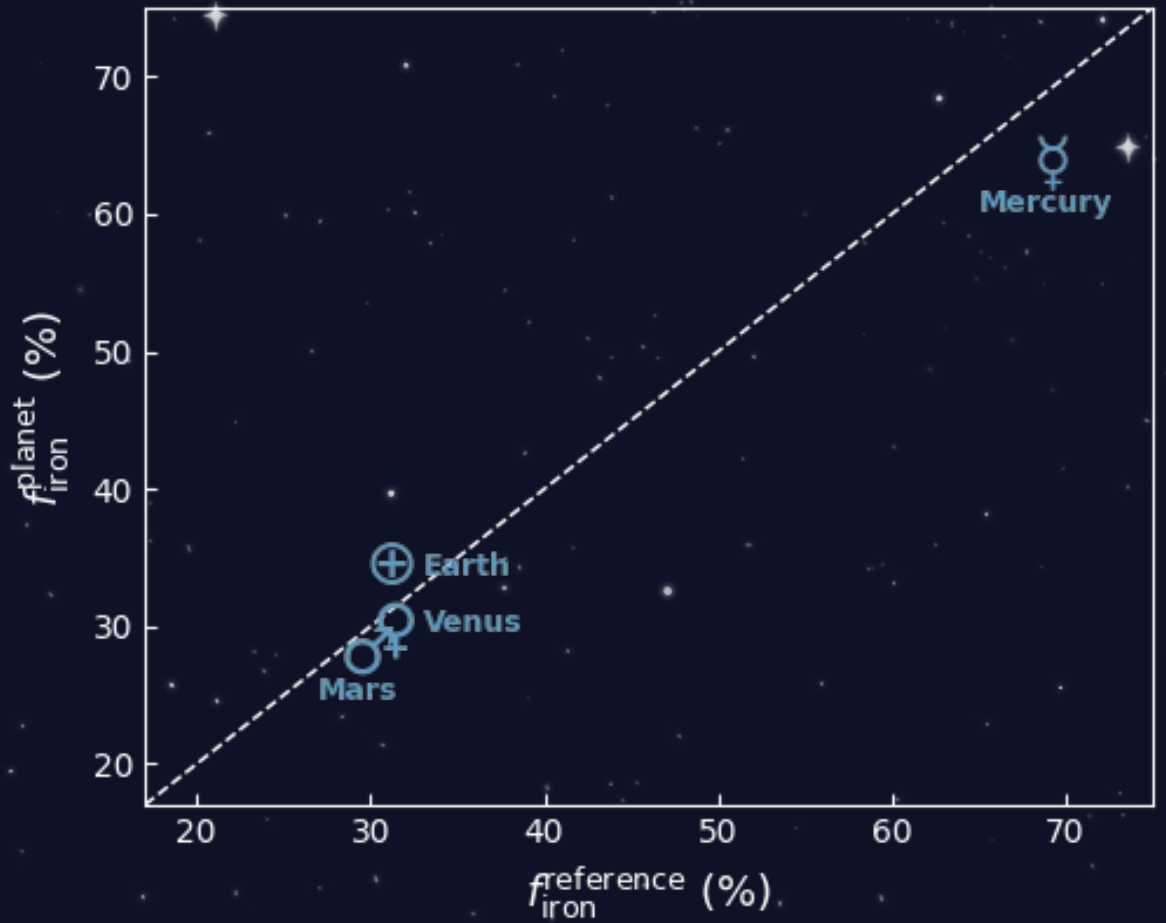
Stoichiometric relations from
Santos, Adibekyan et al. (2015, 2017)

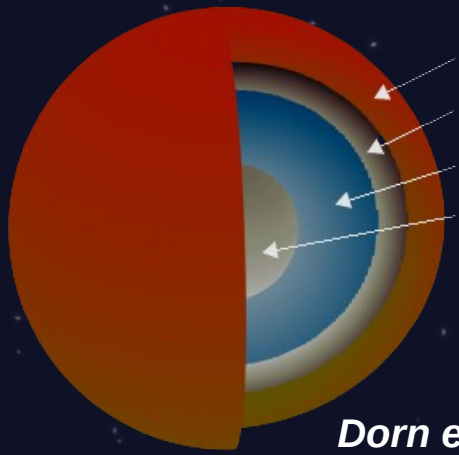
Planet density and host star composition



$\rho_{\text{earth-like}}$ is the density of a planet with Earth-like composition for a given mass

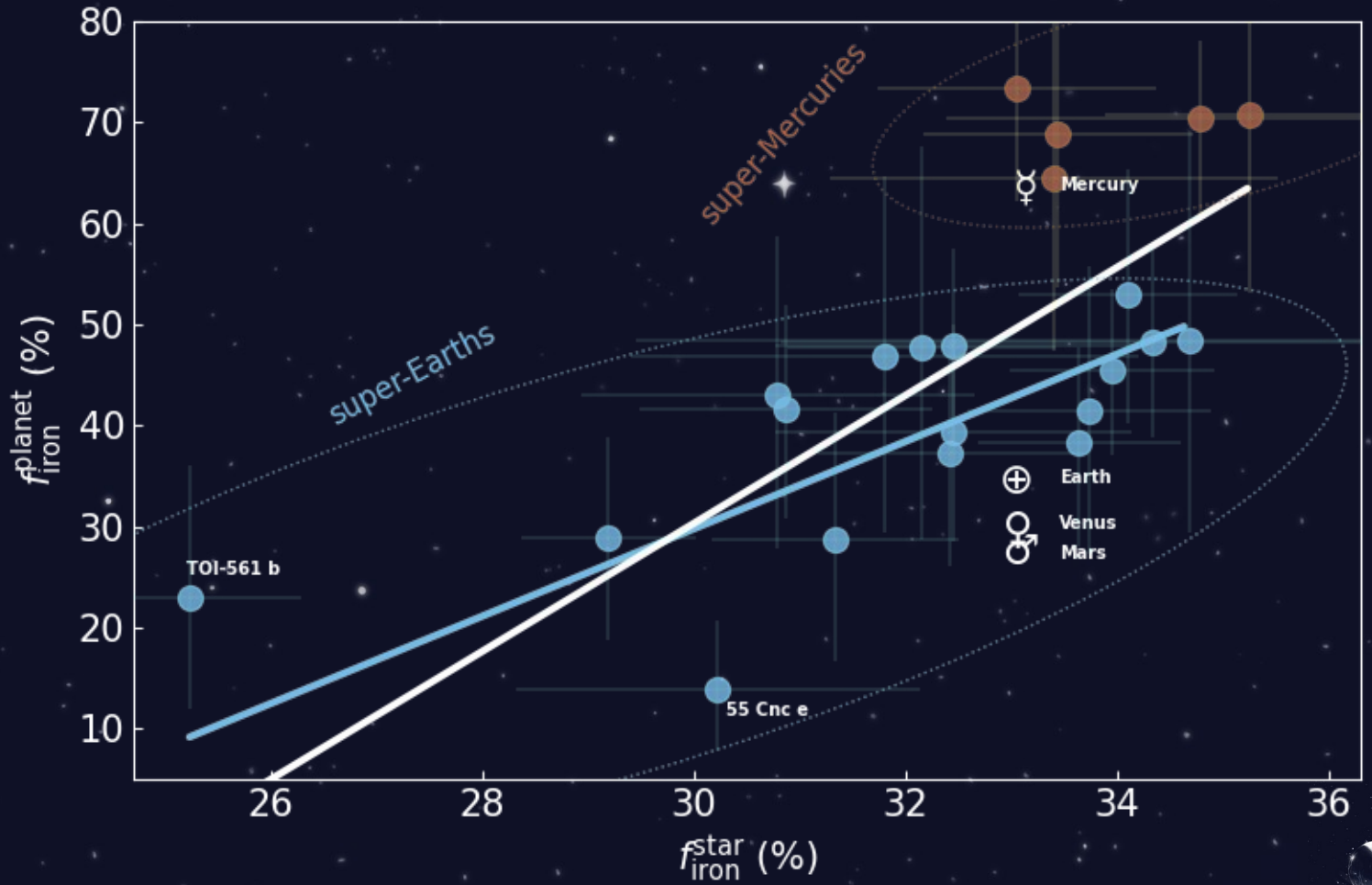
Iron mass fraction of Solar System planets





Dorn et al. (2015, 2017)

Iron mass fraction of planets and their building blocks

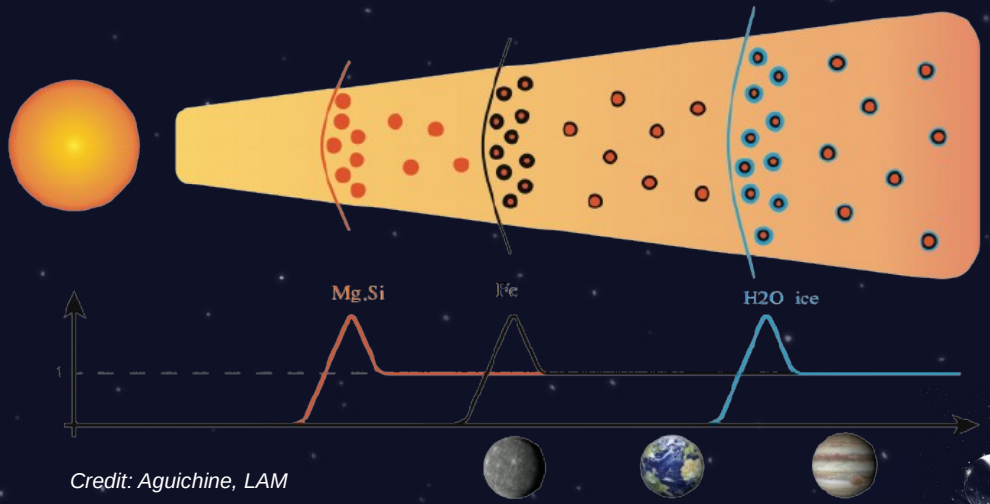


Iron mass fraction of planets and their building blocks

There is a correlation between $f_{iron,star}$ and $f_{iron,planet}$!

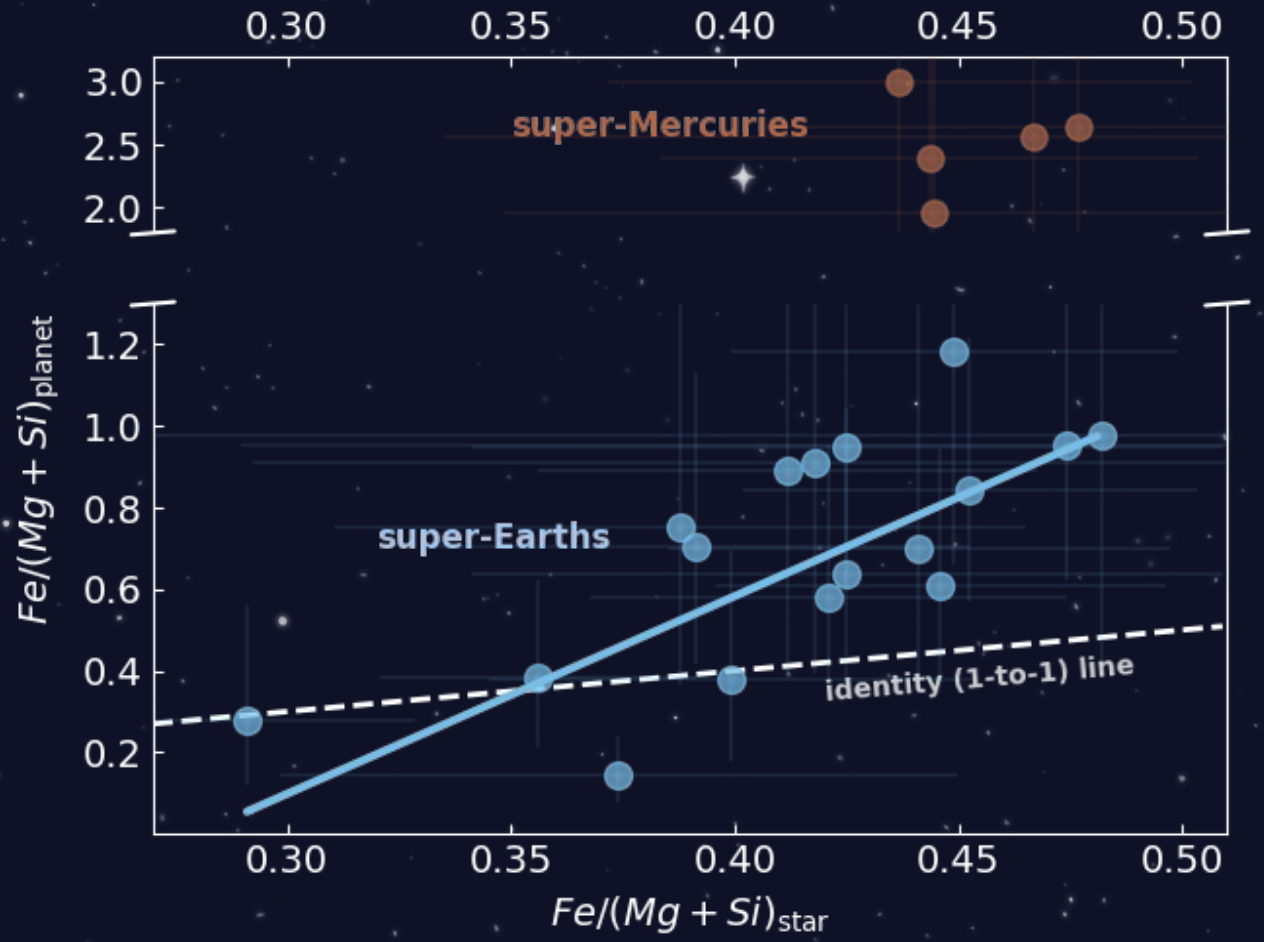
The correlation is not one-to-one!

Planets formed close to rocklines can have an increased proportion of iron – *Aguichine et al. (2020)*



Credit: Aguichine, LAM

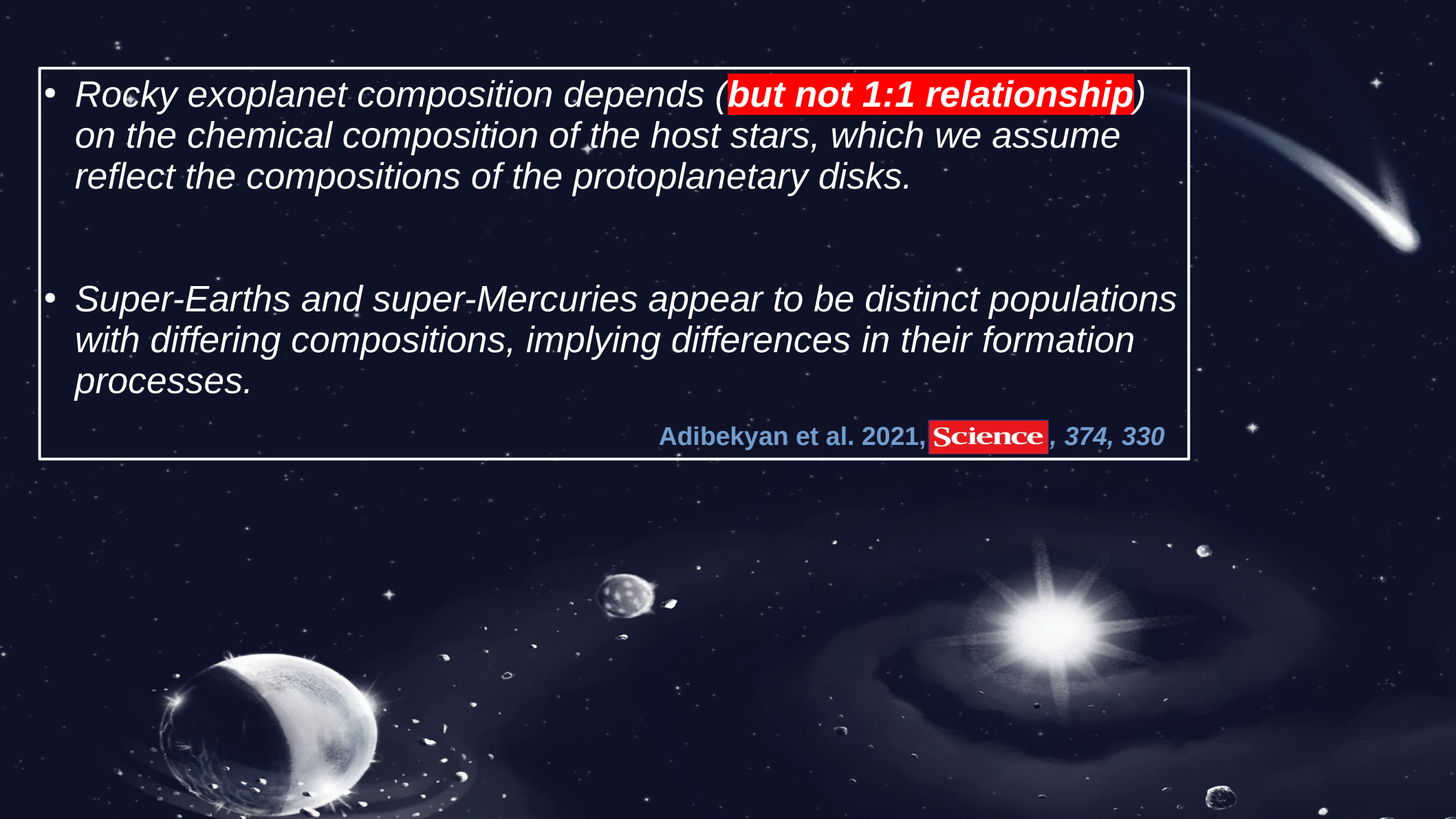
Super-Earths and super-Mercuries



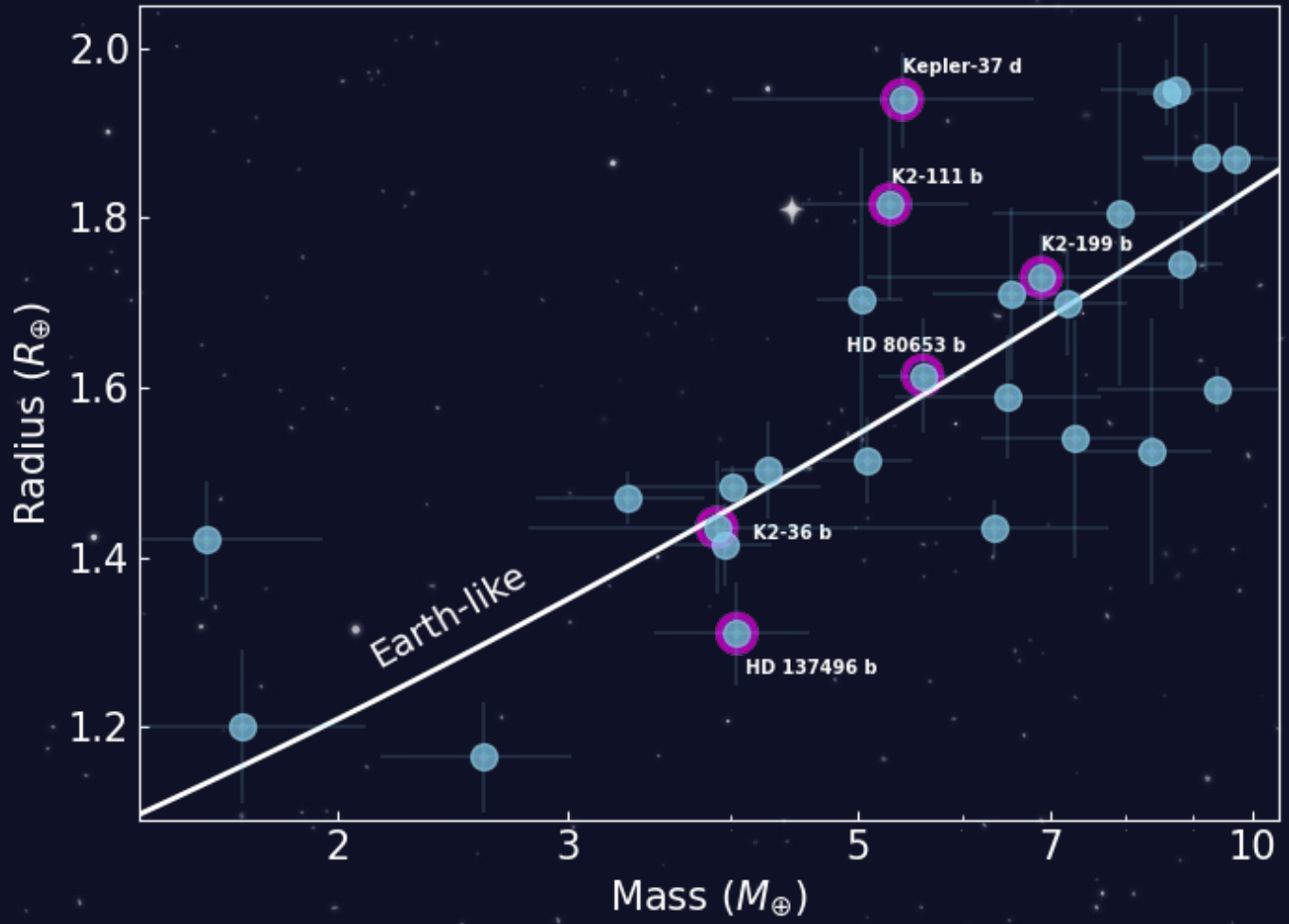
- *Rocky exoplanet composition depends (**but not 1:1 relationship**) on the chemical composition of the host stars, which we assume reflect the compositions of the protoplanetary disks.*

- *Super-Earths and super-Mercuries appear to be distinct populations with differing compositions, implying differences in their formation processes.*

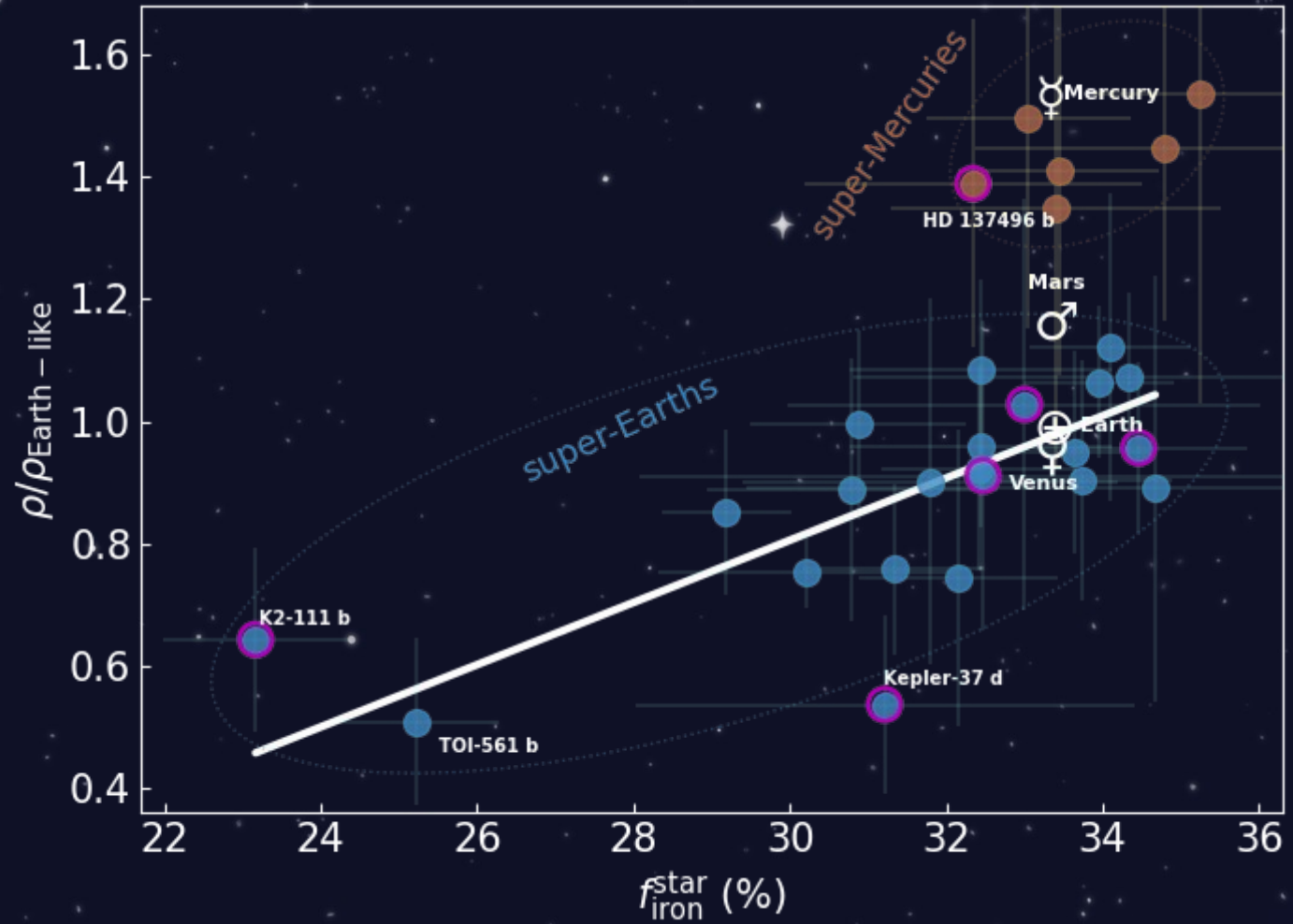
Adibekyan et al. 2021, Science, *374, 330*



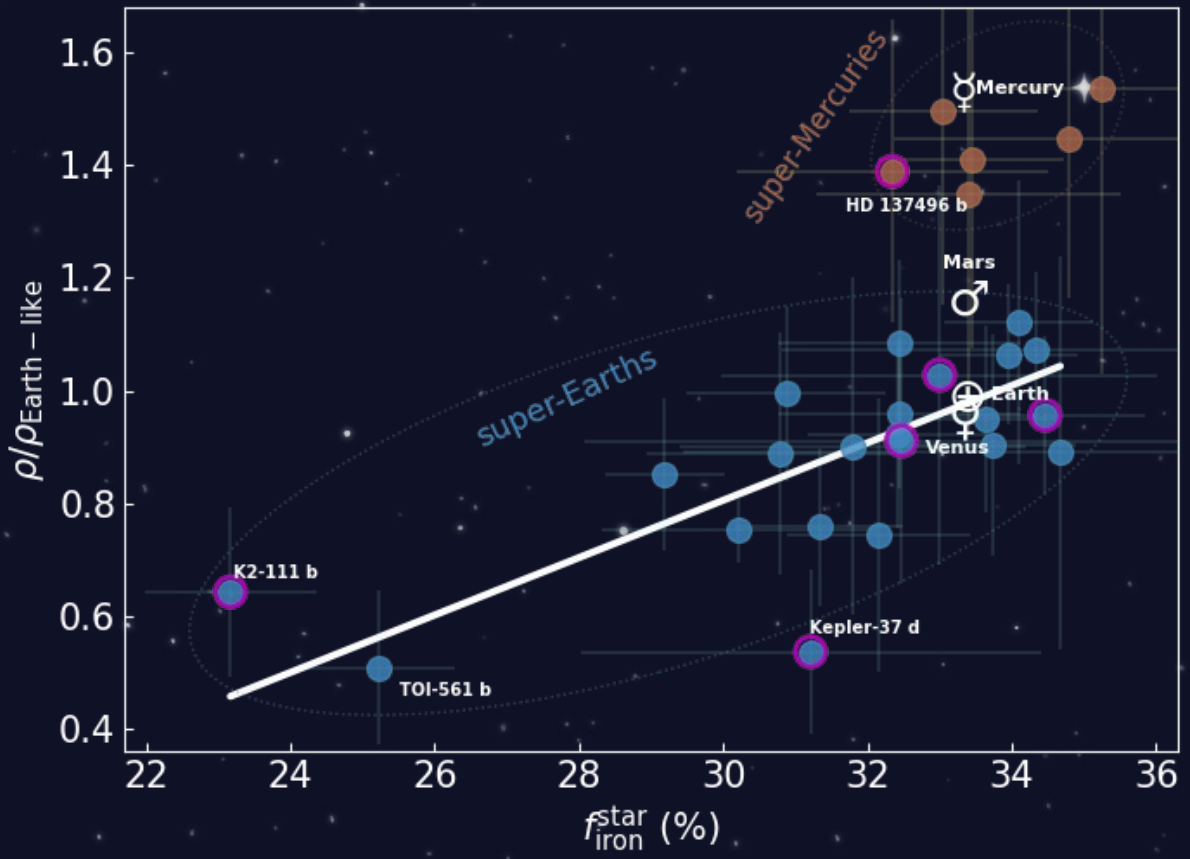
Extended sample



Extended sample

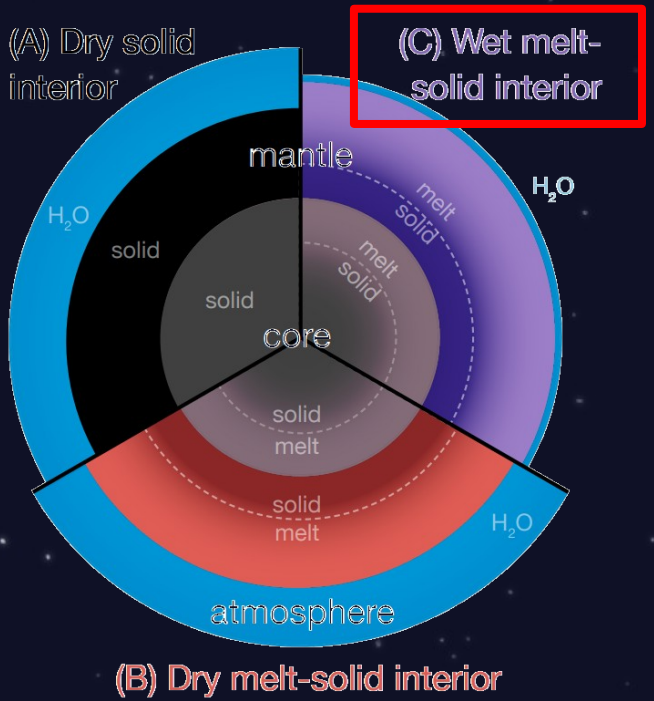


Work in progress:
Populating the low-metallicity regime



T. Wilson & CHEOPS

Work in progress:
Improving planet model and abundance precision



Dorn & Lichtenberg 2021

Poster/video #12

Thank You!

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