Analyzing the Structure and Composition of Kepler 20b

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Motivation

- Figure out the chemical composition of exoplanets' Core and Mantle
- Analyze stellar composition to make predictions about planetary composition
- Use Exoplex to construct the likely structure of Kepler 20b

Why Kepler 20b?

- Tatooine-like star system with 6 planets (Star Wars, 1977™)
- Lies within the Radius Gap ($R = 1.91\ R_E$)
- Very small semi major axis (a = 0.04537 AU)
- High mass ($M = 8.7\ M_E$)
- Data taken from Gautier et al. 2011

Assumptions made about Kepler 20b

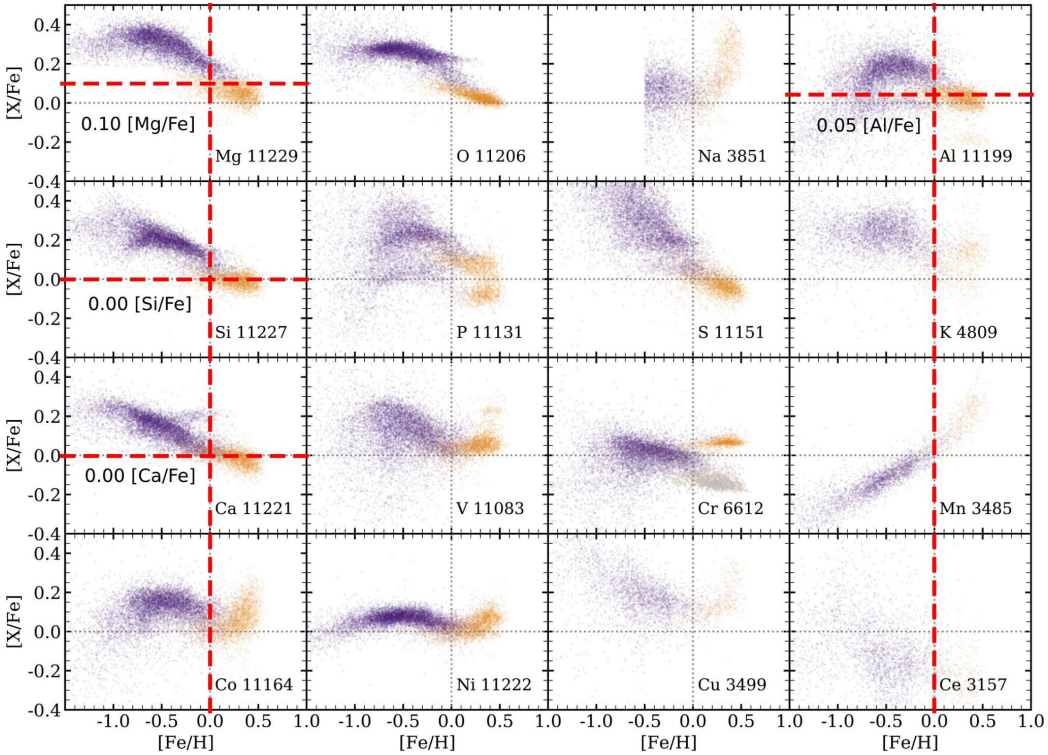
- No atmosphere? (Upper end of radius gap, proximity to host stars)

Stellar Composition

- [Fe/H] = 0.01 from NASA Exoplanet Archive
- [X/Fe] from Griffith et al. (2021)
- Converted to [X/Mg] using:

$$[X/H] = (1 + [Fe/H]) * (1 + [X/Fe]) - 1$$

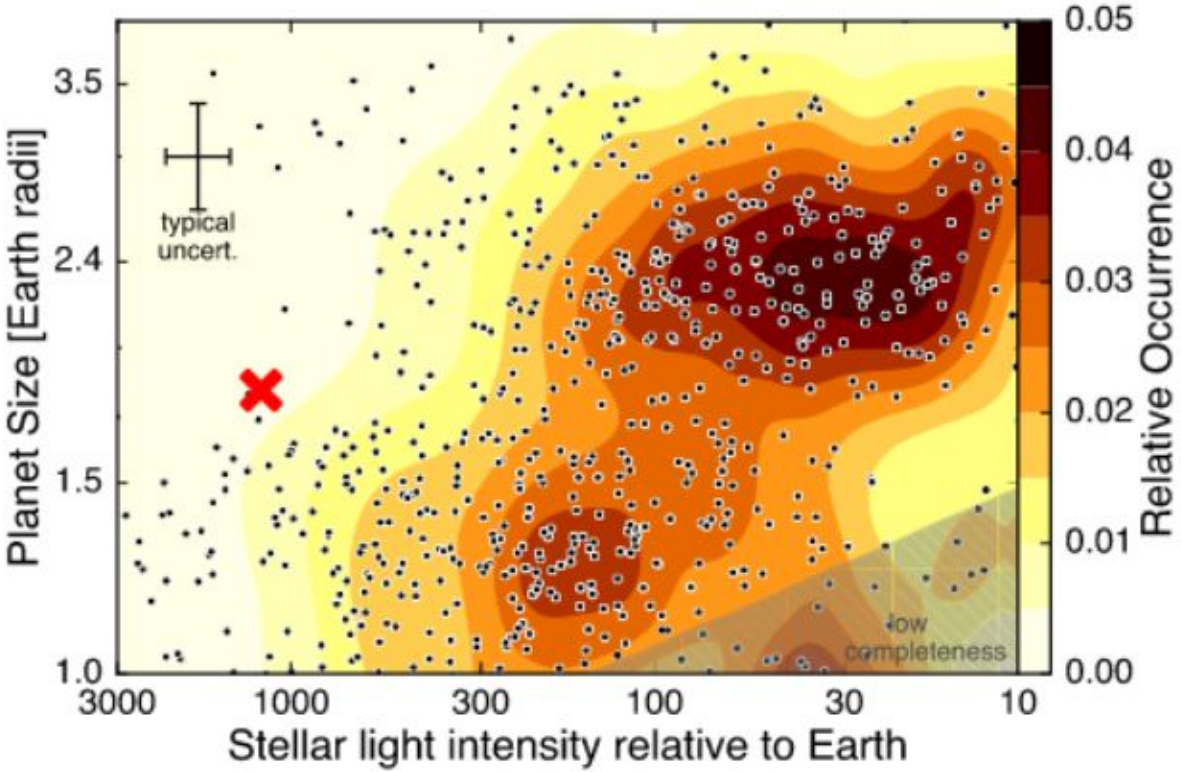
$$[X/Mg] = \frac{10^{[X/H]} * 10^{X - H}}{10^{[Mg/H]} * 10^{Mg - H}}$$



Comparison of Irradiation

	Kepler 20b	Mercury	Earth
Radius (R_E)	1.91	0.383	1
Semi-Major Axis (AU)	0.04537	0.387	1
Surface Irradiation (I_E)	349.636	6.25	1
Total Power (P_E)	1275.4	0.917	1

Location on Radius Valley graph



Planetary Structure Based on only Stellar Composition

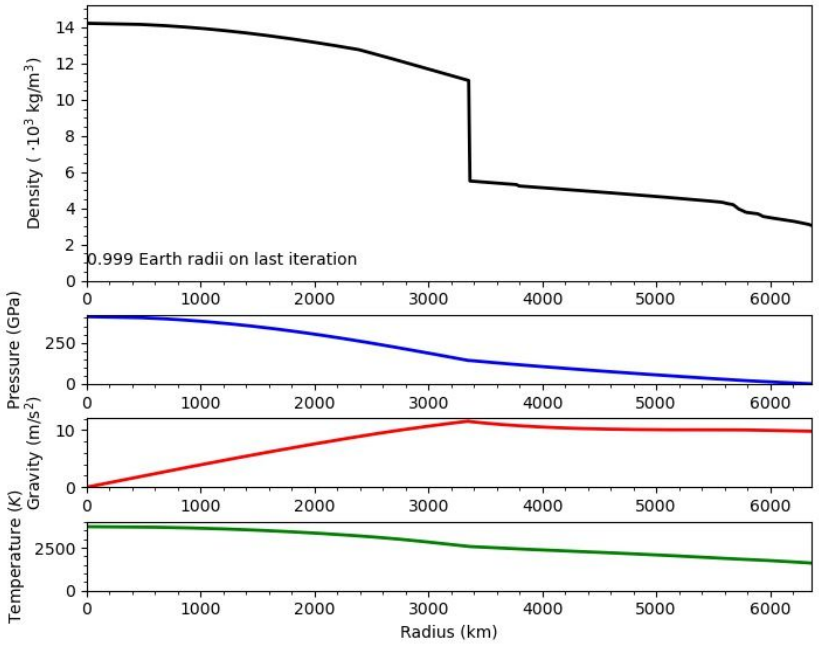
	Officially reported	Upper Bound	Lower Bound
Mass (M_E)	8.7	10.8	6.5
Radius (R_E)	1.796	1.89	1.67
Density (g/cm^3)	8.269	8.782	7.679
Core Radius Fraction (% of R)	48.02	47.91	48.23

Adjusted Core Mass Fractions

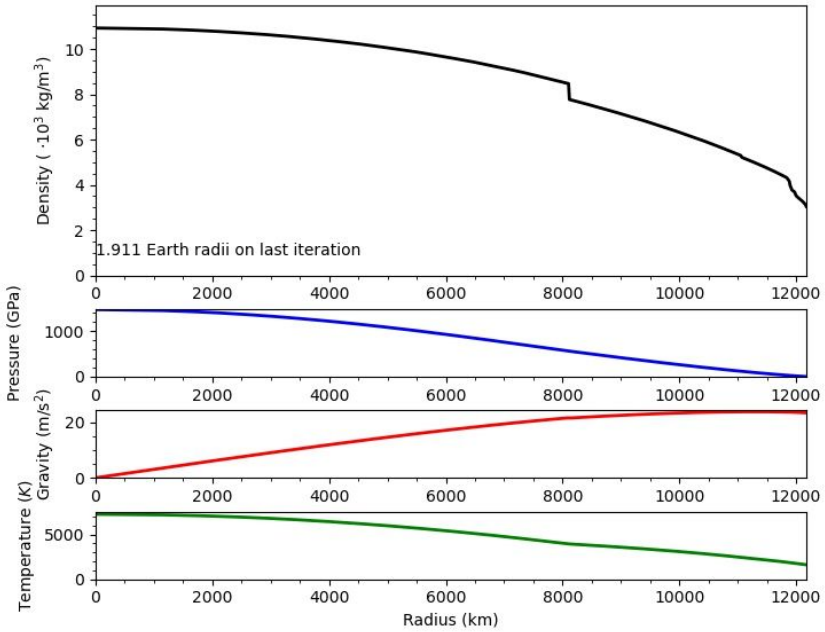
	Officially reported	Upper Bound	Lower Bound
Mass (M_E)	8.7	10.8	6.5
Radius (R_E)	1.91	2.01	1.77
Density (g/cm^3)	6.872	7.245	6.426
Core Radius Fraction (% of R)	66.55	66.37	66.82
Core Si Mass Fraction	30%	30%	30%

Comparing Exoplex data plots

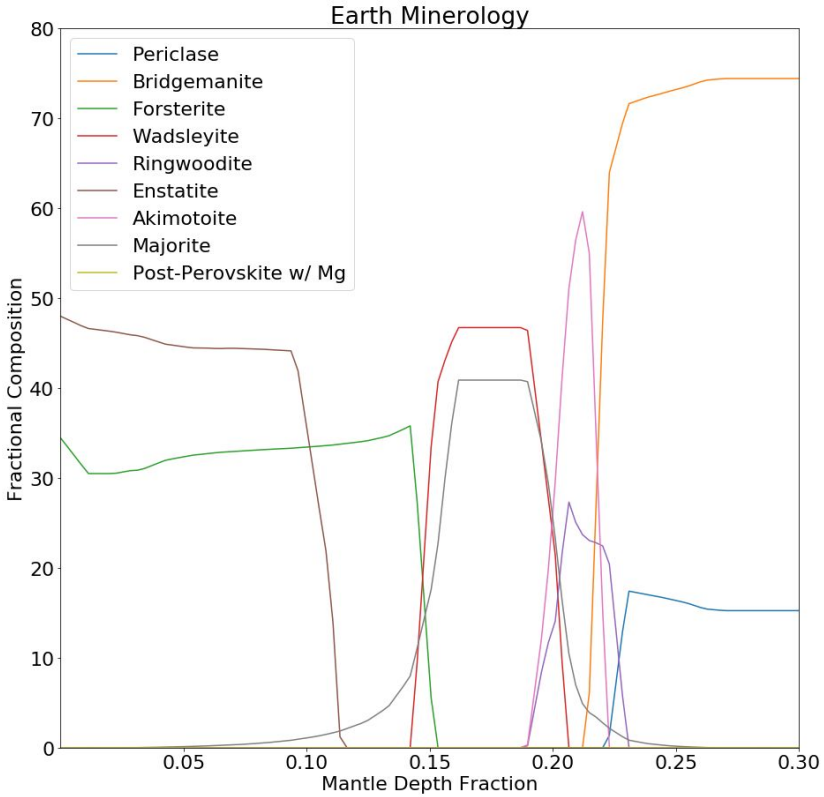
Earth

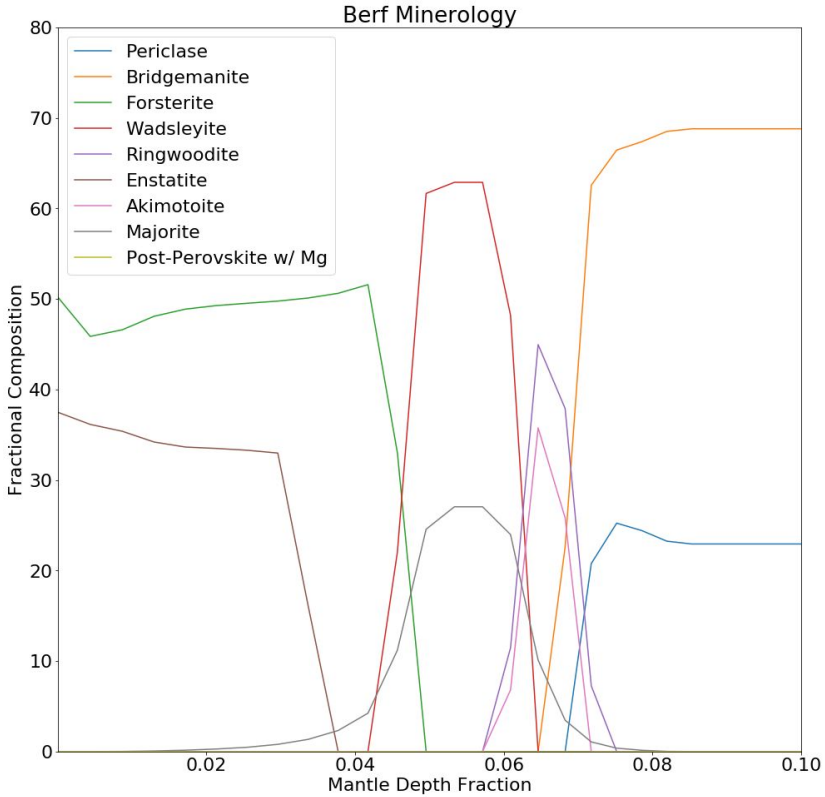


Kepler 20b



Mantle Mineral Composition





Results

Radius

- Officially listed radius: 1.91 (+0.12, -0.21) R_E
- Calculated radii (with adjusted core mass fractions): 1.91 R_E, 2.01 R_E, 1.77 R_E
- All calculated radii lie within the predicted errors

Density

- Officially listed density: 6.5 (+0.20, -0.27) g/cm^3
- Calculated densities (with adjusted core mass fractions): 6.872 g/cm^3, 7.245 g/cm^3, 6.426 g/cm^3
- 2/3 calculated densities are close to predicted error range

Internal Structure

- Core much bigger compared to the Earth
- Density variation at core-mantle boundary much smaller than the Earth

Next Steps...

- Make more accurate calculations regarding the presence of an atmosphere using exobase temperature

- Vary core composition to align with the officially reported density value

Questions?????

Citations

- Griffith, E. et al. (2021.). *The similarity of abundance ratio trends and nucleosynthetic patterns in Milky Way disk and bulge.* ApJ 909 77. https://iopscience.iop.org/article/10.3847/1538-4357/

- Gautier, T. N. et al. (2012). *Kepler-20: A sun-like star with three sub-neptune exoplanets and two Earth-size candidates*. NASA/ADS. https://iopscience.iop.org/article/10.1088/0004-637X/749/1/15/