1. Search the composition of the planet’s host star (in most cases, you will find [Fe/H] and little else). If you cannot find it, use Griffith et al., 2020 to scale the [Fe/H] to a likely [Mg/H] and [Si/H], and calculate the molar ratios: Si/Mg and Fe/Mg. For all other ratios, go ahead and use the solar ratios as already in ExoPlex.
2. Place the planet’s size and orbital distance in context of a likely rocky planet and its surface irradiation.

Size: 1.66 Earth masses, 1.13 Earth radii

Orbital distance: 0.015 AU

Fits well in with rocky exoplanets.

* Maybe a graph plotting it with other rocky exoplanets? (mass/radius-semi-major axis)

1. Use the likely refractory composition of the star to determine the expected radius and density of the planet given its measured mass. Explore how your results vary given the uncertainties in measured mass.

1.66±0.23 Earth masses (Bonfils et al. 2018)

Fe/Mg: 0.9311

Si/Mg: 0.8790

Core composition: {'Fe': 100.0, 'Si': 0.0, 'O': 0.0, 'S': 0.0}

Mantle composition: {'FeO': 0.0, 'SiO2': 51.96593677, 'MgO': 39.65732729, 'CaO': 3.86230099, 'Al2O3': 4.51443494}

python Group\_1.py --mass=1.66 --FeMg=0.9311 --SiMg=0.8790

Mass = 1.660 Earth masses

Radius = 1.149 Earth radii

Core Mass Fraction = 33.98

Core Radius Fraction = 53.05

CMB Pressure = 225.00 GPa

* Mass: 1.66 Earth masses, radius: 1.149 Earth radii, density: 5.98 g/cm3

python Group\_1.py --mass=1.82 --FeMg=0.9311 --SiMg=0.8790

Mass = 1.820 Earth masses

Radius = 1.179 Earth radii

Core Mass Fraction = 33.98

Core Radius Fraction = 52.93

CMB Pressure = 245.66 GPa

* Mass: 1.82 Earth masses, radius: 1.179 Earth radii, density: 6.07 g/cm3

python Group\_1.py --mass=1.43 --FeMg=0.9311 --SiMg=0.8790

Mass = 1.430 Earth masses

Radius = 1.102 Earth radii

Core Mass Fraction = 33.98

Core Radius Fraction = 53.24

CMB Pressure = 195.41 GPa

* Mass: 1.43 Earth masses, radius: 1.102 Earth radii, density: 5.83 g/cm3

1. Adjust mantle FeO, core mass fraction (via FeMg), and core composition to find a structure model that explains both the mass and radius. You may need to force an atmosphere onto the planet, to do this, assume that the atmosphere is massless and accounts for the radius beyond the reasonable rocky radius from ExoPlex. What is the probable range of planet structure described by its mass and radius?

python Group\_1.py --mass=1.XX --FeMg=0.XX --SiMg=0.XX --mol\_frac\_Fe\_mantle=0.XX -- wt\_frac\_Si\_core=0.XX

Arguments we can vary:

* mass (from 1.43 to 1.83 Earth masses
* FeMg (ratio of iron to magnesium)
* SiMg (ratio from silicon to magnesium)
* mol\_frac\_Fe\_mantle (molar fraction of iron in the mantle, big value 🡪 less in core)
* wt\_frac\_Si\_core (fraction of silicon in the core, big value 🡪 more in the core)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Mass | FeMg | SiMg | Fe frac | Si frac | Radius | density |
| 1.66 | 0.9311 | 0.8790 | - | - | 1.149 | 5.98 |
| 1.43 | 0.9311 | 0.8790 | - | - | 1.102 | 5.84 |
| 1.82 | 0.9311 | 0.8790 | - | - | 1.179 | 6.07 |
| 1.66 | 0.99 | 0.8790 | - | - | 1.145 | 6.04 |
| 1.66 | 0.9311 | 0.8 | - | - | 1.147 | 6.01 |
| 1.66 | 0.9311 | 0.8790 | 0.01 |  | 1.150 | 5.96 |
| 1.66 | 0.9311 | 0.8790 | - | 0.01 | 1.150 | 5.96 |
| 1.75 | 0.95 | 0.85 | - | - | 1.164 | 6.06 |
| 1.6 | 0.98 | 0.8 | - | - | 1.132 | 6.03 |
| 1.63 | 0.99 | 0.78 | - | - | 1.136 | 6.08 |
| 1.63 | 0.97 | 0.84 | - | - | 1.14 | 6.01 |

Radius range we want in our result:

1. 1.13±0.056 (Bonfils et al. 2018)
2. 1.43±0.16 (Southworth et al. 2017) (SEE BELOW)

The radius INCREASES if we

* Increase mol\_frac\_Fe\_mantle and increase wt\_frac\_Si\_core
* We start with values for radius within range but on the higher side, so we do not need these arguments to further increase the radius.

The radius DECREASES if we

* Increase FeMg and decrease SiMg

If we want a radius and density similar to that from Bonfils et al. 2018, we should probably not increase the fractions (mol\_frac\_Fe\_mantle & wt\_frac\_Si\_core) but increase FeMg and decrease SiMg. Varying the mass also helps.

Generally, there is a wide variety of compositions possible because the ranges we can find for the mass, radius and density are rather vague.

Depending on which paper we compare our data to, the planet either has none or a very thin atmosphere (Bonfils et al. 2018) or a very thick atmosphere (Southworth et al. 2017). If we assume the no/thin atmosphere case, we can easily match the radius range without forcing an stmosphere.

1. How does the mantle mineralogy compare to the Earth?

python Group\_1.py --mass=1

Core composition: {'Fe': 100.0, 'Si': 0.0, 'O': 0.0, 'S': 0.0}

Mantle composition: {'FeO': 0.0, 'SiO2': 52.55497015, 'MgO': 39.17101638, 'CaO': 3.81493827, 'Al2O3': 4.45907521}

Mass = 1.000 Earth masses

Radius = 0.999 Earth radii

Core Mass Fraction = 32.95

Core Radius Fraction = 53.02

CMB Pressure = 141.56 GPa