Evidence for Exposed Superdense Planetary Cores

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Background

Generally two types:

- Terrestrial exposed cores - impacts during early solar system
- Cthonian Planets - hydrodynamic escape of gas envelope (usually in extreme thermal cases)

Approach:

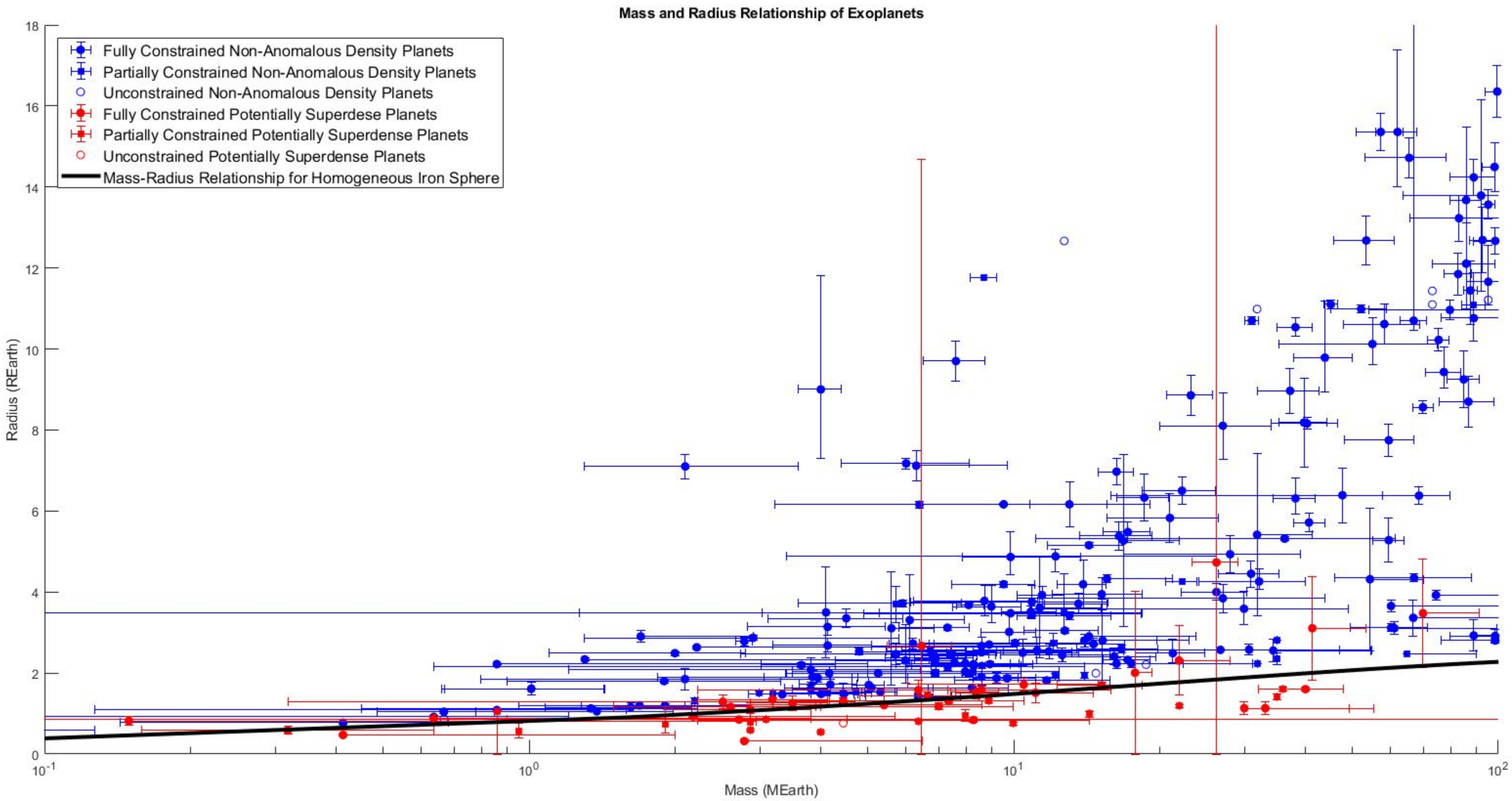
- Try to find planets with densities that imply compositions close to pure iron by comparing to a modified polytropic equation of state

Exoplanet Data

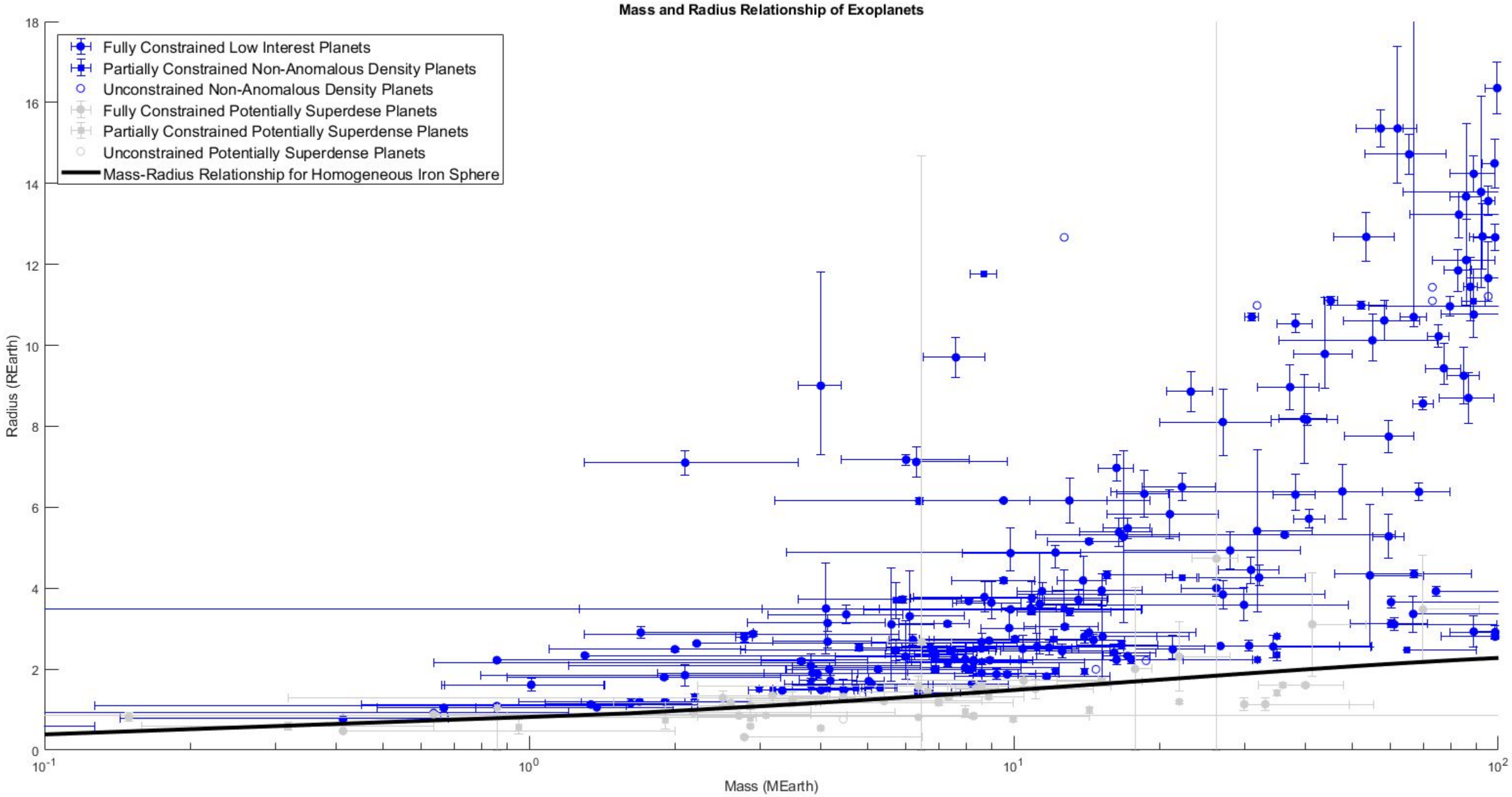
Data Processing:

- All data used retrieved from Exoplanet.eu database
    - 3711 confirmed planets
- Removed planets missing Mass or Radius data
    - 678 planets
- Mass Radius relationship only accurate for $<100\ M_{Earth}$
    - 236 planets

Starting Point



Removing Low-Density Planets



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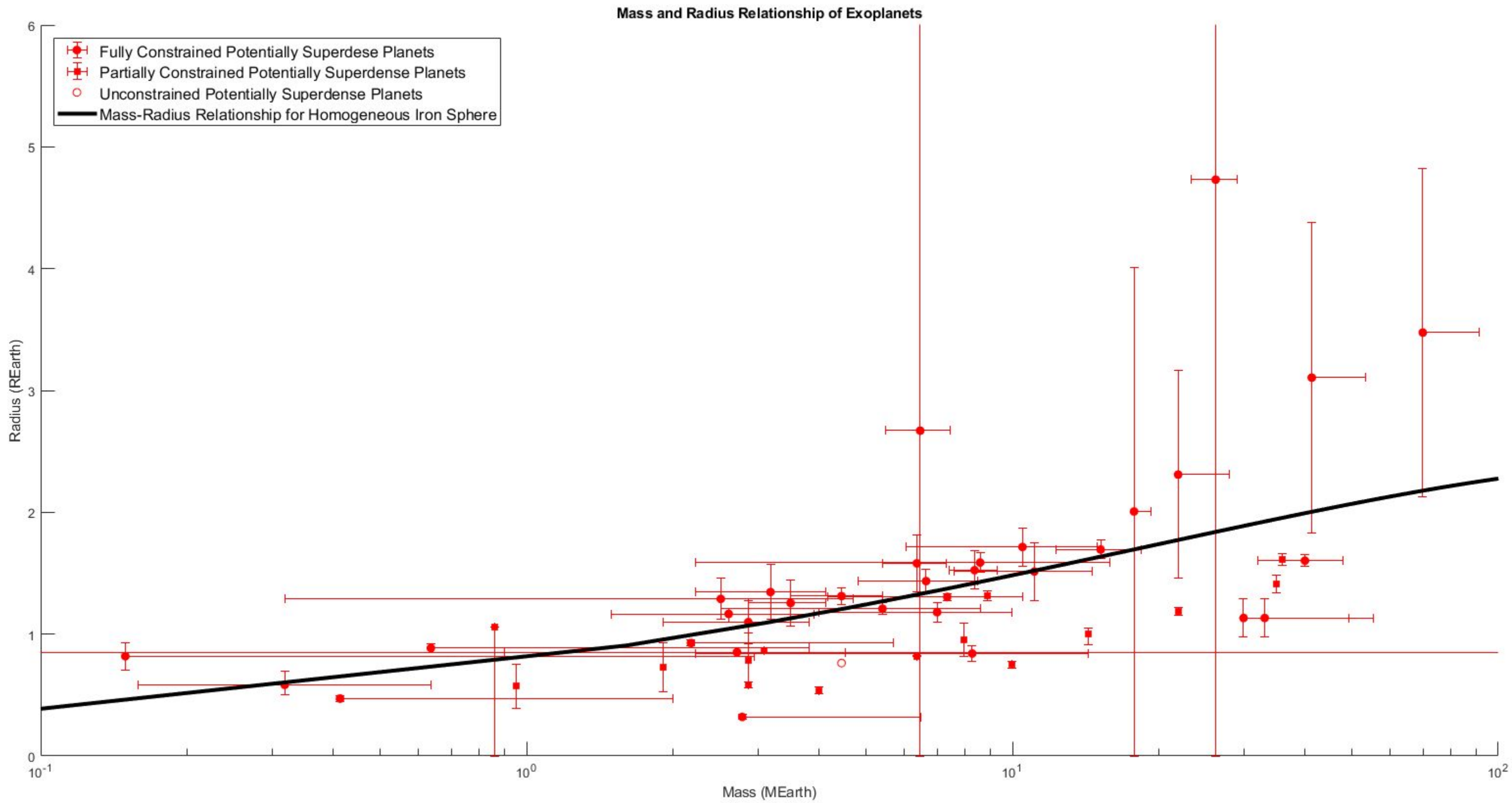
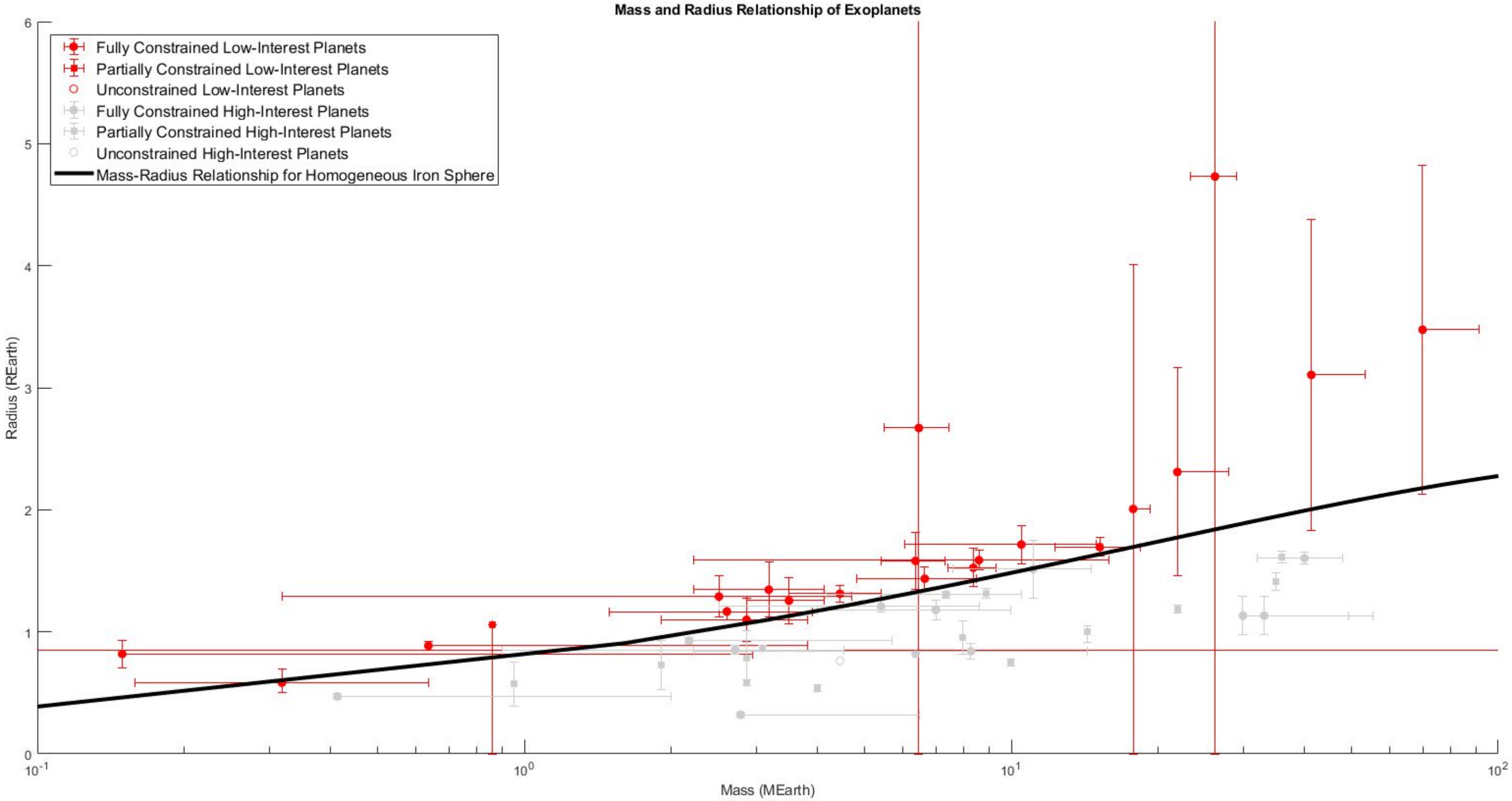
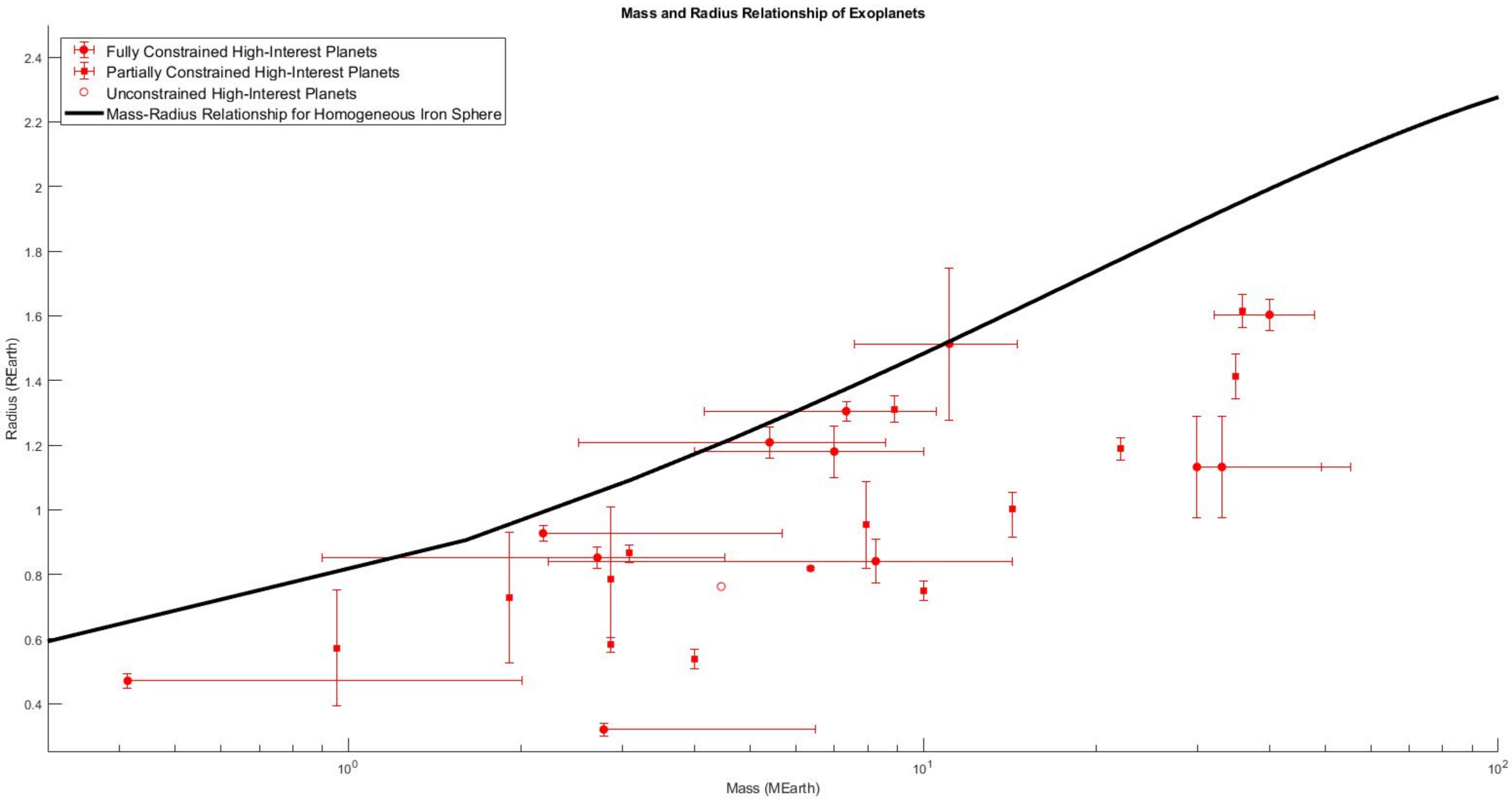


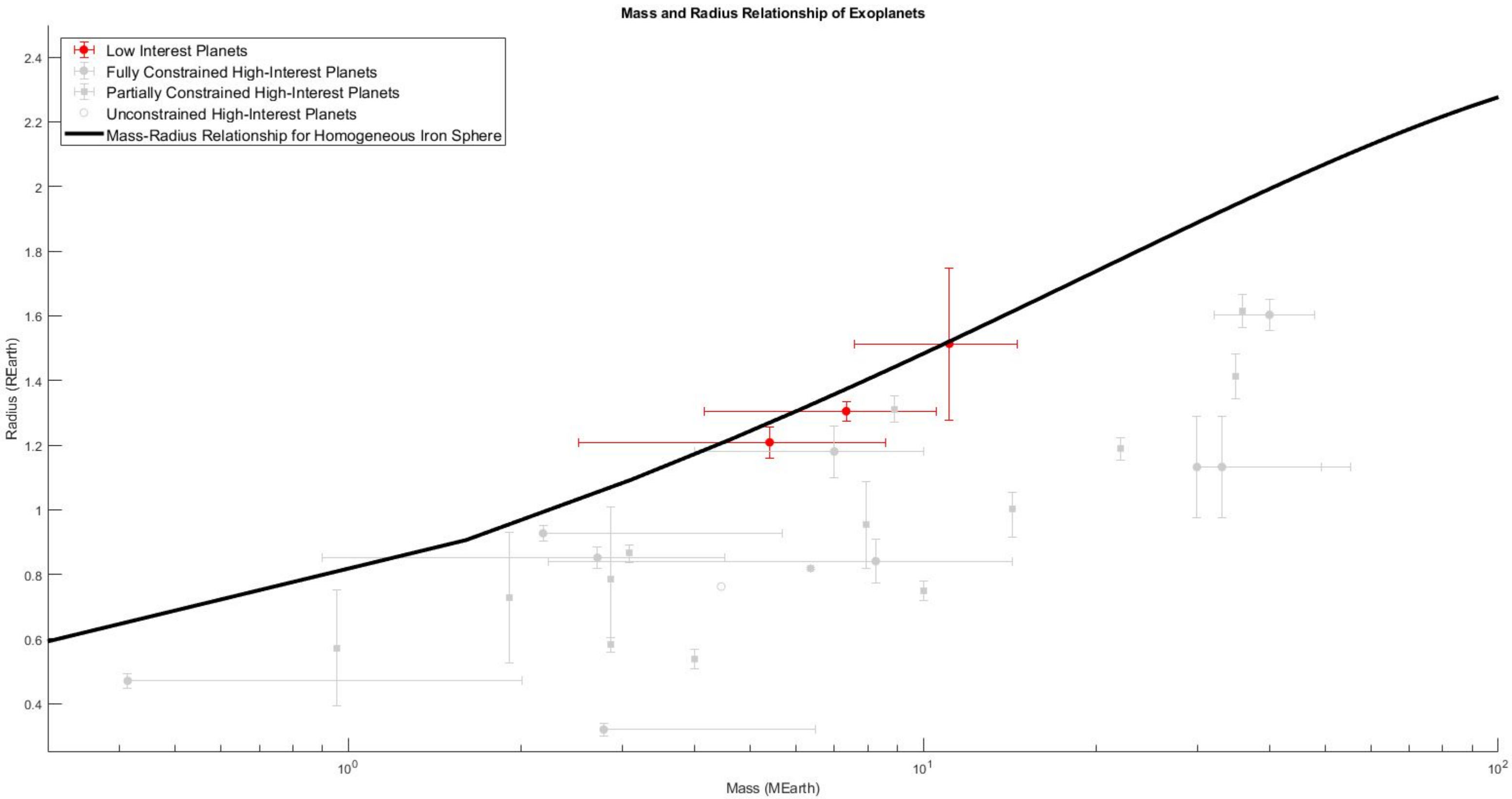
Removing Statistically Unlikely Candidates



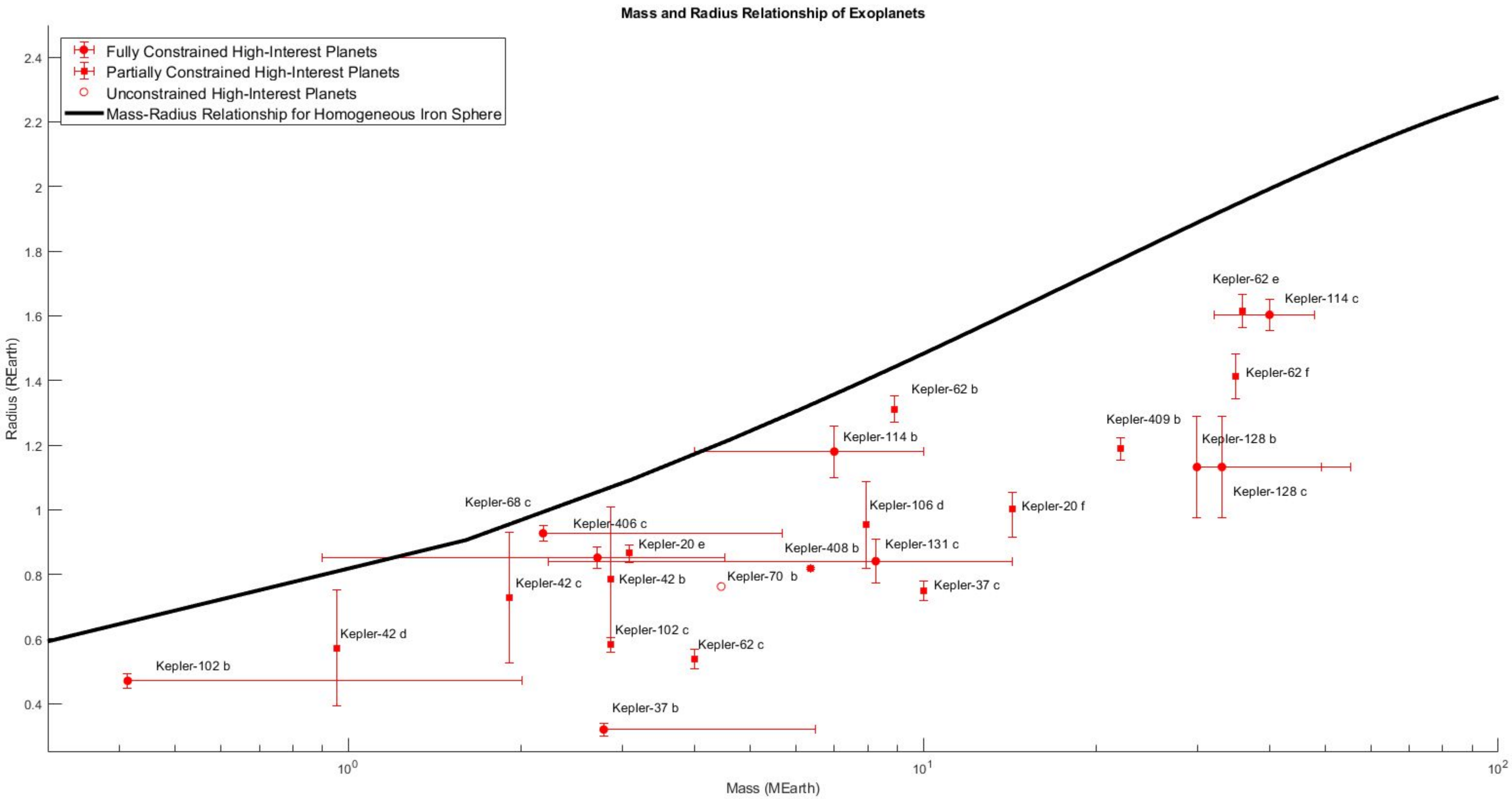
Removing Statistically Unlikely Candidates



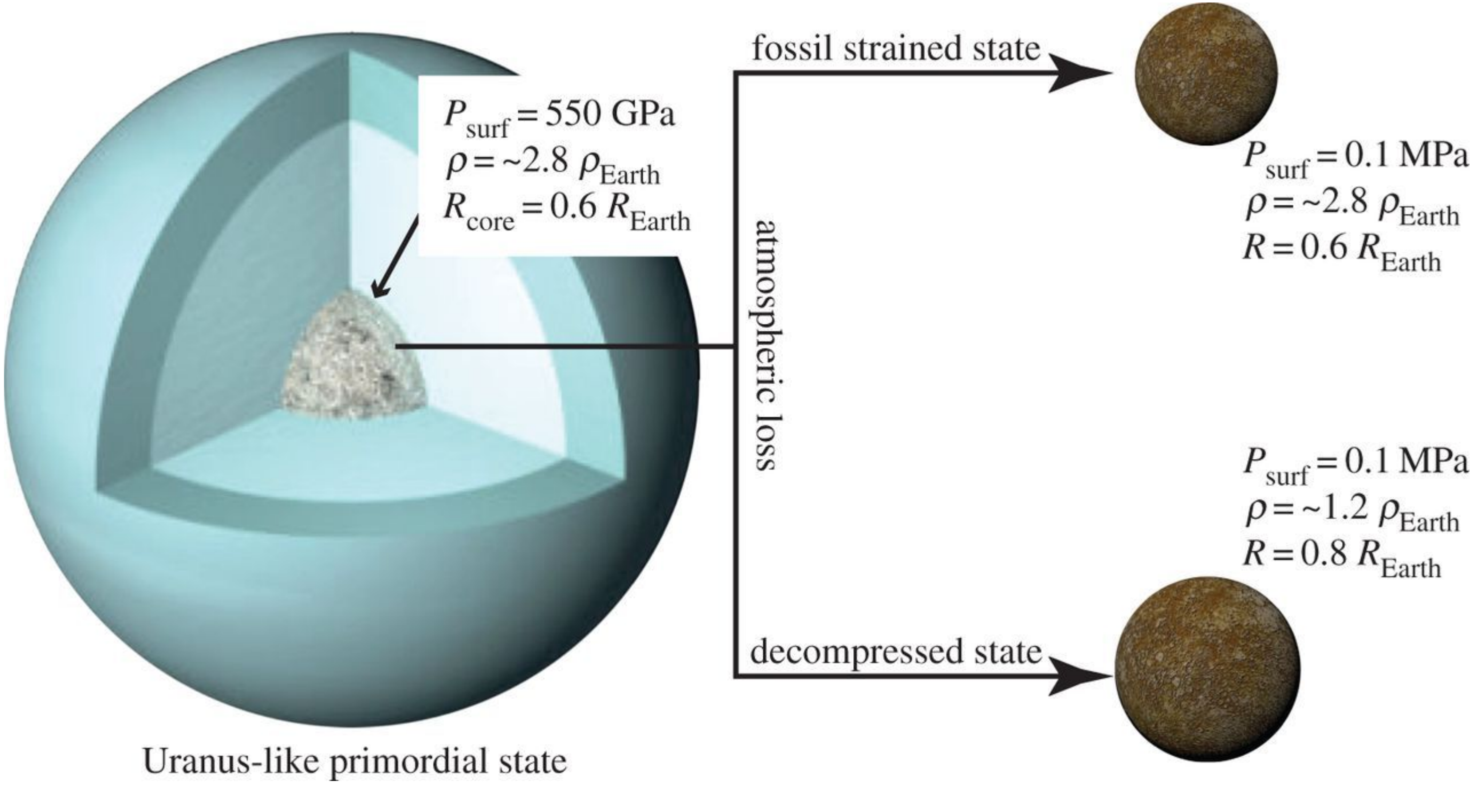
Removing Statistically Unlikely Candidates



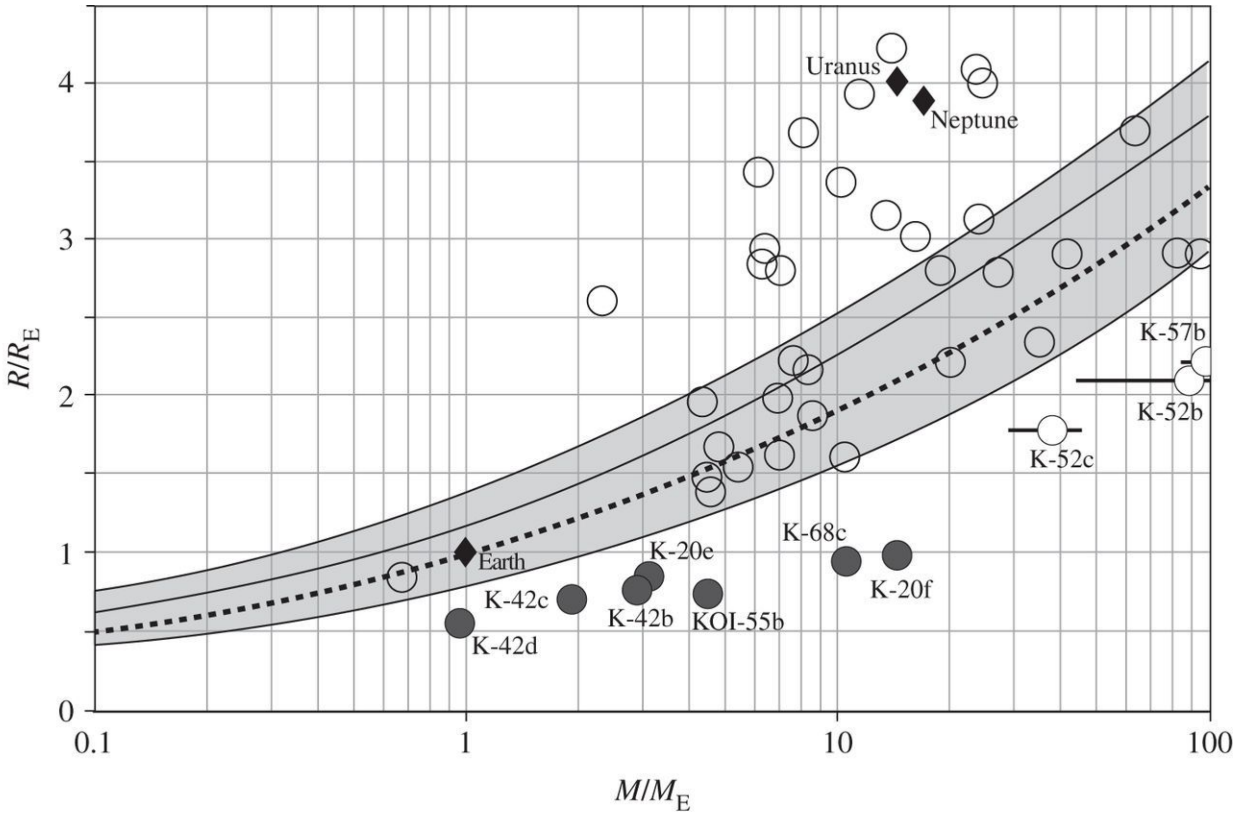
24 Superdense Planetary Core Candidates



Mechanism for Formation



Previous Work



Assumptions and Criteria for Continued Consideration

Assumptions:

- Fossilized core theory is correct
- Solar abundance of elements

Must Satisfy:

- Consistent with observed gas/ice giant core data and/or core accretion models
- Very close to host star

Planetary Embryo Size Discussion on Size

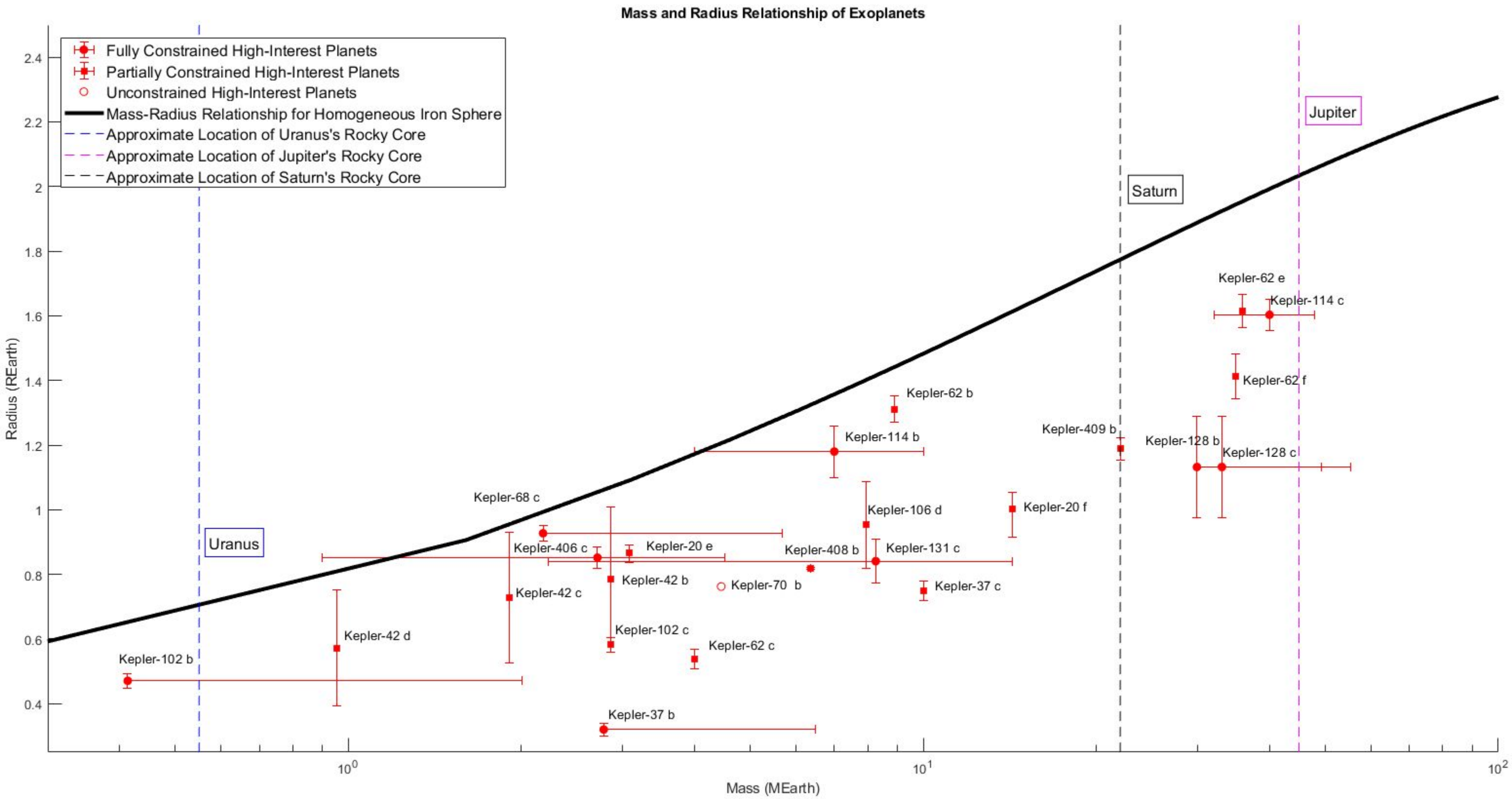
- Sources suggest an embryo of 10-20M_{Earth} is required for runaway gas accretion, though rocky planetary cores seem to be smaller than this.
- Simulations can create 100M_{Earth} planets over short (1Myr) time scales with an embryo of 0.6M_{Earth}

Hypothesized gas/ice giant core masses potentially more useful:

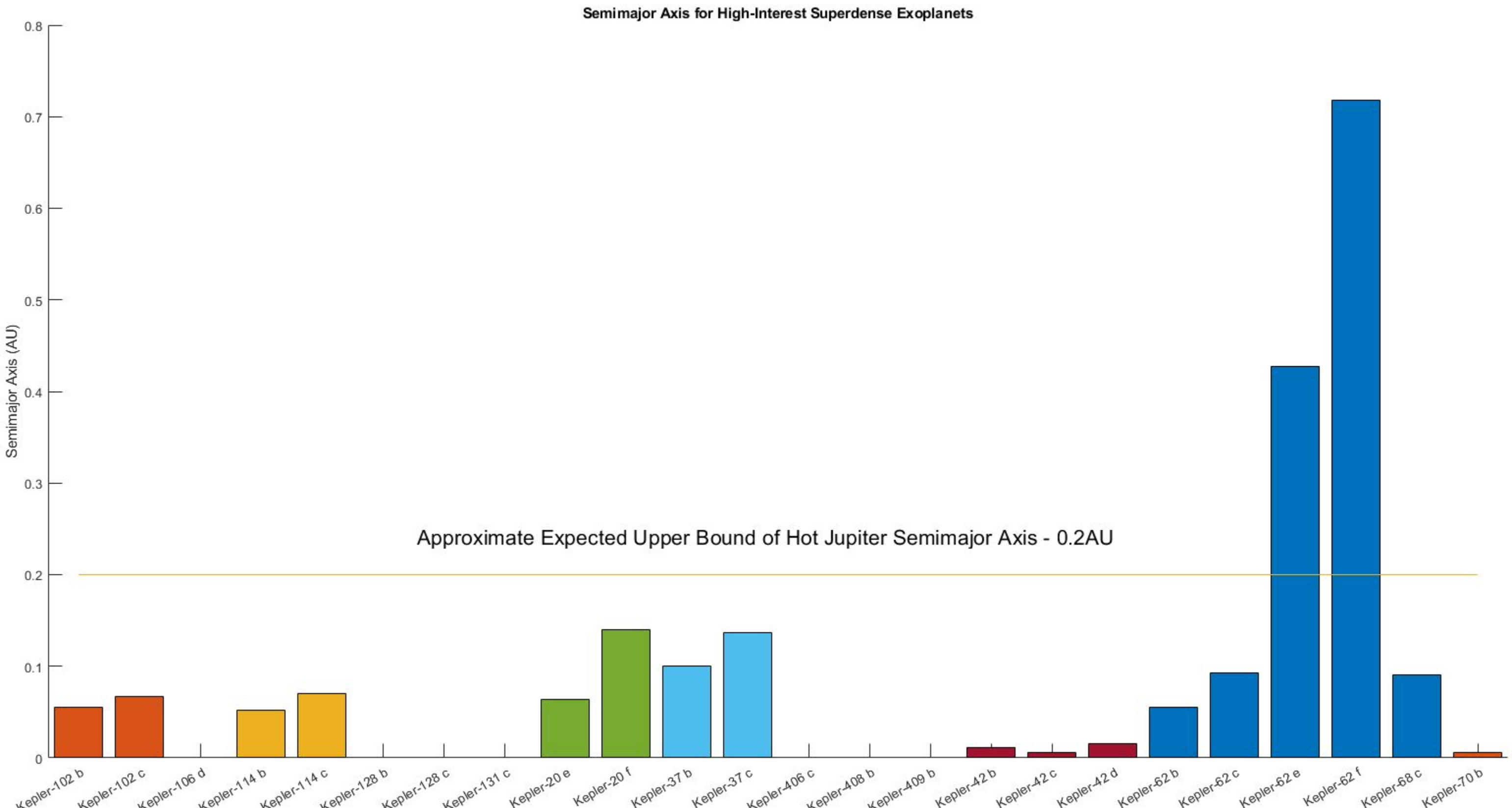
- Jupiter: 12-45MEarth
- Saturn: 9-22MEarth
- Uranus: ~0.55MEarth

May not be exactly consistent with core accretion model, but roughly consistent with solar system planets

Comparison With Our Solar System



Semimajor Axis Criteria



Conclusions

- There are at least 24 planets that current data suggest are more dense than a pure iron sphere of the same radius
- These planets have masses consistent with those of the cores of gas and ice giants in our own solar system
- For these planets that have semimajor axis data, most are within the expected semimajor-axis range for Hot Jupiters
- Many have unconstrained or poorly constrained masses, followup data would help with certainty
- In many cases, multiple or all planets from a system exhibit superdense traits, potentially showing signs of systematic error

Future Work

- Try to understand the primordial planetary envelopes that would produce internal pressures consistent with the observed compression
- Similar past work has potentially found envelopes indicative of brown dwarf sized planets -- more research would help understand brown dwarf formation
- Examine escape methods that would produce fossilized cores on reasonable timescales