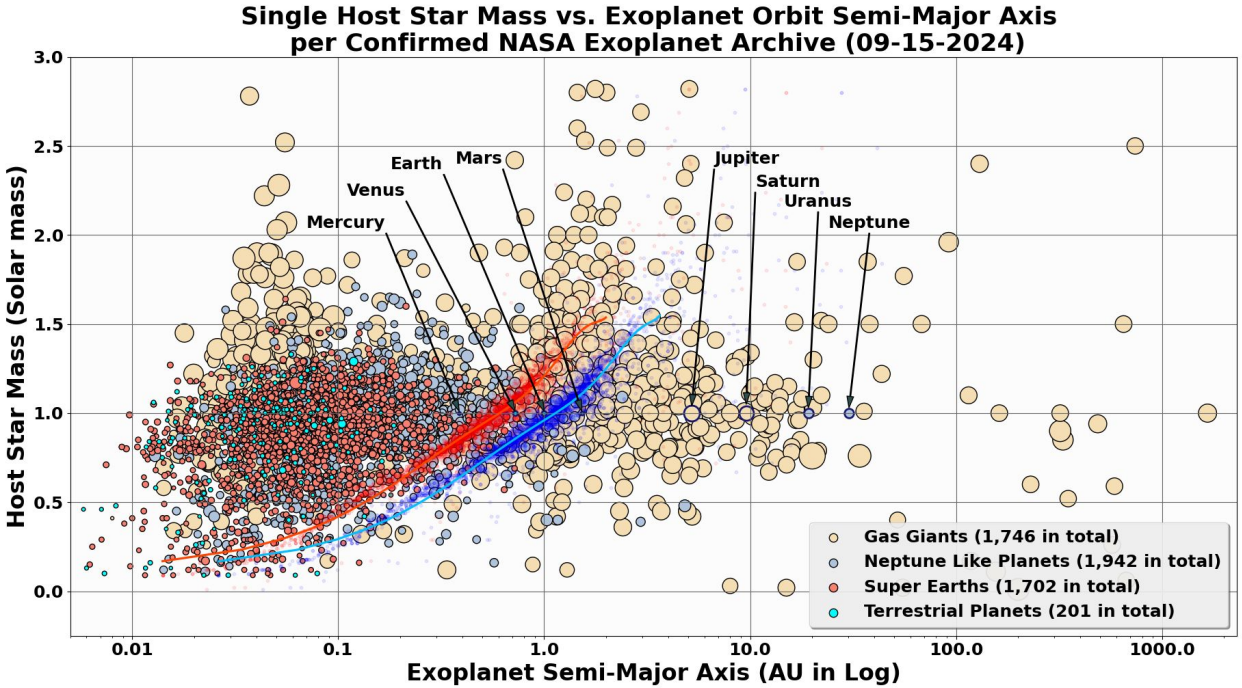
february 1st, 2025

exoplanet classification

Agenda

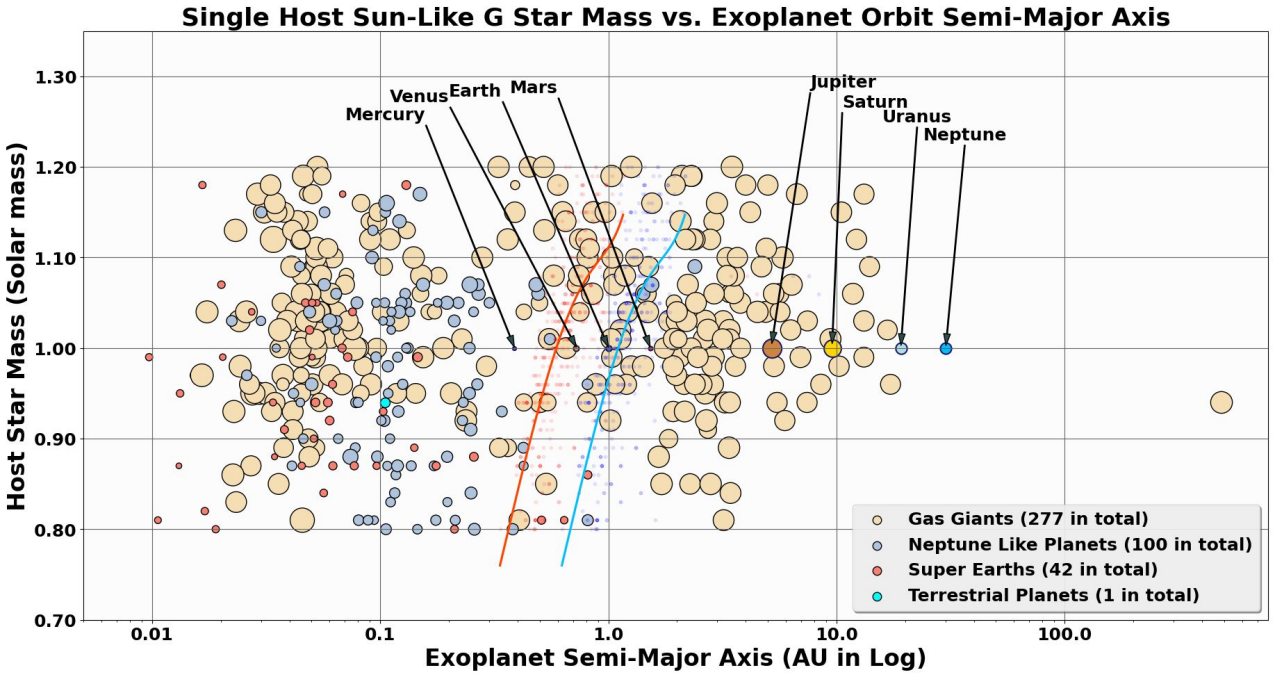
- single host star mass vs planet orbit graph
- single host sun-like G/K star mass vs planet orbit graph
- simple stellar system classes based on member planet types
- star mass vs planet orbit graphs per stellar system class - G (0.8~1.2 solar mass)
- star mass vs planet orbit graphs per stellar system class - K (0.6~0.8 solar mass)

single host star mass vs planet orbit semi-major axis



- single host stars only.
- added solar system planets for references.
- exponent types fetched from NASA Exoplanet Catalog
  - **Terrestrial**
  - **Super-Earth**
  - **Neptune-Like**
  - **Gas-Giant**
- HZ inner and outer boundaries are calculated according to our paper.

single host sun-like G star mass vs. exoplanet orbit

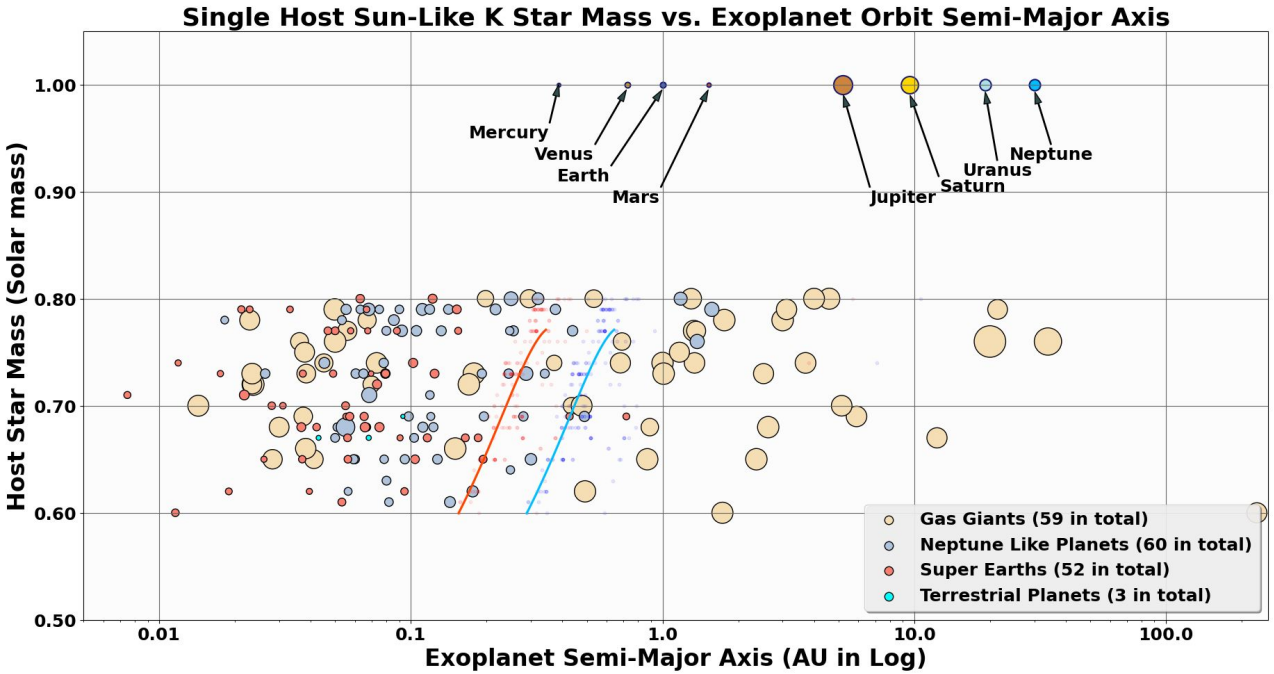


selection criteria:

- single host
- **0.8** solar_mass ≤ star_mass ≤ **1.2** solar_mass

in total 301 G stars.

single host sun-like K star mass vs. exoplanet orbit



selection criteria:

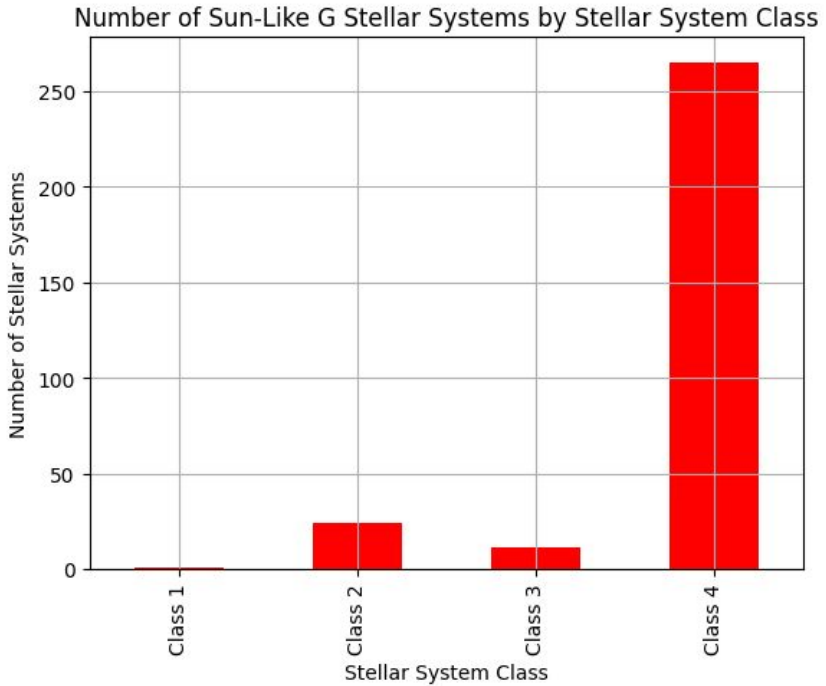
- single host
- **0.6** solar_mass ≤ star_mass ≤ **0.8** solar_mass

in total 108 K stars.

stellar system classes

- create simple stellar system classes based on member planet types:
  - **class 1**: at least one Terrestrial + at least one Neptune-Like or Gas-Giant
  - **class 2**: at least one Super-Earth + at least one Neptune-Like or Gas-Giant
  - **class 3**: only Terrestrial or Super-Earth
  - **class 4**: only Neptune-Like or Gas-Giant

stellar system classes - G stars (0.8 ~ 1.2 solar mass)

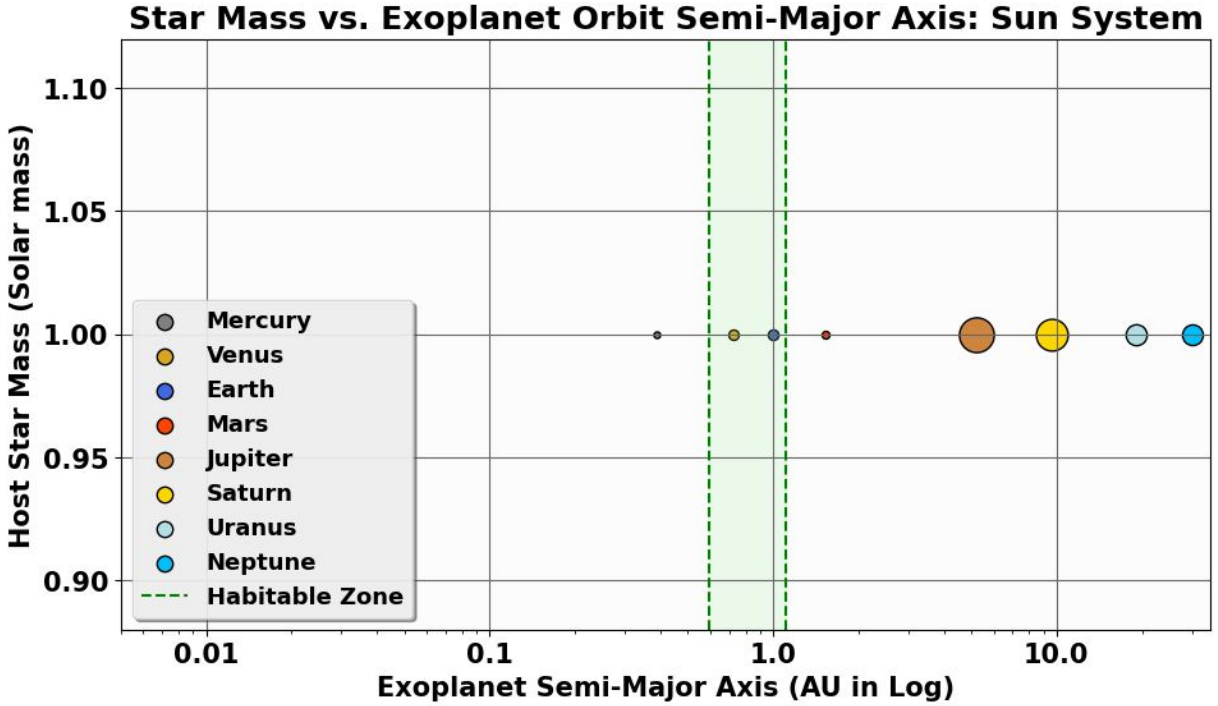


st_system_class	count
Class 1	1
Class 2	24
Class 3	11
Class 4	265

simple stellar system classes:

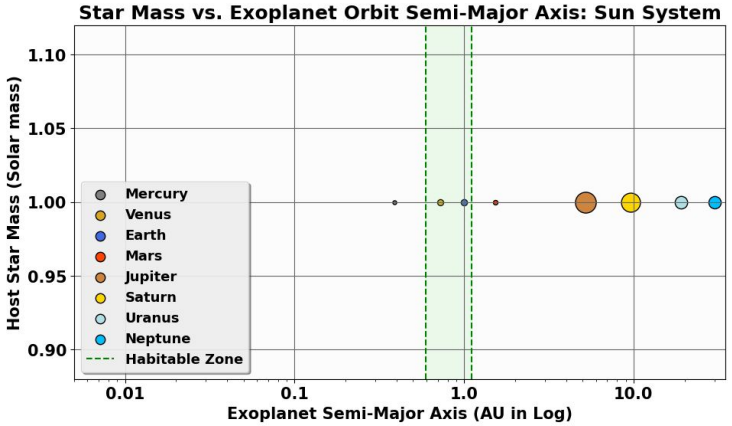
- **class 1**: at least one Terrestrial + at least one Neptune-Like or Gas-Giant
- **class 2**: at least one Super-Earth + at least one Neptune-Like or Gas-Giant
- **class 3**: only Terrestrial or Super-Earth
- **class 4**: only Neptune-Like or Gas-Giant

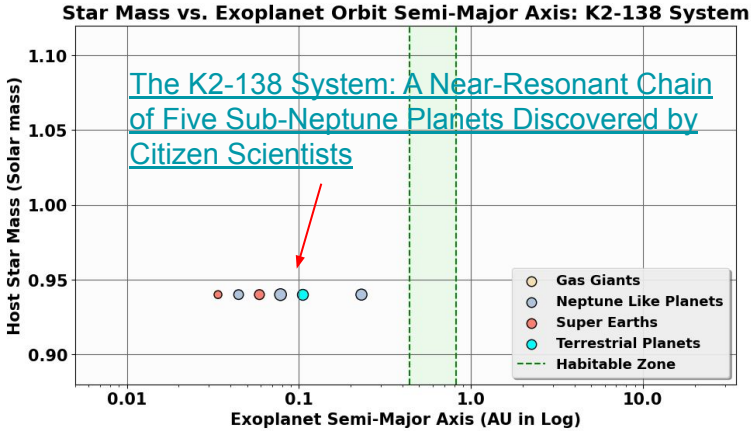
star mass vs. exoplanet orbit: our solar system



HZ inner and outer boundaries are calculated according to our paper.

star mass vs. exoplanet orbit: G stellar systems - class 1

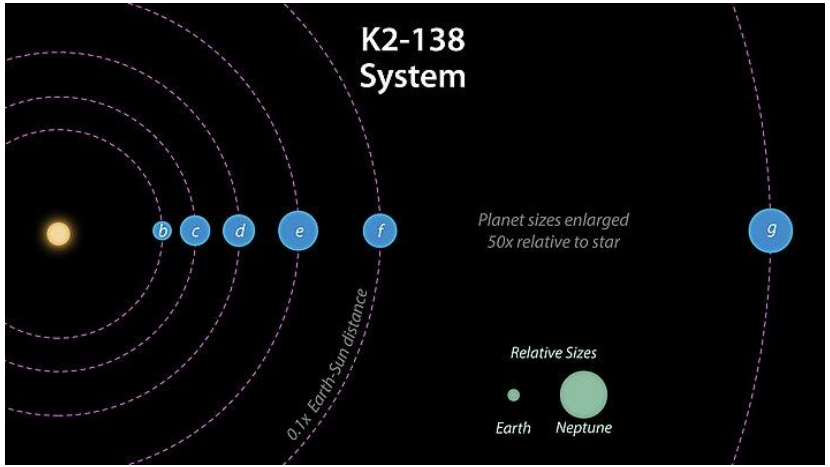




[The K2-138 System: A Near-Resonant Chain of Five Sub-Neptune Planets Discovered by Citizen Scientists]

[K2-138 overview at NASA exponent archive]

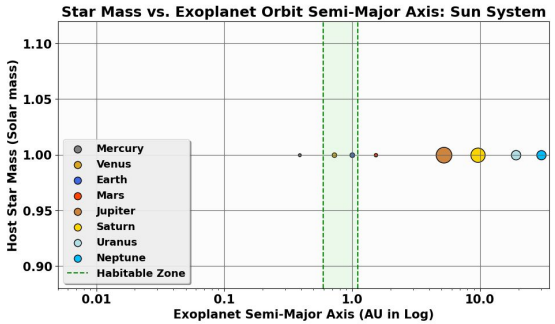
[K2-138 at wikipedia]

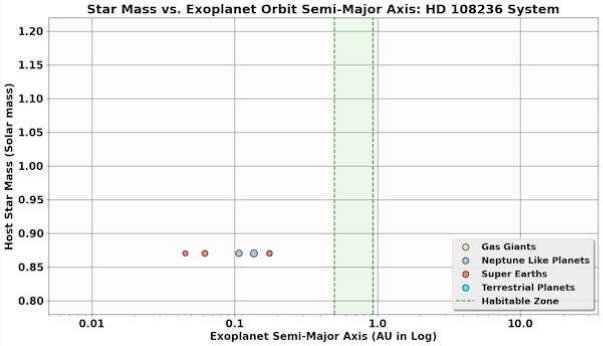


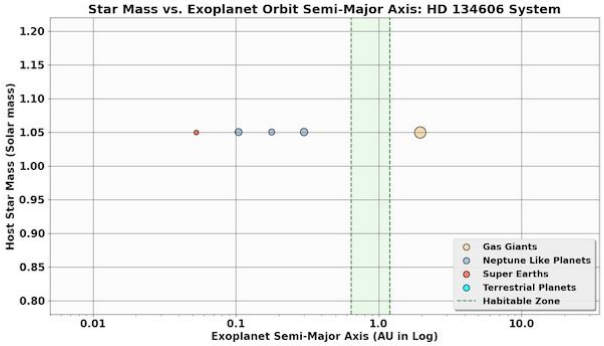
the above image comes from [wikipedia]

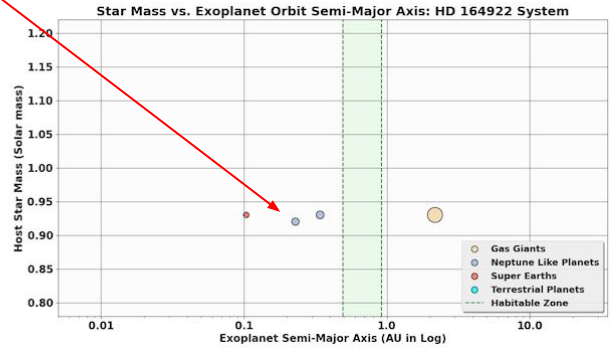
star mass vs. exoplanet orbit: G stellar systems - class 2

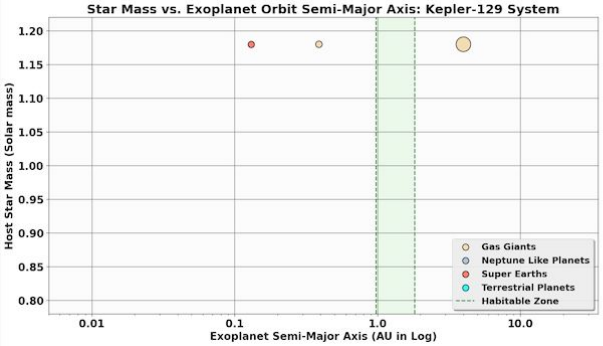
st_mass value for “HD 164922 e” is 0.92 in NASA Exoplanet Archive, while other planets in the same system are 0.93

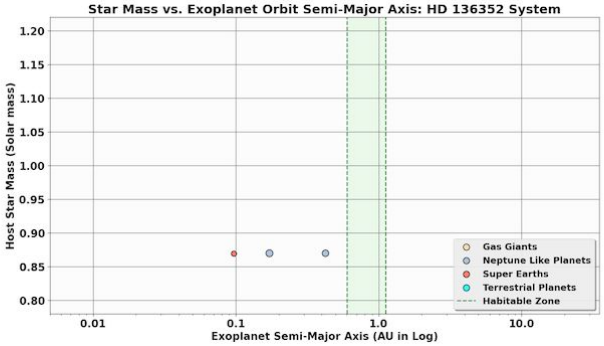


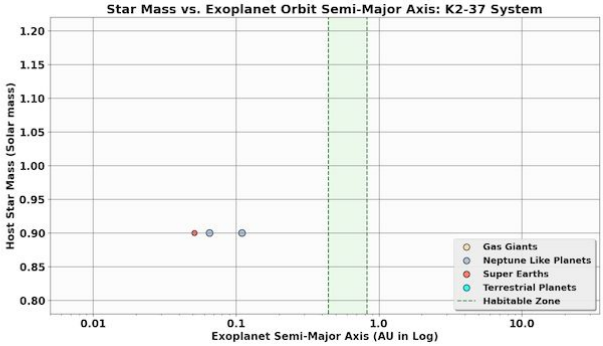




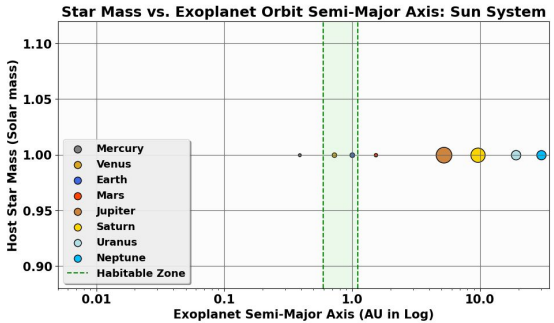


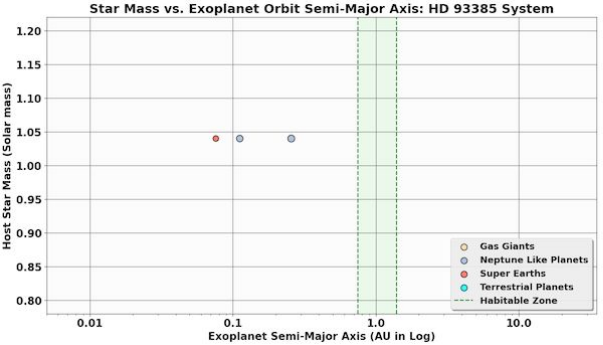


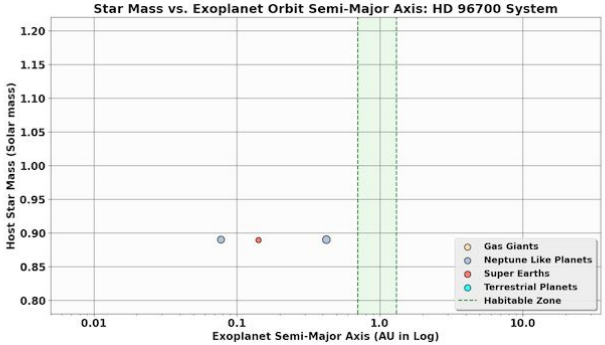


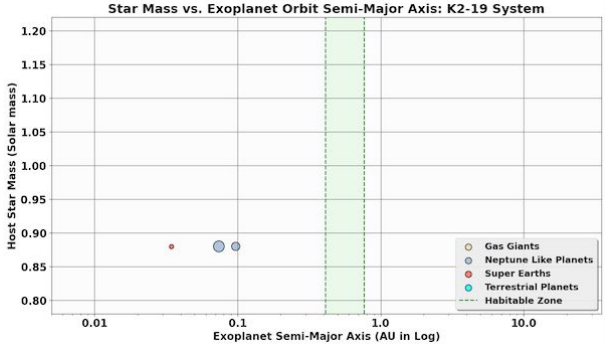


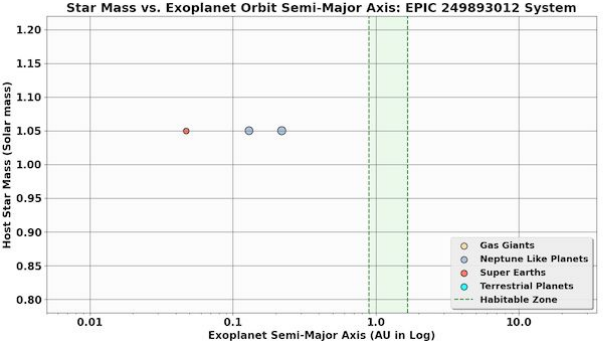
star mass vs. exoplanet orbit:
G stellar systems - class 2 (cont.)

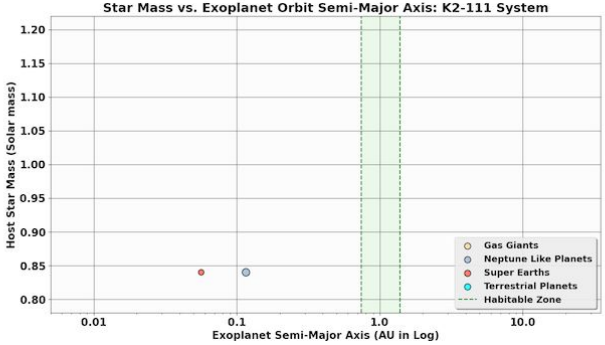


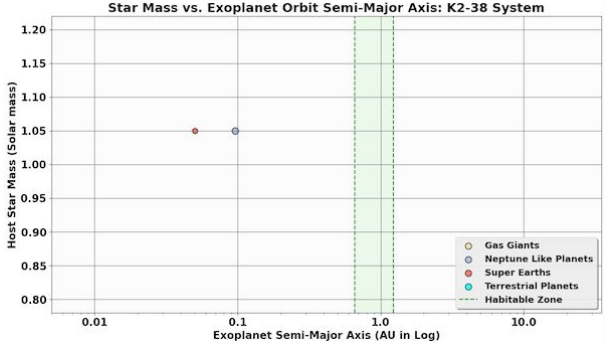




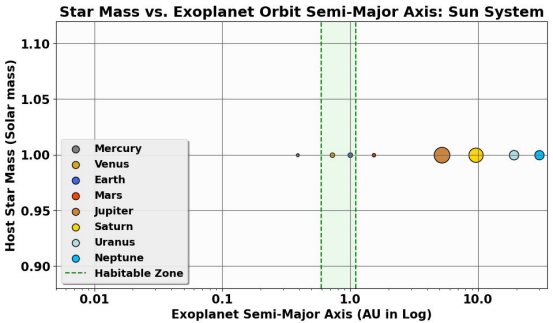


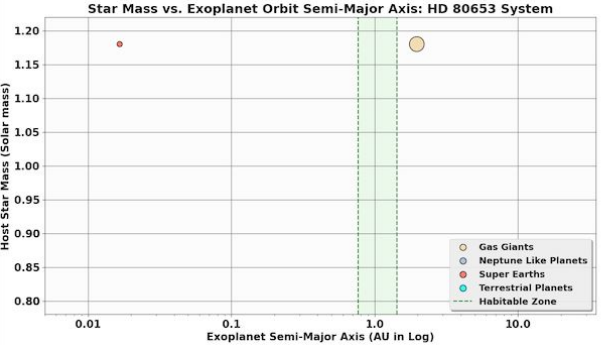


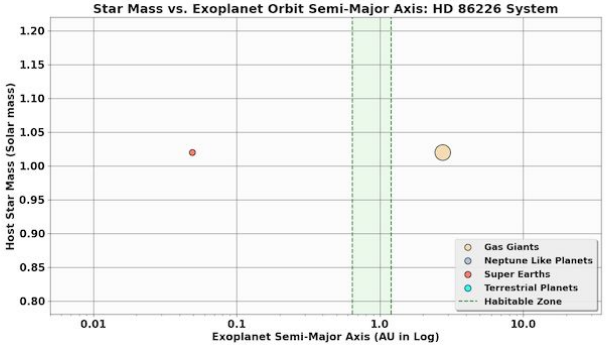


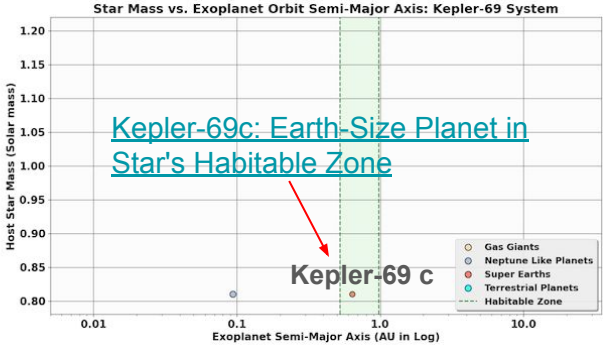


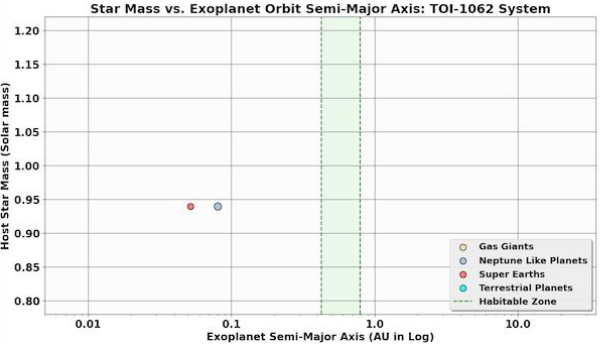
star mass vs. exoplanet orbit: G stellar systems - class 2 (cont.)

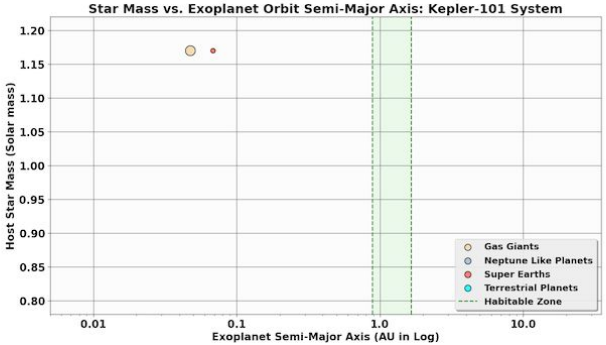


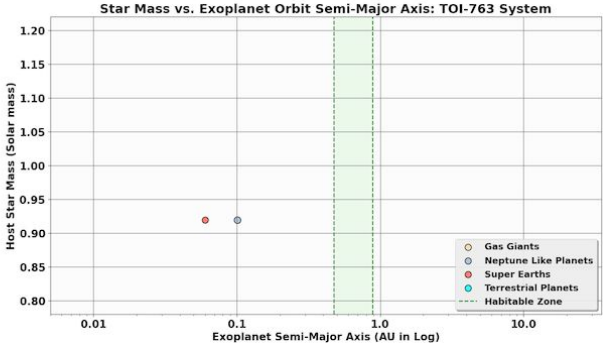






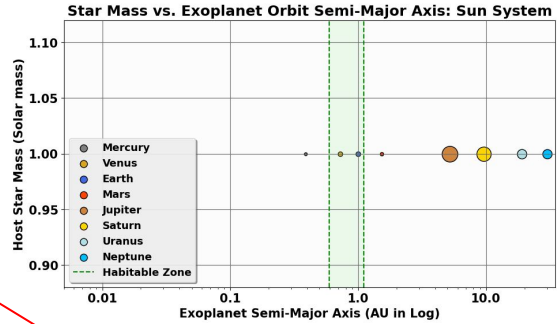


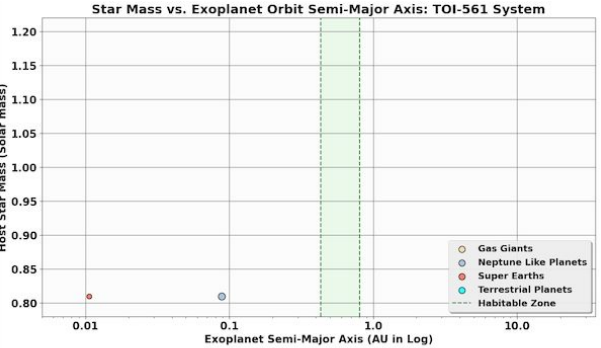


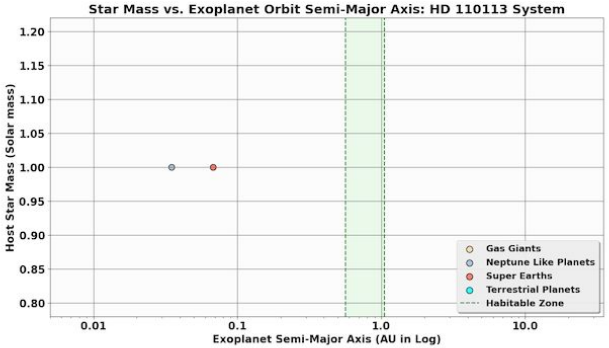


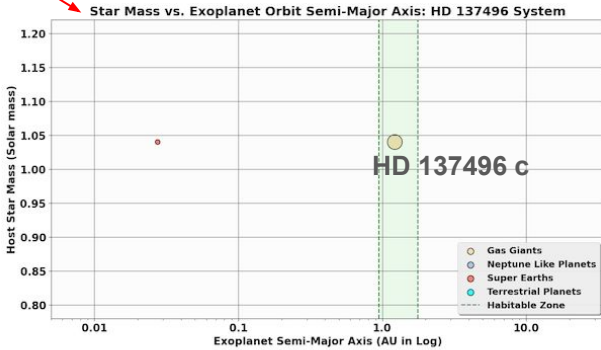
star mass vs. exoplanet orbit:
G stellar systems - class 2 (cont.)

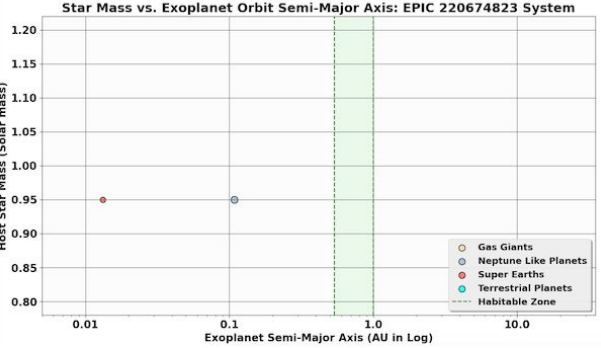
[The HD 137496 system: A dense, hot super-Mercury and a cold Jupiter]

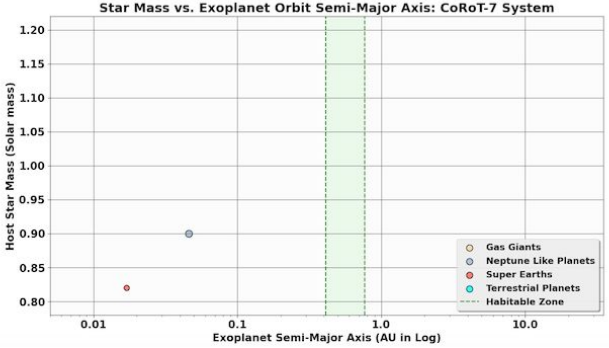


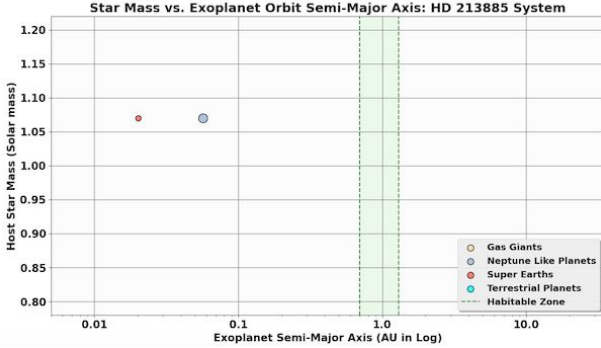




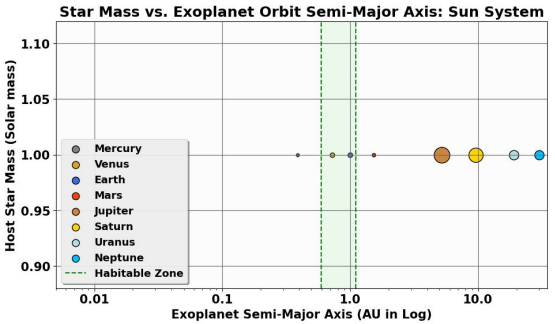


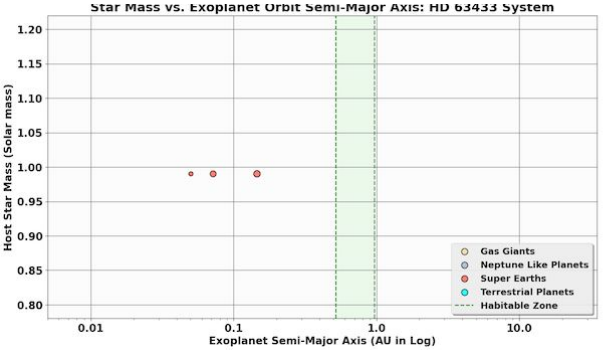


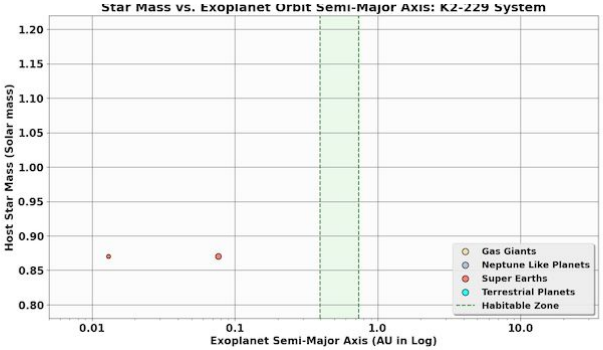


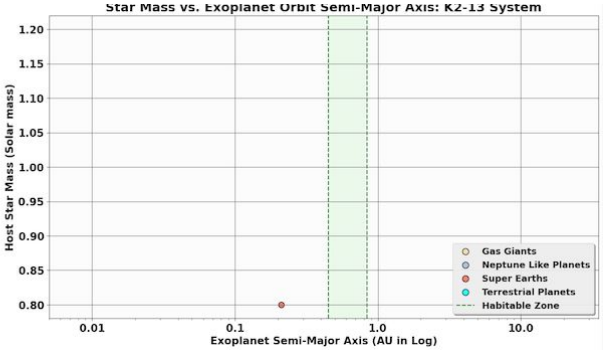


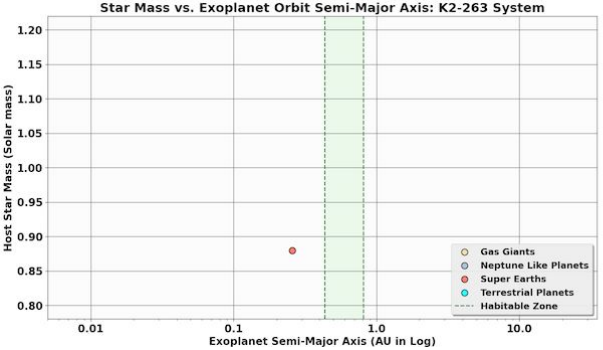
star mass vs. exoplanet orbit: G stellar systems - class 3

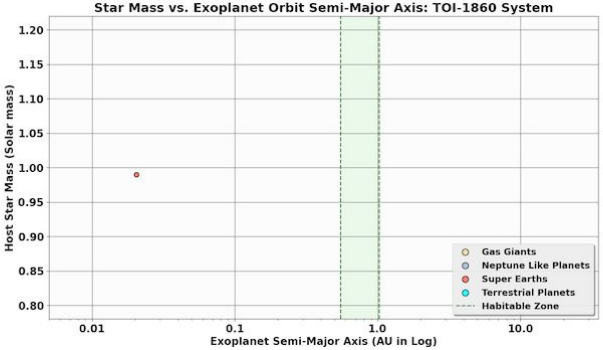


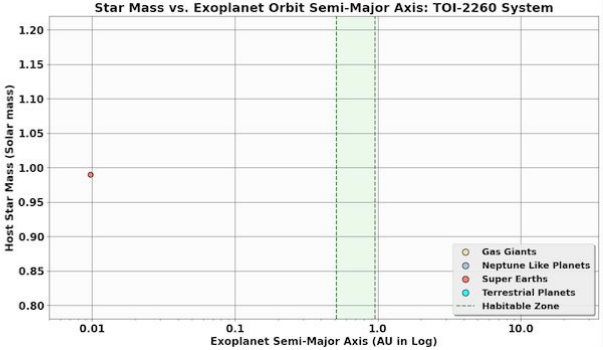




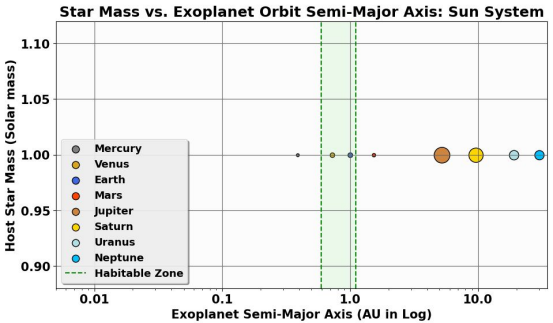


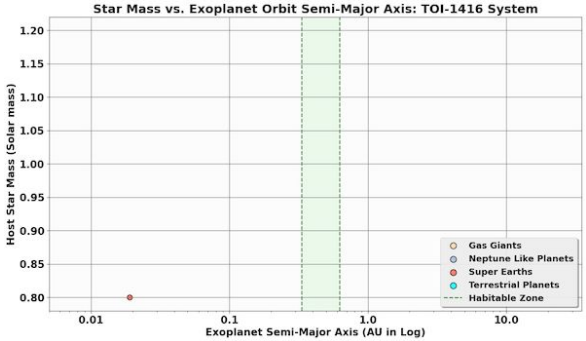


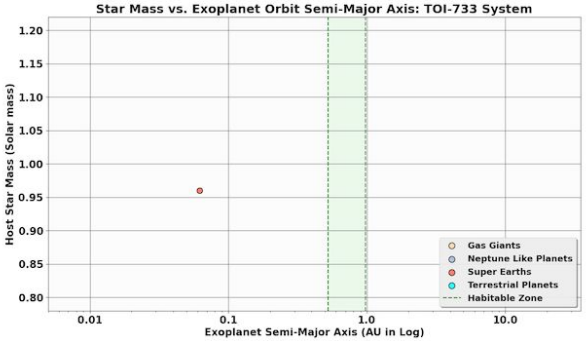


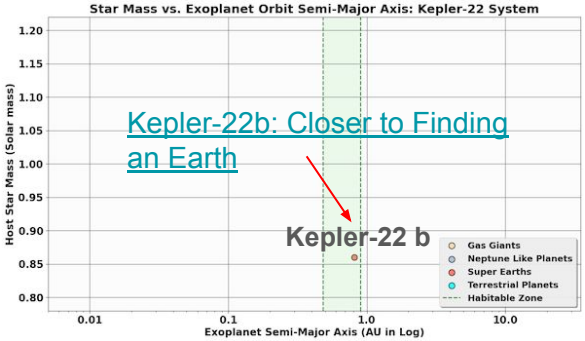


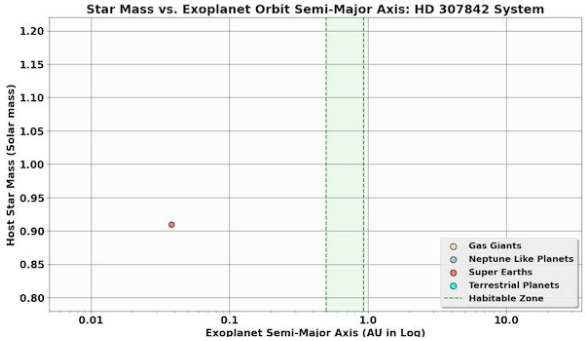
star mass vs. exoplanet orbit: G stellar systems - class 3 (cont.)

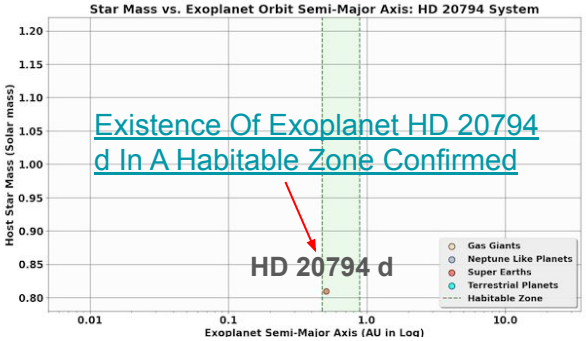




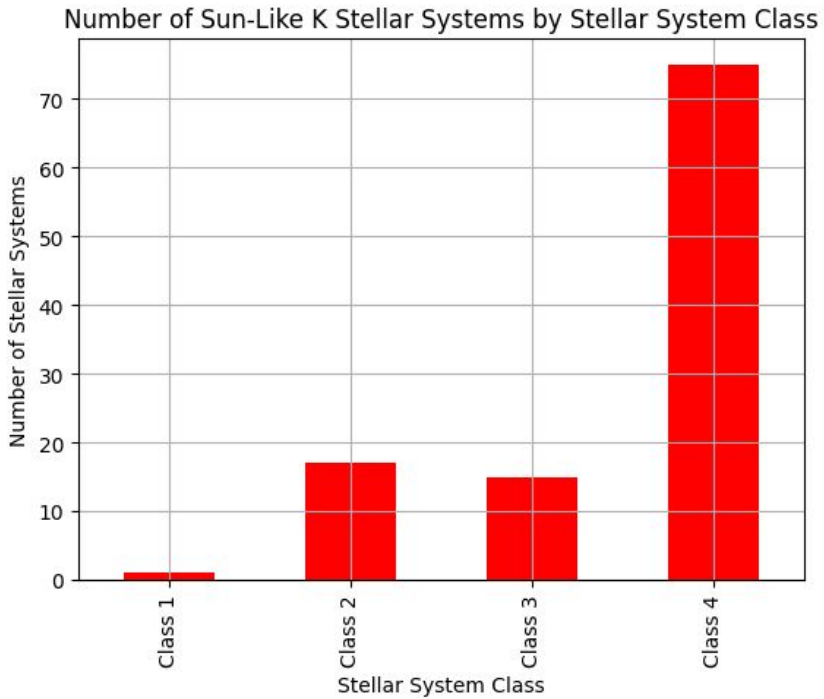








stellar system classes - K stars (0.6 ~ 0.8 solar mass)

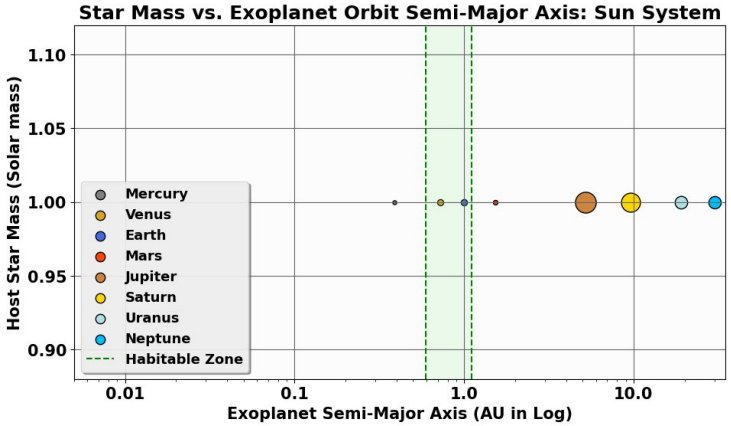


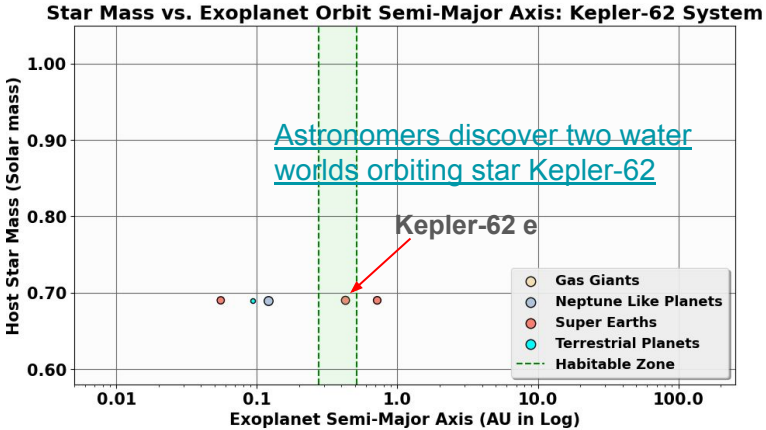
st_system_class	count
Class 1	1
Class 2	17
Class 3	15
Class 4	75

simple stellar system classes:

- **class 1**: at least one Terrestrial + at least one Neptune-Like or Gas-Giant
- **class 2**: at least one Super-Earth + at least one Neptune-Like or Gas-Giant
- **class 3**: only Terrestrial or Super-Earth
- **class 4**: only Neptune-Like or Gas-Giant

star mass vs. exoplanet orbit: K stellar systems - class 1

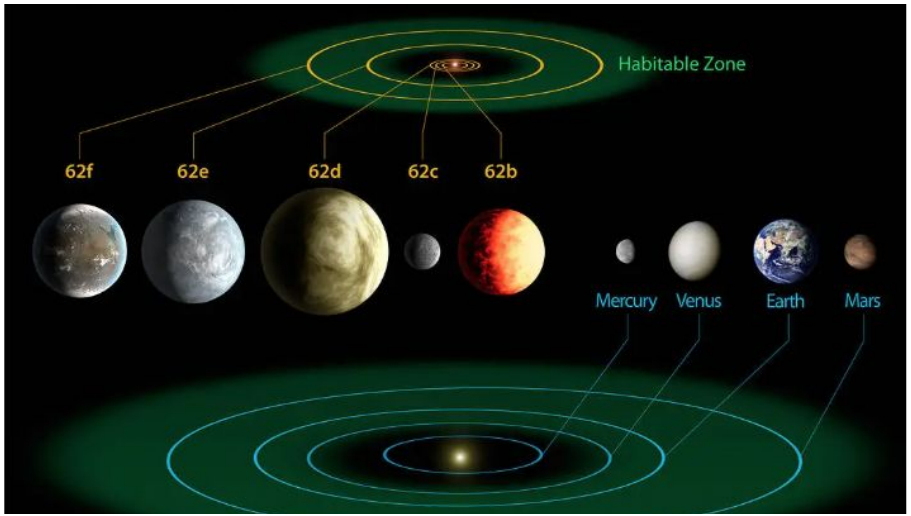




[Astronomers discover two water worlds orbiting star Kepler-62]

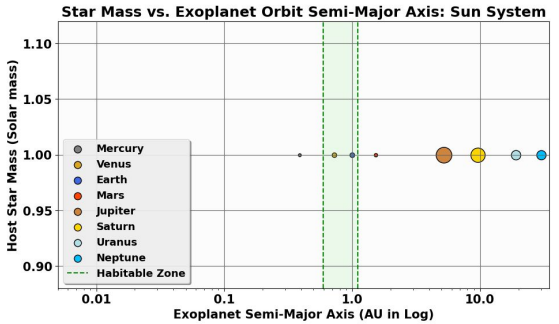
[Kepler-62 overview at NASA]

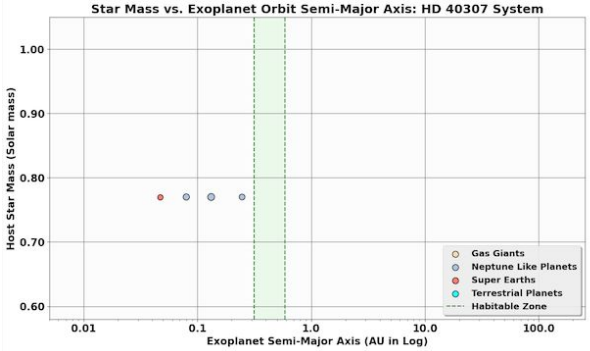
[Kepler-62 at wikipedia]

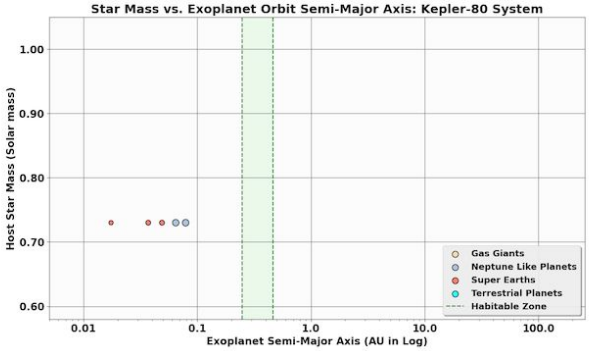


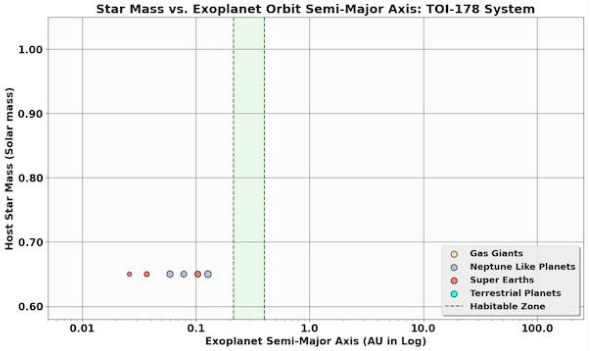
the above image comes from [NASA]

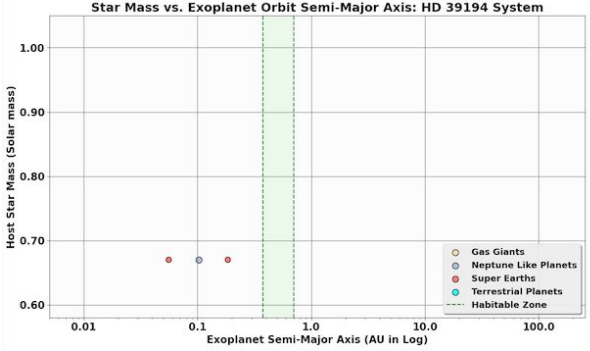
star mass vs. exoplanet orbit: K stellar systems - class 2

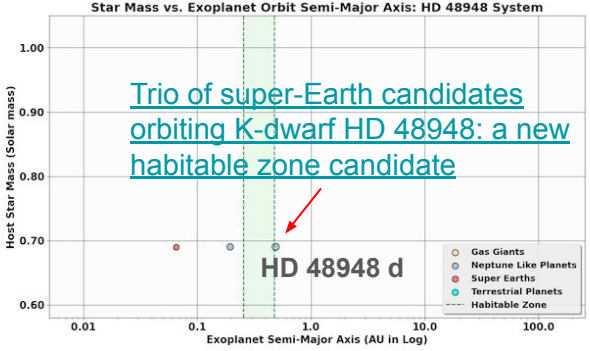






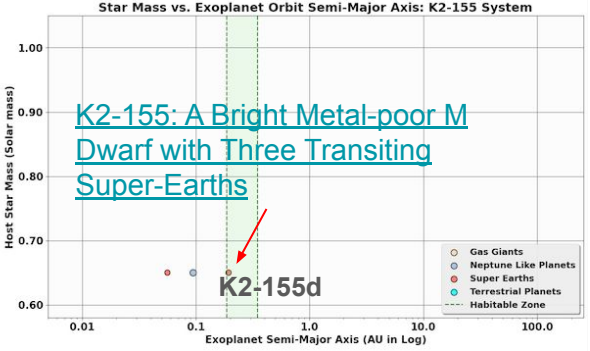






[Trio of super-Earth candidates orbiting K-dwarf HD 48948: a new habitable zone candidate]

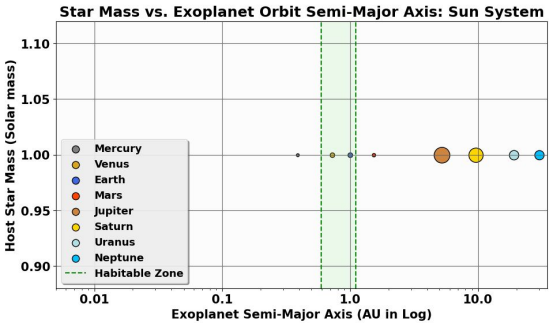
HD 48948 d

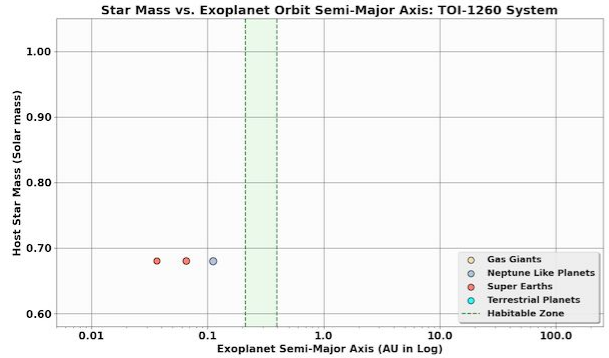


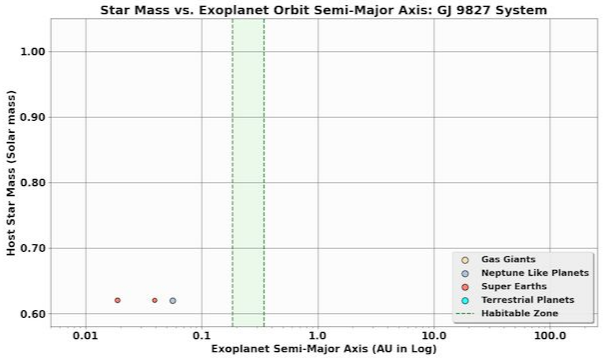
[K2-155: A Bright Metal-poor M Dwarf with Three Transiting Super-Earths]

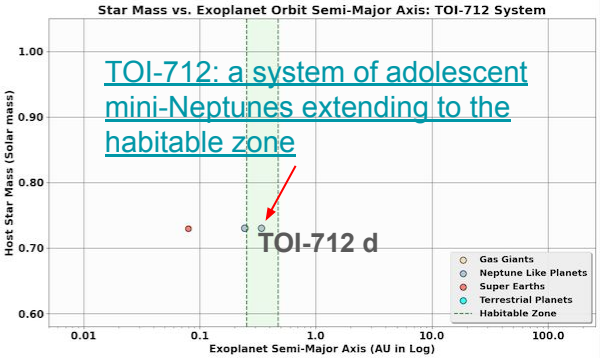
K2-155d

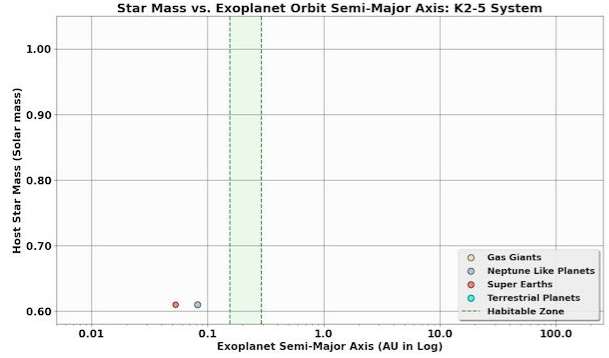
star mass vs. exoplanet orbit: K stellar systems - class 2 (cont.)

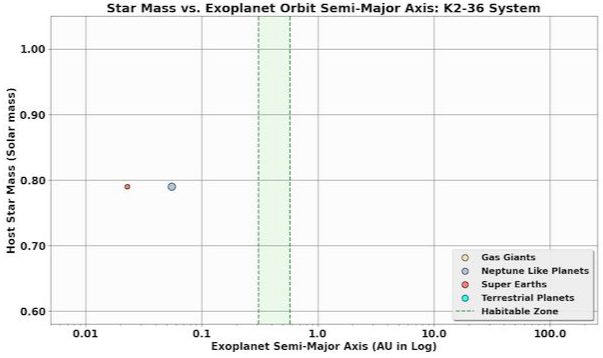


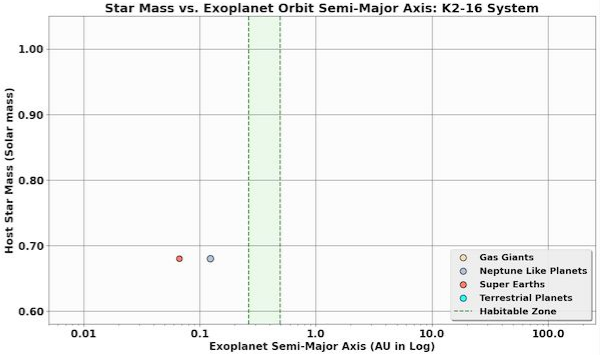




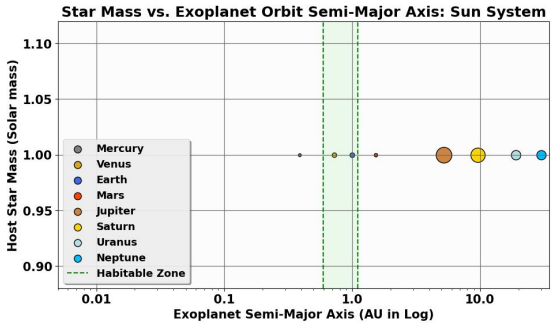


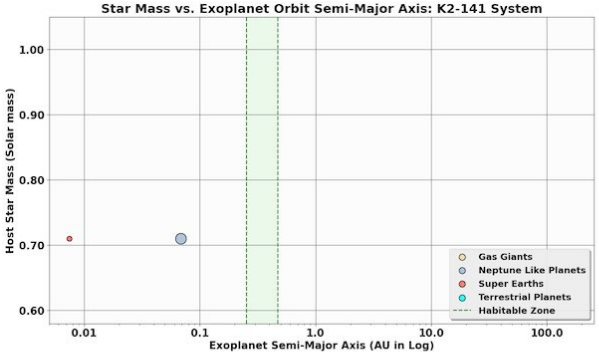


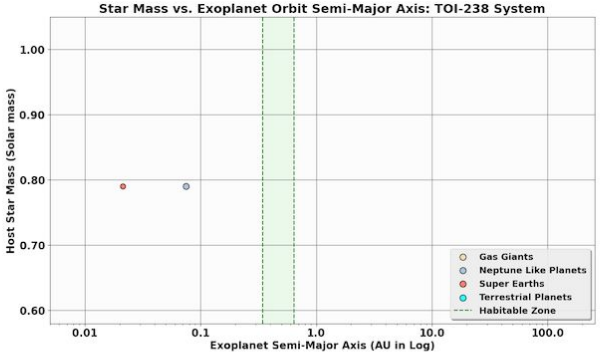


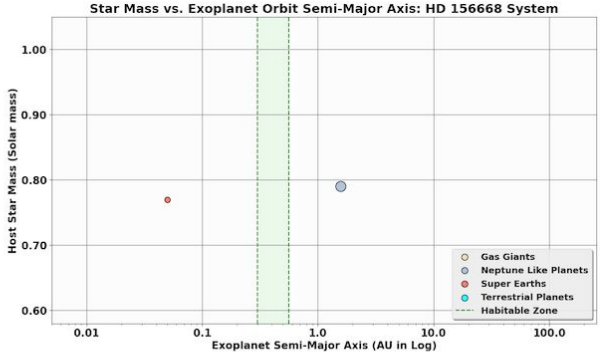


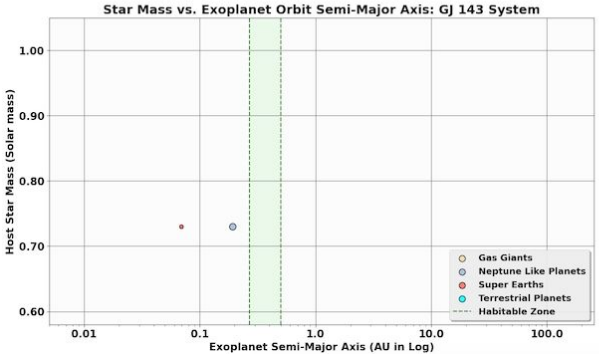
star mass vs. exoplanet orbit:
K stellar systems - class 2 (cont.)

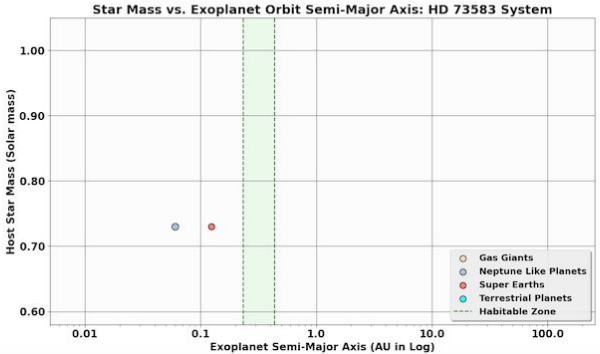




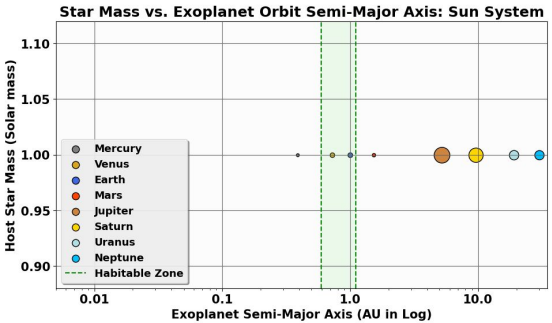


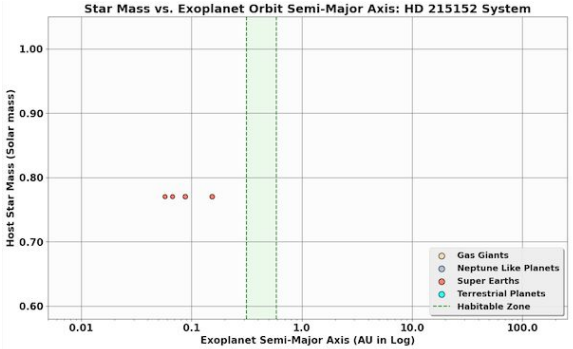


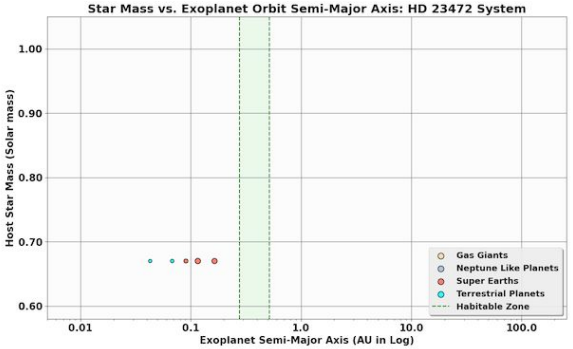


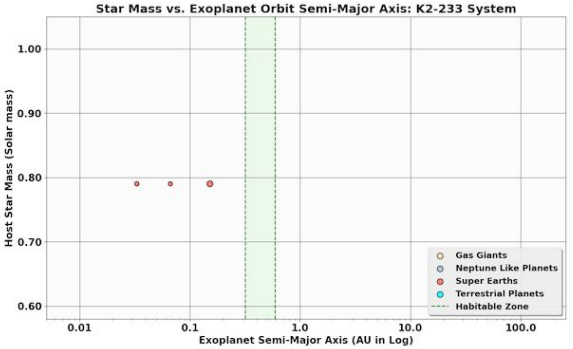


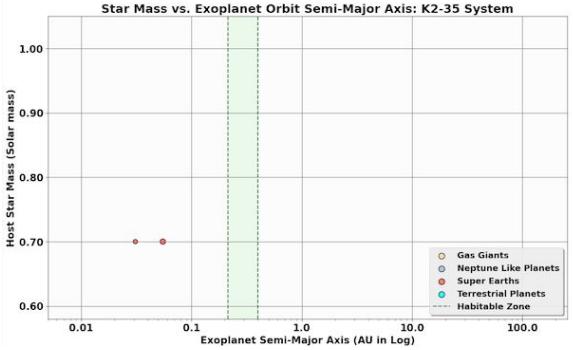
star mass vs. exoplanet orbit: K stellar systems - class 3

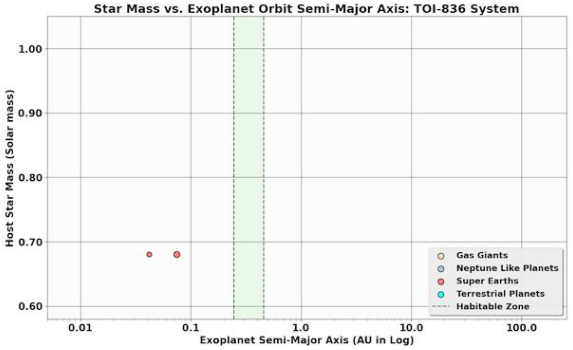


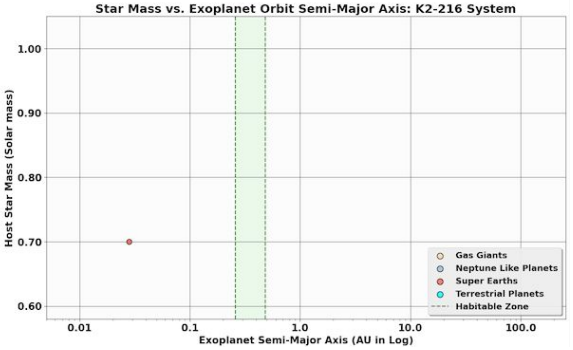




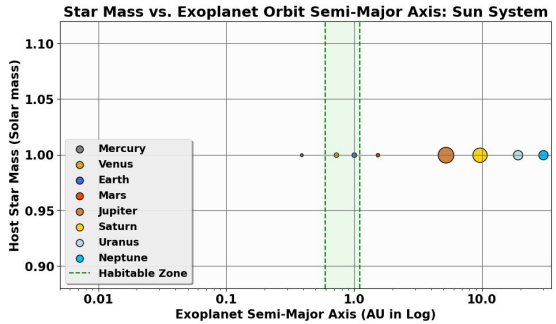


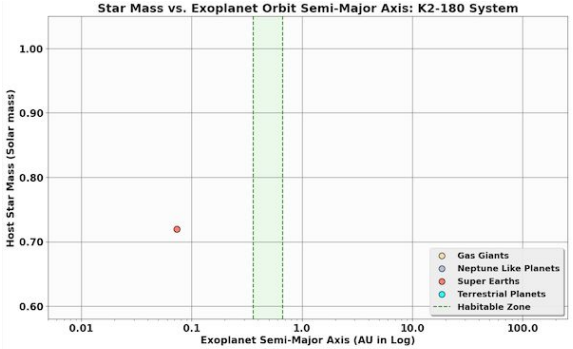


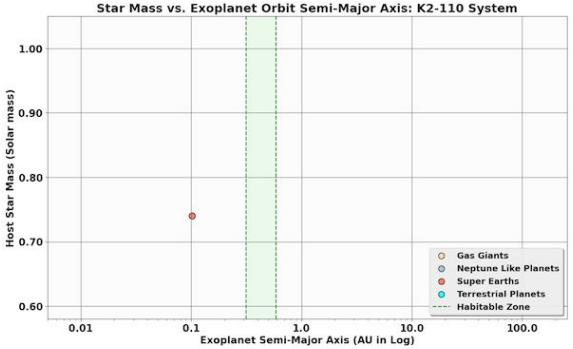


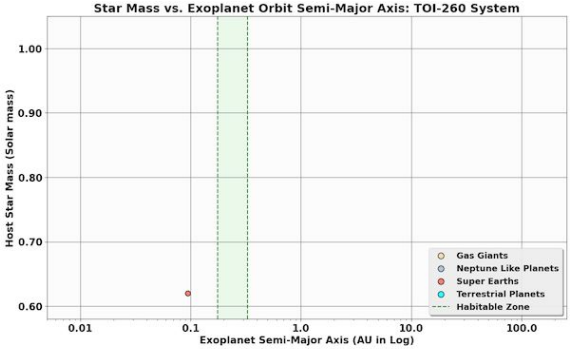


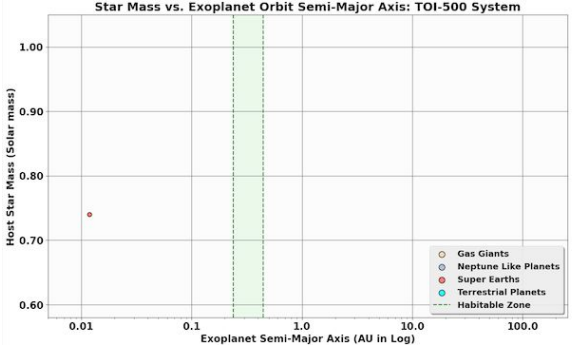
star mass vs. exoplanet orbit:
K stellar systems - class 3 (cont.)

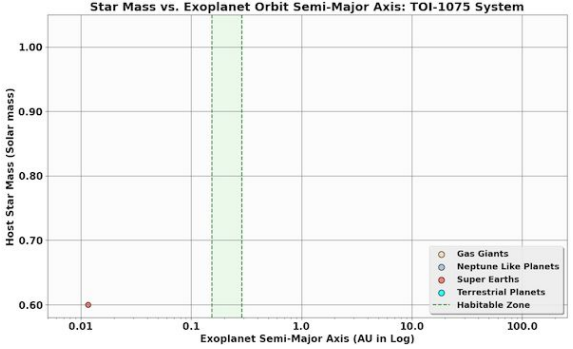


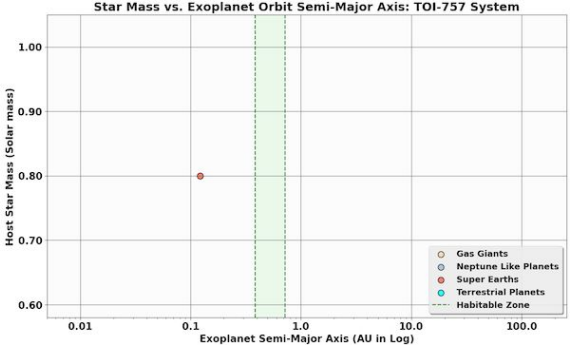




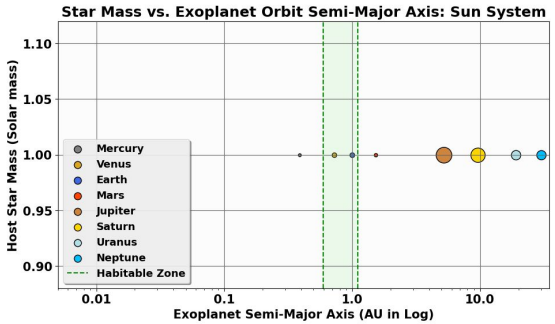


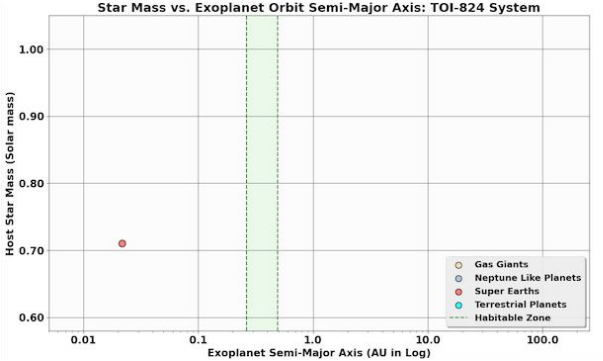


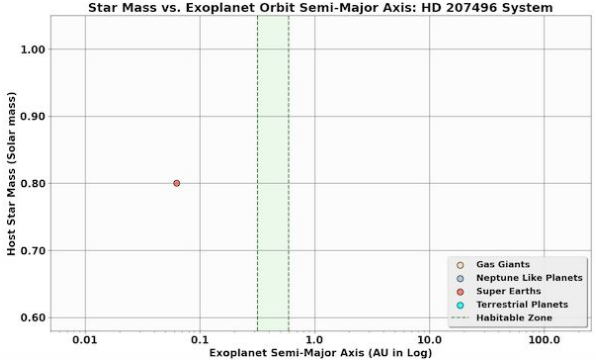


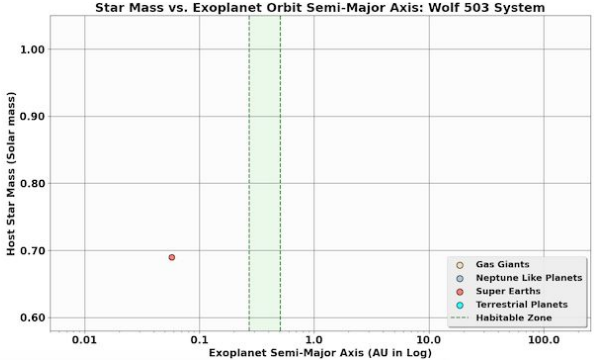


star mass vs. exoplanet orbit:
K stellar systems - class 3 (cont.)









future work

- try joining with Habitable Worlds Catalog (HWC), PHL @ UPR Arecibo data.
- maybe try with K-mean ML model to cluster stellar systems based on similarities?