

**february 8th, 2025**

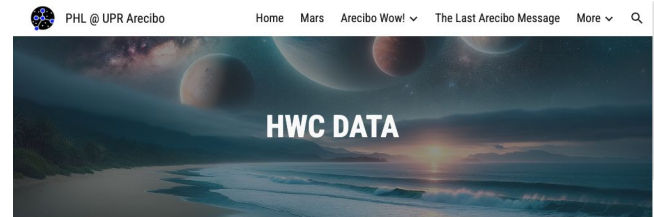
exoplanet classification

# Agenda

- join NASA exoplanet archive data with HWC, PHL @ UPR Arecibo
- analysis on the single-host stellar systems that contain conservative & optimistic habitable exoplanets
- star mass vs planet orbit graphs per stellar system class - conservative habitable
- star mass vs planet orbit graphs per stellar system class - optimistic habitable

# joining NASA Exoplanet Archive with HWC, PHL

- join the NASA Exoplanet Archive data with [Hibitable World Catalog \(HWC\)](#) data from PHL @ UPR Arcibo
- HWC data contains a  $P\_HABITABLE$  data field:
  - $P\_HABITABLE = 1$ : more likely to be rocky planets capable of surface liquid water
  - $P\_HABITABLE = 2$ : might include water worlds or mini-Neptunes, with less likelihoods of habitable conditions
  - $P\_HABITABLE = 0$ : non-habitable exoplanets



PHL @ UPR Arcibo Home Mars Arcibo Wow! The Last Arcibo Message More

## HWC DATA

### Simplified Catalog

These simplified tables of the Habitable Worlds Catalog (HWC) are easier to explore online. Columns can be sorted in ascending or descending order by clicking the headers. Search within these tables using the browser search function Ctrl+F (Windows, Linux, and Chrome OS) or ⌘-F (Mac).

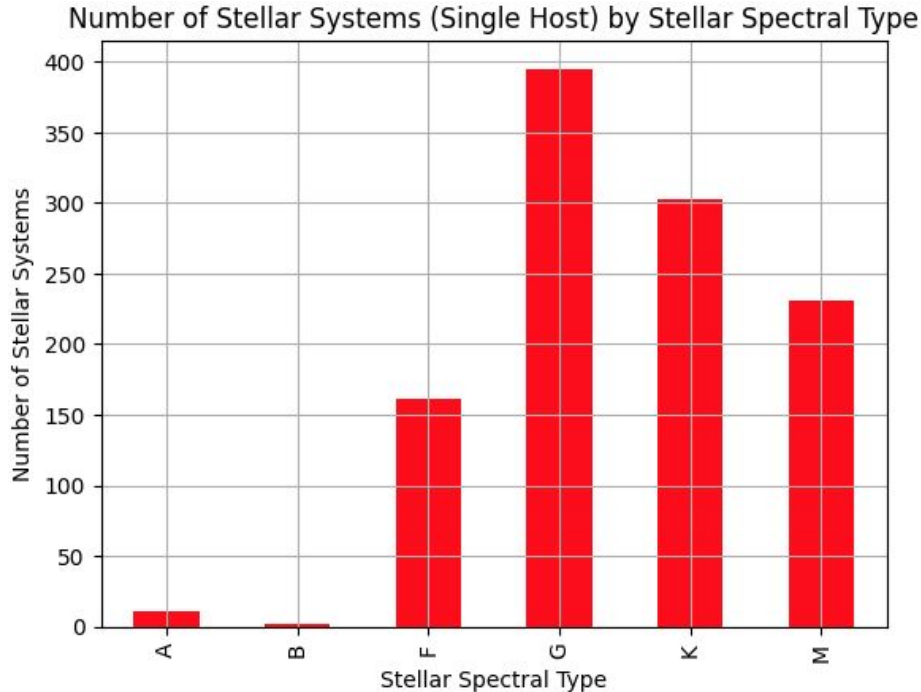
**Table 1.** List of the potentially habitable exoplanets in the HWC, including the conservative and optimistic samples. They are sorted by the Earth Similarity Index (ESI).

Name	Type	Detection Method	Mass (M <sub>J</sub> )	Radius (R <sub>J</sub> )	Flux (S <sub>J</sub> )	T <sub>surf</sub> (K)	Period (days)	Distance (ly)	Age (Gy)	ESI
1 Teegarden's Star b	M Warm Terran	Radial Velocity	≥ 1.16	~ 1.05	1.08	~ 293	4.91	12.5	> 8.00	0.97
2 TOI-700 d	M Warm Terran	Transit	~ 1.25	1.07	0.86	~ 276	37.4	101	> 1.50	0.94
3 Kepler-1649 c	M Warm Terran	Transit	~ 1.20	1.06	1.23	~ 302	19.5	300		0.93
4 TOI-700 e	M Warm Terran	Transit	~ 0.82	0.95	1.28	~ 305	27.8	101	> 1.50	0.91
5 TRAPPIST-1 d	M Warm Subterran	Transit	0.39	0.79	1.12	~ 295	4.05	40.5	> 0.50	0.91
6 LP 890-8 e	M Warm Terran	Transit	< 25.3	1.37	0.91	~ 280	8.46	105	7.20	0.89
7 K2-72 e	M Warm Terran	Transit	~ 2.21	1.29	1.30	~ 306	24.2	216		0.87
8 Proxima Cent b	M Warm Terran	Radial Velocity	≥ 1.07	~ 1.03	0.68	~ 261	11.2	4.2		0.86
9 GJ 1102 b	M Warm Terran	Radial Velocity	≥ 1.08	~ 1.03	0.67	~ 260	10.3	15.8		0.86
10 GJ 1061 d	M Warm Terran	Radial Velocity	≥ 1.64	~ 1.16	0.69	~ 246	13.0	12.0	> 7.00	0.86

# stellar system classes - recap

- 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 spectral types (single host)



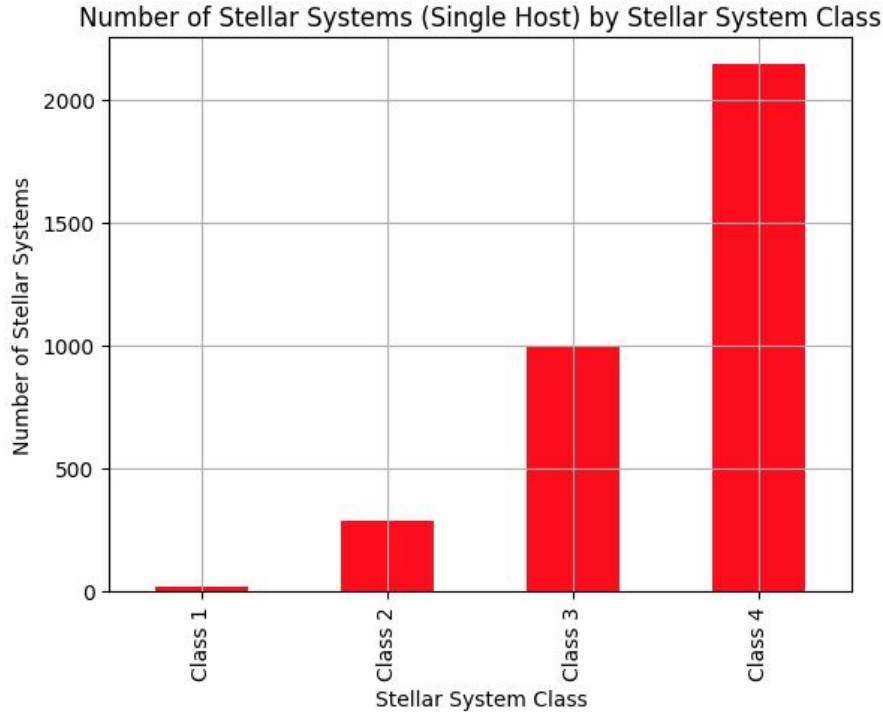
## Notes:

- lots of stellar hosts in the NASA exoplanet archive data set miss spectral types
- data points with stellar spectral types other than OBAFGKM are dropped

## st\_spectype\_short

G	395
K	303
M	231
F	161
A	11

# stellar system classes (single host)

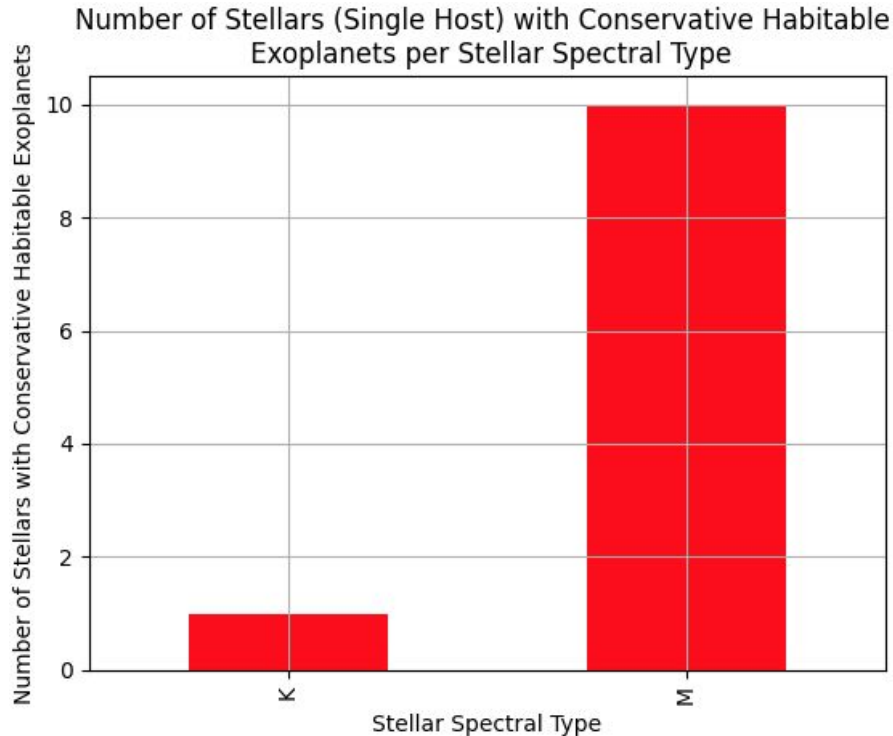


st_system_class	count
Class 1	18
Class 2	286
Class 3	997
Class 4	2144

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

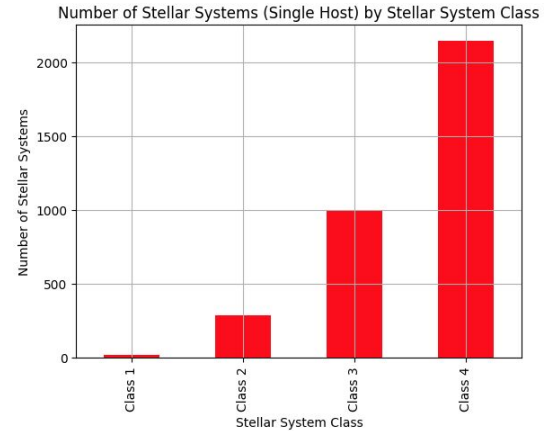
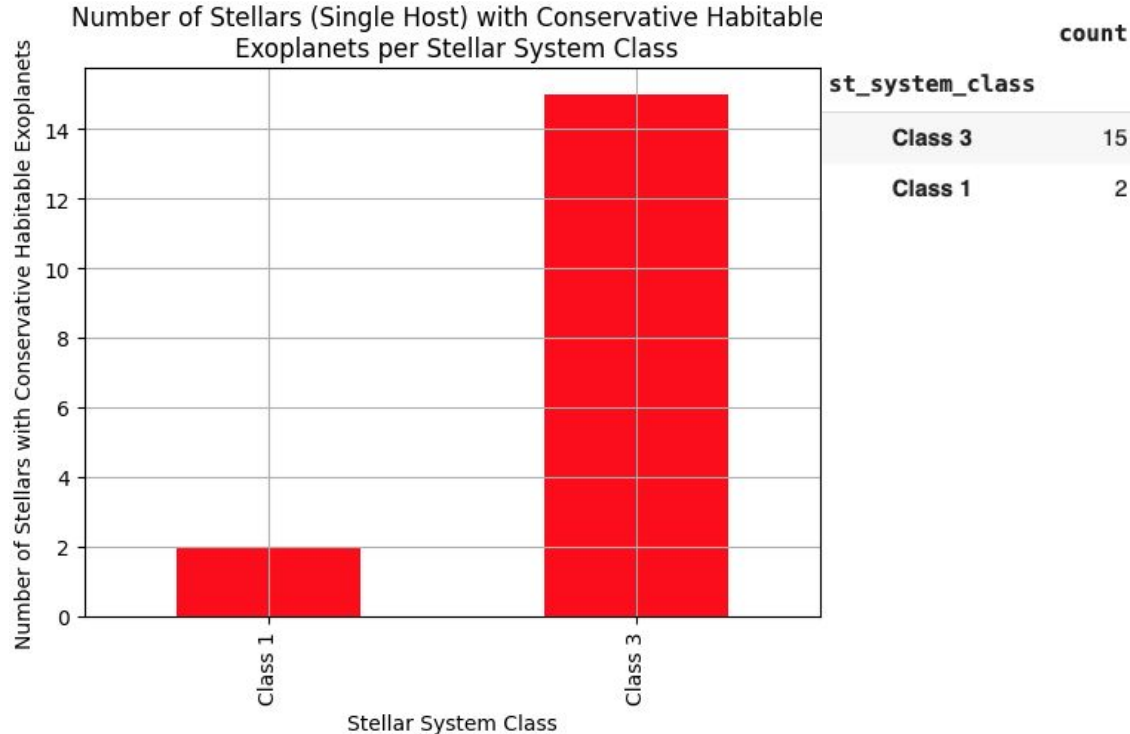
# stellar spectral types (single host) - with conservative habitable exoplanets



st_spectype_short	count
M	10
K	1

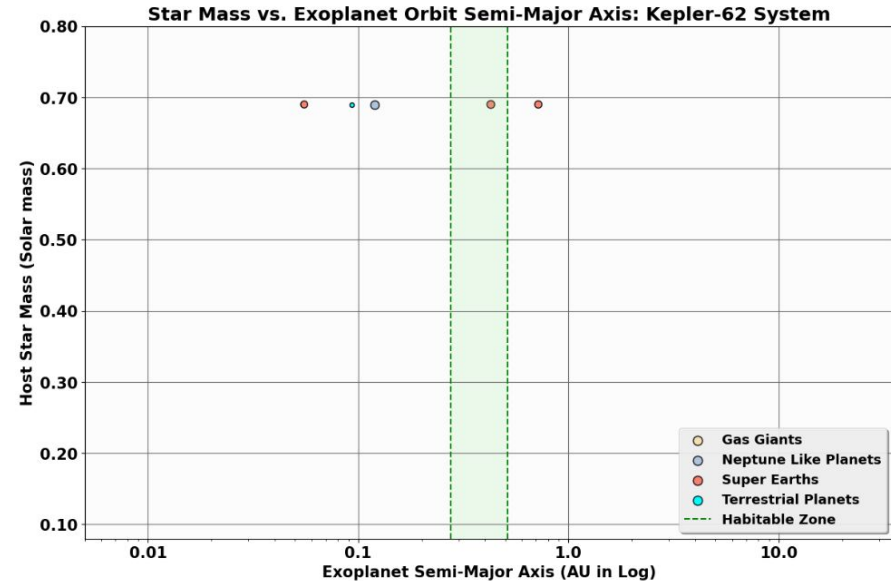
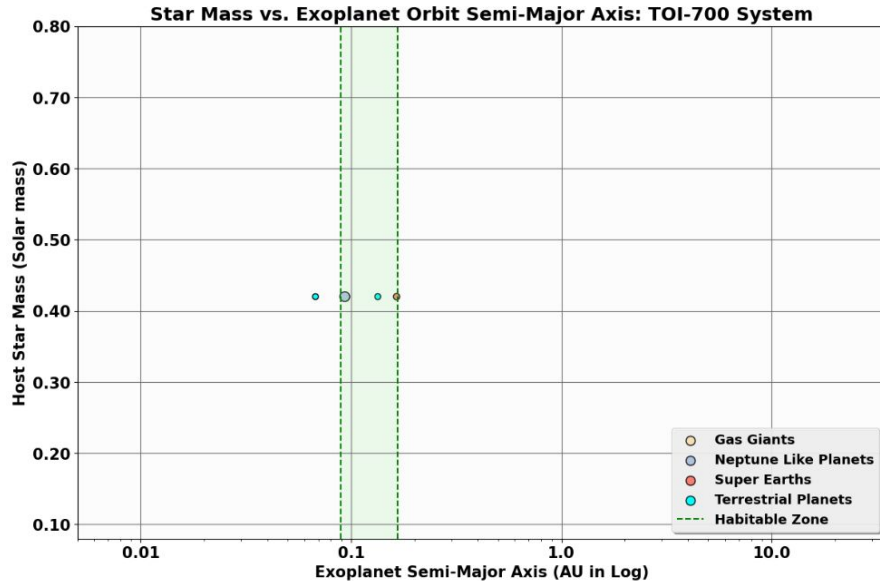
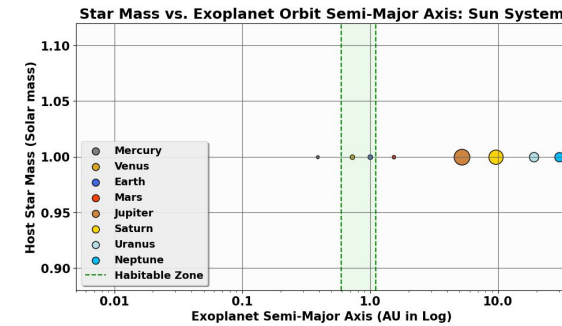
hostname	st_spectype_short
GJ 1002	M
GJ 1061	M
TOI-700	M
Teegarden's Star	M
GJ 273	M
K2-3	M
Kepler-62	K
LP 890-9	M
Ross 128	M
TOI-715	M
Wolf 1069	M

# stellar system classes (single host) - with conservative habitable exoplanets

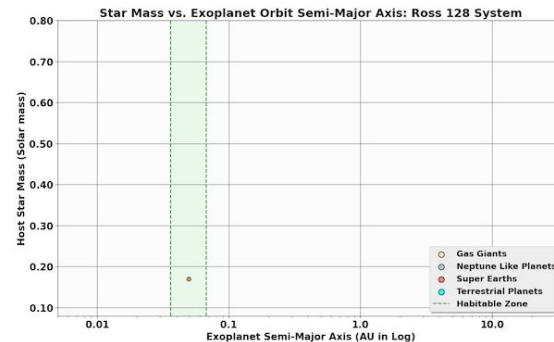
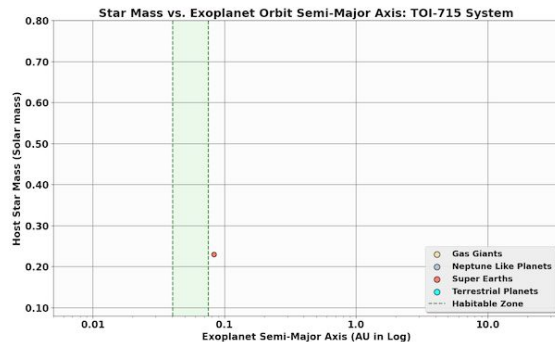
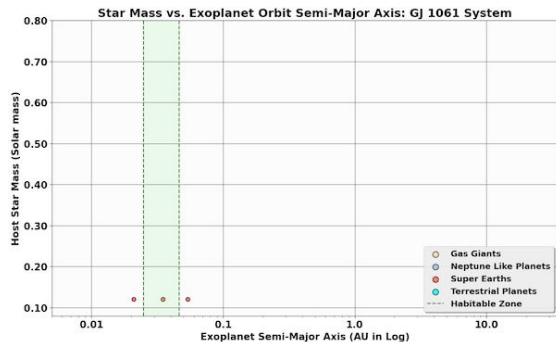
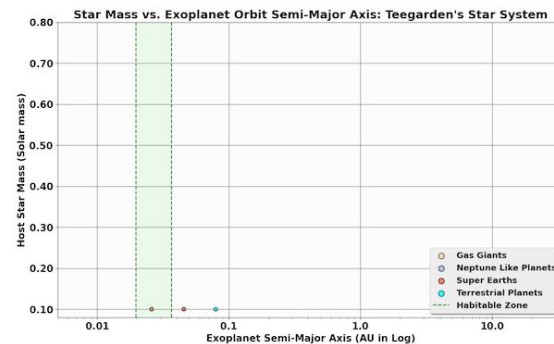
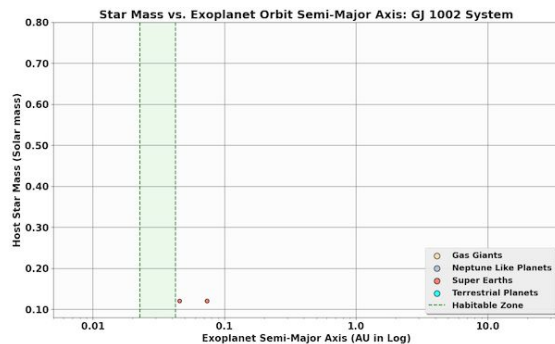
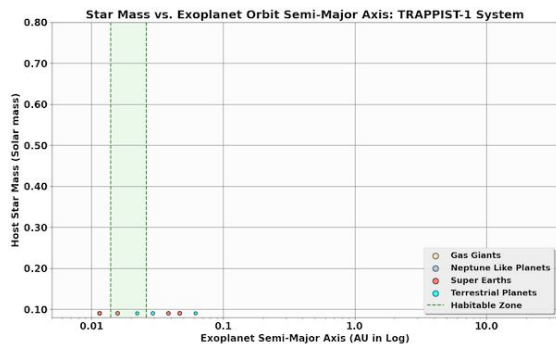
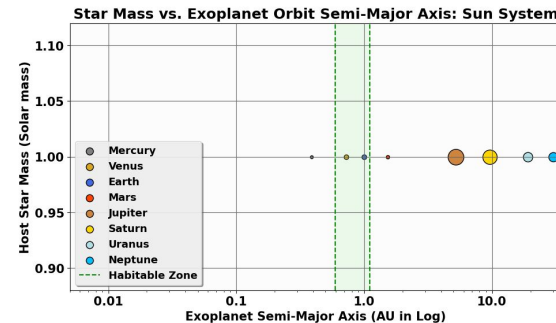




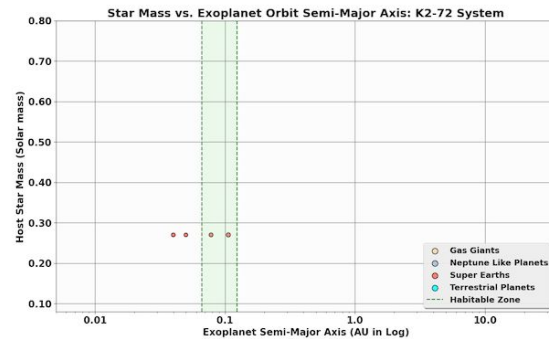
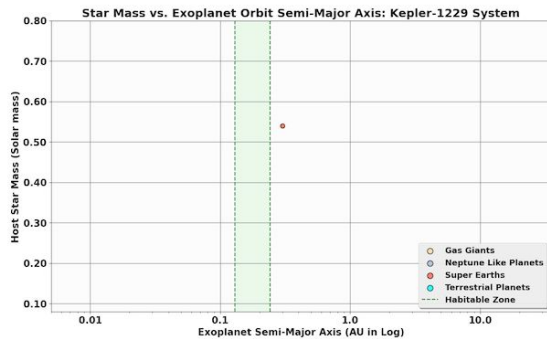
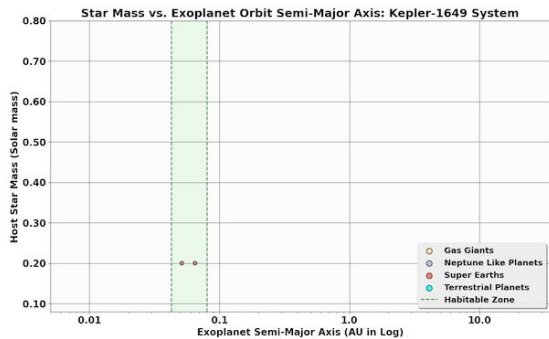
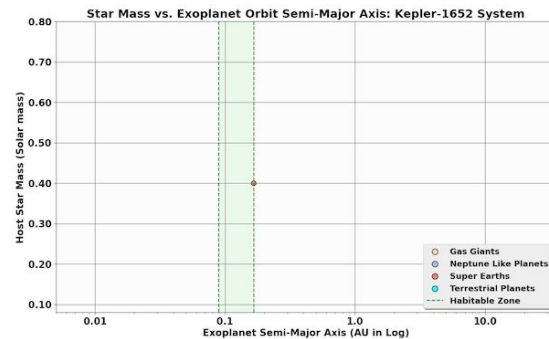
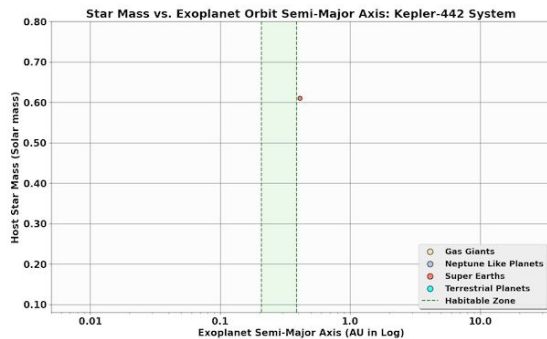
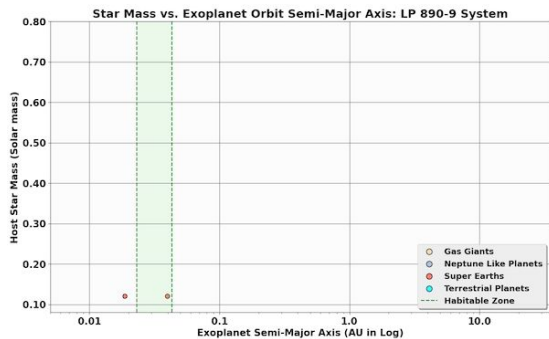
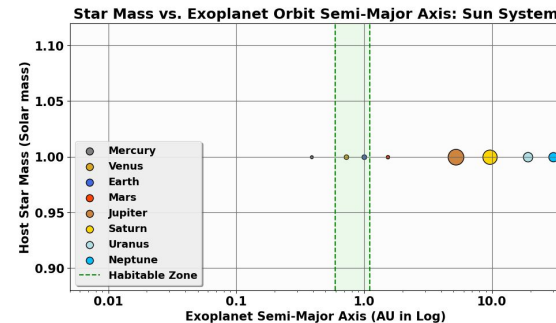
# star mass vs. exoplanet orbit: stellar systems with conservative habitable exoplanets - class 1



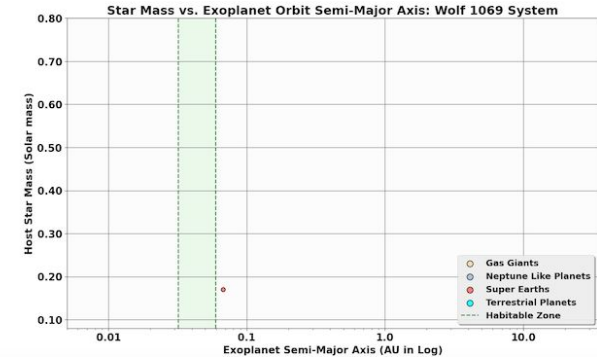
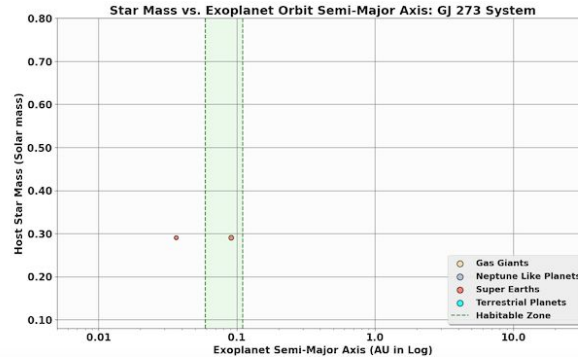
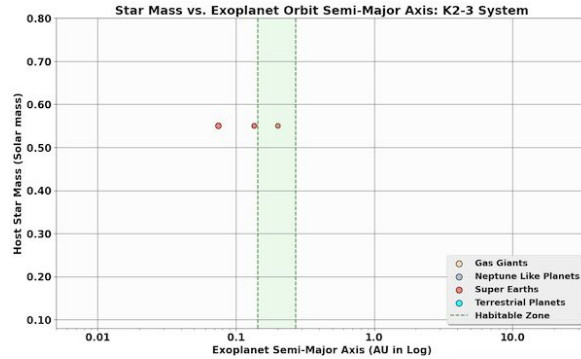
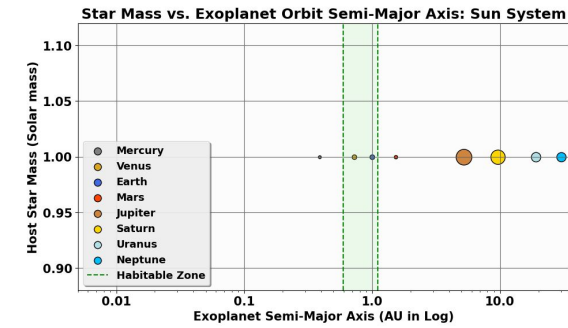
# star mass vs. exoplanet orbit: stellar systems with conservative habitable exoplanets - class 3



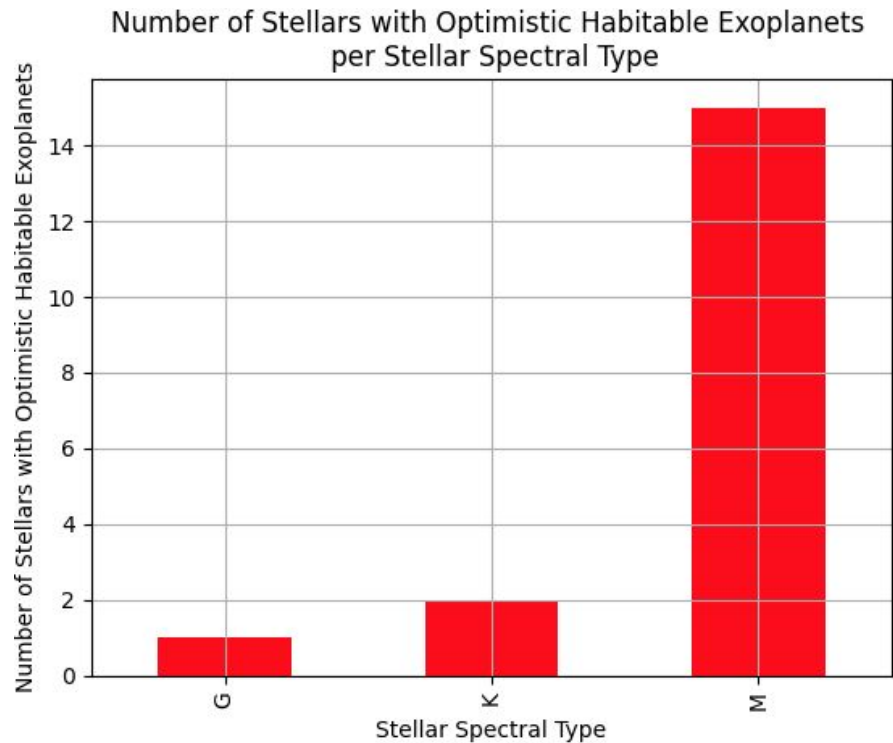
# star mass vs. exoplanet orbit: stellar systems with conservative habitable exoplanets - class 3 (cont.)



# star mass vs. exoplanet orbit: stellar systems with conservative habitable exoplanets - class 3 (cont.)



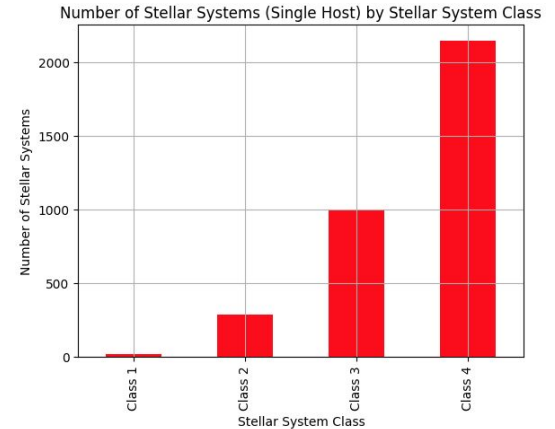
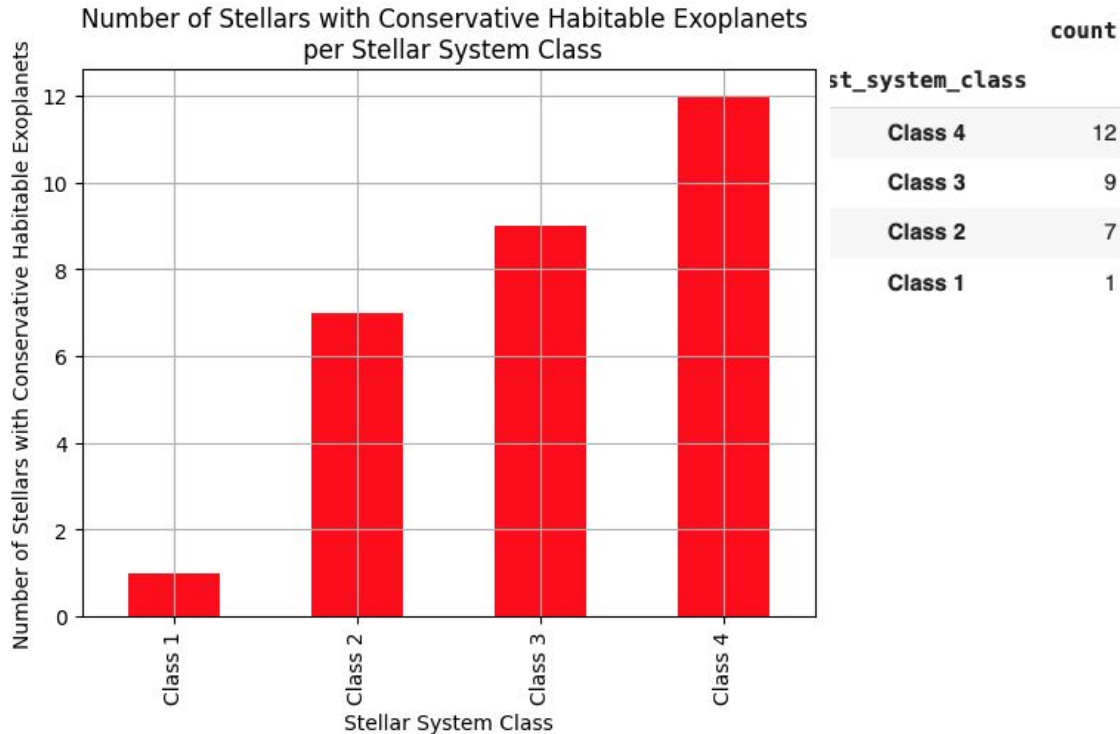
# stellar spectral types (single host) - with optimistic habitable exoplanets



st_spectype_short	count
M	15
K	2
G	1

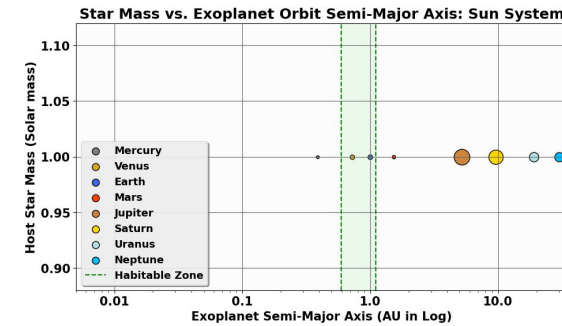
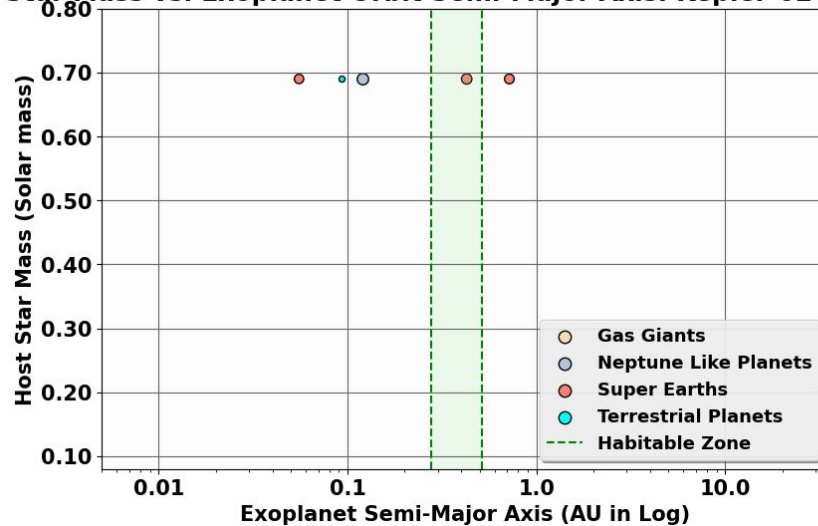
hostname	st_spectype_short
GJ 180	M
GJ 163	M
TOI-2257	M
Ross 508	M
LHS 1140	M
Kepler-62	K
Kepler-22	G
Kepler-155	M
K2-9	M
K2-18	M
HN Lib	M
HD 216520	K
GJ 682	M
GJ 514	M
GJ 433	M
GJ 357	M
GJ 3293	M
Wolf 1061	M

# stellar system classes (single host) - with optimistic habitable exoplanets

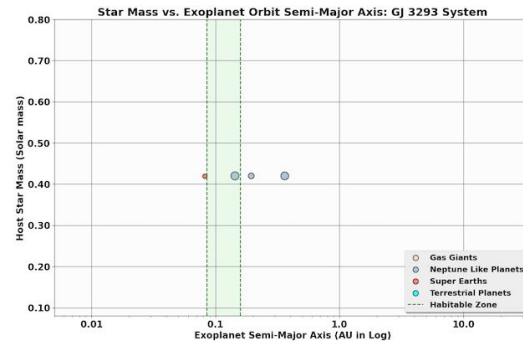
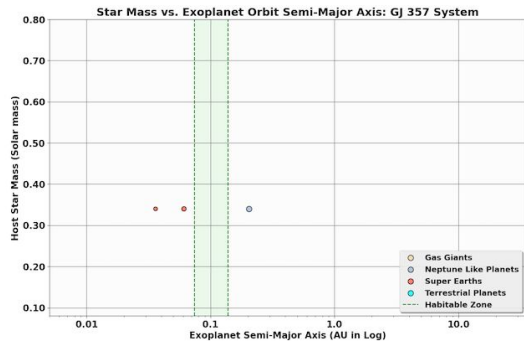
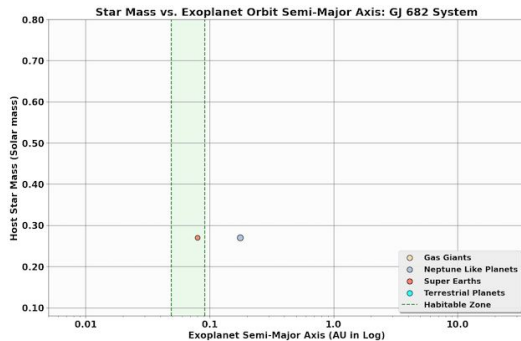
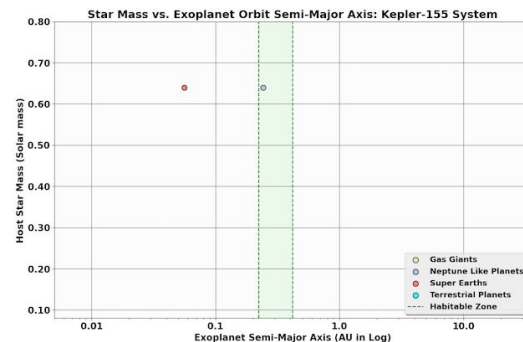
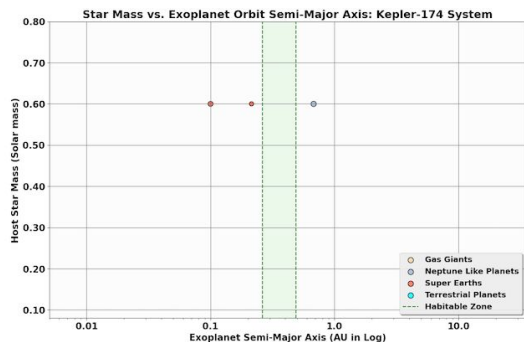
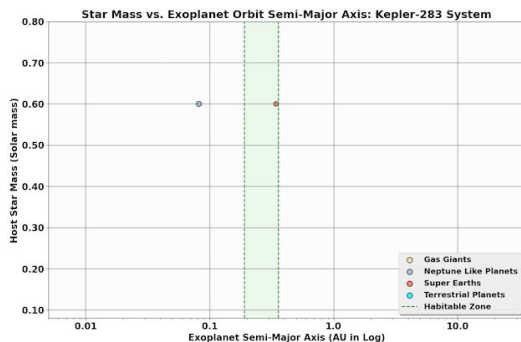
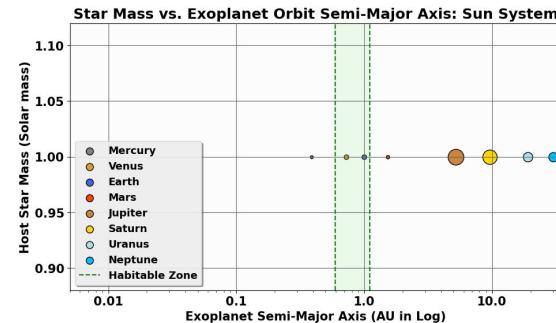


# star mass vs. exoplanet orbit: stellar systems with optimistic habitable exoplanets - class 1

Star Mass vs. Exoplanet Orbit Semi-Major Axis: Kepler-62 System

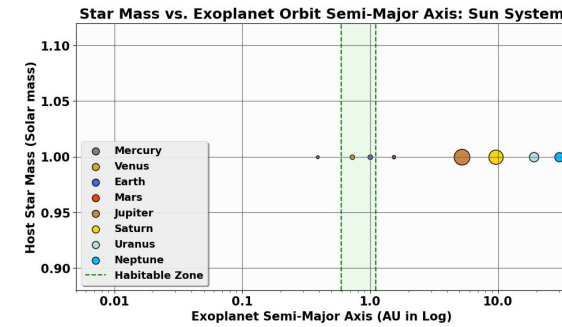
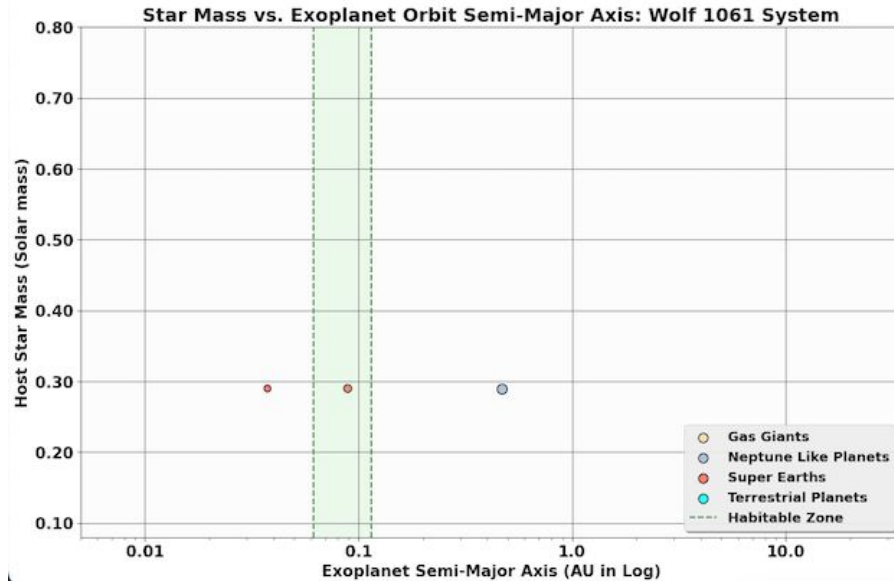


# star mass vs. exoplanet orbit: stellar systems with optimistic habitable exoplanets - class 2





# star mass vs. exoplanet orbit: stellar systems with optimistic habitable exoplanets - class 2 (cont.)



## **future work**

- continue working on the draft of the short paper.
- try with K-mean ML model to cluster stellar systems.