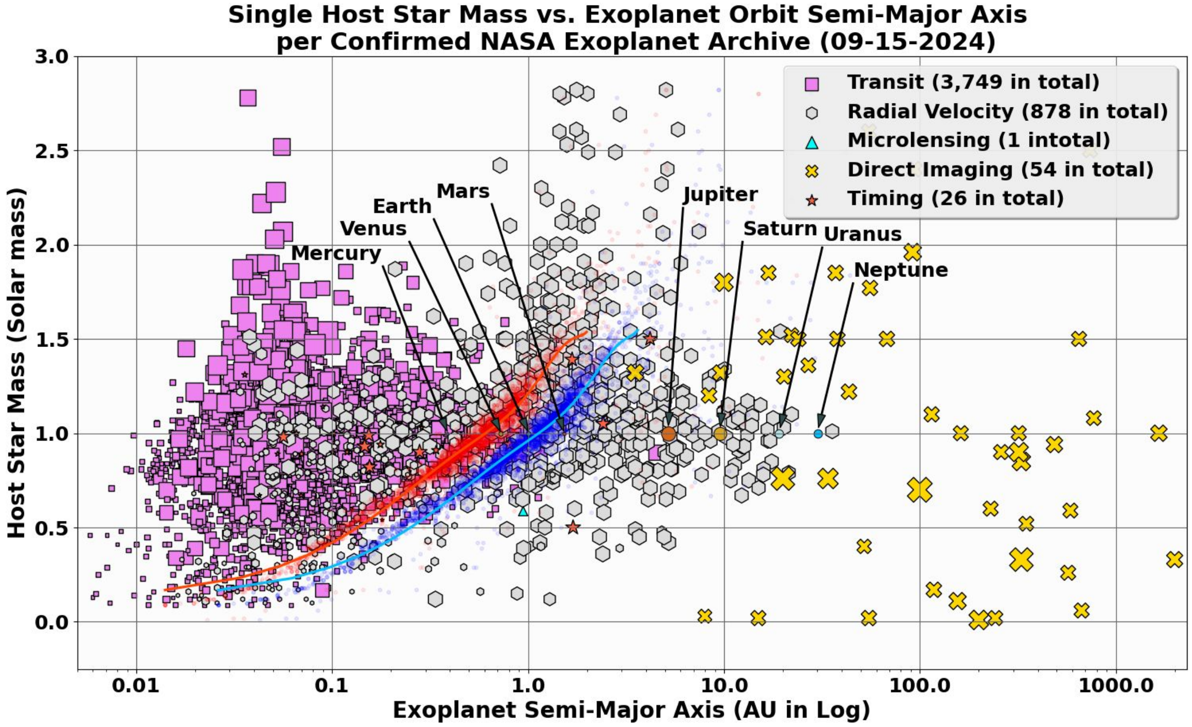
january 4th, 2025

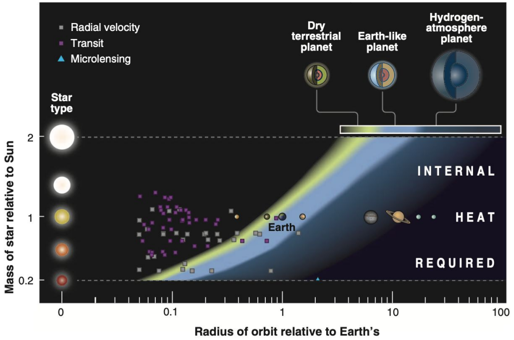
exoplanet classification

recap – single host star mass vs planet orbit semi-major axis



- single host stars only.
- added solar system planets for references.
- HZ inner and outer boundaries are calculated according to the paper.

graph from Seager's paper:



breakdown by exoplanet type

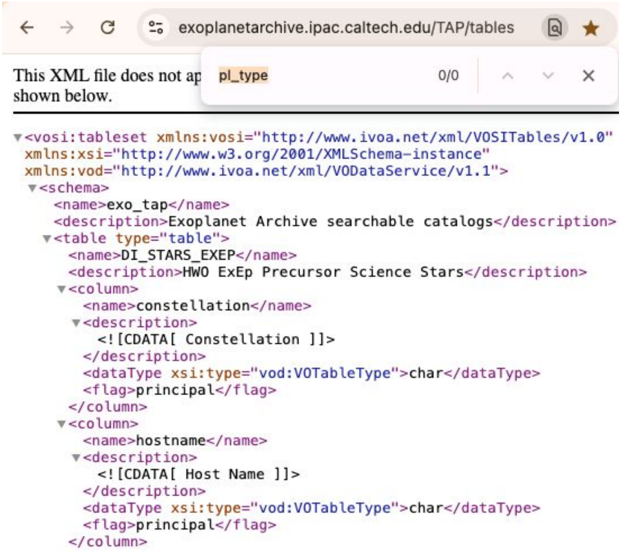
- figure out exoplanet types
- plot the star mass vs. planet orbit graph per exoplanet type

finding exoplanet type – NASA Exoplanet Archive

- the NASA Exoplanet Archive provides the following programmatic data access mechanisms:
    - Table Access Protocol (TAP)
    - TAP service: programmatically access data instead of interactive web interface

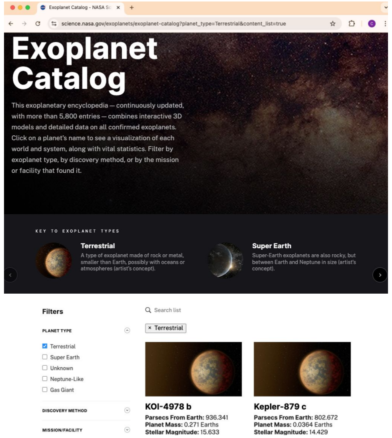
- the following TAP interface returns all the tables and corresponding data field columns. however, “pl_type” cannot be found.

  https://exoplanetarchive.ipac.caltech.edu/TAP/tables



finding exoplanet type – NASA Exoplanet Archive

- NASA Exoplanet Catalog provides exoplanet types through interactive web interface. however, no programmatic interface is found (as far as i know).
- implemented a python program in Google Colab to fetch web pages under the NASA Exoplanet Catalog, and to parse the web page content to extract exoplanet names with types (saving as CSV file).

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Fetched 5800 exoplanets from NASA Exoplanet Catalog completed.
Breakdown of number of exoplanets per type:
Number of Terrestrial exoplanets: 210
Number of Super+Earth exoplanets: 1735
Number of Neptune-like exoplanets: 1987
Number of Gas+Giant exoplanets: 1868
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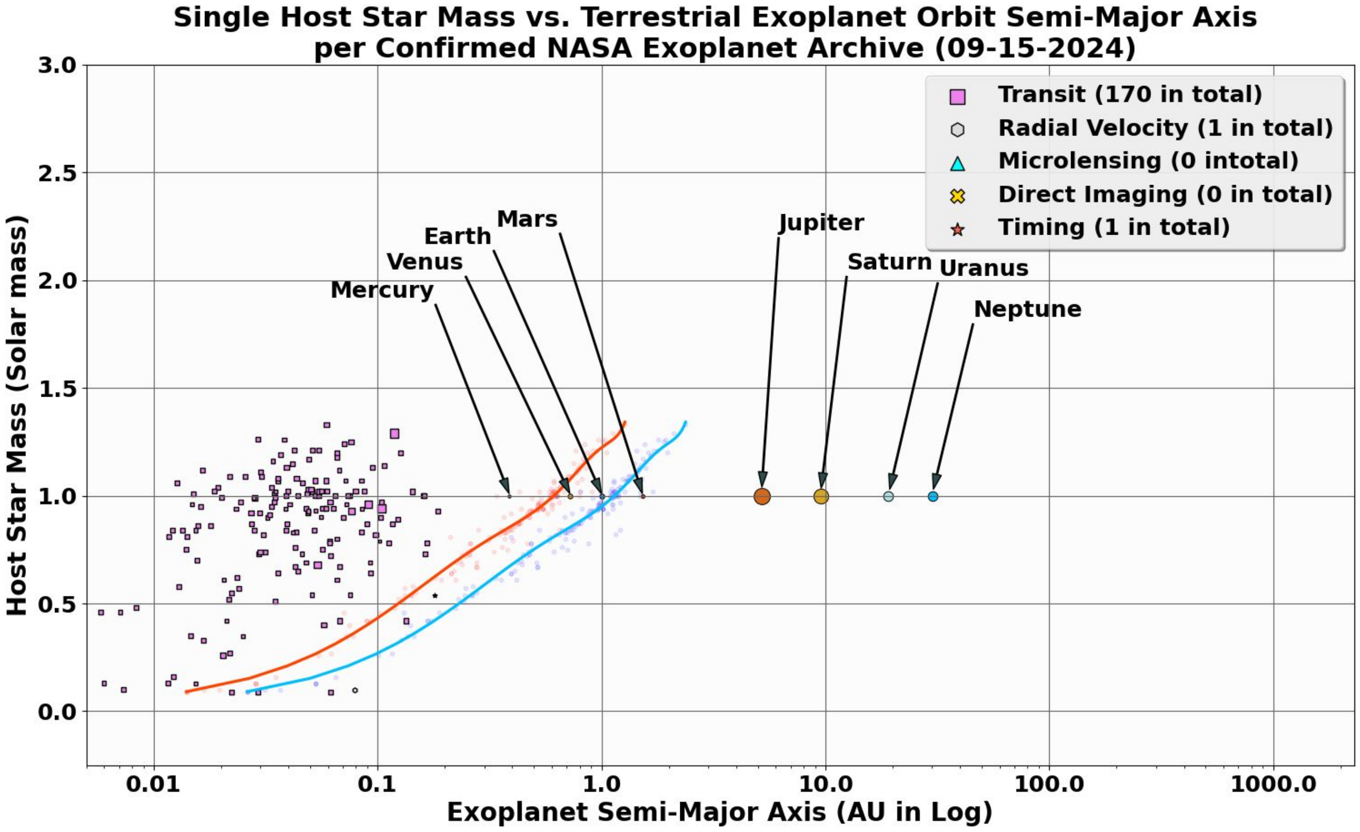
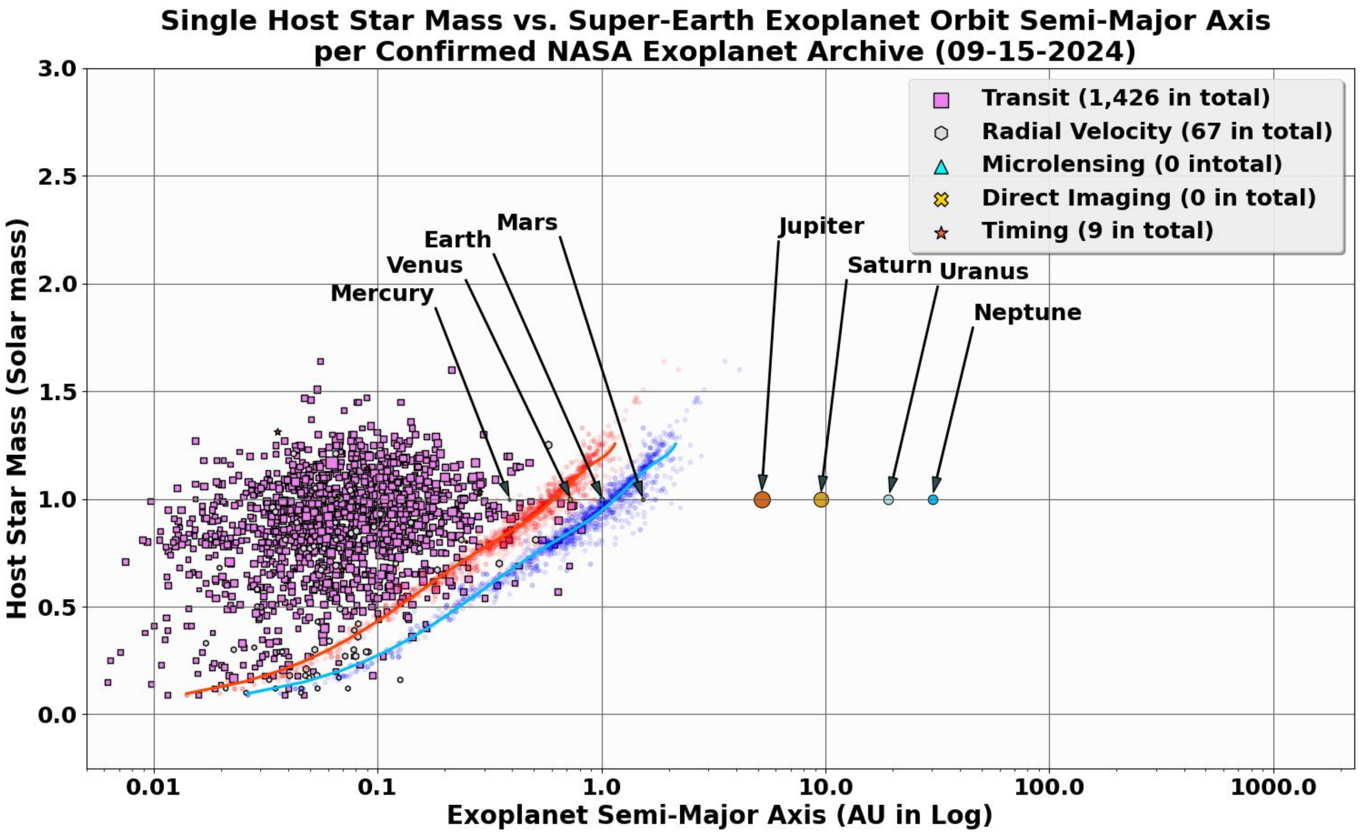
single host star mass vs. terrestrial exoplanet orbit



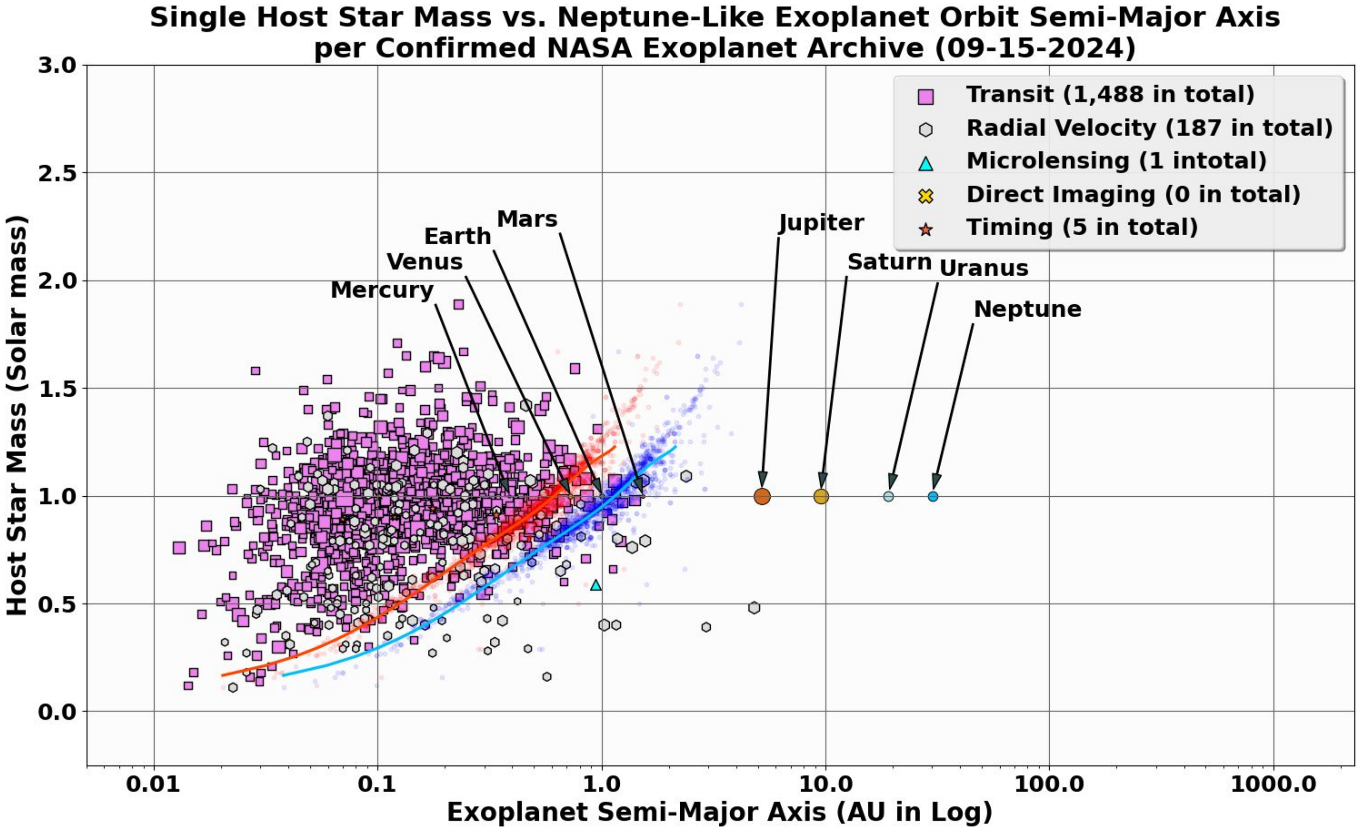
The terrestrial exoplanets within HZ:

- Kepler-138 e
- TOI-700 e
- TRAPPIST-1 d

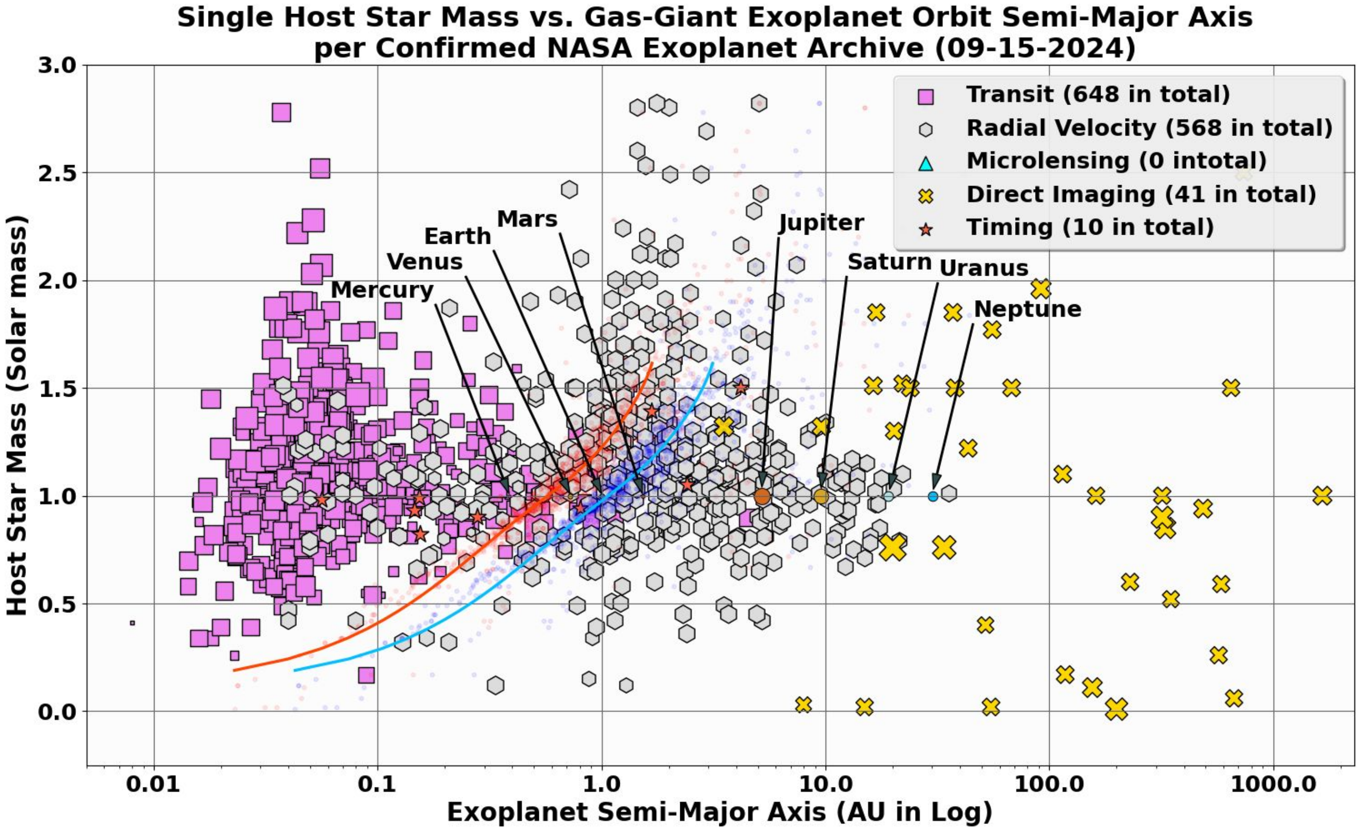
single host star mass vs. super-earth exoplanet orbit



single host star mass vs. neptune-like exoplanet orbit



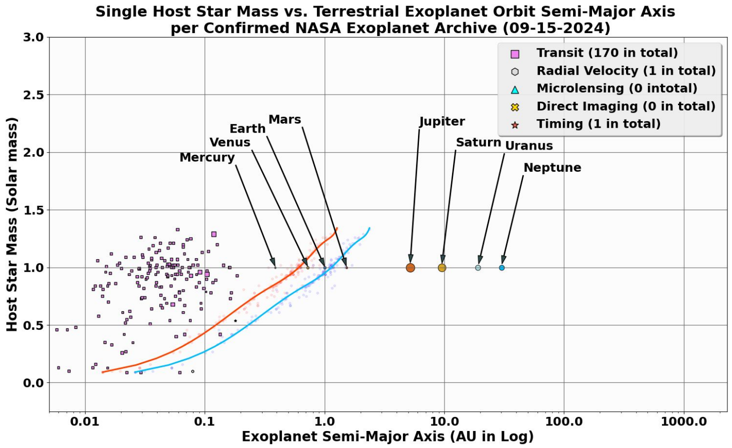
single host star mass vs. gas-giant orbit

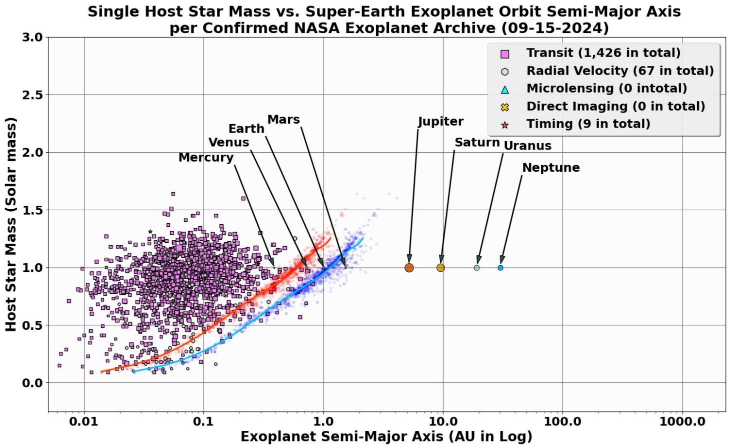


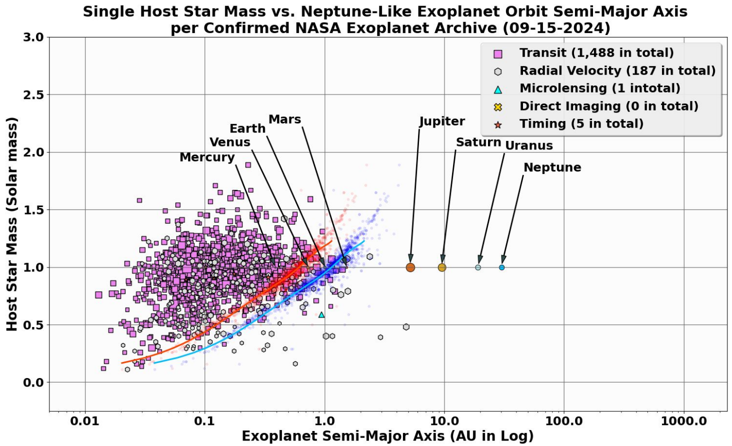
gas-giants within HZ aren't habitable due to lack of solid surface.

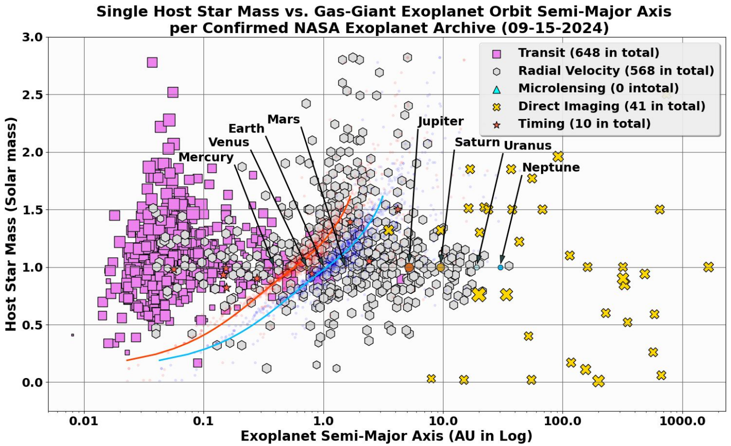
however, they could potentially harbor habitable moons.

single host star mass vs. exoplanet orbit







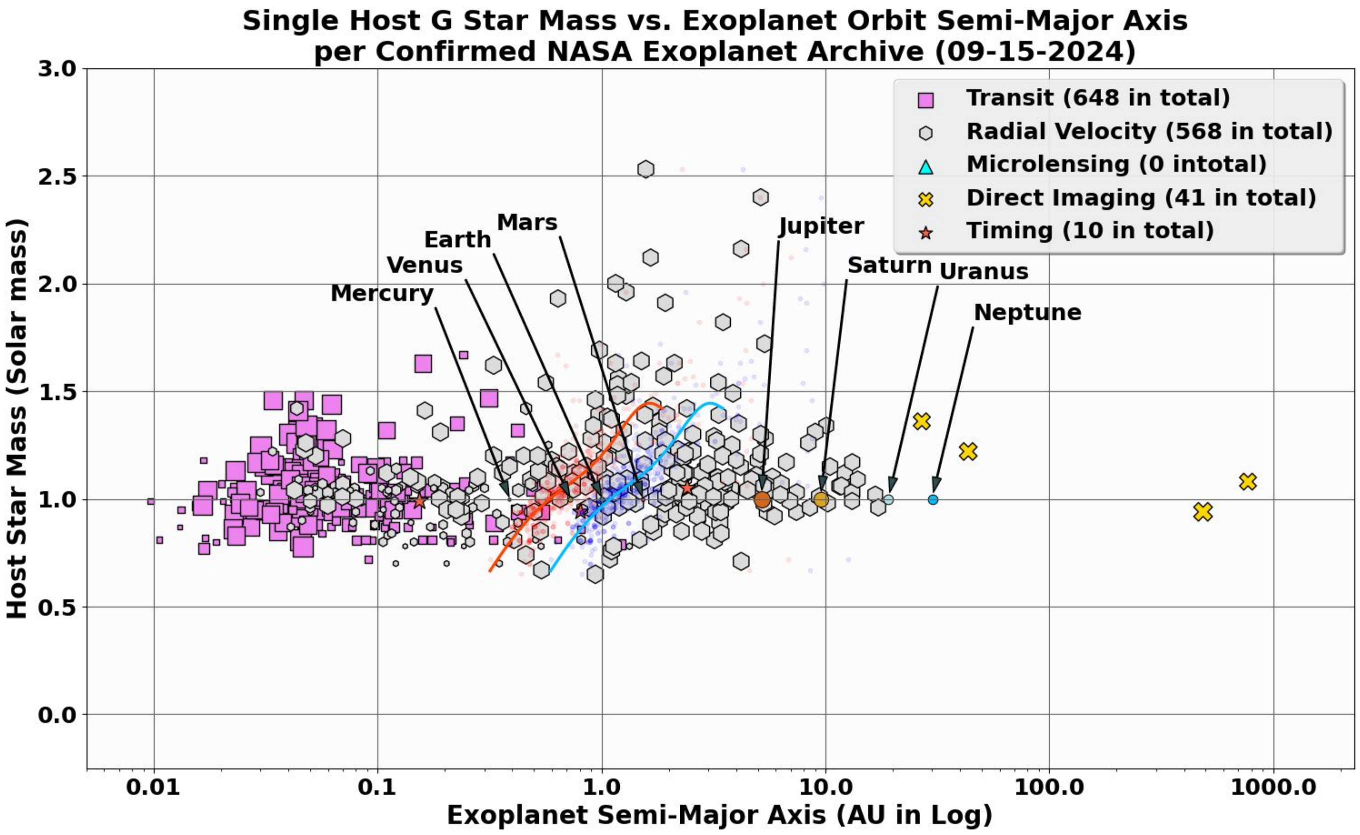


breakdown by star spectral type

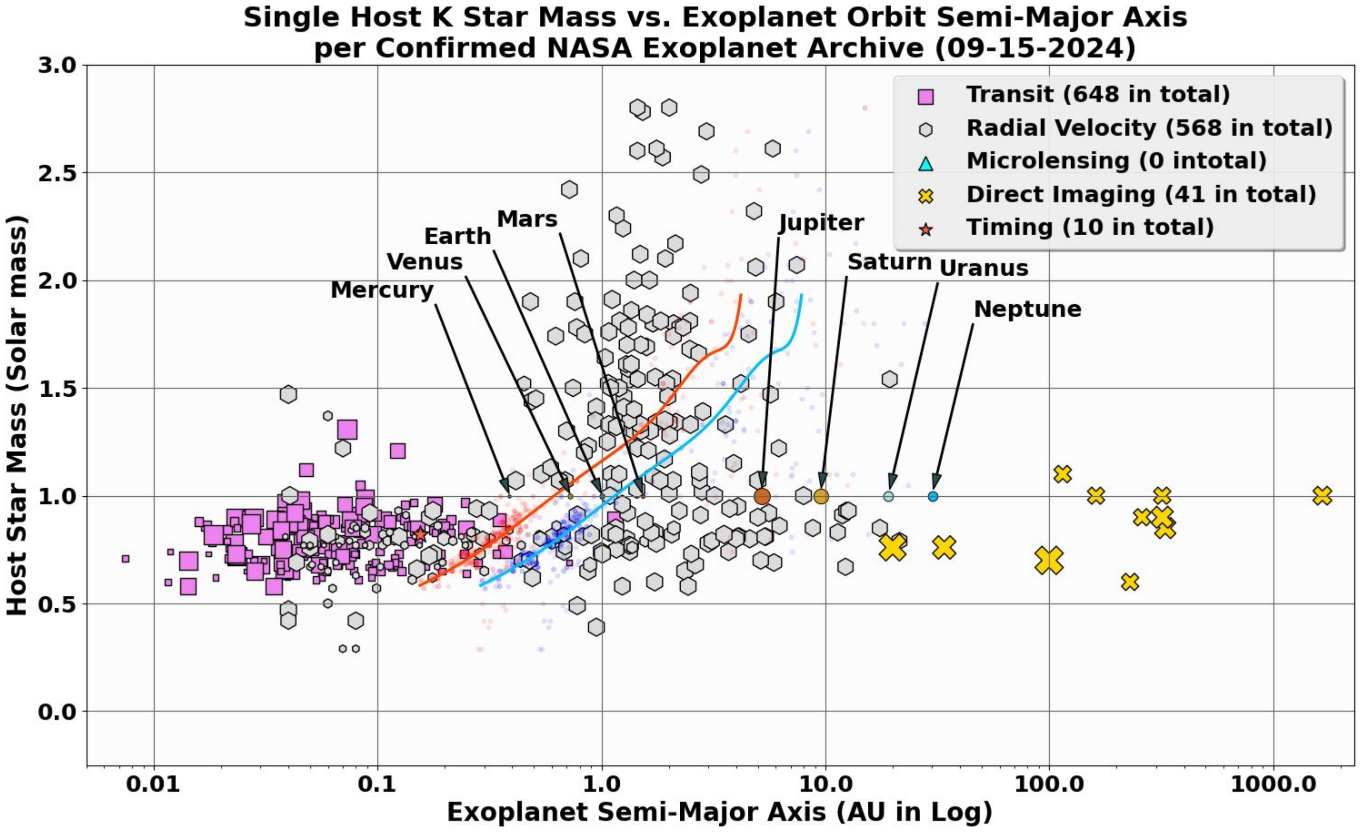
- only some data points have spectral types:

st_spectype	
G	554
K	471
M	371
F	184
A	16
B	7

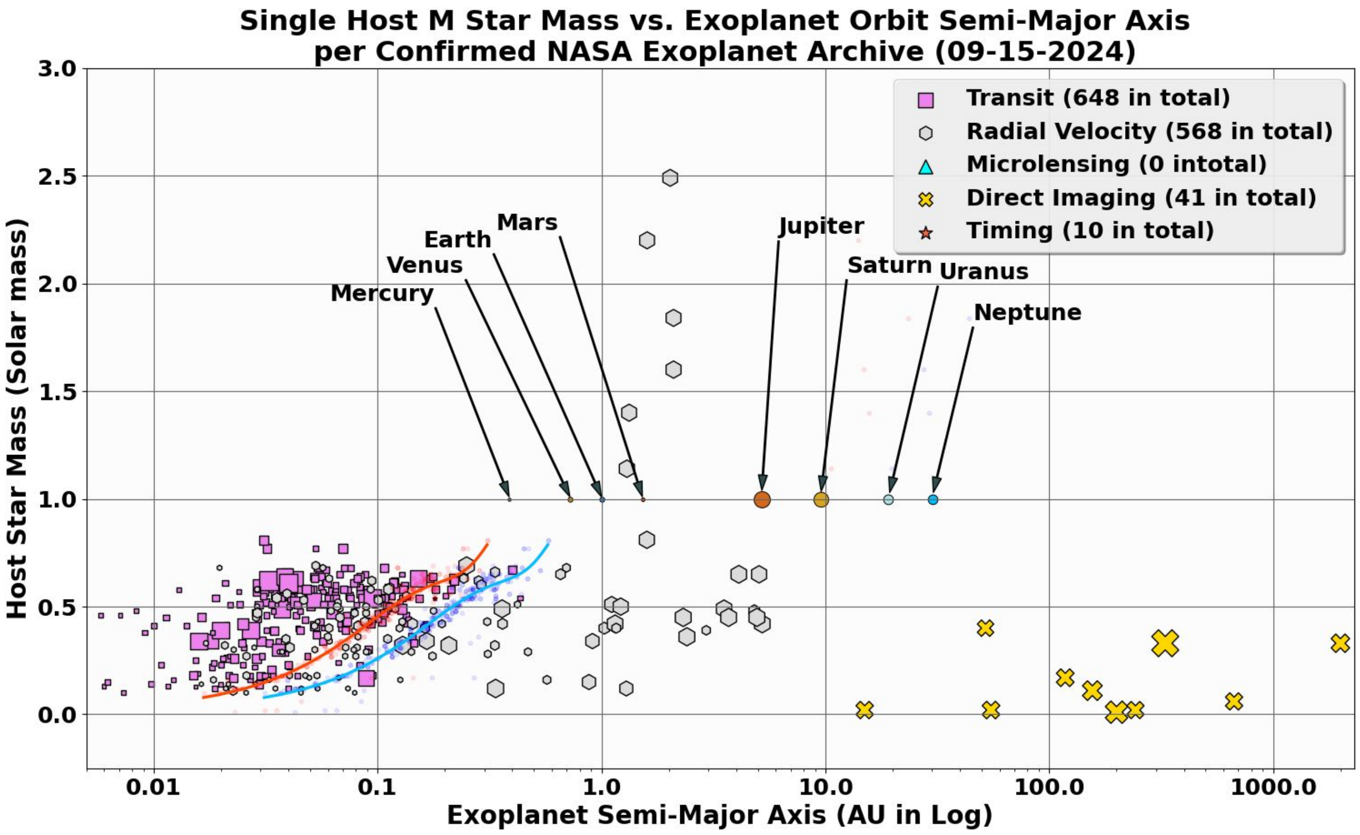
single host spectral type G star mass vs. exoplanet orbit



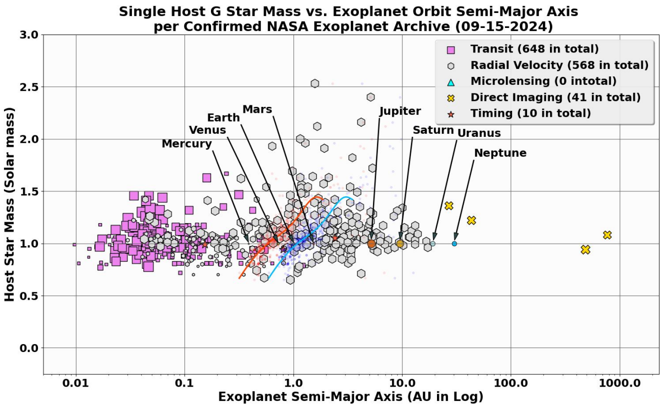
single host spectral type K star mass vs. exoplanet orbit

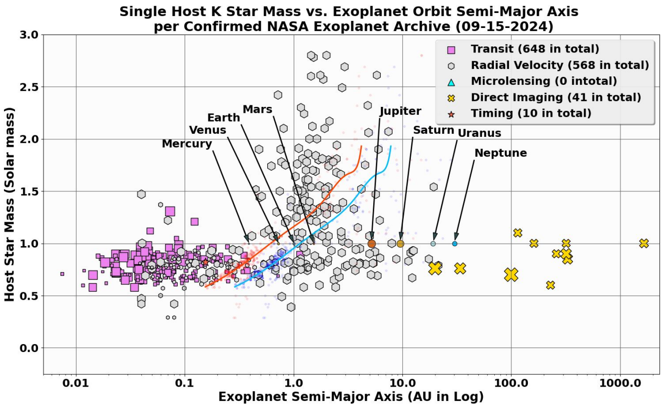


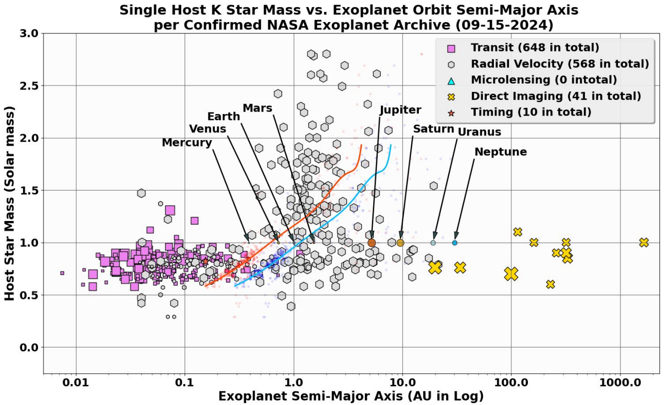
single host spectral type M star mass vs. exoplanet orbit



single host star mass (diff. spectral types) v. exoplanet orbit



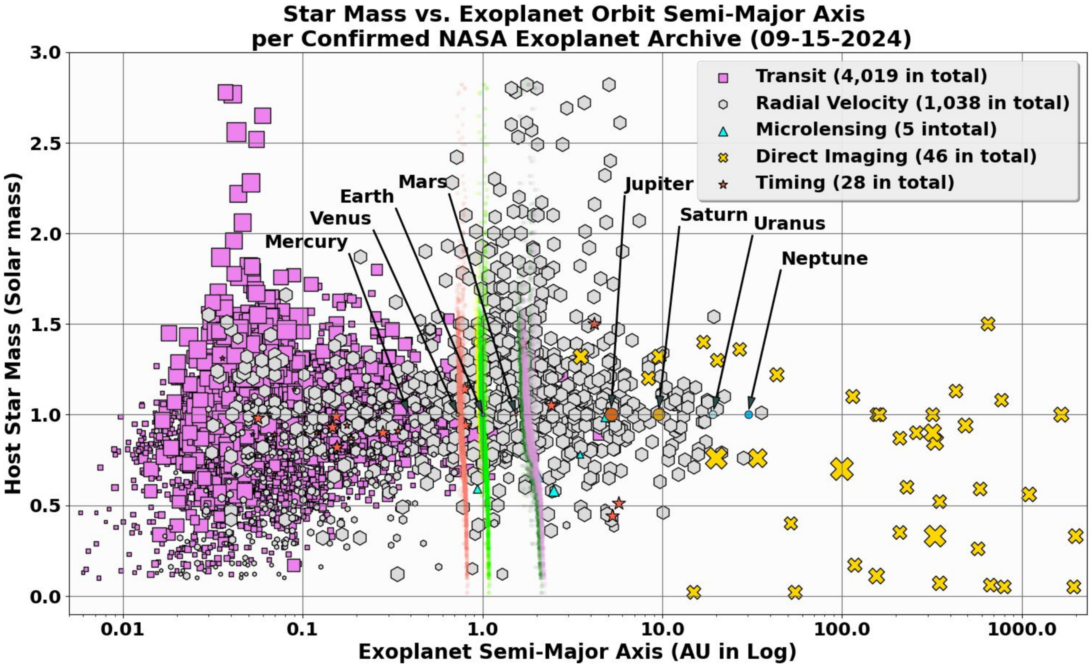




future work

- **work on graphs isolating certain spectral types of stars**
- explore graphs related to Seager's paper
- fine tune neural networks classifier
  - simpler model architecture: less layers, less connected units
  - hyperparameter tuning (learning rate, batch size, etc.)

star mass vs. terrestrial exoplanet orbit



HZ calculation is based on [this paper]

is dependent on the type of star considered. Therefore, we have derived relationships between HZ stellar fluxes (S_{eff}) reaching the top of the atmosphere of an Earth-like planet and stellar effective temperatures (T_{eff}) applicable in the range 2600 K $\leqslant T_{\mathrm{eff}} \leqslant$ 7200 K:

$$S_{\mathrm{eff}} = S_{\mathrm{eff}\odot} + aT_\star + bT_\star^2 + cT_\star^3 + dT_\star^4, \tag{2}$$

where $T_\star = T_{\mathrm{eff}} - 5780$ K and the coefficients are listed in Table 3 for various habitability limits.[19] The corresponding HZ distances can be calculated using the relation

$$d = \left(\frac{L/L_\odot}{S_{\mathrm{eff}}}\right)^{0.5} \mathrm{AU}, \tag{3}$$

where $L/L_\odot$ is the luminosity of the star compared to the Sun.

Table 3
Coefficients to Be Used in Equation (2) to Calculate Habitable Stellar Fluxes, and Corresponding Habitable Zones (Equation (3)), for Stars with 2600 K $\leqslant T_{\mathrm{eff}} \leqslant$ 7200 K

Constant	Recent Venus	Runaway Greenhouse	Moist Greenhouse	Maximum Greenhouse	Early Mars
$S_{\mathrm{eff}\odot}$	1.7753	1.0512	1.0140	0.3438	0.3179
a	1.4316×10^{-4}	1.3242×10^{-4}	8.1774×10^{-5}	5.8942×10^{-5}	5.4513×10^{-5}
b	2.9875×10^{-9}	1.5418×10^{-8}	1.7063×10^{-9}	1.6558×10^{-9}	1.5313×10^{-9}
c	-7.5702×10^{-12}	-7.9895×10^{-12}	-4.3241×10^{-12}	-3.0045×10^{-12}	-2.7786×10^{-12}
d	-1.1635×10^{-15}	-1.8328×10^{-15}	-6.6462×10^{-16}	-5.2983×10^{-16}	-4.8997×10^{-16}