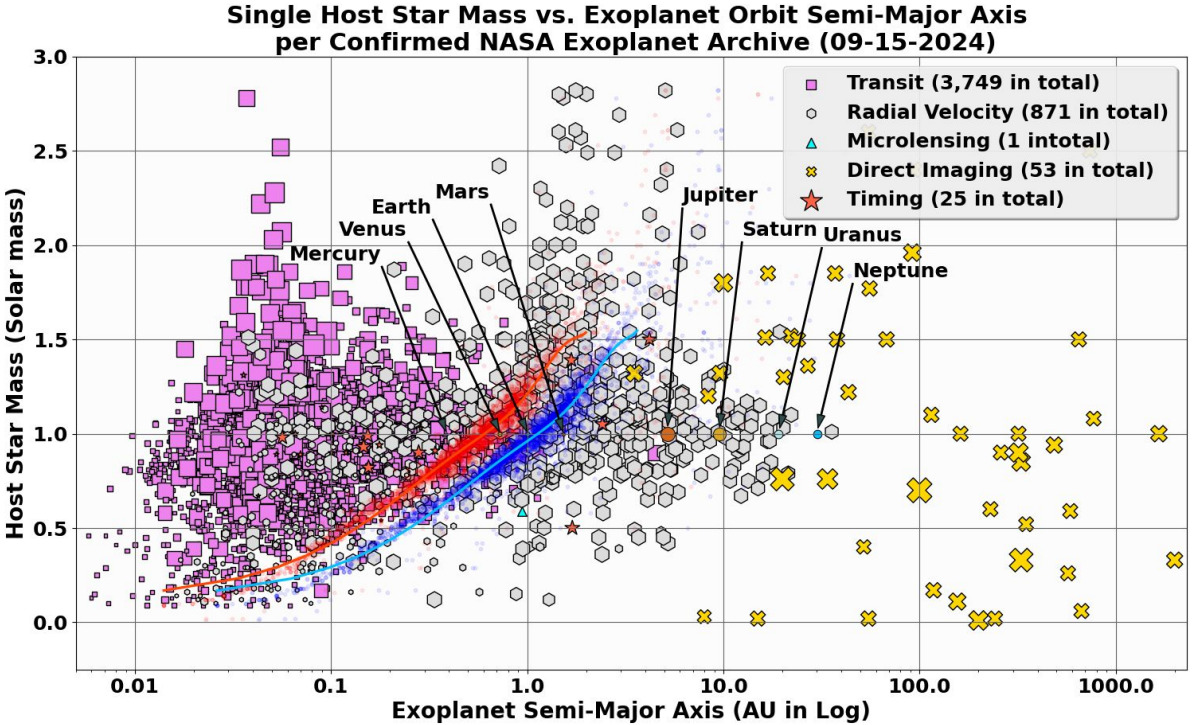
december 21st, 2024

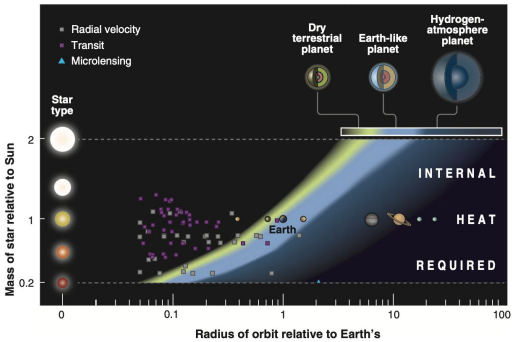
exoplanet classification

single host star mass vs planet orbit semi-major axis

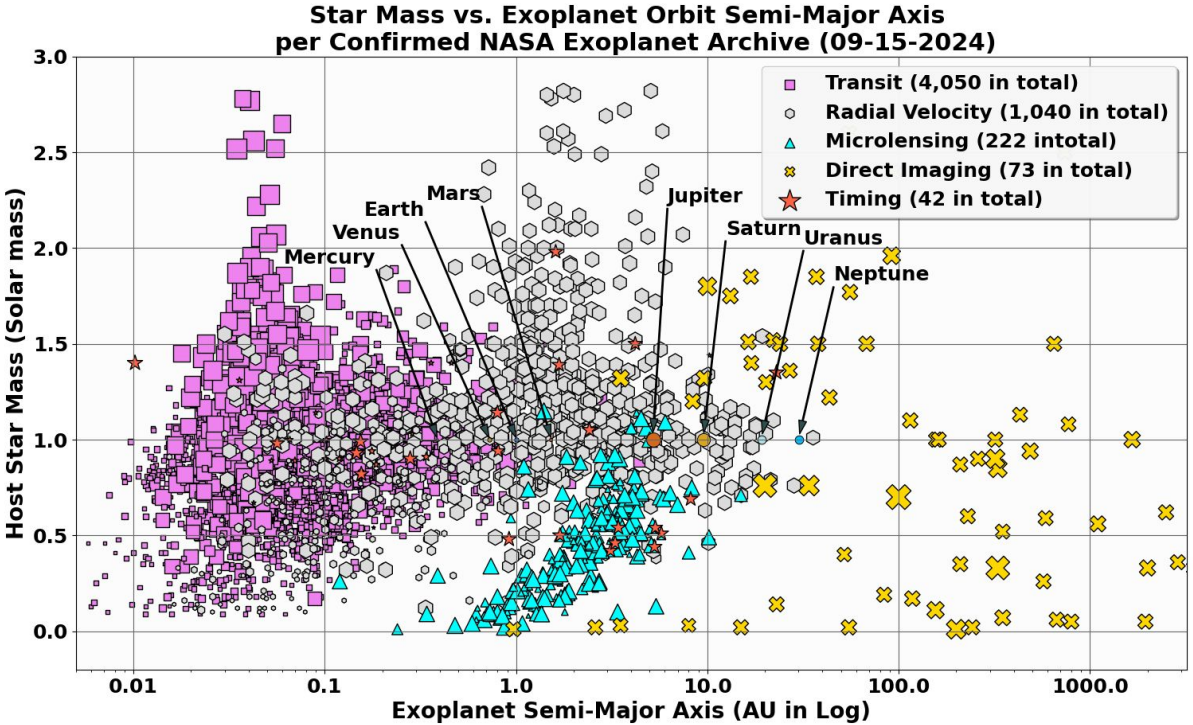


- single host stars only.
- added solar system planets for references.
- HZ inner and outer boundaries are calculated according to the paper.

graph from Seager's paper:

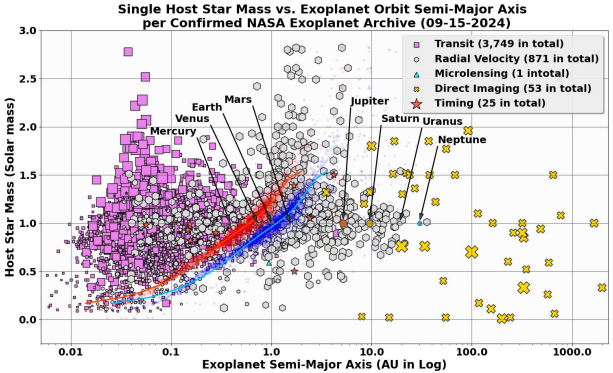


star mass vs planet orbit semi-major axis



- include all the host stars.
- added solar system planets for references.

single host star graph (from previous slide):



neural networks classifier

- goal: classify exoplanet habitability (binary classifier)

training data processing

- join NASA 09-15-2024 data with HWC data from PHL.
- HWC data has a "*P_HABITABLE*" data field that can be used as label
- training data preprocessing:
  - remove data fields that are not relevant to training
  - drop data fields with too much missing values
  - for categorical data fields:
    - filling missing values with mode
    - encode with LabelEncoder
  - for numeric data fields:
    - filling missing values with MICE imputation
  - use SMOTEENN to oversample and downsample to overcome sample imbalances

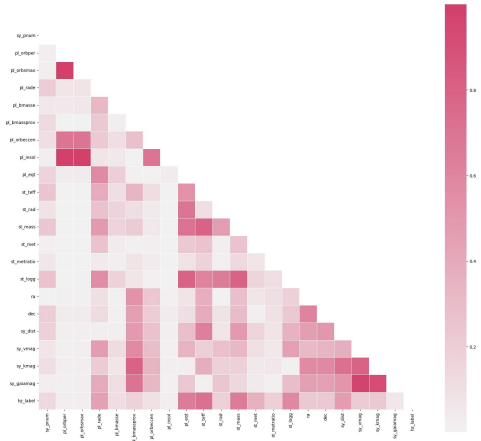
```
hz_label=0, count=4520 (98.798%)
hz_label=1, count=55 (1.202%)
```

training features and correlation analysis

correlation analysis removes highly correlated features:

- pl_orbeccen
- pl_insol
- sy_gaiamag

ends up with 17 features in the training data



17 Features in the final training data:

```
Data columns (total 17 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   sy_pnum       8924 non-null   int64
 1   pl_orbper     8924 non-null   float64
 2   pl_orbsmax    8924 non-null   float64
 3   pl_rade       8924 non-null   float64
 4   pl_bmasse     8924 non-null   float64
 5   pl_bmassprov  8924 non-null   int64
 6   st_teff       8924 non-null   float64
 7   st_rad        8924 non-null   float64
 8   st_mass       8924 non-null   float64
 9   st_met        8924 non-null   float64
 10  st_metratio   8924 non-null   int64
 11  st_logg       8924 non-null   float64
 12  ra            8924 non-null   float64
 13  dec           8924 non-null   float64
 14  sy_dist       8924 non-null   float64
 15  sy_vmag       8924 non-null   float64
 16  sy_kmag       8924 non-null   float64
```

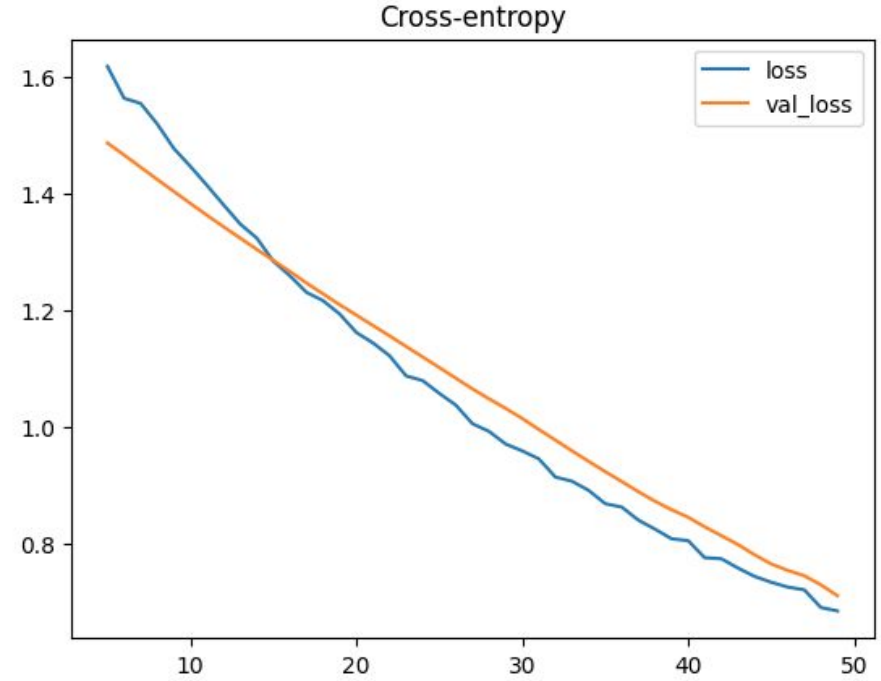
neural networks classifier

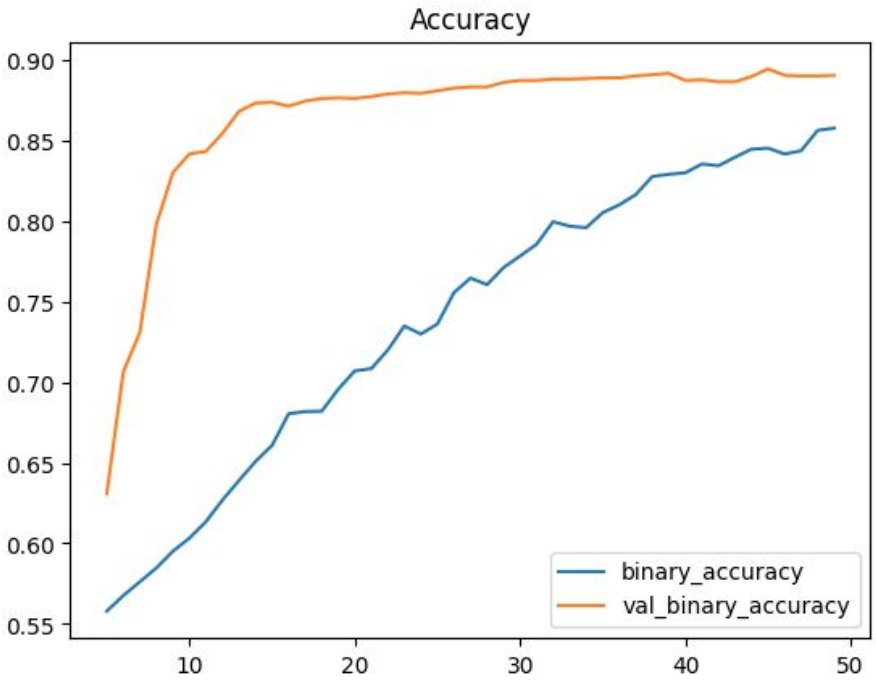
```
dnn_classifier = keras.Sequential([
    layers.Dense(64, kernel_regularizer=regularizers.l2(0.01), activation='relu', input_shape=[17]),
    layers.Dropout(rate=0.5),
    layers.BatchNormalization(),
    layers.Dense(32, kernel_regularizer=regularizers.l2(0.01), activation='relu'),
    layers.Dropout(rate=0.5),
    layers.BatchNormalization(),
    layers.Dense(16, kernel_regularizer=regularizers.l2(0.01), activation='relu'),
    layers.Dropout(rate=0.5),
    layers.BatchNormalization(),
    layers.Dense(1, activation='sigmoid')])

optimizer = keras.optimizers.Adam(learning_rate=0.0005)
```

```
dnn_classifier.compile(
    optimizer=optimizer,
    loss='binary_crossentropy',
    metrics=['binary_accuracy'])

dnn_classifier_training_history = dnn_classifier.fit(
    features_train, labels_train,
    validation_data=(features_test, labels_test),
    shuffle=True,
    batch_size=1024,
    epochs=50,
    callbacks=[early_stopping])
```

neural networks classifier - initial results

```
Best Validation Accuracy: 0.8944
```





future work

- 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.)