Detection and characterization of TESS single transit events: a strategy to find habitable zone planets

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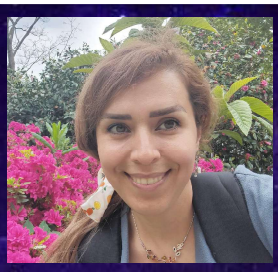
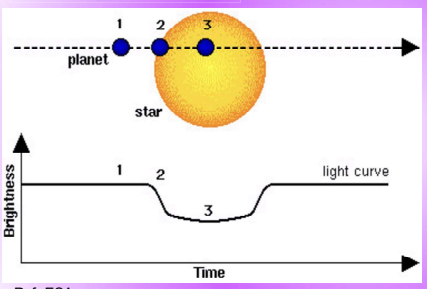


Transit method



Ref: ESA

Planets around sun	transit depth
Jupiter	1%
Earth	0.0084 %

TESS NASA space mission launched in 2018
Planet candidate: 6788
characterized: 392
(September 2023)

Radial- velocity method

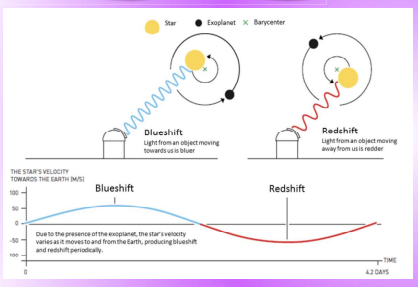
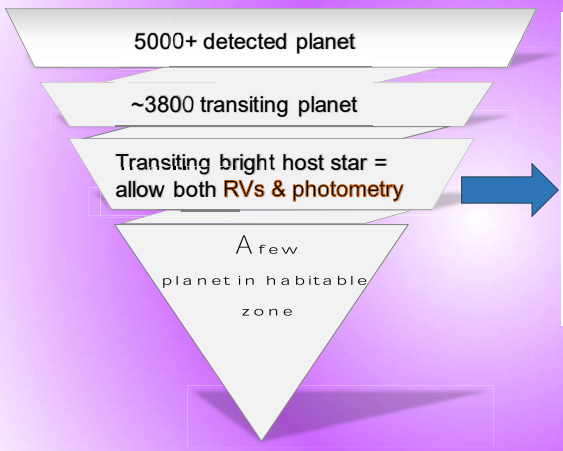


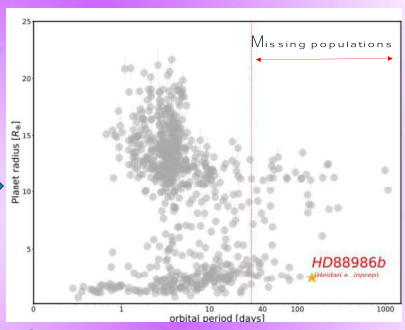
Image credit: Johan Jarnestad/The Royal Swedish Academy of Sciences

planet	Semi major axis	Semi amplitude K
Jupiter	5 AU	12.7 m/s
Jupiter	1 AU	28.4 m/s
Earth	1 AU	0.09 m/s

SOPHIE high precision spectrograph mounted on 1.9 m telescope at OHP, France

Exoplanet demographic:





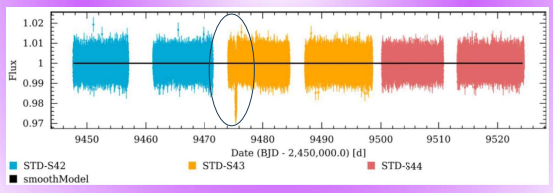
Orbital period versus planet radius of known exoplanets from NASA archival data (May, 2023) with accurate mass and radius (Otegi et al. 2020). HD88986b (Heidari+, 2023) is illustrated with a star mark

Long-period planet detection:

Long-period planets (missing population) show up as a single transit in photometric data

Below is an exxample of a single transit in the TESS data with depth= 1196 ppm and duration of 4.8 h

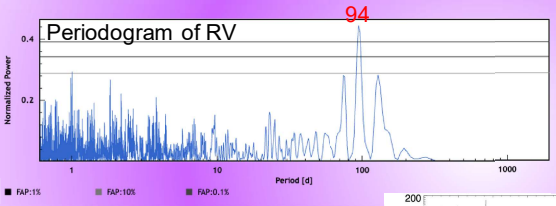
TESS photometry of TOI-XXXX (HEIDARI+, in prep)

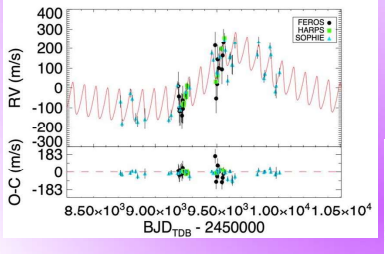


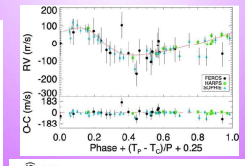
Charactrization of planet:

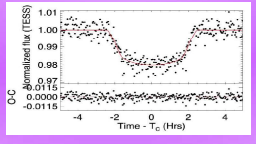
Single transits are challenging. One can characterize them either by detecting other transit or with the help of Radial velocity

For the TOI-XXXX b below, we gathered redial velocity observations of the target using 3 different spectrographs









Planet parameters

Period	94.1±0.2 d
Radius	1.001±0.04 Rj
Temperature	337.1±8.0 K
Mass	1.48± 0.11 Mj

Left: Redial velocity overplotted by the best Keplerian models
Right-top: Phase folded data on planet b. *Bottom-right:* The single transit, overplotted by the best model

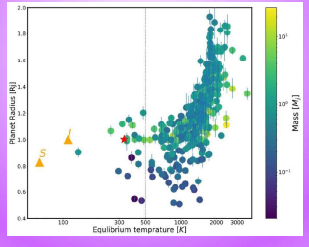
Discussion:

By increasing stellar insolation, Jupiter radii inflate (Miller+, 2011)

Models present a Radius Anomaly problem (Thorngren+, 2018)

TOI-XXXX receive a low star insolation (2.7 S_E)

Valuable control group for modeling hot Jupiter inflation



Planet radius- insolation diagram for giant planet (R > 0.5RJ) from NASA archival data (May, 2023) with accurate mass and radii (Otegi+,2019). The black line is the empirical inflation boundary (Miller & Fortney 2011; Demory & Seager 2011) where planet radii are seen to increase with insolation