Young planetary systems: a pathway from TESS to PLATO

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HD 108236: 5 planets but ...

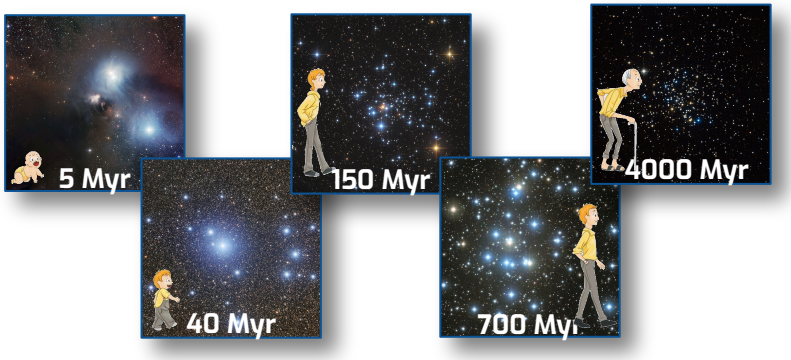
Young or old?

How did this planetary system form?

How can we reconstruct the formation and evolutionary history of a planetary system?

★ Looking for exoplanets orbiting stars with well constrained ages (e.g. stellar clusters, associations and moving groups)
- Many accurate methods to measure the age with extreme precision (isochrones, girochronology, asteroseismology)
- Accurate stellar parameters → Accurate planet parameters
- Temporal evolution of exoplanets, from the earliest stages of their formation until they become elderly

★ Studying young (<1 Gyr) exoplanets:
- Planet formation (properties of the disc, stellar multiplicity, etc.)
- Orbital evolution (Disc vs high-eccentricity migration, tidal circularization, etc)
- Radius evolution (Photoevaporation, Core-powered mass loss, contraction, etc.)



Credits: (1) R Corona Australis (ESO); (2) IC 2602 (Casey Good) ; (3) NGC 2516 (Buenos Aires Skies) ; (4) M44 (G. Donatiello); (5) M67 (Palomar Obs./STScI); (6) HD108236 (DSS2)

Age of the stars

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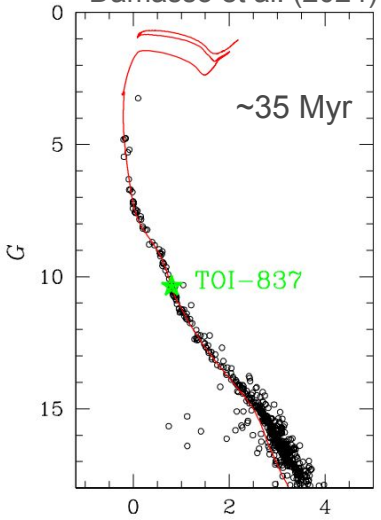
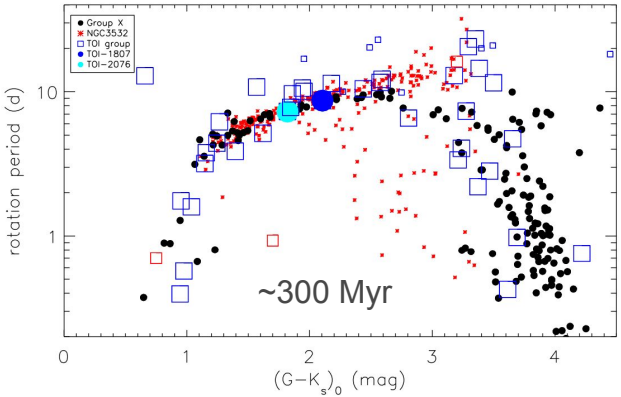
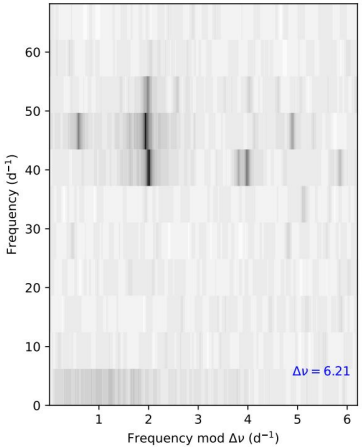
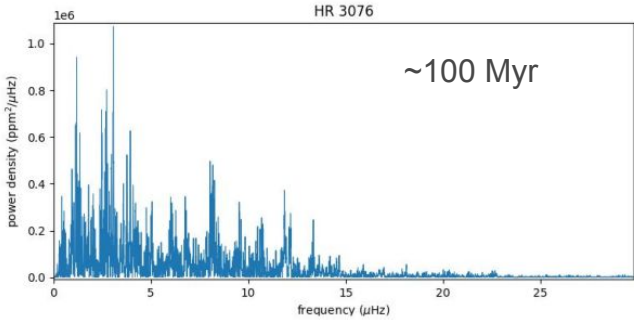
Damasso et al. (2024)



Nardiello et al. (2022)

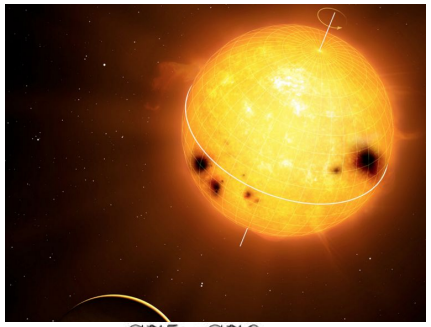






Li et al. (2024)

Young stars & stellar activity: photometry

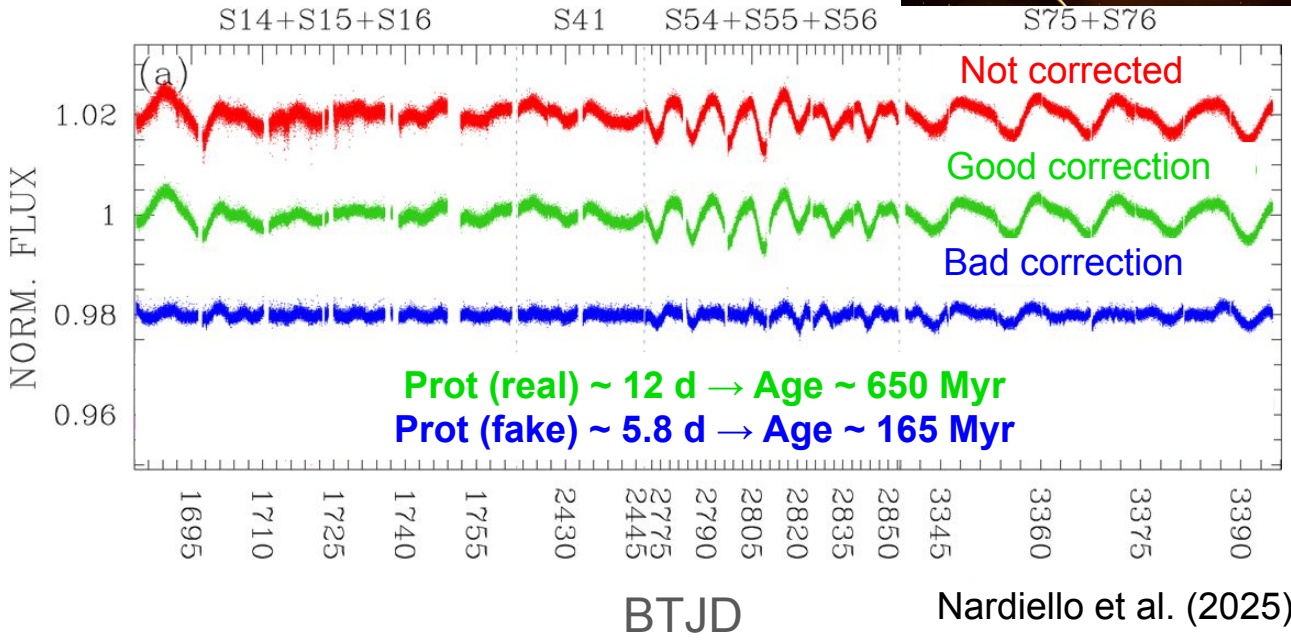


- ★ The search for extrasolar planets orbiting young stars is complicated by the presence of the strong stellar activity

… anyway stellar activity tells us a lot about the star → Prot → Age

Please, **preserve**

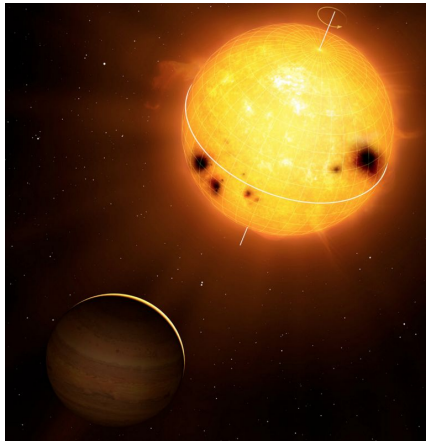
the stellar activity!



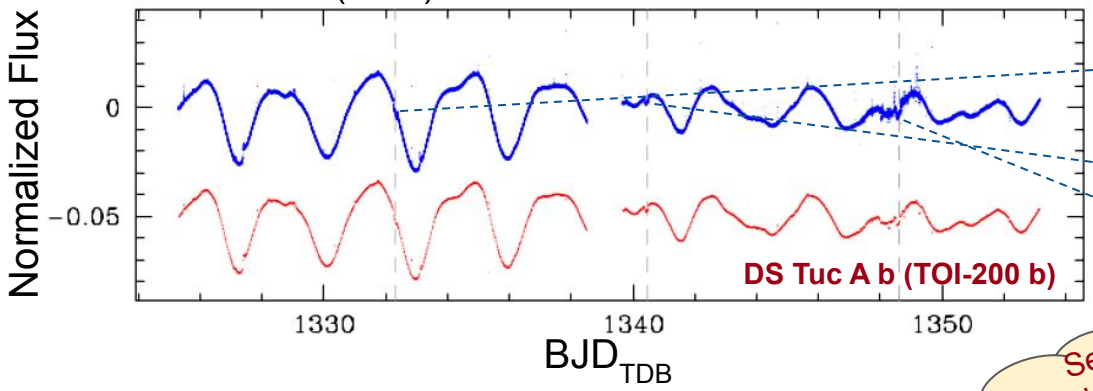
Nardiello et al. (2025)

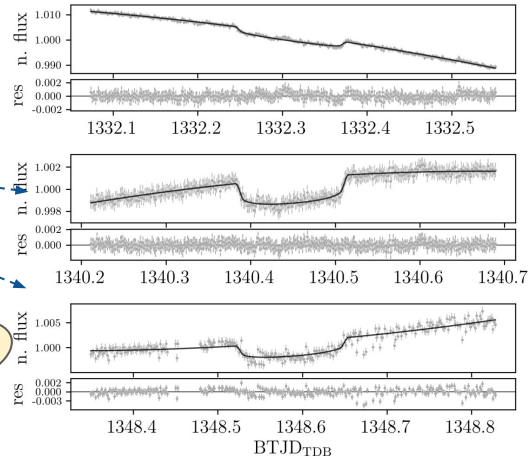
Young stars & stellar activity: photometry

- ★ The search for extrasolar planets orbiting young stars is complicated by the presence of the strong stellar activity
- ★ Active regions (e.g. starspots) affect the light curve: robust detrending methods are mandatory to detect transits



Benatti et al (2019)

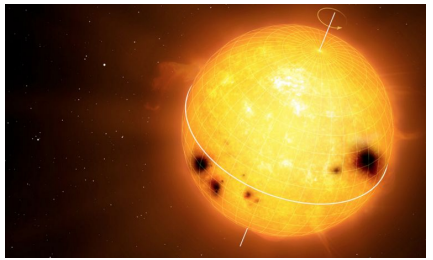




See L. Malavolta's talk

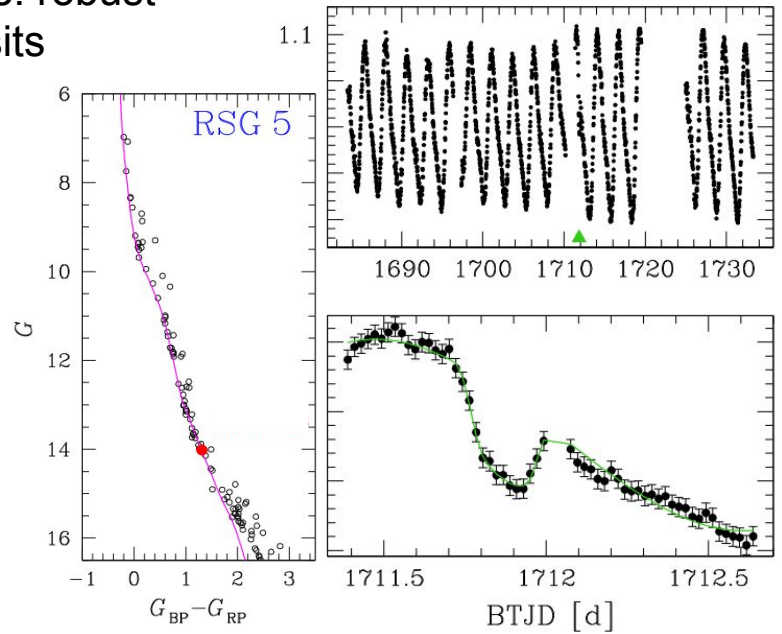
PLATO Stellar Variability Working Group

Young stars & stellar activity: photometry



- ★ The search for extrasolar planets orbiting young stars is complicated by the presence of the strong stellar activity
- ★ Active regions (e.g. starspots) affect the light curve: robust detrending methods are mandatory to detect transits
- ★ Difficulties in detecting
  long period (i.e. few transits)
  and/or small (i.e shallow transits) exoplanets

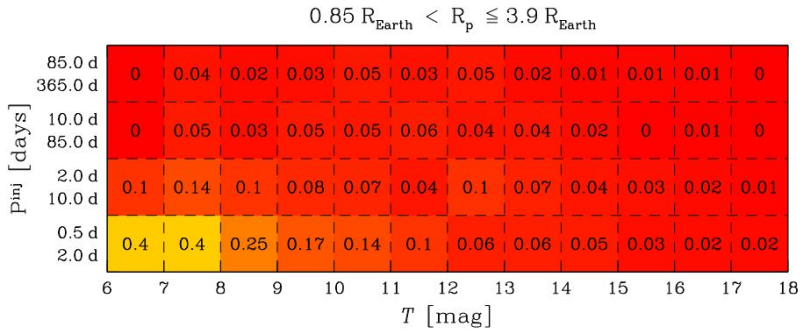
50 Myr!

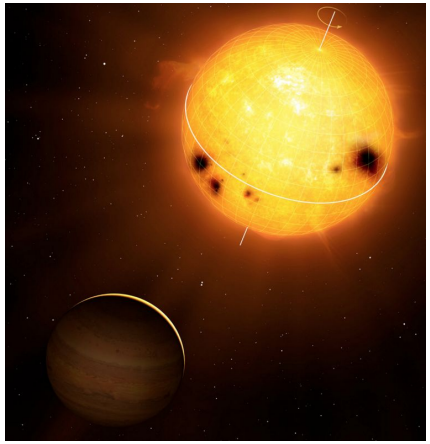


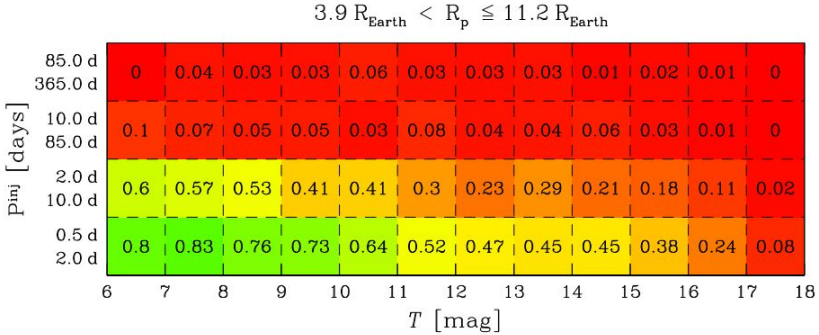
Nardiello et al. (2021)

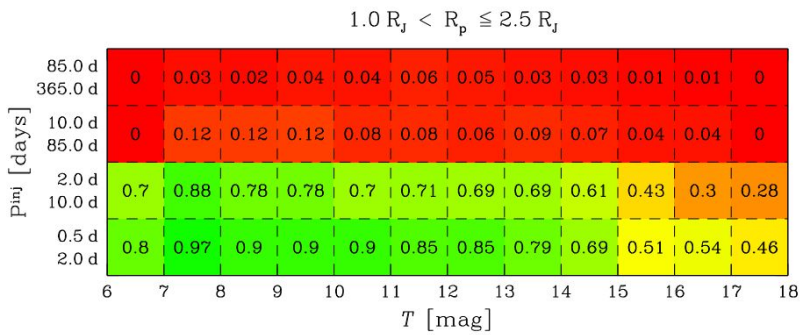
Young stars & stellar activity: photometry

First two years of TESS mission.. Injection / recovery test. Open cluster members (<1Gyr)





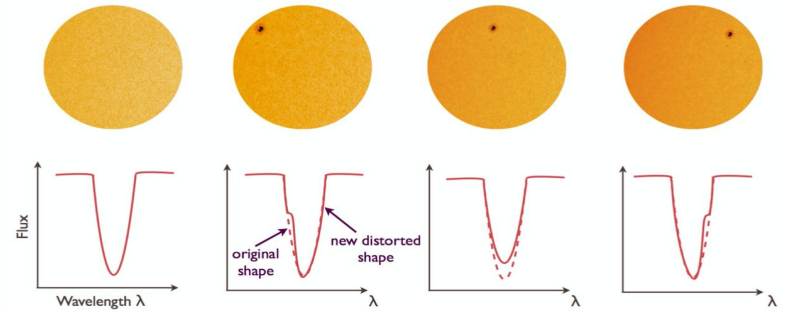




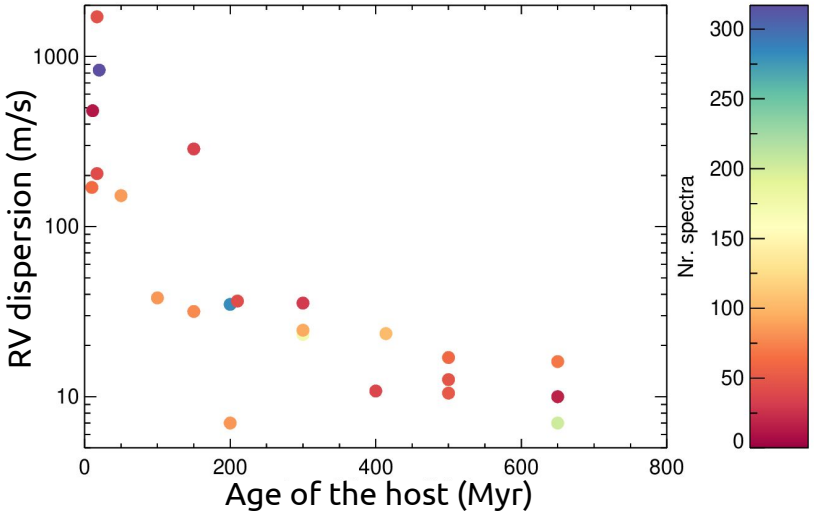
Nardiello et al. (2021)

Young stars & stellar activity: radial velocities

- ★ Moderate-to-high rotation rates worsening the spectral information of the data and a degradation of the RV precision
- ★ Starspots are able to distort the spectral line profiles and injecting fake signals in the RV series
- ★ Difficulties in distinguishing planetary signal from stellar activity in RVs: complementary information from photometry and activity indices to constraint activity



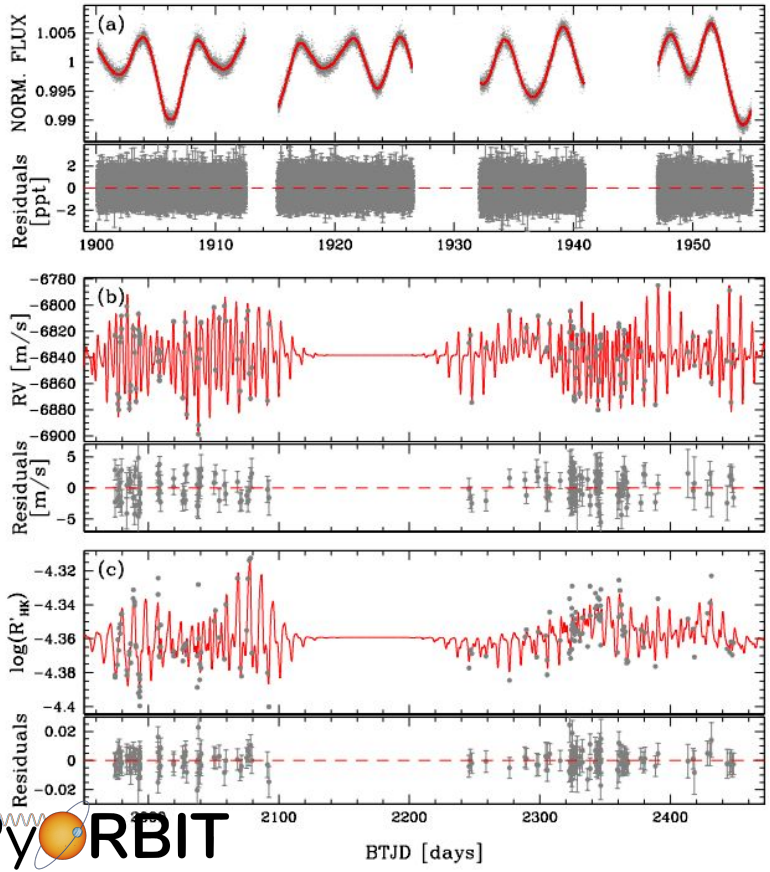
(Adapted from Haywood 2014)



See L. Malavolta's talk

See S. Aigrain's talk

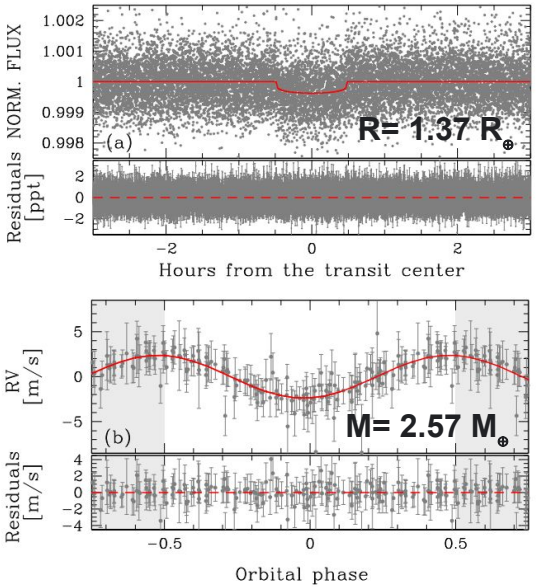
TOI-1807b: the youngest USP with an accurate mass measurement



TOI-1807: K-dwarf in comoving group

Age: 300 +/- 80 Myr → **very** active star

P_{rot} = 8.8 days



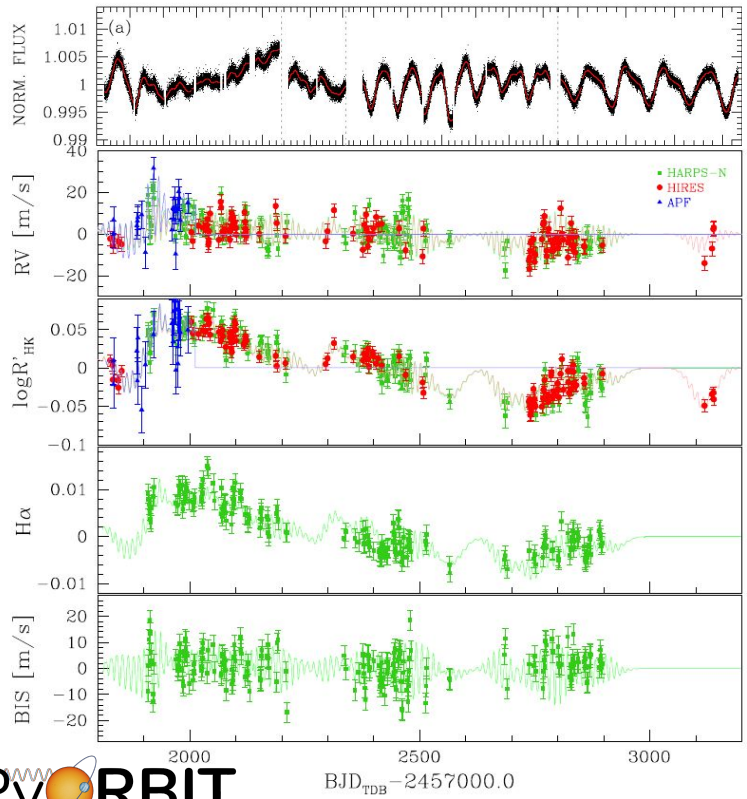
Fit stellar activity + planet through Multidimensional GP implemented in PyORBIT (Malavolta+2016,2018)

P_b = 0.5494 days

Nardiello et al (2022)

PyORBIT

TOI-1430 b: A young planet with evaporating He atmosphere

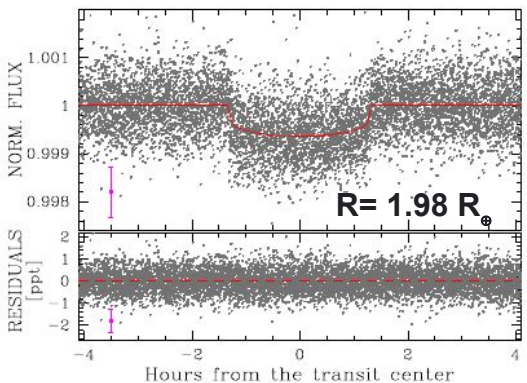


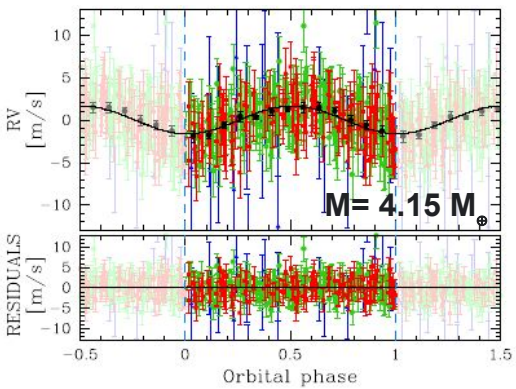
PyORBIT

Young K-dwarf

Age: 700 +/- 150 Myr → **very** active star

P_{rot} = 12.0 days





P_b = 7.434 days

Nardiello et al. (2025)

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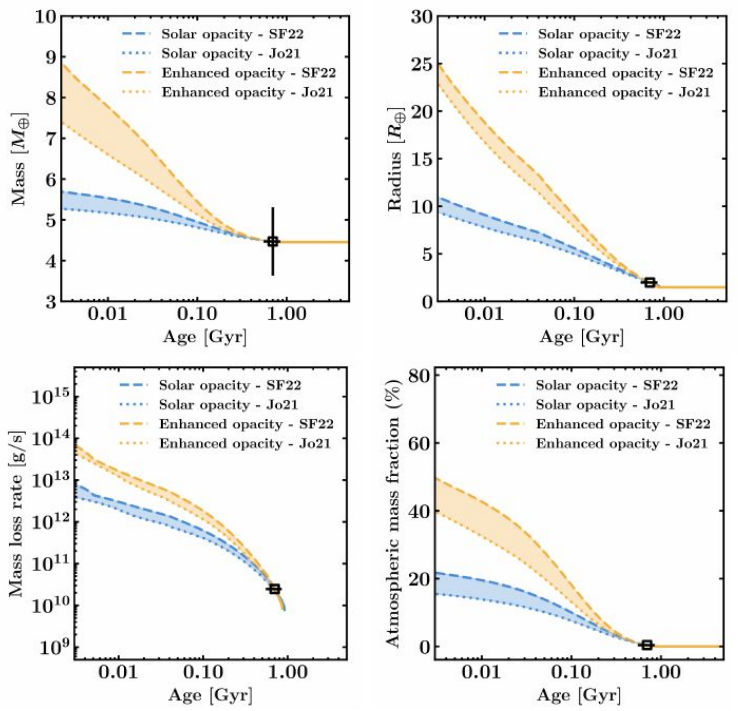
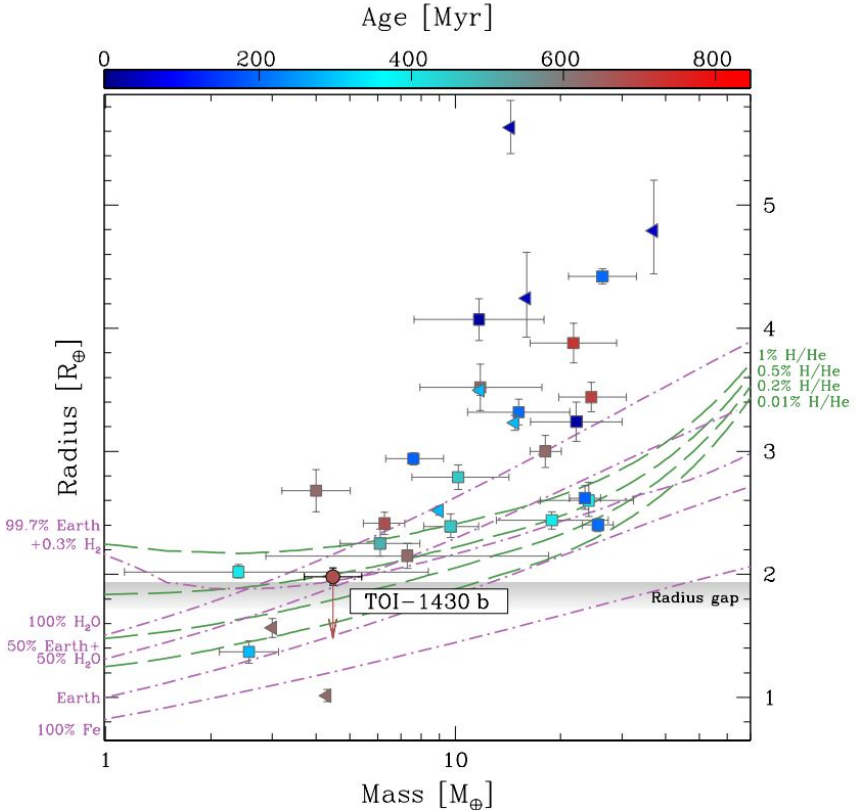


Atmospheric evolution



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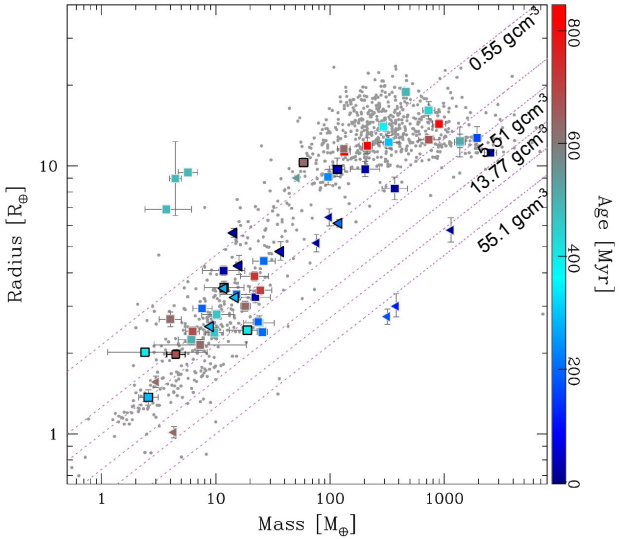

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- ★ Low density young exoplanets (?)
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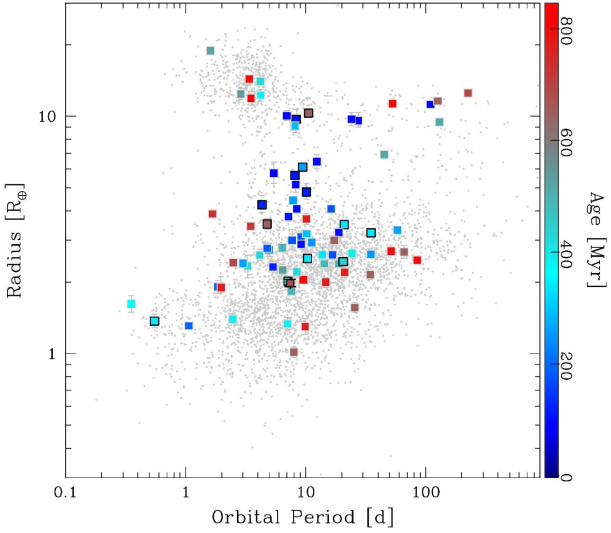
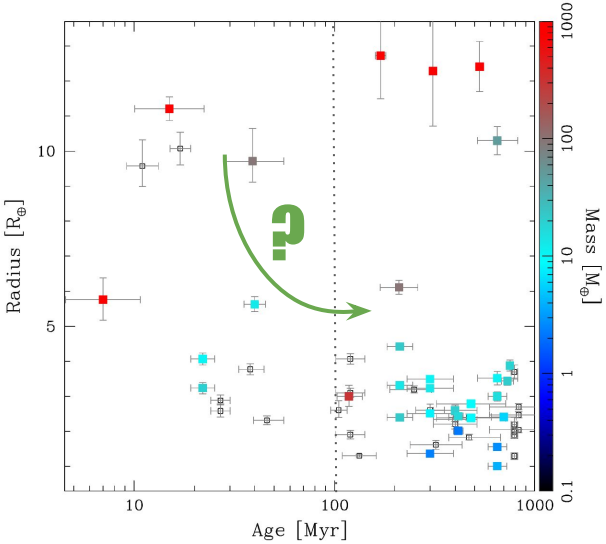
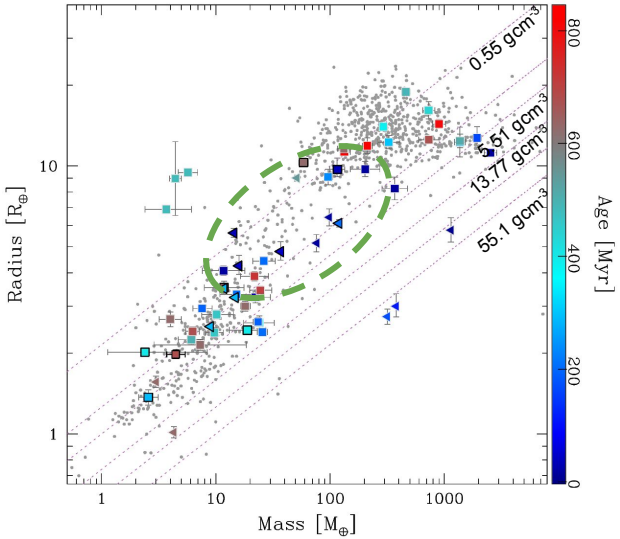
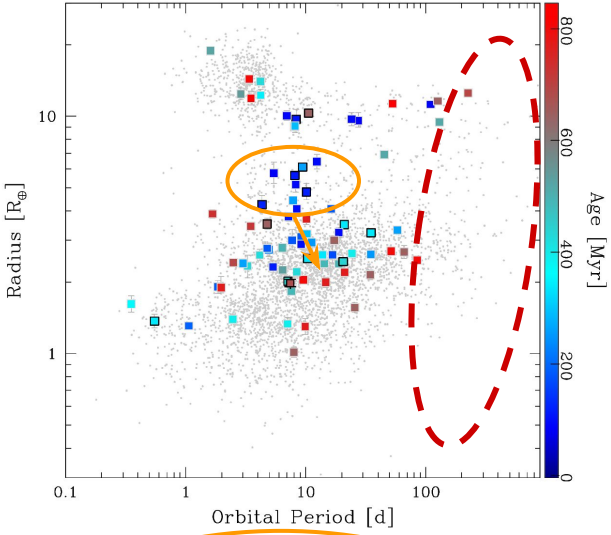


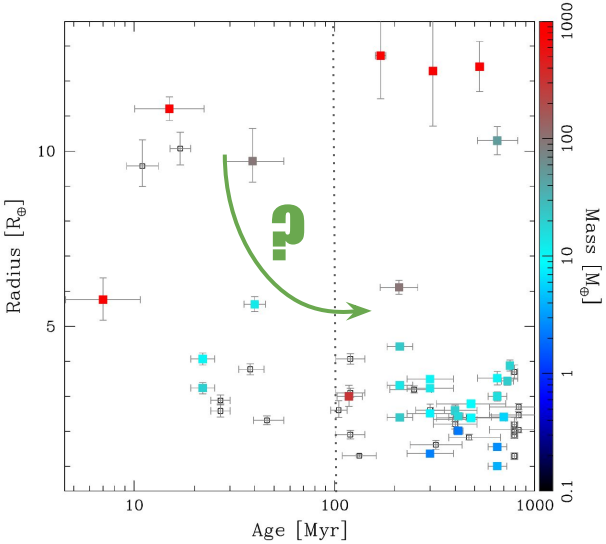
- ★ <100 Myr old planets populate the low density region of the P_{orb} – R_P diagram
- ★ Selection effect or radius evolution with time?
- ★ No information on young planets with P_{orb}>100-200 d!



- ★ Is there a radius evolution with time? Are the planets on the left the progenitors of the planets on the right?
- ★ Lack of young small planets: observational bias?







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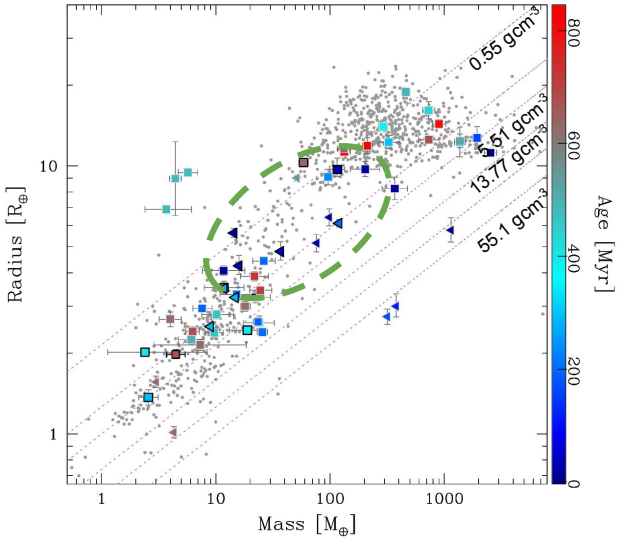

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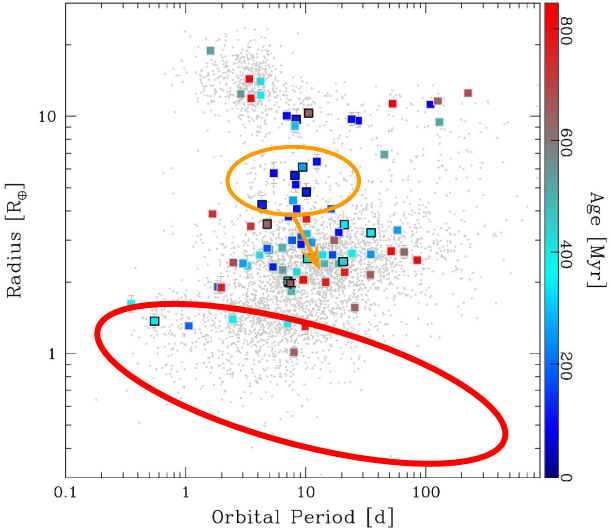

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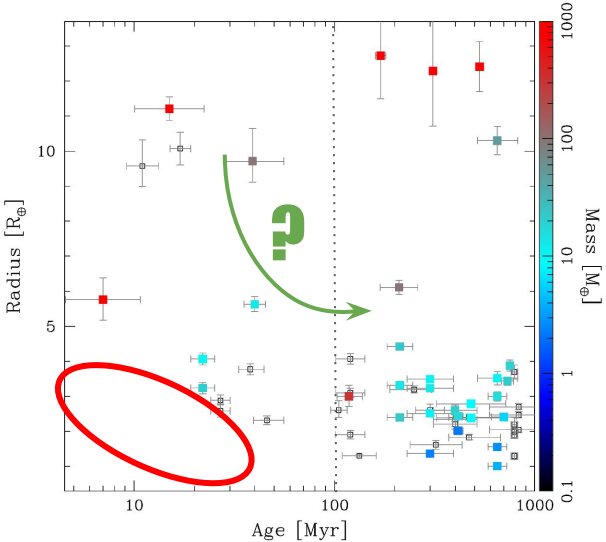

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PLATO Astrometry WG

Main goal: *Combine Gaia and PLATO data to find and characterize the Solar System 2.0, i.e. Earth-like inner transiting planet in the HZ + at least 1 giant astrometric planet in the external planetary system*

… but also:

- False positives analysis
- **not only Exoplanets! → Astrometric/photometric analysis of binary systems (including brown dwarfs!)**
- Development and testing of software for detection and characterization of astrometric signals/planets
- Characterization of Solar-like systems

Membership is open!! If you want to be part of this WG, compile:

or send me an email: domenico.nardiello@unipd.it

First Kick-off meeting on June 17…next one in September …