Exoplanetary Astrophysics

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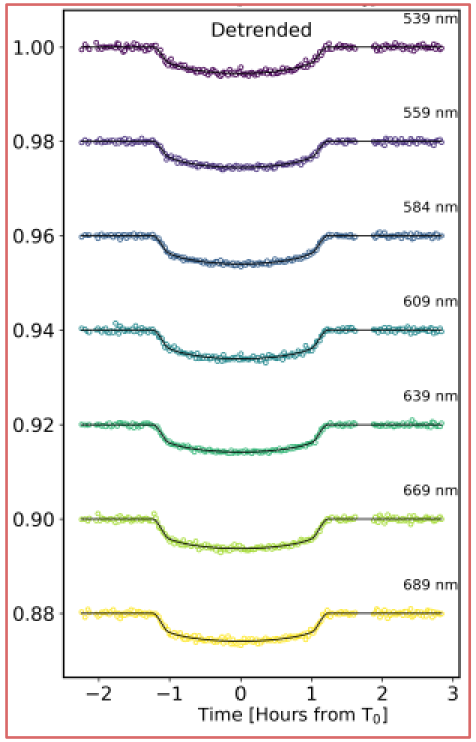
New submissions on Mon, 13 Dec 21

47 papers on astro-ph
11 papers [astro-ph.EP]

A new method to measure the spectra of transiting exoplanet atmospheres using multi-object spectroscopy

- Vatsal Panwar et al.
- arXiv:2112.06678v1
- Accepted for publication in MNRAS
- New Gaussian Processes (GP) regression-based method to analyze ground – based spectrophotometric data, involving non linear mapping between target and comparison star
- 20 % better transit depth precision and residual scatter

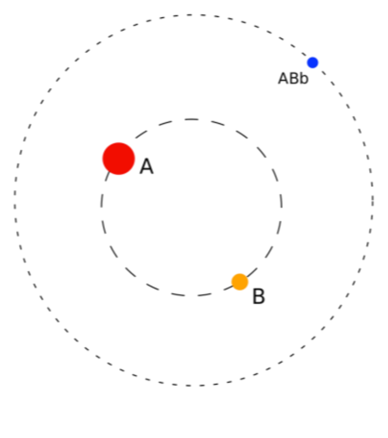


Multi-Wavelength Mitigation of Stellar Activity in Astrometric Planet Detection

- Avi Kaplan-Lipkin et al
- arXiv:2112.06383v1
- Submitted to AAS Journals
- Two or more correlated passbands proposed to correct the astrophysical noise constituted by stellar activity-induced astrometric jitter
- Enhanced precision for astrometric detection of giant and especially lower mass exoplanets in view of GAIA and LUVOIR missions

Observations and independent mass measurement of Kepler-16 (AB) b, the first circumbinary planet detected with radial velocities

- Amaury Triaud et al
- arXiv:2112.06584v1
- Under review at MNRAS
- First radial velocity detection of a circumbinary planet
- M = 0.313 ± 0.039 MJup

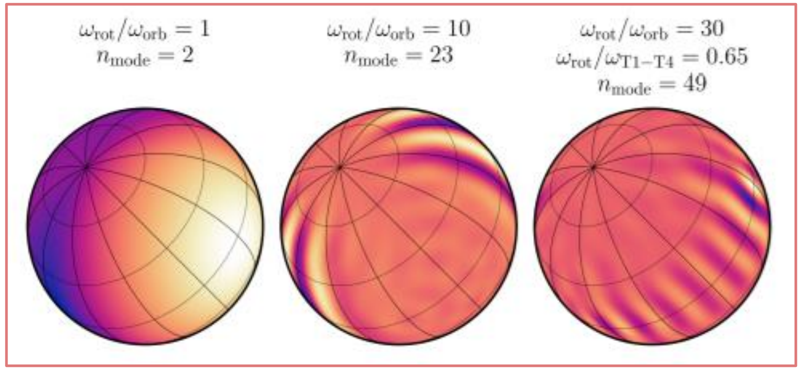


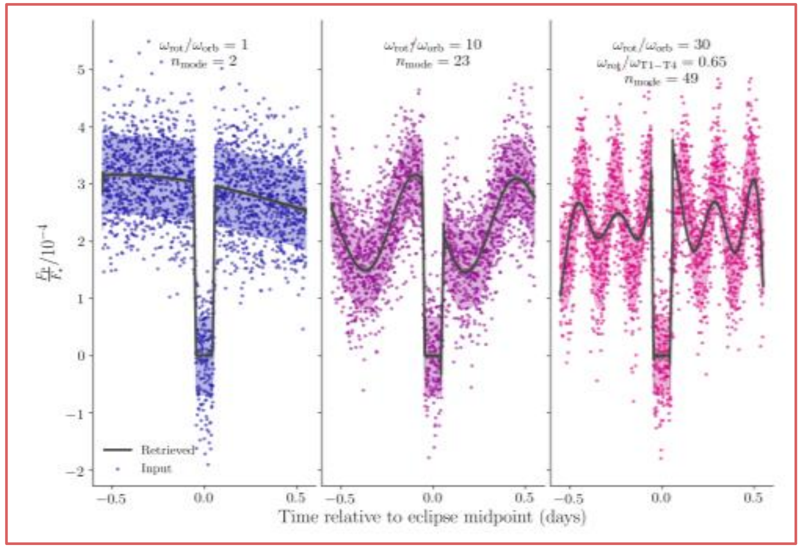
Circumbinary Planet

New submissions on Tue, 14 Dec 21

82 papers on astro-ph
6 papers [astro-ph.EP]

- **The Sensitivity of Eclipse Mapping to Planetary Rotation**
- Arthur Adams and Emily Rauscher
- arXiv:2112.07667
- Submitted to AAS Journals
- Mapping exoplanets across phases and during secondary eclipses provides a direct correspondence between orbital phase and planetary longitude in case of edge-on and synchronous orbits
- New method to obtain the relationship between the shape of the eclipse light curve and the visible portion of the planet surface (translating observed brightness variations into a set of coordinates) for a wide range of spin axis orientations, better characterizing Hot Jupiters in emission





Regular Radial Velocity Variations in Nine G- and K-type Giant Stars: Eight Planets and One Planet Candidate

- Huan-Yu Teng et al
- arXiv:2112.07169
- Accepted for publication in PASJ
- Least-massive giant planets detected around G/K-type giant stars, with minimum masses between 0.45 M_J and 1.34 M_J
- Detected close to the boundary of the 'planet desert' (mass, period diagram) around evolved stars

The similarity of multi-planet systems

- J.F. Otegi, R. Helled, F. Bouchy
- arXiv:2112.07413v1
- Submitted to A&A

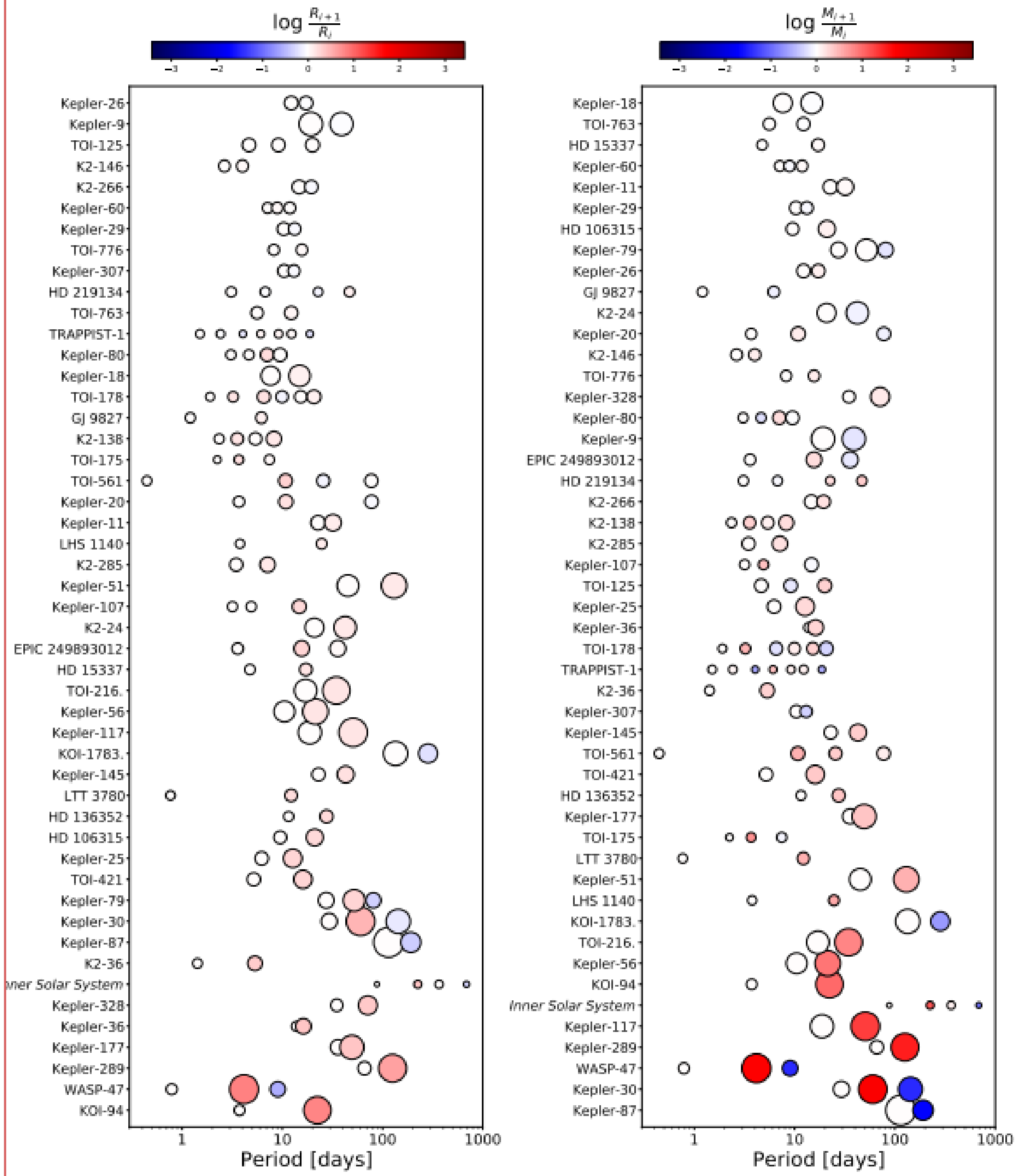
THE SIMILARITY OF MULTI-PLANET SYSTEMS

- From Kepler data, it appears that planets orbiting the same star tend to have similar sizes – "Peas in a pod" assumption

- TESS significantly increased the number of confirmed planets around bright stars with mass measurements, allowing for a more detailed statistical analysis of multi-planet systems.

- In this work the similarity in radii, masses, densities, and period ratios of planets within planetary systems is addressed.

- In-depth study with the aim of
  1. further characterizing the demographic and orbital architecture of planetary systems
  2. establish whether there is an astrophysical origin for the observed intra-system uniformity



- Orbital architecture of the 48 multi-planet systems (144 exoplanets in total) in our sample, taken from NASA Exoplanet Archive
- 27 of the systems characterized via TTVs, 21 by RVs
- Kepler 60 is the most uniform system
- The next four similar uniform systems include pairs of rocky exoplanets (L 98-56) or sub-Neptunes (Kepler 29, TOI 763, Kepler 26).
- The less uniform systems are Kepler 87, WASP 47, Kepler 289, Kepler 30, Kepler 117

- In order to analyze the architectures of planetary systems we define a new metric, where we quantify the similarity of the systems by considering the distance in the logarithmic space of adjacent planets.

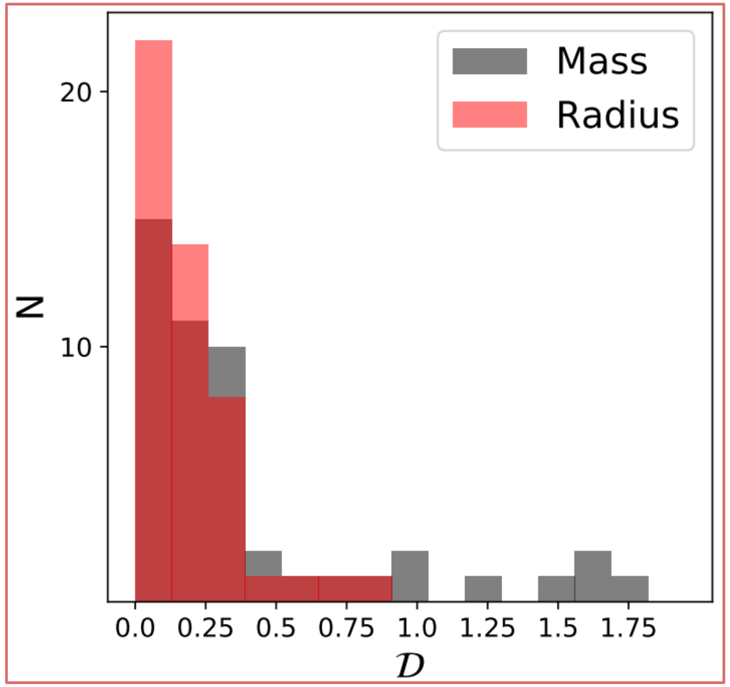
- Equivalent expression for the masses and the radii:

$$\mathcal{D}_M = \sum_{\substack{i=1 \\ P_i<P_{i+1}}}^{N_{pl}-1} \left| \log \frac{M_{i+1}}{M_i} \right| \Big/ N_{pl} - 1$$

- The global distance is the most complete indicator of similarity:

$$\mathcal{D} = \sum_{\substack{i=1 \\ P_i<P_{i+1}}}^{N_{pl}-1} \left[\left(\log \frac{M_{i+1}}{M_i} \right)^2 + \left(\log \frac{R_{i+1}}{R_i} \right)^2 \right]^{1/2} \Big/ N_{pl} - 1$$

- For this metric lower values correspond to more similarity.



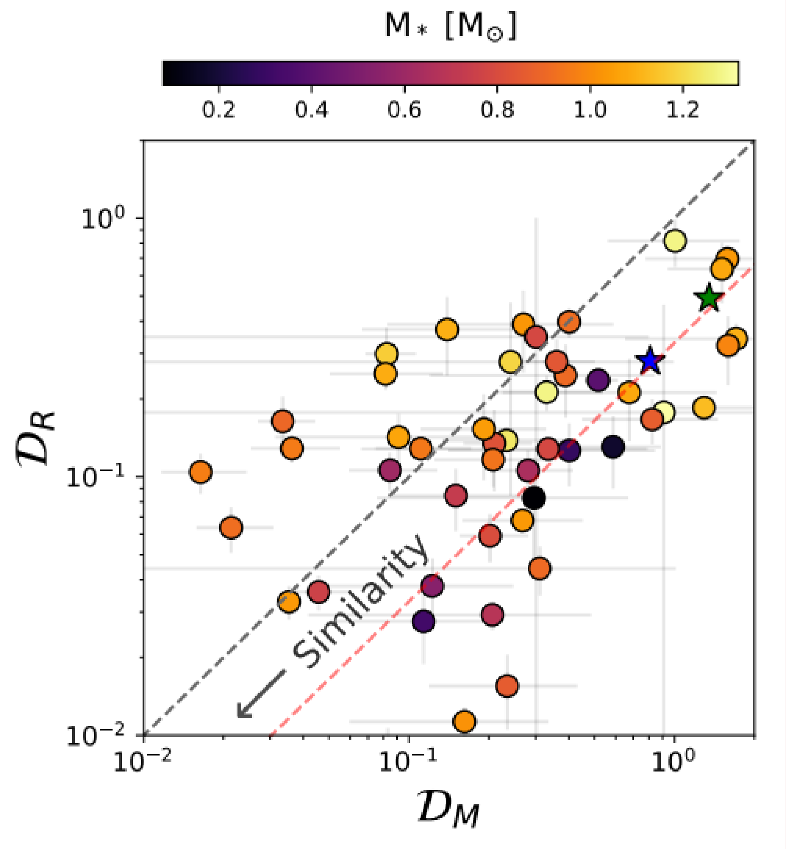
- The values of D_R are much lower than those of D_M: planetary systems in our sample tend to be more similar in radius than in mass

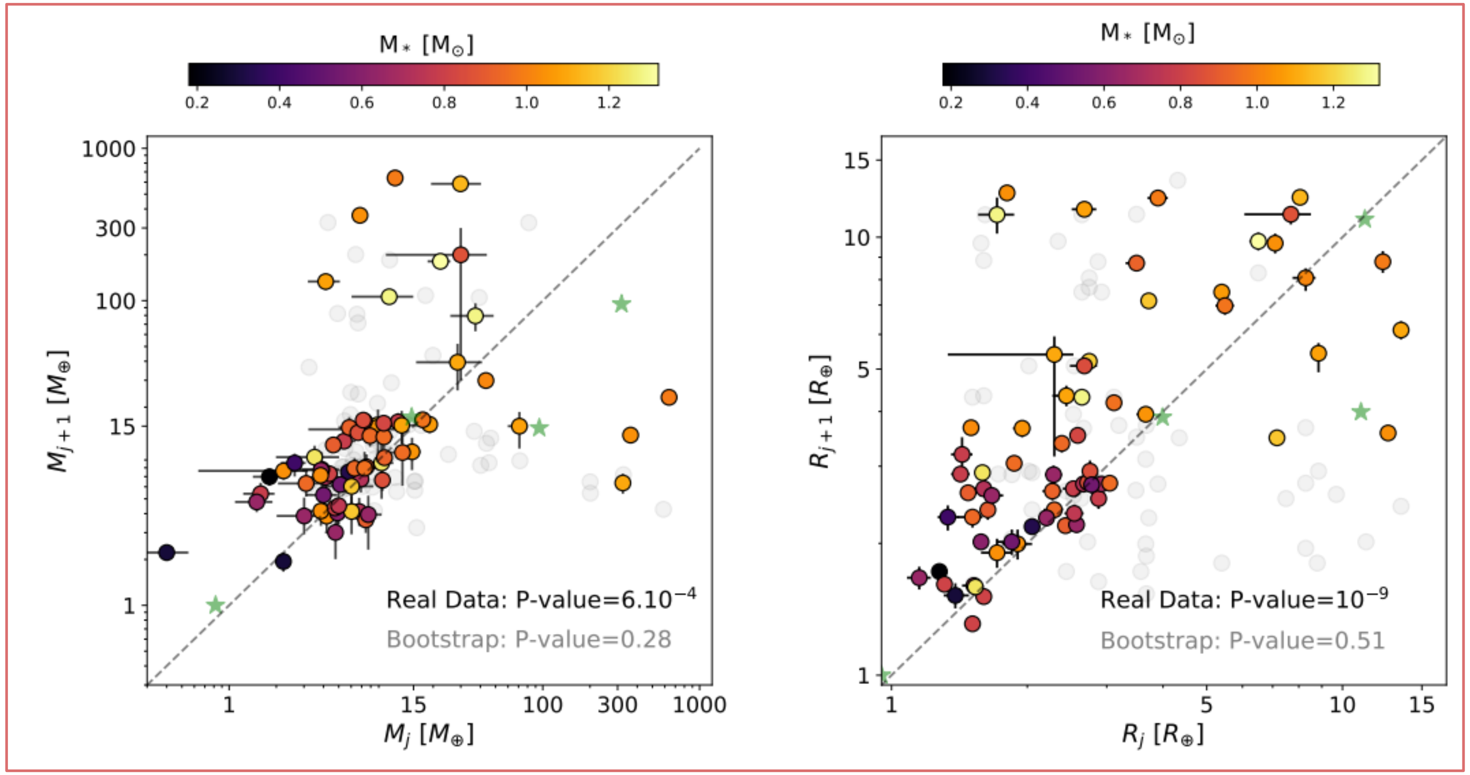
- From the plot, it can be deduced that generally the planets that are most similar in radius do not correspond to the ones that are most similar in mass

- Clear dependence on stellar mass: low-mass stars are more concentrated in the lower part of the figure, indicating that planets orbiting low mass stars tend to be more similar in radius than in mass

- Planetary systems around more massive stars tend to be less uniform in mass and radius, since they tend to host more massive planets

- The red dashed lines corresponds to $D_M = 3 \times D_R$, which would be expected in case of a uniformity in density, and is closely followed by M-dwarfs.





- Pearson correlation test enlightened a clear correlation for both mass and radius: adjacent planets in a multi-planet system are likely to have similar masses and radii.

- The P-value is significantly smaller for the planetary radii, suggesting that the "peas in the pod" pattern is less strong when it comes to the planetary mass

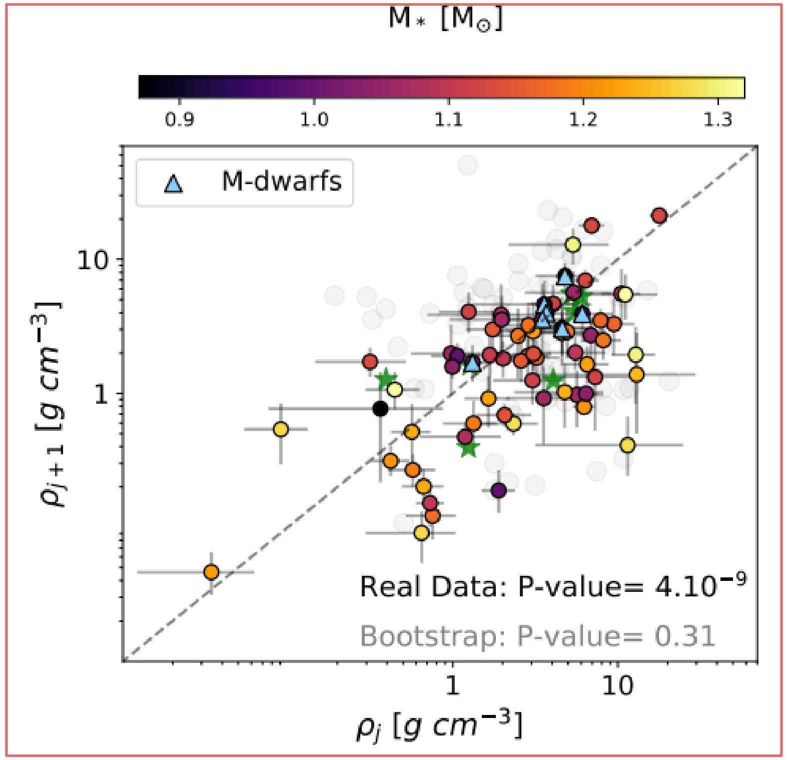
- Bimodality in the uniformity in both plots: systems below 25-100M⊕ and 5-10R⊕ tend to be very uniform while above this threshold they are not correlated

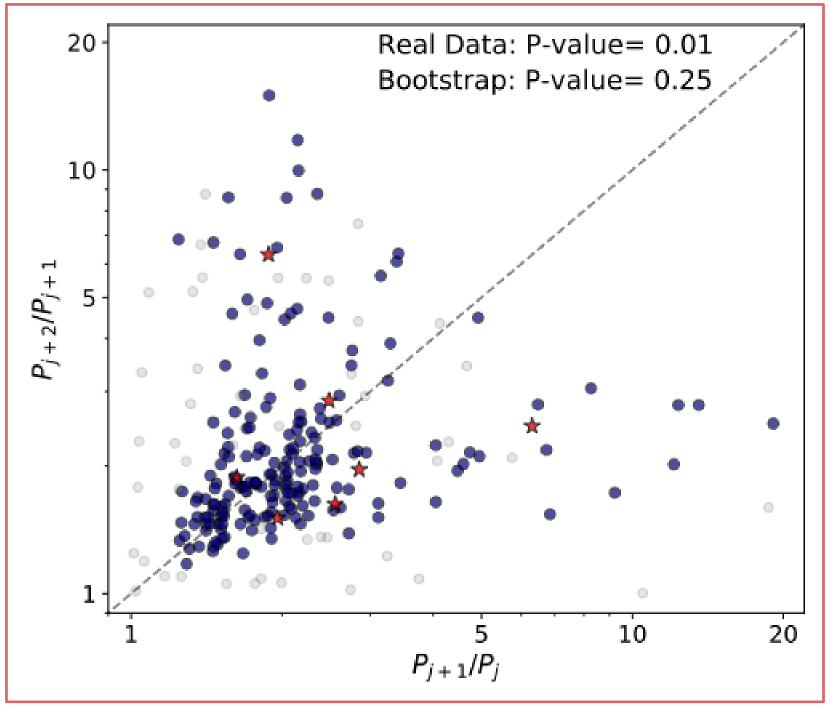
- Plotting the densities of the planets in our sample against the densities of the next planet farther from the star we find that a very strong correlation between densities of adjacent planets

- Since low-mass stars tend to host low-mass planets , this behavior might hint that the physical processes during planet formation tend to produce planets of similar density in planetary systems around low-mass stars

- This would lead, as observed and previously addressed, to a stronger uniformity in radius than in mass since the density is three times more sensitive to radius variations than to mass variations.

- Performances of null hypothesis' bootstrap tests established that detection biases are not responsible for the observed correlation, hence it is a physical one





- Planets orbiting the same star tend to have regular orbital spacings

- Systems with low period ratios of adjacent planets are significantly more uniformly distributed. This could be due to
  1. absence of dynamical interaction between the planets for systems with high period ratios
  2. an observational bias (unlikely)

- From correlation tests, systems with rocky planets are more uniformly spaced than the systems with larger planets

CONCLUSIONS

- Multi-transiting systems tend to have planets with similar sizes and masses
- The planetary radii of a given planetary system are more similar than the masses.
- Planets more massive than ~ 100 $M_\oplus$ and larger than ~ 10 $R_\oplus$ are not uniform and do not follow the "peas in a pod" pattern.
- Strong correlation between densities of adjacent planets
- Planets orbiting the same star tend to have regular orbital spacings
- Systems containing planets with small period ratios are more uniformly distributed, which may be an indicative of stronger dynamical interaction.

- Due to the diversity of planets within a planetary system, increasing the number of detected systems is crucial for understanding the exoplanetary demographics.
- Ongoing and future space missions like TESS, CHEOPS and PLATO, ground-based radial velocity facilities like ESPRESSO and high-precision astrometric survey GAIA will rapidly increase the number of characterized exoplanetary systems and will allow to continue searching for missing planets in the outer regions of multi-planet systems.

APPENDIX
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STATISTICS

- In statistics, the Pearson correlation coefficient is a measure of linear correlation between two sets of data.

- The P-value is the probability you would have to find the current result if the correlation coefficient were in fact zero (null hypothesis).

- Bootstrapping is a statistical technique that allows estimation of the sampling distribution of almost any statistic using random sampling methods.

REFERENCES

- https://arxiv.org

- https://exoplanetarchive.ipac.caltech.edu/

- Efron, Tibshirani, *An introduction to the Bootstrap* , Springer 1993