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Distribution of RV- and transiting exoplanets by masses and orbital periods taking into account observational selection

[1] V.I. Ananyeva, A. E.Ivanova, A.A. Venkstern, I.A. Shashkova, A.V. Yudaev, A.V. Tavrov, O.I. Korablev, and J.-L. Bertaux, Mass distribution of exoplanets considering some observation selection effects in the transit detection technique, Icarus, Volume 346, August 2020, 113773. DOI: 10.1016/j.icarus.2020.113773
[2] Mordasini, C., Planetary Population Synthesis, Handbook of Exoplanets, H. J. Deeg, J. A. Belmonte (eds.) (2018), https://doi.org/10.1007/978-3-319-30648-3_143-1
[3] A. E. Ivanova, O.Ya.Yakovlev, V. I. Ananyeva, I. A. Shashkova, A. V. Tavrov, and J.-L. Bertaux, The Detectability Window" Method to Take into Account Observational Selection in the Statistics of Exoplanets Discovered through Radial Velocity Measurements, ISSN 1063-7737, Astronomy Letters, 2021, Vol. 47, No. 1, pp. 43–49. DOI: 10.1134/S1063773721010059.

By August 30, 2021
4512 confirmed planets,
3410 transit planets (radius is known),
1110 planets with known mass *m,*
900 planets with known projective mass *m* sin *i* are discovered

95% exoplanets are discovered by transit and RV technique

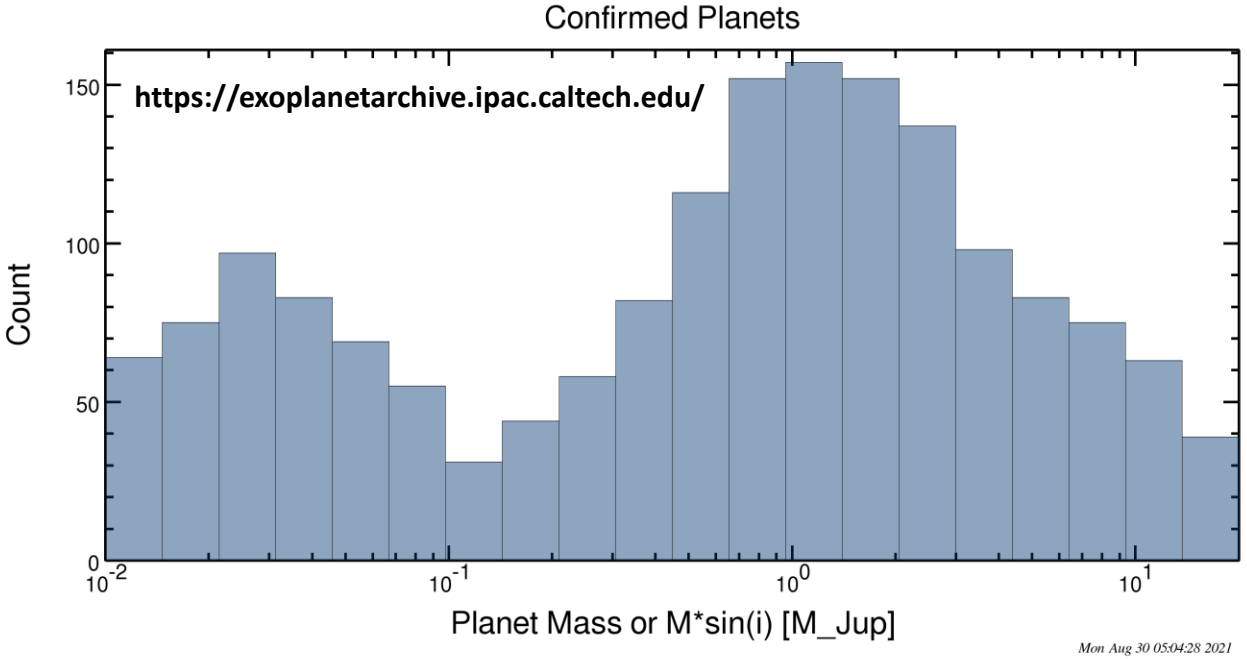
The observational selection factors:

In the transit technique:

– different detection efficiency of planets of different radii

– different proportion of planets with measured mass among planets with different radii

– geometric probability of the transit configuration ~R_{star} /a depends on the distance between a planet and a star



Not corrected (observed) mass distribution of RV-exoplanets

In the RV technique:

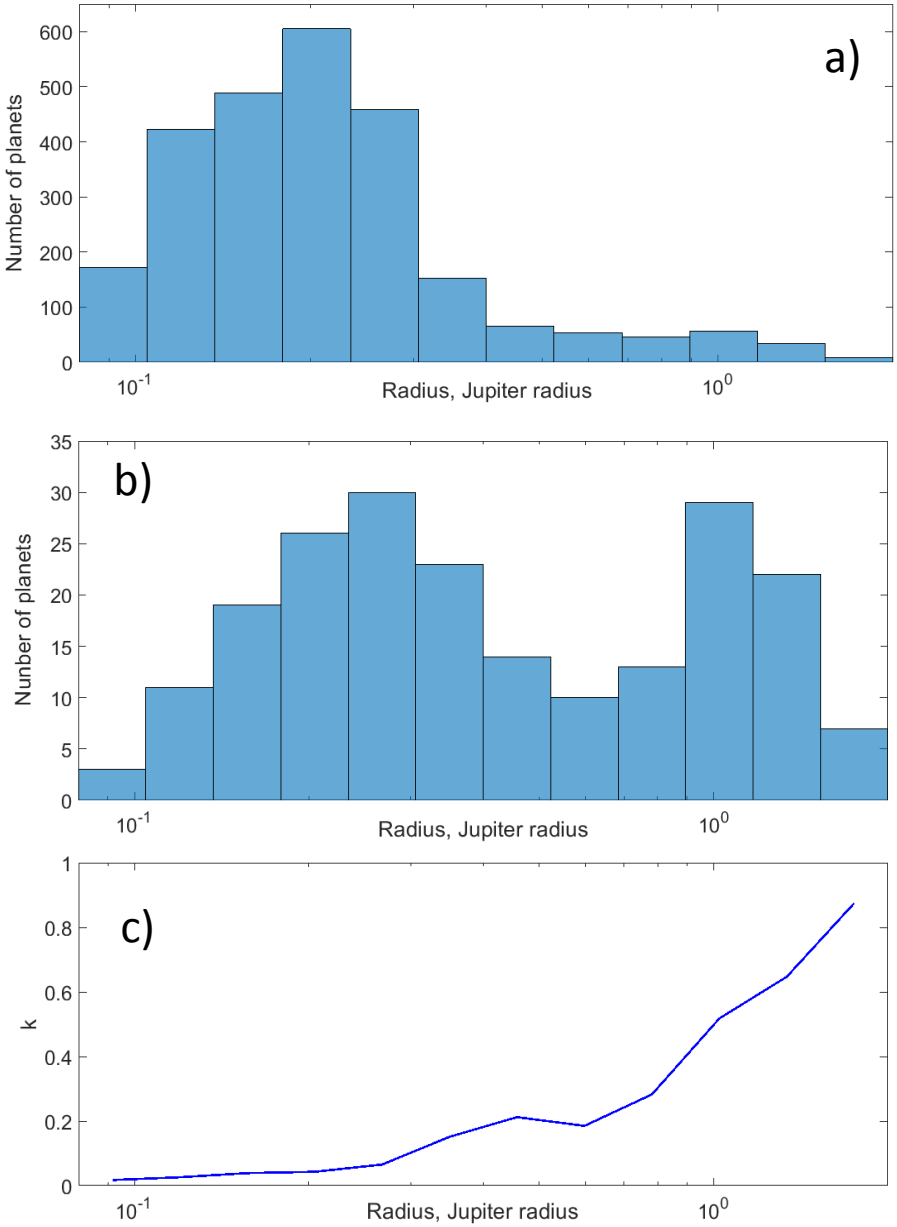
– different accuracy of spectrographs

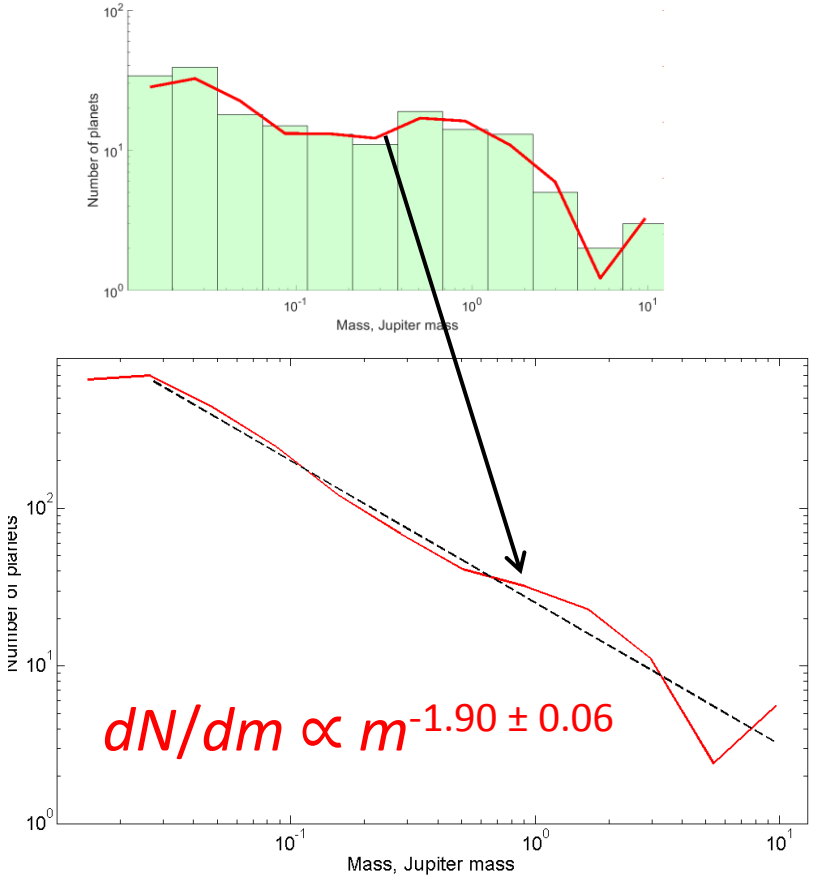
– different levels of internal activity of host stars

– different duration of observations

Observational selection promotes the detection of massive planets with short orbital periods

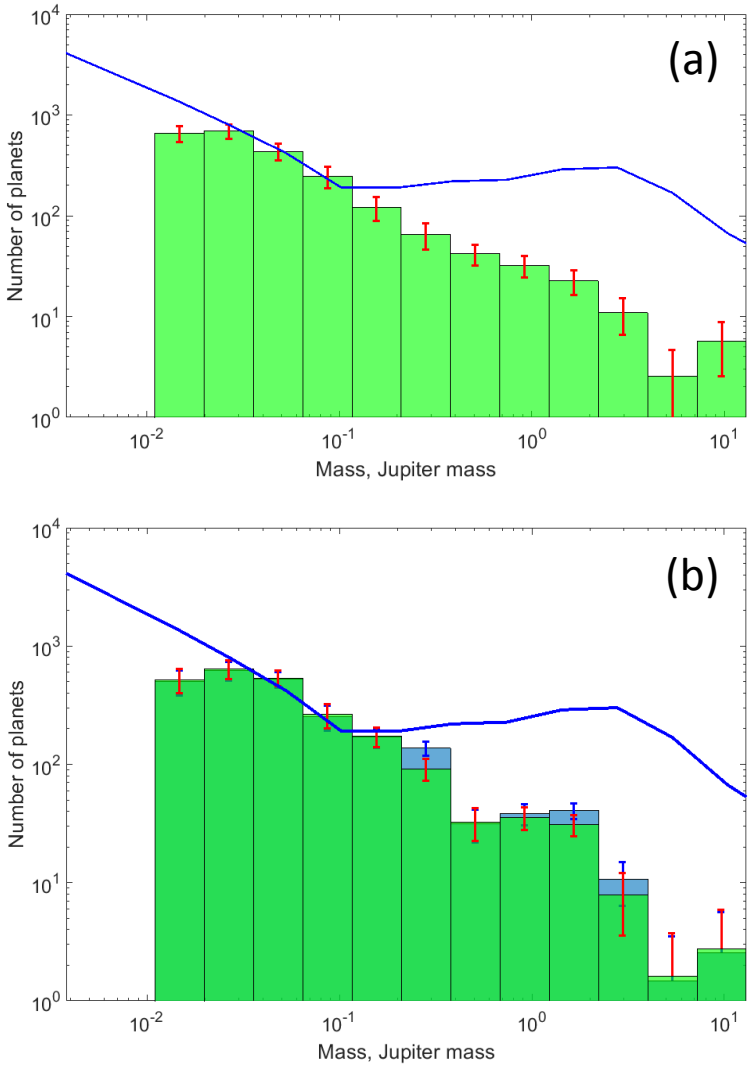
Correction of the Kepler planets mass distribution using the mass determination coefficient *k*

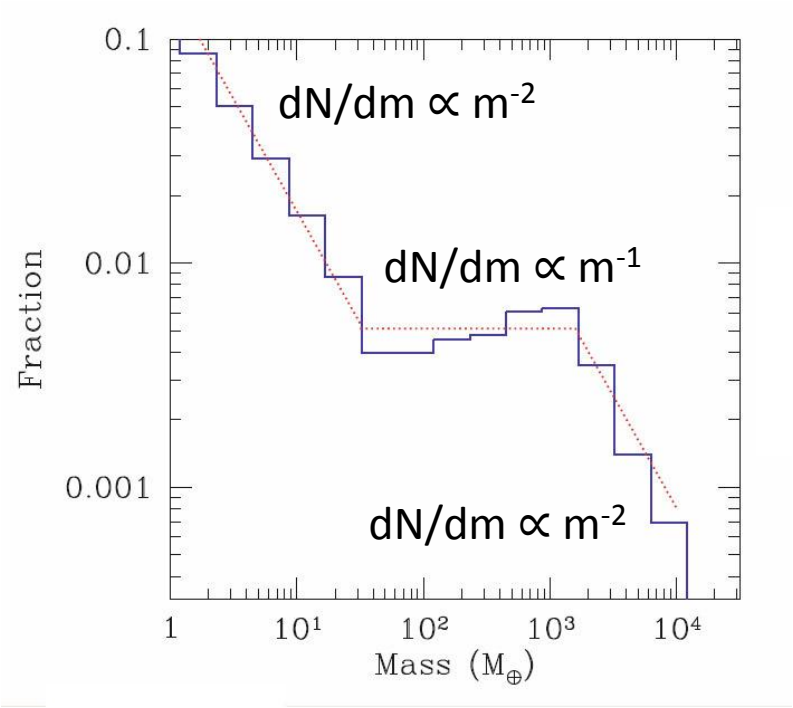




Mass determination for the *Kepler* planets: (a) histogram for all *Kepler* planets by radii; (b) histogram by radii for the *Kepler* planets with measured masses; (c) the mass determination coefficient *k* (the ratio of quantities presented in panels (a) and (b)), [1].

Comparison with the prediction of the population synthesis by [Mordasini, 2018]



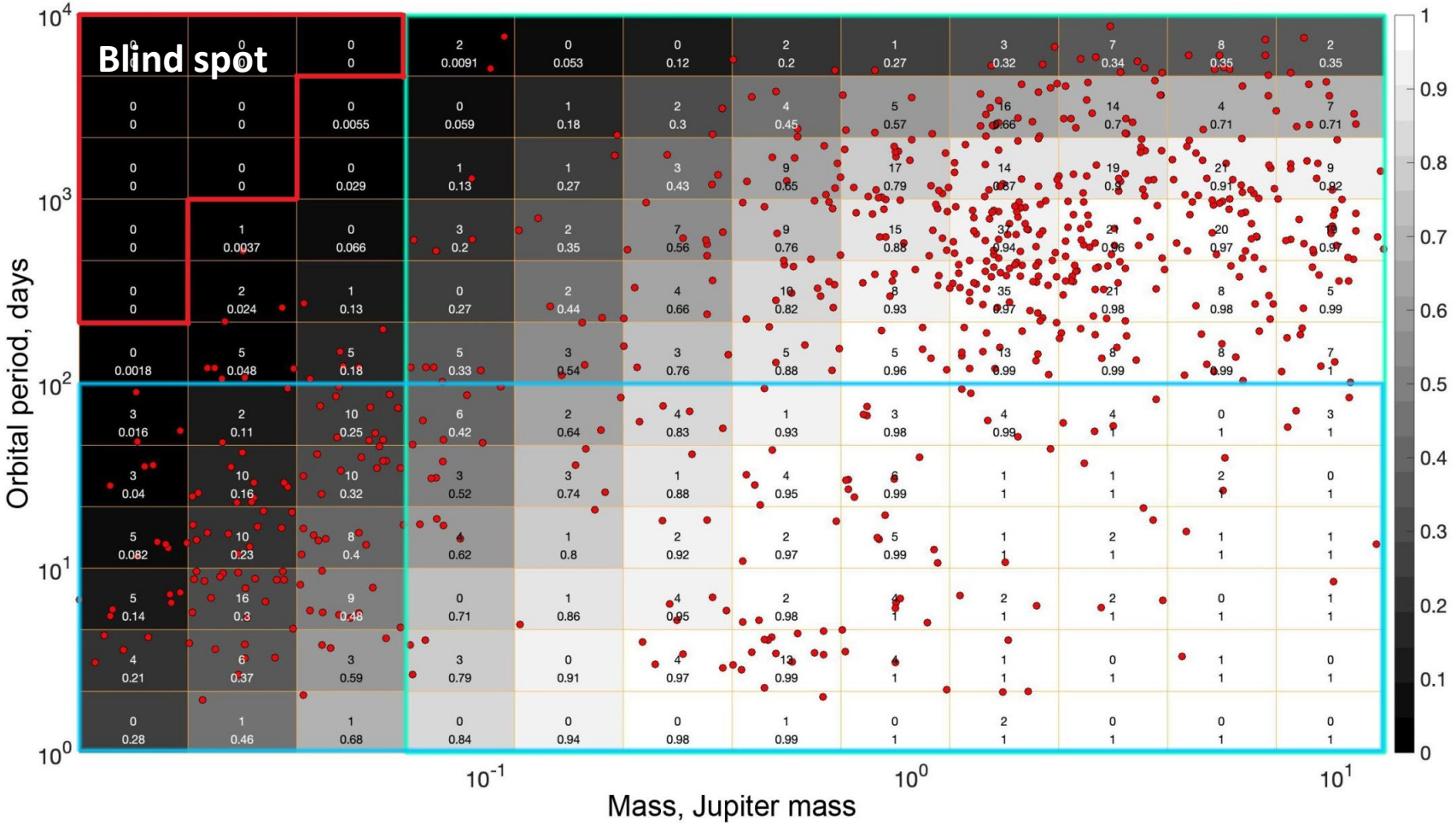


The mass distribution of transit planets demonstrates the lack of giant planets in comparison with the prediction.
Are they in wide orbits?

Mass distribution of Kepler planets (green bars) and distribution predicted by Mordasini (2018) (blue line). (a) de-biased mass distribution without considering the probability of transit configurations, (b) de-biased mass distribution when considering the probability of transit configurations.

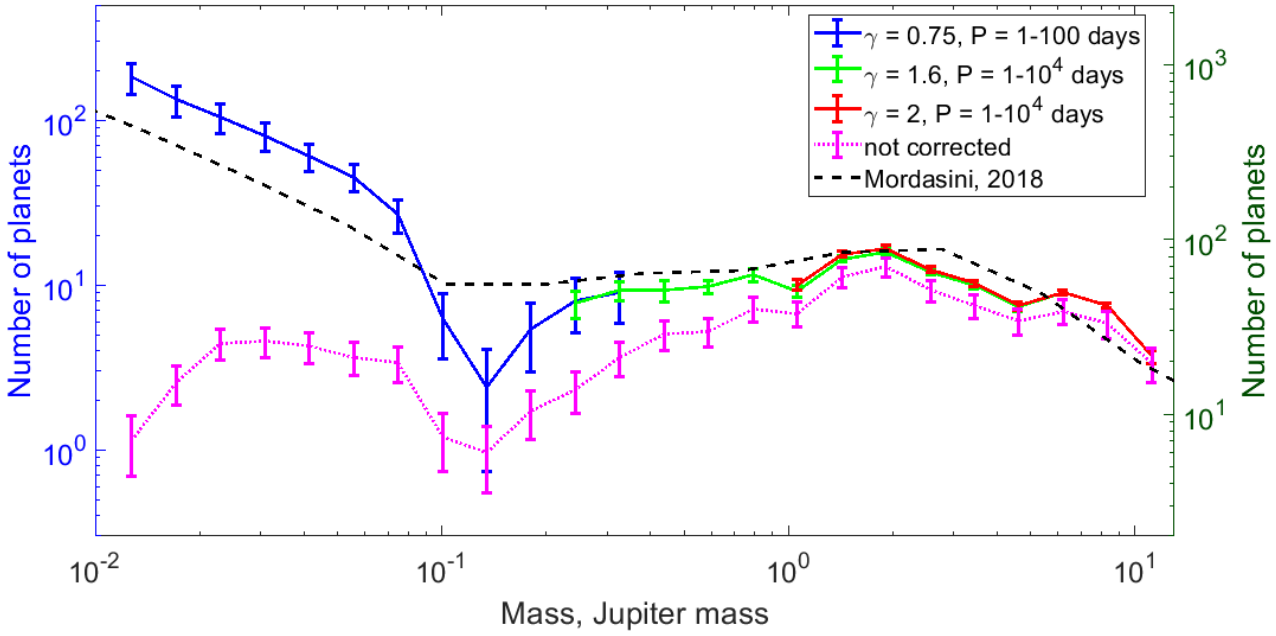
Detectability window regularization algorithm for RV-planets

The detectability window is a matrix of dimension ($n \times n$) in the m–P plane, the elements of which represent the probability of detecting a planet with desired values of the projective mass and the orbital period **W**(m, P). Detailed description of the algorithm is in [3]

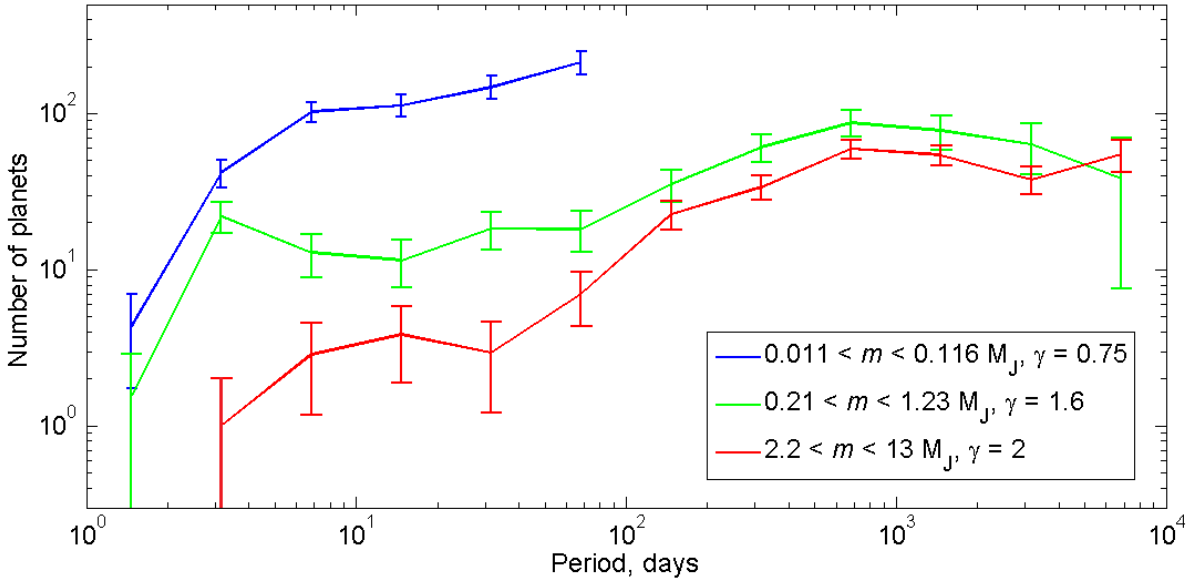


(1) We consider the planets $0.011 < m_{pl} < 13\ m_J$, $1 < P_{orb} < 100$ days (blue rectangle)

(2) We consider the planets $0.0625 < m_{pl} < 13\ m_J$, $1 < P_{orb} < 10^4$ days (green rectangle)



The complex de-biased projective-mass distribution of RV planets in a domain of (0.011–13)M_J.



The de-biased orbital-period distributions for the planets from mass domains of (0.011–0.116)M_J, (0.21–1.23)M_J, and (2.2–13)M_J are shown by blue, green, and red lines, respectively.

The orbital-period distributions of planets with small, intermediate, and large masses differ from each other, which suggests a dominating structure of planetary systems.