Did planet formation occur only recently? Evidences from the GAIA DR3 data

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Motivation

- Stars and planets form from the same molecular cloud and thus their properties are expected to be correlated.
- Metal rich stars tend to host giant planets while small planets do not have any such preferences[1,2].
- Jupiter hosting stars seems to be younger compared to small planet hosting stars[3].
- With the GAIA DR3 data release it is possible to do a statistical analysis for the largest number of exoplanet hosting stars whose parameters are determined homogeneously[4].

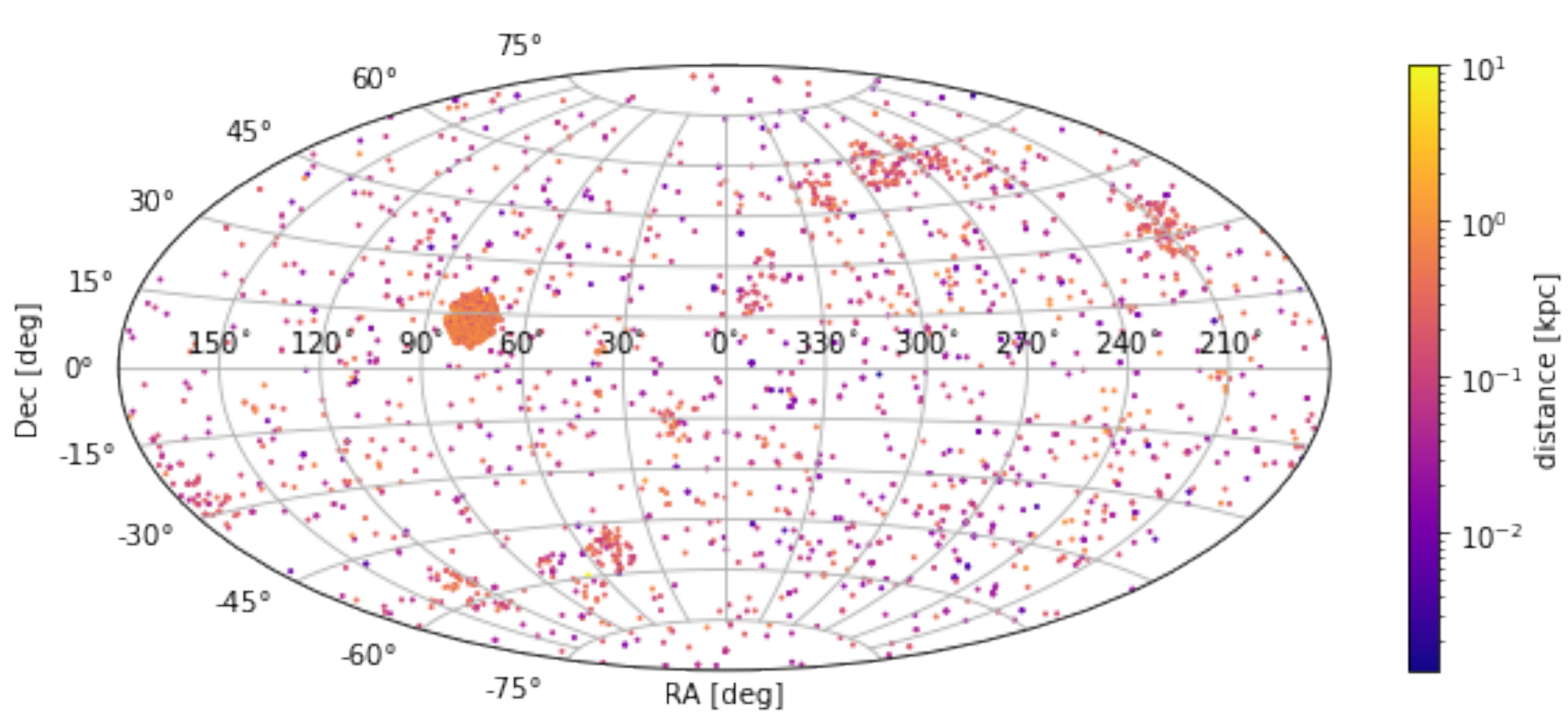

Fig 1 : Exoplanet hosting stars for which Gaiaparameters are available (3617 stars : Photometric and only 1344 stars spectroscopic).

Spectroscopic Results

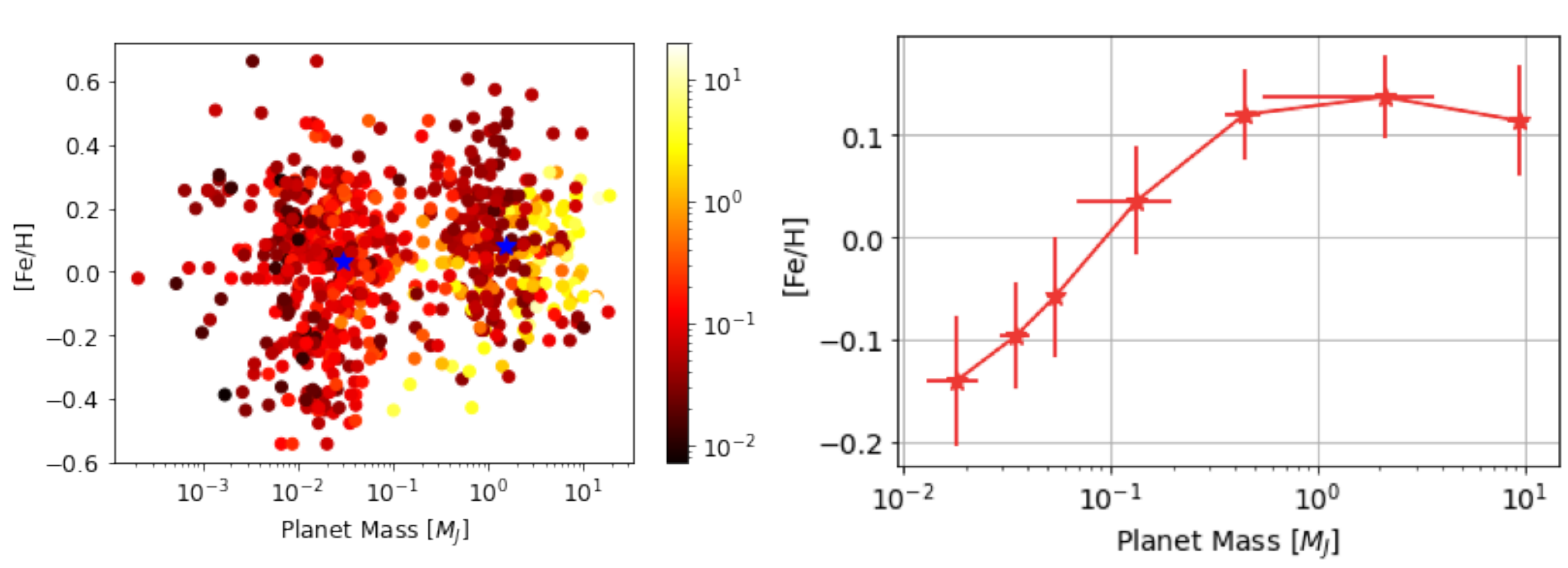

Fig 2 : Left : Planet mass vs Stellar metallicity distribution for the planet hosting stars. Blue stars indicate the median. Right : Same as Left but binned data for both corrected metallicities. Data : GAIA DR3

- We found that the metallicities and abundances (Mg, Si, Ti & Ni) estimated from RVS spectrum from Gaia DR3 and for those obtained using high-res spectroscopy suffers from strong systematics.
- We calibrated the metallicities and abundances from the Gaia DR3 with HARPS-GTO sample[5] for further analysis.
- We find that the planet mass increases with stellar metallicity upto (1-4 M_J) and falls of beyond 4 M_J.
- After proper calibration, we find that for α-elements (Mg, Si & Ti) the trends with planet mass are negative while for the Fe-peak elements (Ni) we find trends are positive.

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Stellar Kinematic Results

- We computed the galactic orbital parameters : eccentricity and Z_{max} and space velocities (U, V, W) using galpy[6].
- The spread in distribution of space velocities (U, V, W) are lower for giant planet hosting stars compared to small planet hosts.
- The distribution for the galactic orbital parameters (gop) for the small (<0.3 M_J) and giant planet (>=0.3 M_J) hosting stars are different ($p < 0.005$) indicating that these two samples belong to separate classes.
- The gop (eccentricity, Z_{max}) is also a proxy for evolution and age[7].

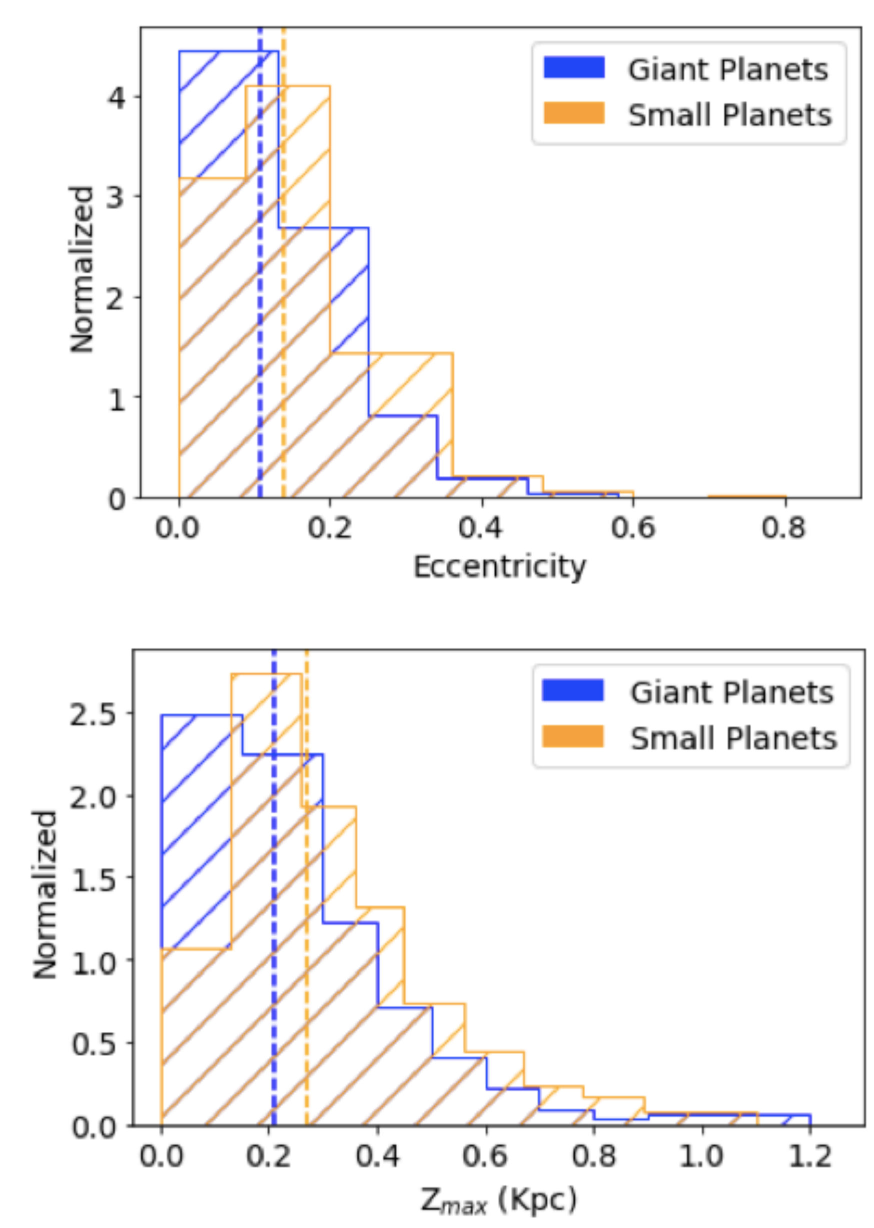

Fig 3 : Eccentricity and Z_{max} distribution for the stars hosting small and giant planets.

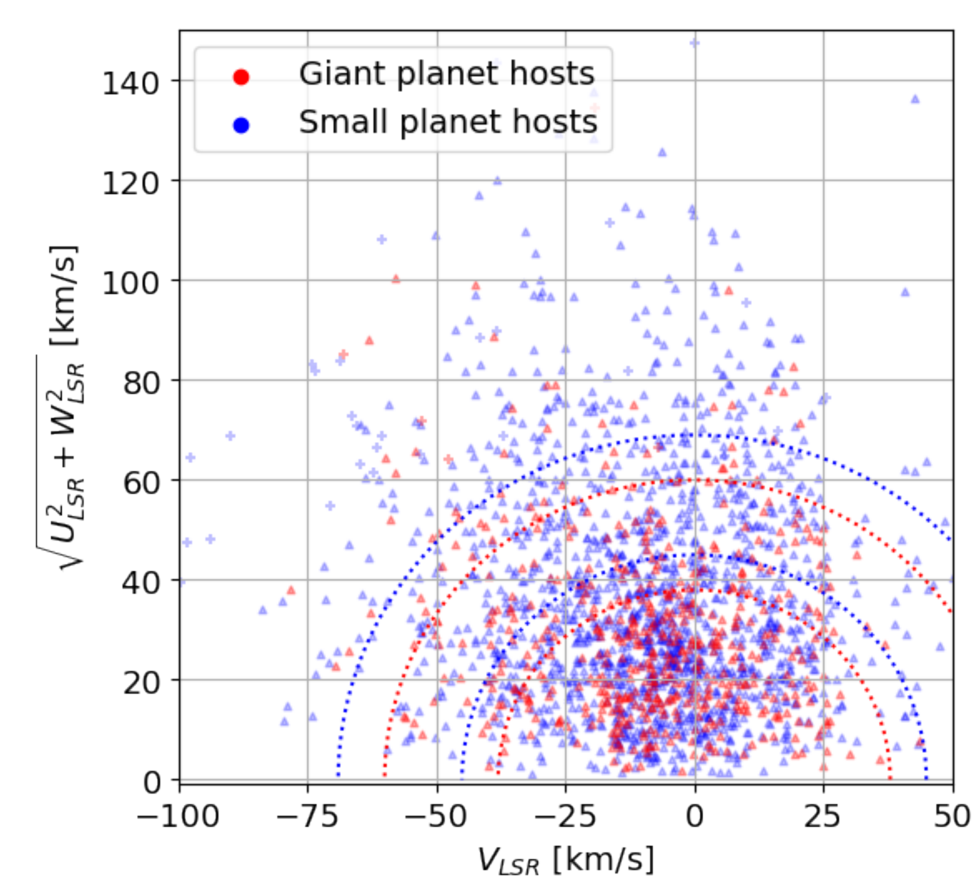

Fig 4: Toomre diagram for the planet hosting stars. The triangle: Thin disk; diamond: thick disk. The inner and the outer blue and red circle represents 80 and 50 percentage of sample located in that radius.

	Ecc	Z_{max} (Kpc)	ν_{pec}	σ_{tot}	Thin disk	Thick disk
SPH	0.14	0.27	40.49	51.53	1475	34
GPH	0.11	0.21	33.03	43.21	579	9

Table 1 : The median values of the Galactic orbital parameters, ages and # of thin and thin disk for the stars with small (SPH) and giant (GPH) planets.

Conclusion

- The stars hosting small and giant planets are different both in terms of spectroscopic and kinematic parameters, indicating that they are two separate population.
- Abundances and kinematic analysis of largest homogeneous sample of planet host stars drawn from the GAIA DR3 shows that the Jupiter hosting stars are statistically younger compared to small planet hosting stars.

Acknowledgements

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