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Exoplanet Radius Dependence on Host Star Type

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Abstract

Using statistical tools we find that the massive stars tend to form larger planets. This relation can be explained by larger fraction of light material for planets surrounding larger stars. We examined the possibility to explain this observation by alternative interpretations: more massive planets or more thermally inflated planets. The effect of those factors found to be insufficient.
In this research we focused on planets surrounding G-stars and K-stars.

1. Introduction

There are above 4,000 confirmed planets as of April 2019. Measured radii of planets from the *Kepler* mission combined with radial velocity (RV) follow-ups or transit timing variations (TTV) provide information on the planetary masses and thus bulk densities. The diversity of planetary masses and radii is large. Determining a structure and composition from given masses and radii is a highly degenerate problem, because very different exoplanet interiors can yield identical masses and radii.

Previous works [1] [2] has given clear evidence that larger planets form around more massive stars and that there is a universal relation between **stellar mass and planet radius**.

There are two main interpretations for this characteristic relation possible:

- The protoplanetary disk surrounding a massive star tends to be more metal-rich and long-lived, and therefore tends to form larger (more massive or more gas rich) planets more rapidly.

- More massive stars more luminous, and therefore deposit more energy to planet's interiors. Volatile-rich planets tend to in inflate due to higher temperatures, and therefore we expect to find more extended radii among more massive stars.

2. Methods

We construct a series of planetary models with a rocky ($MgSiO_3$) core surrounded by a hydrogen-helium (H-He) and water (H_2O) atmosphere. Those models provide mass-radius relations for the possible compositions.

The models depict various changes in planetary radius due to different masses, temperatures, compositions and structures.

3. Results

G-planets tend to be larger, hotter and more massive than the K-planets, as presented in Table 1.

We find that the difference in observed mass cannot be explained by the effect of larger mass: the difference between observed G-planets and K-planets in the terms of radii is $0.5R_{\oplus}$, while the larger masses lead to a difference of $0.09R_{\oplus}$. The effect of the temperature found to be $0.13R_{\oplus}$, much less than the observed difference.

We find that the effects of a composition ($0.47R_{\oplus}$) and structure ($0.60R_{\oplus}$) are more consistent with the observed data, and suggest the following interpretation: Larger stars tend to host planets with larger fraction of light materials(such as H-He).

parameter	G-planets	K-planets
M ($M_{\oplus}$)	9.19±1.51	8.54±1.96
R ($R_{\oplus}$)	2.83±0.41	2.33±0.43
T (K)	915.65±92.16	707.99±101.42

Table 1: Mean observed values of Mass, Radius and mean calculated temperature for G-planets and K-planets. The errors correspond to 95% confidence intervals for the normal distribution.

4. Summary and Conclusions

We conclude that the radius difference between K-planets and G-planets cannot be explained by a simple inflation due to higher temperature, nor by more higher planetary mass. We suggest what the larger radii of the G-planets are a result of different composition: larger stars tend to form planets with **larger volatile fraction**.

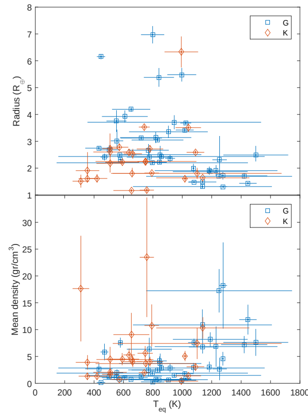

Figure 1: Measured planetary radius (upper panel) and calculated planetary bulk density (lower panel) versus calculated equilibrium temperature for our sample our planets.

References

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