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Interrelated main-sequence MLR, MRR, MTR relations from planet hosting stars

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Abstract. In this study, we investigated the interrelated mass-luminosity, mass-radius, and mass-temperature relations of planet-hosting stars. The sample, which is chosen to be main-sequence systems, is divided into two metallicity regimes: one regime is below the average of all samples (z=0.017) and the other above it. Suitable figures represent the comparisons of each distinct metallicity regime.

Key words: stars:fundamental parameters – stars:host stars

1. Introduction

Understanding the relationships between stellar mass, luminosity, radius, and temperature is fundamental to the study of stellar astrophysics. These interrelated properties are particularly important for main-sequence stars, which constitute the majority of stars in our galaxy and are key targets in the search for exoplanets. Our previous work (Eker et al., 2018) on this topic has garnered significant attention, as evidenced by the diverse range of papers citing our research.

In this study, we focus on a carefully selected sample of main-sequence stars known to host planets. This sample provides a robust basis for examining the Mass-Luminosity, Mass-Radius, and Mass-Temperature relations for two metallicity regimes. Our dataset includes 856 host stars, whose physical parameters are obtained from the NASA Exoplanet Archive, representing a larger sample than that used in Eker et al. (2018), which was based on the components of double-lined detached eclipsing binaries.

2. MLR

We derive the MLR for planet-hosting stars with different metallicities. Using our sample, we generate mass-luminosity diagrams and fit functions for two distinct metallicity values. The results illustrate how metallicity influences the MLR, with higher metallicity stars generally showing different luminosity levels at the same mass compared to their lower metallicity counterparts. In Fig. 1, mass-luminosity data in our sample is shown with two metallicity values, which are shown in grey and black for z<0.017 and z>0.017, respectively. The metallicity value of z=0.017 is the average metallicity of the sample used in this study. The mass regimes are shown with vertical lines in the figure.

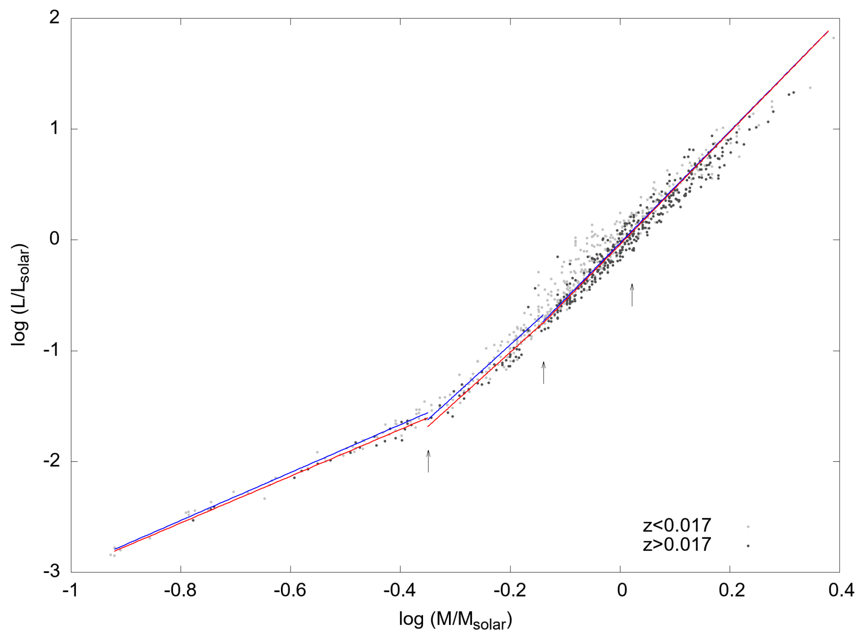
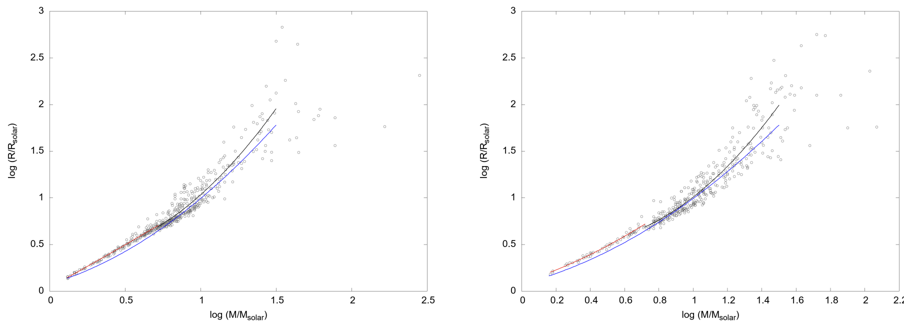


Figure 1. MLR from planet-hosting stars with different metallicities.

3. MRR

By understanding how a star's mass correlates with its radius, we can infer key properties of stars and their planetary systems. The MRR aids in determining the physical characteristics of exoplanets when the host star's parameters are known, allowing for more accurate modelling of planetary sizes and composi-



(a) Lower metallicity (z<0.017) (b) Higher metallicity (z>0.017)

Figure 2. Mass-radius relation (MRR) for planet-hosting stars with different metallicity regimes.

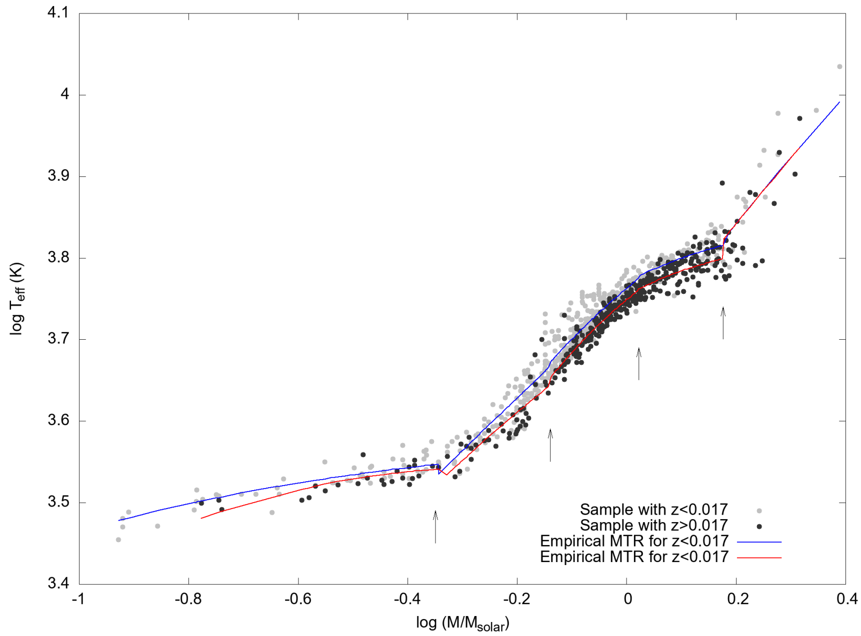


Figure 3. MTR from planet-hosting stars with lower (z<0.017) metallicity (grey data, blue model) and higher (z>0.017) metallicity (black data, red model).

tions. In our analysis, we derive the MRR for our sample of planet-hosting stars. The mass-radius diagrams presented in Fig. 2 show the fitted functions for stars with two different metallicity values. These functions illustrate how metallicity impacts the radius for a given stellar mass, providing insights into the structural differences and evolution of stars with varying compositions. The detailed mass-radius diagrams emphasize the need to account for metallicity when applying the MRR in exoplanet research and cluster studies.

4. MTR

By examining how stellar mass correlates with effective temperature, we can infer key characteristics of stars and their potential to host planets. In this study, we derive the MTR for our sample of planet-hosting stars. The mass-temperature diagrams presented in Fig. 3 illustrate the relationships between stellar mass and effective temperature, with fitted functions accounting for two distinct metallicity values. These functions reveal how metallicity influences the effective temperature for a given stellar mass, shedding light on the variations in stellar atmospheres and evolutionary pathways. The detailed mass-temperature diagrams emphasize the need to consider metallicity when applying the MTR, as it affects the star's temperature and, consequently, the interpretation of observational data.

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References

Eker Z., Bakış V., Bilir S., Soydugan F., Steer I., Soydugan E., Bakış H., et al., 2018, Monthly Notices of the RAS, 479, 5491. doi:10.1093/mnras/sty1834