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Analysing The Distinctive Properties of Stars and Exoplanets.

Abstract

The angular momentum of stars and their planetary systems provides critical insights into stellar structure, rotational history, and star–planet interactions. Using observational data, we analysed the relationships between stellar angular momentum, mass, and radius for G-type main-sequence stars and evolved counterparts (subgiants and giants), separating the samples into single-planetary and multi-planetary systems. For main-sequence stars, angular momentum exhibits a clear positive correlation with stellar mass and radius, consistent with theoretical expectations from J\sim MRˆ2\mathrm{\Omega}. Multi-planet hosts display relatively tight scaling relations, whereas single-planet hosts reveal increased scatter, plausibly linked to tidal interactions with close-in massive planets. Evolved G-type stars demonstrate steeper angular momentum–mass relation and stronger dependence on stellar radius, with least-squares fits showing higher predictive power for radius than mass. These results indicate that envelope expansion during post-main-sequence evolution dominates angular momentum storage, while residual scatter reflects mass loss, magnetic braking, and differential rotation. Comparisons between single- and multi-planet systems suggest that tidal spin–orbit coupling is more significant in single-planet hosts, particularly in evolved systems where stellar envelopes are extended. Overall, the study emphasizes that stellar angular momentum is best described by a two-parameter scaling law involving both mass and radius, with planetary architecture further modulating the degree of scatter.

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