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Surveying Nearby M dwarfs with Gaia: A Treasure Trove for Exoplanet Astrophysics

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Abstract

Cool, nearby M dwarfs within a few tens of parsecs from the Sun are today becoming the focus of dedicated experiments in the realm of exoplanets astrophysics. This is due to the shift in theoretical paradigms in light of new observations, and thanks to the improved understanding of the observational opportunities for planet detection and characterization provided by this sample.

Gaia, in its all-sky survey, will deliver precision astrometry for a magnitude-limited (V=20) sample of M dwarfs in the vicinity of the Sun, providing an inventory of cool nearby stars with a much higher degree of completeness (particularly for late sub-types) with respect to currently available catalogs.

We gauge the Gaia potential for precision astrometry of exoplanets orbiting a sample of actual M stars within 30 pc from the Sun. The stellar reservoir is carefully selected based on cross-correlation among catalogs in the literature (e.g., Lepine, PMSU). We express Gaia sensitivity thresholds as a function of system parameters and in view of the latest mission profile, including the most up-to-date astrometric error model. The simulations also provide insight on the capability of high-precision astrometry to reconstruct the underlying orbital elements and mass distributions of the generated companions.

We investigate the synergy between the Gaia data on nearby M dwarfs and other ground-based and spaceborne programs for planet detection and characterization, with a particular focus on: a) the improvements in the determination of transiting planet parameters thanks to the exquisitely precise stellar distances determined by Gaia; b) the betterment in orbit modeling when Gaia astrometry and precision radial-velocities are available for the same targets; and c) the ability of Gaia to carefully predict the ephemerides of detected (transiting and non-transiting) planets around M stars, for the purpose of spectroscopic characterization of their atmospheres with dedicated observatories in space, such as EChO.