High fluid-Rossby in the Kepler field: Promising candidates for anti-solar differential rotation

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Abstract

Anti-solar differential rotation (DR) profiles are characterized by a slow equator and fast rotating poles (reversed with respect to the Sun). They have been reported in numerous 3D numerical simulations over the last decades for slowly rotating solar-like models experiencing high Rossby numbers. However, unambiguous observation of anti-solar DR profiles is still pending for solar-type stars on the main-sequence, although it has been reported for later evolutionary stages.
During their main-sequence, stars spin-down, which increases their Rossby number and could induce a transition toward an anti-solar DR state. Such a rotational transition would have an impact on the large-scale dynamo process, activity and angular momentum evolution for old solar-type stars.

We show in this work the development of a new theoretical formula in order to estimate the effective fluid Rossby number Rof of solar-type stars. We express it as a function of observational quantities such as Teff and Prot, while considering several aspects, such as structure, evolutionary stage, and metallicity. We then quantify the fluid Rossby number of the most recent Kepler catalog of rotational periods by Santos et al. (2019, 2021).
After sanity checks, we obtain 22 targets experiencing high Rossby numbers and being promising candidates to host anti-solar differential rotation. The method can then be applied to future PLATO observations in order to extend this sample, whose future characterization would increase our understanding of magnetic and rotational evolution of solar-type stars. For that purpose, the formula we developed here will be implemented in the mission analysis pipeline.

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