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Towards theoretical modeling of planet-induced stellar activity using A.I.K.E.F. simulations

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Plasma flows and turbulences in stellar atmospheres and chromospheres can be disturbed by the presence of a planet in close orbit around the star. Such disturbances can be generated through tidal interactions between the two, or through direct magnetic interaction between the magnetic fields of the star and the planet. The presence of an outer disturber and its influence on the generation of stellar activity, together with the knowledge about stars with no close planets, provide a unique laboratory for the investigation of plasma turbulence in stellar atmospheres. In this work we develop an integrated model covering the star and the planet as an interacting system where gravitational and electromagnetic forces are implemented self-consistently. The model is based on A.I.K.E.F. hybrid code for simulating stellar wind interaction with astronomical bodies. Compared to previous studies, the solar wind is no longer modeled as inflow/outflow boundary conditions, but created instead by a second body representing a star inside the simulation domain. The incorporation of the star is carried out based on Parker (1952) model for slow rotating stars with moderate stellar magnetic fields or on the sophisticated stellar wind model of Weber and Davis (1967) for fast rotators with strong stellar magnetic fields. Such an approach is not without scaling constraints, which will be discussed in this paper. Here, we present the first results for a configuration where the planet is within the star's Alfvén radius, i.e., where the stellar wind flow velocity is subcritical. In this case, the resulting current system is extended and may even propagate against the inflowing stellar wind with possible consequences for the stellar activity.