EPSC Abstracts
Vol. 12, EPSC2018-532, 2018
European Planetary Science Congress 2018


# Do magnetic fields modify tidal dissipation in the convective envelope of low-mass stars along their evolution?

**Aurélie Astoul** (1,2), Stéphane Mathis (1), Clément Baruteau (2), Antoine Strugarek (1), Emeline Bolmont (1), Florian Gallet (3), Kyle Augustson (1)

(1) Laboratoire AIM Paris-Saclay, CEA/DRF - CNRS - Univ. Paris Diderot - IRFU/DAp, Centre de Saclay, 91191, Gif-sur-Yvette Cedex, France; (2) IRAP, Université de Toulouse, CNRS, UPS, Toulouse, France; (3) Université Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France (aurélie.astoul@cea.fr)

## Abstract

The dissipation of the kinetic energy of large-scale and wave-like tidal flows within the convective envelope of low-mass stars is one of the key physical mechanisms that shape the orbital and rotational dynamics of short-period exo-planetary systems. In the case of stable binary systems, they lead to the orbit circularisation and to the spins synchronisation and alignment; in the case of unstable systems they drive the spiraling of the planet towards the central star.

In addition, stellar convective envelopes are (differentially) rotating, turbulent, and magnetized regions where an active dynamo action is sustained (e.g. Brun & Browning 2017 and references therein). Therefore, as demonstrated by first theoretical works and numerical simulations, tidal flows and waves excitation, propagation, and dissipation can be impacted by stellar magnetic fields (e.g. Wei 2017, Lin & Ogilvie 2018, Wei 2018). For instance, the so-called dynamical tide is constituted of magneto-inertial waves (their restoring forces being the Lorentz force and the Coriolis acceleration) instead of inertial waves in the non-magnetized case. In the meanwhile, the amplitude and the geometry of dynamo-generated magnetic fields vary along the evolution of low-mass stars (e.g. Vidotto et al. 2014, Brun & Browning 2017 and references therein). In this framework, the key question that should be answered is "for which stellar masses, rotation and evolution phases, do we need to take into account the action of magnetic fields on tidal waves excitation, propagation, and dissipation?".

In this work, we identify the terms in MHD equations that should be computed to evaluate the impact of magnetic fields on tidal dissipation in the convective envelope of active rotating low-mass stars hosting planets. Using scaling laws that provide the amplitude of dynamo-generated magnetic fields along the structural and rotational evolution of these stars (e.g. Augustson, Mathis & Brun 2016) combined with detailed grids of rotating stellar models (e.g. Amard et al. 2016), we demonstrate that a full MHD treatment of tidal waves excitation, propagation, and dissipation is required for all low-mass stars (from M to F-type stars) all along their evolution. Consequences for the dynamical evolution of short-period exoplanetary systems are finally discussed.

## Acknowledgements

A. A., S. M., E. B., and K. A. acknowledge funding by the European Research Council through ERC grant SPIRE 647383. F.G acknowledges financial support from CNES and the Swiss National Science Foundation (FNS) and from the SEFRI project C.140049 under COST Action TD 1308 Origins. This work was also supported by the Programme National de Planétologie (CNRS/INSU), the Programme National de Physique Stellaire PNPS (CNRS/INSU), and PLATO CNES grants at Départment d'Astrophysique (CEA-Saclay) and IRAP.

## References

[1] Brun A.-S., Browning M. K., Living Reviews in Solar Physics, Vol. 14, 4, 2017.

[2] Wei X., The Astrophysical Journal, Vol. 828, 30, 2016.

[3] Lin Y., Ogilvie G., Monthly Notices of the Royal Astronomical Society, Vol. 474, p.1644-1656, 2018.

[4] Wei X., The Astrophysical Journal, Vol. 854, 34, 2018.

[5] Vidotto A., et al., Monthly Notices of the Royal Astronomical Society, Vol. 441, p. 2361-2374, 2014.

[6] Augustson K., Mathis S., Brun A.-S., The 19th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun (CS19) proceedings, 152, 2016.

[7] Amard, L., Palacios, A., Charbonnel, C., Gallet, F., Bouvier, J., Astronomy & Astrophysics, Vol. 587, 105, 2016.