# The HADES Program with HARPS-N@TNG
# HADES: THE HArps-n red Dwarf Exoplanet Survey

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Many efforts to detect Earth-like planets around low-mass stars are currently devoted to almost every extra-solar planet search. M dwarfs stand as ideal targets for Doppler radial velocity searches as their low masses and luminosities make low-mass planets orbiting within their habitable zones more easily detectable than those around higher-mass stars. Nonetheless, the statistics of the frequency of this kind of planet hosted by low-mass stars remains poorly constrained.

Our M-dwarf radial velocity monitoring with HARPS-N within the HARPS-N Red Dwarf Exoplanet Survey Radial Velocity (HADES) project started in 2012 and is contributing to the widening of the current statistics through the in-depth analysis of accurate radial velocity observations in a narrow range of spectral subtypes from M0 to M3, to investigate the planetary population around a well-defined class of host stars.

The HADES project is the result of a collaborative effort between the Italian Global Architecture of Planetary Systems (GAPS) Consortium, the Institut de Ciències de l'Espai de Catalunya (ICE), and the Instituto de Astrofísica de Canarias (IAC).

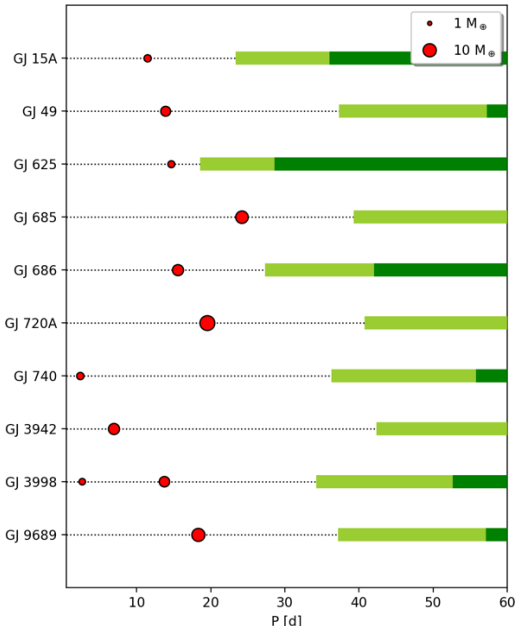


**Figure 1:** Overview of the HADES detected planetary systems.The sample's published planets are shown as red circles: the symbol size is proportional to the minimum planetary mass. Each system's Habitable Zone conservative and optimistic limits, are shown as thick dark green and light green bands, respectively (from [3]).

Two photometric programs regularly and almost simultaneously follow up the sample of M stars to characterize the stellar activity, to highlight periods that are due to chromospheric inhomogeneities modulated by stellar rotation and differential rotation, and thus to distinguish from the periodic signals those due to activity and to the presence of planetary companions.

We present the complete analysis of the HADES survey and the results obtained concerning the statistical ([1], [2], [3]), activity ([4], [5], [6]), and characterization ([7], [8]) part as well as the planet revealing part ([9] to [18]), around M dwarfs.

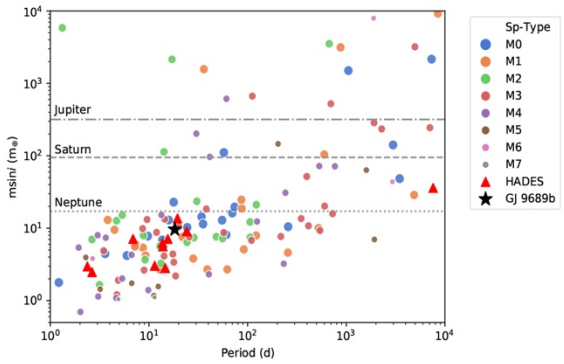


**Figure 1:** Known radial velocity planets (planetary mass vs. orbital period diagram) around M dwarfs (as listed at http://exoplanet.eu/ in December 2020. Planets discovered by the HADES survey are shown as red triangles (from [18], the planet GJ 9689 is shown as a black star).

## References:

[1] M. Perger et al. (2017) *A&A*, Volume 598, id.A26. [2] E. González-Álvarez et al. (2019) *A&A*, Volume 624, id.A27. [3] M. Pinamonti. et al. (2022) *A&A,* Volume 664, id.A65. [4] J. Maldonado et al. (2017) *A&A*, Volume 598, id.A27. [5] G. Scandariato et al. (2017 *A&A*, Volume 598, id.A28. [6] A. Suárez Mascareño et al. (2018) *A&A*, Volume 612, id.A89. [7] J. Maldonado et al. (2015) A&A, Volume 577, id.A132. [8] J. Maldonado et al. (2020) *A&A*, Volume 644, id.A68. [9] L. Affer et al. (2016) *A&A*, Volume 593, id.A117. [10] A. Suárez Mascareño et al. (2017) *A&A*, Volume 605, id.A92. [11] M. Perger et al. (2017) *A&A*, Volume 608, id.A63. [12] M. Pinamonti et al. (2018) *A&A*, Volume 617, id.A104 [13] L. Affer et al. (2019) *A&A*, Volume 622, id.A193. [14] M. Perger et al. (2019) *A&A*, Volume 624, id.A123. [15] M. Pinamonti et al. (2019) *A&A*, Volume 625, id.A126. [16] B. Toledo-Padrón et al. (2021) *A&A*, Volume 648, id.A20. [17] E. González-Álvarez et al. (2019) *A&A*, Volume 649, id.A157. [18] J. Maldonado et al. (2021) *A&A,* Volume 651, id.A93.