1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title: Star-planet interactions in evolved planetary systems.

1.1. Project goals

This project aims at detection and detailed characterisation of planetary systems undergoing significant star-planet interaction processes or already affected by such interactions. In addition to yet identified dynamical and tidal interactions it is planned to study in more detail stellar wind and magnetic field influence on planets and their environment. The primary targets for this project will be exoplanetary system observed within the Pennsylvania-Toruń Planet Search (PTPS) and Tracking Advanced Planetary Systems with Harps-N (TAPAS) projects, i.e. matured systems around evolved solar-type stars. Several new examples of evolved planetary systems will be delivered within this project. Detailed analysis of individual systems as well as an attempt to present a wider perspective on the star-planet interactions in evolved planetary systems are the goals of this project.

1.2. Outline

The first planets orbiting other stars were discovered over 30 years ago. Massive exoplanet searches launched since then resulted in detections of thousands of such objects. These research projects revealed a vast variety of exoplanetary system architectures and a multitude of exoplanet types, including unobserved in our Solar System Hot Jupiters, Super Earths, Hot Neptunes, and others. Statistical analysis of exoplanet detections so far with different techniques (radial velocity measurements, planetary transits, gravitational microlensing) show, that planets are common, most stars host some kind of planets. As stars evolve their characteristics change: they lose mass, vary significantly in size and luminosity, alter structure of their magnetic fields. All those processes affect the planetary systems they host, and lead to a variety of new, not yet well understand phenomena – star-planet interactions.

Proposed project will be based on existing spectroscopic observations of stars from PTPS for which radial velocity measurements obtained with the Hobby-Eberly Telescope resulted in detection of over 30 low-mass, planetary companions already. These observations will be supported with TAPAS observations and, if necessary, with additional observations from other instruments. This project will deliver new detections. For selected objects detailed three-dimensional (3D) magnetohydrodynamic simulations of the interactions between the magnetised stellar winds and planetary magnetospheres are planned. Follow-up observations of selected targets in search of evidences of star planet interactions including radio wavelengths are also planned as at this wavelength range magnetised stellar wind interactions with planetary magnetospheres are expected to provide information that is difficult to attain at other wavelengths.

This project will deliver a tailored analysis of star-planet interactions in several newly detected extrasolar systems based on existing and new observations. We expect the resulting PhD Thesis to be based on three refereed journal publications.

1.3. Work plan

Three stages of this project are foreseen. In stage one new evolved planetary systems from PTPS/ TAPAS will be presented based on existing unpublished data, and published. Next, additional multi-wavelength data will be collected in search of evidences of star-planet interactions for selected systems. Finally MHD modelling of individual systems will be presented, and published.

1.4. Literature *(max. 7 listed, as a suggestion for a PhD candidate preliminary study)*

Lau, R., M. et al. (2025) **Revealing a Main-sequence Star that Consumed a Planet with JWST**, The Astrophysical Journal, Volume 983, Issue 2, id.87, 17 pp.

Callingham, J. R. Et al. (2024) **Radio signatures of star-planet interactions, exoplanets and space weather**, Nature Astronomy, Volume 8, p. 1359-1372

Maciejewski, G., Niedzielski, A. et al. (2024) **Tracking Advanced Planetary Systems (TAPAS) with HARPS-N. VIII. A wide-orbit planetary companion in the hot-Jupiter system HD 118203**, Astronomy & Astrophysics, Volume 688, id.A172, 13 pp.

Deka-Szymankiewicz, B., Niedzielski, A. Et al. (2018) **The Penn State - Toruń Centre for Astronomy Planet Search stars. IV. Dwarfs and the complete sample**, Astronomy & Astrophysics, Volume 615, id.A31, 11 pp.

O'Gorman, E. Et al. (2018) **A search for radio emission from exoplanets around evolved stars**, Astronomy & Astrophysics, Volume 612, id.A52, 9 pp.

Hans J. Deeg and Juan Antonio Belmonte eds. (Springer 2025) Handbook of Exoplanets**, Section IX Planets and Their Stars: Interactions.**

1.5. Required initial knowledge and skills of the PhD candidate

Knowledge: MSc in astronomy. English level B2 minimum.
Skills: Unix/Linux/MacOS system, Python programming, experience with PLUTO simulations.

1.6. Expected development of the PhD candidate's knowledge and skills

The PhD candidate is expected to become an expert in the field of multi-wavelength observations of planetary systems and state-of-art modelling of star-planet interactions.