

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

Project title: Study of outbursts and superoutbursts of dwarf novae cataclysmic variable stars based on observations provided by ground-base and satellite instruments.

1.1 Project goals

The main goal of this project is the study of cataclysmic variables (in particular dwarf novae stars) in quiescence and during outbursts and superoutbursts. Based on photometric observations, it will be possible to estimate the orbital parameters of selected objects and this will give us a better understanding of the evolution of close binary systems with accretion mass transfer. The study of accretion disk structures will allow us to evaluate proposed models describing mechanisms responsible for the activity of cataclysmic variable stars. The project aims to:

- Long-term observations on the 0.6-meter and 0.9-meter telescopes located in the Piwnice Observatory, and in the Polish Astrophysical Observatory Cerro Murphy located in Chile. Investigation of data provided by satellites (i.e. the TESS mission).
- Based on the comprehensive analysis of cataclysmic variables of dwarf novae type during their outbursts, superoutbursts and quiescence, we will be able to verify the theory describing accretion disks and mechanisms responsible for the activity of cataclysmic variable stars and other accreting systems.

1.2 Outline

Cataclysmic variable stars are close binary systems containing a white dwarf (the primary) and a main sequence star (the secondary). In that system, the matter flows from the secondary to the primary component through the inner Lagrangian point L1 inside the Roche lobe (more in [1]). Due to non-zero momentum, the matter does not hit the white dwarf directly but creates an accretion disk or columns around the primary component. The hot spot is the place where the matter hits the accretion disk. Dwarf novae are the subclass of the cataclysmic binary systems, and in their light curves, we can observe outbursts and superoutbursts. Superoutbursts are about one magnitude brighter and last longer than typical outbursts. During superoutbursts, there are periodic tooth-shaped oscillations called superhumps. The time between outbursts and superoutbursts, when the amount of light observed in the light curves is approximately the same, is called quiescence. The TTI model, proposed by Y.Osaki [2], describes the mechanism responsible for outbursts, superoutbursts and superhumps. Lately, there has been a discussion about the validity of the TTI model (see [3] and [4]). Also, the origin of the superhumps observed in cataclysmic variables and X-ray binaries is, contrary to the common opinion, still unknown [5]. Hence, the proposed project has a key role in our understanding of the physics of accretion onto compact objects.

1.3 Work Photometric observations on small and medium size telescopes (in particular, on the instruments)

- Observations on small and medium size telescopes (in particular, on the instruments located in the Piwnice Observatory)
- Reduction, calibration and analysis of collected data
- Estimation of physical and orbital parameters of cataclysmic variables.
- Verification of the existing models describing mechanisms responsible for activity of cataclysmic variables

1.4 Literature (max. 10 listed, as a suggestion for a PhD candidate)

[1] Hellier C., "Cataclysmic Variable Stars", Springer, 2001.

[2] Osaki Y., 1996, PASP, 108, 39.

[3] Schreiber M.R., Lasota J.-P., 2007, A&A, 473.

[4] Smak J., 2009, Acta Astron., 59, 121.

[5] Lasota, J.P., "Highlights of the Compact Objects Sciences in the Last Decade", IU Press, 2023.

1.5 Required initial knowledge and skills of the PhD candidate

- Experience in observations on small and medium-size telescopes
- Good knowledge of the software which is used in the Piwnice Observatory to conduct
- and to calibrate observations
- Good programming skills (preferably python)

1.6 Expected development of the PhD candidate's knowledge and skills Data processing of photometric and spectroscopic data from miscellaneous instruments

- Data processing of observational data from miscellaneous instruments
- Good knowledge of close binary stars
- Broad knowledge of cataclysmic variable stars and their properties