Abstract of the PhD dissertation of MSE Rafał Pawłaszek

“Towards automated spectroscopic and photometric survey of eclipsing binaries with the network of robotic telescopes SOLARIS”

It was John Goodricke who was the first to suggest the phenomenon of eclipsing the light of one star by another to explain the effect of changes in light curve in the observations of β Persei in 1783. However, the term *double star* was coined by William Hershel, when he observed a visual binary, that is when on a photographic plate two stars had been resolved. Further history leads to the year 1889, when Edward Pickering started the research of tight binary star systems, which stemmed from a spectroscopic observation of a surprising behaviour of spectral lines of the star Mizar. These lines had been not only changing their position in the spectrum, but sometimes became double. Later, Carl Vogel, explaining the nature of the movement, coined the term spectroscopic binary system. The first observed system, however, that was not only a double, which manifested itself in the movement and separation of spectral lines, but also eclipsing, which in turn was visible during the photometric observations as a temporary decrease of brightness, was β Aurigae, discovered by Joel Stebbins in 1911.

Since then the research of eclipsing binary stars has been ongoing. Such systems are the foundation of current stellar and galactic astrophysics. This is since relying solely on photometric and spectroscopic observations we can determine the basic parameters of the stars and carry out a wide range of tests on the structure, dynamics and evolution of stars in general. Henry Russell even called it *the royal road of stellar astrophysics*.

From this group of stars, a very interesting subgroup is formed of detached eclipsing binaries (DEBs). A system is detached, if the distance between the components allows for the assumption that there had been no matter exchange in the system. This in turn allows to assume that the evolution of stars in the system can be considered as the evolution of single stars. Now, however, the number of precisely characterized DEBs is around 200. Why is it so?

In the last broad review in 2010 the results of an analysis of several decades of observations for a group of 94 systems was presented. Given that the periods of the binaries in the review are mostly below 10 days, it is straightforward to conclude that the effectiveness of the survey was limited by the availability of the instrument, observer and weather conditions.

This, in fact, is the premise of the project SOLARIS, in general, and the work of the author as a member of the project. Although SOLARIS is scientific in nature, it was realized early in the design phase that it would be very technical in execution. It seems always true that entering new domains one should expect unexpected and to reach for the aim must overcome hurdles that emerge on the way. Moreover, there are new possibilities appearing which may enhance the preliminary idea but will add to the tasks’ pool. It is always difficult to include them, but we are explorers and new things call us.

Project SOLARIS started as a photometric survey. In 2013, however, the BACHES spectrograph was introduced to the project with the promise of simultaneous photometric and spectroscopic survey execution by the system that would provide radial velocities to the light curves and by this - extend the currently small number of precisely analysed DEBs.

The dissertation is a story of the endeavour to set up SOLARIS as an automated photometric and spectroscopic survey of eclipsing binaries to allow for continuous provision of precisely-analysed systems pursuing the royal road of stellar astrophysics and ultimately - increase our understanding of the Universe. The focus is on the spectroscopic observations and inclusion of BACHES-equipped SOLARIS-1 telescope as an enhancement of SOLARIS

The current goal of the project is to become a fully automated project performing both photometric and spectroscopic survey of eclipsing binary systems and quest for enabling ~ 20 new systems to be described annually. A note has to be made that as the photometric survey aims at providing high-quality (with the errors of ~ 1 mmag data its spectroscopic counterpart would not reach the ms^{-1} precision yet has proven to produce results of few $km\ s^{-1}$ which results in mass precision of ~3% and this publication shows that in favourable conditions it can be brought down even to $\sim 1\%$. Nevertheless, for the most interesting and demanding cases the approach with the photometric and spectroscopic survey would be obtaining time on large-aperture telescopes and high-resolution spectrographs to bring the precision in both masses and radii to $\sim 1\%$ or below.

The author took part in physical assembly and maintenance of the SOLARIS network, has been the core architect and developer of the software solutions for command and control (C2), administering, managing and monitoring of the single nodes as well as the network as a whole; designed and implemented the communication and transfer of the observing results; worked on the metadata and data persistence layer; implemented the necessary parts of the processing pipeline (including the dedicated FITS library as well as precision timing library for the project); and has been the main architect and implementer of the robotic operation of the spectroscopic observations within SOLARIS. In the context of technological establishment of the project the work has been done mainly with Piotr Sybilski and Stanisław Kozłowski. In the scientific discussion, analysis and modelling the author has been working mainly with Krzysztof Hełminiak and Piotr Sybilski.