

The OGLE survey is the most productive project in the history of Polish astronomy and continuously sets the standards for the world astronomical community. Since the beginning in 1992, the OGLE survey has discovered nearly 100 extrasolar planets, 20 thousand microlensing events, but also probed the structures and measured the distances inside our Galaxy and in the nearby galaxies – the Magellanic Clouds. Astronomers from the OGLE survey have also created the largest catalog of variable stars in history, containing one million objects today. Only periodically variable stars have been cataloged, however, as the non-periodic objects are generally much more difficult to study. In this proposal we are going to, in a way, finish and complete the catalog of variable stars by adding to it the non-periodic variables. Having the experience in searching and analyzing variability in distant quasars, that also show non-periodic variability, we are going to search for and analyze the light curves of tens of thousands of non-periodic variable stars. We are going to create the largest in history and also uniform dataset containing such sources. Not only we are going to classify these sources into the known classes of stellar variability, but plausibly we are going to find yet unknown, new classes of variable stars.

There exist many ongoing sky surveys on the surface of the planet Earth and in the outer space, and the new ones are currently built. Since early 2014, the sky has been monitored by the Gaia satellite mission. Two data releases from this project have been publicized and the data have been used by astronomers around the world. Meanwhile, there is a new, the largest survey telescope being built – The Large Synoptic Survey Telescope (LSST), which will start its operations in early 2022. Observations by these two surveys will provide a gigantic data stream for objects that change brightness non-periodically, including distant quasars. We have already created software allowing for simulations of changing brightness in both periodic and non-periodic sources in any sky survey, so we can predict the quality of future data coming from these surveys. We are going to simulate hundreds of thousands of light curves for distant quasars and then analyze them with a number of methods within our expertise. We will be able to compare the input and output parameters in these light curves. We have already performed such a research for the SDSS survey, where we showed that for a fair fraction of quasars the input and measured parameters differ significantly, while the expectation was they would exactly be the same. Equipped with the knowledge of the existing biases, astronomers are able to correctly measure the variability parameters.

Quasars are objects, where the matter falls onto a super-massive black hole at a galaxy center and forms a very luminous disk of matter. Changes of brightness of this disk, that we observe on Earth with our telescopes as the luminosity changes, depend critically on the black hole mass and the amount of infalling matter. Both these quantities are readily measurable by astronomers these days. On the other hand, to study the relations between the variability and the black hole mass and the infalling matter rate, first we need to correctly characterize the variability. In the proposed project, through simulations of mock light curves with the known input parameters, we will study how well we are going to be able to measure the variability from Gaia and LSST, but also we will identify the origin of plausible biases. Once the genuine Gaia and LSST data are collected in full and public, analyzing quasar variability should be straightforward.

This topic is of high importance, because quasars are distant and very luminous objects in the Universe, therefore their studies improve our understanding of its evolution. Due to high luminosity, quasars can be observed from the distant, early Universe. Our understanding of the relations between the luminosity, changes in this luminosity, the black hole mass, and the infall rate of matter, with the availability of the Gaia and LSST data, may be the key to a new distance measure in the Universe. We are going to participate in this quest by providing the methodology to quasar variability studies in these surveys.