Binary stellar systems as a key to understanding Galactic bulge initial mass function

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When we look at the sky on a cloudless night far from artificial lights, we see the beautiful Milky Way. For us, Milky Way looks like a strip of many stars, but in fact, it is a spiral galaxy, in which we reside. Milky Way is also the best-studied spiral galaxy because it is the only one in which we can observe low-mass stars; other spiral galaxies are simply too far away. For a full understanding of the Milky Way structure, it is key to study regions near its center, called bulge, where many stars reside. Astronomers study stars by measuring their brightness, but the most important parameter of a star is its mass, which is hard to be measured directly. Stellar masses can be estimated based on observed brightness, but only if we know the brightness of single stars, i.e., the ones without a stellar companion. Some of the stars are in binary systems. Such systems have been well studied in the Solar neighborhood and we now know that around half of the stars are in binary systems. In the case of low-mass stellar binaries in the Milky Way bulge, we are not able to separate light from each of the components because the stars are too close to one another compared to the resolution of even the largest telescopes. This hinders studies of Milky Way – without studying bulge binary systems we cannot construct models of Milky Way.

The goal of this project is to solve the problem of Milky Way bulge stellarbinaries. We will use the gravitational microlensing technique, which is used by astronomers from the Astronomical Observatory University of Warsaw for many years. Microlensing happens when a distant star, called "source", is aligned on one line with a closer object, called "lens". Then the lens gravity bends the light rays and causes the apparent source brightening. It is important that the brightening depends on lens mass, not brightness. Hence, microlensing can study lenses which are not visible at all or are extremely faint, such as free-floating planets, single black holes, or low-mass stellar binaries. If the lens is a binary system, then microlensing allows us to measure masses of both components, their on-sky separation, and distance from Earth. Hence, microlensing is key to solve the problem of low-mass binary stellar systems in the Milky Way bulge!

We will begin the project by searching for microlensing binaries in the data of the *Optical Gravitational Lensing Experiment* (OGLE) project conducted by the University of Warsaw astronomers. We will combine OGLE data with data from other telescopes to study each lens in detail. We will estimate how effective, relative to theoretical predictions, are our observations and searches, which combined with measured parameters will give us an understanding of the population of stellar binaries in the Milky Way bulge. Among the statistics which we will study, the most important ones are: 1) fraction of stars in the bulge that are binary systems, and 2) distribution of components mass ratios – how often binaries have equal-mass components and how often components differ in mass significantly. We will use these results to correct the crucial parameter describing Milky Way: the distribution of stellar masses in the bulge. Additionally, for selected events, we will analyze observations collected using adaptive optics, i.e., the technique which eliminates the impact of Earth's atmosphere on the sharpness of stellar images. These observations will be conducted a few years after the microlensing event took place so that the relative motion of source and lens allows us to see them separately and better estimate the event parameters. We will also design a method to study triple lens event and will use it to study selected events.