Reg. No: 2015/18/M/ST9/00544; Principal Investigator: dr hab. Łukasz Wyrzykowski

Black holes are a fascinating topic for everyone, not only the science fiction literature readers or fans of the ``Interstellar'' movie. The black holes are intriguing because they are mysterious and still all we know about them is just that they attract and consume essentially everything, including the light, hence their name. They are the end-products of the stellar evolution of the most heavy stars with masses larger than dozens of Suns. Life of such stars lasts very short, just a mere few million years, and often ends in a spectacular supernova explosion. What is left after such explosion is the matter which is very densely packed in a very small space. This is the cause of those fascinating and unique properties of black holes, like capturing the light and causing the curvature of the space-time.

There are billions of stars in our Galaxy, therefore there should also be loads of black holes. However, so far only about 30 black holes has been found in the Milky Way and beyond. Moreover, all of them exist in binary systems, where the black hole gradually swallows its stellar companion. However, only thanks to that consuption and released radiation those black holes have been detected. But, so far there has been no discoveries yet of single isolated black holes, as they are completely invisible and do not interact with anything.

Nevertheless, such a lone black hole still affects the space-time due to its mass. The path of light rays of some distant and unrelated star, passing next to a black hole will therefore get slightly bend. An observer on Earth will be able to observe such phenomenon only if located close to the line-of-sight between the distant star and the black hole. But because in our Galaxy everything rotates, such lucky configurations happen from time to time. Still, one needs to keep monitoring very many stars in order to detect one in a few million events of space-time curvature caused by a black hole.

Such event is called gravitational microlensing. Polish astronomer, Bohdan Paczyński, invented this branch of astronomy and suggested that it could be used to detect dark compact objects, for example, black holes or planets. Polish group OGLE (Optical Gravitational Lensing Experiment) from the Warsaw University Astronomical Observatory, for last 20 years has been exploiting this method to find thousands of such events every year and has already used it to discover numerous extrasolar planets. However, it was still impossible to recognise, which of the microlensing events was caused by a single black hole. This is caused by an imperfection of the ground-based observations. The lensing works such that the distant star gets split into two images, but they can not be separated and what is observed is just the sum of their light. This causes the brightenning of the distant star, however, the separation between the images is the missing bit of information we require in order to measure the mass and distance of the lens.

Space mission Gaia, launched by the European Space Agency (ESA), will be capable of measuring the subtle offsets caused by the movement of the two lensed images, hence it will be for the first time possible to extract the information about their separation. Once combined with the ground-based continuous observations from OGLE, such data can directly tell how far is the lens and how heavy it is. The black hole lenses tend to cause larger separations, hence they will be even easier to find among other microlensing events and to measure. Once detected, such single black holes will for the first time provide crucial insight into the mass distribution of the end-products of the stellar evolution and will help solve the discrepancies between theoretical predictions and observations.