POLITBH

Everyone must have heard about black holes, either seen them in science-fiction movies or read about them in Stephen Hawking's books. The idea of a black hole is quite old — scientists were predicting that if a large mass is enclosed within a small volume, the gravity of such object will be so strong that it will stop the light itself. First black holes were found as emitters of X-rays detected with space observatories. Their radiation comes from the fact that these black holes have stellar companions, regular stars, which are consumed slowly by the black holes. Very different black holes were detected in 2015 in gravitational waves. These were two massive black holes found in the process of merging into even more massive black hole. Therefore, there is no doubt black holes do exist. Theories of stellar evolution predict that at the end of life of massive stars black holes are being formed and therefore there should be millions of black holes floating around. However, there is only a small few dozens known in our own Galaxy! Where is the rest? What are they masses? Are there black holes in the Milky Way which are as massive as these found with gravitational waves?

How can we find a single black black hole, which has no companion? Our method uses the fact that a black hole bends the space-time in such way that the light of a distant background star aligned behind the black hole, travels on a different trajectory. Such effect is tiny, but can be detected and is called gravitational microlensing. It was proposed by Polish astronomer, Bohdan Paczynski in the eighties last century and since then has been used to discover objects which do not shine, including planets and black holes. The Polish project OGLE has been observing the densest parts of the sky towards the Galactic Centre for 25 years and has successfully found already thousands of microlensing events, including dozens of planets.

However, it is much more difficult to distinguish black hole lens from a regular star lens. Despite thousands of events detected we still do not know which ones are due to black holes and so far only have a mere few candidates! This is because a fast moving black hole will look exactly the same in our data as a slowly moving star. Without additional information it will be impossible to distinguish the two cases. Such data, however, will be provided by the European space mission, Gaia, operating since 2014 and observing the entire sky in order to measure distances and motions of a billion stars in the Galaxy. On the other hand, Gaia data alone will not suffice to discover black holes. Therefore, in this project we propose to organize a large observing campaign for all microlensing events for which Gaia data will be available in order to collect a complete picture of black holes population in the Milky Way.

Lensing occurs more frequently in places where there is many background stars, where each can act as source of light bend by the mass of a black hole. Therefore, it is the best to look for microlensing events towards the Milky Way stars. The events occurring in the Galactic Disk (part of the Milky Way away from its centre), are rare (one in 10 million stars), but since the black hole density is similar in all directions, these events are more likely to be due to black holes than due to stars. Hence, if we make sure that all events found in the Disk are well observed both from Gaia and from the ground, we can guarantee to find the first isolated black holes in the Milky Way.

The duration of such events can vary from months to years, therefore we need to make sure there is always a telescope available somewhere on the ground to collect brightness measurements of the event. We need to gather thousands of observations using multiple telescopes, since the weather and clouds are against us. In this project Polish and Lithuanian experienced astronomers will be using their national telescopes as well as telescopes from Europe, Canary Islands, US and Chile, to gather the necessary data. Astronomers from both countries are one of the most experienced observers in Europe, hardened by the harsh and demanding weather. This experienced gained over generations of astronomers will now be used in the international context of a network of observatories, collecting data of the same targets, candidates for lensing black holes.

Involvement of Polish and Lithuanian astronomers in this project will strengthen the collaboration between the countries. It will also allow the researchers to lead the path for more discoveries of black holes in next projects, in particular the enormous Large Synoptic Survey Telescope (LSST), which will start observing in 2023 and might be able to detect hundreds of black holes. Polish and Lithuanian scientists will be able to provide necessary expertise in this field and maintain our strong position in observational astrophysics.