

## **Polish-Lithuanian Black Hole Hunt - Harvest time**

**DAINA project no 610319**

### GENERAL PUBLIC DESCRIPTION

When two black holes collide, they shake space-time and produce gravitational waves (Nobel Prize 2017). When two objects, a black hole and a star, orbit each other on a very tight orbit, they emit energetic X-ray radiation. However, lonely black holes can pass through our Galaxy completely unnoticed. Our picture of the population of black holes and other compact objects is therefore incomplete, as is our understanding of the origin and evolution of black holes and other stellar remnants. Most black holes and neutron stars were born in supernova explosions of massive stars, but some black holes could have been born at the dawn of the Universe from the contractions of dark matter. Discovering new lonely black holes in our Galaxy is essential to help answer questions on their origin, study their properties and address their potential contribution to the long-standing issue of the composition of dark matter.

How can we find lonely black holes? Currently, the only way is by using the gravitational lensing phenomenon. It occurs when a black hole passes in front of a distant star and the light of the star is bent due to the space-time curvature around the black hole. From the observer's point of view, the background star is magnified for a couple of months or years, hence the term gravitational lensing. Lensing events can also be caused by regular stars, which are far more common than black holes. Therefore, we need to study hundreds of millions of stars regularly to detect at least a couple of events which can be attributed to black holes.

However, since gravitational lensing is caused by gravity only, how can we distinguish whether a lensing event occurs due to a star or a black hole? So far thousands of events have been discovered, but only one black hole has been identified using the lensing phenomenon. The reason is that the detection of a star's brightness magnification alone is not enough to measure the mass of the lens. It is also necessary to detect and measure the tiny displacement of the background star caused by lensing. The problem is that this positional change of the background star, even due to a black hole in our Galaxy and several times heavier than the Sun, is still very small and very hard to measure.

The Gaia space mission was designed exactly for such a task. Since 2014 it has been scanning the entire sky and regularly measuring the positions and brightness of almost two billion stars with unprecedented precision. It is only now, however, that its data can be fully explored and investigated, as its superb quality data has become available to members of the Gaia Collaboration. This includes the Polish team of this project and it will be their task to investigate the vast Gaia data.

However, despite the exceptional quality of Gaia data, there are limitations when it comes to lensing events. Often, the distance to the faint source remains unknown, hindering our ability to accurately classify the lens as either a black hole or a star. To address this challenge, supplementary observations of hundreds of candidates identified by Gaia are essential. This is where the expertise of Lithuanian scientists becomes invaluable, as they possess extensive knowledge in both photometric and spectroscopic observations. In this project, we will also exploit the data collected during our previous Daina project (2019-2023) and collect new ones with a global network of telescopes, including telescopes in Poland and Lithuania. Additionally, close collaboration with the broader European Gaia team will further enhance the value of this project within the European astronomical community.

With this groundbreaking project, we anticipate we will find elusive black holes and enigmatic dark objects that have eluded detection until now. With the study of their properties, we will complement the picture of those exotic objects in the Milky Way.