Astrometric microlensing with the extended Gaia space mission.

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Gaia space mission was launched by the European Space Agency in December 2013. Since then it regularly scans the entire sky and measures the positions and brightness of a billion of stars of the Milky Way with an unprecedented accuracy. In April 2018 Gaia has published its first results showing the most accurate 3D map of the Galaxy. Apart from the information about the current position of the stars, the map contained also data allowing us to compute where stars were in the past and where are they going to be in the future. This publication has initiated a revolution in astronomy, since the knowledge about the distances and motion of stars is a crucial piece of information for correct understanding of the observational properties of stars.

However, Gaia mission catalogue published in 2018 was not the final one and, more importantly, was incomplete. It did not contained stars which had their observed regular motion on the sky perturbed by the presence of a massive black hole located near the line-of-sight. Such black hole causes the space-time to curve significantly, hence the light of a distant star travels on a different trajectory. The motion of the black hole causes the background star to brighten for a short while and its observed position on the sky to trace a characteristic yet tiny loop. This effect is called astrometric gravitational microlensing. The size of the astrometric anomaly caused by the presence of a black hole is smaller than the height of an astronaut on the Moon observed from the Earth. However, it is still significant enough to disturb the trajectory of the source and hence the exclusion from the Gaia catalogue.

Within the proposed project the scientists from the Warsaw University Astronomical Observatory will be analysing data collected every day by the Gaia space mission. The mission has been extended and it is planned to operate until at least the end of 2020. During that time the researchers will be searching for subtle anomalies in the astrometric Gaia data, which could signal a passing black hole. So far, here is only about 50 black holes known in the Galaxy, all of them in binary systems with other objects. A small number of known black holes as well as the fact that they have companions causes problems in our understanding of the stellar evolution leading to black holes, especially since there are no black holes observed below the mass of 5 Solar masses. Moreover, recent gravitational wave-detected black holes turned out to be very massive, more than 30 Solar masses, and such heavy ones have not been yet seen in our Galaxy. Are these massive black holes the explanation of the mysterious dark matter, which constitutes almost 25% of the Universe? The astrometric microlensing method applied in this project will help explore a wide range of masses of black holes and will lead to the detection of the very first isolated black holes in the Milky Way.