Microlensing provides a unique opportunity for detecting non-luminous objects. In the rare case where it is possible to measure Einstein ring size theta_E and microlensing parallax pi_E, the mass of the lens can be determined by accurately covering the light curve. However, this requires special circumstances - usually recording the source crossing the caustic. An alternative way is to calculate the size of the Einstein ring by observing the so-called astrometric microlensing, i.e. changes in the position of the light centroid. This effect is much more subtle and more difficult to detect than the photometric part of the phenomenon. Nevertheless, as technology advances in both ground and space observatories, astrometric measurements are becoming feasible, which could lead to a more routine determination of theta_E and, as a consequence, also lens mass. This is particularly important in the context of stellar black holes - according to theoretic predictions from stellar evolution models, there are several hundred million of these peculiar objects in our Galaxy, but so far they were only detected in binary systems. Microlensing is the only method that allows to directly calculate the mass function and spatial distribution of non-luminous single objects in the Milky Way, such as neutron stars or stellar black holes.

In this work, we explore the possibilities of measuring the astrometric microlensing signal, focusing primarily on the Gaia space mission and the Nancy Grace Roman Space Telescope - a planned NASA mission, scheduled to launch in 2027.
We are also considering the possibilities of combining astrometric measurements from space with photometric ground-based observations. This allows for the dense coverage of the light curve, which is necessary for the precise determination of vital parameters, especially the microlensing parallax. We analyse several examples of microlensing events observed in the Gaia mission, for which extensive ground-based photometric campaigns were organised. We also present one of the first astrometric microlensing signals ever detected, found in the preliminary Gaia astrometric time series, collected for the Gaia16aye microlensing event. It allowed for the independent measurement of Einstein's ring and lens mass.

Based on the simulation of the data from space telescopes, as well as the analysis of a few example events observed by the Gaia mission, we conclude that the astrometric microlensing, which was first detected only recently, will significantly increase our knowledge of the Galaxy within the next decade. This process has been initiated by the Gaia space mission, while the Nancy Grace Roman Telescope will completely revolutionise the field and approach to microlensing. Thanks to regular measurements of the Einstein ring, it will be possible to accurately characterise a large part of the lenses, which is important especially for studying the population of stellar remnants, in particular neutron stars and isolated black holes, unavailable with other methods.