Search for lensed QSOs in the OGLE-IV survey

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We present the results of our search for gravitationally lensed quasars in the OGLE survey. We show one best candidate from a 670 square degrees area behind the Magellanic Clouds System. The study of strong lensing time delays serves as a powerful probe in cosmology. The OGLE database provides long time light curves, allowing for a cost-effective way to accurately derive time delays and therefore study the Hubble constant.

1 Introduction

Gravitational lensing is a powerful tool; acting as a natural telescope it can potentially allow astronomical observations to reach smaller and fainter objects than would otherwise be observable (Schneider et al., 1992; Schneider, 2006). In strong lensing a massive foreground galaxy deflects the light from a background object, resulting in multiple images of the distant source. In addition the source is typically magnified by a factor of 10 (e.g. Newton et al., 2011). This provides a wide range of applications of the lensing phenomenon. Strong lenses have been used, for example, to investigate the density profile of lensing galaxies, the evolution of galaxies and the properties of dark energy.

2 QSOs in the OGLE survey

The Magellanic Quasars Survey (MQS) has now increased the number of quasars known behind the Magellanic Clouds by almost an order of magnitude using OGLE-III data (Kozłowski et al., 2011, 2012, 2013). With the advent of OGLE-IV phase it is natural to perform a similar, extensive search of the increased area in the vicinity of the Magellanic System (Kozłowski et al. in prep.) The search was organised as follows:

- locating all objects in the WISE survey fulfiling the mid-IR colours criteria for quasars put forth in Stern et al. (2005) and Assef et al.;
- crossmatching the selected WISE objects with the OGLE database;
- performing a variability analysis of the OGLE objects and isolating the final sample.

Observing about 670 square degrees with $I < 21$ mag we expect less than 10 lensed QSO systems, both doubles and quads (Oguri & Marshall, 2010). We select lensed quasar candidates in the vicinity of QSO candidates found with the above described procedure (search radius < 6 arcsec). The main criteria are: similar variability and $V - I$ colour. We exclude the false positive objects with the difference image analysis.

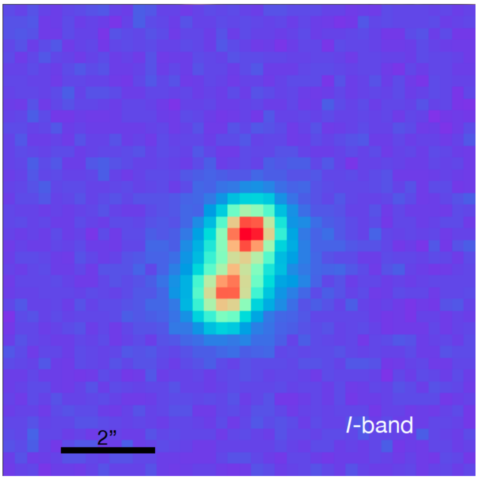

Fig. 1: I-band deep reference image for OGLE-MBR113.23.916

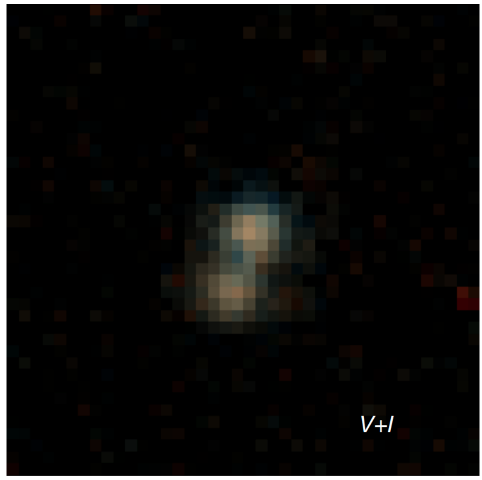

Fig. 2: $V + I$ colour composition for OGLE-MBR113.23.916

3 Candidate

We present our first candidate, OGLE-MBR113.23.916, for a strongly lensed quasar behind the Magellanic Clouds, which consists of two images with the average magnitudes in I-band: the brighter image A – 19.74 mag and the fainter image B – 19.96 mag. Our estimated redshift from fitting the spectral energy distribution is $z \sim$2.2. Under the hypothesis that the lens is midway between the source and the observer its redshift is ∼0.8, which gives the limit for the lensing galaxy brightness that is outside of the OGLE magnitude limits, consistent with the lack of galaxy observation.

3.1 Lens model and time delay

For the current data we can use the simplest model for the lens mass density profile - Singular Isothermal Sphere model. The Einstein radius is approximated by half the image separation (∼0.68 arcsec). The OGLE database provides long time light curves, allowing for a cost-effective way to accurately derive time delays. Strong gravitational lenses with measured time delays between the multiple images and models of the lens mass distribution allow for a estimation of cosmological parameters. We use the publicly available JAVELIN code to study time delays in our candidate systems. This code is based on a damped random walk model to describe quasar light curves and estimate the lags between them (Zu et al., 2013). We obtain the time delay value of 85 ± 5 days.

Final confirmation of this lensed QSO will be possible after obtaining the spectra of both images and/or the lensing galaxy.

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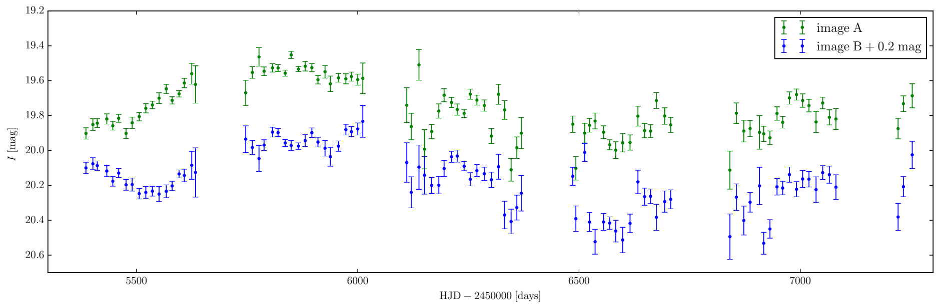

Fig. 3: Light curves in I-band from 6 observational seasons. The image B lags the image A by $\sim$100 days (observer frame).

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