GRAVITATIONAL LENSING OBSERVATIONS OF QUASARS WITH THE 4-m ILMT

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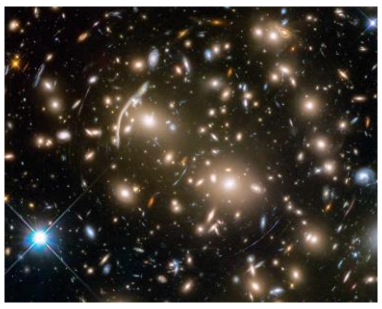
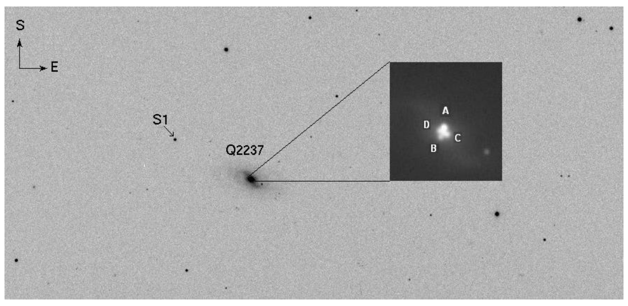
Abstract

Gravitational lensing may enrich our view of the distant Universe and affect our physical understanding of various classes of extragalactic objects. The great interest in gravitational lensing comes from the fact that this phenomenon can be used as an astrophysical and cosmological tool to solve a number of scientific problems. Quasars and gravitationally lensed quasars (GLQs) are of particular interest since they sufficiently probe the deep Universe and can be bright enough to be detected and investigated. But to do this successfully we need to know how many multiply imaged quasars we will be able to detect, how to analyze the observational data, their sensitivity, what problems and challenges await us. In this poster, we try to briefly highlight these points: why GLQs are interesting to us, what objects should we observe, how many of them, etc? According to our last estimations, the number of quasars which may be detected with the ILMT is ~ 6700. So, at least 15 of them should consist of multiply imaged quasars.

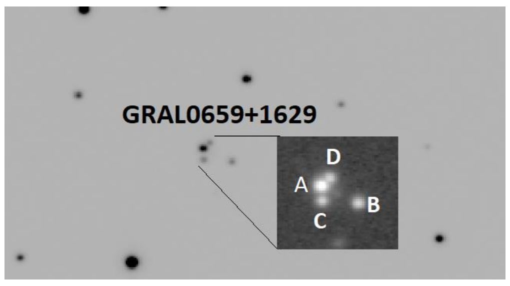
Introduction

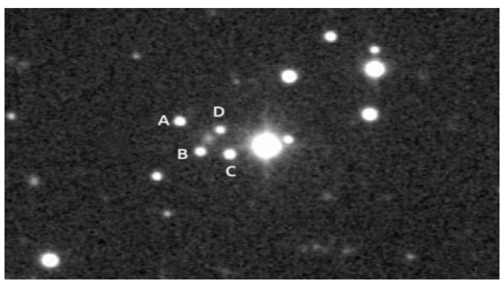
The phenomenon of gravitational lensing based on the deflection of light rays in gravitational field and had been predicted as a consequence of General Relativity. According this theory, the gravitational potential associated with a massive object distort spacetime in its vicinity and gradient of this field is responsible for the angular deflection of the light trajectories. As a result we can see perturbed, distorted, multiply imaged distant sources.

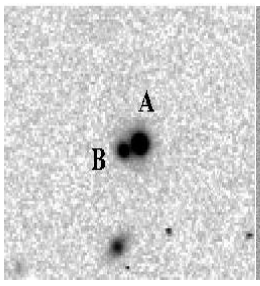


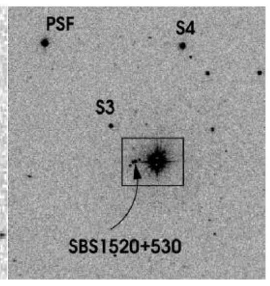


Well known lensing around the Abell 370 galaxy cluster (Photo: NASA, ESA/Hubble) and the Einstein Cross [1].









A few more examples of multiply imaged quasars obtained with the ground-based telescope ATZ-22 at MAO. Top: GRAL0248+1913, GRAL0659+1629. Bottom: GRAL1651-0417, UM673, SBS1520+530. The angular separation between the lensed images ranges between 2" and 10".

Why Gravitational Lensing Is Interesting?

The great interest in gravitational lensing comes from the fact that this phenomenon can be used as an astrophysical and cosmological tool. Indeed, gravitational lensing may help astronomers to solve a number problems [2]:

- an independent determination of the Hubble constant H_0 will result in a better estimate of the distance scale of the Universe and possibly the values of other cosmological parameters (the cosmological density Ω_0 and the cosmological constant λ_0)
- to constrain the mass distribution $M(r)$ of the lens
- to derive the extinction law in the deflector, usually located at high redshift
- to probe the nature and distribution of luminous and dark matter in the Universe
- to investigate the size and structure of quasars, e.g. microlensing-induced variations allow to investigate the structure of the accretion flow around their central supermassive black holes
- to measure the size of absorbing intergalactic gas clouds
- to set upper limits on the density of a cosmological population of massive compact objects

Acknowledgement

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Probable number of GLQs

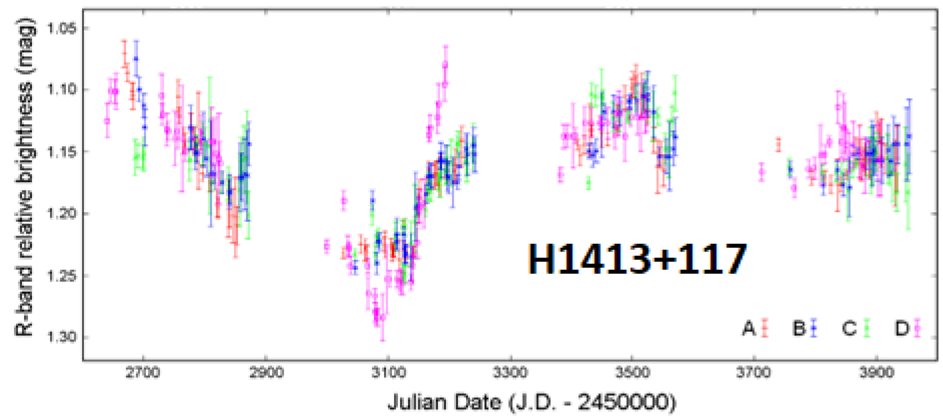
Probable number of quasars and GLQs which can be detected in the field of view of the 4-m ILMT was first derived by Surdej & Claeskens [3,4]. The optical depth τ_q for the formation of multiple lensed images of a quasar at redshift z_q by galaxies distributed along their line-of-sight is given by the relation:

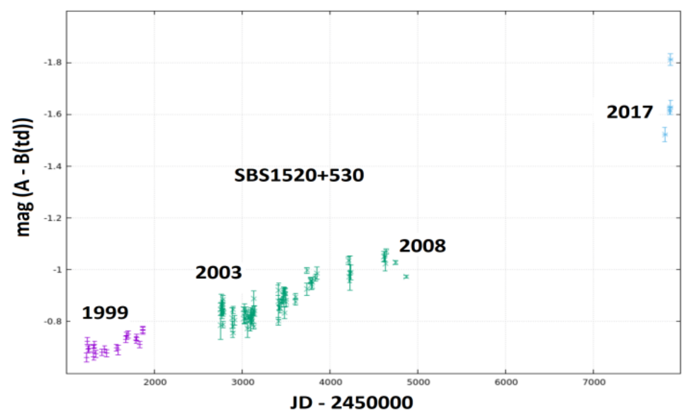
$$\tau_q = \frac{4}{15} F \left(1 - \left(1 + z_q\right)^{-0.5}\right)^3$$

where the parameter F is the effectiveness of the galaxies to produce multiply imaged quasars. So, adopting $F \cong 0.047$, we find $\tau_q = 9.46 \cdot 10^{-4}$ for $z_q = 2$. At that time, it was assumed that the 4-m ILMT would be able to detect about 20,000 quasars and that about 50 of them could be composed of multiple lensed images.
Later these values were re-estimated by Finet [5]. The probable number of quasars was estimated as 9072 and about 22 of them are GLQs. However, more recently, by comparing and cross-correlating various catalogues (Milliquas, Gaia-DR2, etc.), a new estimation of the number of quasars that will fall into the FOV of the 4-m ILMT telescope has been obtained by Mandal et al. [6]. The final quasar catalogue for the ILMT contains 6738 objects, and accordingly the probable number of lensed quasars is about 15. The redshifts of the majority of the lensed quasars are in the range $z_q = [0.5 \div 2.5]$, and their apparent magnitude $G = [18 \div 22.5]^{\mathrm{m}}$ by an estimate using the Sloan magnitudes (g, r or i).

Light Curves: Time Delay and Microlensing

Homogeneous and continuous observational data through the three SDSS filters g, r and i allow us to provide photometric measurements and plot light curves. All available methods of digital photometry will be used to measure the apparent magnitudes of the sources: direct fitting of the PSF, adaptive fitting of the PSF, image deconvolution and restoration, etc. Photometric light curves will allow detect variable sources among them. Correlated variations of brightness of the quasars located close to each other will reveal GLQ candidates. Next we will get precise positions of the sources and lensed images, time delay values, microlensing events.





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