Gravitational lensing studies with the 4-m International Liquid Mirror Telescope (ILMT)

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Abstract. A 4 m International Liquid Mirror Telescope (ILMT) is being built in the north of Chile by an international consortium and will become operational in two years from now. We present here a short description of the telescope as well as estimates of the microlensing, macrolensing and weak lensing effects expected from a deep, multicolor imaging survey made with such a telescope.

1.   What is a Liquid Mirror Telescope?

A Liquid Mirror Telescope (hereafter LMT) consists of a container, filled with mercury, which spins around a vertical axis at a constant speed. Thus, the surface of the reflecting liquid takes the shape of a paraboloid which can be used as the primary mirror of a telescope. By placing a CCD detector at the prime focus of the mirror, one obtains a telescope suitable for astronomical observations. Because an LMT cannot be tilted and hence cannot track like conventional telescopes do, the time delay integration (TDI) technique (also known as drift scan) is used to collect the light of the objects during their transit along the CCD detector. A semi-classical corrector is added in front of the CCD detector in order to provide a larger field of view and to remove the TDI distortion. This distortion arises because the images in the focal plane move at different speeds on distinct curved trajectories while the TDI technique moves the pixels on the CCD at a constant speed along a straight line.

2.   The 4 m ILMT

The 4 m International Liquid Mirror Telescope (ILMT) will be installed in the Atacama desert in Chile and will be fully dedicated to a zenithal direct imaging survey in two broad spectral bands (B and R). The possible construction of an array of several (≥ 2) liquid mirrors, working at different wavelengths, is also being considered. It should allow one to reach limiting magnitudes B = 23.5 and R = 23 in a single scan of a 4096 × 4096 pixels CCD or an equivalent mosaic

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of four 2048×2048 pixels CCDs. The telescope field of view is about 30 x 30 arcminutes and the telescope will be operated during no less than 4-5 years. Thus, very precise photometric and astrometric data will be obtained in the drift scan mode night after night, during several consecutive months each year, for all objects contained in a strip of sky of approximately 140 square degrees, at constant declination. Due to its location in the Atacama desert, both low and high galactic latitude regions will be studied. The low galactic latitudes are propitious to microlensing effects and the high galactic latitudes to observations of macrolensing by galaxies as well as to strong and weak lensing effects induced by galaxy clusters.

3. Gravitational lensing studies

Numerical simulations were carried out to estimate the gravitational lensing effects we can expect from a survey made with a $4\,\mathrm{m}$ LMT.

3.1. Microlensing in the Galaxy

We used a galactic model with 3 components: the halo, the disk and the Galactic bulge. About 50 (resp. 10, 3) microlensing events due to the bulge (resp. the disk, the halo) are expected after one year of ILMT observations at an observing latitude of $-29°$ assuming that the Galaxy is entirely made of 1 $\mathrm{M}_\odot$ dark compact objects.

3.2. Macrolensing

Considering the quasar number counts relation and the optical depth of cosmologically distributed "singular isothermal spherical" galaxies, we expect to detect approximately 50 new multiply imaged quasars.

3.3. Weak lensing

We used a model similar to that described by Nemiroff and Dekel (1989, ApJ, 344, 51) and conclude that in a survey of $100^{°^2}$ with a limiting brightness B_{lim} of 26.5 mag/arcsec^2 or fainter, one can expect at least 50 luminous arcs (axial ratio $A \geq 5$, angular extent $\theta \geq 10°$).

3.4. Monitoring and determination of $\mathbf{H}_0$

The daily monitoring of the 50 new lensed quasars will significantly contribute to a statistical and independent determination of the Hubble constant and to a better understanding of the QSO source structure and of the distribution of dark matter in the Universe, through the analysis of microlensing effects.