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Limits On The Core Radii Of JVAS/CLASS Gravitational Lenses

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Abstract.
Gravitational lenses typically consist of either two or four images (doubles and quads) of the background source. However, it has been shown that gravitational lensing by transparent extended matter distributions should produce an odd number of images. An upper limit for the flux of the missing 'odd image' can be obtained using high sensitivity radio observations, such as 5GHz MERLIN (Multi-Element Radio Linked Interferometer Network) data. Limits on the 'odd image' flux can then be converted into an upper limit on the core radius of the lensing galaxy.

1. Introduction

JVAS/CLASS (Jodrell Bank VLA Astrometric Survey; Patnaik et al. 1992, Cosmic Lens All Sky Survey; Myers et al.1995) is a large survey of 11685 flat-spectrum radio sources ($\alpha < 0.5$ between 1.5GHz and 4.85GHz, where $S_\nu \propto \nu^{-\alpha}$) with the purpose of identifying multiple image gravitational lensing. To date a total of 18 multiple image gravitational lenses have been discovered in the combined JVAS and CLASS surveys. Typically gravitational lenses consist of either two or four images of the background source. However, it has been shown that gravitational lensing by an extended matter distribution produces an odd number of images (Burke 1981). However, the flux of the 'odd image', close to the lens centre, is highly de-magnified and is hard to observe.

Using sensitive radio data of the JVAS & CLASS gravitational lenses it is possible to place upper limits on the flux of the 'odd image' from the rms noise level. This can then be converted into an upper limit on the core radius of the lensing galaxy by numerical modelling, in which the position and magnification of the 'odd image' is calculated as a function of core radius. The mass profile of the lensing galaxy is approximated by a Non-Singular Isothermal Ellipsoid (NSIE;Kormann, Schneider & Bartelmann 1994), whose parameters are obtained by minimising a suitable χ^2 function. The position of the 'odd image' is found by performing a grid search centered on the lensing galaxy confined to the inner critical curve. Limits on the core radii can then be found by repeating the process for a range of core radii.

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2. Data

The data consist of MERLIN 5GHz observations of the 18 confirmed gravitational lenses identified in the JVAS & CLASS surveys. With typical integration times of $\sim$ 12 hours, the data have an rms map noise of 50μJy. An upper limit on the magnification of the 'odd image' can be obtained using an estimate of the background source flux and the $5\sigma_{rms}$ noise level (corresponding to 0.3mJybeam^{-1}).

3. Results and Conclusions

Preliminary results show that the most suitable lens systems for placing constraints on the core radii are doubles, in particular highly asymmetric doubles in which the background source is far from the lens centre. In double lens systems the 'odd image' forms away from the lens centre, where the magnification is higher. For the odd image to remain undetected, a higher central mass density is required. An example of a double lens system with a particularly favourable geometry is B1030+074, in which a core radii upper limit of $0.004\theta_E$ is found (corresponding to a core radius of 20pc). For quad lens systems upper limits of $0.06\theta_E$ are found, corresponding to a core radius of 150pc. However, supermassive black holes at the centre of the galaxy (Ferrarese et al. 2000) have so far been ignored and may play a significant role in the position and magnification of the 'odd image'. In particular for B1030+074 the mass of the central black hole may be super-critical ($4\times10^8 M_\odot$), in which case the 'odd image' does not exist and no limits can be placed on the core radii using this technique (Mao et al. 2000).

The absence of the 'odd image' can be used to place constraints on the core radii of the lensing galaxy, or in the case of highly asymmetric doubles place tight constraints on either the core radius or the mass of a central supermassive black hole.

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