The CLASS survey galaxies

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Abstract

We are currently engaged in followup of gravitational lenses disovered during the JVAS-CLASS surveys. HST imaging has revealed the lensing galaxies in all cases, and the lensed images in all but one. We discuss the nature of the lensing galaxies. From ground-based work, two of the five are clearly spiral systems, one because of molecular absorption and the other because of extreme elongation; HST imaging reinforces this view. At least one other is almost certainly a late-type system.

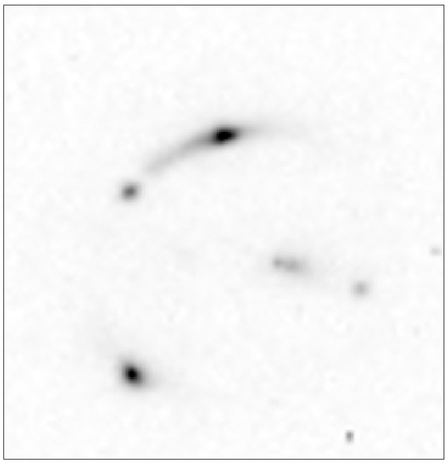
Introduction

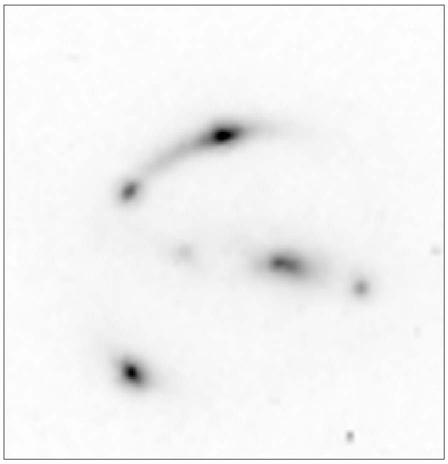
The JVAS/CLASS surveys consist of VLA snapshot images of over 7000 flat-spectrum radio sources. Eventually the number will reach 10000 and cover the sky down to a level of 25 mJy at 5 GHz (δ >30) and approximately 70 mJy (0< δ <30). The surveys should be essentially complete for lens separations $0\farcs2$ – $30''$(see e.g. Marlow, this volume) and considerable efforts are being made to ensure that the survey is complete and does not miss lenses. In particular, all remotely plausible two-image systems are being followed up with high-resolution radio observations to make sure that two-image systems are not missed. The first phase of CLASS produced a total of six new lens systems. Five of these have so far been imaged with the HST in two optical bands: V-band (555 nm) and I-band (814 nm). NOT ground-based images have also been obtained of one lens, 1600+434.

Morphological evidence is gone into in more detail by Jackson et al. (1997). Here we present the images, discuss each object individually and show some profile fits to the radial brightness distributions of each galaxy.

1608+656

This lens was discovered by Myers et al. (1995); the HST images are shown below.

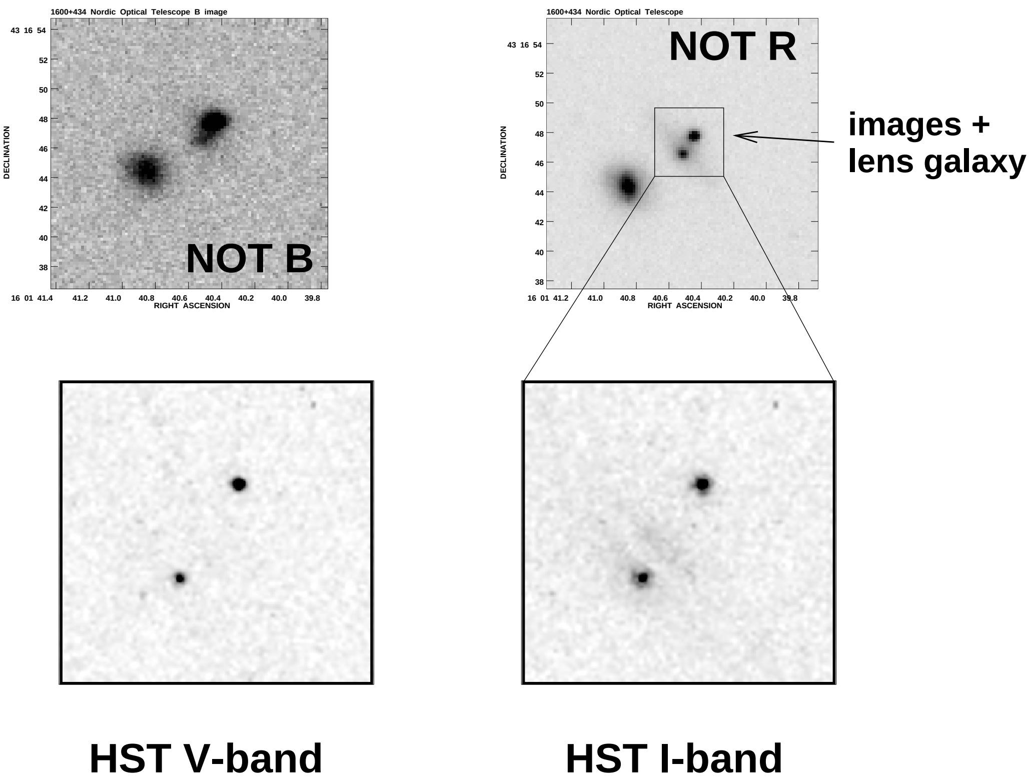




The system consists of a z=1.394 post-starburst galaxy being imaged by a galaxy at redshift 0.6304 (Myers et al. 1995; Snellen et al. 1995; Fassnacht et al. 1996). The four images seen in the radio are also seen in the optical. In addition, an extended region of the lensed object is seen stretched into arcs. The lensing galaxy is also visible, and a clear variation in colour is seen across it; towards the eastern end there is a distinct reddening. We suggest this is due to intervening dust. This dust may be responsible for the apparent splitting of the lensing galaxy into two, or there may be two (possibly interacting/merging?) galaxies contributing to the lensing. Models involving one or two galaxies are under way to test this (Fassnacht et al., in preparation).

1600+434

In Fig. 1 we show our NOT B and R images of 1600+434 taken on July 30, 1995. This is a double system, with separation $1''.4$ and was the first system to be found in the CLASS survey (Jackson et al. 1995). The lensing galaxy is clearly visible close to the southeastern image, and is clearly spiral[1]. Jaunsen & Hjorth (1997) independently reached this conclusion.



The HST V and I images (Fig. 1) also show an elongated system, although the signal-to-noise (or noise-to-signal in the case of the V image) is not ideal. The I image shows a dust lane running through the centre of the lensing galaxy from SW to NE, suggesting that the lens is an edge-on spiral system.

[1]This is more clearly seen on a TV screen!...

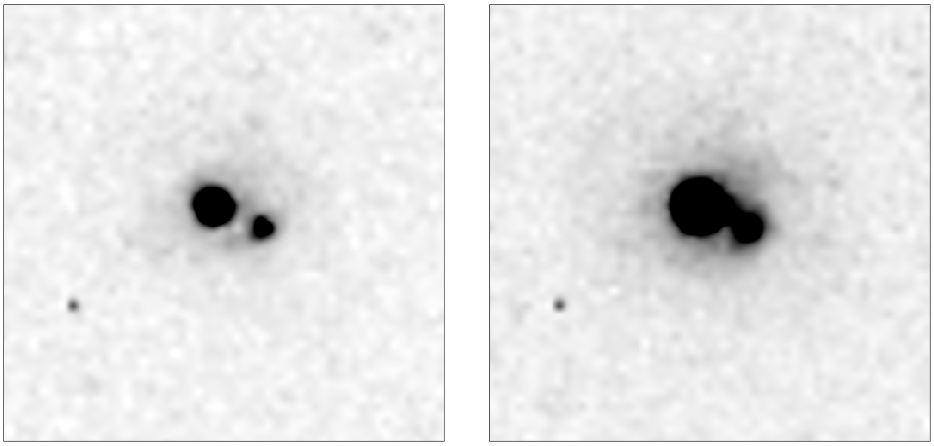
0218+357

This system consists of two objects of separation 335 mas in the radio (Patnaik et al. 1992). In our HST images we see not only the two images, but also the lensing galaxy. This is faint compared to the quasar images but is nonetheless clearly detected. It has been detected in both neutral and molecular gas (see Carilli et al. 1993; Wiklind & Combes 1995 and in these proceedings).

There are two major interesting features in our HST image. The first is that the separation of the components in the image is different from the separation in the radio. This holds whether one fits Gaussians to the two images, or whether one attempts to simultaneously fit the underlying galaxy, also with a Gaussian. This has been done with two different software packages with essentially identical results.

Filter	Separation (mas)	Fit type
V-band	305±6	2 Gaussian
(F555W)	312±5	2 Gaussian + galaxy
I-band	297±12	2 Gaussian
(F814W)	316±6	2 Gaussian + galaxy

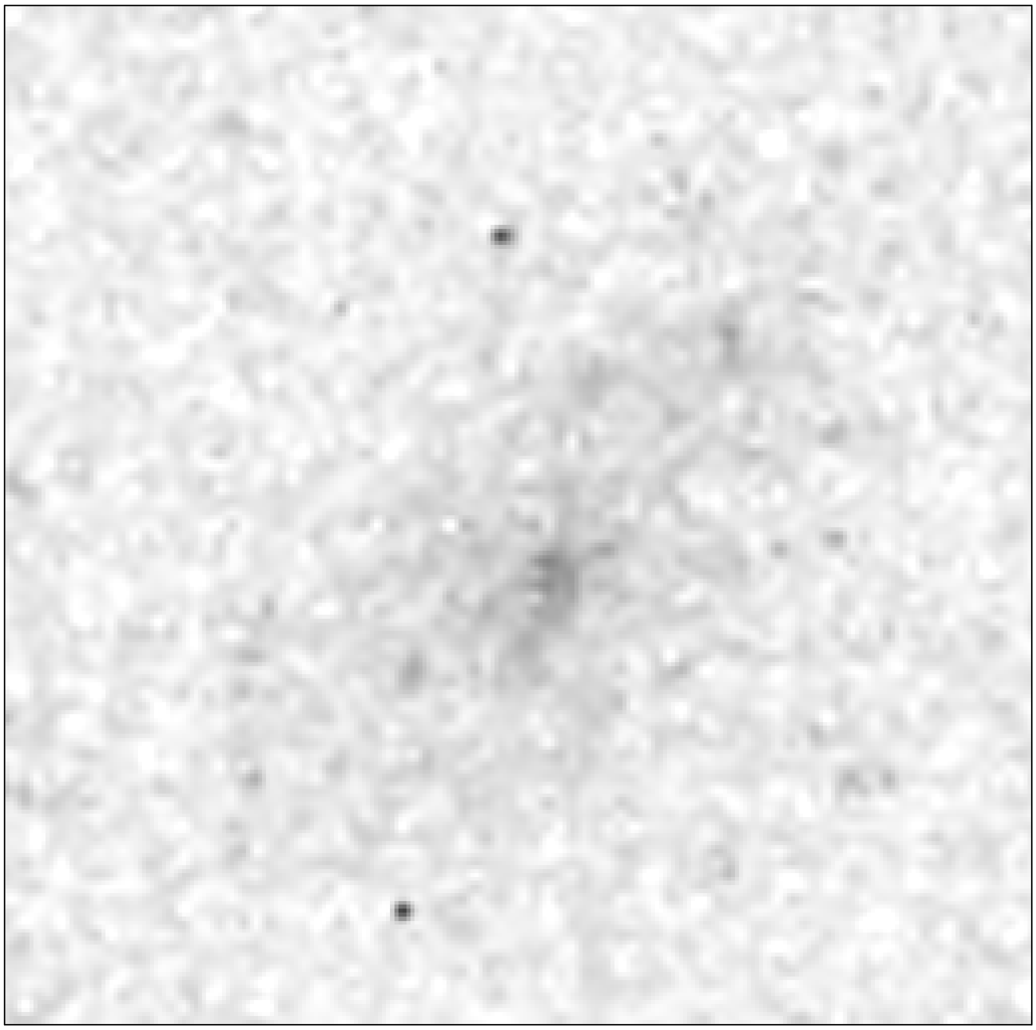
The second feature is that the difference between the radio and optical flux ratios is very large. In the radio, the brightness ratio of images A to B is $\sim$4; at 540 nm it is $\sim$0.15 and at 810 nm it is $\sim$0.11 (±0.03 in each case as the images are superposed on the lensing galaxy). This makes it likely that the regions of the lensed object seen in the radio and optical are not identical.



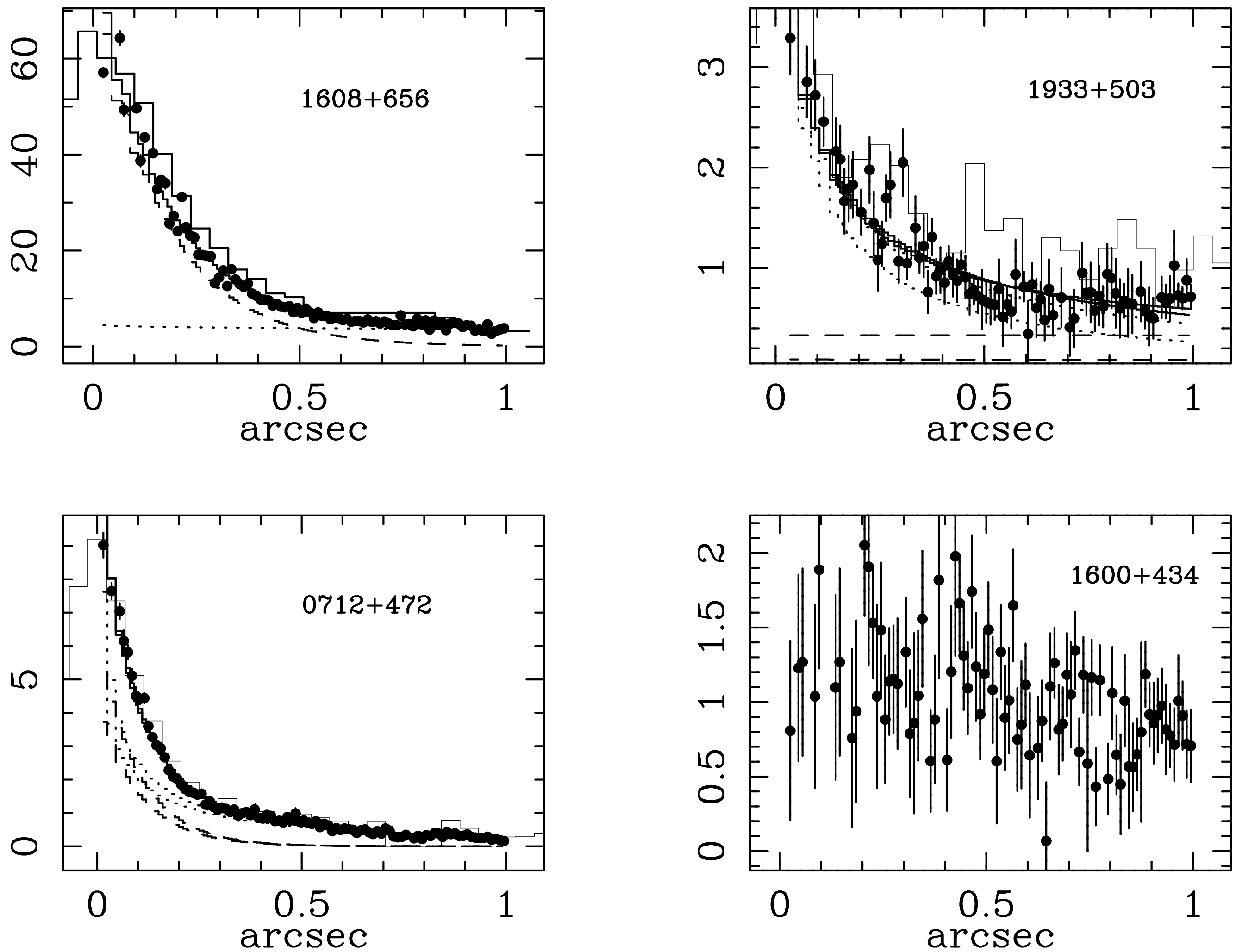
HST images: (left) V-band: (right) I-band

1933+503

The signal-to-noise ratio of this image is not good. However, an elongated structure can be seen. There is little sign of any lensed images – considerable reddening is indicated as the optical components must be fainter than $m_I \sim 25$. NICMOS observations will be obtained to try to detect them.



Profile fits



Profile fits (disk + de Vaucouleurs) are shown for three galaxies. The 0218+357 lensing galaxy is not shown as it is hopelessly confused by the quasar images; and as can be seen 1600+434 is difficult to fit due to the low signal-to-noise (however, ground-based images have already made a convincing case that this is a spiral system). In the Figure we show the data, projected onto the axis using ellipse fits from IRAF (0712+472 and 1933+503) or estimates of ellipticity from IRAF (1608+656,1600+434) as filled circles with error bars. The histogram (weak solid line) represents a slice through the centre of each galaxy along the major axis. The resulting fits are shown as the sum (solid lines) of a disk component (dashed line) and a de Vaucouleurs $r^{1/4}$ law (dotted line). In the case of 0712+472 we show two fits with almost the same χ^2. A disk fit alone is preferred in the case of 1608+656. In the case of 0712+472 both components seem to be necessary. The 1933+503 are rather too noisy for good fitting, but a de Vaucouleurs profile is marginally preferred. The evidence is therefore that 0218+357, 1600+434 and 1608+656 are disk systems; 0712+472 and 1933+503 are more equivocal.

Acknowledgments

This research is supported by the European Commission, TMR Programme, Research Network Contract ERBFMRXCT96-0034 "CERES". The MERLIN array is operated as a national facility by NRAL, University of Manchester, on behalf of the UK Particle Physics & Astronomy Research Council. This research was based on observations with the Hubble Space Telescope, obtained at the Space Telescope Science Institute, which is operated by Associated Universities for Research in Astronomy Inc. under NASA contract NAS5-26555. For further details see our web page on http://www.jb.man.ac.uk/ .

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