A New Einstein Ring

Using the VLT, Rémi Cabanac and colleagues[1] have discovered a new and very impressive Einstein ring. This cosmic mirage, dubbed FOR J0332-3557, is seen towards the southern constellation Fornax (the Furnace), and is remarkable on at least two counts. First, it is a bright, almost complete Einstein ring. Second, it is the farthest of its type ever found.

"There are only a very few optical rings or arcs known, and even fewer in which the lens and the source are at large distance, i.e. more than about 7 000 million light years away (or half the present age of the Universe)", says Rémi Cabanac, former ESO Fellow and now working at the Canada-France-Hawaii Telescope. "Moreover, very few are nearly complete", he adds.

The ring image extends to almost 3/4 of a circle. The lensing galaxy is located at a distance of about 8 000 million light years from us, while the source galaxy whose light is distorted, is much farther away, at 12 000 million light years. Thus, we see this galaxy as it was when the universe was only 12 % of its present age. The lens magnifies the source almost 13 times.

The observations reveal the lensing galaxy to be a rather quiet galaxy, 40 000 light years wide, with an old stellar population. The much more distant lensed galaxy, however, is extremely active, having recently experienced bursts of star formation. It is a compact galaxy some 7 000 light years across.

"Because the gravitational pull of matter bends the path of light rays, astronomical objects – stars, galaxies and galaxy clusters – can act like lenses, which magnify and severely distort the images of galaxies behind them, producing weird pictures as in a hall of mirrors", explains Chris Lidman (ESO), co-discoverer of the new cosmic mirage.

[1] The paper describing this research has recently been published as a Letter to the Editor in Astronomy and Astrophysics, Volume 436, L21–L25, by Rémi A. Cabanac (CFHT, Hawaii), David Valls-Gabaud (Observatoire Midi-Pyrénées), Andreas Ortmann Jaunsen (ESO Chile), Chris Lidman (ESO), and Helmut Jerjen (Mount Stromlo Observatory, Australia).

Figure 1: Composite image taken in bands B and R with VLT/FORS, which reaches to magnitude 26. A zoom-in on the position of the newly found ring.

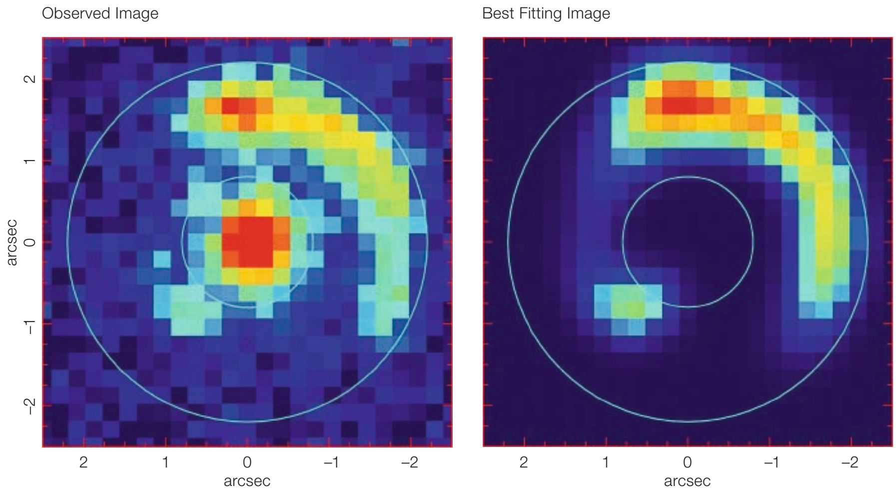

Figure 2: The left image is magnified and centred on the newly discovered Einstein ring. The image quality ("seeing") of the *R*-band image is exceptional (0.5″) and the image reveals the lensing system in stunning details. The central feature is the lens, a quiescent massive galaxy that distorts the light emitted by background sources. The large arc surrounding the central lens is part of the Einstein ring created by a background source finely aligned with the lens. The reddish colour indicates that the redshift of the system is very large. FORS2 spectroscopy of the lensing system yielded a redshift close to 1 for the lens (we see the lens as it was when the Universe was half its present size), and a redshift $z = 3.8$ for the ring (a background star-forming galaxy seen as it was when the Universe was only 12 % of its present age. The lensing model indicates that the light of the source is magnified at least 13 times. The right panel shows the reconstructed image based on the model of the lens and the source; the ring is found to extend over 3/4 of a complete circle.

In the most extreme case, where the foreground lensing galaxy and the background galaxy are exactly aligned, the image of the background galaxy is stretched into a perfect ring. Such an image is known as an Einstein ring, because the formula for the bending of light, first described in the early twentieth century by Chwolson and Link, uses Einstein's theory of General Relativity.

Gravitational lensing provides a very useful tool with which to study the Universe. As a "weighing scale", it provides a measure of the mass within the lensing body, and as a "magnifying glass", it allows us to see details in objects which would otherwise be beyond the reach of current telescopes.

From the image, co-worker David Valls-Gabaud (CFHT), using state-of-the-art modelling algorithms, was able to deduce the mass of the galaxy acting as a lens – it is almost one million million solar masses.

(Based on ESO Press Photos 20b+c/05)