

**Astr/Phys 571: Gravitation**

**Gravitational Lensing in Astrophysics**

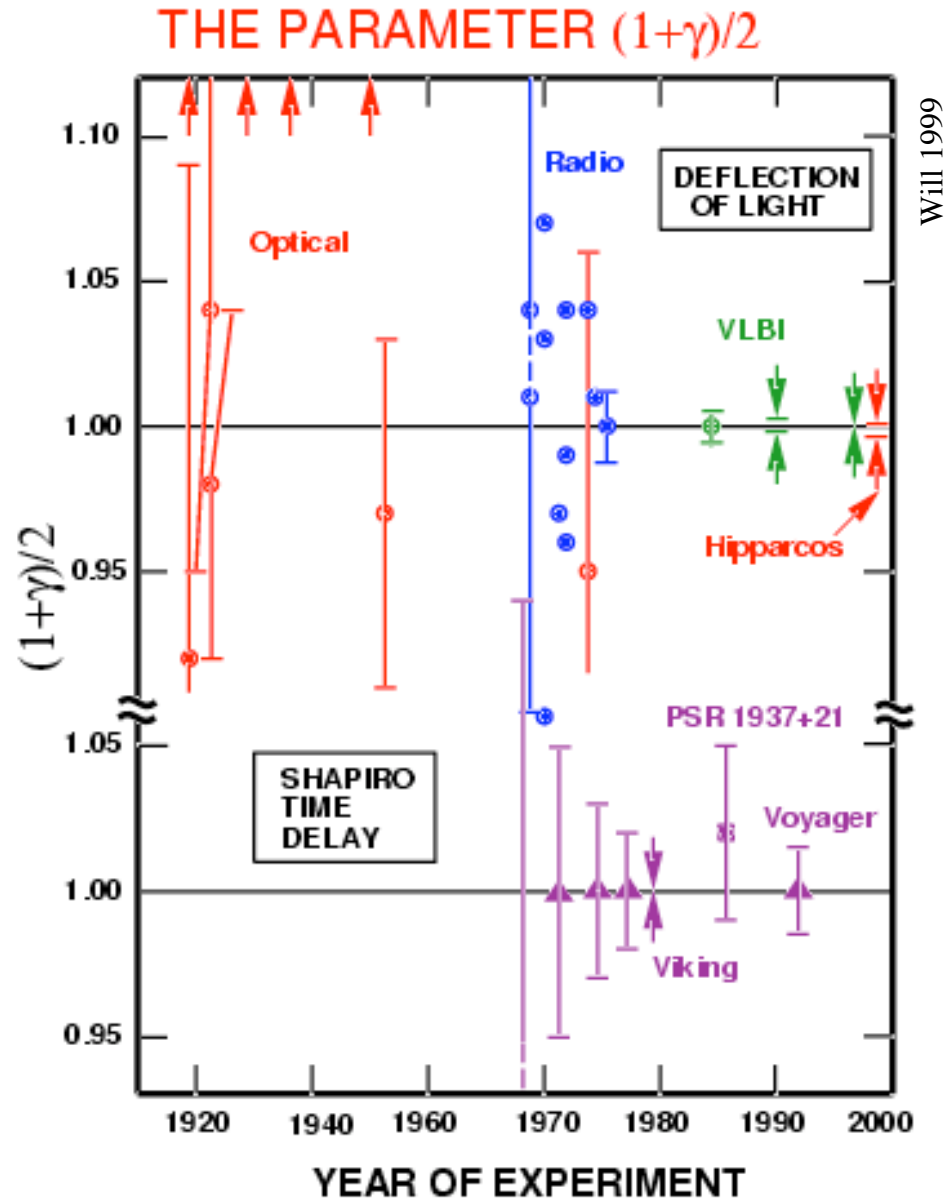
**February 17, 2005**

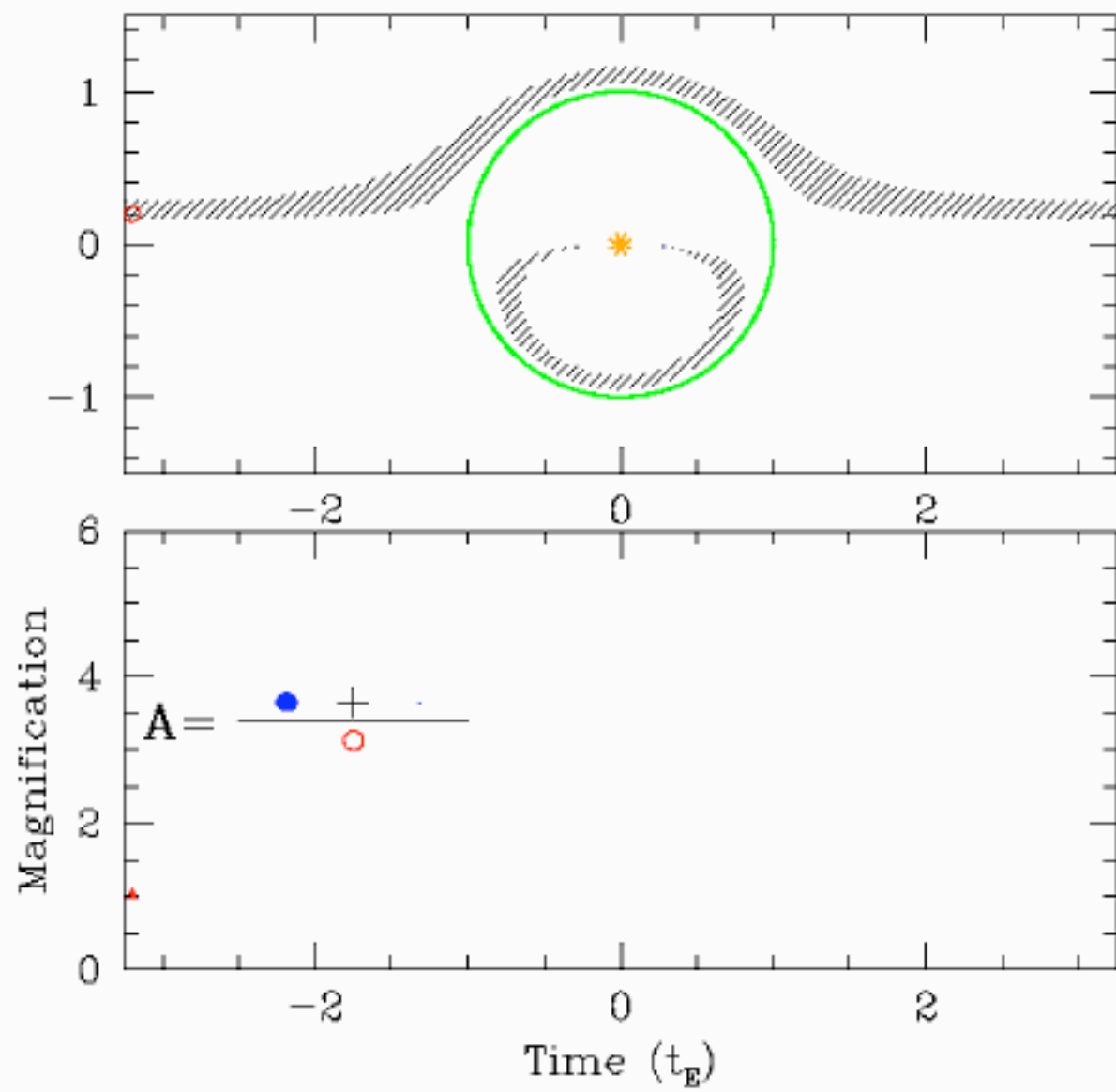
Deflection of light:

$$\delta\phi_{def} = \left(\frac{1+\gamma}{2}\right) \left(\frac{4GM}{c^2 b}\right)$$

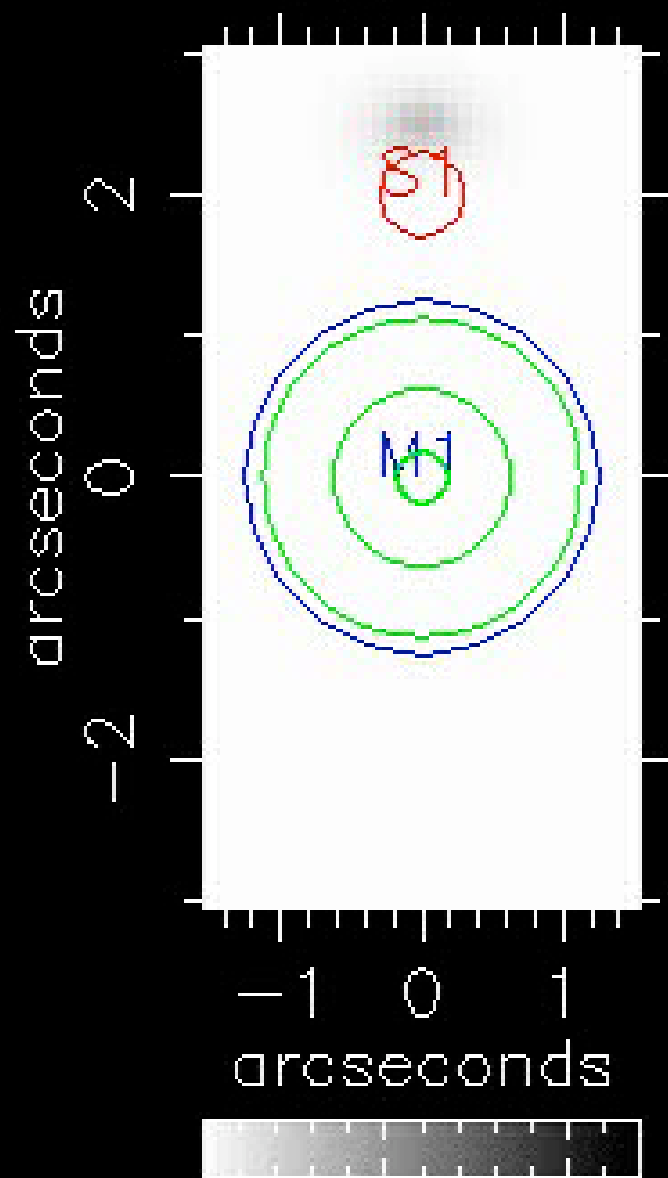
Shapiro Time Delay:

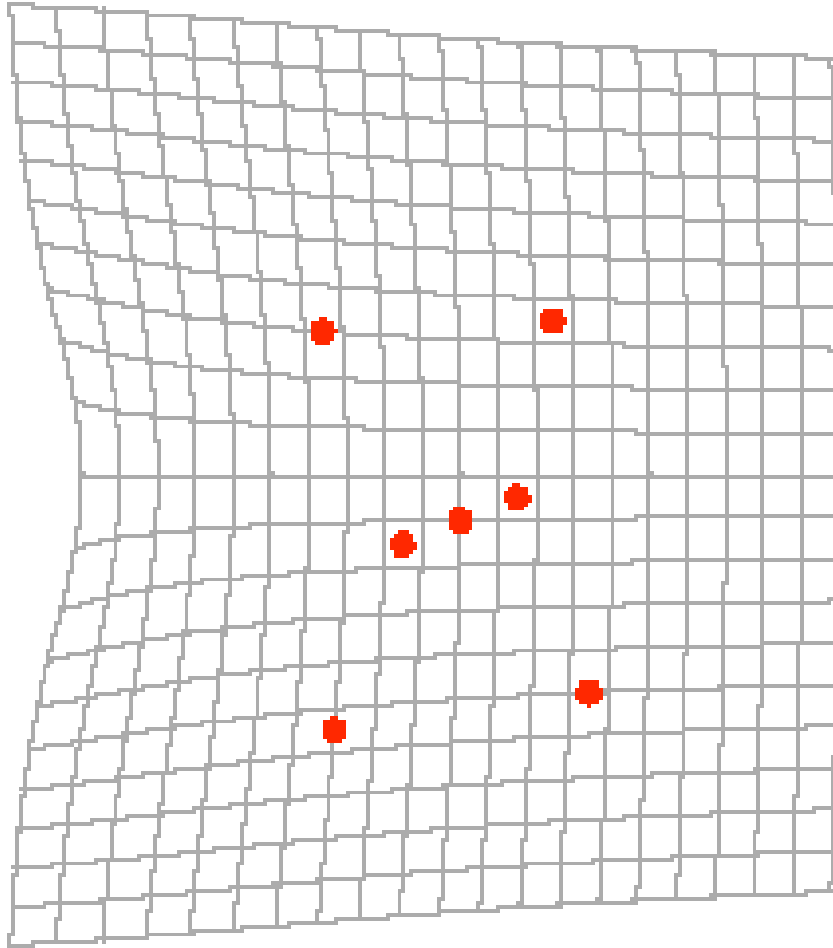
$$\delta t = \left(\frac{1+\gamma}{2}\right) \left(\frac{4GM}{c^3}\right) \left[\log\left(\frac{4r_e r_R}{r_c}\right) + 1\right]$$





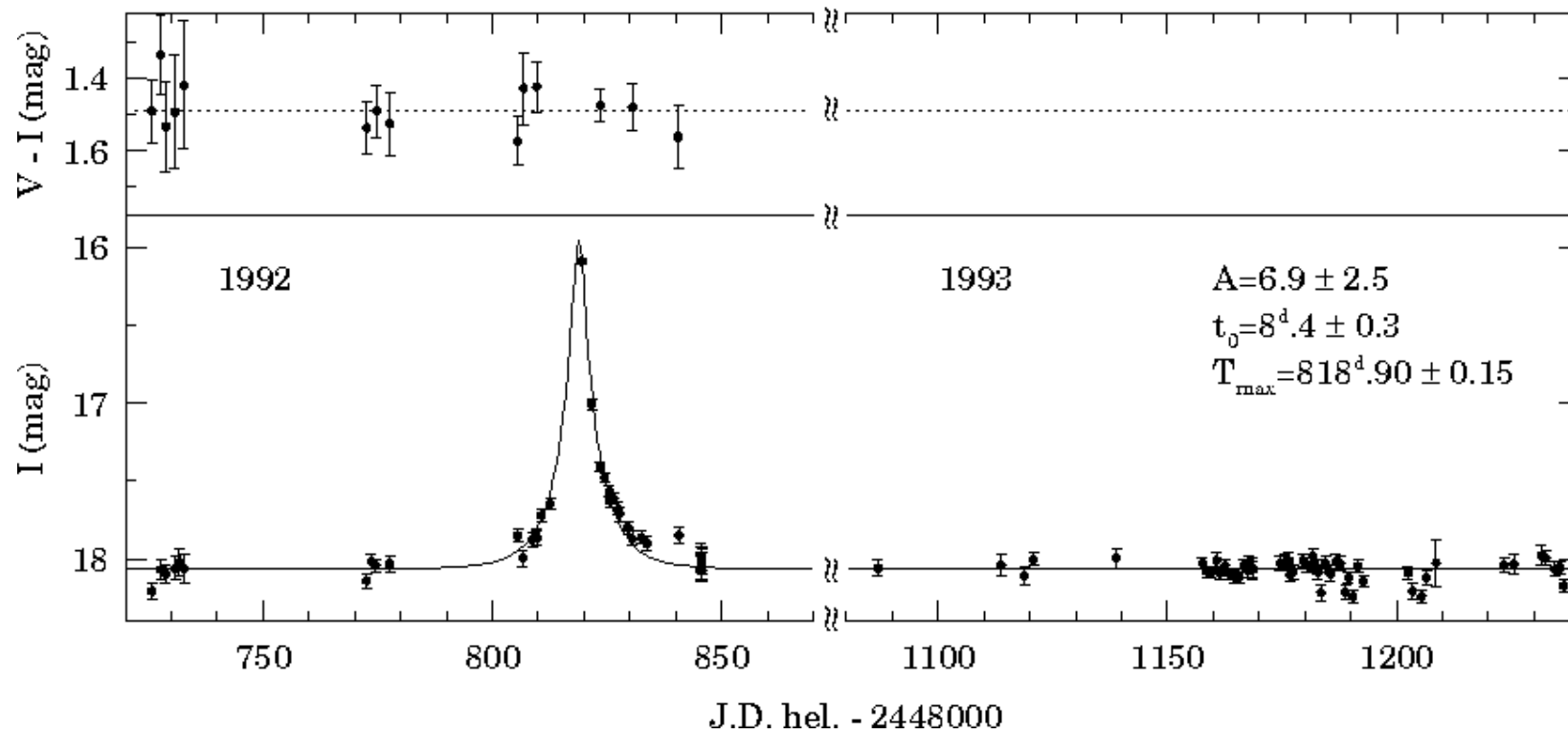
SIS Einstein Ring from file test2



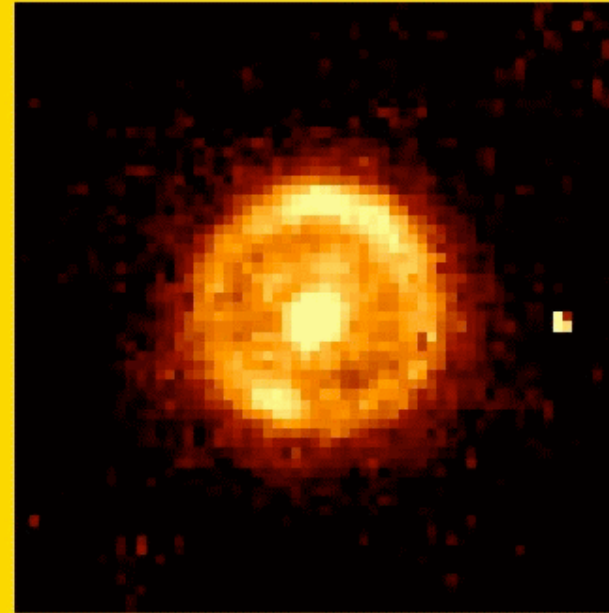
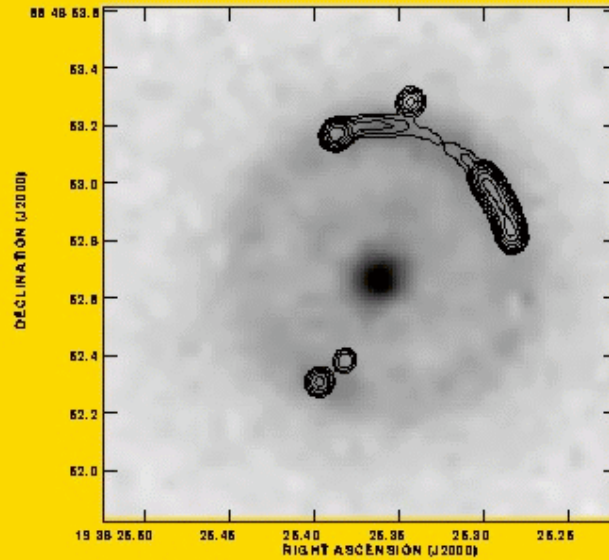


# Gravitational Microlensing

OGLE  $\mu$ LENS #6: MM5-B I 128727



# An example of an Einstein ring

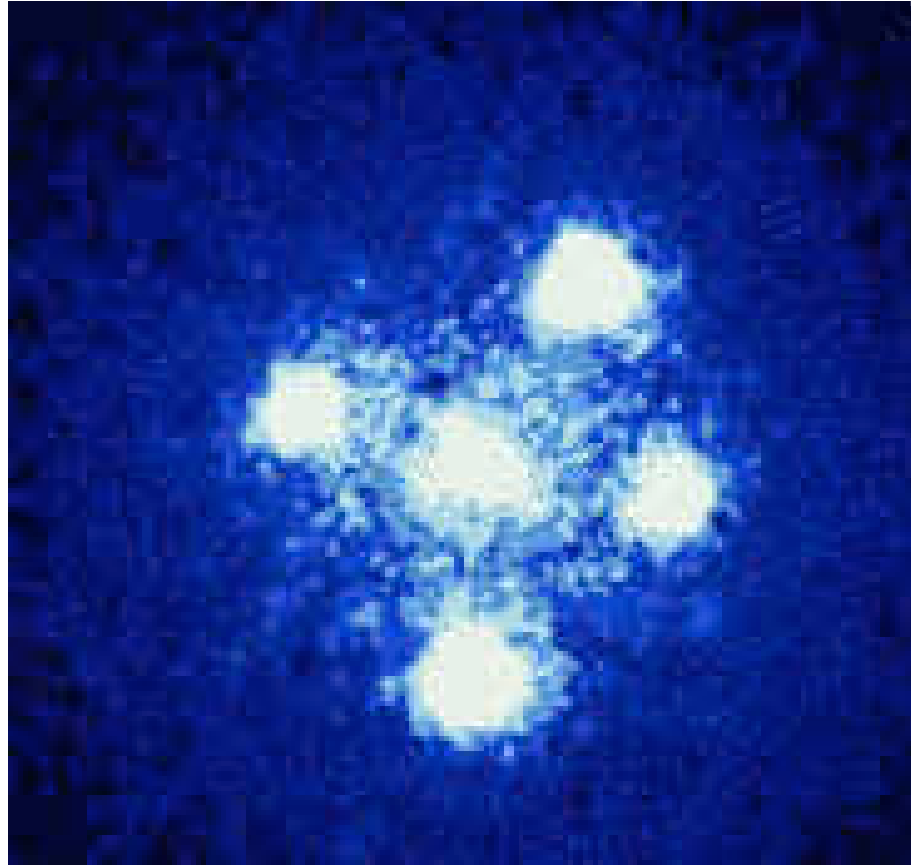


The gravitational lens JVAS B1938+666

Left: HST/NICMOS greyscale with MERLIN radio contours

Right: Colour image of the HST/NICMOS image

## An example of an Einstein cross



## Giant Arcs

