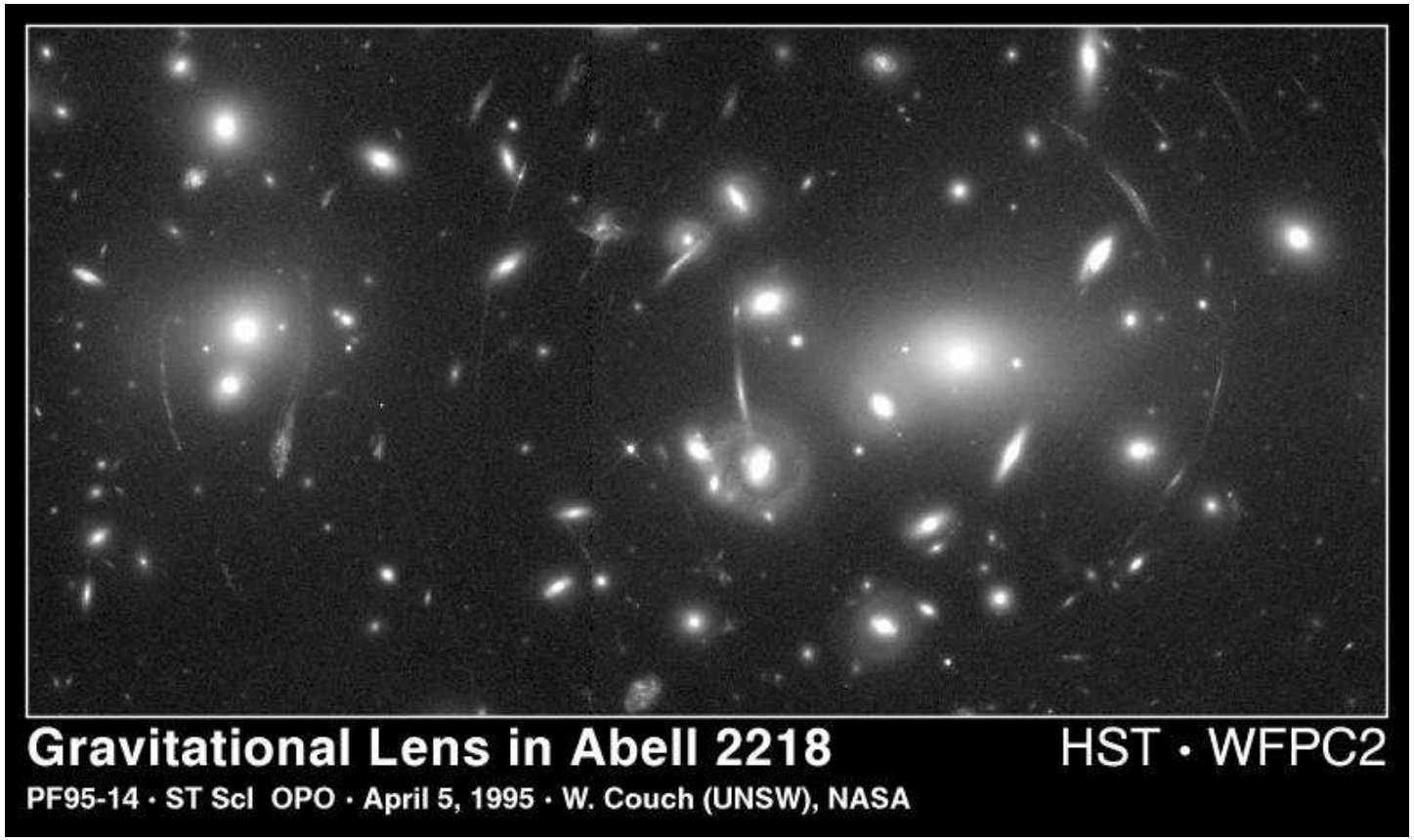
Gravitationslinsen

Volker Perlick (ZARM, Universität Bremen)

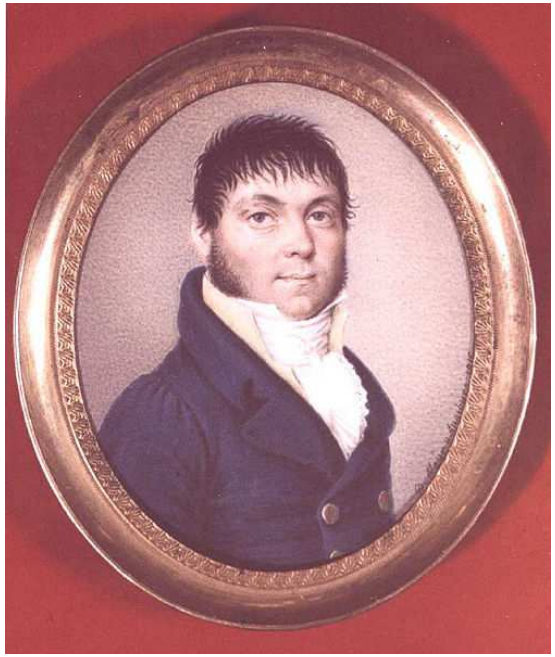


Bremen, Haus der Wissenschaft, 4. Juni 2015

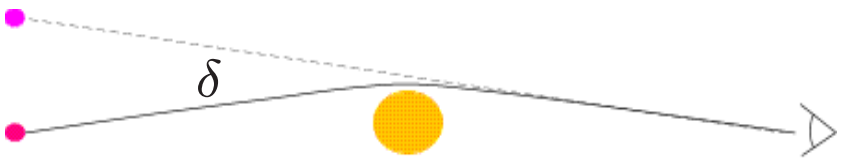
Newtonsche Lichtablenkung:

Henry Cavendish 1786, Johann v. Soldner 1801

Henry Cavendish
(1731 – 1810)

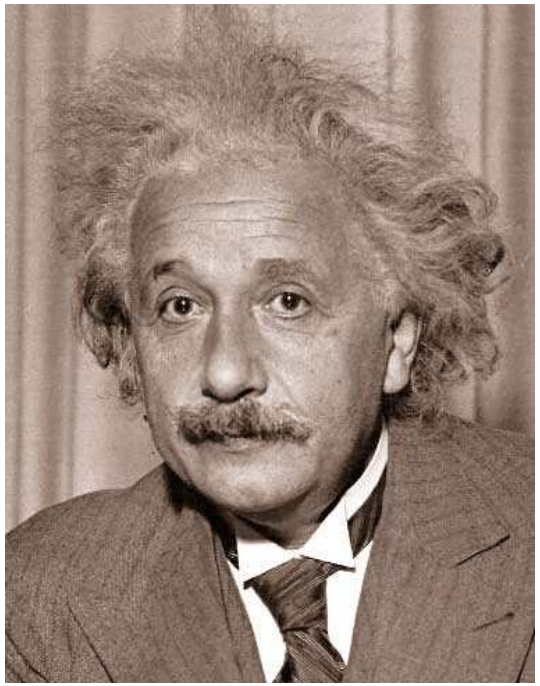


Johann v. Soldner
(1776 –1833)

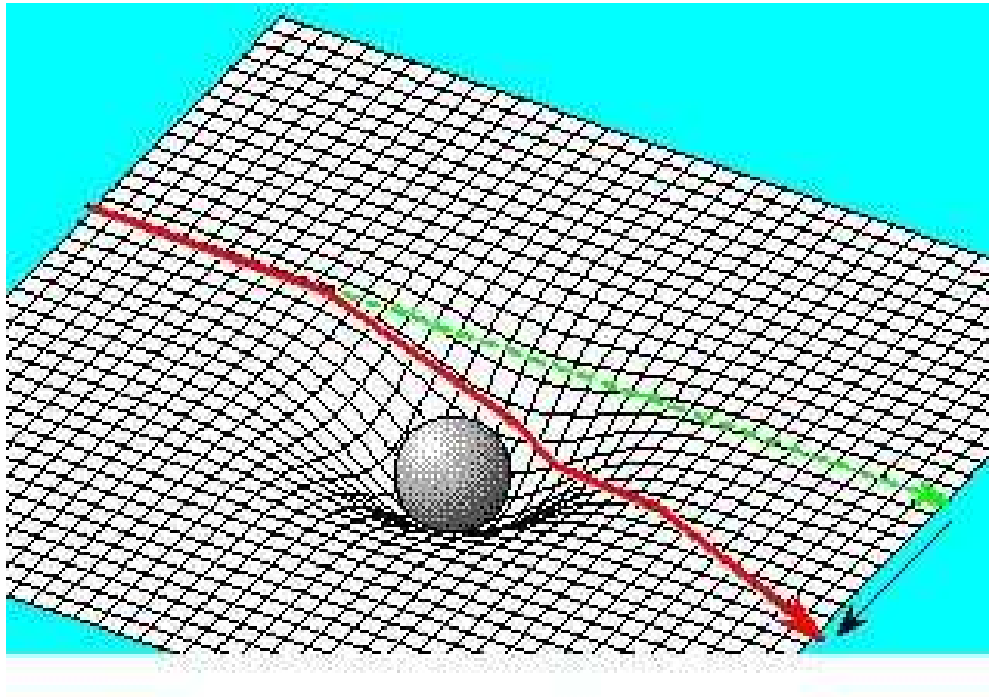


$$\delta = \frac{2\,G\,M}{c^2\,R}, \quad \delta_\odot = 0,87''$$

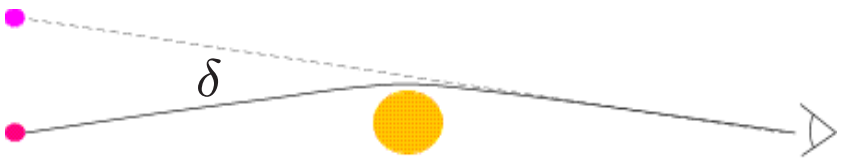
Einsteinsche Lichtablenkung:
Albert Einstein 1915



Albert Einstein
(1879-1955)



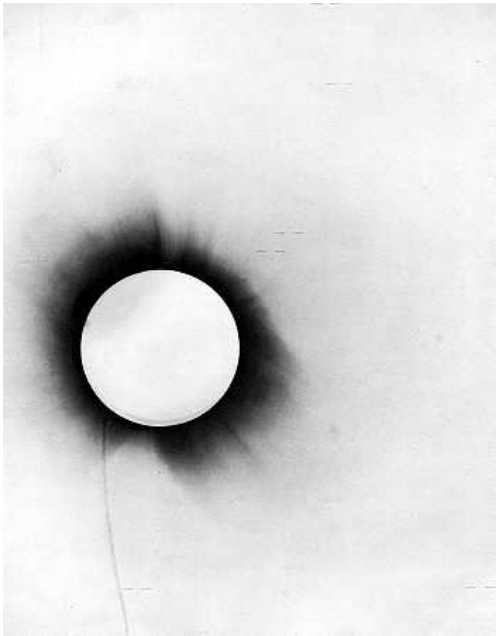
Raumzeitkrümmung



$$\delta = \frac{4\,G\,M}{c^2\,R}\,,\quad \delta_\odot = 1,75''$$

Bestätigung der Einsteinschen Lichtablenkung:
Arthur S. Eddington 1919

Arthur S. Eddington
(1882 – 1944)

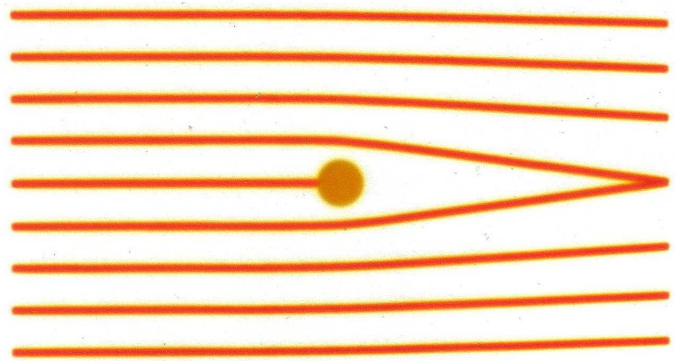


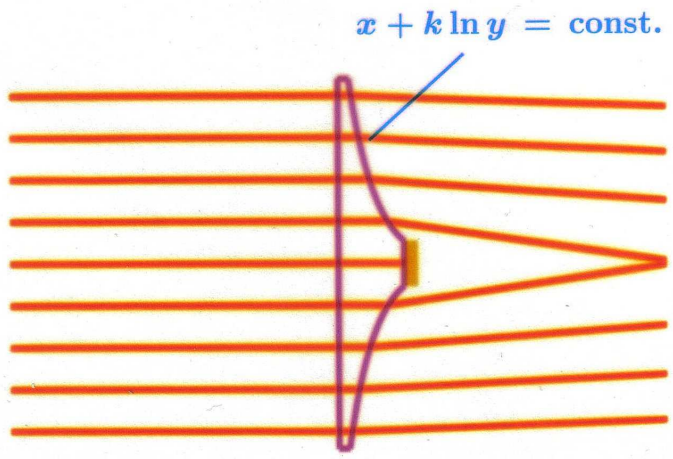
Sonnenfinsternis
1919

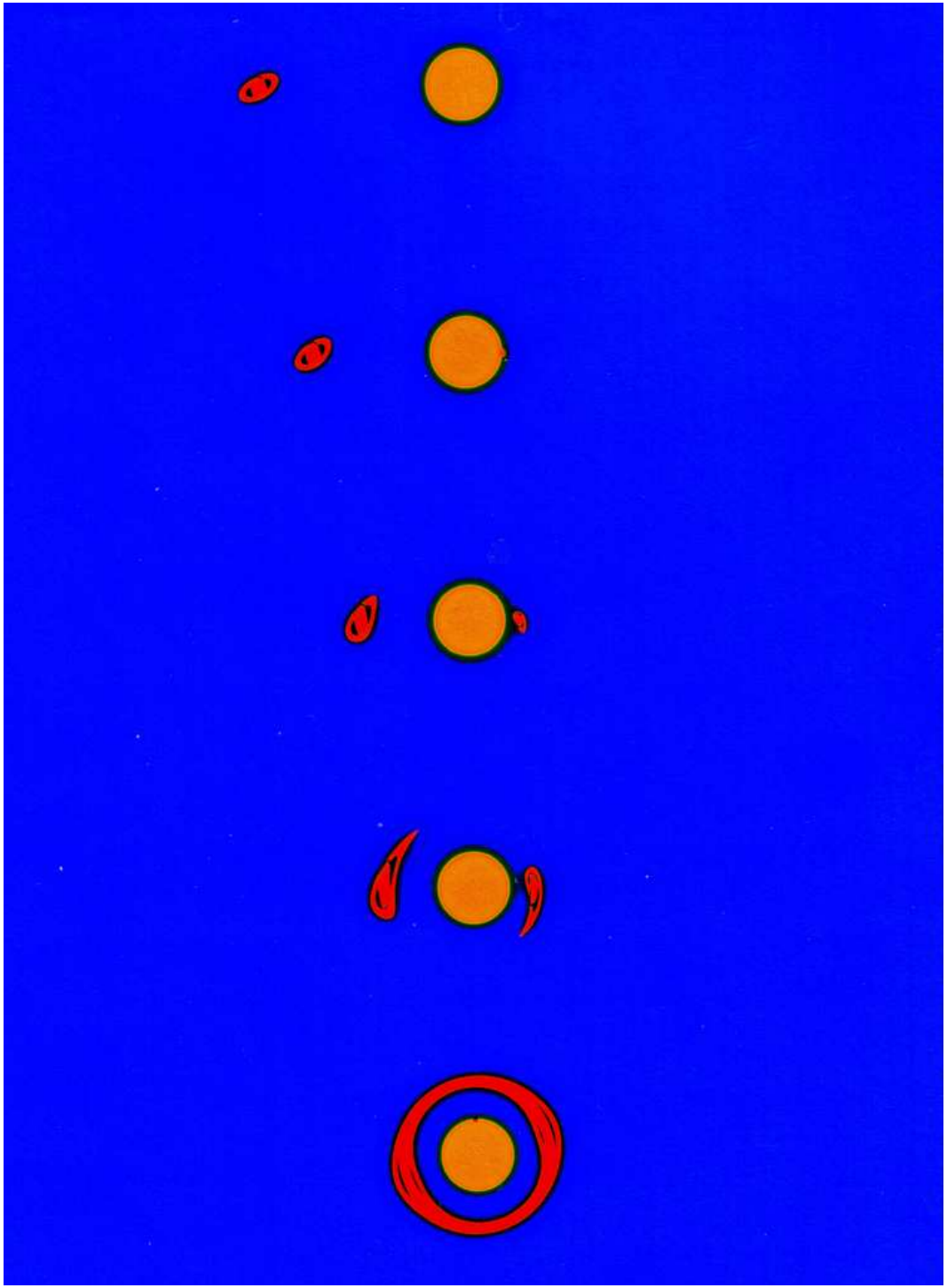
Principe: $\delta = 1,61'' \pm 0.40''$, **Sobral:** $\delta = 1,98'' \pm 0,16''$

D. Lebach et al. (1995): $\left|\frac{\delta - \delta_{\text{Einstein}}}{\delta_{\text{Einstein}}}\right| \leq 0,02\,\%$

Simulation der Lichtablenkung mit Plastiklinse:



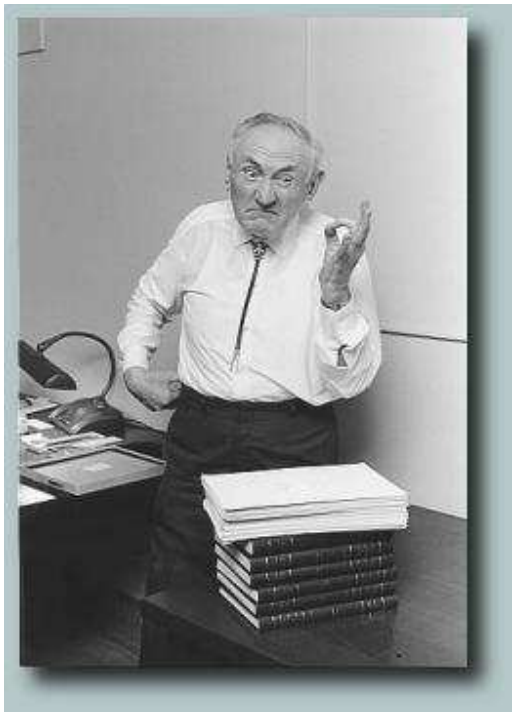




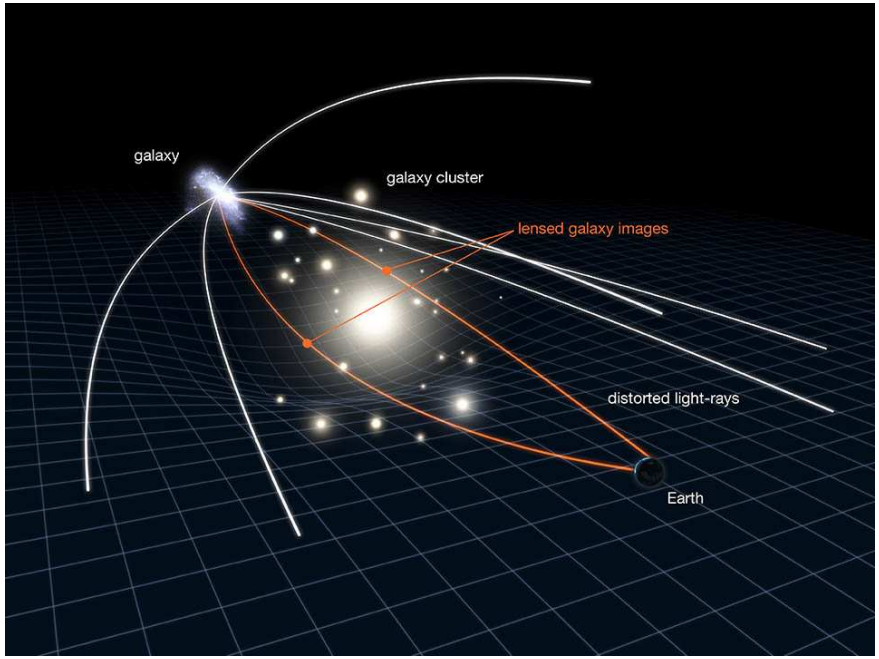
Sind Mehrfachbilder oder Ringe beobachtbar?

Stern "linst" Stern — **Albert Einstein (1936): praktisch unbeobachtbar**

Galaxie "linst" Galaxie — **Fritz Zwicky (1937): wahrscheinlich beobachtbar**

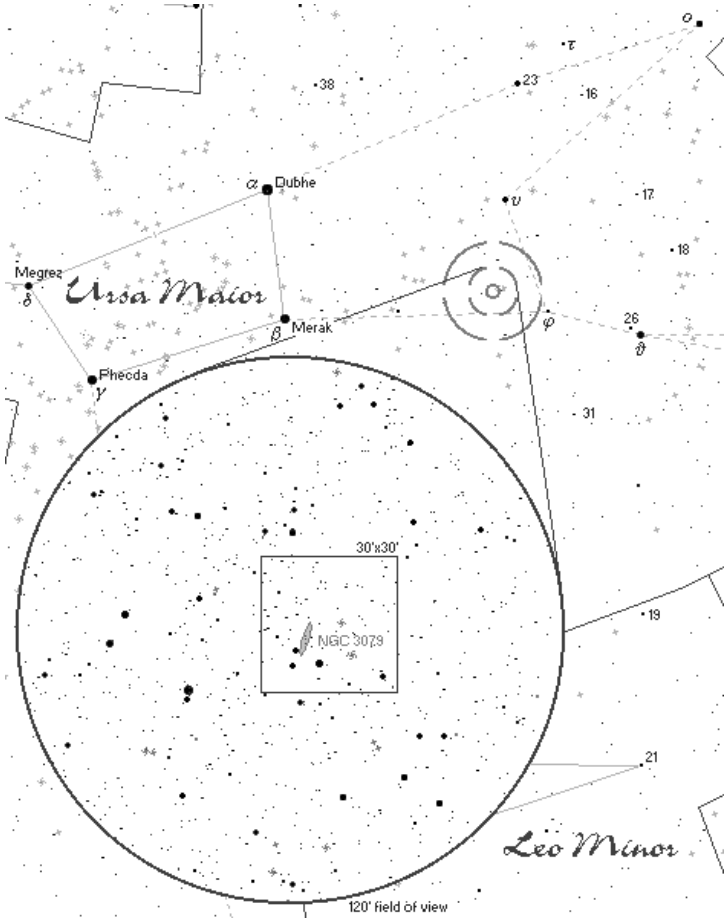


Fritz Zwicky
(1898 – 1974)

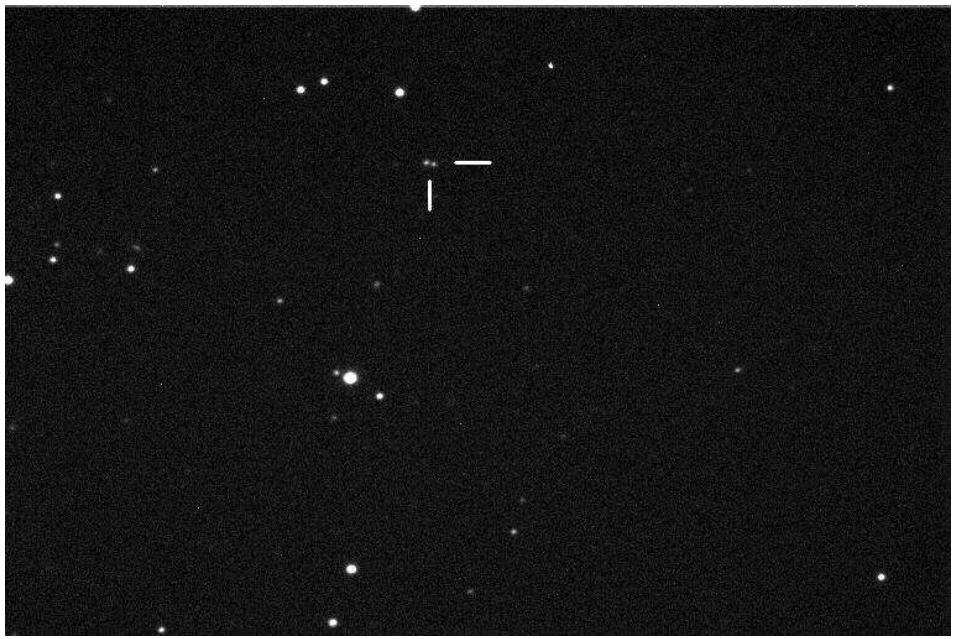


Erstes Mehrfachbild entdeckt:

D. Walsh, R. Carlswell, R. Weyman (1979)



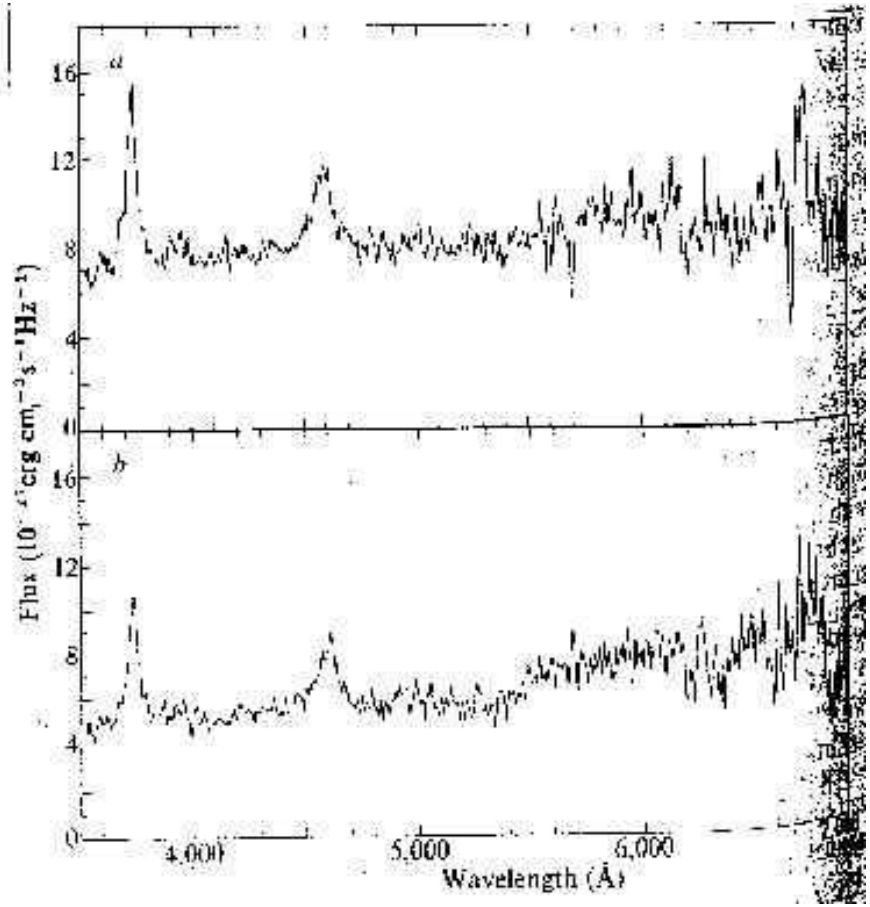
Doppelquasar QS0 0957 +561



Winkelabstand $= \ 6''$

Helligkeit $= \ 17^{\mathrm{m}}$

Spektren

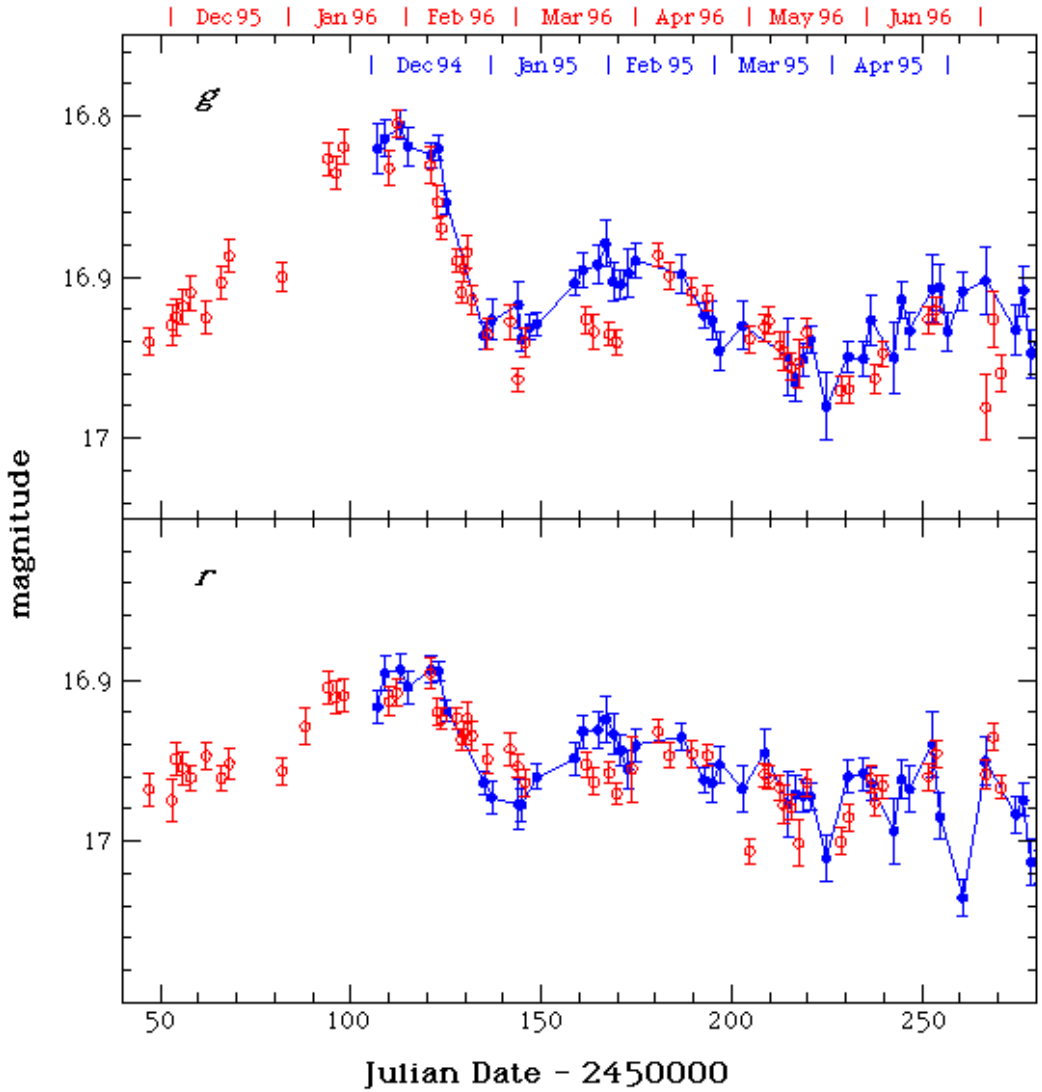


Rotverschiebung:

$$z_{\text{Quasar}} = 1,4$$

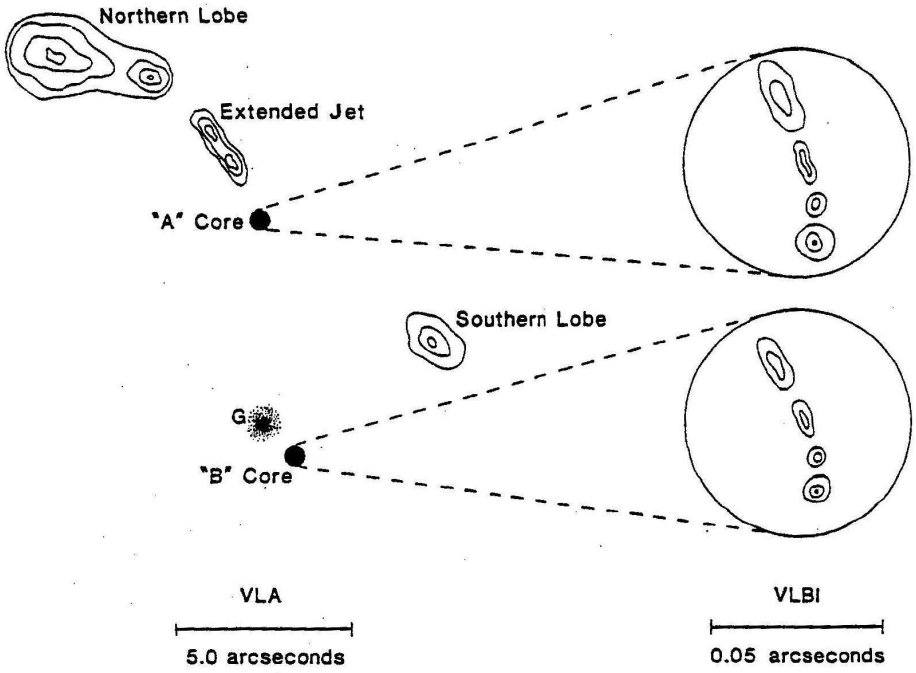
$$z_{\text{Galaxie}} = 0,4$$

Lichtkurven

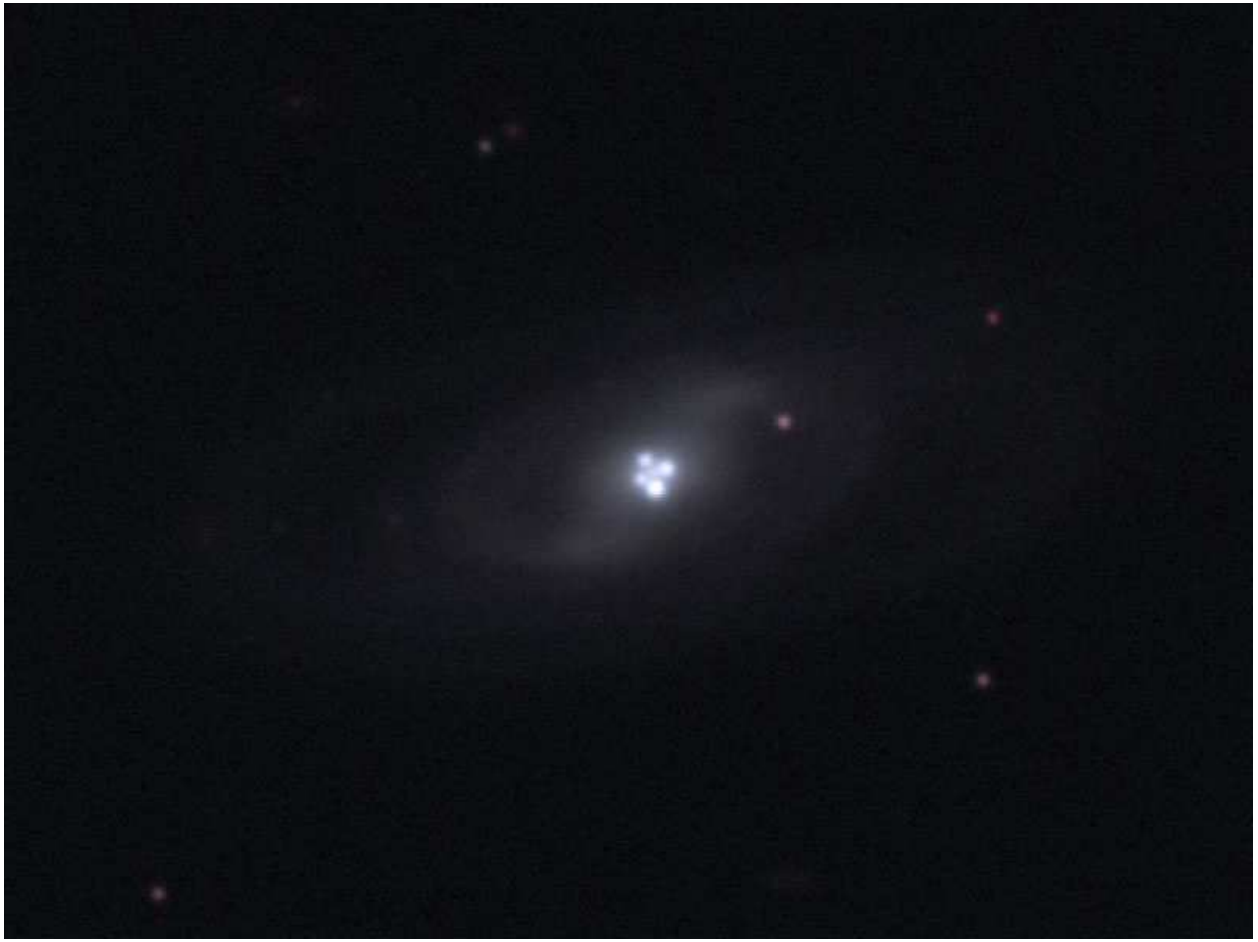


Laufzeitunterschied = 417 Tage

Höhere Auflösung:



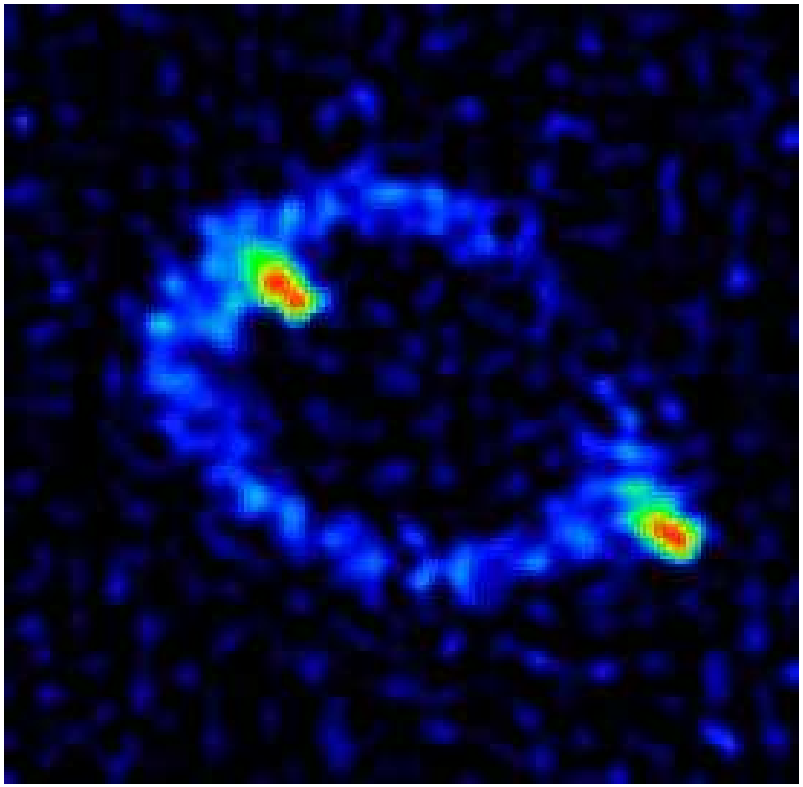
Anderes Beispiel für Mehrfachbild:



Einstein-Kreuz

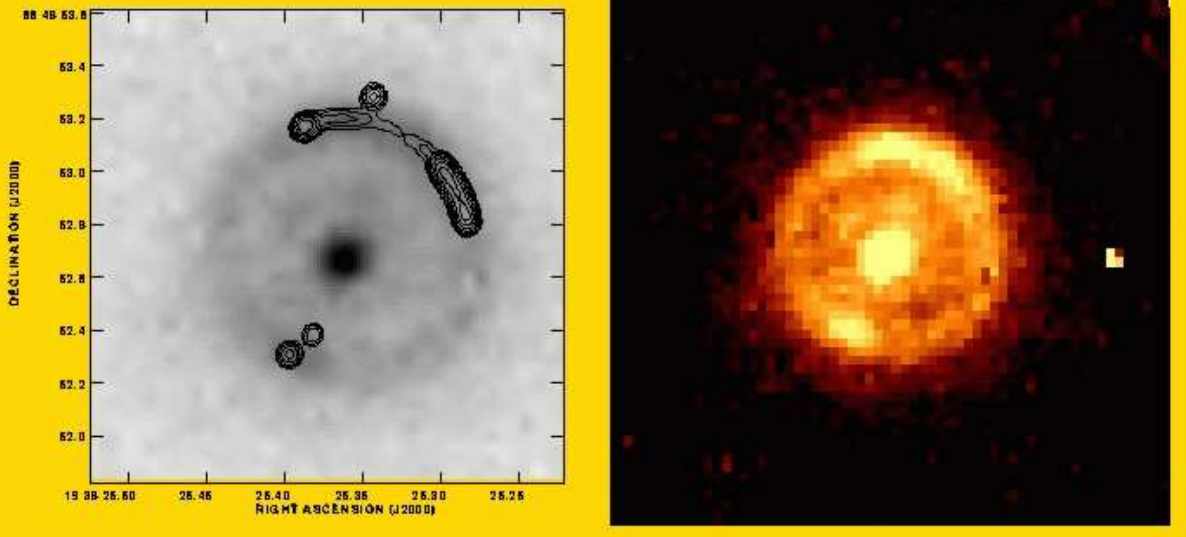
Erster Einsteinring beobachtet:

Jacqueline Hewitt et al. (1988)



MG1131+0456

Anderes Beispiel für Einsteinring:

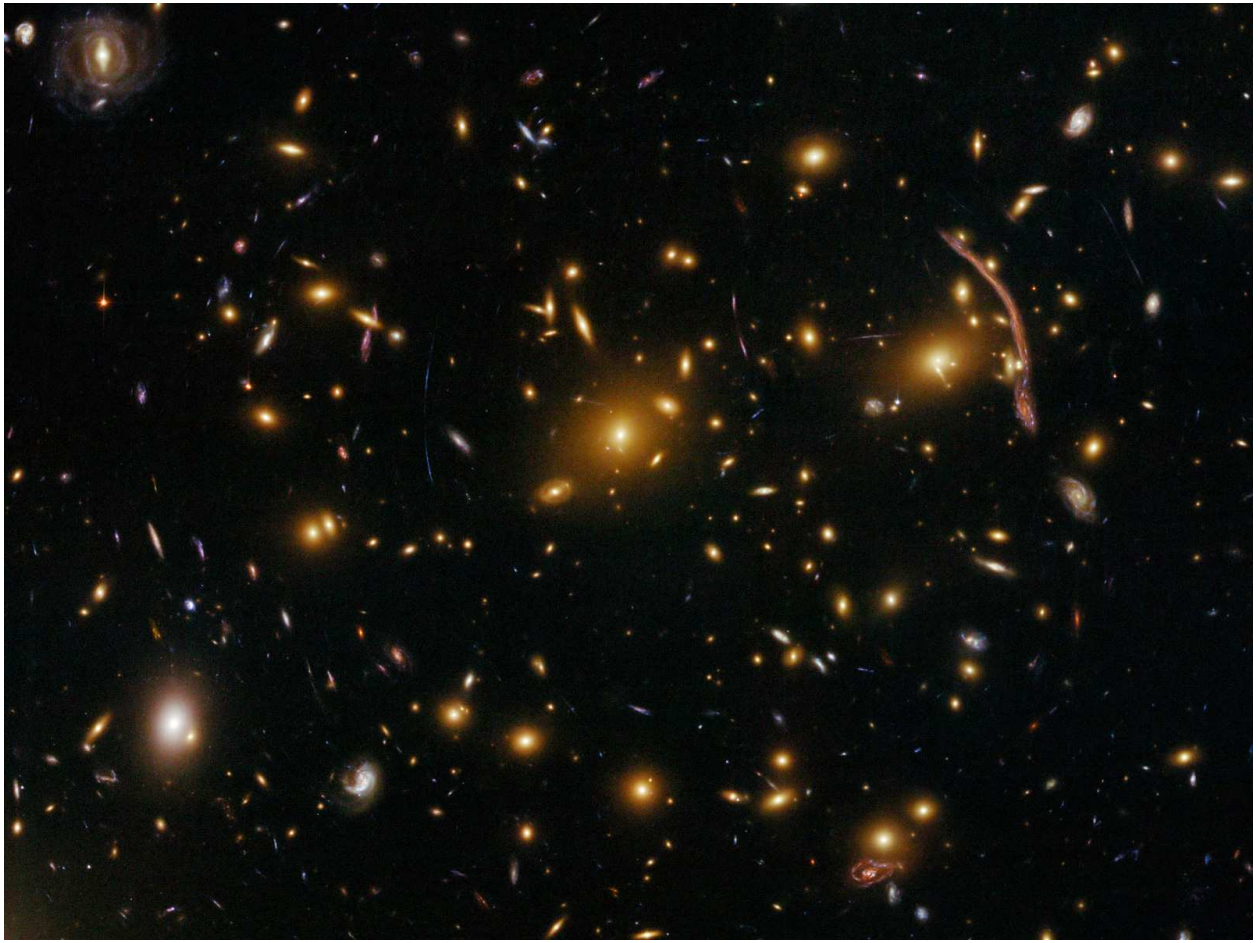


The gravitational lens JVAS B1938+666

Left: HST/NICMOS greyscale with MERLIN radio contours
Right: Colour image of the HST/NICMOS image

Entdeckung von “Giant Luminous Arcs”:

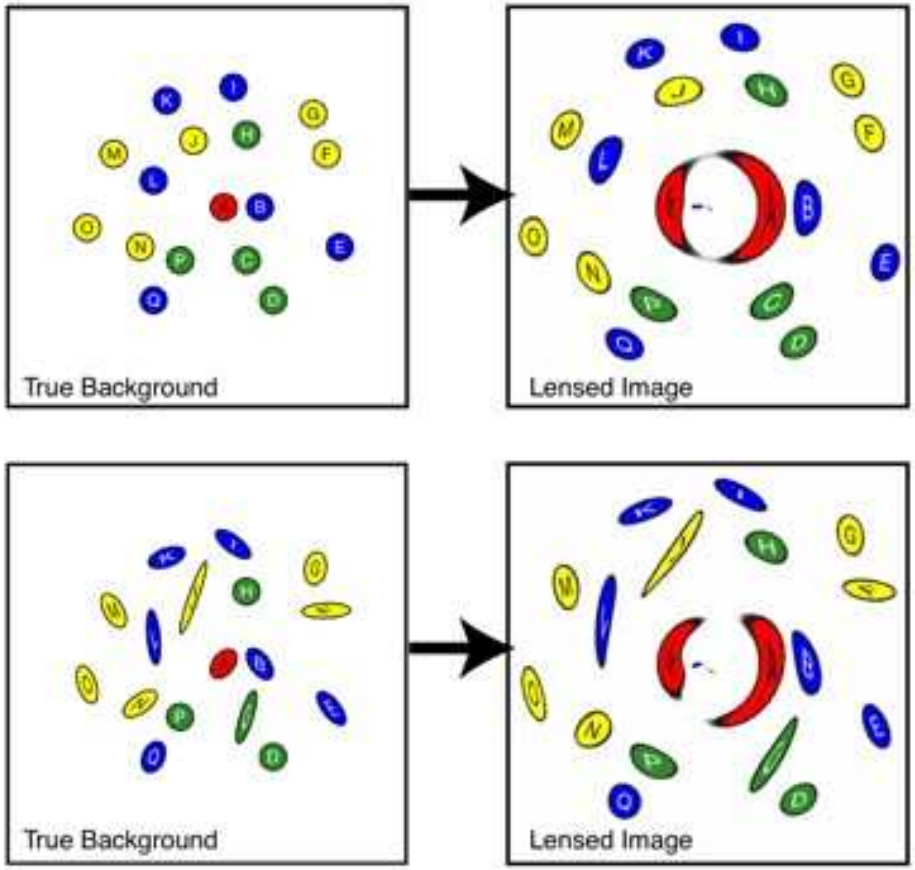
R. Lynds, V. Petrosian (1986), G. Soucail et al. (1987)



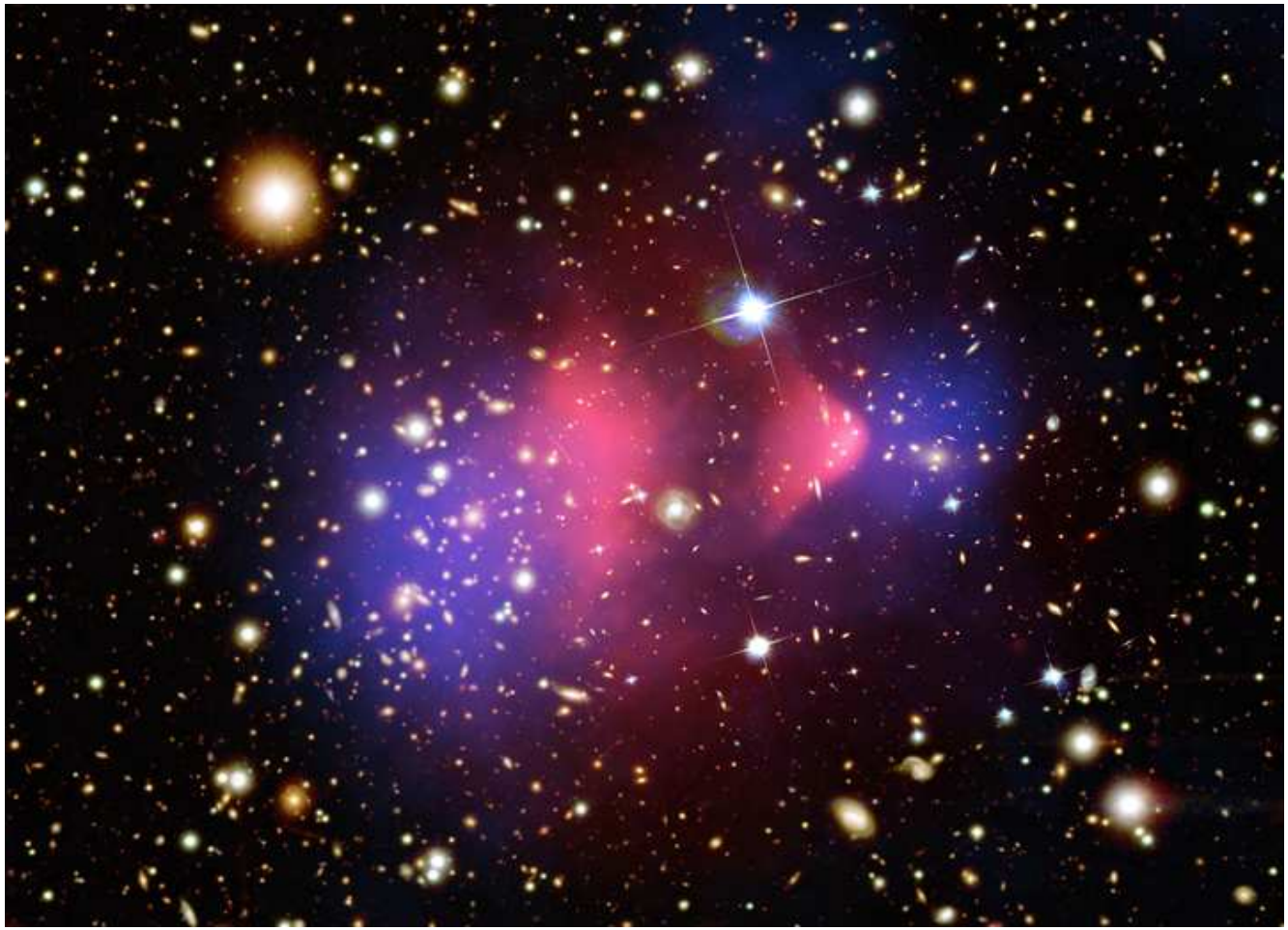
Abell 370

Weak Lensing:

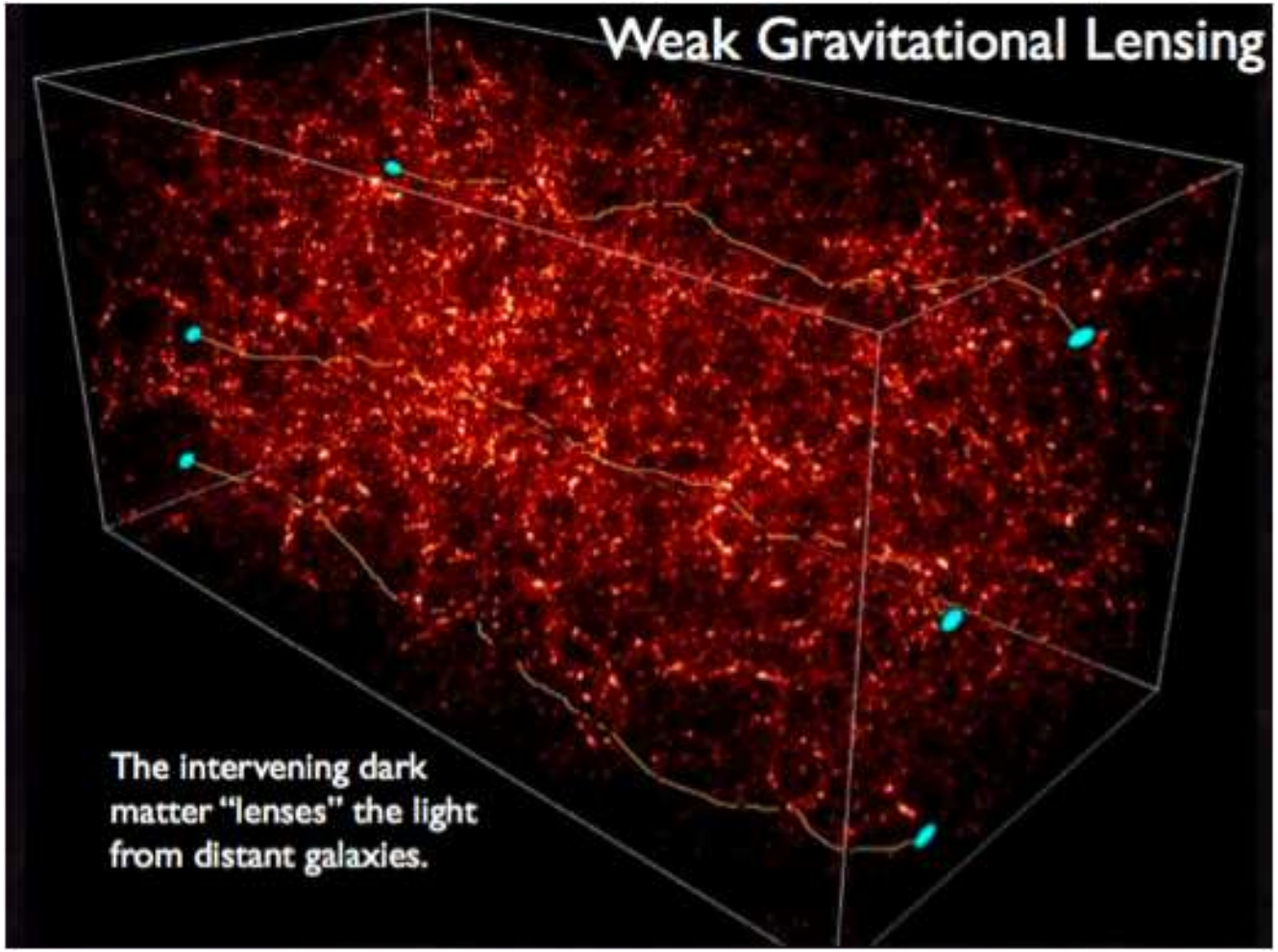
Aufspüren von Dunkler Materie in Galaxienhaufen



Bullet Cluster

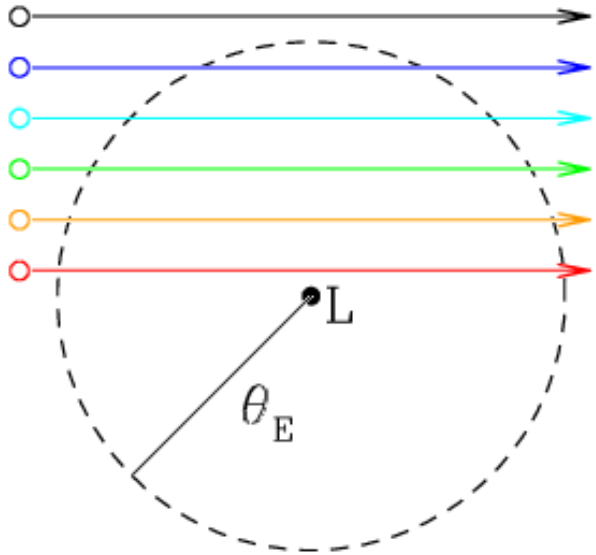


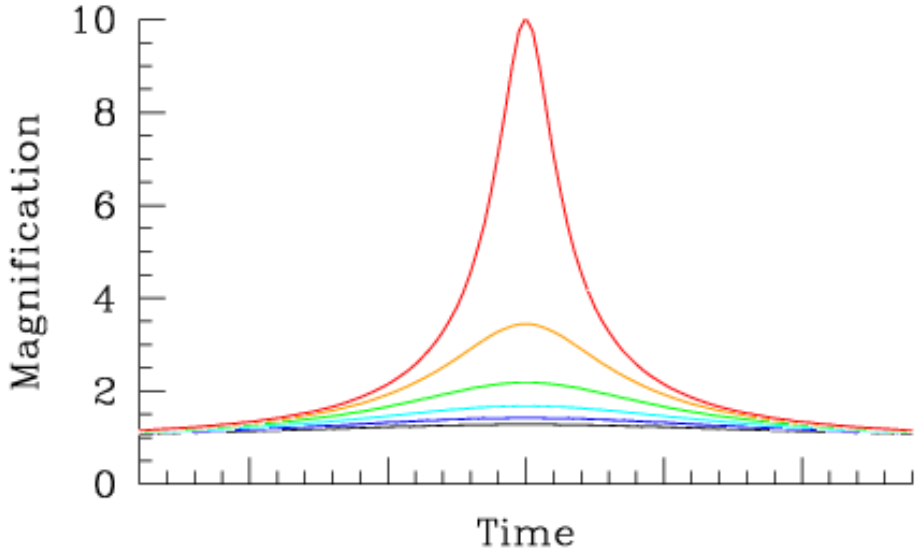
3D Verteilung aus Weak-Lensing-Daten (Columbi und Mellier)



Microlensing:

Aufspüren von Braunen Zwergen, Exoplaneten, etc.

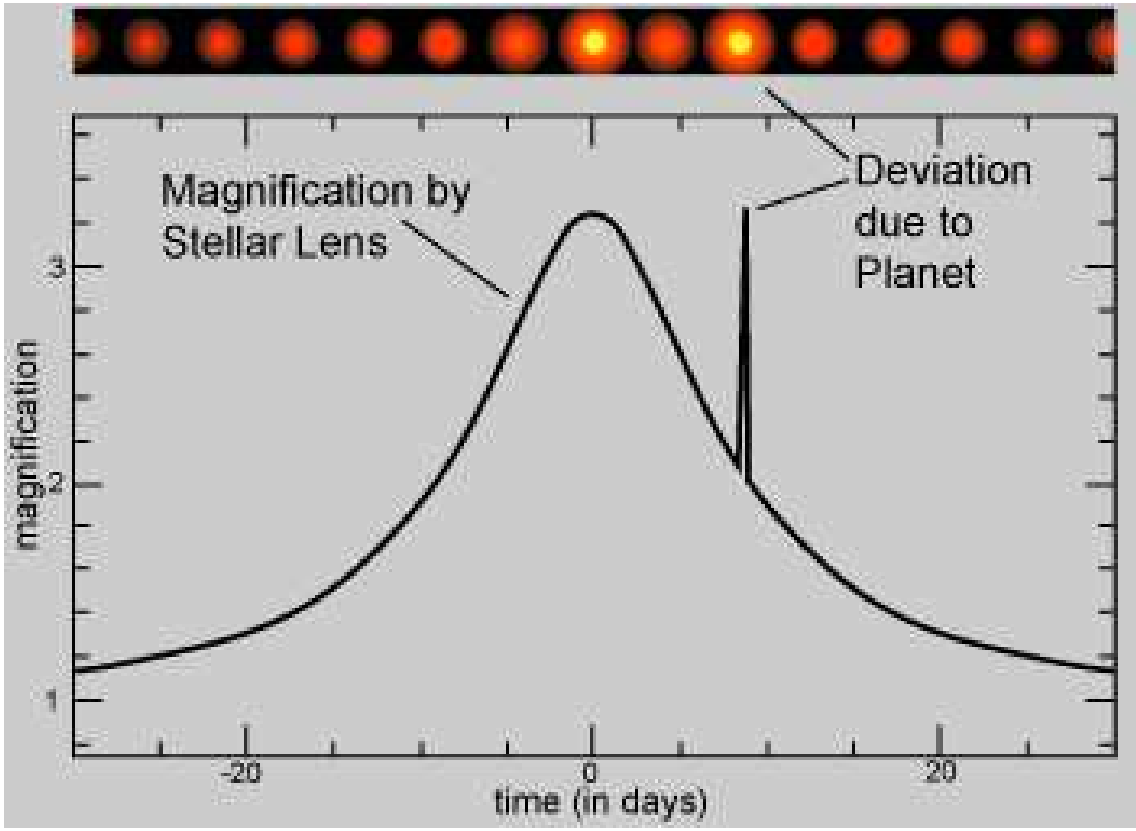




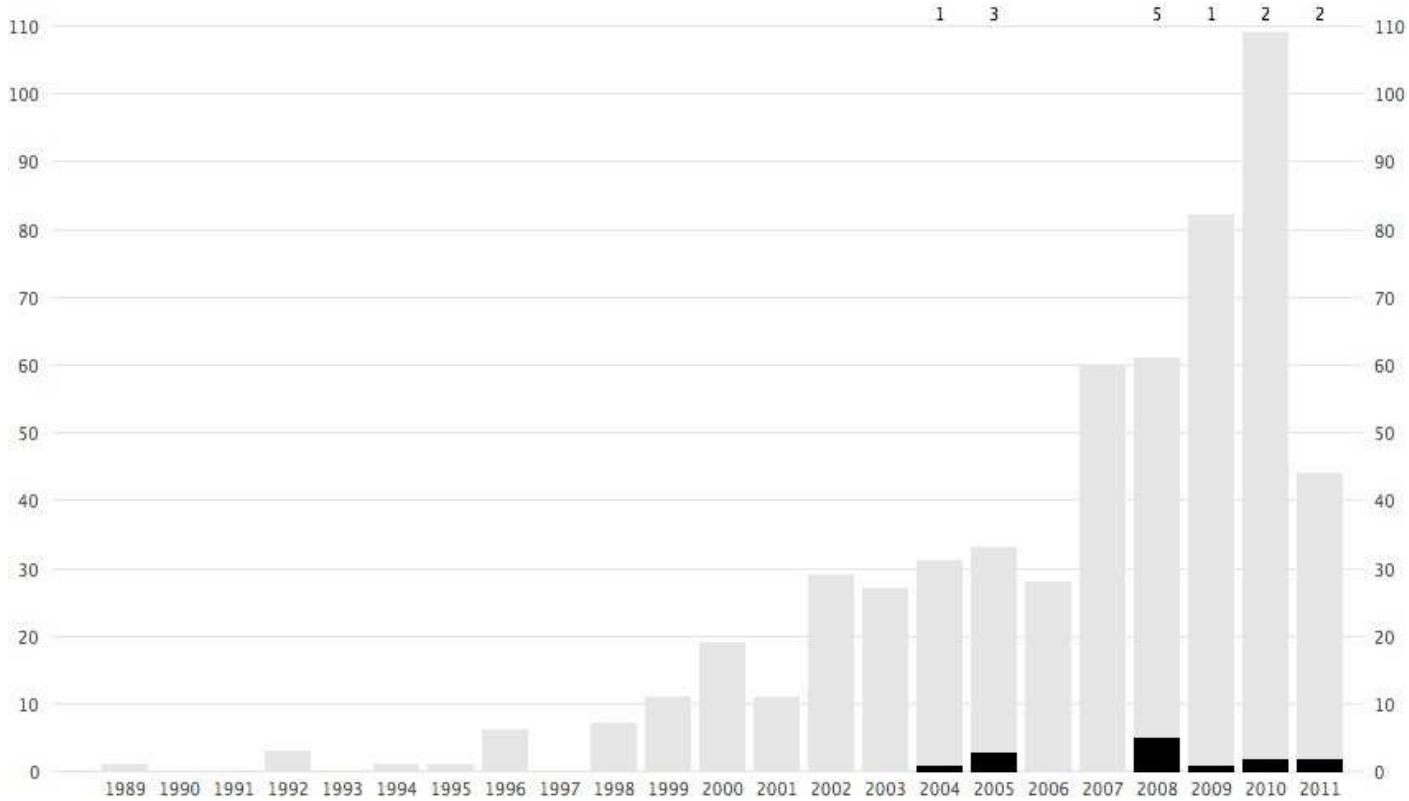
Größenordnung: 500 Ereignisse pro Jahr

Zu wenig, um die Dunkle Materie zu erklären!

Suche nach Exoplaneten
(Microlensing Planet Search Project)



Bisher gefundene Exoplaneten



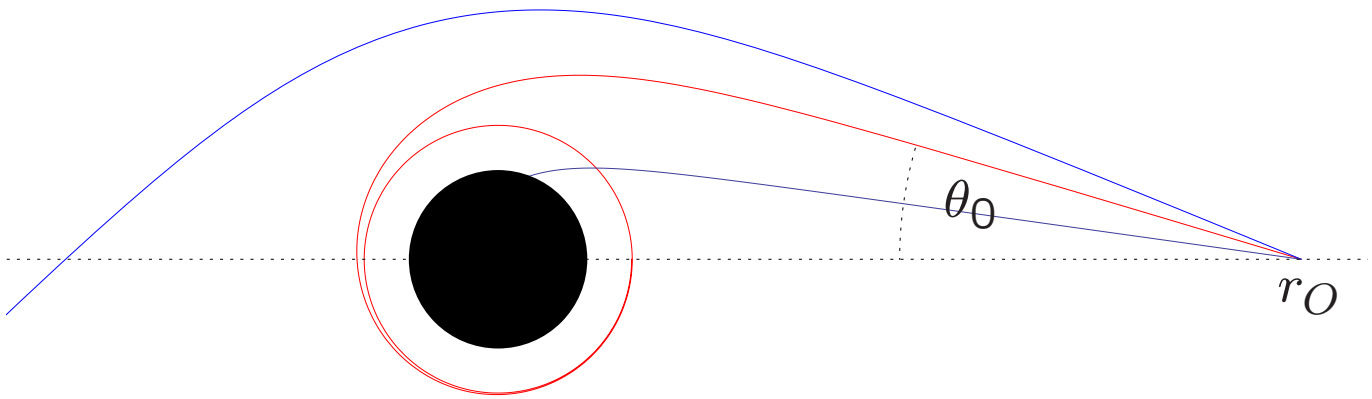
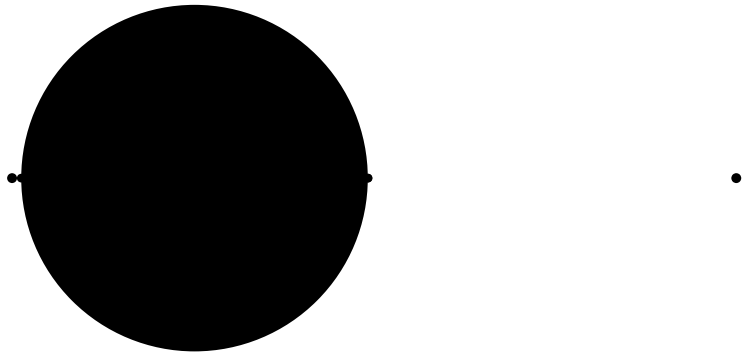
grau: insgesamt

schwarz: mit Microlensing

Visualisierung eines Schwarzen Lochs

Interstellar

Wissenschaftliche Beratung: Kip Thorne


θ_0
r_O