



Second Italy-Ukraine meeting in Astronomy

**MULTIWAVELENGTH ASTROPHYSICS FROM
RADIO TO GAMMA-RAYS**

Kharkiv, September 25, 2018

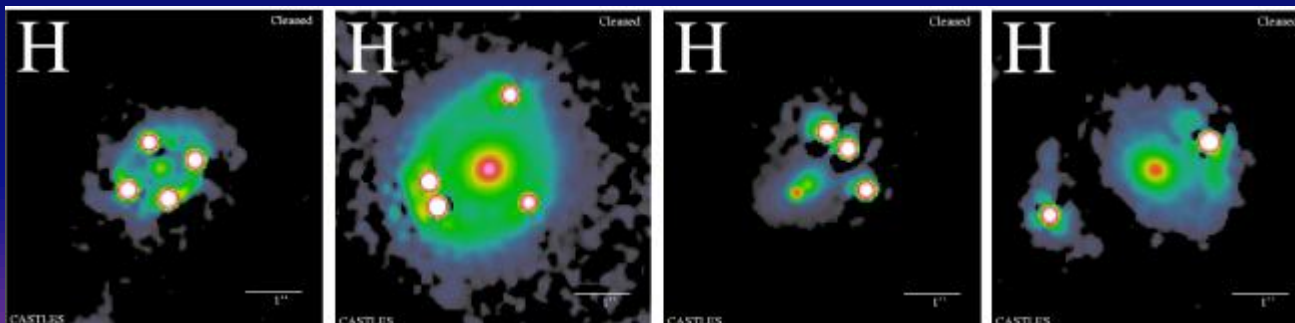
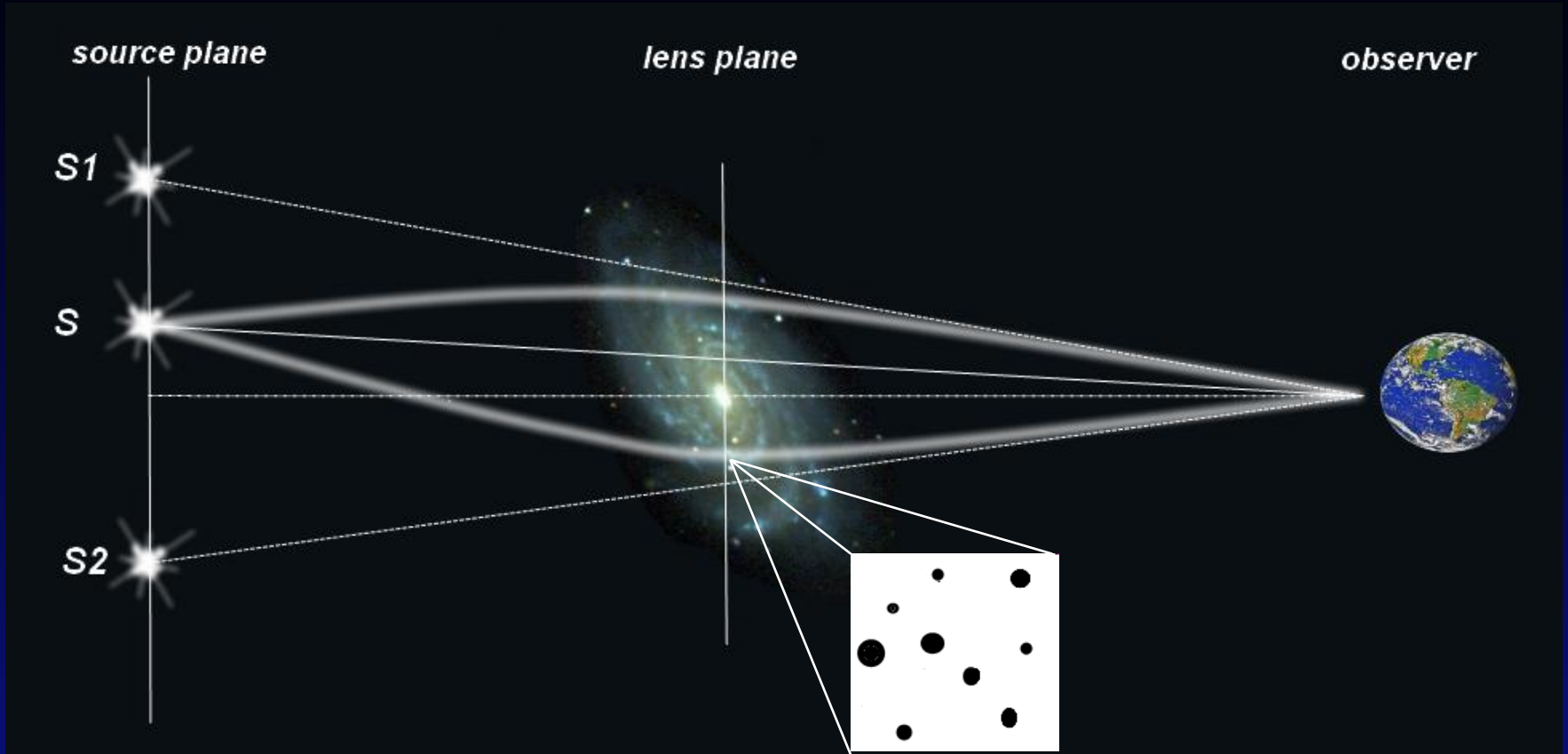
Investigations of Gravitational Lensing in Kharkiv

A. Zheleznyak

*Institute of Astronomy of V.N. Karazin National
University*



The phenomenon of the gravitational lens



HST / NICMOS

Theory of gravitational lensing

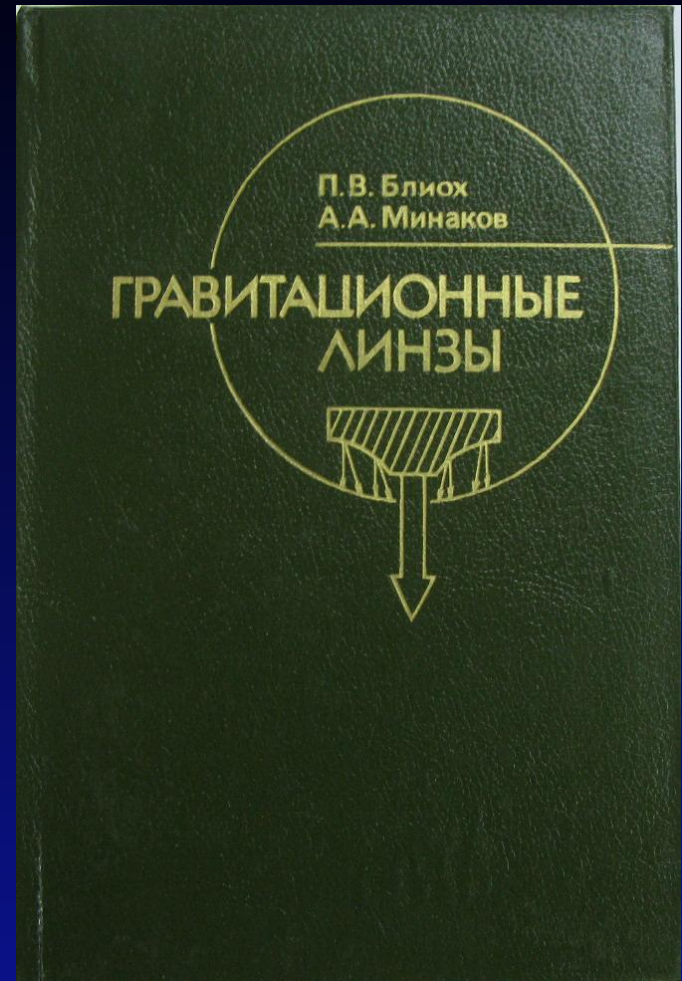


Pavel Bliokh
(1922 -2000)



Anatoly Minakov
(1949 -2012)

Book of P.Bliokh & A.Minakov
“Gravitational lenses”, 1989 (in russian)

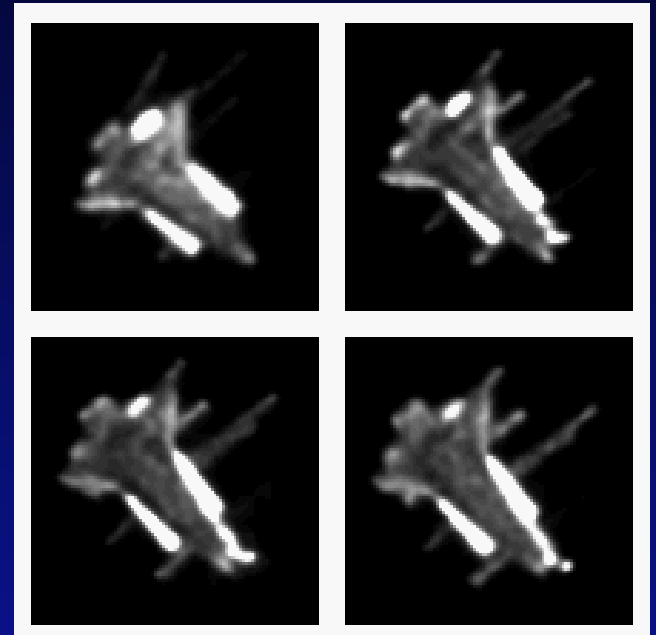


Department of astrophysics



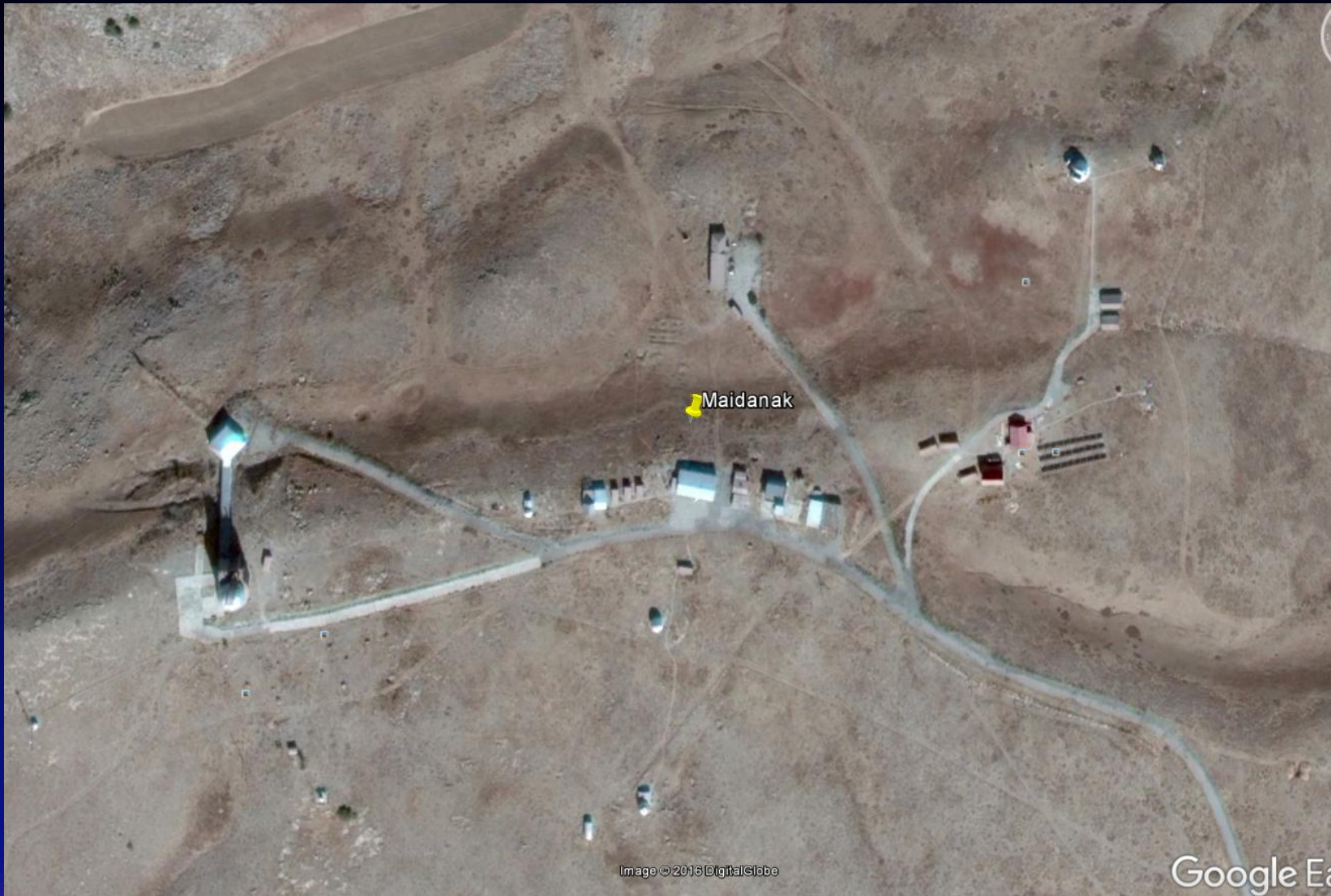
Members of Department of Astrophysics
Institute of Astronomy
V.Karazin National University (2007)

- *high – resolution imaging*
- *image processing*
- *speckle- interferometry*



Images of Mir-Atlantis complex

Maidanak observatory



AZT-22 telescope



Tower of AZT-22

- *climate control system*
- *forced dome ventilation*



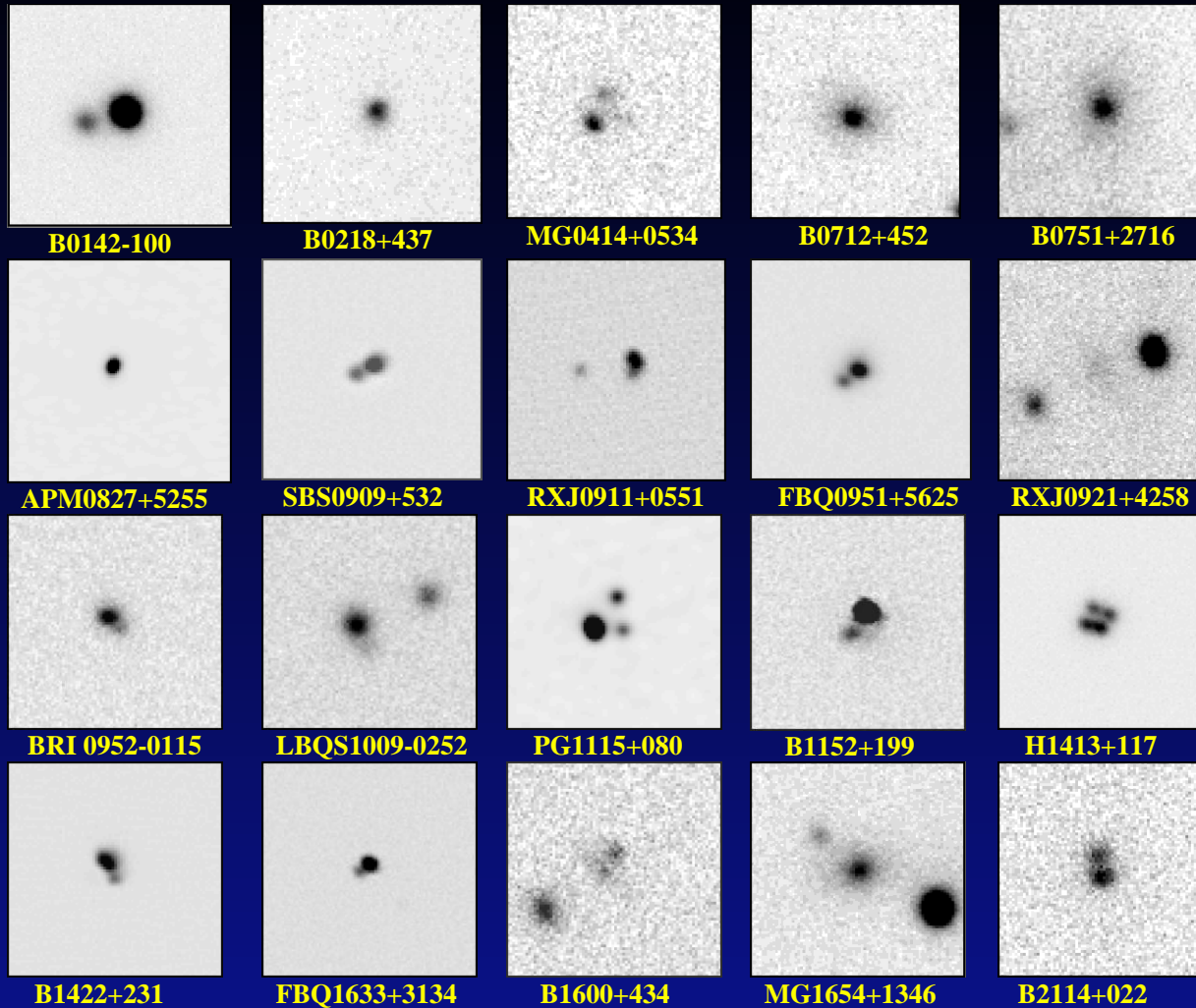
AZT-22 telescope

- *1.5 m Ritchey-Chretien (F/7.7 & F16)*
- *diffraction-limited optics*

Maidanak observatory 1991

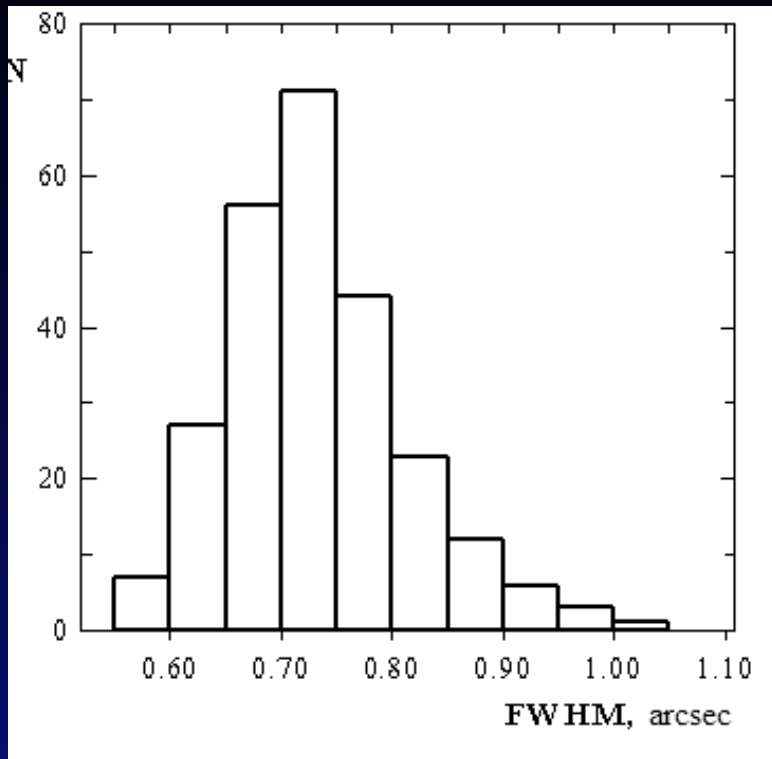
- *Institute of Astronomy of V.N.Karazin National University*
 - *Institute of Radioastronomy of National Academy of Science of Ukraine*
 - *Ulug Beck Astronomical Institute of Academy of Science of Uzbekistan*
 - *Sternberg Astronomical Institute of Moscow University*
-
- *first CCD observations of GLQ (Q2237+0305) - 1995*
 - *regular monitoring of lensed QSO – since 1997*

Lensed QSO sample

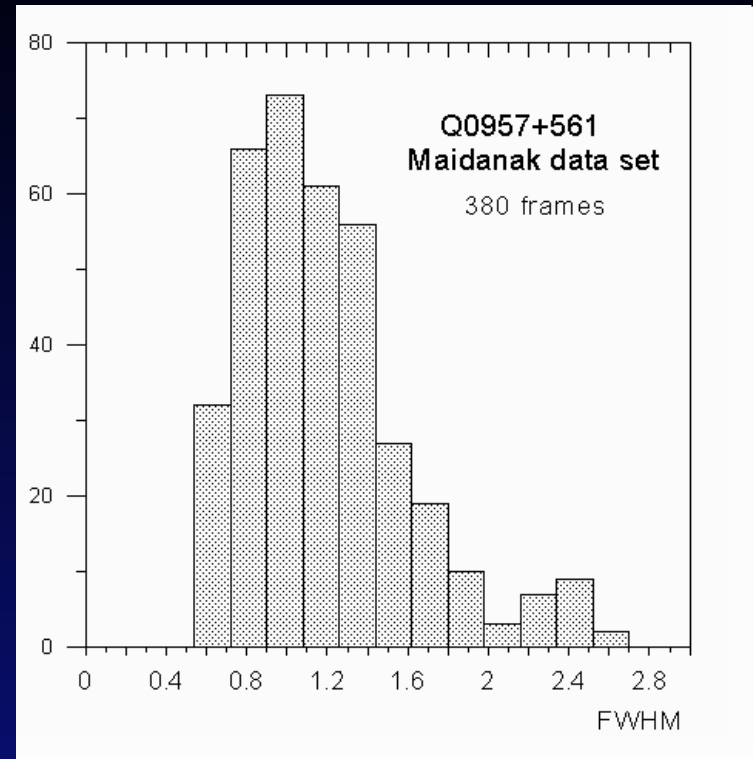


Part of Initial sample of lensed QSO for observation with AZT-22

Maidanak observatory

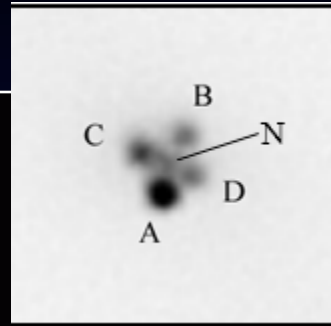


*Seeing estimation (FWHM) distribution
– one good night on June 2005*



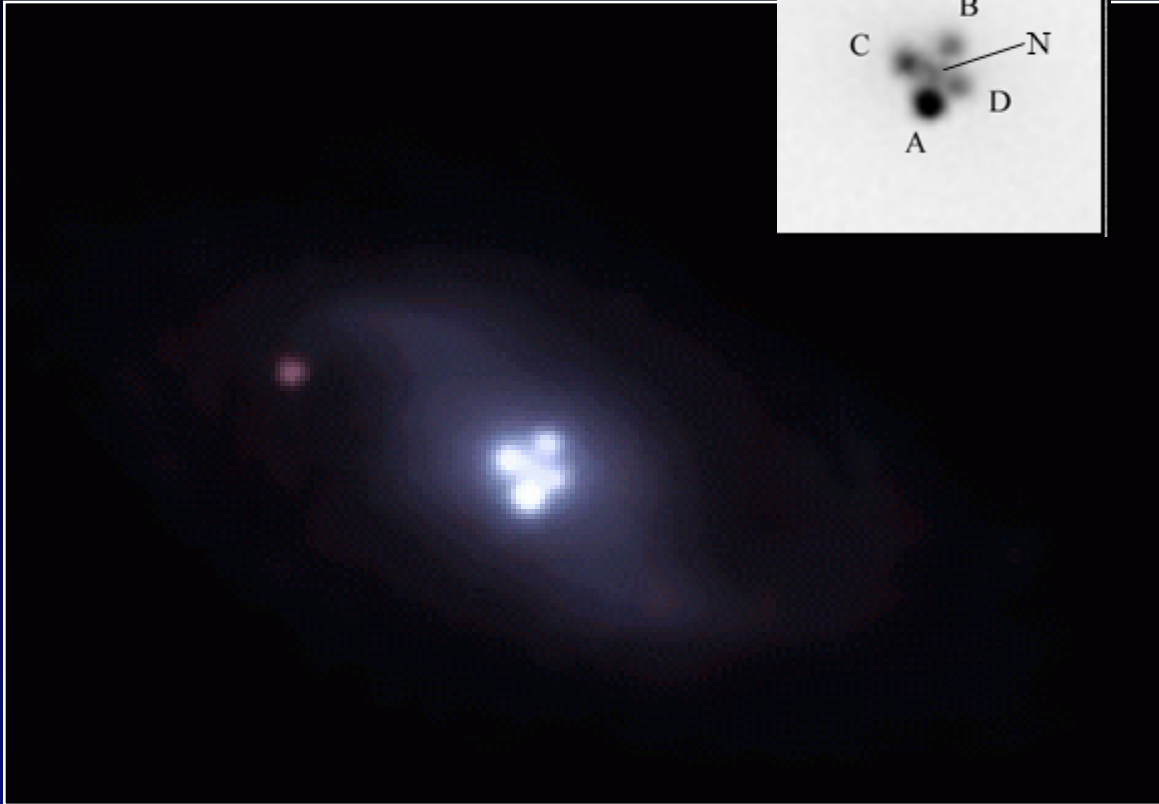
*Seeing estimation (FWHM) distribution
– 6 nights on March 2001*

Q2237+0305 "Einstein Cross"

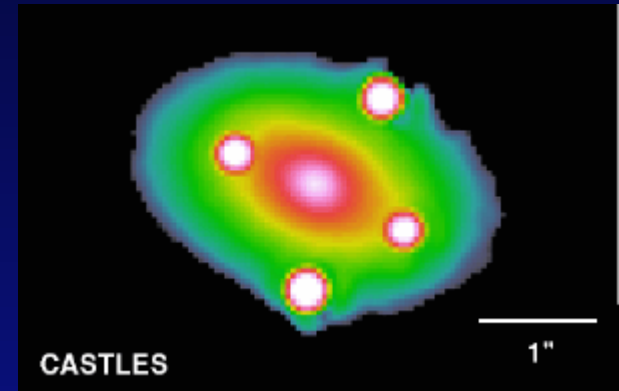


$$Z_S = 1.7$$

$$Z_L = 0.04$$

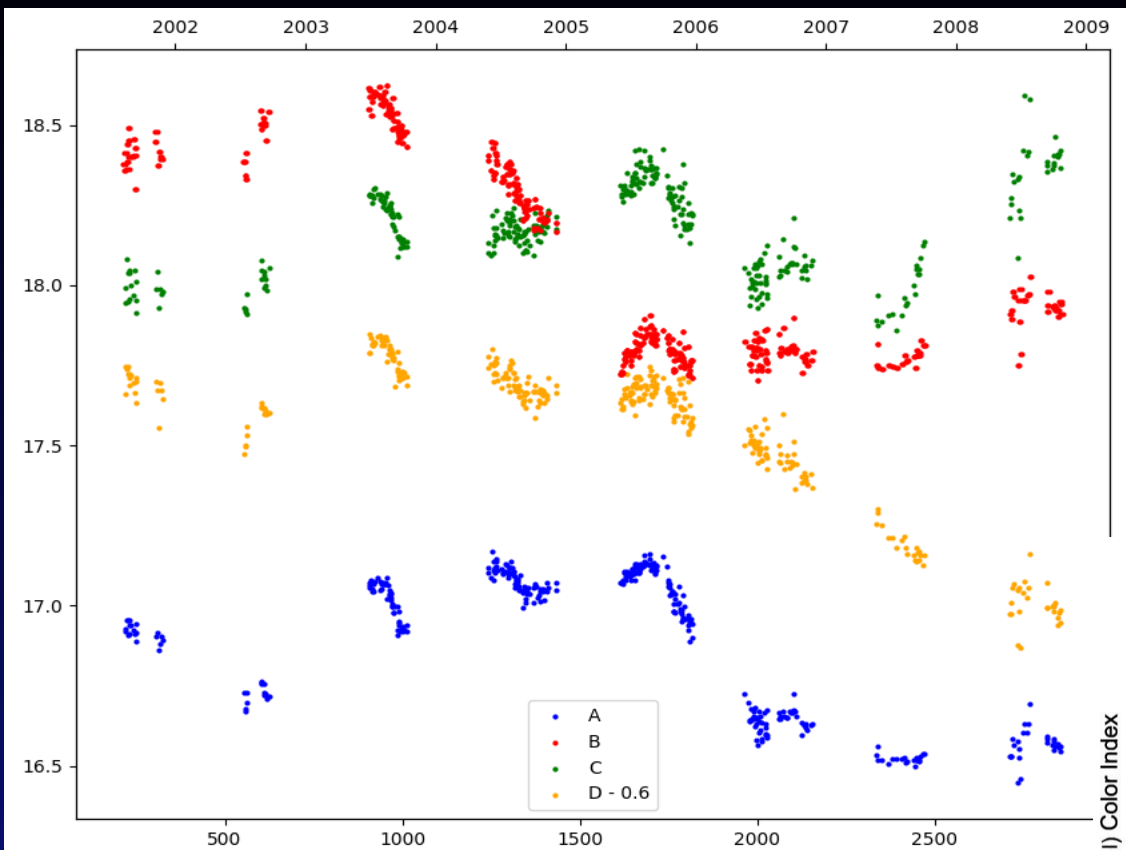


Pseudo-color VRI image of Q2237+0305, obtained with AZT-22 telescope (FWHM 0.7")

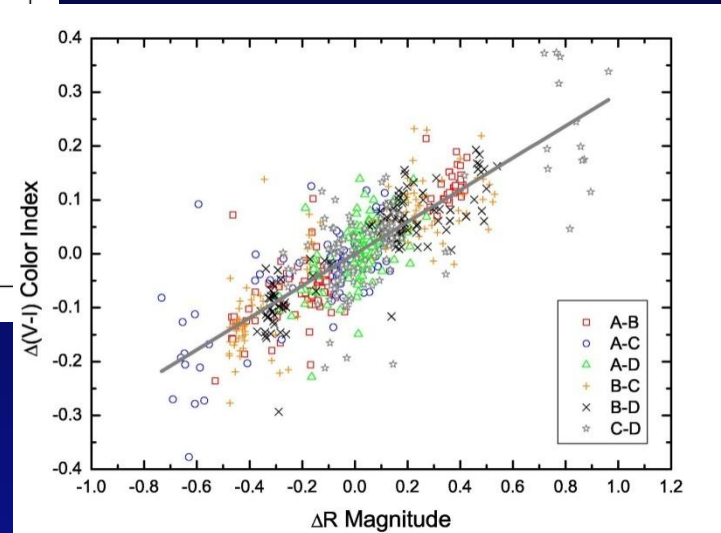


HST / NICMOS image of Q2237+0305

Q2237+0305 "Einstein Cross"

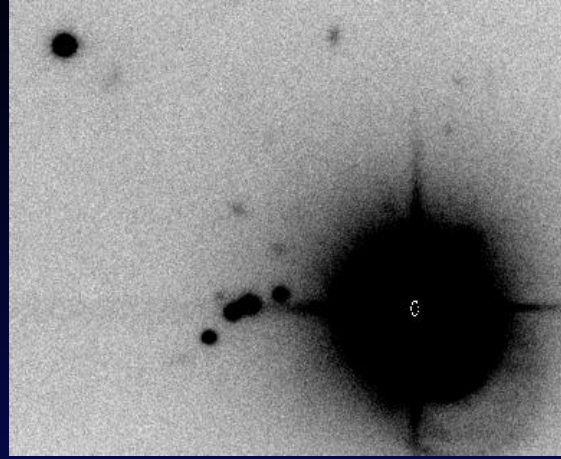
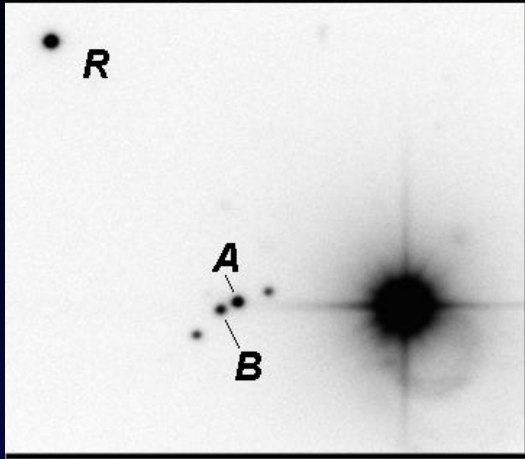


Historical lightcurve of A-D component of Q2237+0305 in R band



Color changes of A-D component

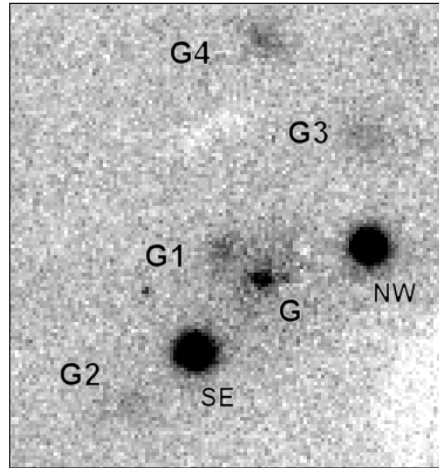
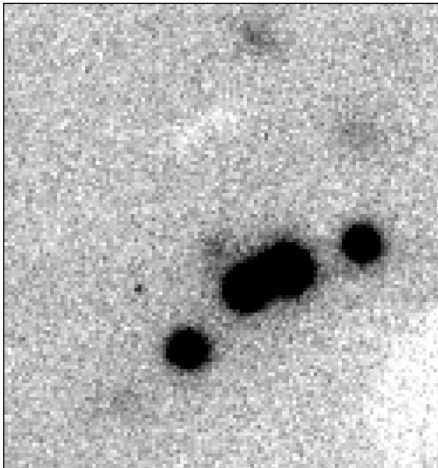
Lensed QSO SBS1520+530



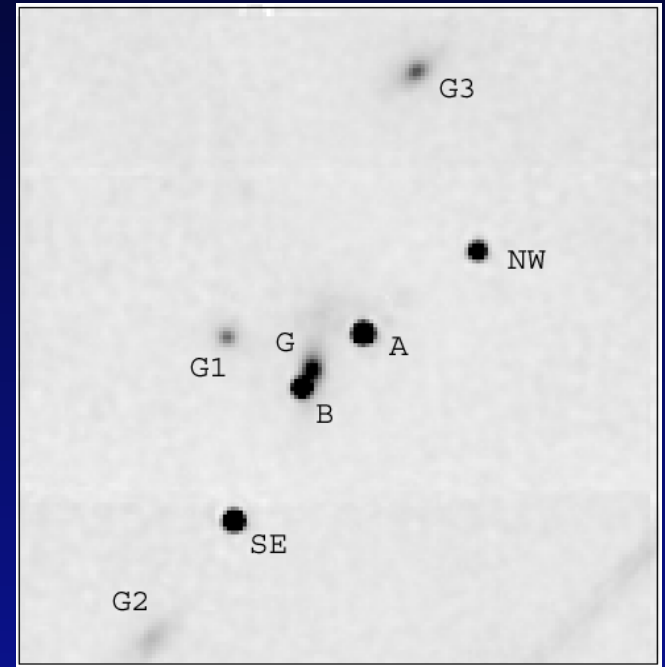
$$Z_S = 1.85$$

$$Z_L = 0.72$$

image of SBS1520+530, obtained with AZT-22

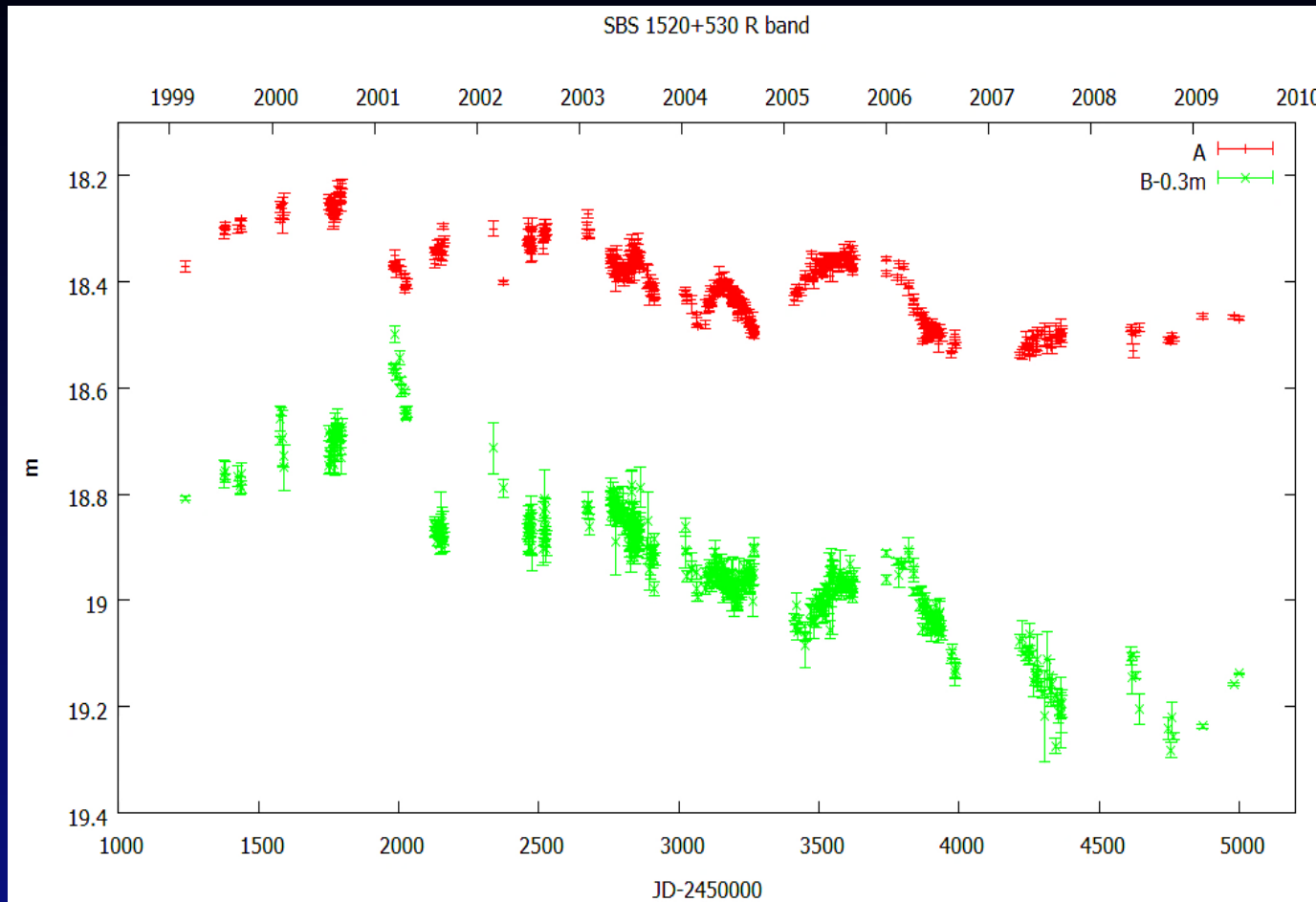


Lensing galaxy and galaxies in the field of SBS1520+530 components in I band



HST / NICMOS image of SBS1530+530

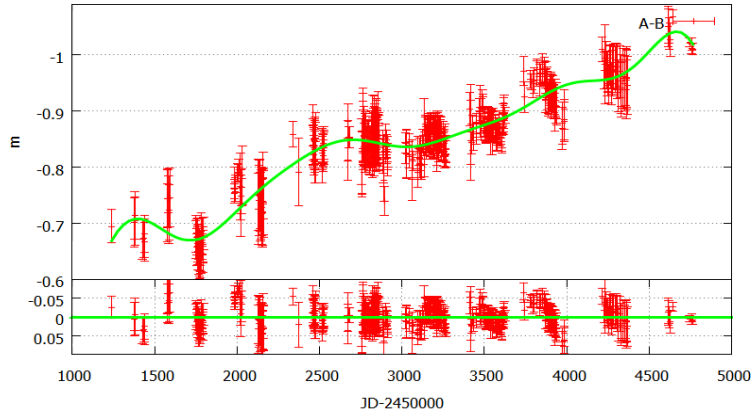
Lensed QSO SBS1520+530



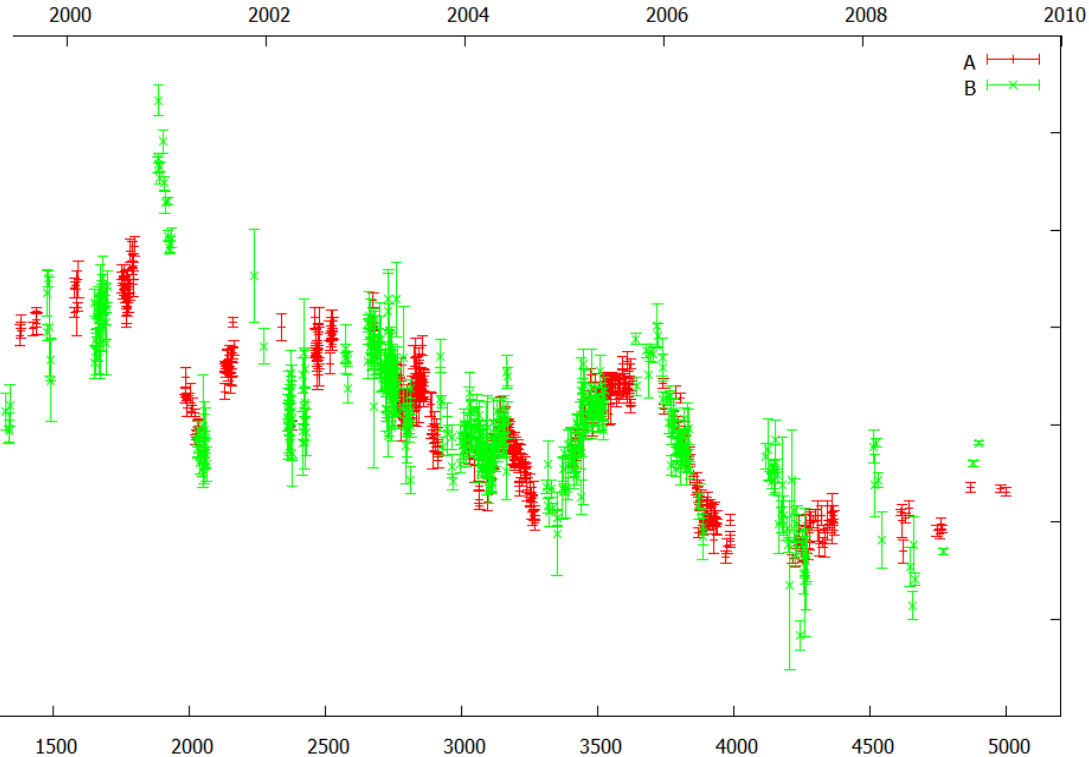
Historical lightcurve of A and B component of SBS 1520+530 in R band

Lensed QSO SBS1520+530

Microensing curve of SBS 1520+530 band R



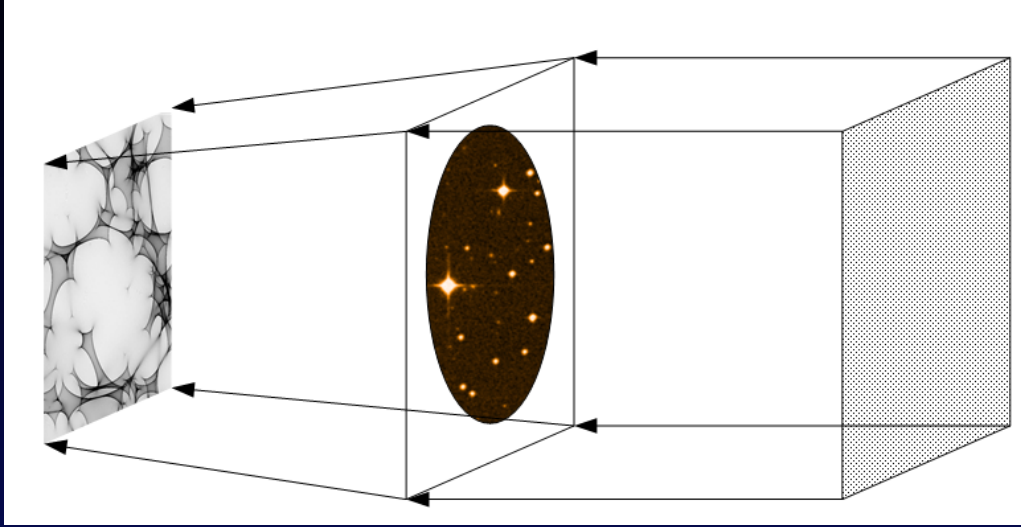
Microensing lightcurve of SBS1520+530



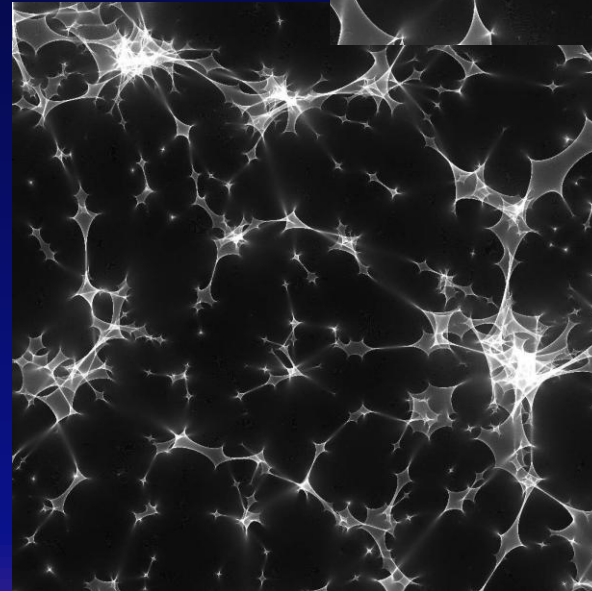
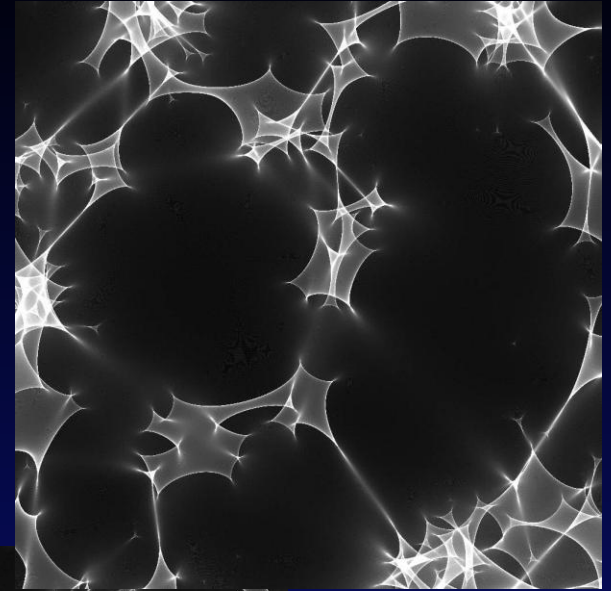
Time delay
 $dt_{AB} = 96.4$ days

Combined A-B lightcurve representing own variability of QSO-source of SBS1520+530

Microlensing modeling

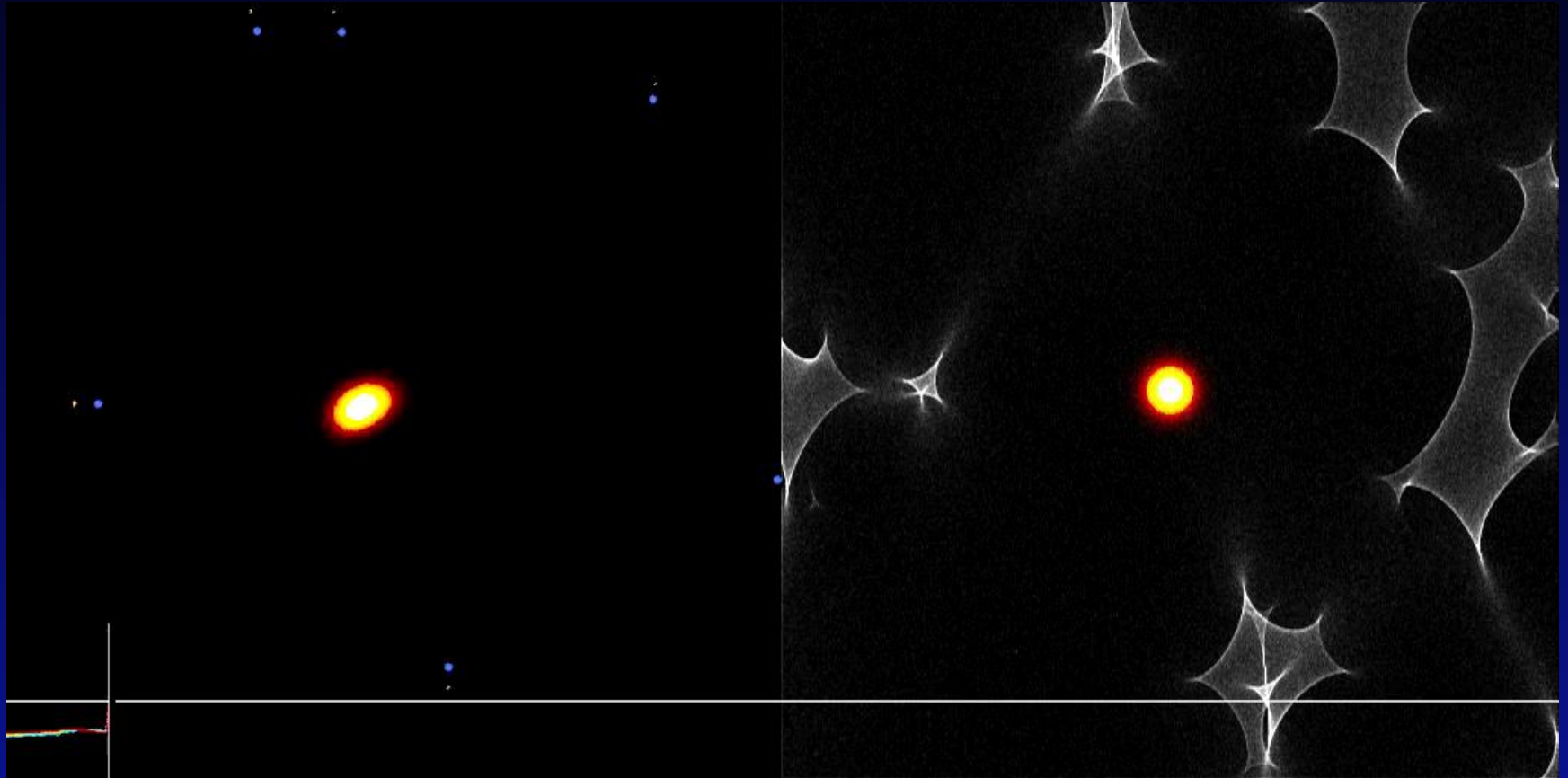


The principle of Ray-shooting method

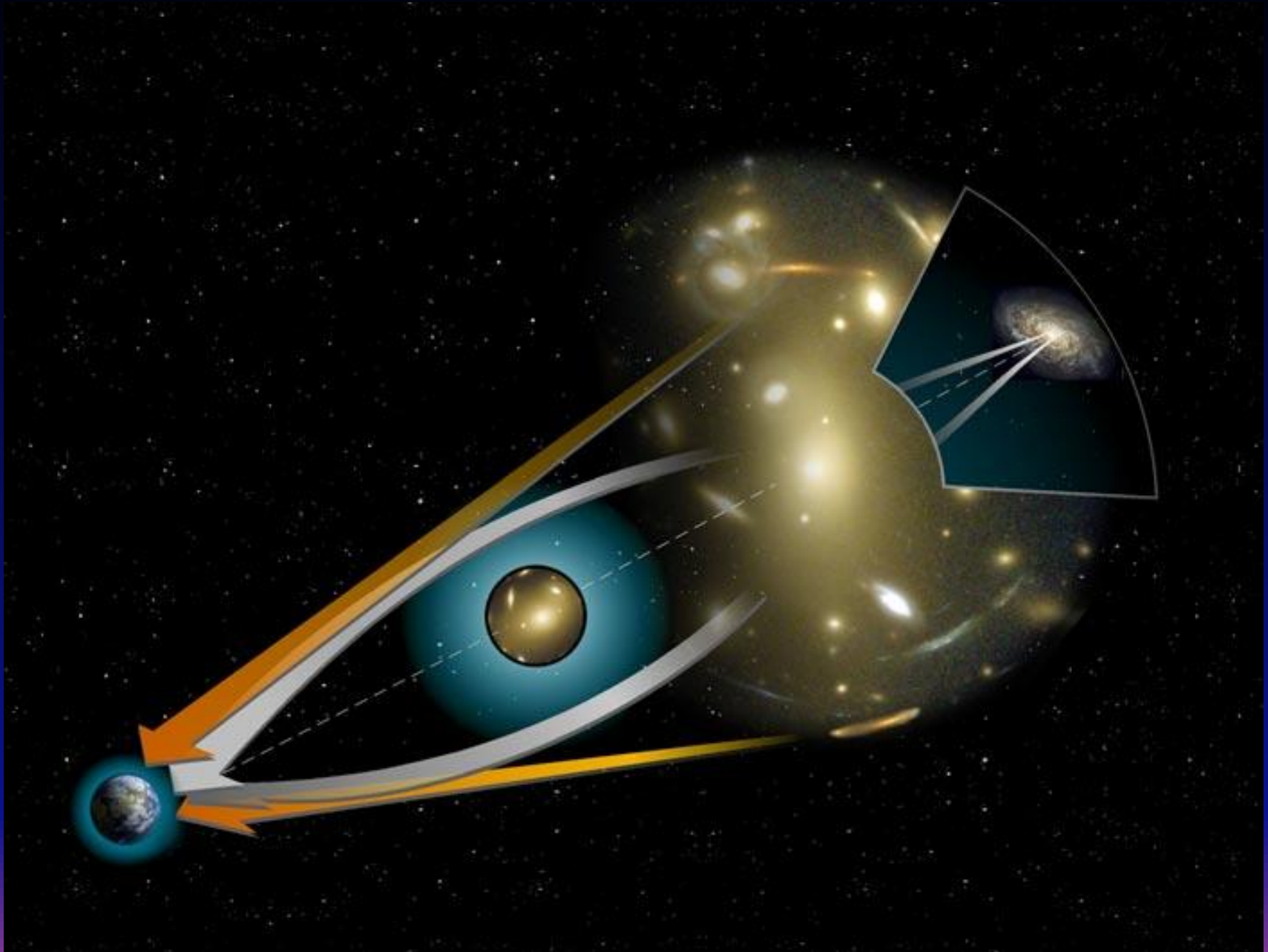


Example of caustic patterns for different mass of microlenses

Microlensing modeling with GPU

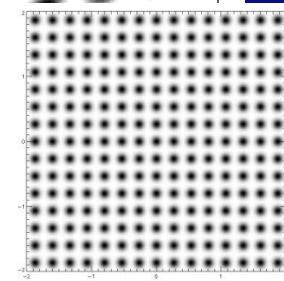
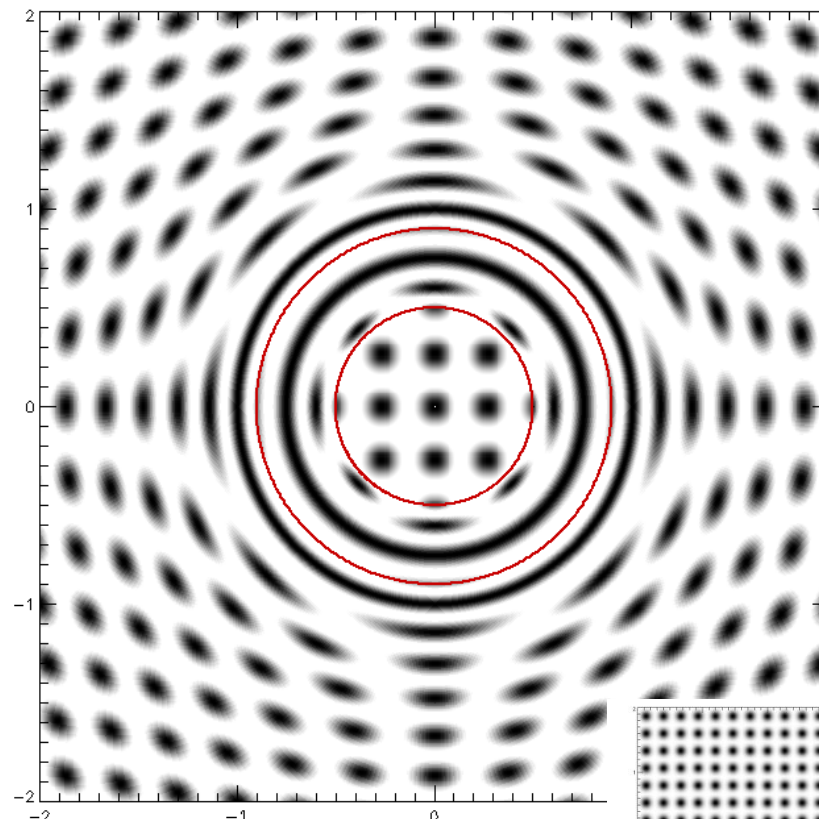
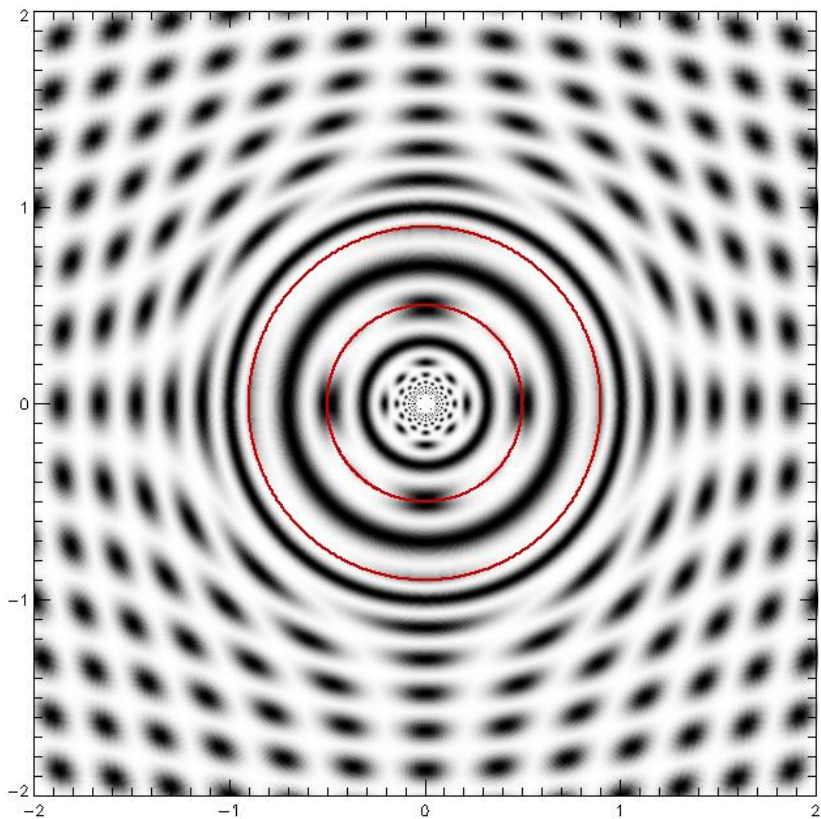


What can we see if a gravitational lens is a ring galaxy?



Three Einstein rings: explicit solution and numerical simulation

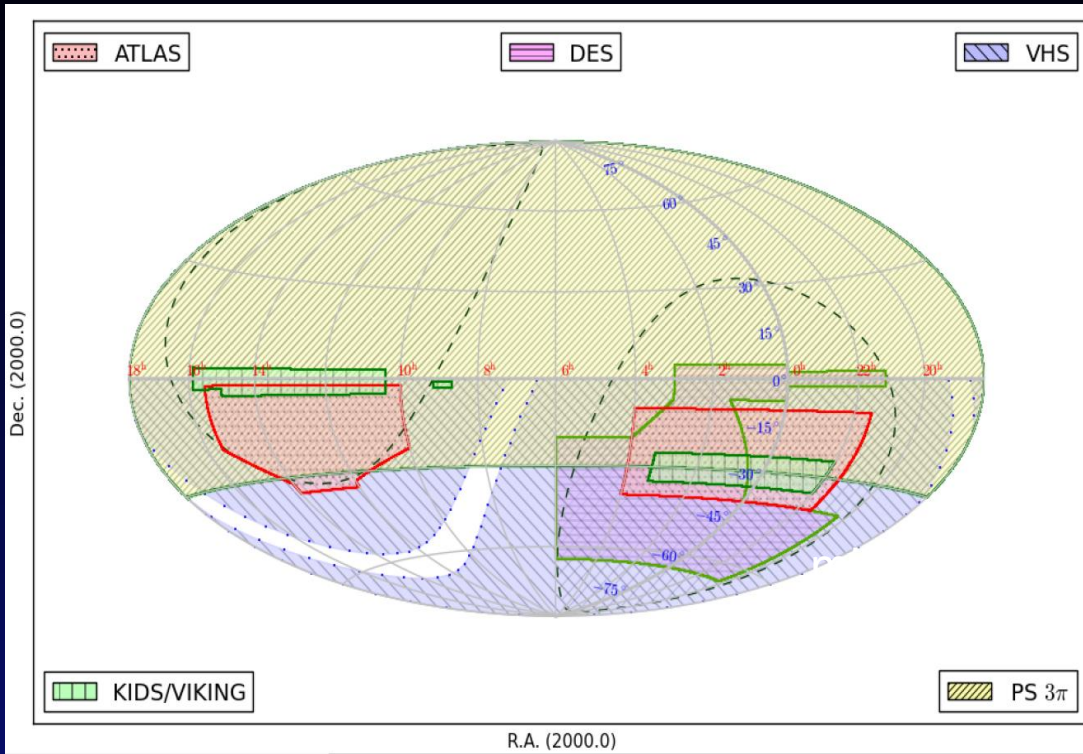
E. Yu. Bannikova^{1,2}★ and A. T. Kotvytskiy^{1,2}



Central mass + disk $\mu_{\text{disc}}=0.9, \mu_{\text{disc}} + \mu_{\text{c}}=1$

Only disk $\mu_{\text{disc}}=1.0$

Era of digital sky



The sky coverage map of digital sky surveys



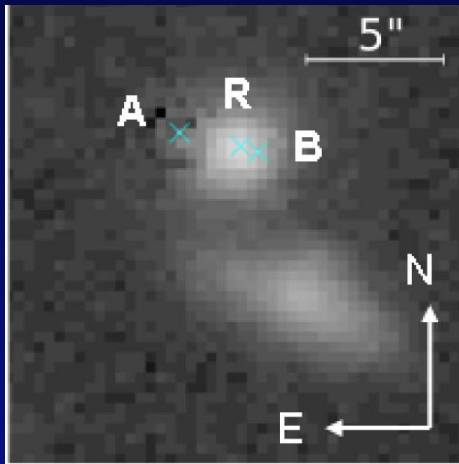
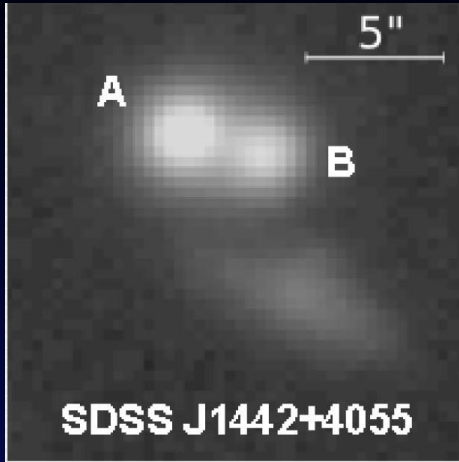
VST Surveys - KIDS, ATLAS



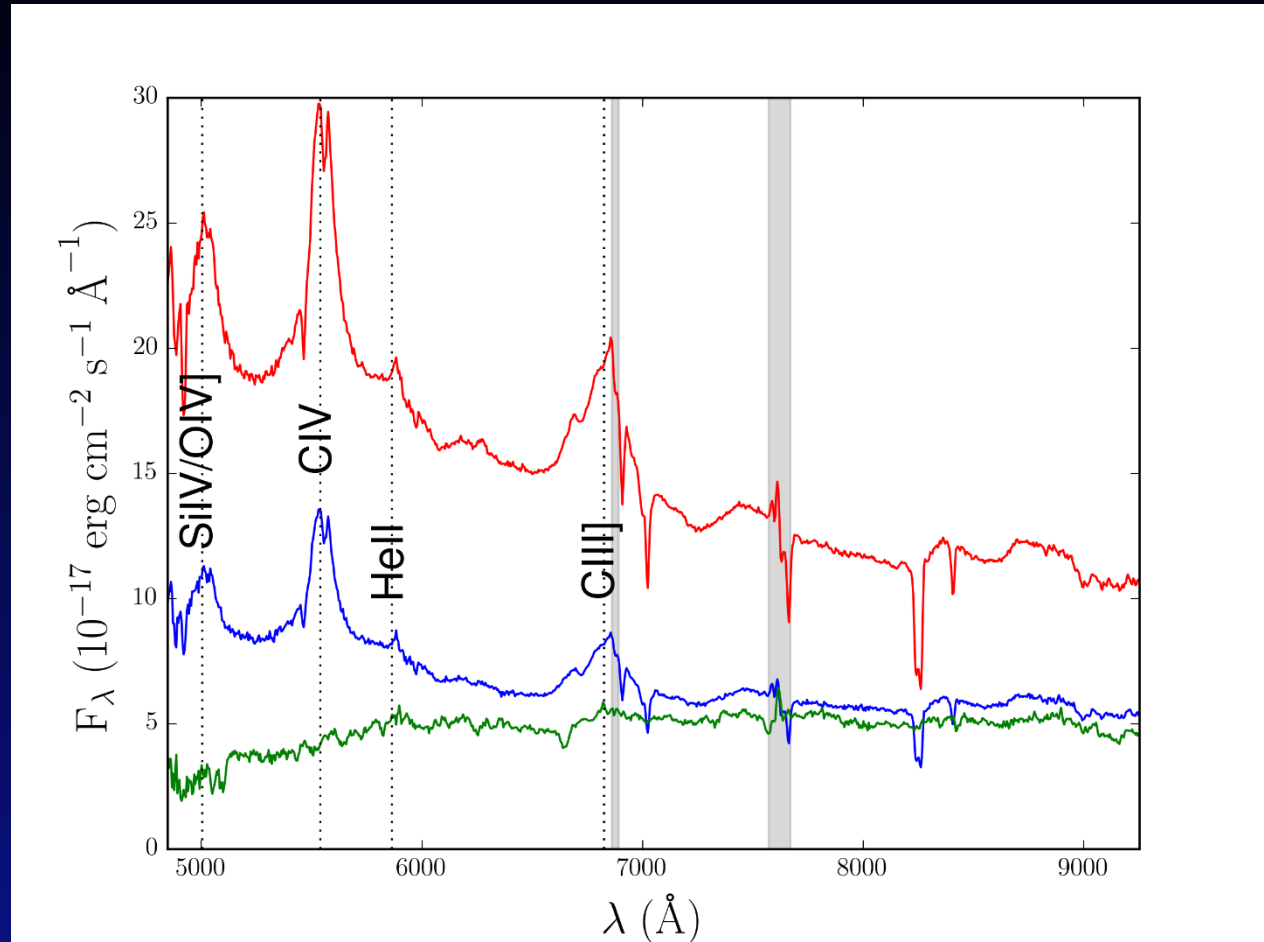
GAIA



The new lensed QSO SDSSJ1422+4055



AZT-22 R band, 1h



Spectra of A,B and galaxy, GTC



Thank you for attention