Astrophysical Research

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Astrophysical Research in Kharkiv

- Theoretical investigations of Active Galactic Nuclei
- Dynamics of galaxies
- Spectroscopy of interstellar molecules
- Gravitational lensing effects
  - Modeling
  - Long-term monitoring
  - Searching of new lensed quasars

Dusty torus in AGNs: unified scheme

- The observational properties of AGNs are explained by the different orientation of the torus relative to an observer

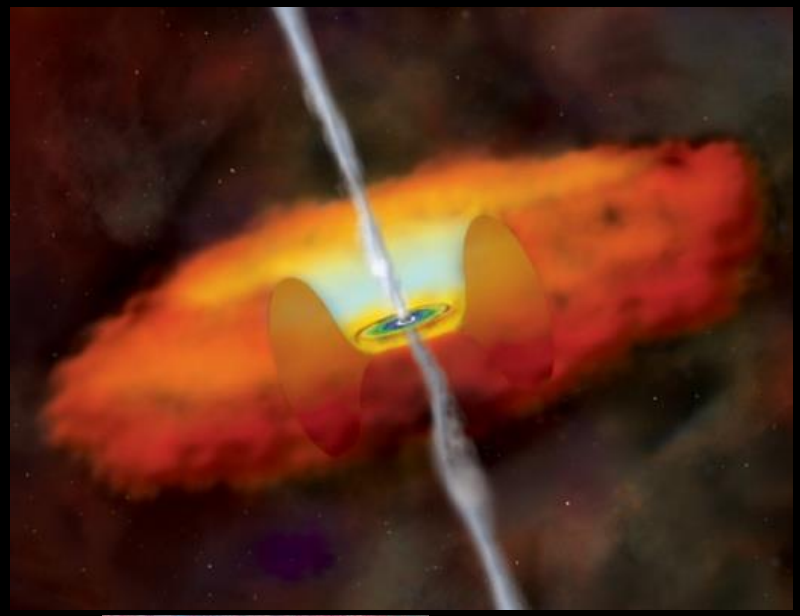
Antonucci ,1985,1993

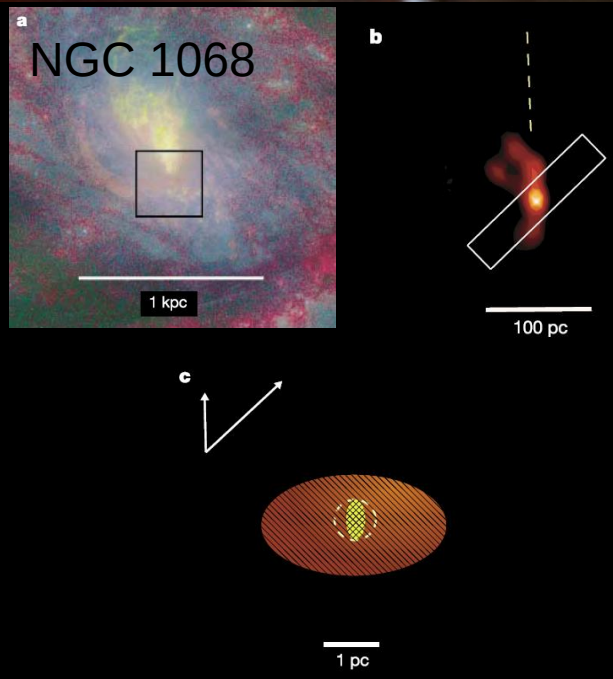
Main properties of a torus
- Geometrically thick
- Clumpy structure
- Parsec scale

Rotation curves (water masers 1.35cm)
Greenhill et al. 1996; Gallimore 1996

- VLTI/MIDI: 10 mas (λ≈10μm)
- Thermal emission of dust
- The first direct resolution of torus

Jaffe et al. 2004





ALMA observations of a torus in NGC1068

- **January 2018**
- **Resolution is 40 mas**

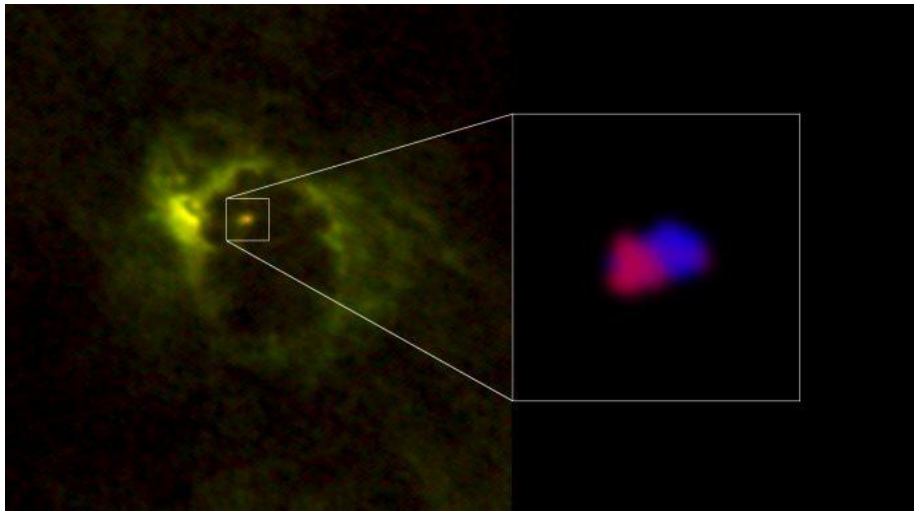
✓ The motion in the torus is far from Keplerian.

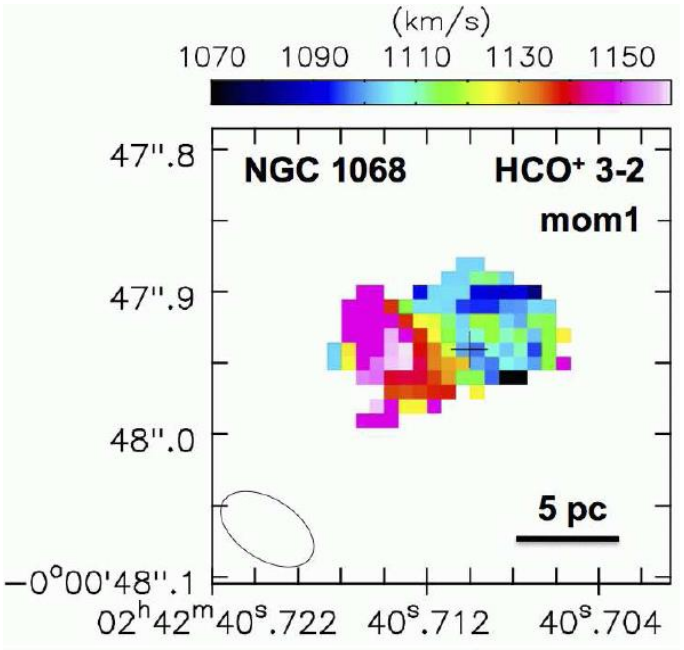
✓ The rotational velocity to be $v/\sin(i) \approx 20$ (km s^{-1}) at distance $r \approx 3$pc from the mass-accreting SMBH

✓ The mass inside the rotating molecular disk is $9 \times 10^5 M_\odot$, which is much lower than the early estimated SMBH mass.

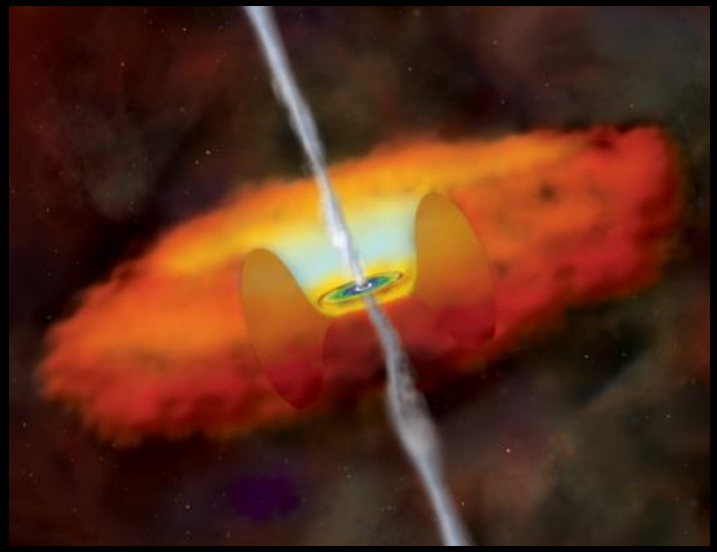
How can we explain these observations ?

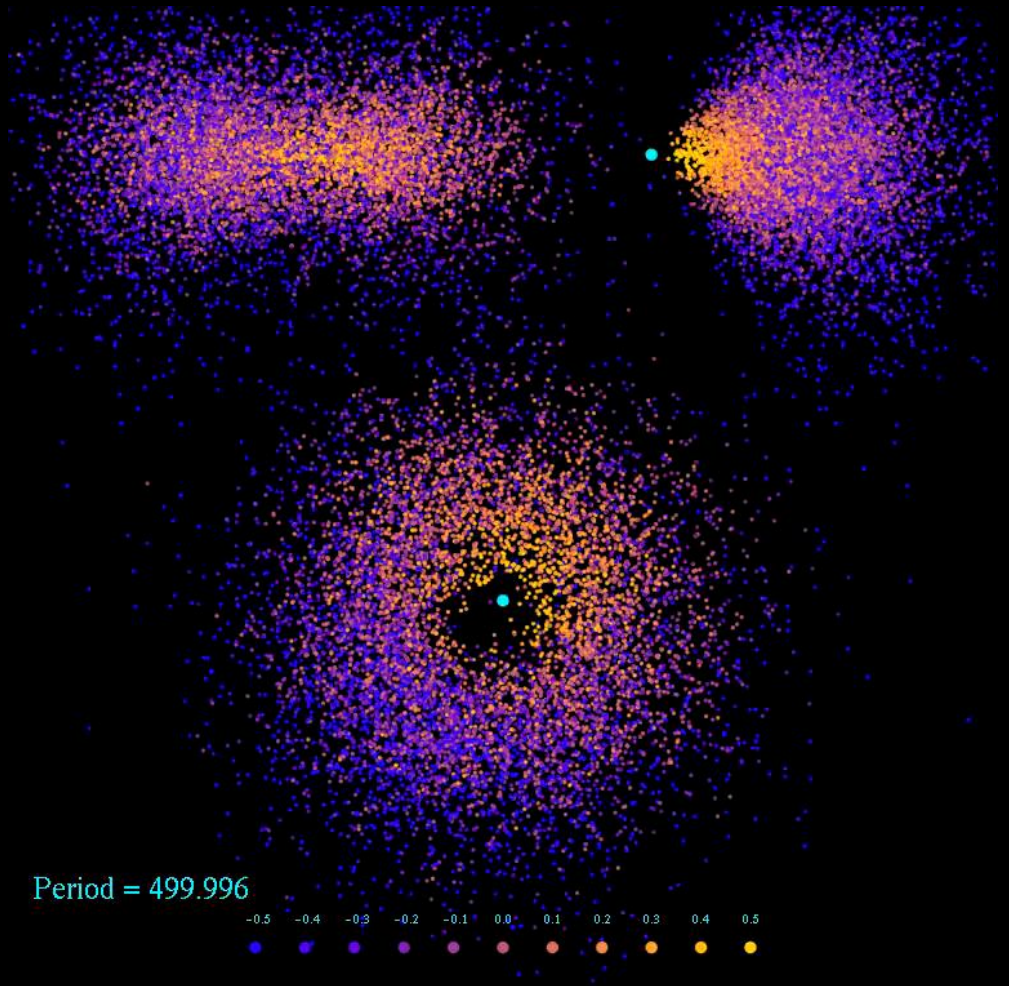
Imanishi et al., 2018





Theoretical model of active galactic nucleus (AGN)





- N-body simulation of clumpy torus taking into account the dissipation effects and influence of winds.

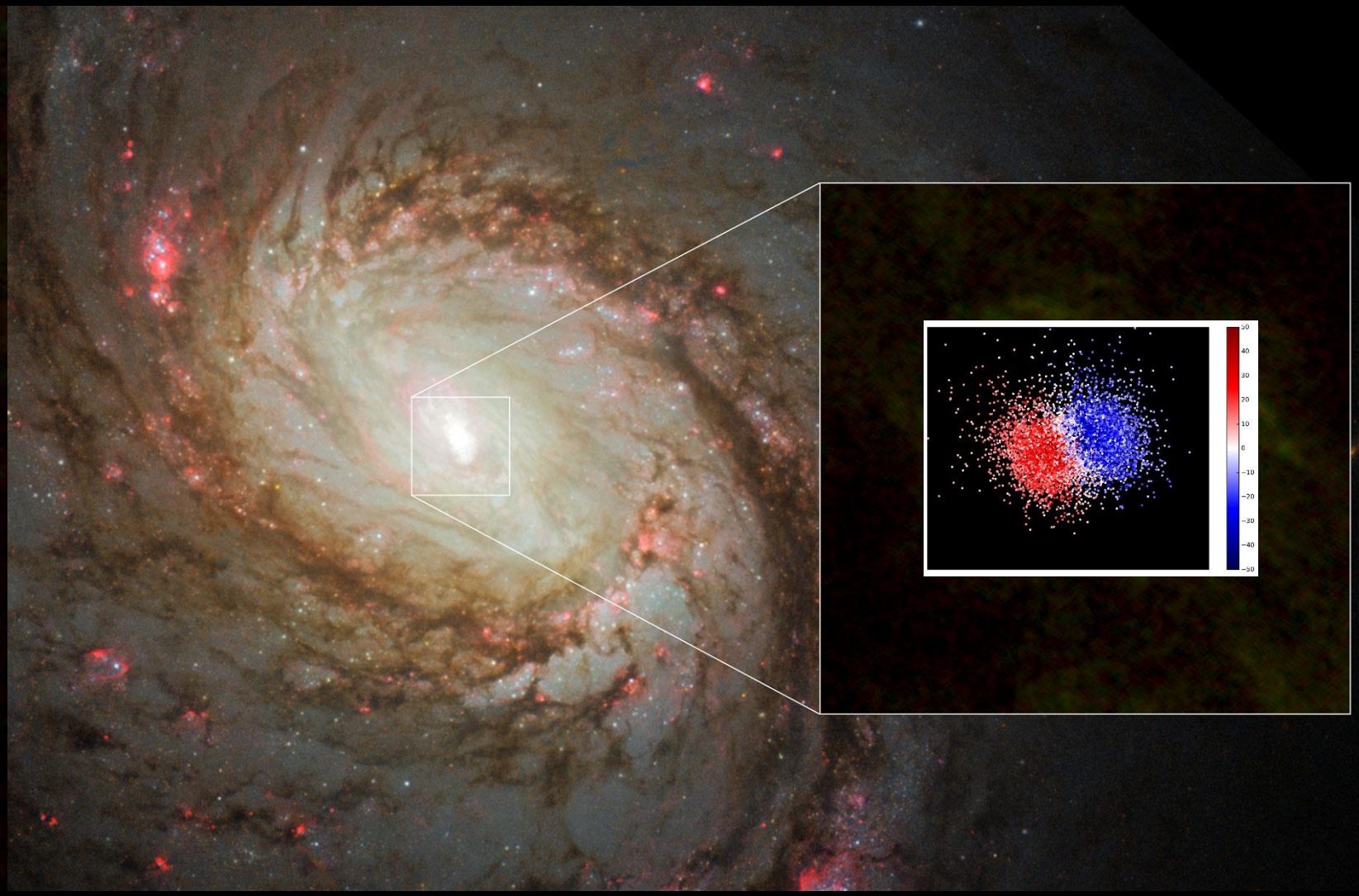
- Investigation of thick torus stability and its role in the evolution of AGNs.

- Explanation of non-Keplerian rotation and observational velocity dispersion in the obscuring tori of Sy 2 galaxies

Bannikova&Sergeyev, 2017
Bannikova et al,2012, MNRAS

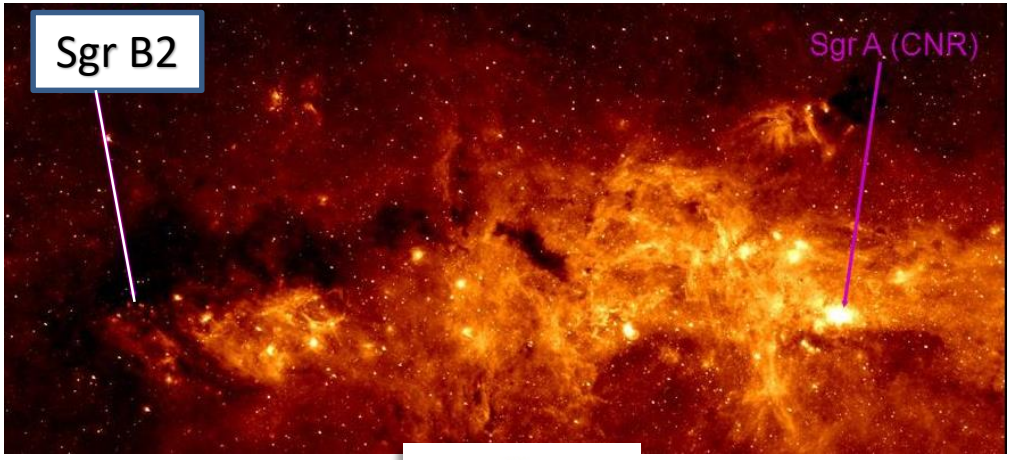
ALMA observations: torus in NGC1068

N-body simulation of clumpy torus

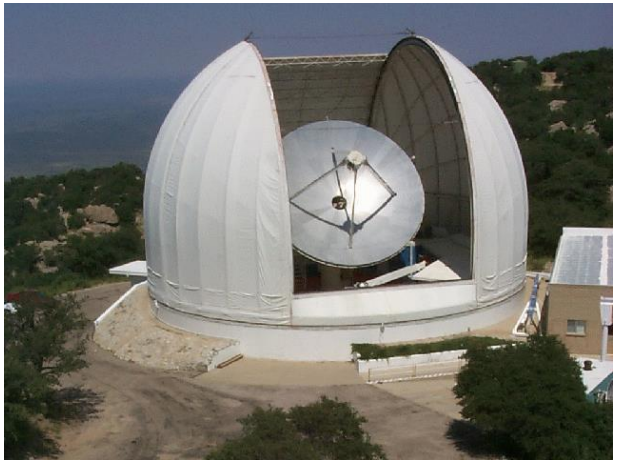


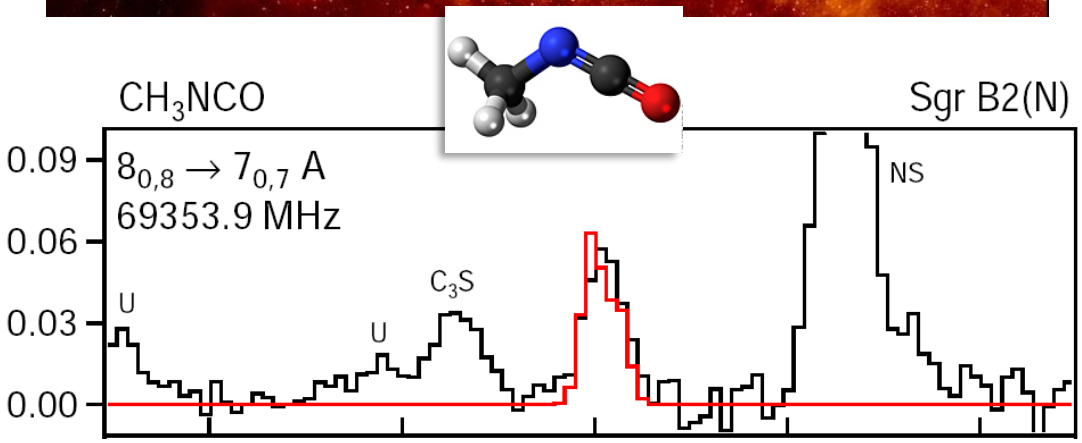
Detection and identification of interstellar molecules

Galactic Center, Sgr B2(N)



Arizona Radio Observatory (ARO):
12m ALMA prototype antenna





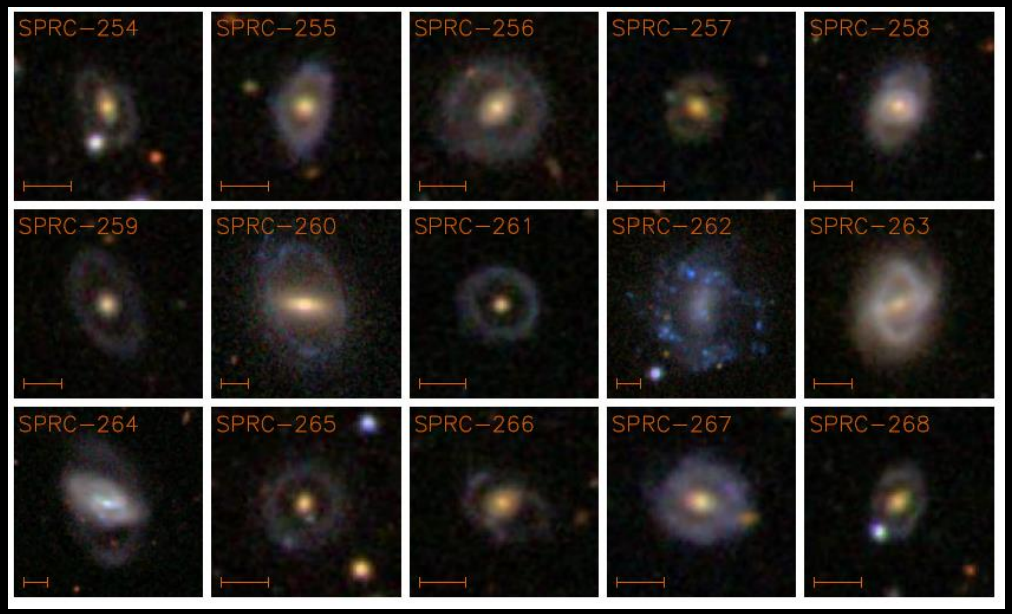
Identification of **CH_3NCO** molecule (methyl isocyanate)

Halfen, Ilyushin et al. 2015

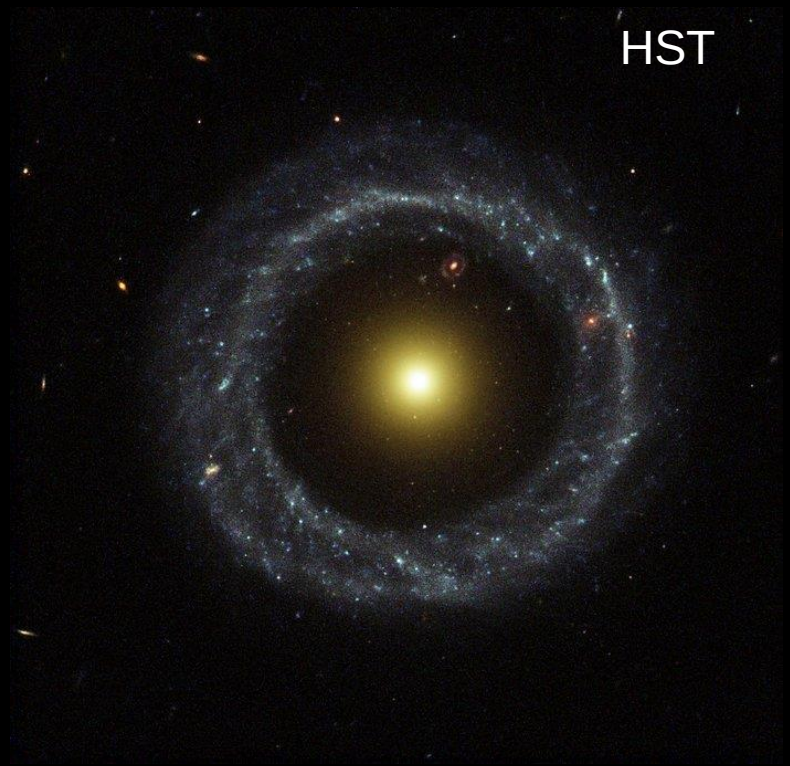
3 from ~190 molecules are identified by spectroscopy team in Radio Astronomy Institute.

Dynamics in Hoag-like ring galaxies

Catalog by Moiseev et al., 2011



HST



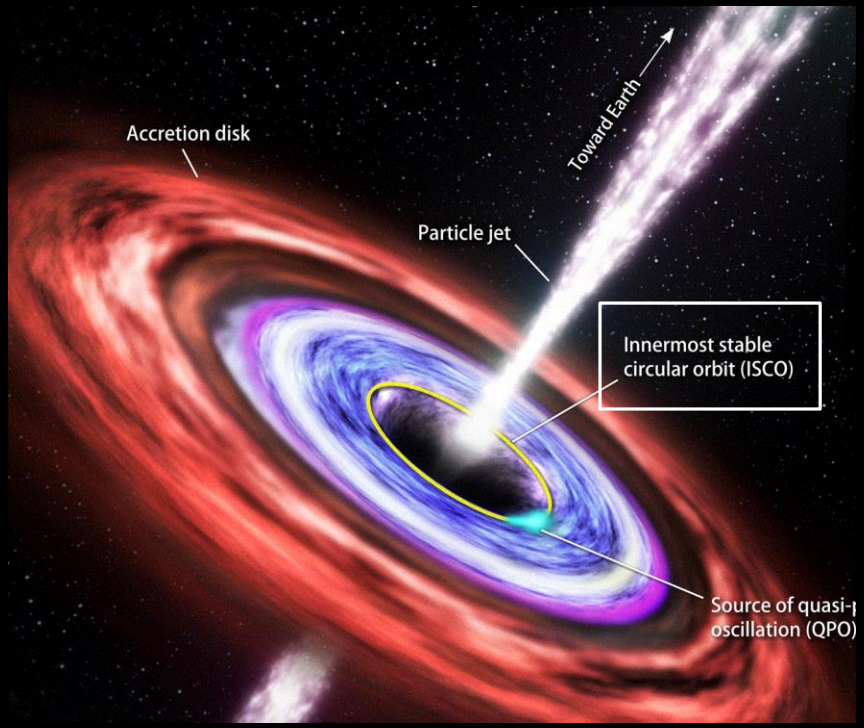
- The mass of the central galaxy is comparable to the mass of the ring

Dynamics in Hoag-like ring galaxies

Black Hole

ISCO

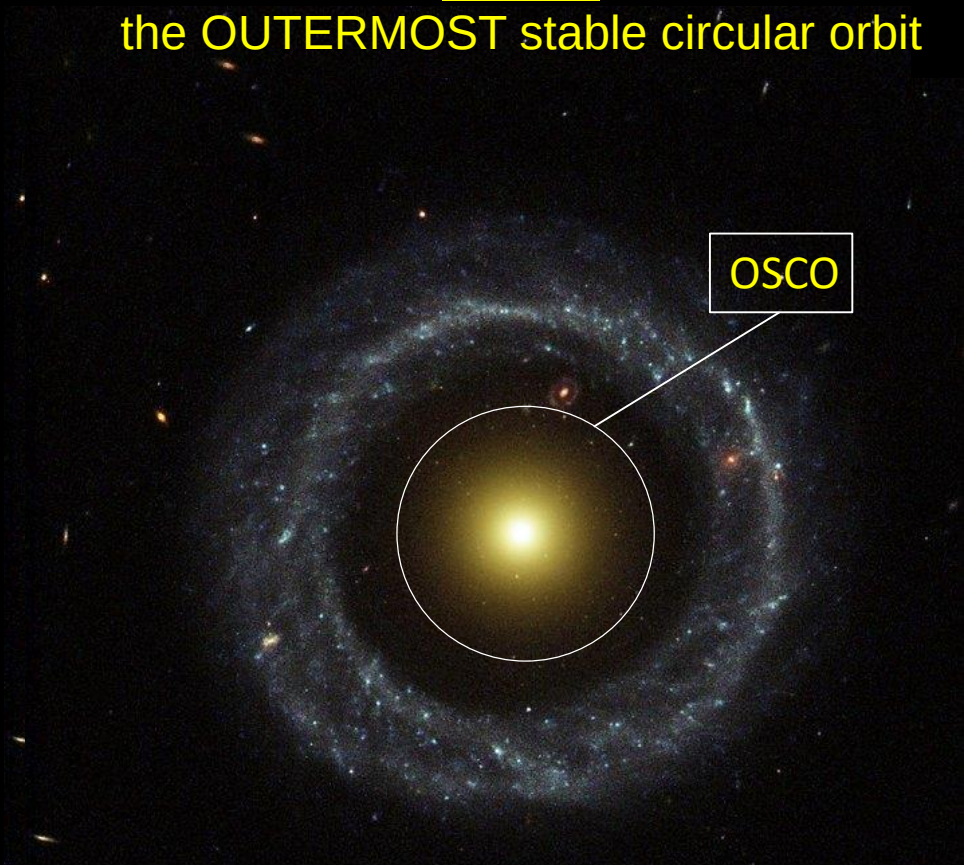
the INNERMOST stable circular orbit



Hoag's Object

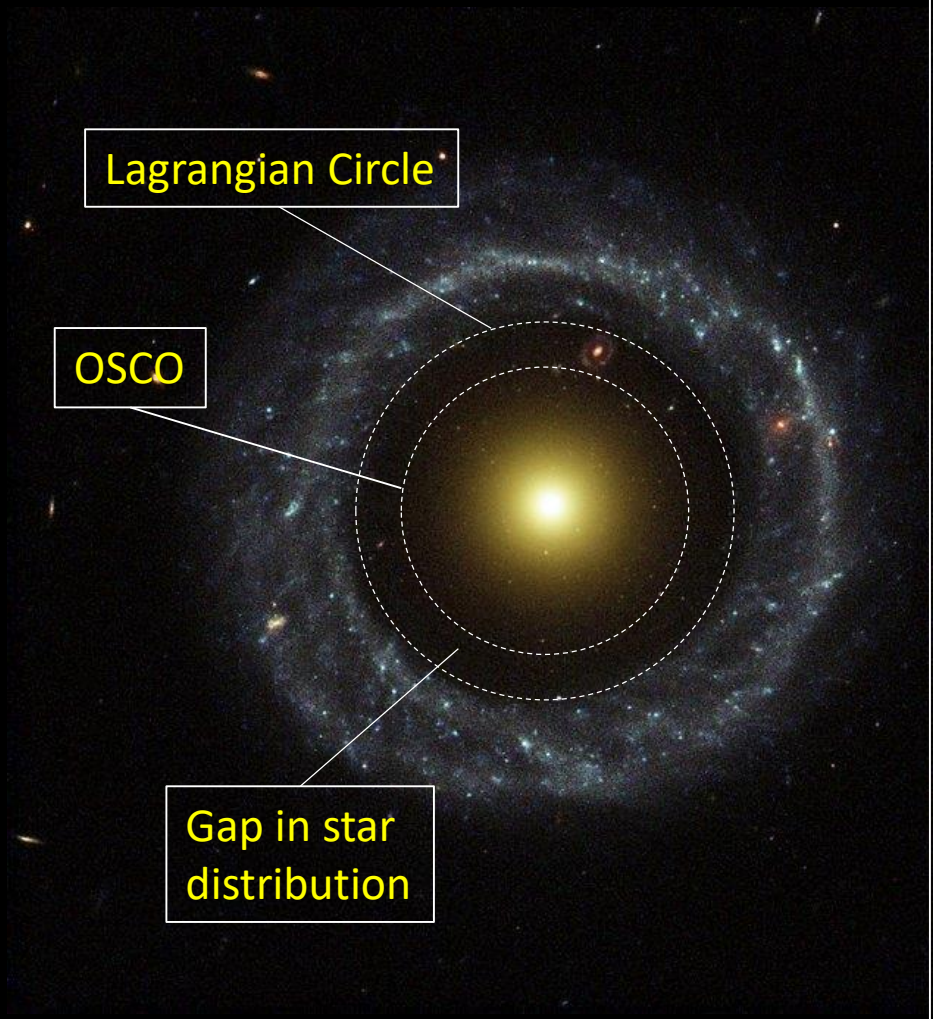
OSCO

the OUTERMOST stable circular orbit



The OSCO can be a useful tool for investigating Hoag-like galaxies as well as ISCO is used in order to model black holes via the surrounding accretion disc.

Dynamics in Hoag-like ring galaxies

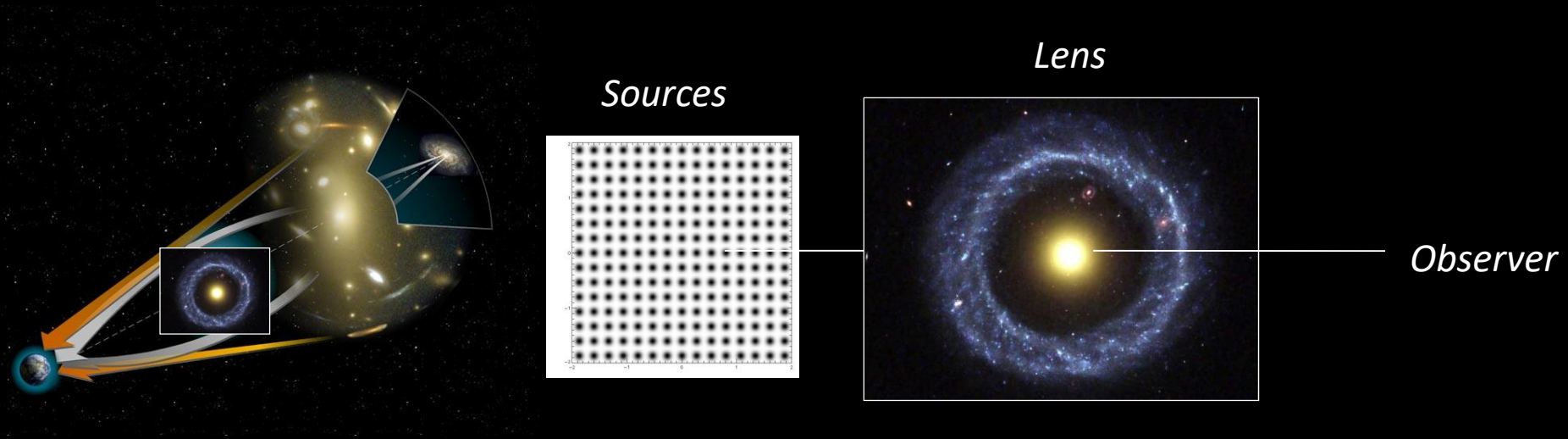


- *Lagrangian Circle (LC)* is a circle where the forces by the massive ring and the central core balance each other.
- The stable circular motion is possible only inside this last stable circular orbit, which we call *"the outermost stable circular orbit" (OSCO)* in analogy with a relativistic case.
- Region of unstable orbits can lead to the formation of *a stellar matter gap* in Hoag-like ring systems.
- The width of the region of unstable orbits is about 3kpc for Hoag Object.
- Analysis of gap position can give information about the central core-to-ring mass ratio

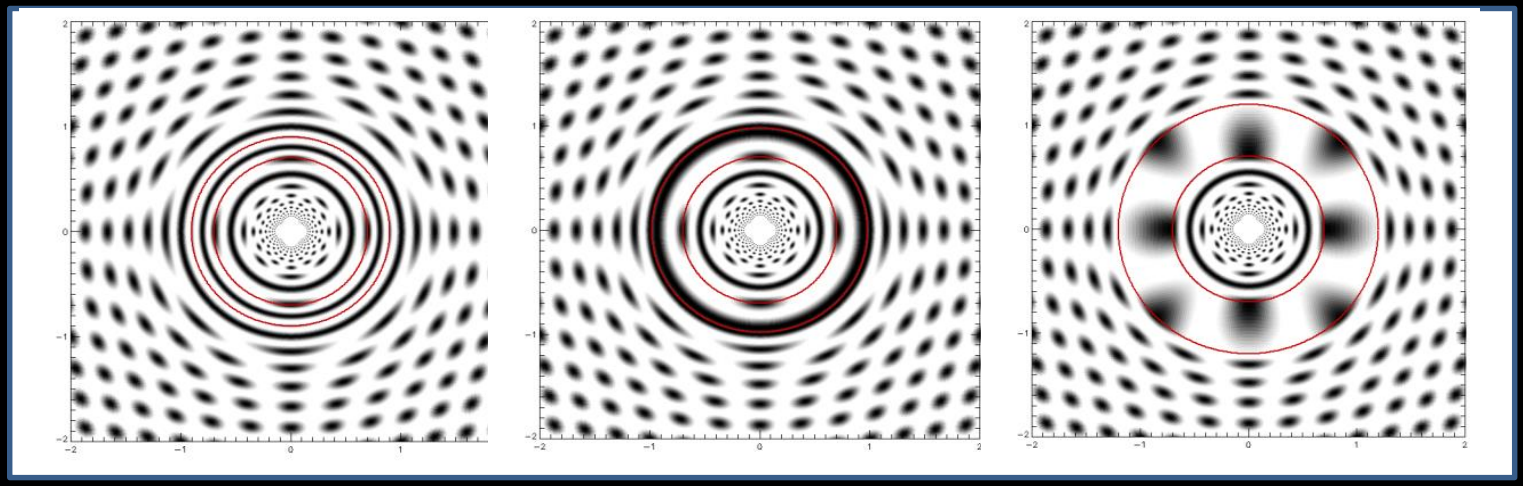
Bannikova, 2018, MNRAS

Modeling of gravitational lensing effects

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



Three Einstein rings

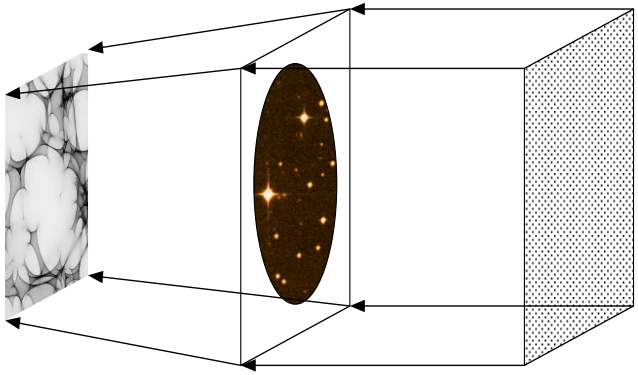


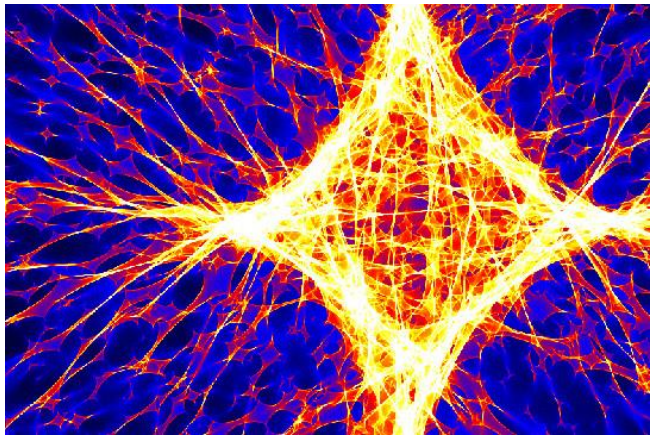
Bannikova & Kotwitsky, 2014, MNRAS

Modeling of gravitational lensing effects using GPU technology

Alexey Sergeyev

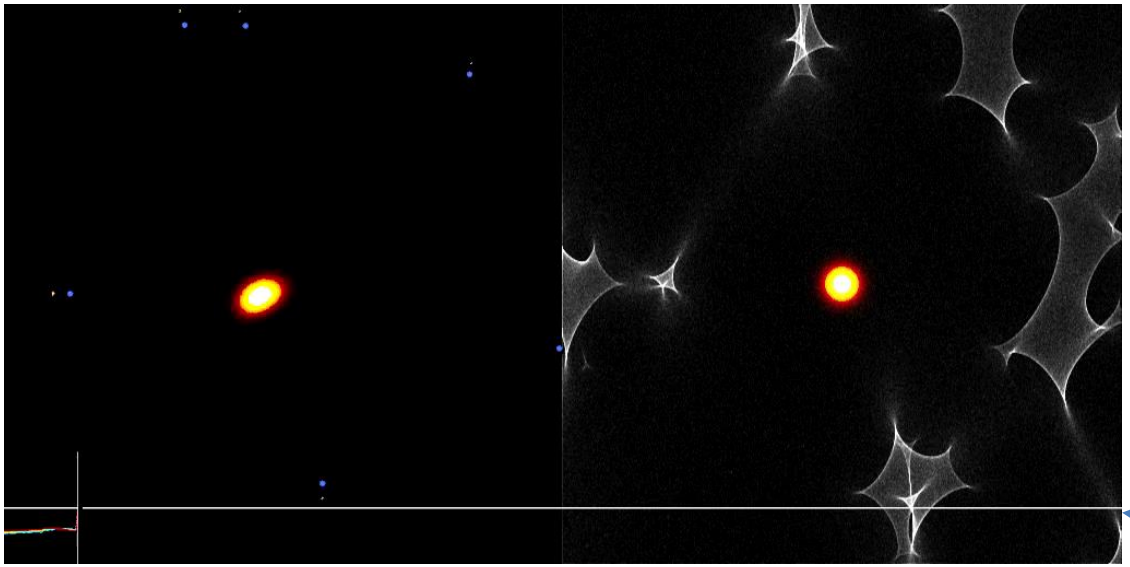
The principle of ray tracing method





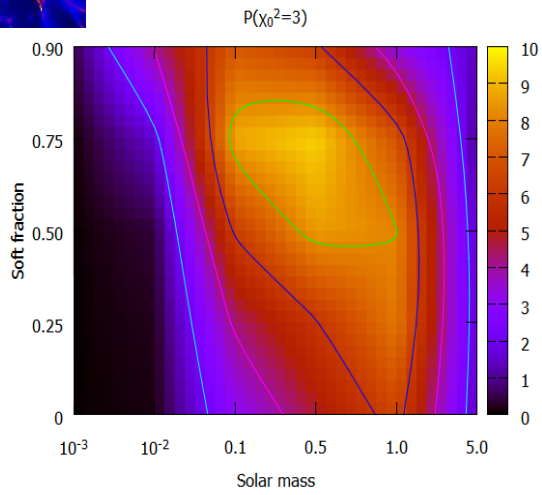
Building of lensing galaxy model contains 10^6 stars using GPU CUDA technology

Dynamic microlensing simulation



Lens plane

Source plane



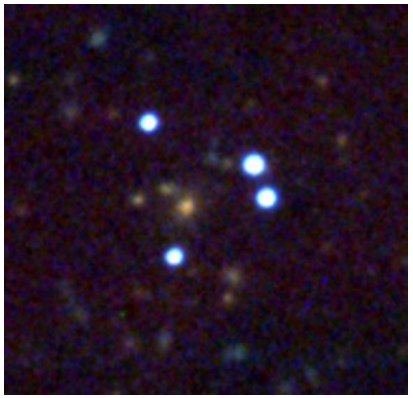
Estimation of probable microlens mass

Observed light curve of the source

Long-term monitoring of gravitationally lensed quasars

Main goal of monitoring is to obtain light curves of components of lensed quasars

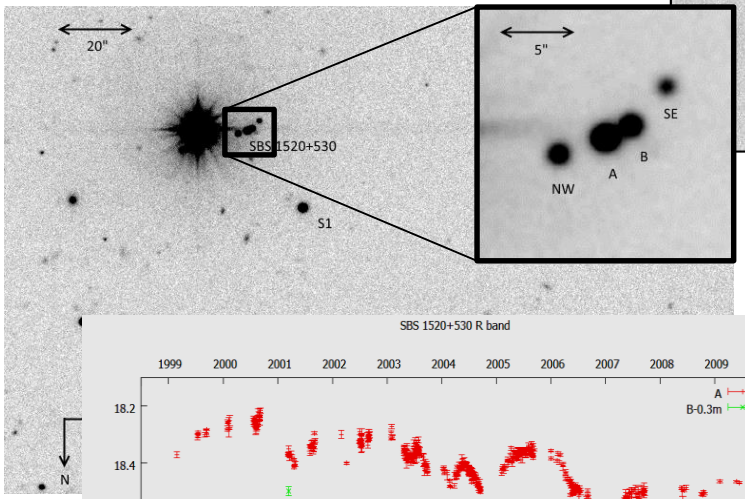
1.5 m AZT-22 telescope

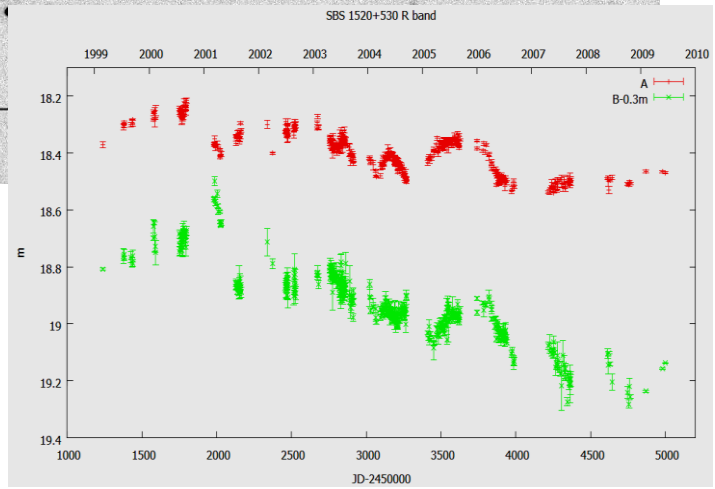


SDSS 1004+4112

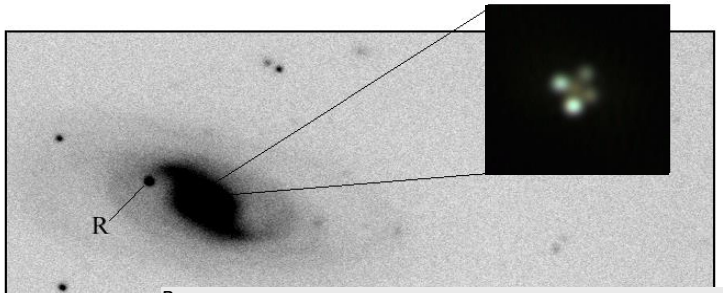
Time delay, color variation, microlensing

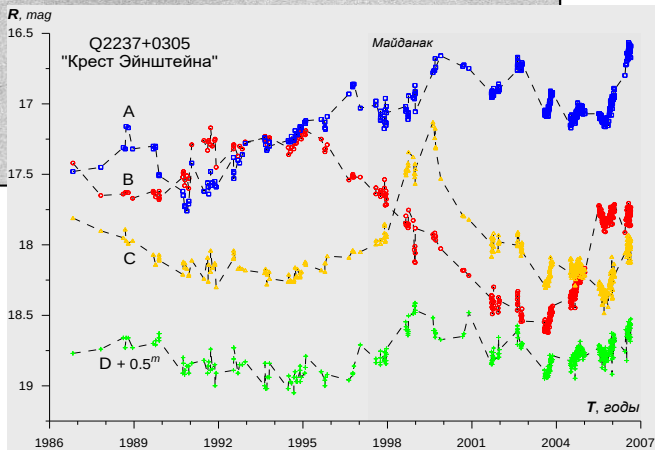
GLQ SBS1520+530





GLQ Q2237+0305 (“Einstein cross”)

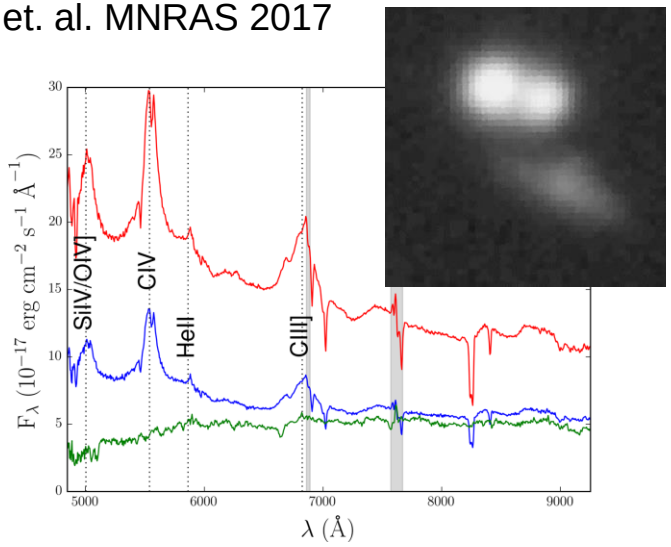




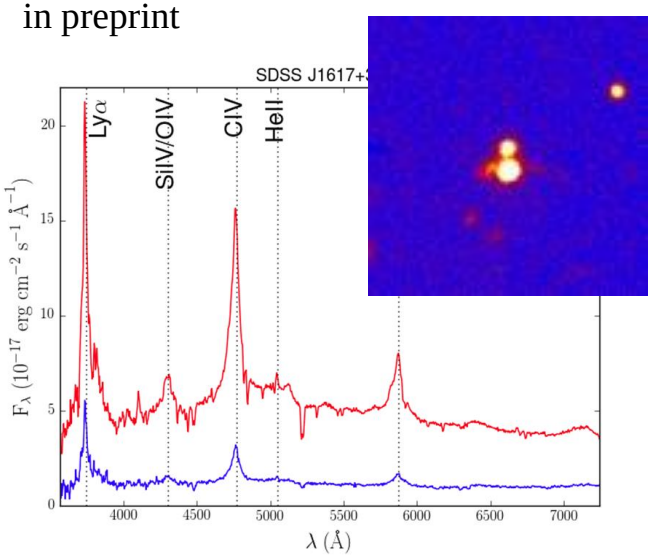
Hubble constant, fine quasar structure, lensing galaxy population

Gravitationally lensed quasar search program

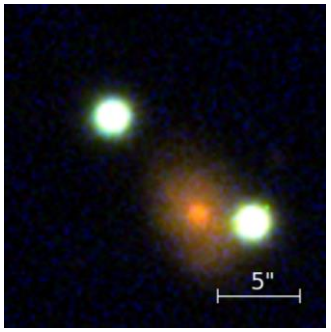
Sergeyev A.V., Zheleznyak A.P. et. al. MNRAS 2017

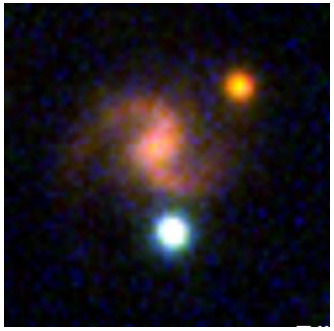


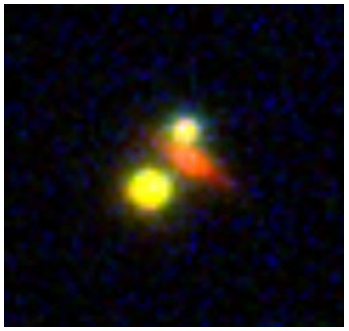
Shalyapin, V. N., **Sergeyev, A. V.** et. al. in preprint

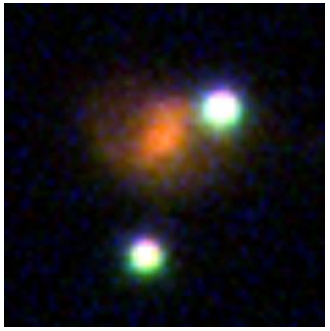


The new method of GLQ candidates search use **KiDS (VST)** frames for direct image analysis.

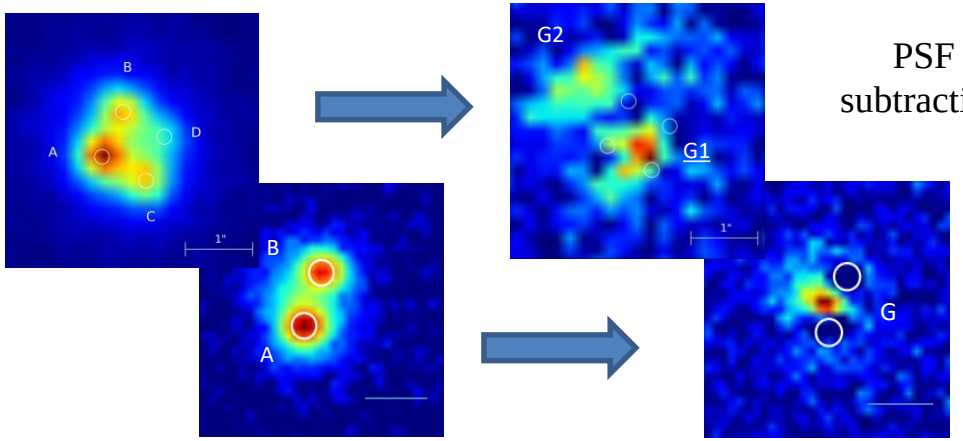








Perfect quality of the KiDS frames allow to extract the lensing galaxy under pint-like (quasar) images.



Grazie mille !