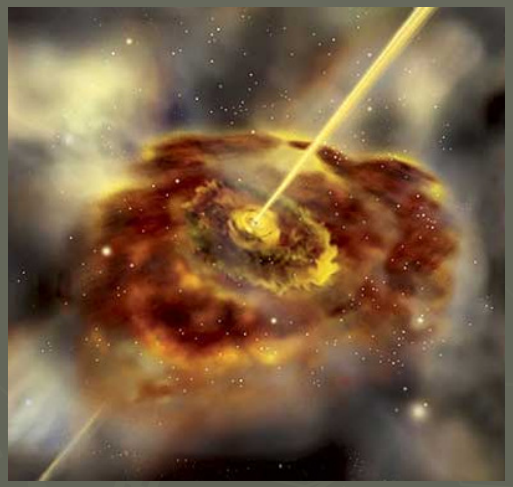
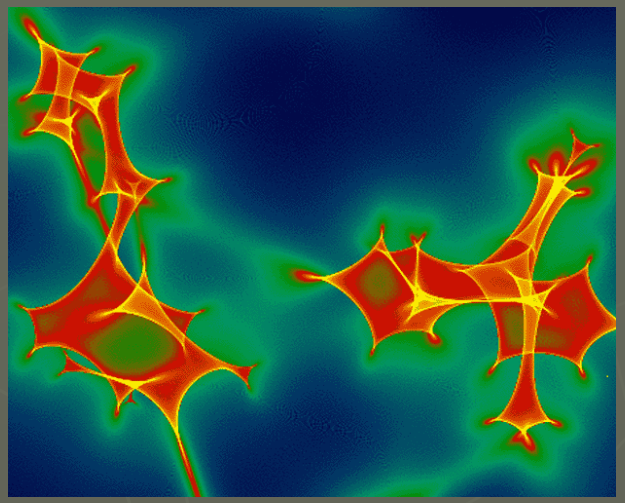
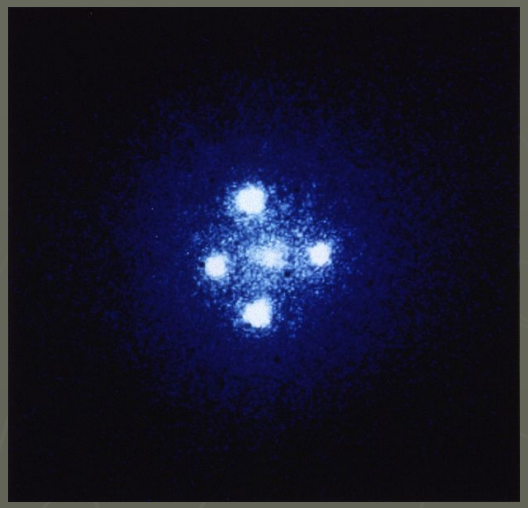
GRAVITATIONAL MICROLENSING AGN DUSTY TORUS







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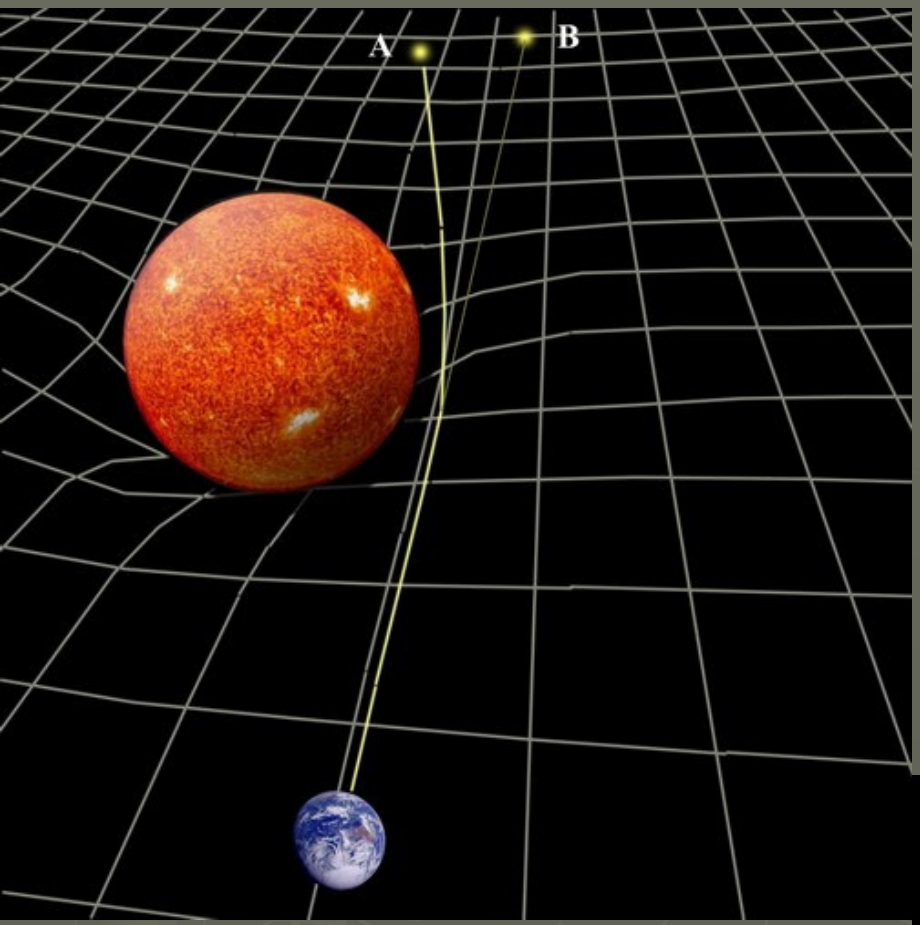
GRAVITATIONAL LENSING

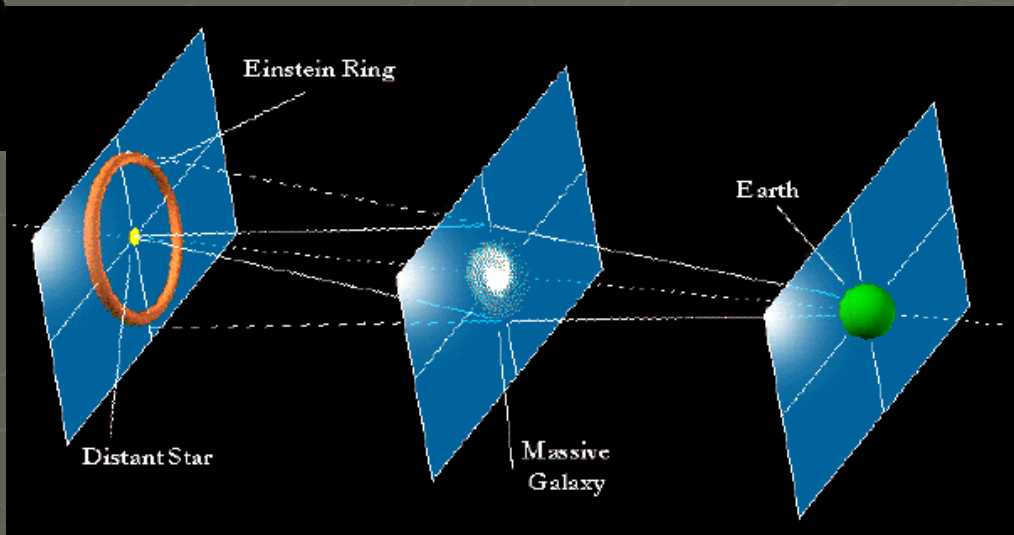


- Bending of light in the gravitational field of a massive object
- Einstein, GTR, 1915:

  → GL is achromatic

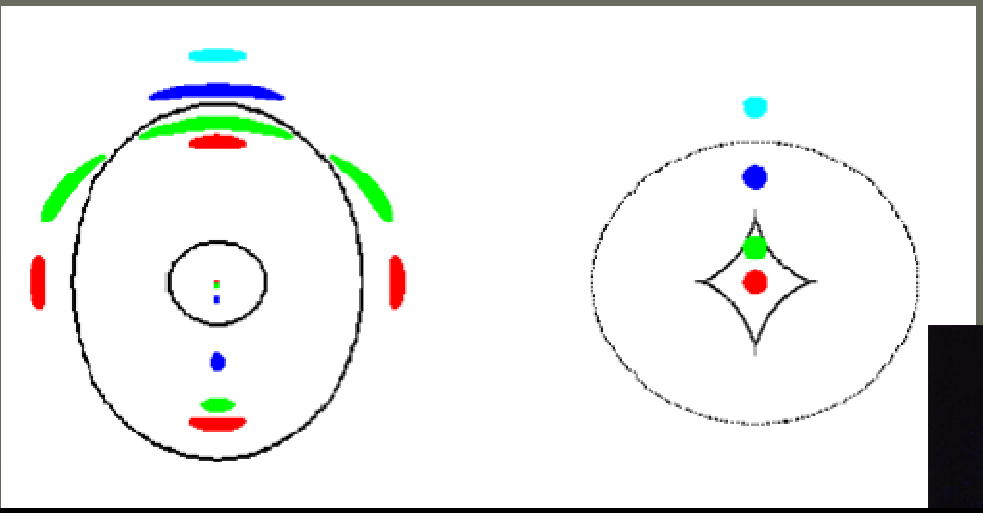
$$\Theta = \frac{4GM}{c^2 R}.$$

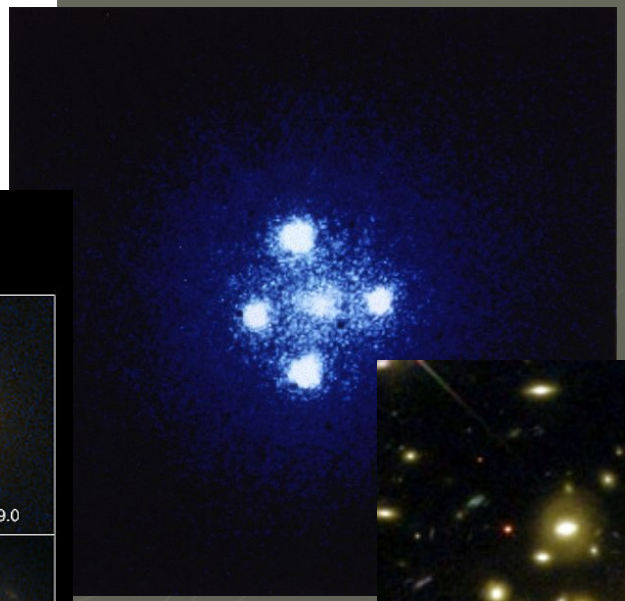
- Observable effects: change of source position; magnification; multiple images, arcs, rings…
- Einstein ring radius (R_E):

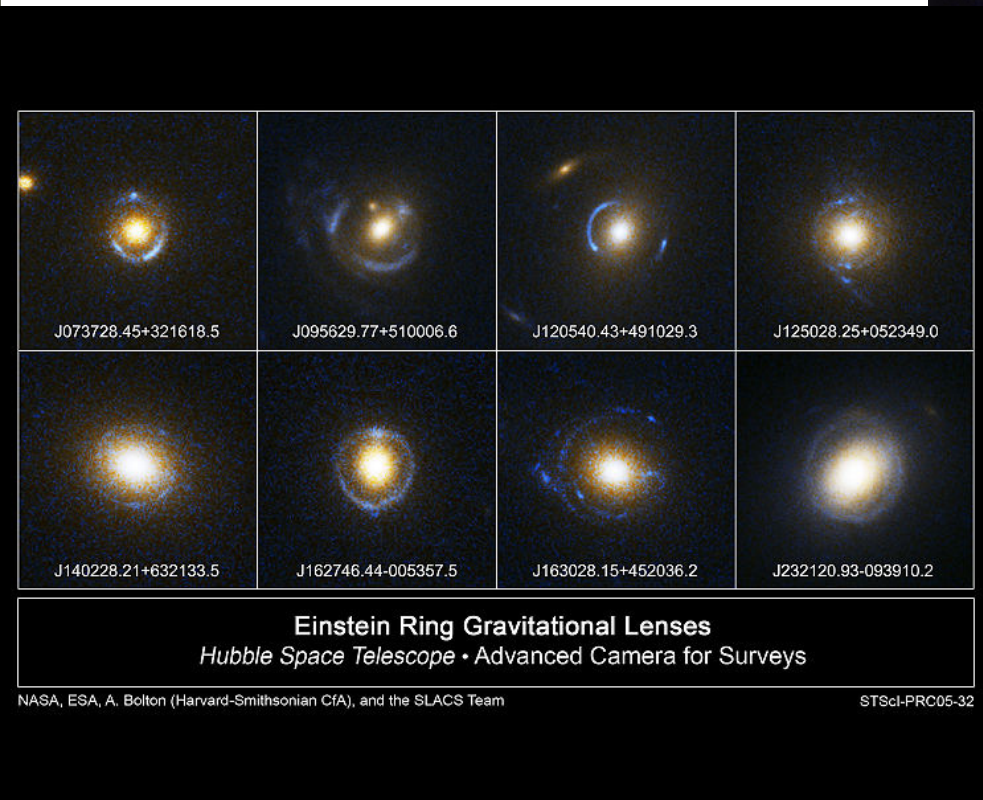


STRONG LENSING

- Lens is very massive object (galaxy, galaxy cluster…)
- Multiple images, arcs, rings…

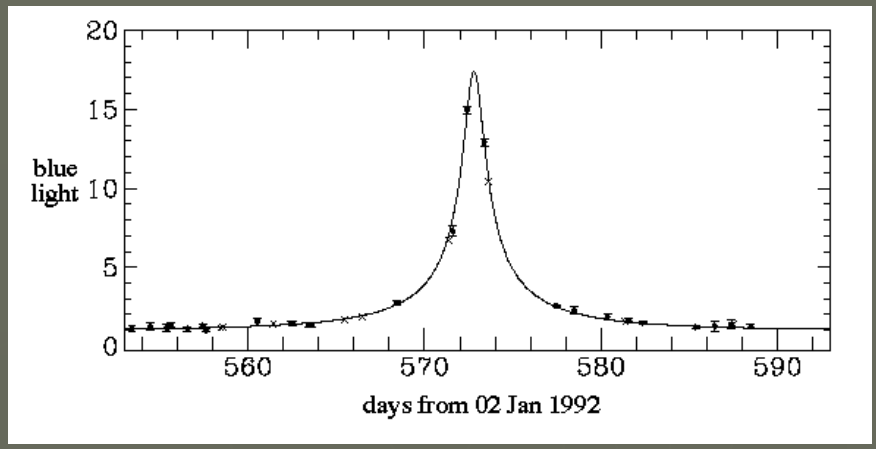


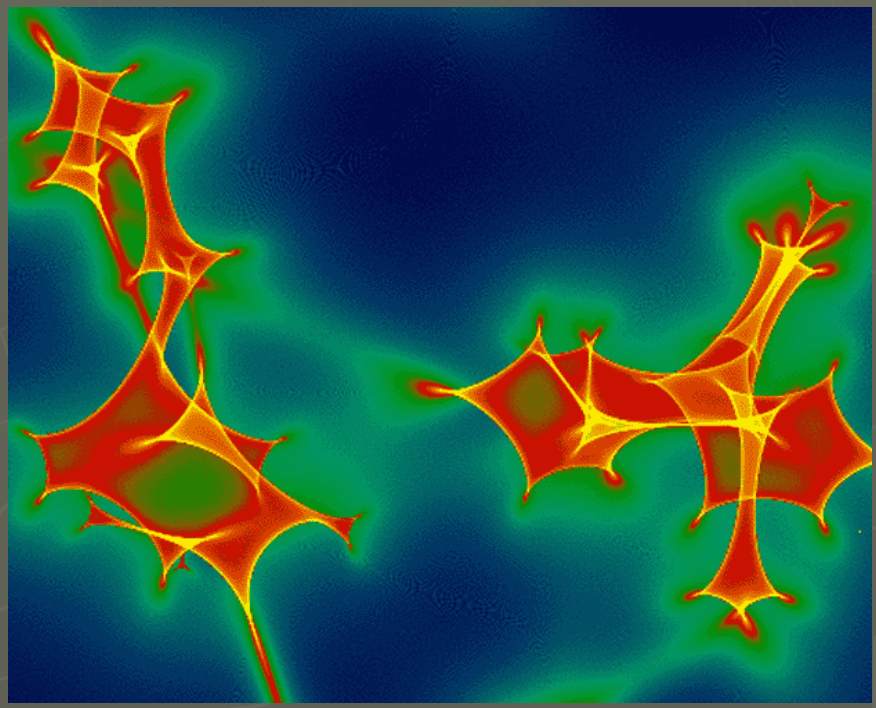




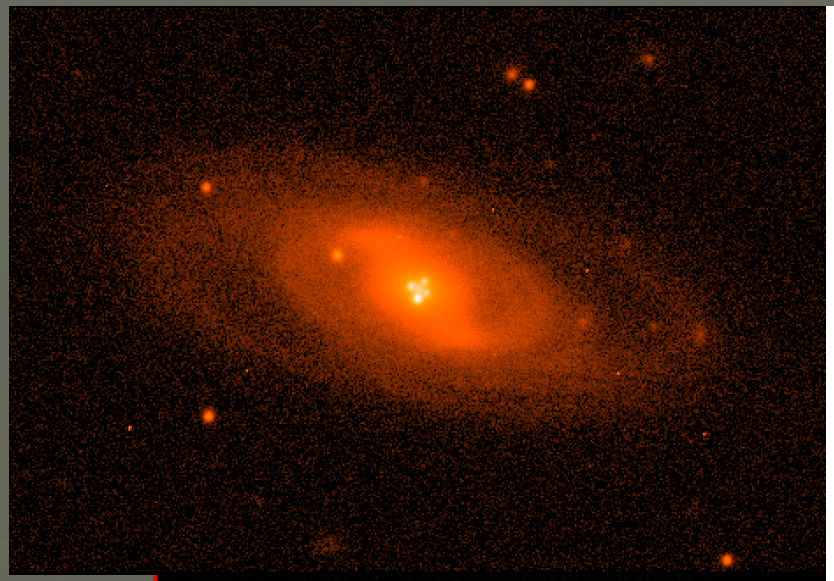
MICROLENSING

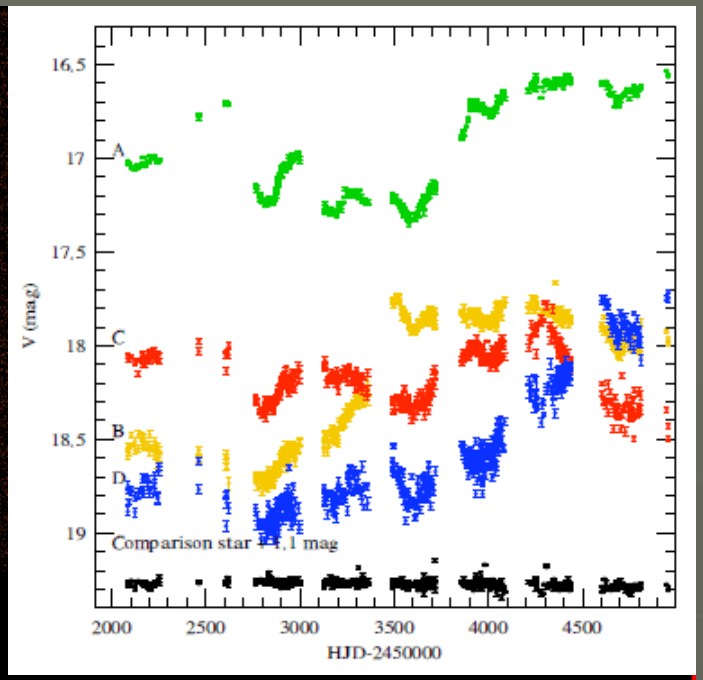
- Lens is compact object (e.g. star)
- No deformations, no multiple images, only magnification
- Single microlens (1 caustic)
- Large number of lenses: magnification map (caustic network)

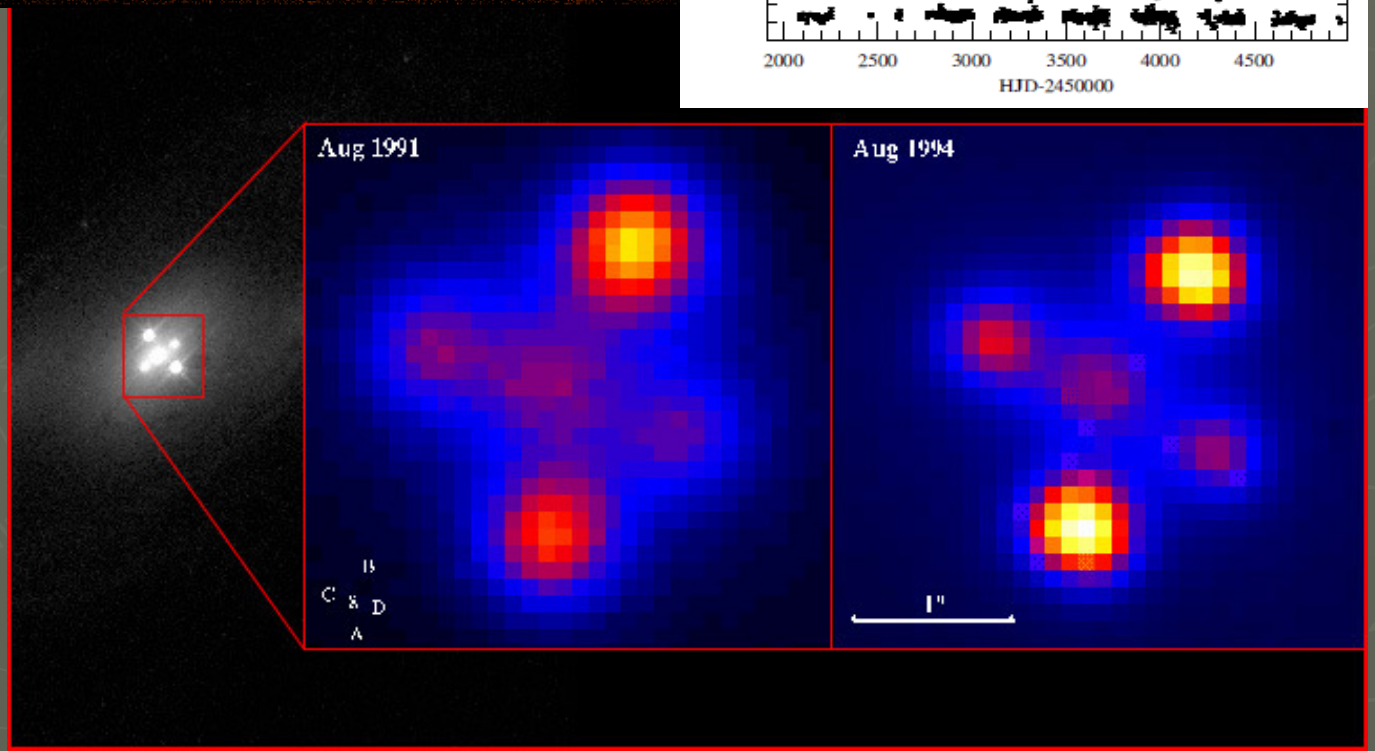




GL QSOs: STRONG + MICRO LENSING







MOTIVATION AND GOALS

- $R_{tor} > R_E$;
- Toy models

  → No microlensing of dusty torus

BUT:

- Recent observations:

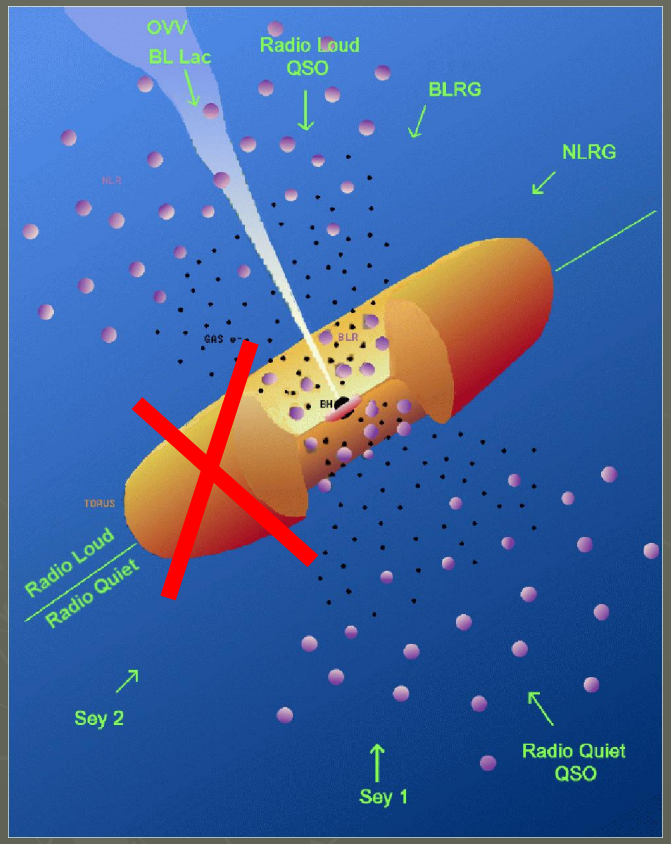
  $R_{tor} \approx 1 - 6$ pc (Packham+ 2005, Tristram+ 2007, Alonso-Herrero+ 2011)

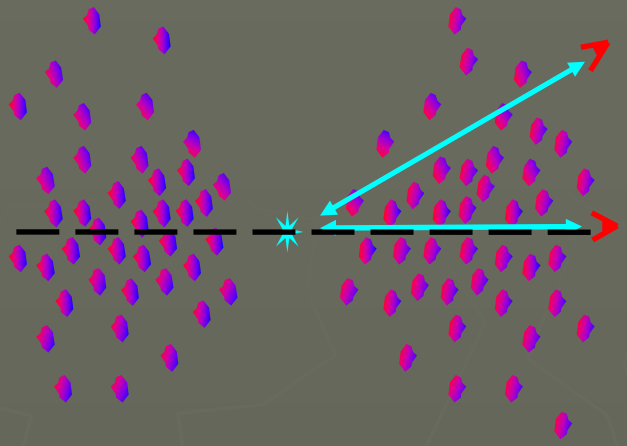
- MCRT modeling of dusty torus: (Stalevski+ 2012)
  - Wavelength dependency of size
  - Dust density gradient

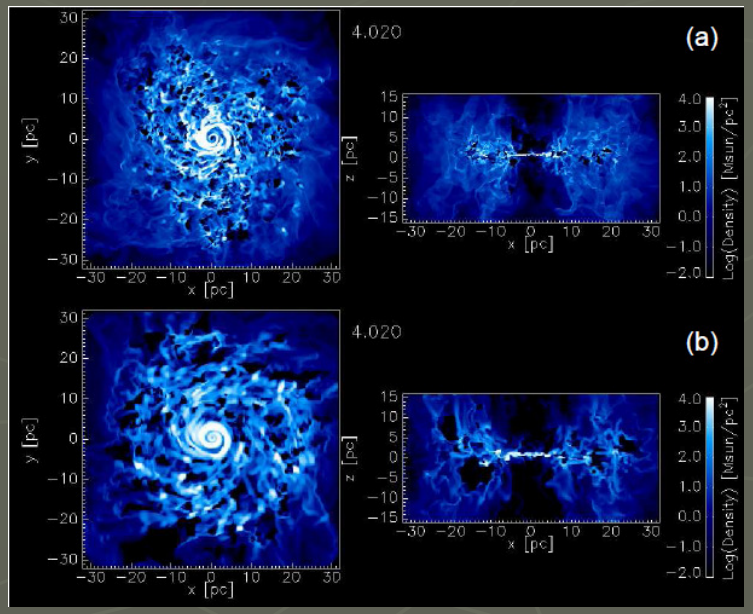
  → more compact torus

- GOALS: Investigate microlensing of AGN dusty tori in IR:
  - Magnification amplitudes
  - Time scales
  - Influence of torus parameters

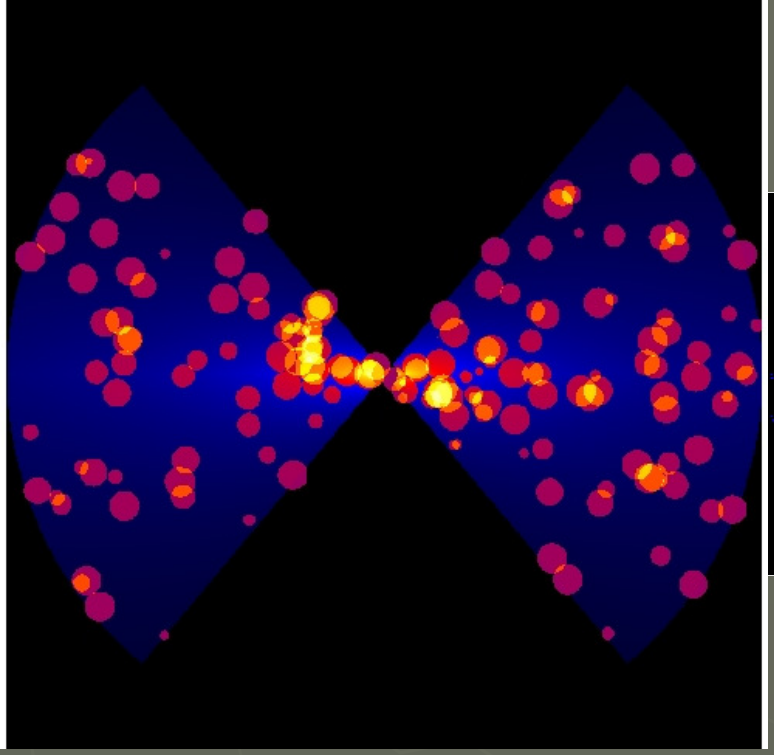
DUSTY TORUS: CLUMPY MULTIPHASE MEDIUM

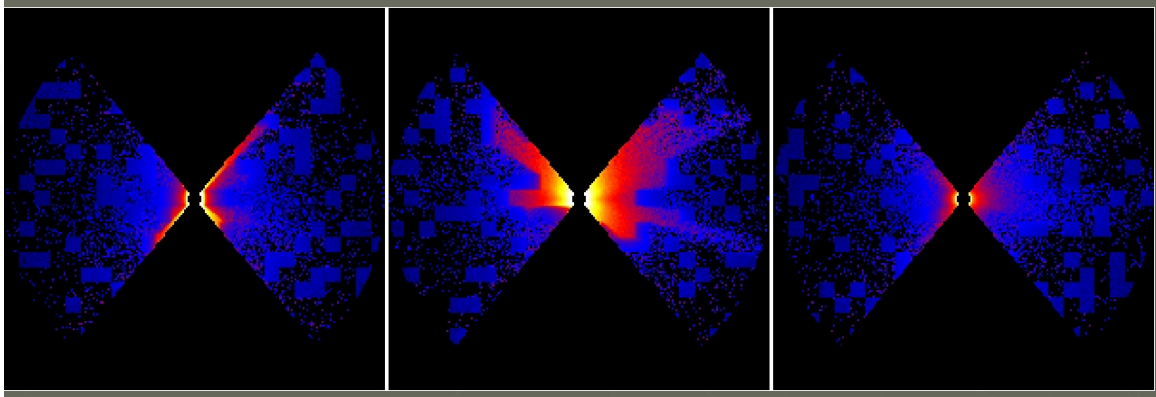




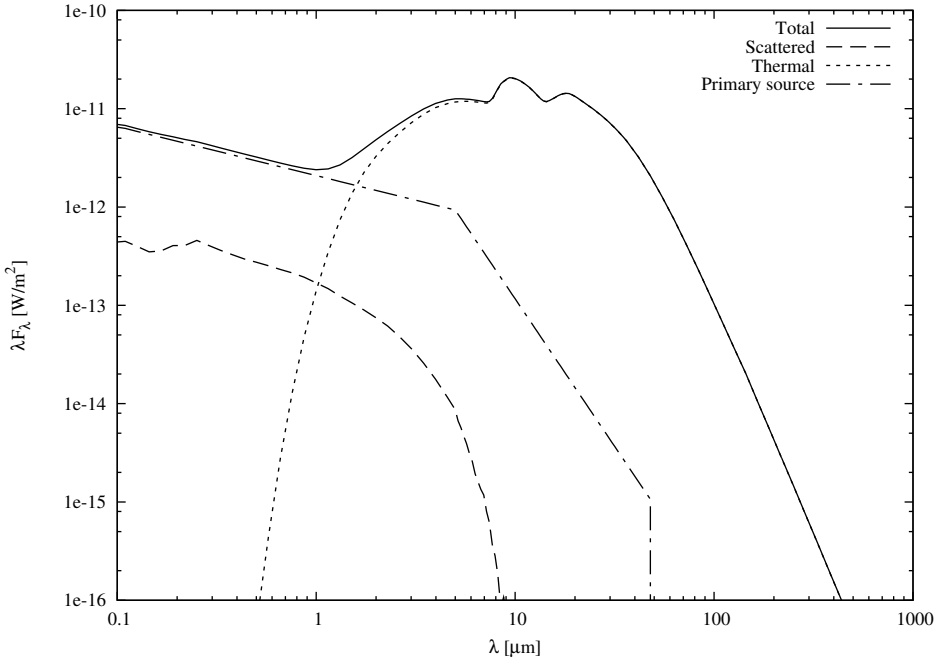


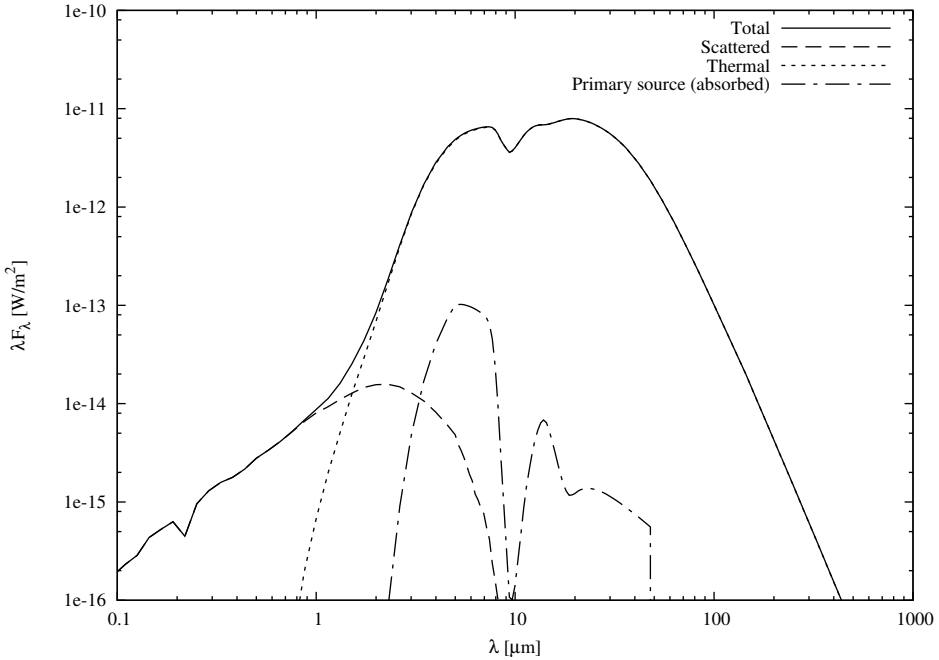
AGN dusty torus



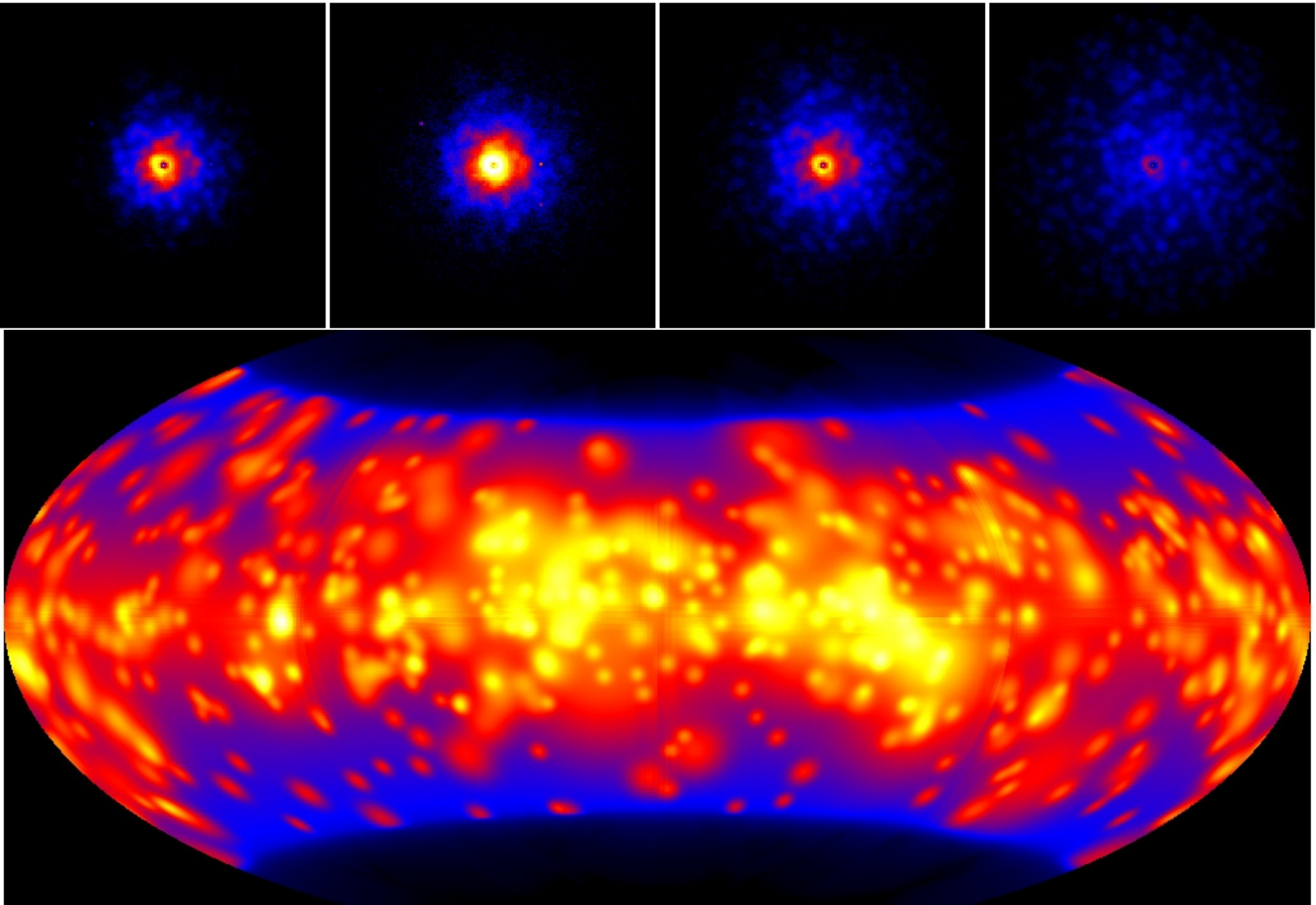


Stalevski et al. 2012, MNRAS, 420, 2756





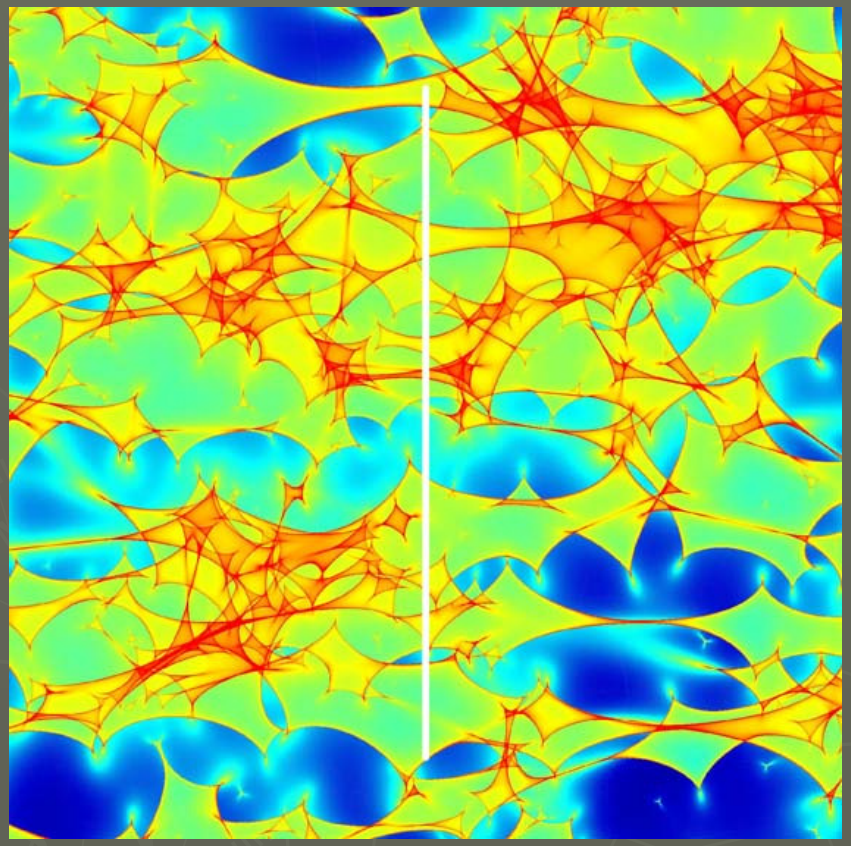
https://sites.google.com/site/skirtorus/

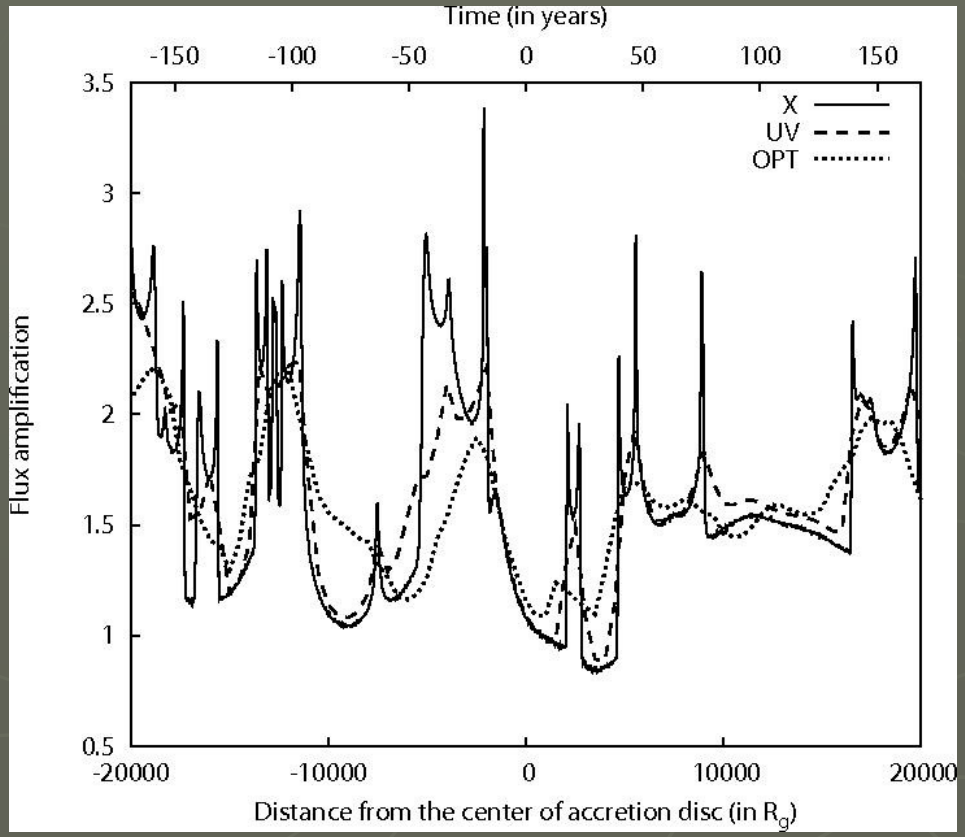


AGN MICROLENSING – ACCRETION DISK

$$\Theta = \frac{4GM}{c^2 R}.$$

BUT: chromatic effects can appear due to the size and wavelength dependency of different emitting regions!





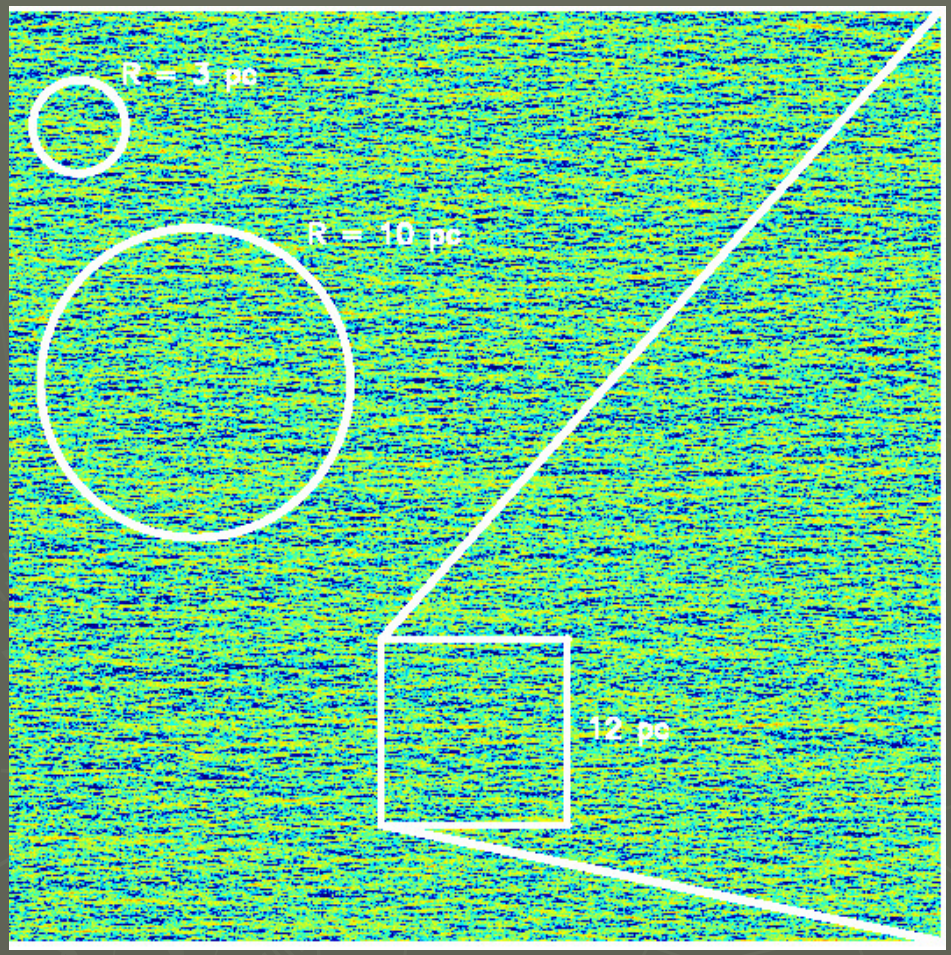
(Jovanović et al., 2008)

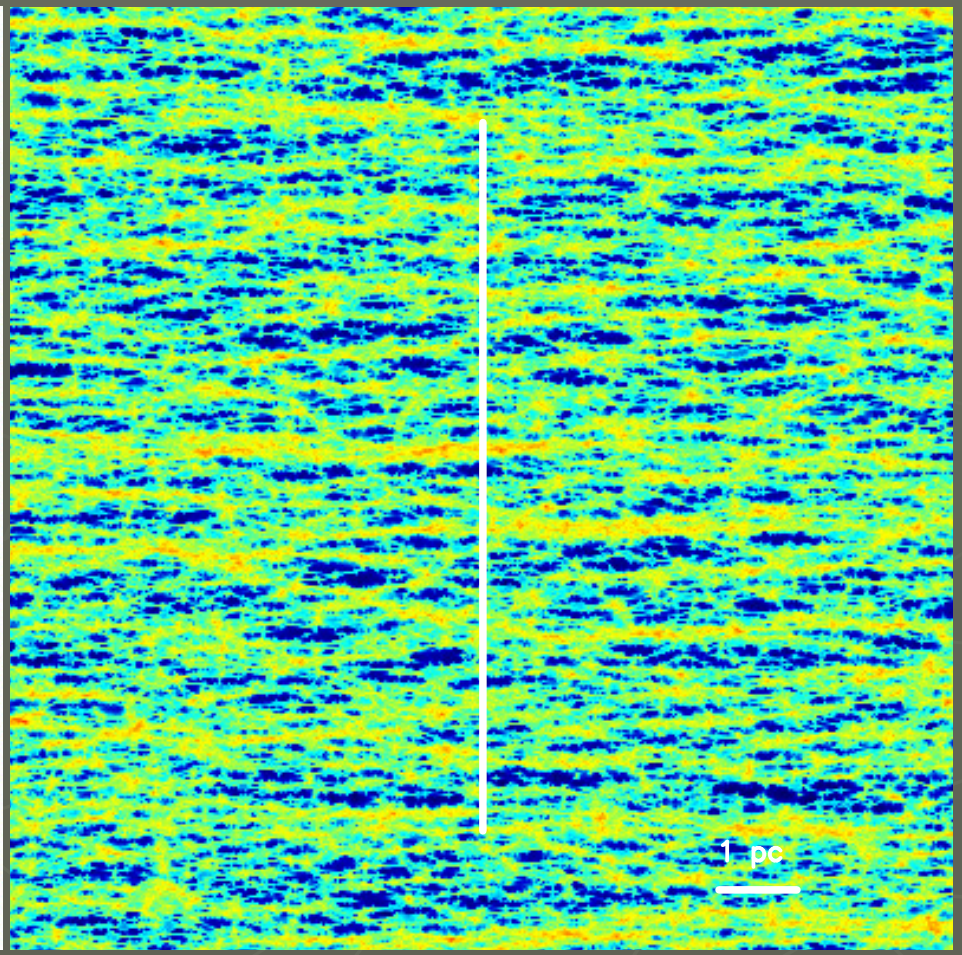
MICROLENSING MAGNIFICATION MAP

Magnification map

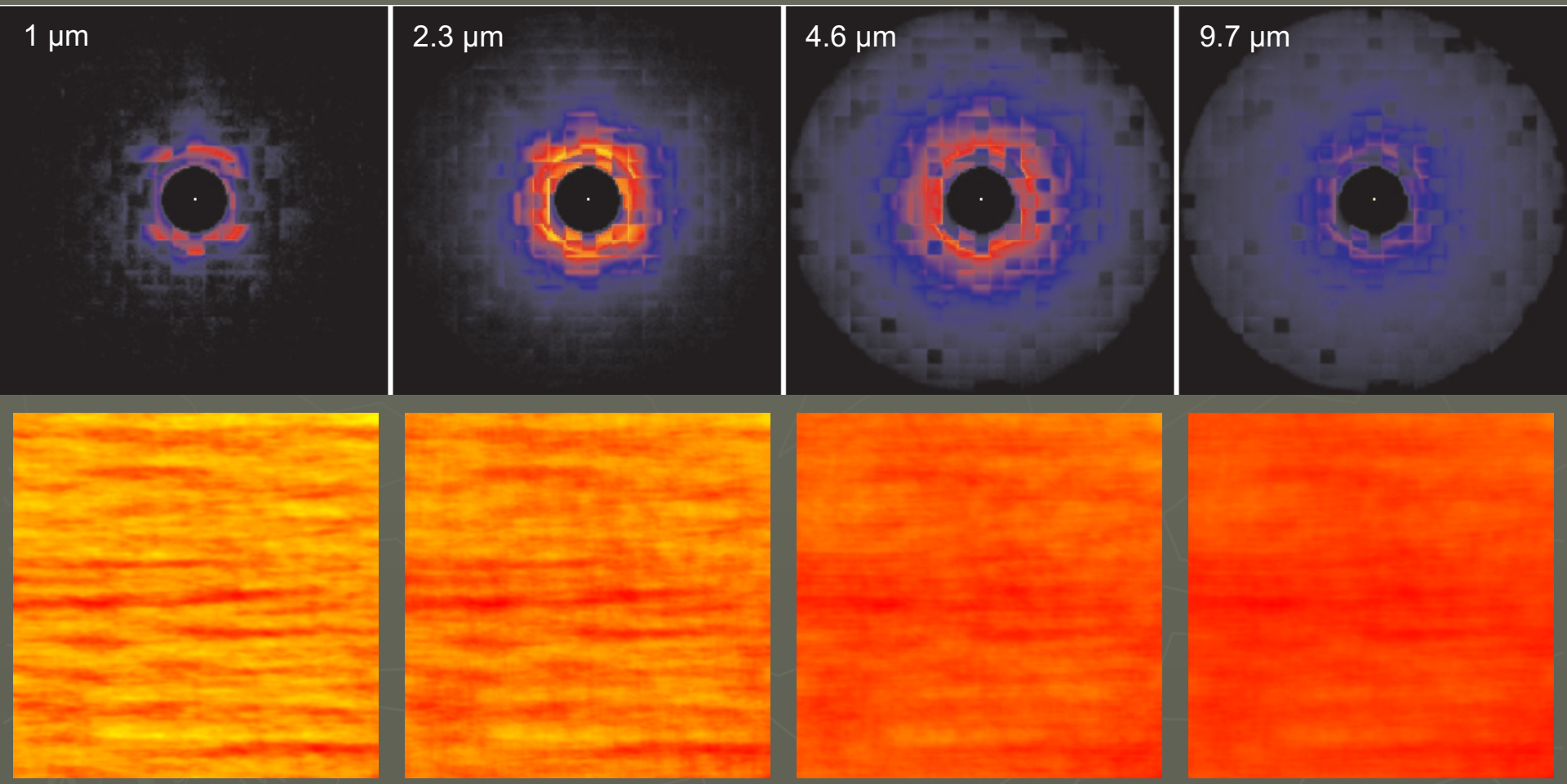
$Z_l = 0.05$ Convergence: = 0.4

$Z_s = 2$ Shear: = 0.4

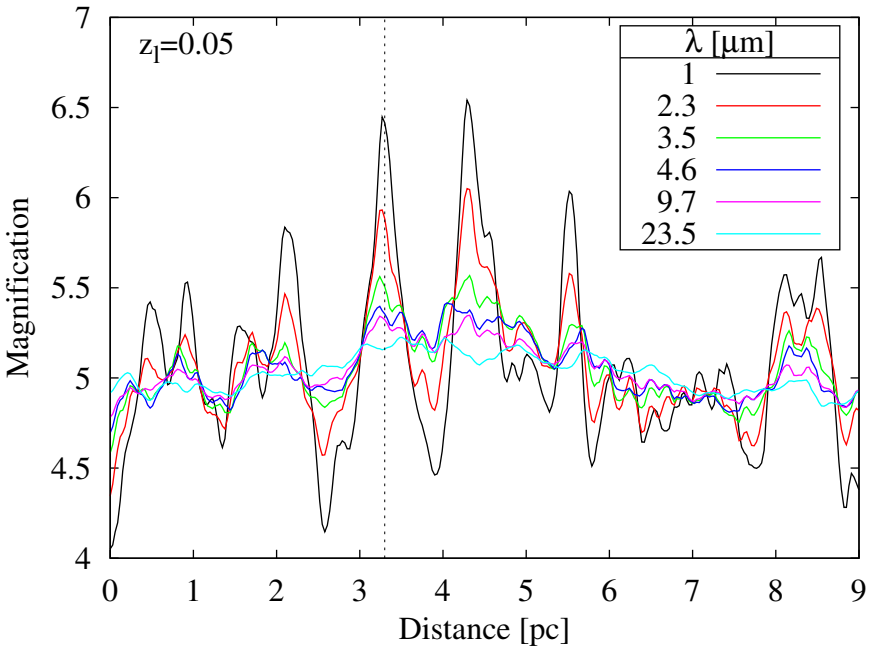


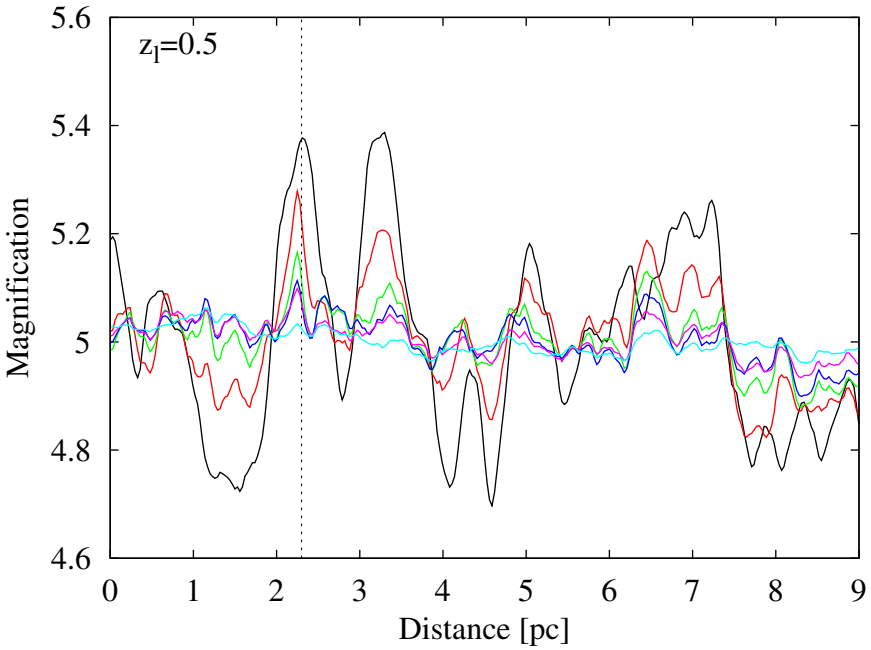


MICROLENSING MAGNIFICATION MAP

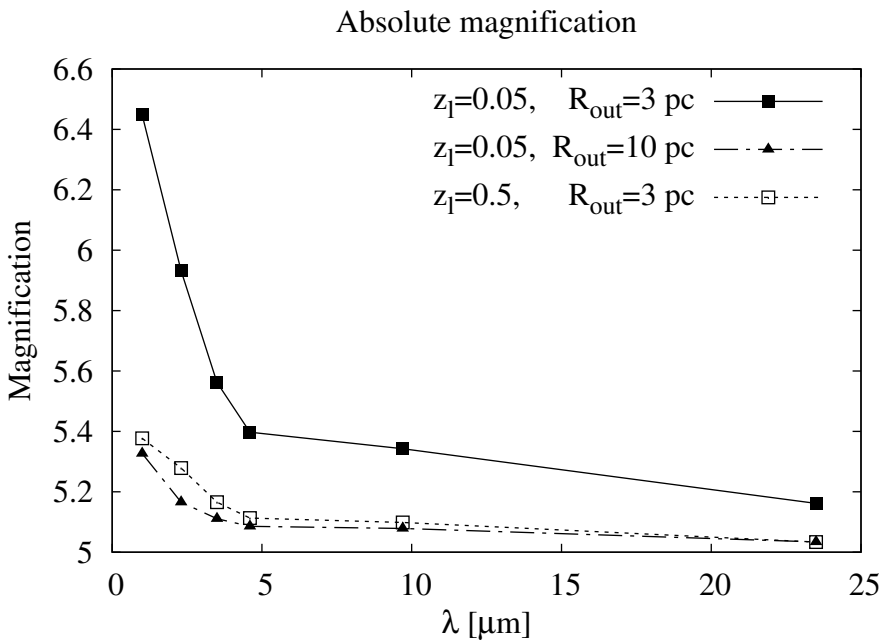


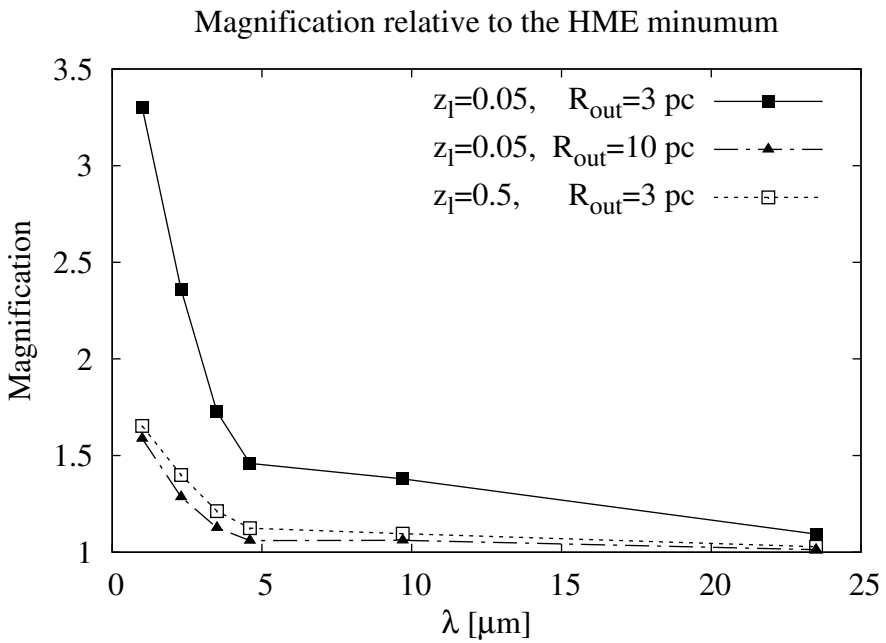
Light curves of simulated microlensing events at different wavelengths (rest frame)



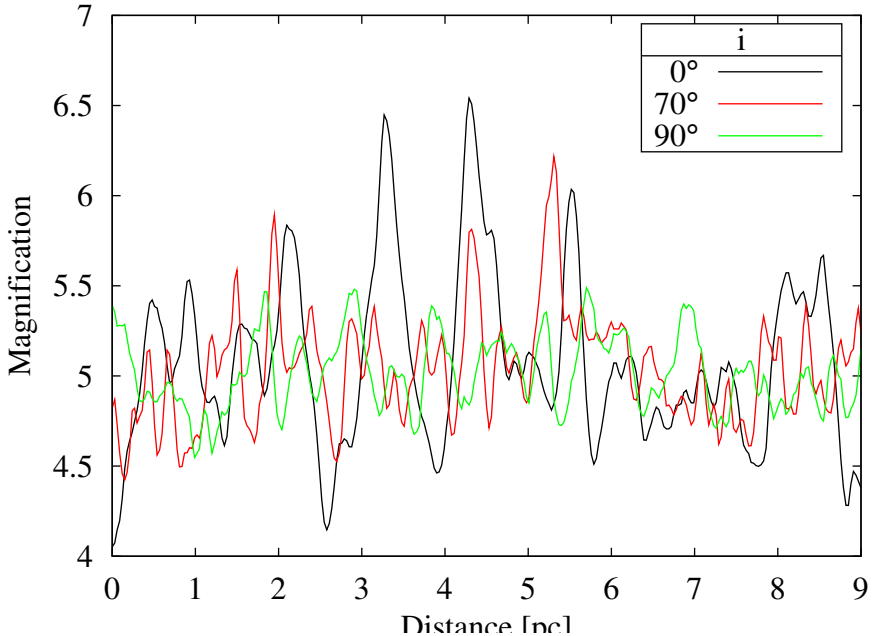


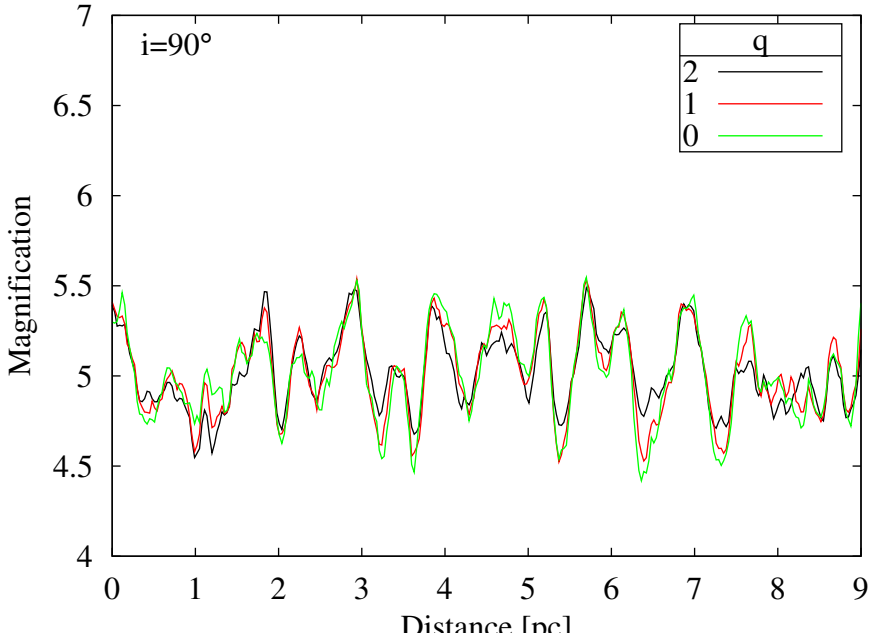
Magnification – wavelength dependence

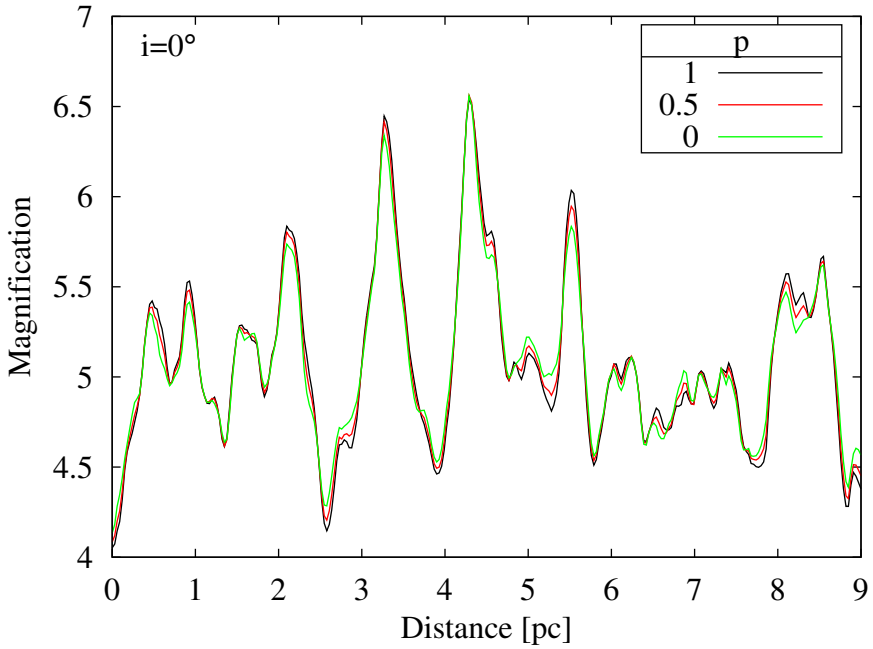


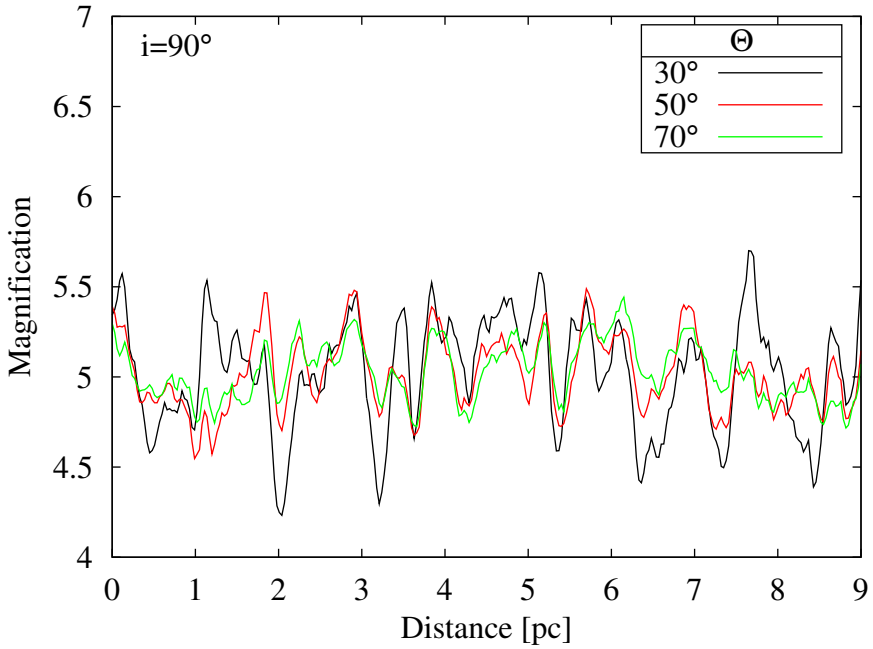


Light curve - dependence on torus parameters

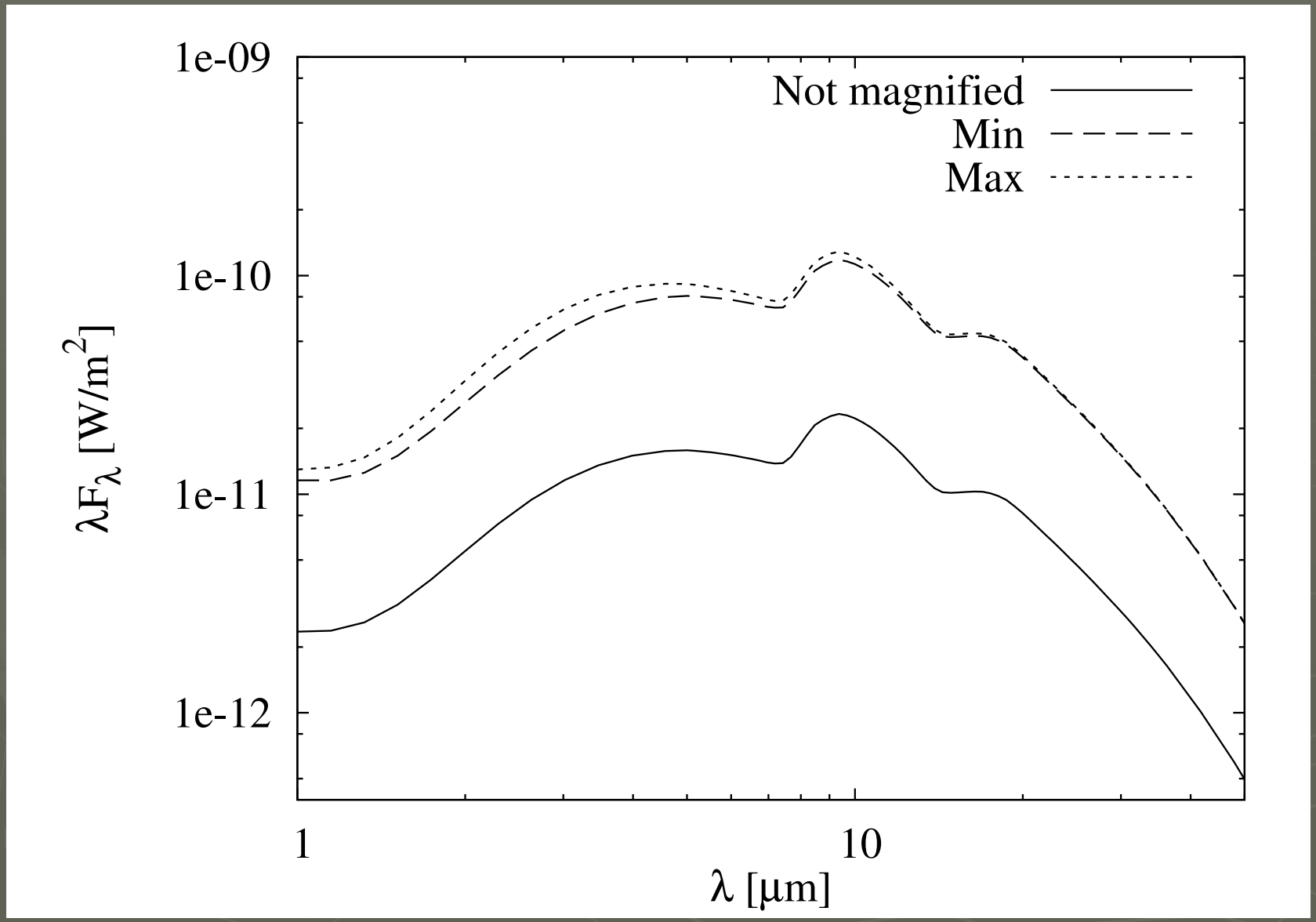








ML influence on entire IR SED



CONCLUSIONS

(Stalevski et al, submitted)

- AGN dusty torus could be significantly magnified by microlensing, depending on the:
  - Wavelength – highest amplitudes in NIR, decreasing towards MIR and FIR
  - Size of torus (R_{tor} < 10 pc)
  - Dust distribution parameters (p, q)
  - Lens system configuration (z_L, z_S, m_l)
- Typical time scales (rise time of HME): from several decades to hundreds of years → not a practical tool to study structure of dusty tori
- But to be kept in mind when investigating flux ratio anomaly in lensed QSOs: even the lightcurves in IR could be contaminated by the microlensing!

THANK YOU FOR ATTENTION!