EAYAM
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Subaru Telescope adaptive optics observations of gravitationally lensed quasars

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Contents

- Brief description of the adaptive optics imaging campaign

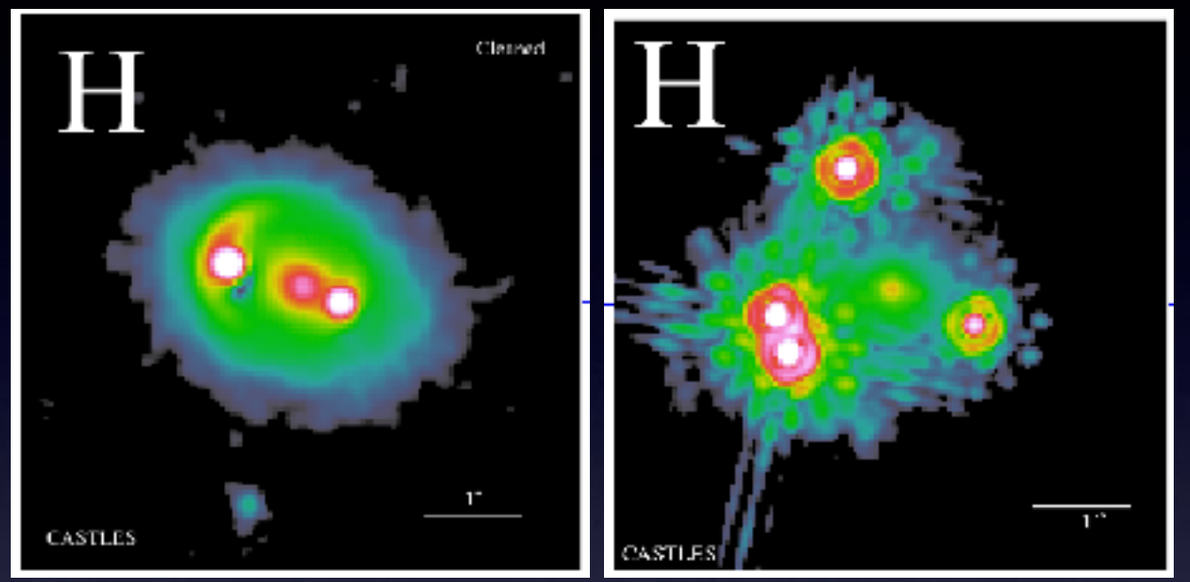
- Selected result: J1405: and the “natural coronagraph” lens

Gravitationally lensed quasars (GLQs)

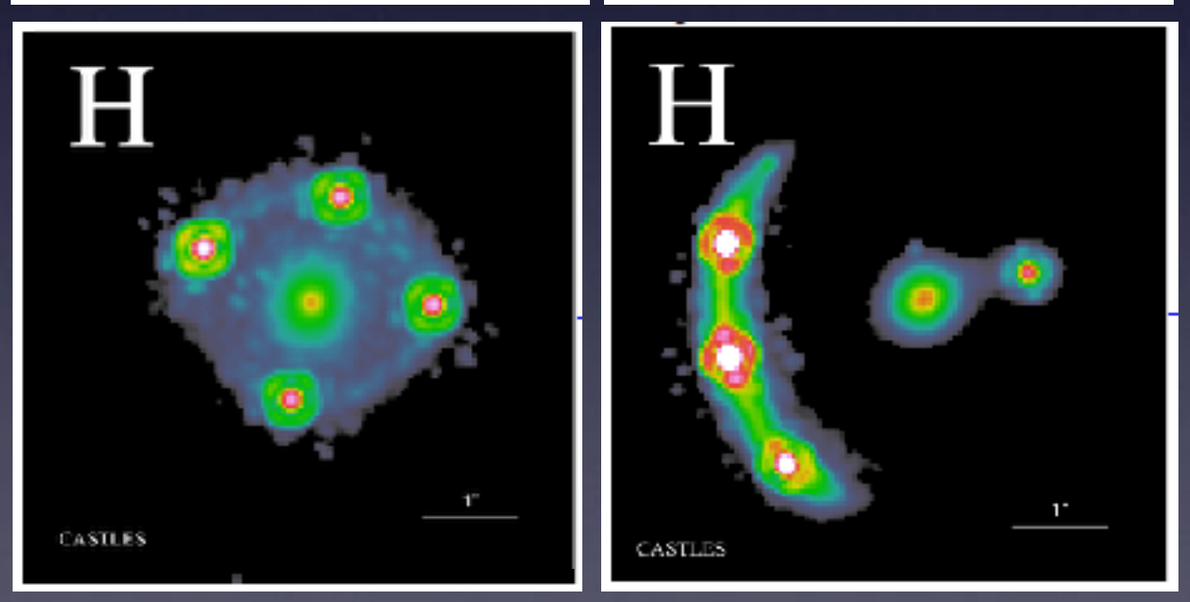
- First discovery Walsh et al. 1979; ~ 150 lensed quasars known

- Typical configurations:

CfA-Arizona Space Telescope LEns Survey (CASTLES)



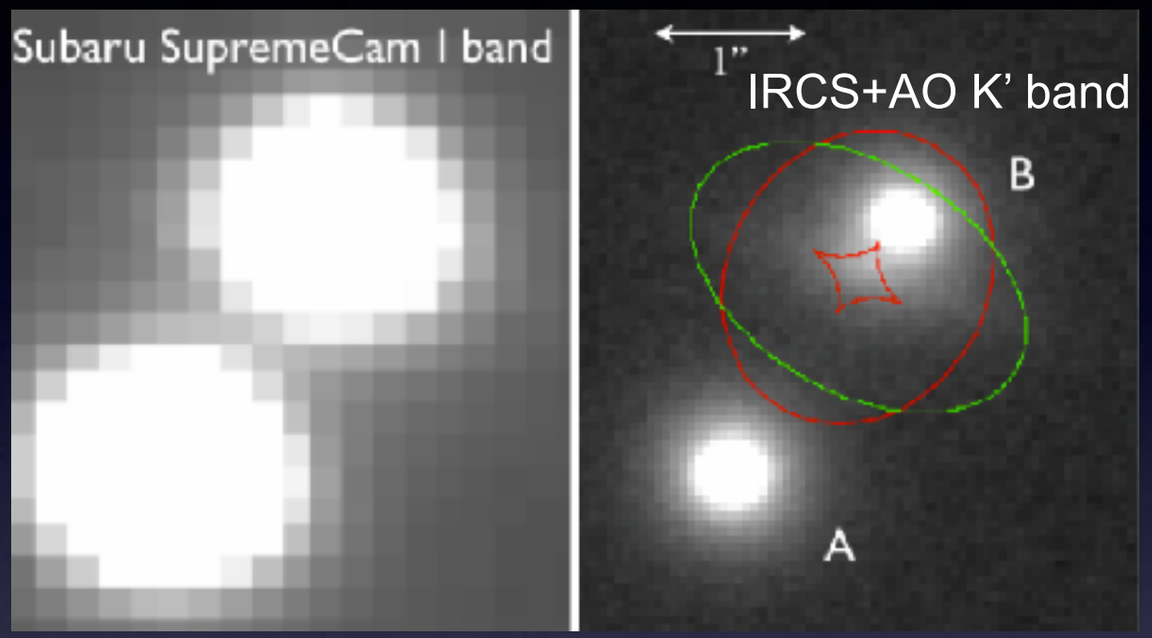
Hubble Space Telescope (HST)



- enable the study of the lens galaxy mass profile, quasar host galaxy, AGN structure, cosmological parameters

The need for high resolution imaging

- Typical GLQ image separation 1”– 2” ~ atmospherical seeing size
- The advent of AO: high resolution imaging possible from ground

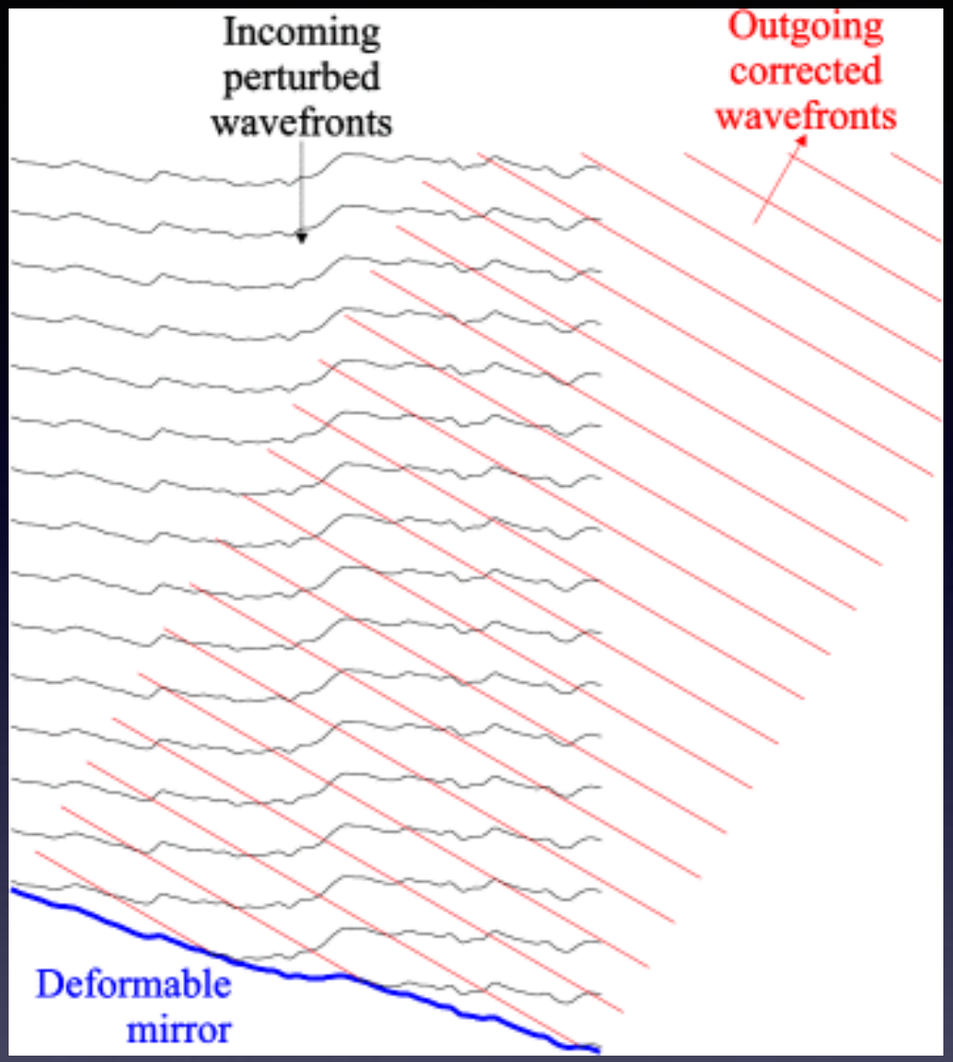


- Conducted the first dedicated AO campaign of GLQs (2011-2014; Rusu et al. 2016)
- Targets selected from SQLS: campaign to discover new lensed quasars from SDSS (Oguri et al. 2006) ~ 60 new discoveries

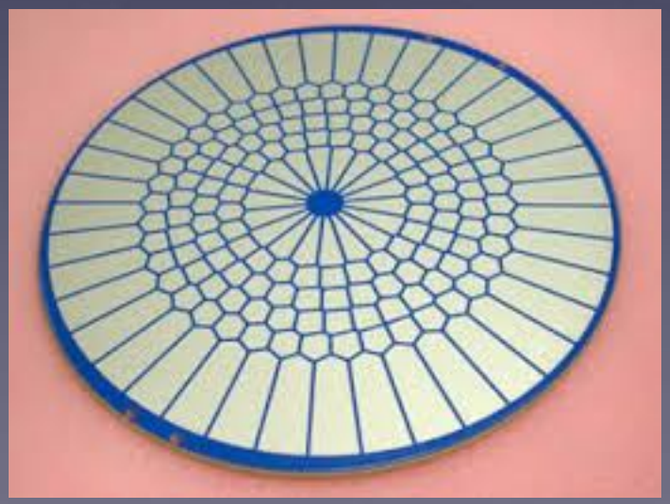
Main goals:

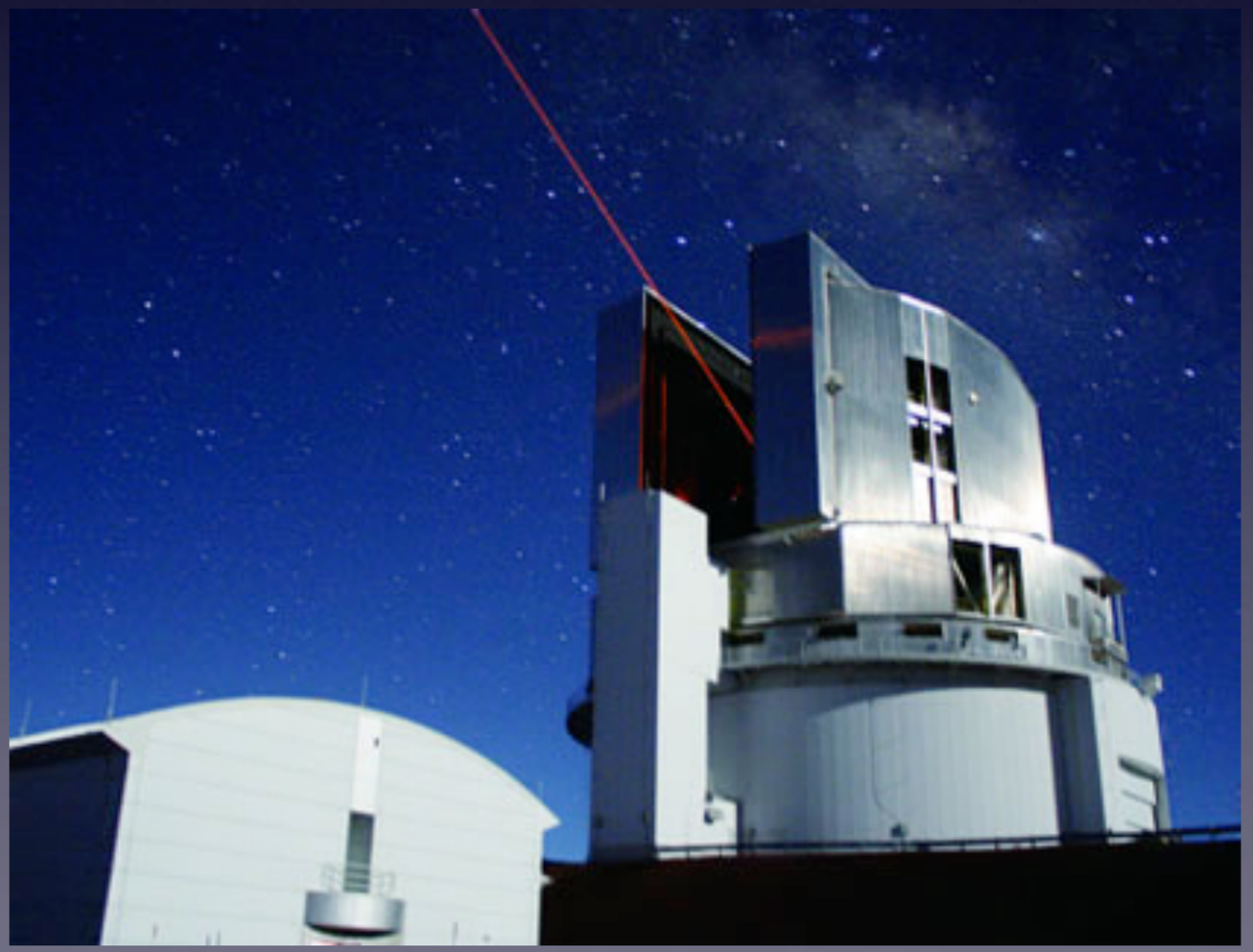
- obtain accurate relative astrometry/photometry/lens galaxy shape
- detect previously unseen features such as the host galaxy

Adaptive optics



- Beacon to monitor wavefronts (NGS, LGS R<18 mag)
- Deformable mirror to correct distorsions
- Beacon monitoring, correction computing, mirror correction cycle ~ 500 Hz



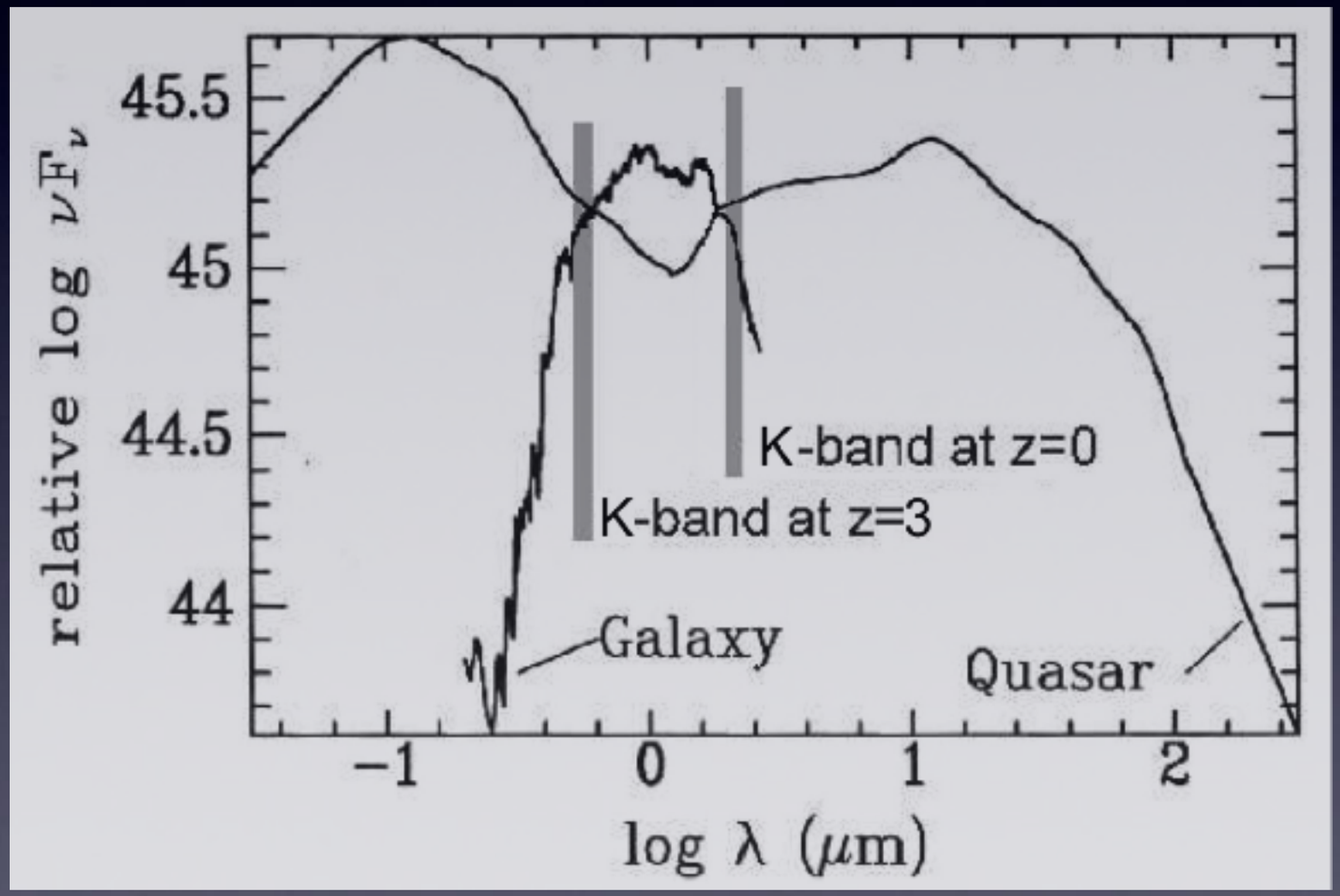


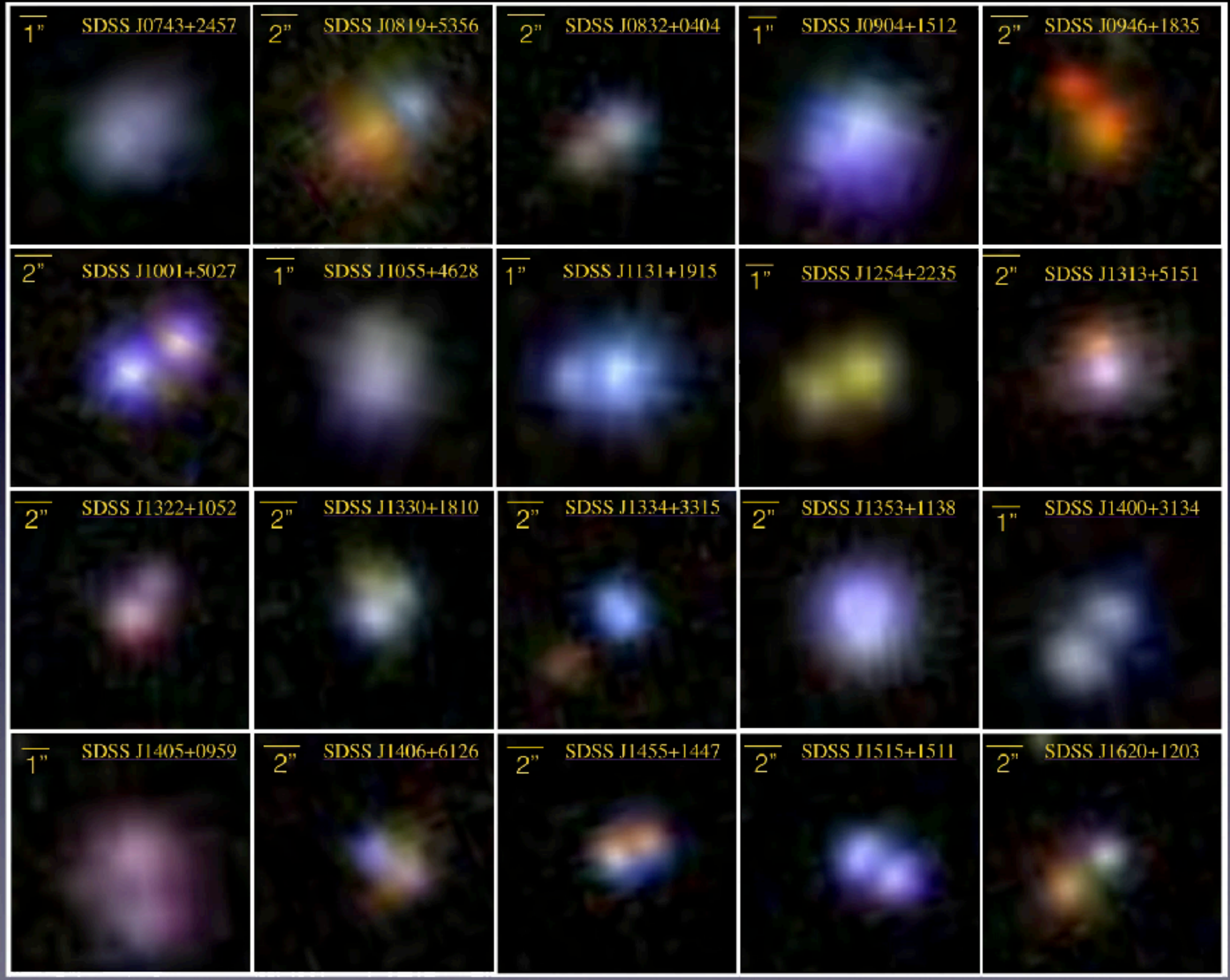
Subaru Telescope AO imaging campaign

- ~1h/target imaging in K' (with overhead) with IRCS+AO
- observed 25 systems

K' band:

- better AO correction
- less microlensing, intrinsic variability, reddening
- host galaxy more prominent

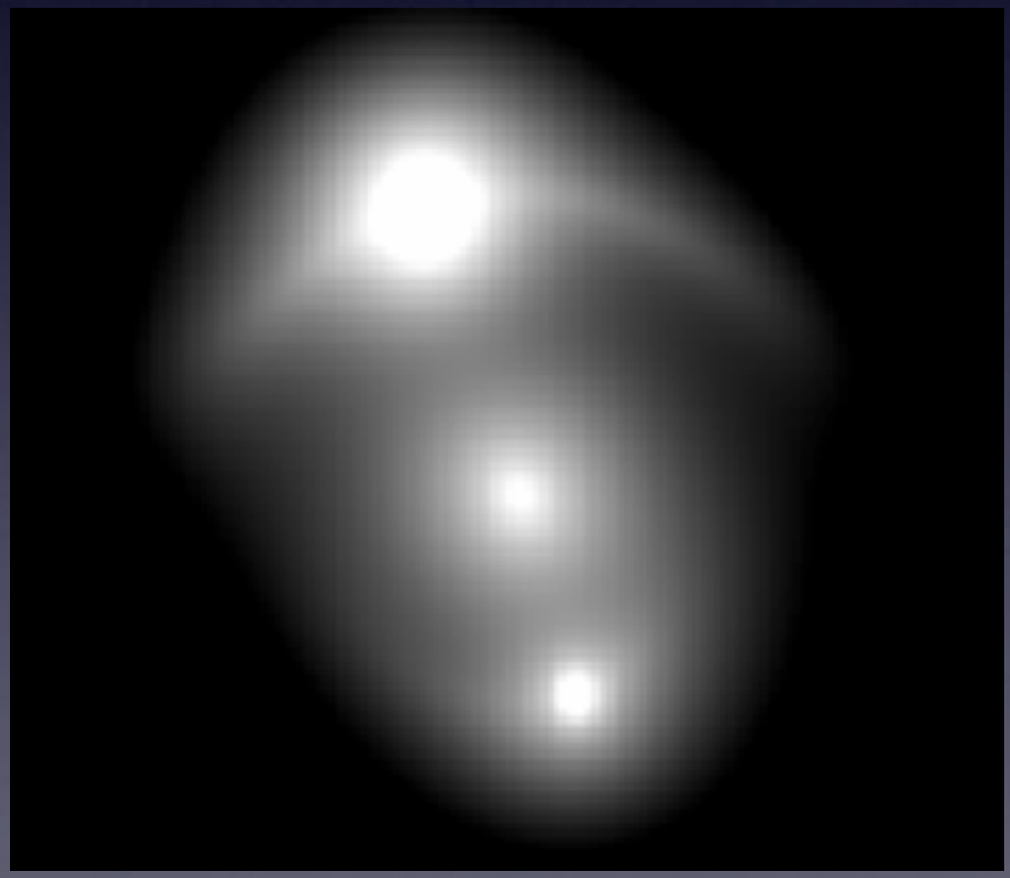



1" SDSS J0743+2457
2" SDSS J0819+5356
2" SDSS J0832+0404
1" SDSS J0904+1512
2" SDSS J0946+1835
2" SDSS J1001+5027
1" SDSS J1055+4628
1" SDSS J1131+1915
1" SDSS J1254+2235
2" SDSS J1313+5151
2" SDSS J1322+1052
2" SDSS J1330+1810
2" SDSS J1334+3315
2" SDSS J1353+1138
1" SDSS J1400+3134
1" SDSS J1405+0959
2" SDSS J1406+6126
2" SDSS J1455+1447
2" SDSS J1515+1511
2" SDSS J1620+1203

- Data modeling is non-trivial: how to characterize the PSF?
    - field too small to contain stars
    - AO PSF is time varying

- Unique feature of lensed quasars: two/four point-like sources surrounding the lens galaxy
    - PSF: 2 Moffat components
    - lens light: Sersic
    - lens mass: singular isothermal ellipsoid
    - Extended source: lensed Sersic

- More details (fitting technique, simulations) in Rusu et al. 2016



SDSS J1405+0959

- z_{lens}=0.66 z_{QSO}=1.98
- new components: GX, GY
- GX: morphology unclear
- J,H, K' imaging for photo-z

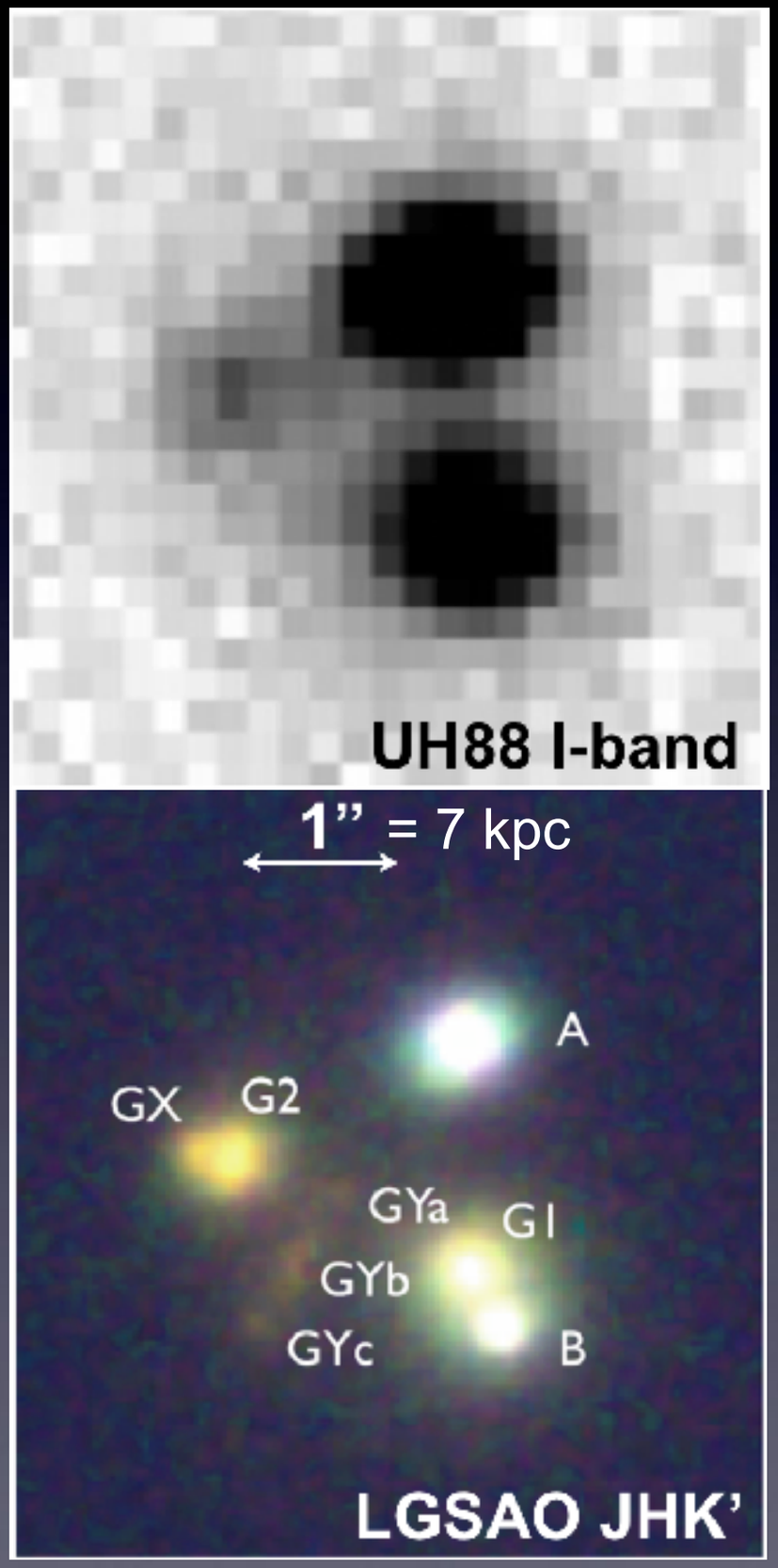
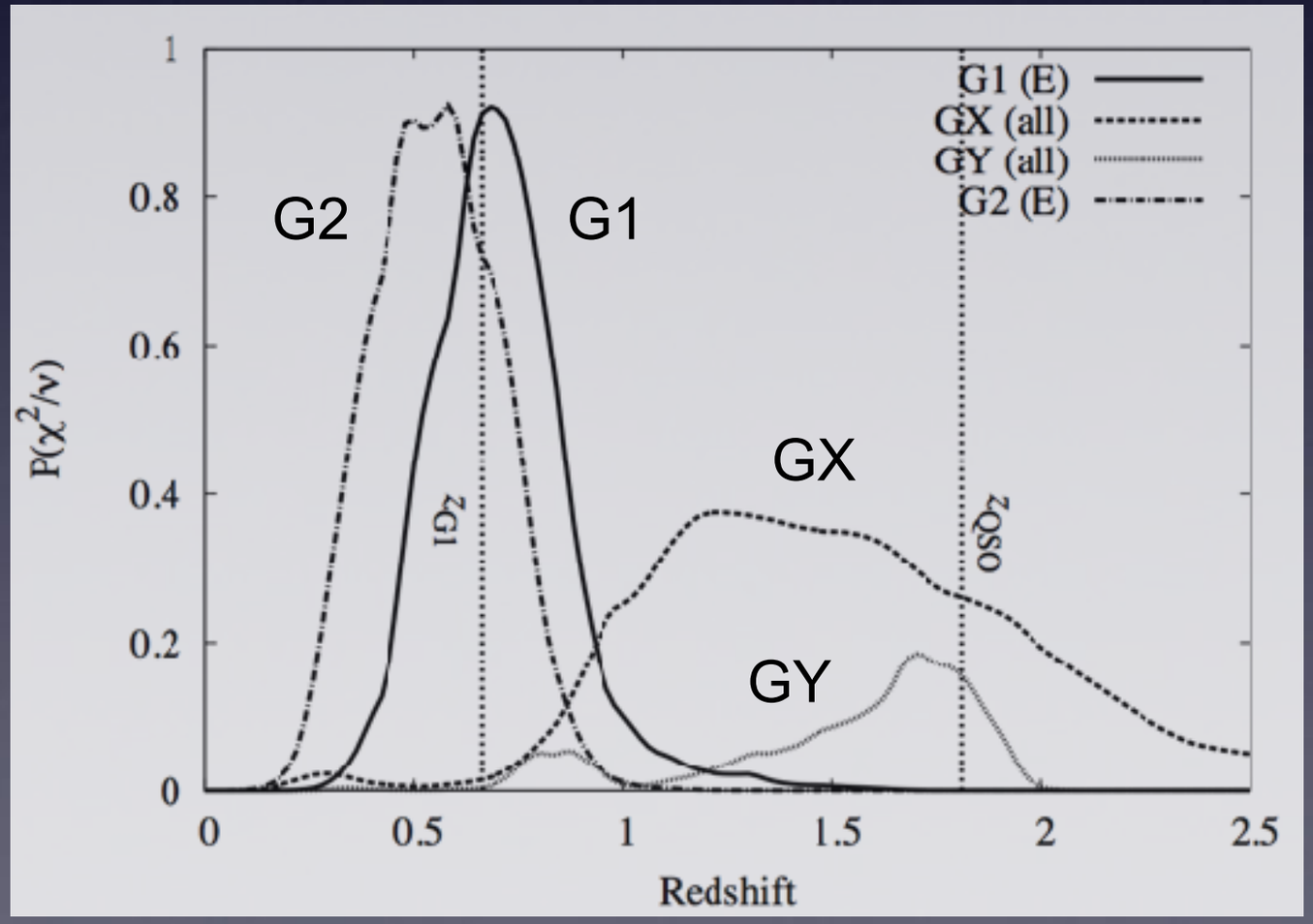


Photo-z estimates

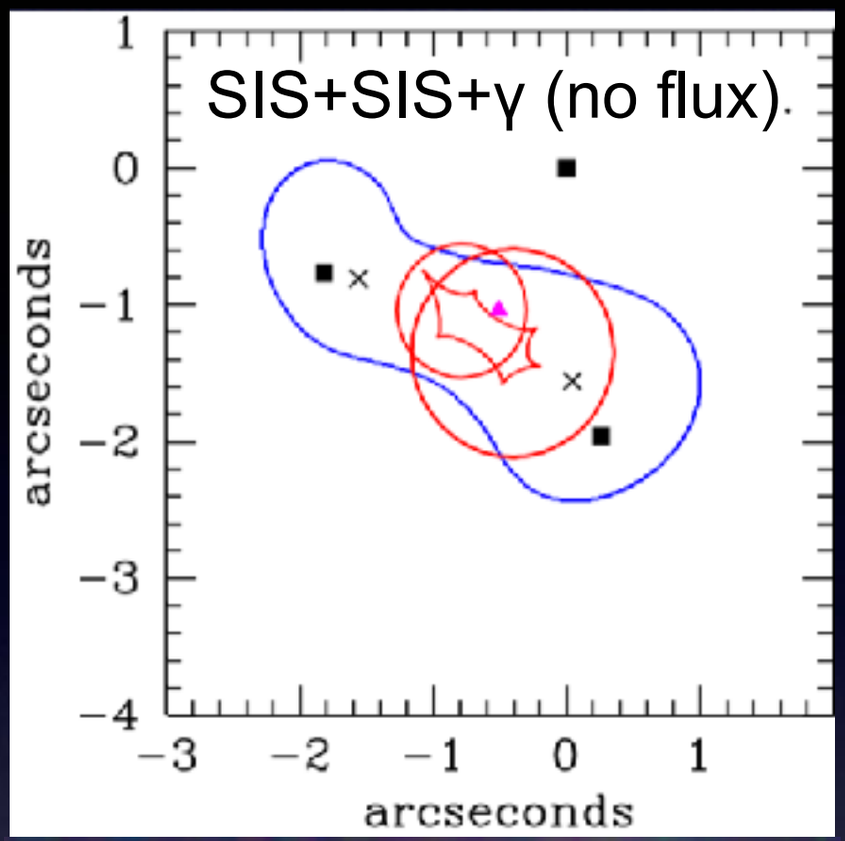
G1, G2 ellipticals consistent with same redshift

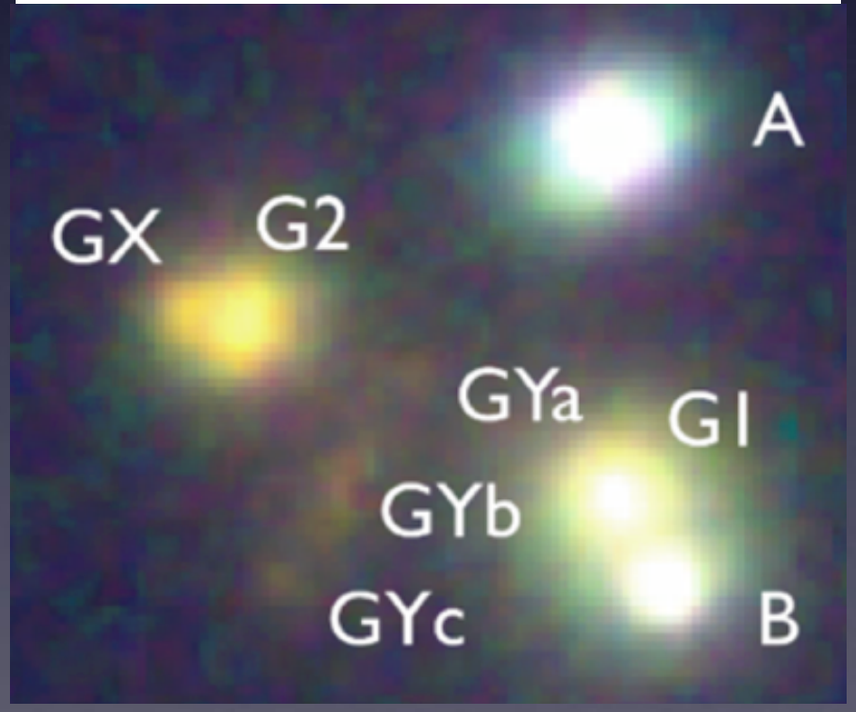
GX (assuming galaxy): larger, broad redshift

GY (aperture photometry) consistent with quasar redshift



Nature of GX





1) galaxy at high-z: unlikely, multiply imaged by G2

2) star: NO, different colors from any stars in near-IR

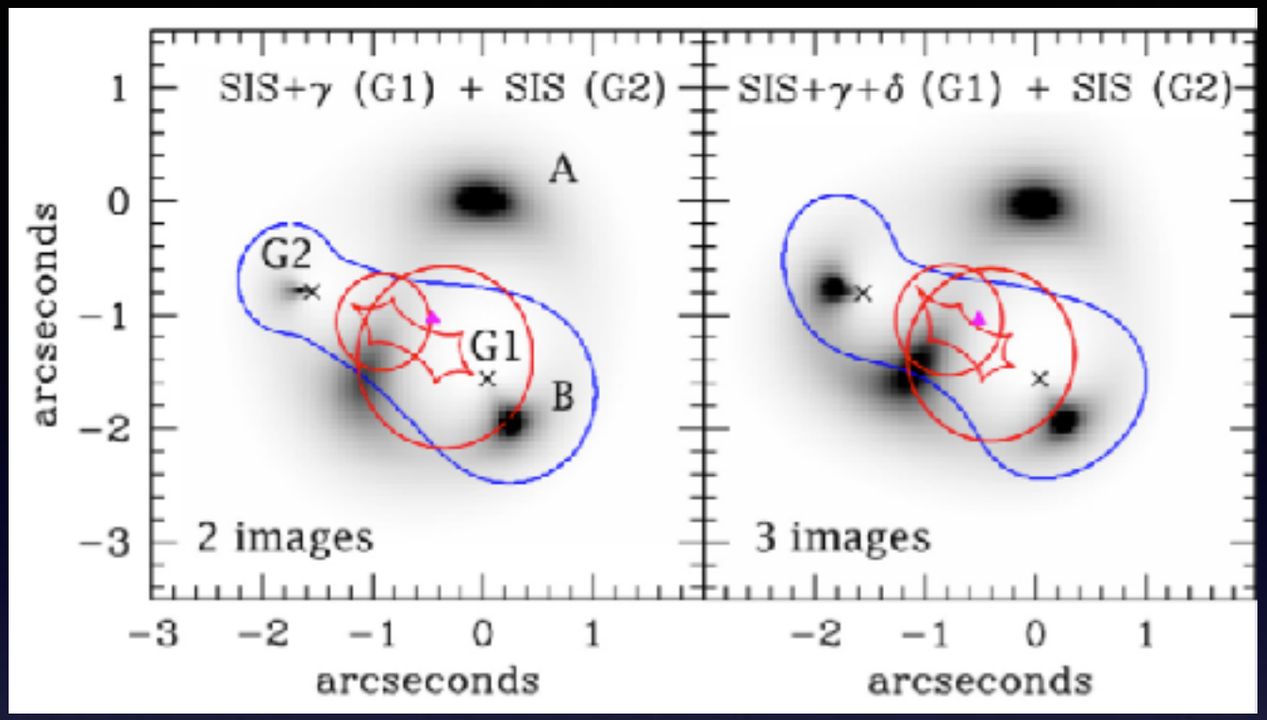
3) 3rd quasar image: lensing models with GX as the 3rd quasar image produce a good fit

Assuming color difference due to extinction, can GX be a 3rd quasar image?

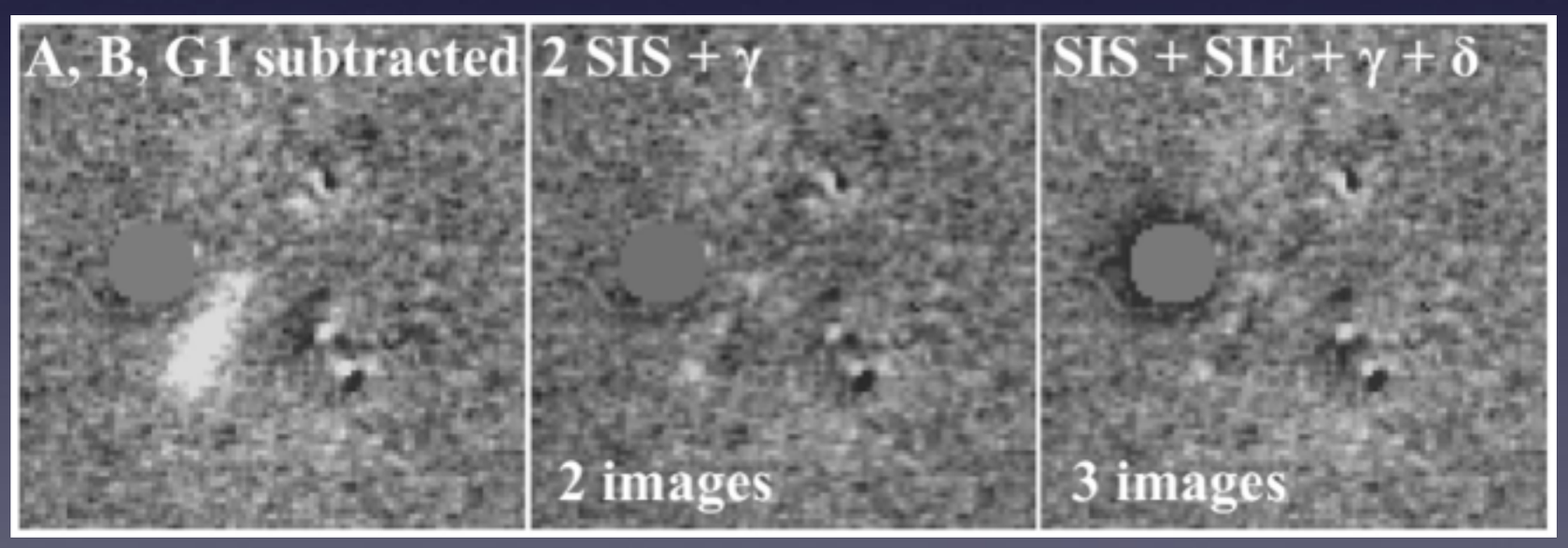
$$R_V = 3.1 \rightarrow E(B-V) \sim 0.8$$

Such extinction has been found in other lensed quasars

Nature of GY

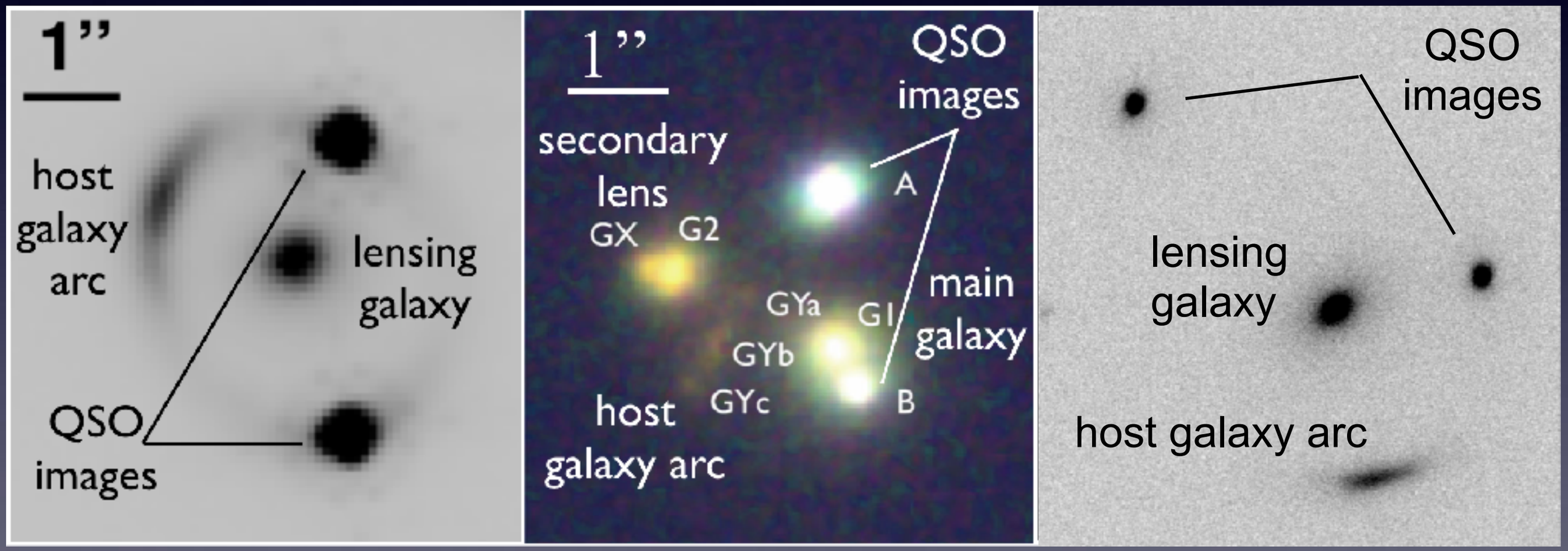


source: sersic profile * PSF



Position, elongation and orientation of GY consistent with the host galaxy

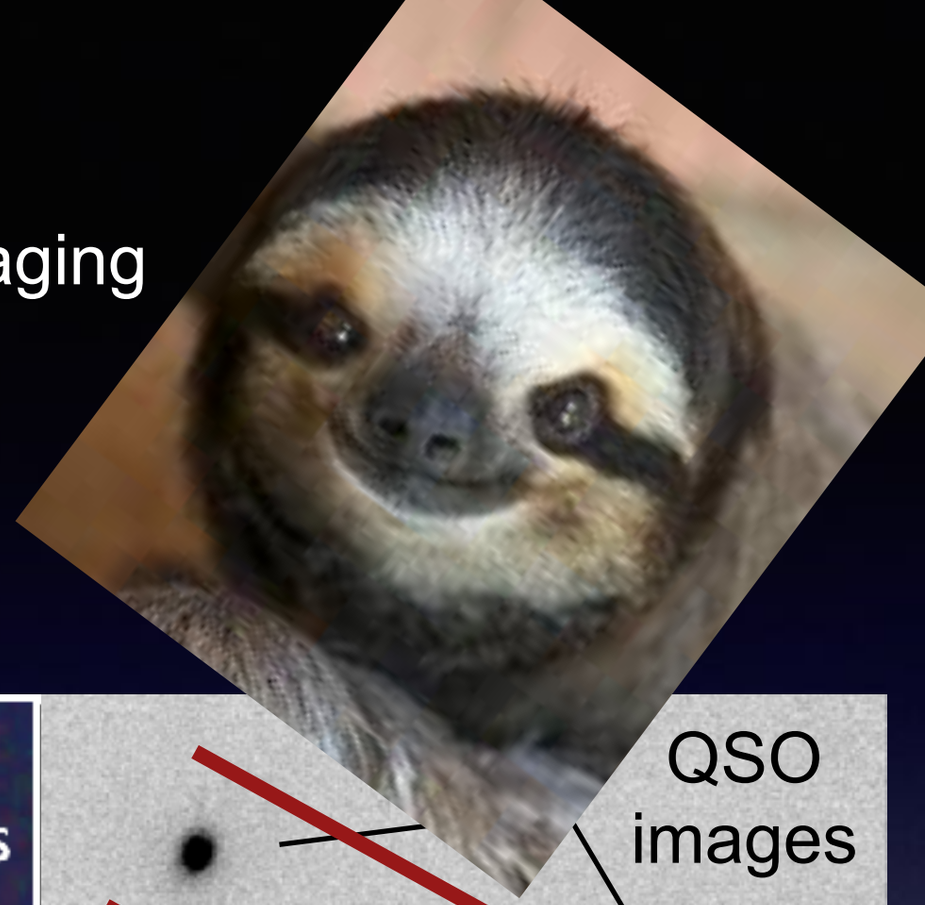
- SDSS J1405+0959 has an observed host galaxy arc without a central quasar image → “natural coronagraph”
- only three other natural coronagraphs are known

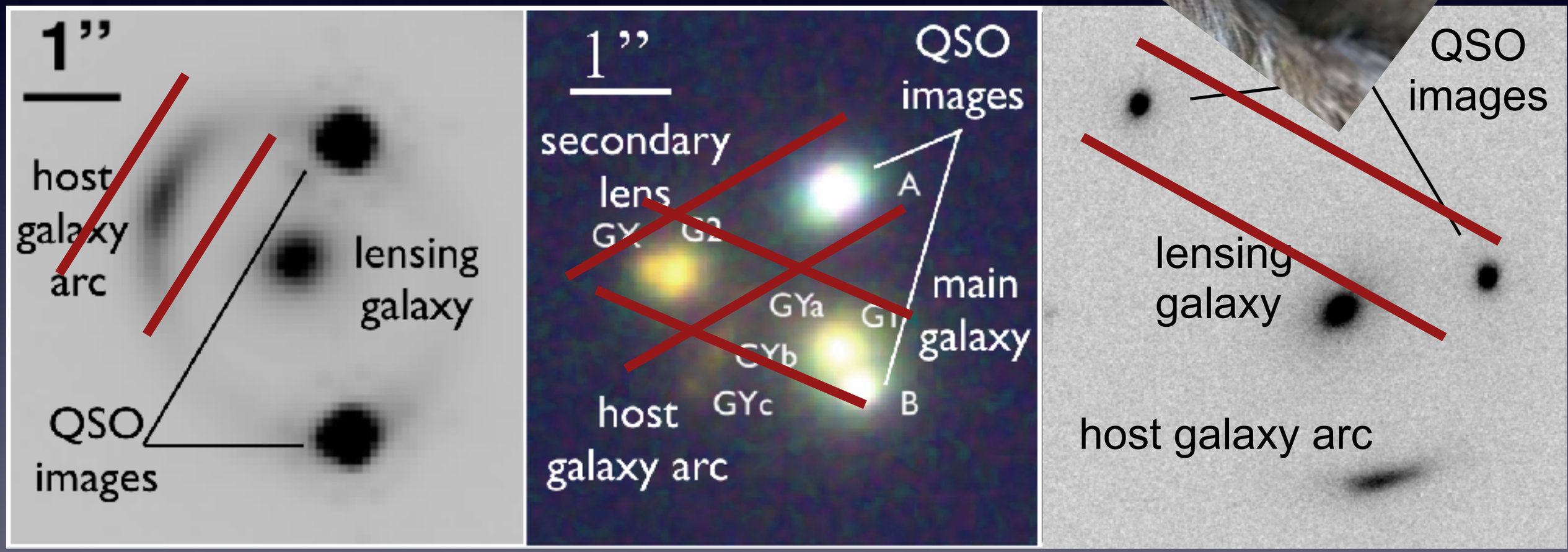


J1206 J1405 MG 2016

- Observed all three with spectroscopy and AO imaging

Stay tuned for results...





J1206 J1405 MG 2016

Conclusions and future prospects

• Conducted the first ever AO imaging campaign of a large number of lensed quasars (25 systems with Subaru Telescope)

• Obtained astrometry, morphology and mass models competitive with HST-based data → vast improvement over results from low-resolution data

• Discovered a “natural coronagraph” lens, a class of objects currently under investigation;

• Other results in Rusu et al. 2016:

- showed that it is possible to study the SMBH-host coevolution with AO data, without an a-priori known PSF

- for systems with large ellipticity, the mass is less elliptical than the light

• Plans to continue the campaign as new lensed quasars are discovered from HSC Survey