Key Programs the cosmology and fundamental physics ISDT is working on

TMT.OPS.PRE.15.029.REL01

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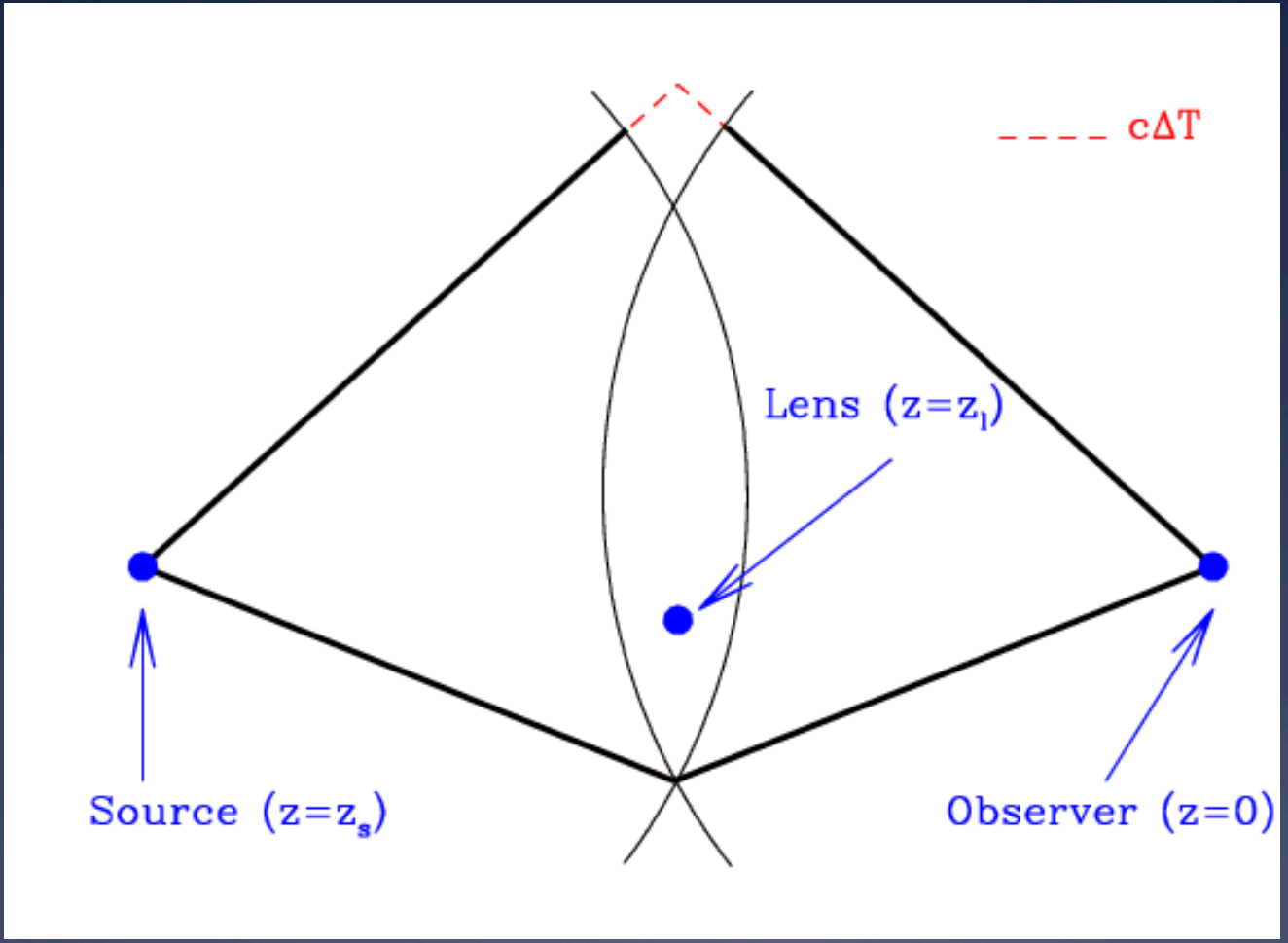
Overview

- Dark energy and dark matter with lensed quasars
  - IRIS imaging and spectroscopy
  - Overlapping interest with AGN/GALAXIES/HIGHZ
- Proper Motion of stars in dwarf spheroidal galaxies
  - IRIS astrometry
  - Overlapping interest with GALAXIES
- High-z clusters for cosmology and galaxy evolution
  - IRIS imaging; IRMS and WFOS Spectroscopy
  - Overlapping interests with HIGHZ

Cosmography from time delays: how does it work?



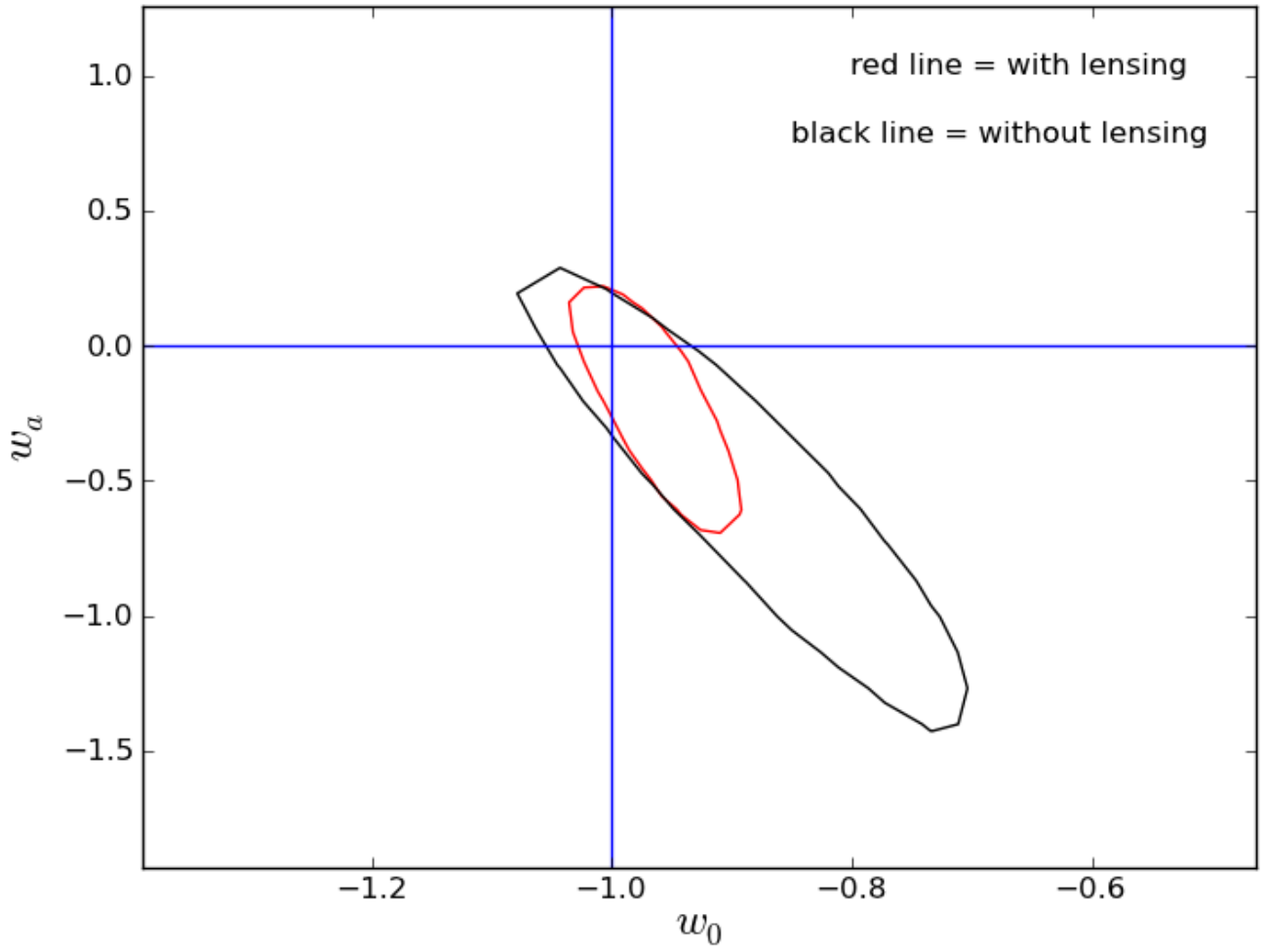
Time delay distance in practice

$$\Delta t \propto D_{\Delta t}(z_s, z_d) \propto H_0^{-1} f(\Omega_m, w, ...)$$

Steps:

- Measure the time-delay between two images
- Measure and model the potential
- Infer the time-delay distance
- Convert it into cosmological parameters

Forecast for 150 lenses

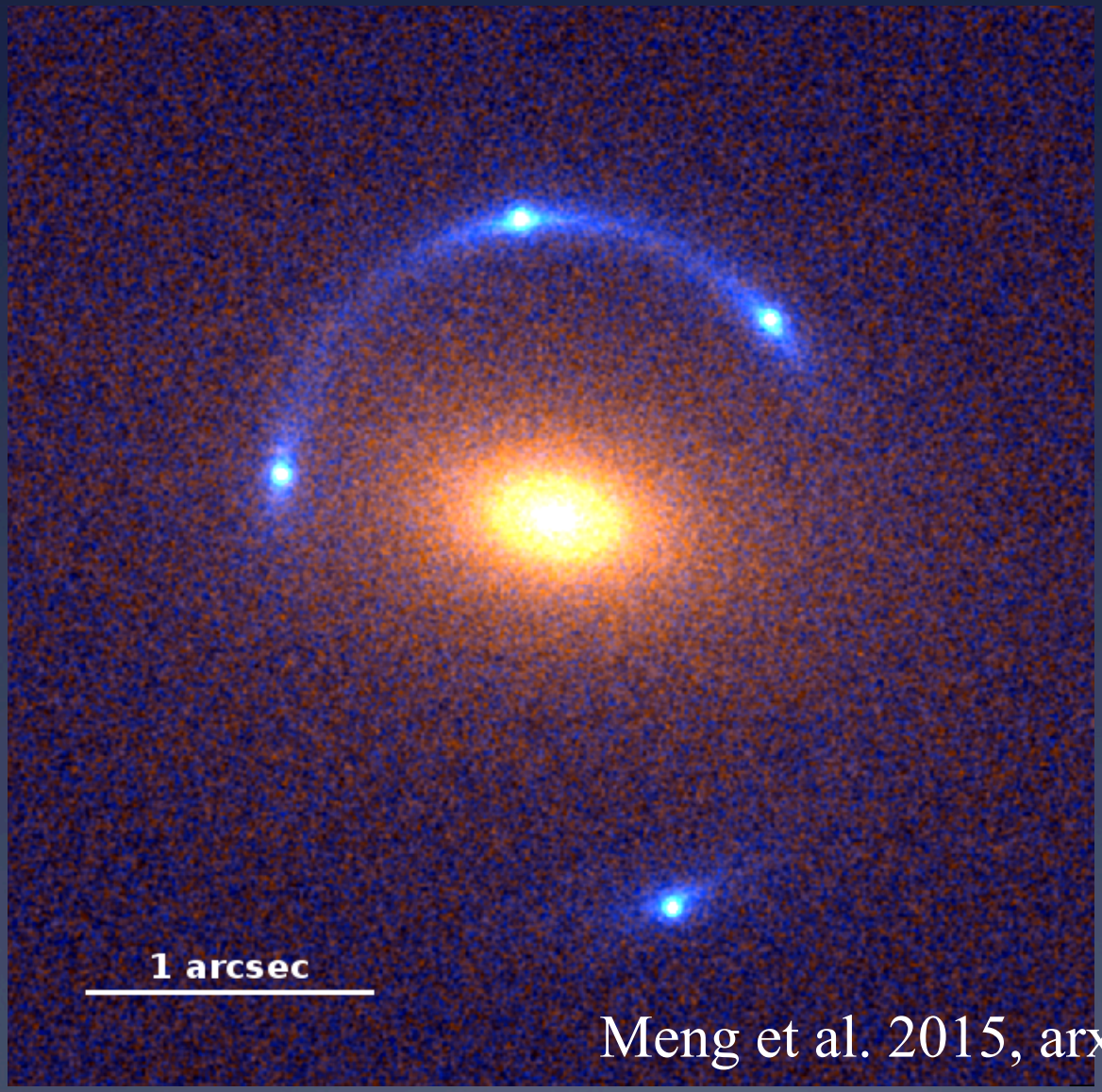


A.Sen & S.Kumar

Ingredients

- Lensed quasars
  - From DES/HSC/PANSTARRS
- Time delays
  - From LSST or dedicated follow-up
- Spectroscopy for redshifts and velocity dispersion profiles
  - TMT-IRIS!!
- High resolution imaging
  - TMT-IRIS!! (very fast)
- Total TMT-IRIS time per object ~1 hr -> 150 hrs = 15 nights

TMT simulations



Meng et al. 2015, arxiv tonight!

Additional science topics

- Millilensing -> Substructure mass function -> dark matter free streaming length (WDM?) [COSMO]
- Microlensing -> Accretion disk and broad line region structure [AGN]
- Microlensing -> M*/L-> Initial mass function of stellar populations [GALAXIES; STARS]
- AGN host galaxies -> MBH/sigma relation and black hole galaxy co-evolution [AGN/GALAXIES]
- Dark matter halos and structure of the stellar component in the lens galaxy [GALAXIES]

Galaxy Clusters Survey for Cosmology and Galaxy Evolution

Cosmology/Fundamental physics key project proposal

Why?: Low-z clusters are being studied w/ ground based telescopes (z<0.2) and/or HST (0.2<z<0.5). Equivalent datasets don't exist at higher z. JWST will extend studies to high-z, but not get to the same **physical** resolution for these clusters.

What: Surveying 100 galaxy clusters with 0.5<z<2.5:

50 with 0.5<z<1: Mass scale Calibration; cosmology via SL(and WL?) tomography; high-z lensed galaxies, faint cluster galaxy populations

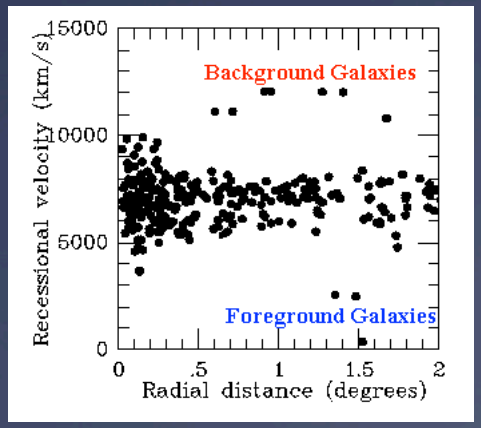
50 with z>1 (out to z=2.5+?): masses of high z clusters, evolution of brighter galaxy populations, evolution of cluster merging.

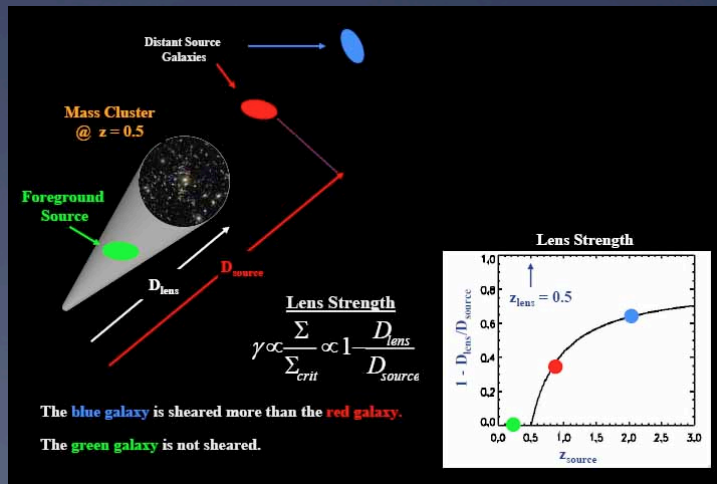
A Legacy survey—the "golden cluster" sample covering the entire redshift range of cluster formation

Imagine this at 3-5x resolution!

The science

- Tomographic measurements of SL(+WL?) to make an independent cosmological measurement—relies on resolution to increase number of "arcs" and spectroscopic redshifts to improve mass model.
- Calibration of cluster mass scale (at z>0.5)—SL+WL+ background redshift measurements of clusters spanning mass/redshift to remove systematic uncertainties in LSST/WFIRST dark energy measurements.
- Mass measurements via WL+SL of z>>1 clusters where the mass-observable relations will not work.
- Spectroscopy of cluster members—kinematics (masses), star formation, and (for the central galaxies) resolved spectroscopy (via IRIS IFU)
- High-z lensed galaxies (resolve individual SFR, find higher z galaxies, increase the M>10 area by factors 10-20x over Frontier Fields.





The Instruments.

IRIS—35”x35” FOV—200 kpc across at z=0.5

-- 6x the HST ACS resolution at 1 micron, ~3x at Ks (relative to F606W). 120 minutes will give S/N>10 detections of K~29 galaxies; ~2-6 hours/cluster. ~20-60 nights.

IRMS-- ~50 multiplex IR spectroscopy of lensed galaxies AND faint cluster members. 2-3 pointings/cluster. 1-2 clusters/night– (~50 nights) Subsample? How much of this science will be done by JWST?

WFOS: star forming galaxy redshifts behind clusters—calibrate mass scale for WFIRST/LSST clusters.~10-20 nights.

Legacy value

Largest sample of lensed galaxies w/uniform reduction.

Clusters uniformly observed (and analyzed the same way)

Collection of other datasets will be basis for more and more studies

Cadence of observations may allow other science (lensed supernovae?)

Legacy Requirements

Good pipeline software (and a way to contribute improvements back to observatory)

Uniform data archive with reduced data

A large and diverse enough collaboration