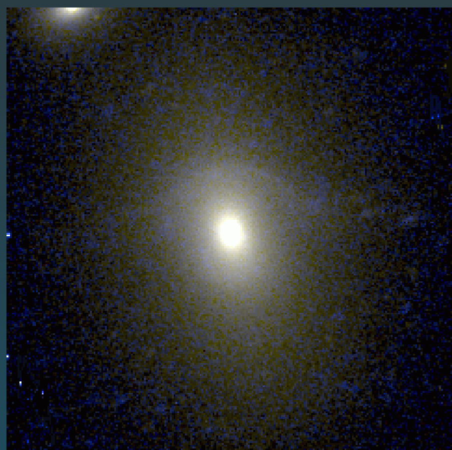
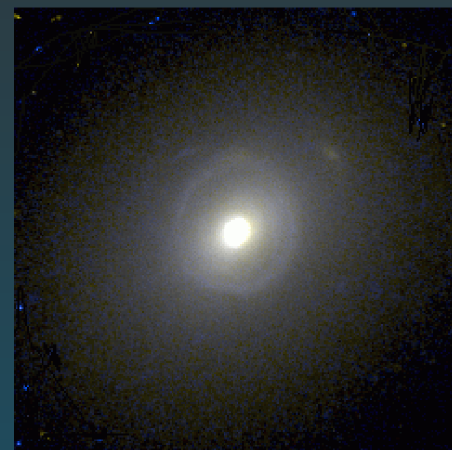
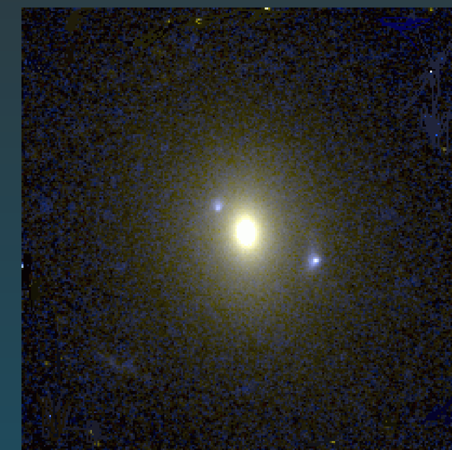
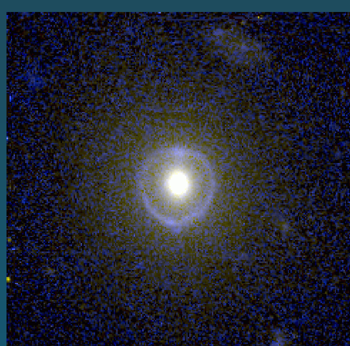
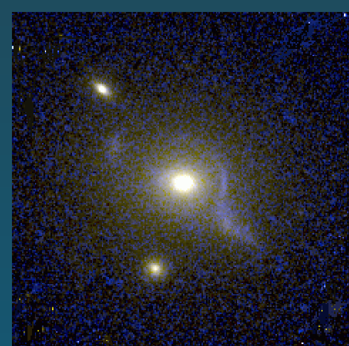
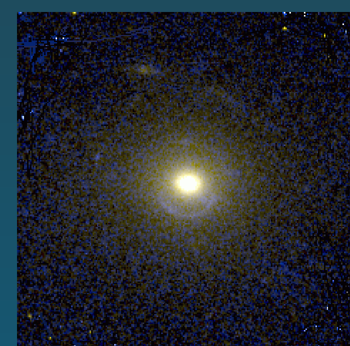
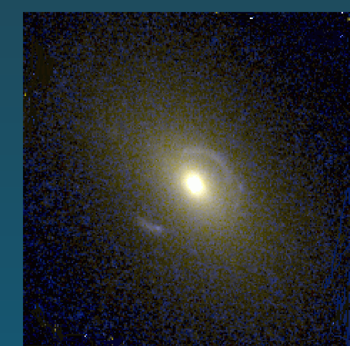
Combining Lensing and Dynamics for SLACS Lenses

Oliver Czoske
Kapteyn Institute, Groningen, NL

“Gas and Stars in Galaxies – A Multi-Wavelength 3D Perspective”
Garching, 12 June 2008

Collaborators

Léon Koopmans (Kapteyn)

Matteo Barnabè (Kapteyn)

Tommaso Treu (UCSB)

Adam Bolton (IfA, Hawai‘i)

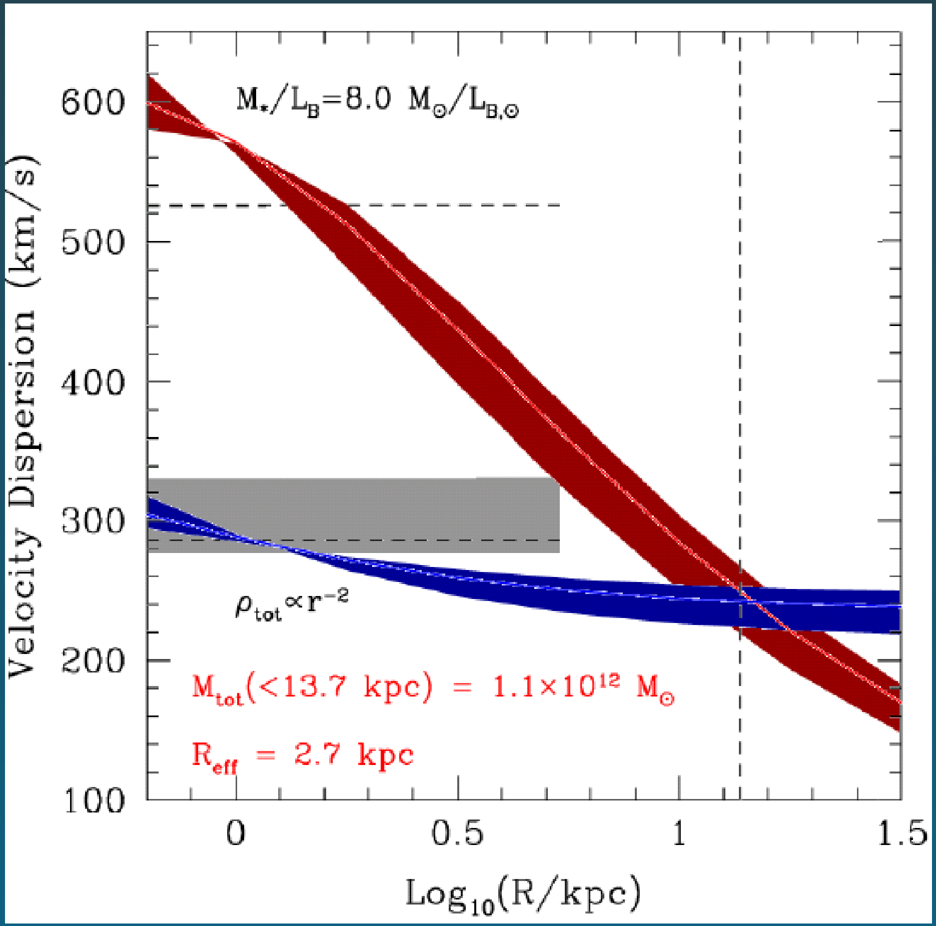
Advantages of gravitational lensing:

- sensitive to *all* kinds of matter (DM + stars + gas + . . .)
- insensitive to dynamic state of matter
- robust and model-independent estimate of total mass contained within Einstein ring

But: model degeneracies!
These can be broken by combination with, e.g., kinematic information.

Lenses Structures and Dynamics
(L. Koopmans, T. Treu)

- detection of DM halos at high significance
- inner total mass profiles close to isothermal
- *etc...*



(MG2016, Léon Koopmans)

The project

Sample:

$\{17 \text{ lens systems}\} \subset$ SLACS $\subset$ SDSS LRG and MAIN (quiescent)

Observations:

Large programme with VIMOS/IFU

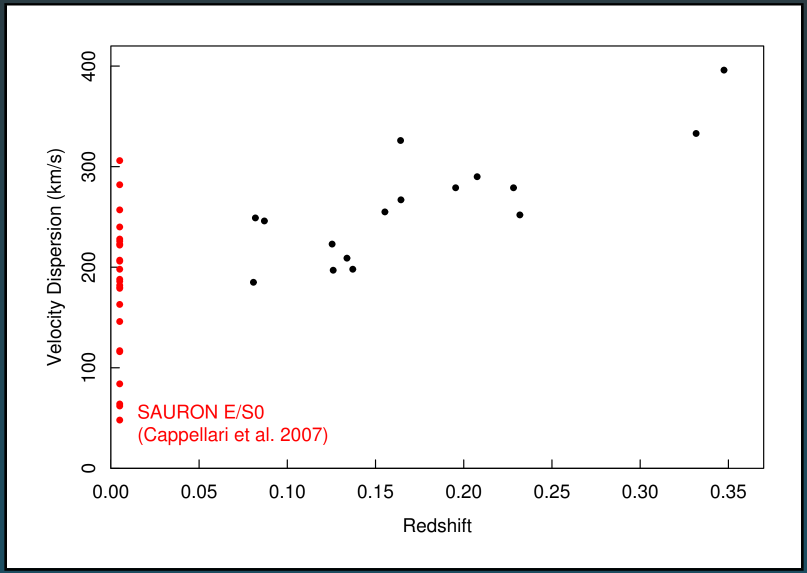
Data reduction:

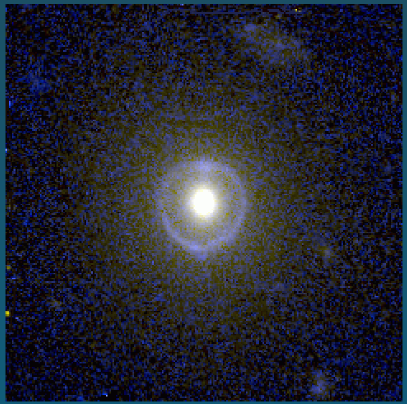
VIPGI

Kinematic analysis:

Template fitting in pixel space

$\longrightarrow v(x,y),\ \sigma(x,y)$



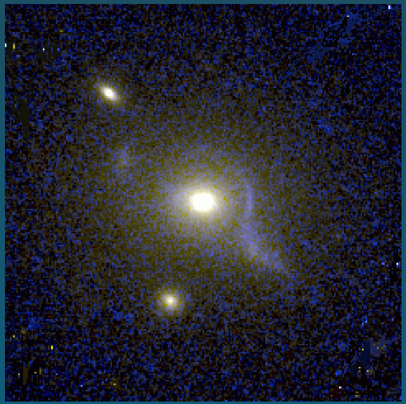


J162746.44−005357.5

$z_{\rm lens} = 0.2076$

$z_{\rm source} = 0.5241$

$\sigma_{\rm v} = 275 \pm 12$

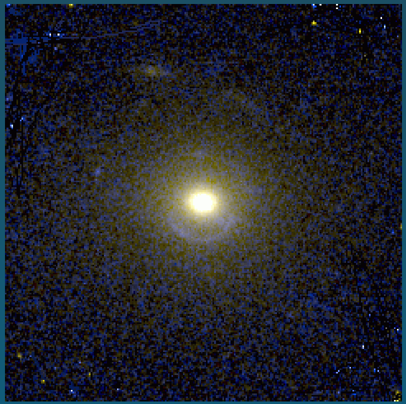


J021652.54−081345.3

$z_{\rm lens} = 0.3317$

$z_{\rm source} = 0.5235$

$\sigma_{\rm v} = 332 \pm 23$

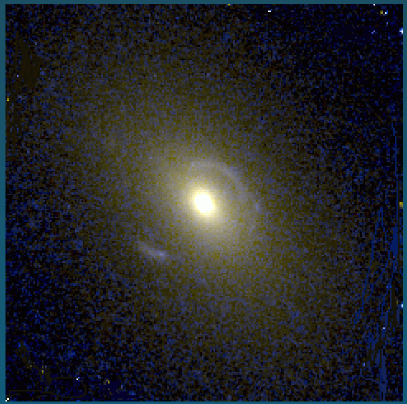


J230053.14+002237.9

$z_{\rm lens} = 0.2285$

$z_{\rm source} = 0.4635$

$\sigma_{\rm v} = 283 \pm 18$



J230321.72+142217.9

$z_{\rm lens} = 0.1553$

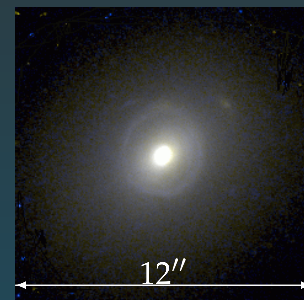
$z_{\rm source} = 0.5170$

$\sigma_{\rm v} = 260 \pm 15$

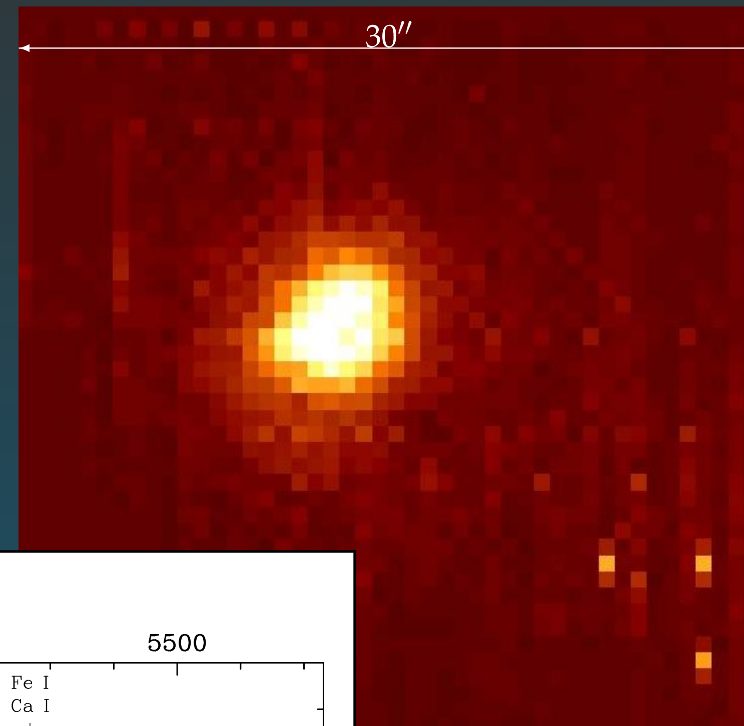
SLACS IFS

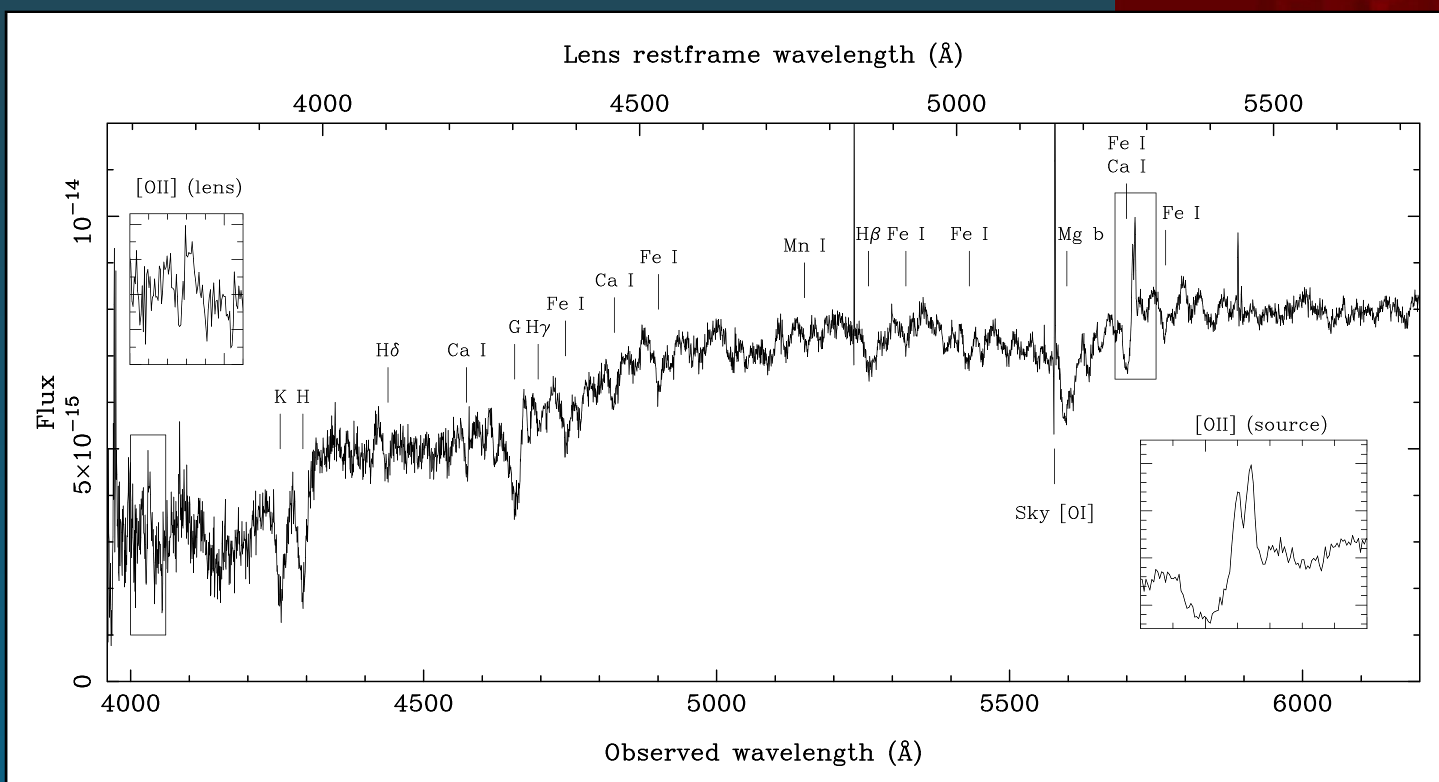
Reduction Results: SDSS J2321

SDSS J232120.93−093910.2



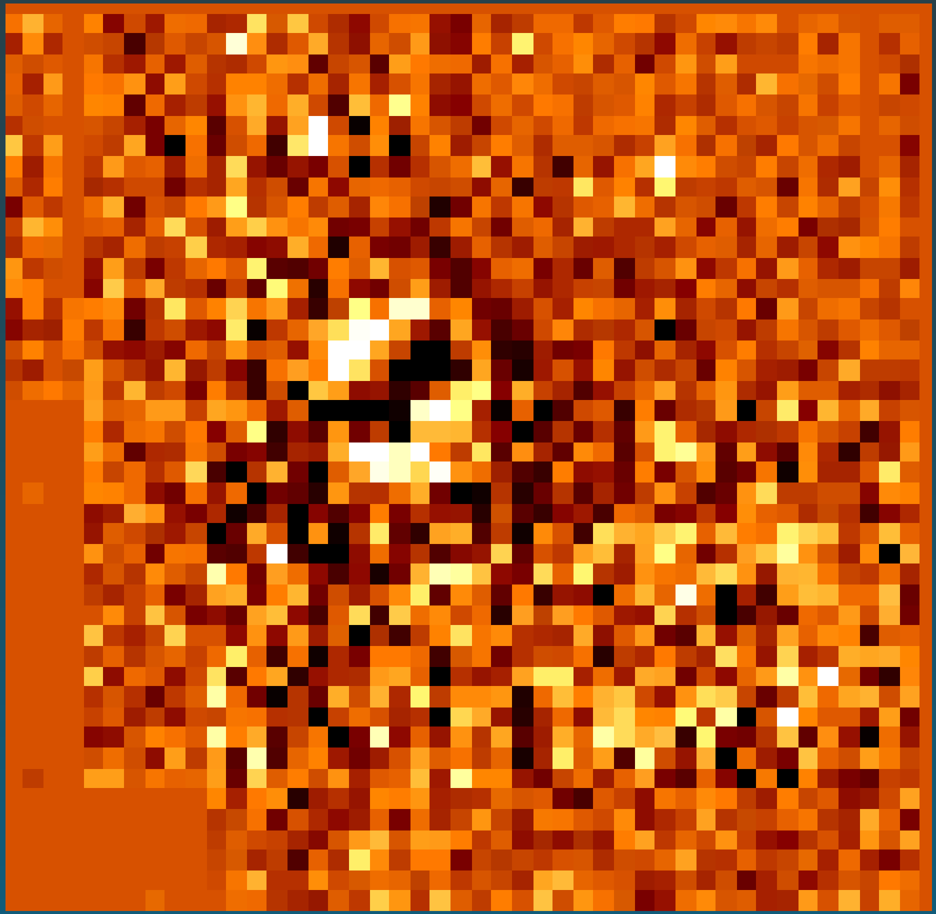
HST / ACS



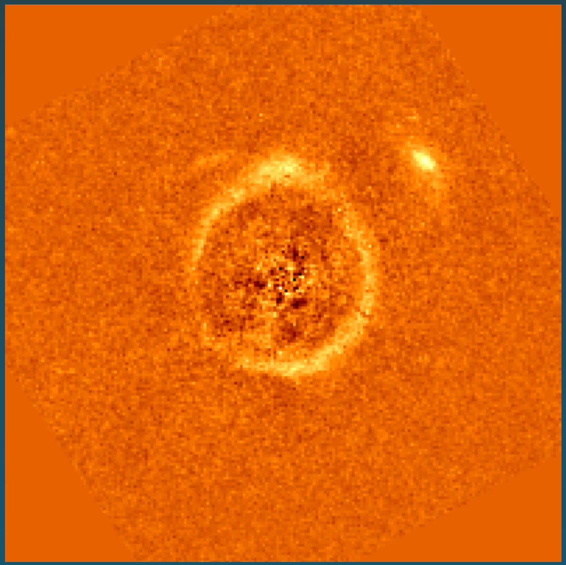


[OII] narrow band image

We can recover the structure of the lensed source by extracting an [O II] intensity image:



VIMOS/IFU, narrow-band [O II] − continuum



HST/ACS, lens subtracted

CAULDRON

Combined Algorithm for Unified Lensing and Dynamics ReconstructiON

Axisymmetric density distribution: $\rho(R, z)$

Gravitational potential: $\Phi(R, z, \eta_k)$

linear optimization

Lensed image reconstruction

$\mathsf{L}\boldsymbol{s} + \boldsymbol{n}_{\mathrm{L}} = \boldsymbol{d}$

linear optimization

Dynamical model

$\mathsf{Q}\boldsymbol{\gamma} + \boldsymbol{n}_{\mathrm{D}} = \boldsymbol{p}$

Maximize the Bayesian evidence

allows model comparison

automatically embodies Occam's razor

non-linear optimization: vary η_k

at convergence

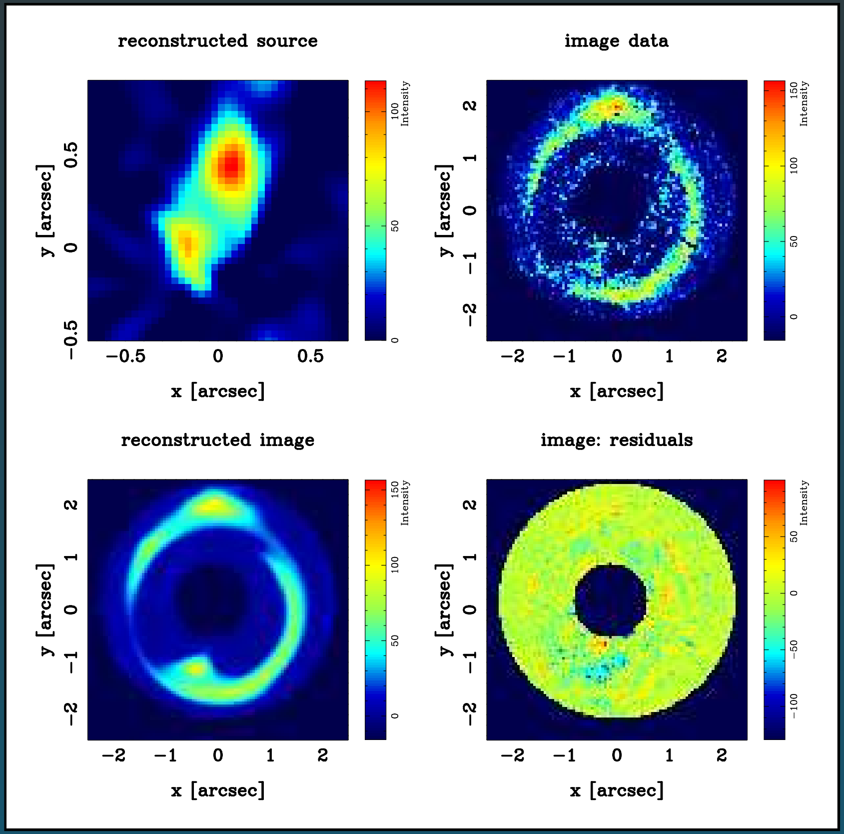
Best values for the non-linear parameters η_k

source reconstruction & DF reconstruction

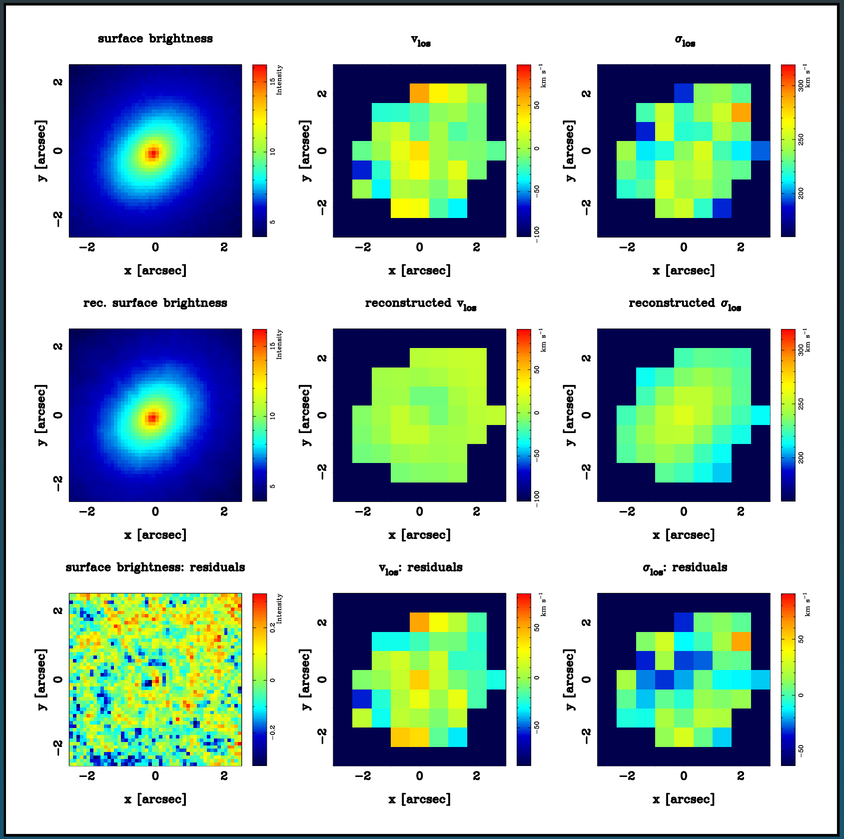
Barnabè & Koopmans (2007)

J2321−097: Results

Lensing



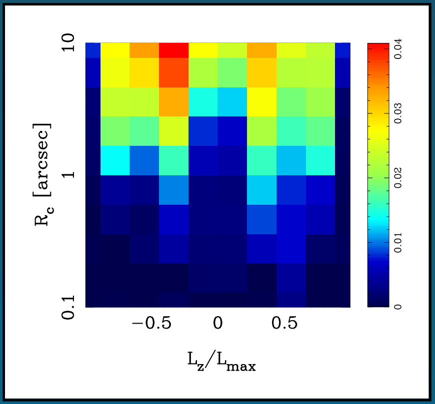
Dynamics



adopted model: Power Law

$\rho(R,z) \propto (R^2 + z^2/q^2)^{-\gamma/2}$

- inclination: $i = 65° \pm 10°$
- slope: $\gamma = 2.04 \pm 0.1$
- axis ration: $q = 0.73 \pm 0.08$
- "lens strength": $\alpha_0 = 0.47 \pm 0.01$



Summary

Furthermore:

- Stellar population modelling (with Scott Trager) $\longrightarrow$ stellar M/L, disentangle stellar and dark matter contributions
- place systems in $(v/\sigma, \epsilon)$ diagram, inclination correction from detailed modelling

For further information, please consult our papers:

- SLACS: e.g. Bolton et al. (2008), arXiv:0805.1931
- CAULDRON: Barnabè & Koopmans (2007), ApJ **666**, 726
- First IFU results: Czoske et al. (2008), MNRAS **384**, 987

Contents