Combining Lensing and Dynamics for SLACS Lenses

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Collaborators

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

Observations:
- Large programme with VIMOS/IFU

Data reduction:
- VIPGI

Kinematic analysis:
- Template fitting in pixel space
  \[ \rightarrow v(x, y), \sigma(x, y) \]

\[ \begin{align*}
  \text{J162746.44-005357.5} & \quad z_{\text{lens}} = 0.2076 \quad z_{\text{source}} = 0.5241 \quad \sigma_v = 275 \pm 12 \\
  \text{J021652.54-081345.3} & \quad z_{\text{lens}} = 0.3317 \quad z_{\text{source}} = 0.5235 \quad \sigma_v = 332 \pm 23 \\
  \text{J230053.14+002237.9} & \quad z_{\text{lens}} = 0.2285 \quad z_{\text{source}} = 0.4635 \quad \sigma_v = 283 \pm 18 \\
  \text{J230321.72+142217.9} & \quad z_{\text{lens}} = 0.1553 \quad z_{\text{source}} = 0.5170 \quad \sigma_v = 260 \pm 15
\end{align*} \]
SLACS IFS

Reduction Results: SDSS J2321

SDSS J232120.93−093910.2

HST/ACS

Lens restframe wavelength (Å)

Observed wavelength (Å)
We can recover the structure of the lensed source by extracting an \([\text{O} \, \text{II}]\) intensity image:
CAULDRON

Combined Algorithm for Unified Lensing and Dynamics Reconstruction

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

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

Lensed image reconstruction

$\mathbf{Ls} + n_L = d$

Dynamical model

$Q\gamma + n_D = p$

Maximize the Bayesian evidence
allows model comparison
automatically embodies Occam’s razor

at convergence

Best values for the non-linear parameters $\eta_k$
source reconstruction & DF reconstruction

Barnabè & Koopmans (2007)
J2321−097: Results

Lensing

- adopted model: Power Law
  \[ \rho(R,z) \propto (R^2 + z^2 / q^2)^{-\gamma/2} \]

- inclination: \( i = 65^\circ \pm 10^\circ \)
- 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) → 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
- First IFU results: Czoske et al. (2008), MNRAS 384, 987
<table>
<thead>
<tr>
<th></th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Collaborators</td>
</tr>
<tr>
<td>2</td>
<td>SLACS IFS</td>
</tr>
<tr>
<td>3</td>
<td>The project</td>
</tr>
<tr>
<td>4</td>
<td>SLACS IFS</td>
</tr>
<tr>
<td>5</td>
<td>CAULDRON</td>
</tr>
<tr>
<td>6</td>
<td>J2321–097: Results</td>
</tr>
<tr>
<td>7</td>
<td>Summary</td>
</tr>
<tr>
<td>8</td>
<td>Contents</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
</tr>
<tr>
<td></td>
<td>Reduction Results: SDSS J2321 [OII] narrow band image</td>
</tr>
</tbody>
</table>