Combining Weak and Strong Cluster Lensing cont.

July 18, 2008
The Method

We combine weak and strong galaxy cluster lensing in the following way:

- Reconstruction quantity is the lensing potential $\psi$
- Maximum-likelihood approach

$$\chi^2(\psi) = \chi^2_w(\psi) + \chi^2_s(\psi)$$

- Fully non-parametric
- Grid-based
- Weak lensing input: ellipticity catalogue
- Strong lensing input: critical curve or arc position
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Weak Lensing

- State-of-the-art observations allow only for a ($\sim 10 \times 10$) pixel reconstruction grid
- Furthermore galaxies are not distributed homogeneously over the field
- Solution: Adaptive-averaging-process
- Problem: Grid points become correlated

$$\chi^2_w(\psi) = \sum_{i,j} \left( \varepsilon - \frac{Z(z) \gamma(\psi)}{1 - Z(z) \kappa(\psi)} \right)_i C^{-1}_{ij} \left( \varepsilon - \frac{Z(z) \gamma(\psi)}{1 - Z(z) \kappa(\psi)} \right)_j$$
Strong Lensing

- The exact position of the critical curve is not observable.
- Position of arcs is a very good approximation for the location of the critical curve.
- Arc positions are known with high accuracy.
- Using weak lensing grid resolutions would result in information loss.

\[
\chi_s^2(\psi) = \sum_i \frac{|\det A(\psi)|^2_i}{\sigma_i^2} = \sum_i \frac{|(1 - Z(z)\kappa(\psi))|^2 - |Z(z)\gamma(\psi)|^2|}{\sigma_i^2}
\]
So far we did reconstructions of:

- Purely synthetic simulations
  Feed real calculated cluster values into the code together with full critical curve
- Realistic simulations by using Massimo’s simulator code
  Ray-tracing lensing simulation including realistic noise (background galaxy shape, PSF, seeing, foregrounds)
- One reconstruction of a real galaxy cluster
  MS 2137 using VLT and HST images
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Figure: Fieldsize: 120”x120”; 2000 background galaxies, full critical curve
A Synthetic Example

[Two images of contour plots with color bars and axes labeled 0 to 60 and 20 to 80]
The only 1D profile-plot I will show!
Realistic Simulation

Figure: Fieldsize 400” x 400”; 1826 background galaxies

Figure: Simulated CCD-image with Subaru characteristics
Realistic Simulation
<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td>g1</td>
</tr>
<tr>
<td>Fieldsize:</td>
<td>1280”x1280”</td>
</tr>
<tr>
<td>Weak lensing:</td>
<td>13797 galaxies</td>
</tr>
<tr>
<td>Strong lensing:</td>
<td>Full critical curve</td>
</tr>
</tbody>
</table>
**Name:** g51  
**Fieldsize:** 1900” x 1900”  
**Weak lensing:** 30839 galaxies  
**Strong lensing:** Full critical curve

![Image showing galaxy distribution]
Figure: Fieldsize 405’’ x 405’’; 1500 background galaxies, arcs included

Figure: HST/WFPC2 image, first radial arc to be discovered (Fort et al. 1992)
Outlook (large scale)

- Comparison of weak, strong and combined lensing-reconstructions with Massimo.
- Web interface for the lensing simulator and reconstructions of a big simulated cluster sample with Peter and Massimo.
- Application to more real data.
Outlook (small scale): The $\nabla, \triangle, \nabla\triangle$-Project

**Flexion**

- Flexion finite differences schemes
- Testing their implementation
- Flexion $\chi^2(\psi)$-function
- Fast $\chi^2$-minimisation algorithm
- Testing its implementation
- Reconstructions of synthetic clusters
- Realistic simulations including flexion

**Multiple image systems**

- ...
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Have a nice semester break!