DETF - Weak lensing
Introduction to gravitational lensing

- **Strong lensing**
  - Multiple img, arc, ring
  - Map out mass distribution on small scales (missing satellite problem)

- **Weak lensing**
  - Small distortion
  - Intrinsic unknown
  - Need statistics of $\varepsilon$ of all galaxies in many patches of sky

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*Fig. VI-6: Schematic of gravitational lensing: the deflection angle apparent to the observer at left depends both upon the mass of the deflector and on the distance ratios between source, lens, and observer.*
Measurable quantity of distortion

- Distortion tensor \((A_{ij})\) depends on mass distribution
  \[
  \theta'_i = A_{ij} \theta_j \\
  A_{ij} = \delta_{ij} + \frac{\partial^2 \Psi}{\partial \theta^i \partial \theta^j}
  \]

- \(\Psi\) - lens potential projected along the line of sight

- Shear is a component of distortion tensor
  \[
  A_{ij} = \begin{pmatrix}
  1 + \kappa + \gamma_1 & \gamma_2 \\
  \gamma_2 & 1 + \kappa - \gamma_1
  \end{pmatrix}
  \]

- \(\kappa\) - mag or de-magnification  \(\gamma_1\) and \(\gamma_2\) - shear

- Galaxy ellipticity is an estimator of shear
  \[
  < \epsilon_i > \approx 2 \gamma_i
  \]
Effect of dark energy on WL statistics

- Modifies the angular-diameter distances
  - Universe expansion depends on DE, D(z)

- Modifies the rate of growth of the structure
  - Large scale evolution depends on DE, g(z)

- Modifies the shape of linear matter power spectrum
WL as a powerful tool

- Weak lensing is potentially the most powerful probe of dark energy ... The ultimate limit would be set by the extent to which the systematic can be controlled – ‘DETF’
- Based on clean physics, measure directly mass instead of light
- Powerful technique to measure large scale structure and the evolution of large scale structure (3D lensing, slice in redshift)
- Map of the dark matter distribution
- Precise and complementary measurement of cosmological parameters
- Test of general relativity
Why is WL hard

- Accurate galaxy shape measurement is essential
  - Atmosphere seeing (largest effect if ground-based)
  - Intrinsic alignments (e.g. tidal field)
  - Instrument PSF and detector effect (e.g. charge transfer inefficiency)

- Need accurate redshift
  - Photometric redshift

- Good statistics comes from large sky converge
  - Power spectrum of lensing signal, etc.
Future surveys

- Kilo Degree Survey (KiDS): sloan bands, 1500 deg$^2$, VST
- VISTA Kilo-degree IR Galaxy Survey (VIKING): Z, Y, J, H, Ks
- PanSTARRS
- Dark Energy Survey (DES): 5000 deg$^2$, 4m at CTIO
- Subaru: 2000 deg$^2$, HyperSuprimeCam on 8.2m
- LSST, SKA
- Space: Dark UNiverse Explorer (DUNE), SNAP
- Future space: JDEM, Euclid