Corrective lenses for high-redshift supernovae

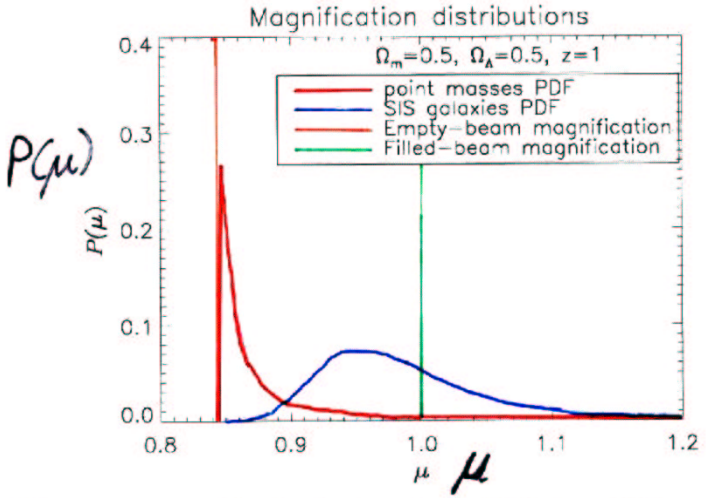
Daniel Holz
Institute for Theoretical Physics
UCSB

TASC meeting, ITP
October 18, 2002

Dalal, N., DH, Chen, X., & Frieman, J.A. 2002
submitted to ApJL; astro-ph/0206339

Magnification Distribution

Probability distribution, $P(\mu)$, of image magnification, μ, at high redshift



- The average magnification is given by the Robertson-Walker filled-beam value (normalized to 1).
- The minimum magnification, $\mu_{\rm min}$, is given by the empty-beam value.
- The distributions are peaked at $\mu < 1$, and have tails to high magnification.

  $\Rightarrow$ The distributions are non-Gaussian.

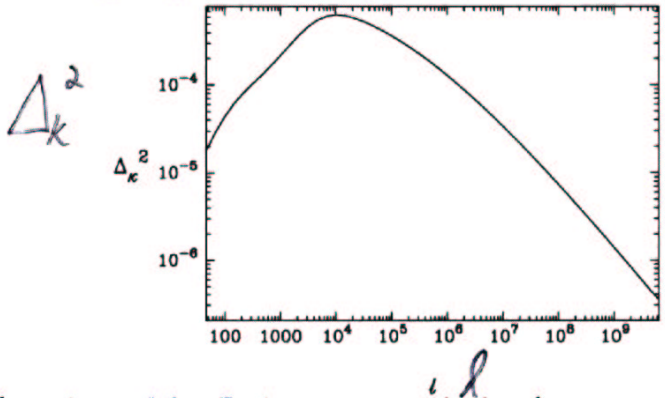
Lensing amplification affects all high-redshift sources.

Is there any way to correct for these lensing effects?

"Fixing" standard candles

- Observe the lens distribution directly
  - Identify luminous sources along the line-of-sight
  - Estimate the mass map, and calculate the lensing amplification.
- Use a weak lensing shear map:
  - Take a deep image of the surrounding field.
  - Measure shear lensing effects on background galaxies.
  - Use the shear mass map to estimate lensing amplification effects.

The convergence power spectrum (at $z = 2$, for ΛCDM):



The variance of the effective convergence is given by:

$$\langle \kappa^2 \rangle = \frac{1}{2\pi}\int_0^\infty d\ell\, \ell\, P_\kappa(\ell)$$
$$= \frac{9\pi}{4}\left(\frac{\Omega_m H_0^2}{c^2}\right)^2 \int_0^{R_S} dR \left(\frac{R(1-R/R_S)}{a(R)}\right)^2 \int_0^\infty \frac{dk}{k^2}\, \Delta^2_{mass}(k, a(R))$$

Lensing can't be undone

The reduction of the lensing error due to inclusion of weak lensing shear measurements is given by:

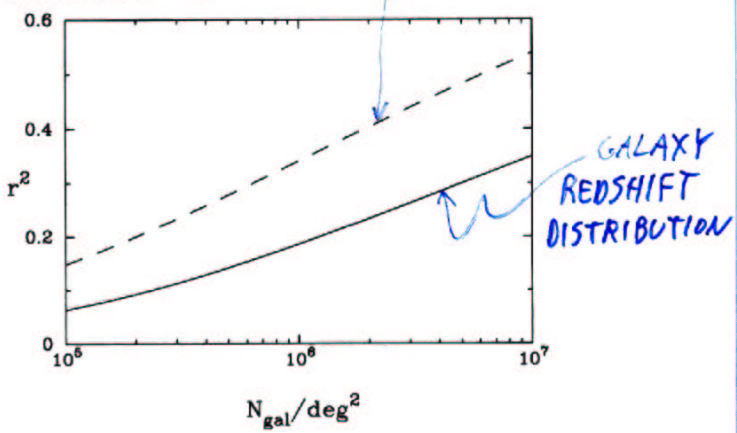
$$\langle \kappa^2 \rangle_\gamma = (1 - r^2)\langle \kappa^2 \rangle$$
$$= \left(1 - \frac{\langle \kappa \kappa_\theta \rangle^2}{\langle \kappa^2 \rangle \left(\langle \kappa_\theta^2 \rangle + \gamma^2/N \right)}\right) \langle \kappa^2 \rangle$$

θ is the shear lensing smoothing angle

γ is the intrinsic galaxy ellipticity

N is the number of source galaxies within θ

For $\gamma = 0.4$, ΛCDM, at $z = 2$:



⇒ Shear maps cannot be used to correct for lensing amplification.

What is to be done?

Safety in numbers.

- The mean lensing amplification is equivalent to the absence of lensing.
- Good statistics will average away all lensing effects.

$\Rightarrow$ Lensing problem can be solved by throwing lots of supernovae at it!