Learning from Lensing: The Power Spectrum and the Bispectrum

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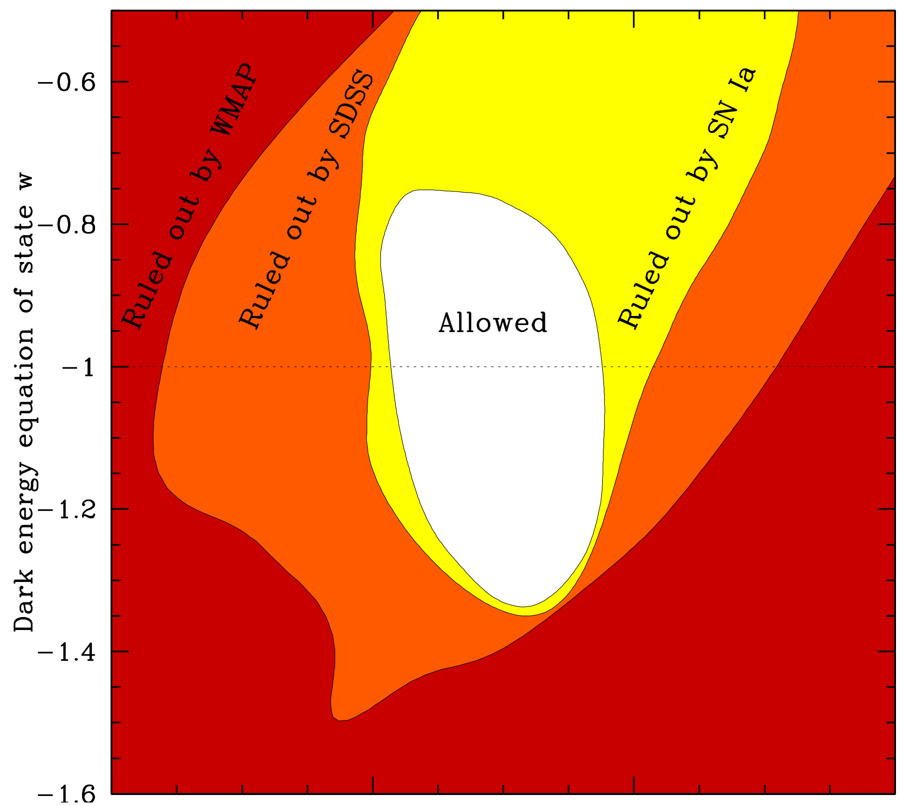
Fundamental Physics Encoded in Cosmic Shear

Neutrino Mass

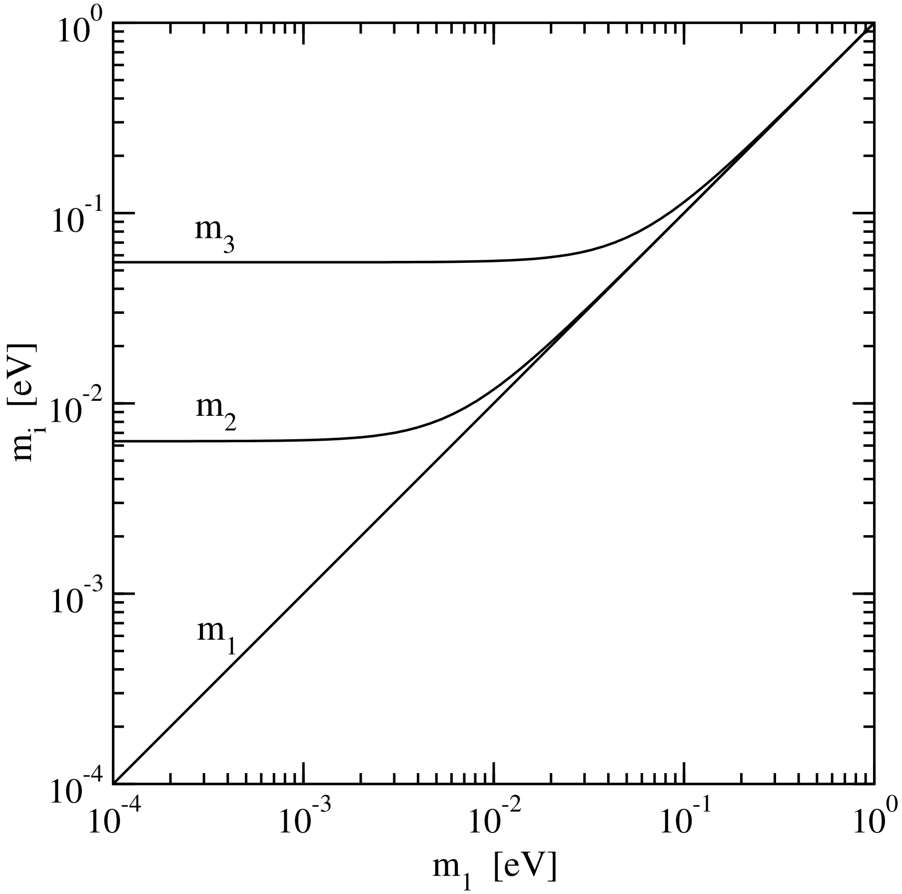
Dark Energy

Current experiments constrain dark energy equation of state to about 10%



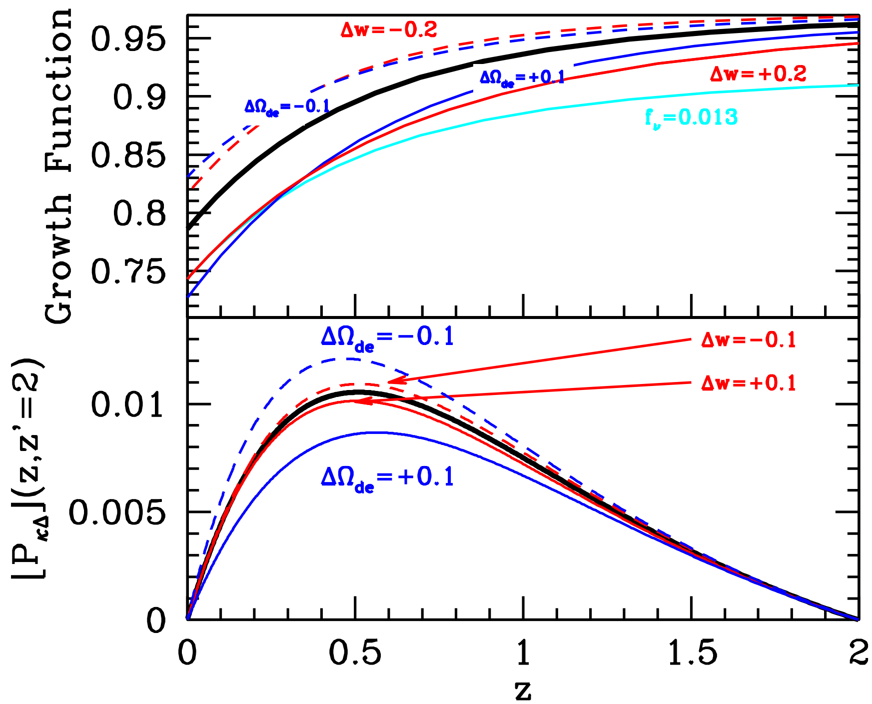
SDSS: Tegmark, Blanton, Strauss, Abazajian, Dodelson et al. (2004)

Three neutrino masses could be degenerate

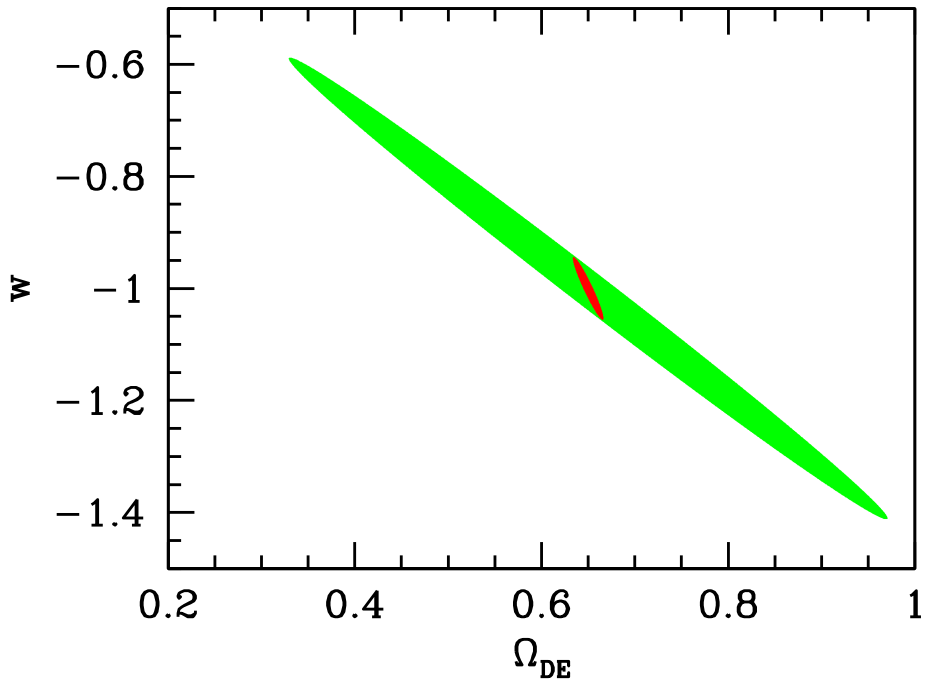


Bell & Beacom (2002)

There are two effects when breaking up background galaxies into bins: potential evolution and projection

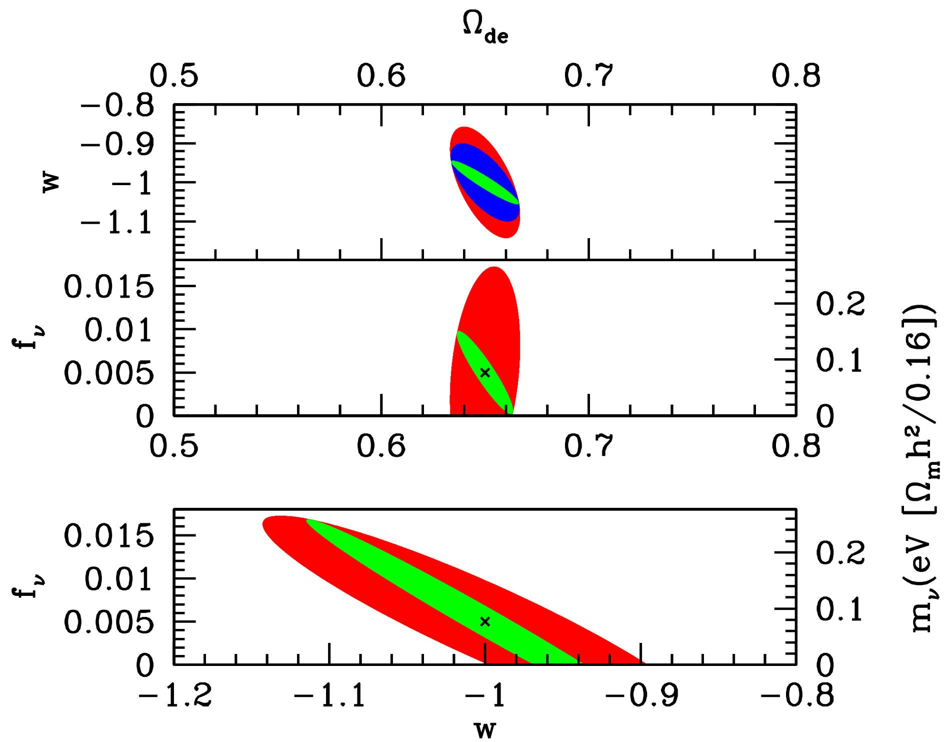


Projection effects are crucial: Green uses only evolution; Red includes projection.

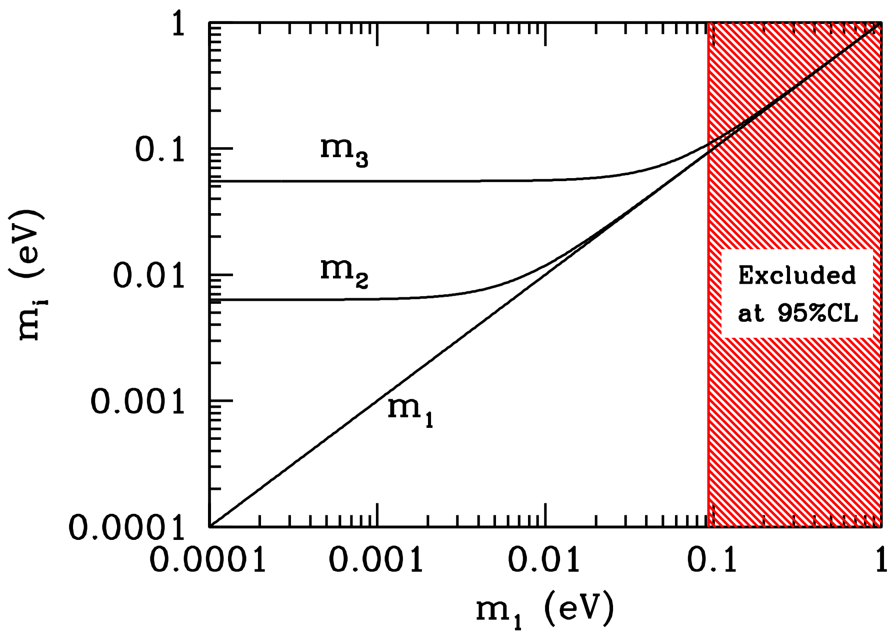


Exploit projection: Jain & Taylor (2003); Bernstein & Jain (2004); Zhang, Hui & Stebbins (2004); Hu & Jain (2004)

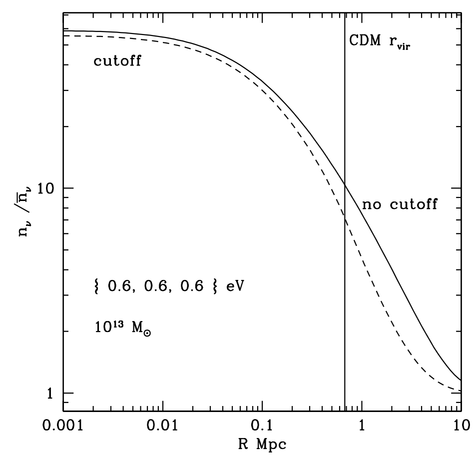
Constraints on m_ν are degenerate with $w, \Omega_{\rm DE}$. If dark energy parameters are known, could detect $m_\nu \sim 0.05$ eV.



With 1/10 of the sky, can exclude degenerate neutrino solution

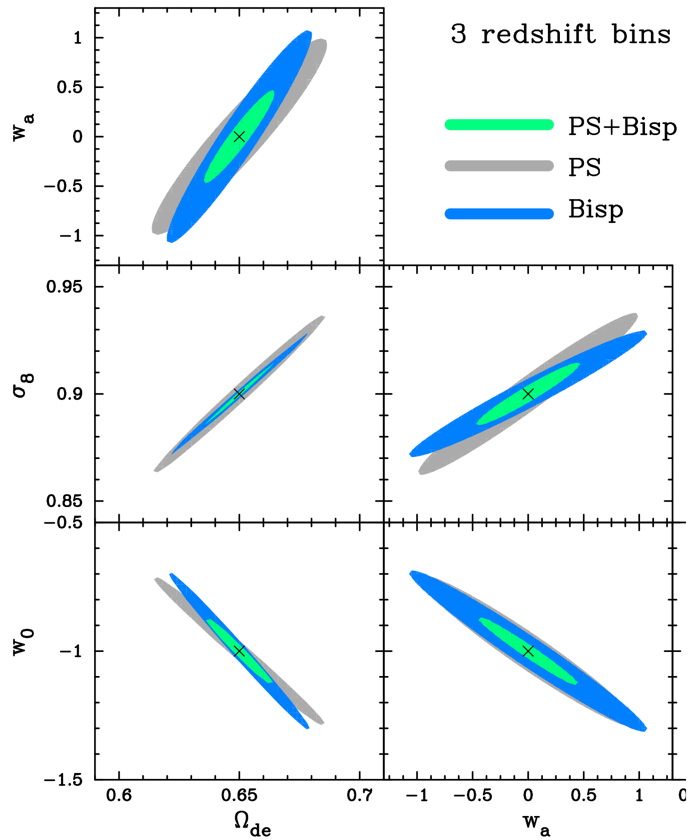


- Need to predict power spectrum with percent accuracy Huterer & Takada (2004)
- How high can we go in l? When do small scale effects become important? White (2004); Zhan & Knox (2004)
- How are these questions resolved in the presence of massive nuetrinos? Halo model will help test simulations.



Learning from the Bispectrum

The bispectrum can be as important as the power spectrum for constraining cosmological parameters. Hui (1999); Benabded & Bernardeau (2001); Cooray & Hu (2001); Refregier et al. (2004); Jain & Takada (2004)

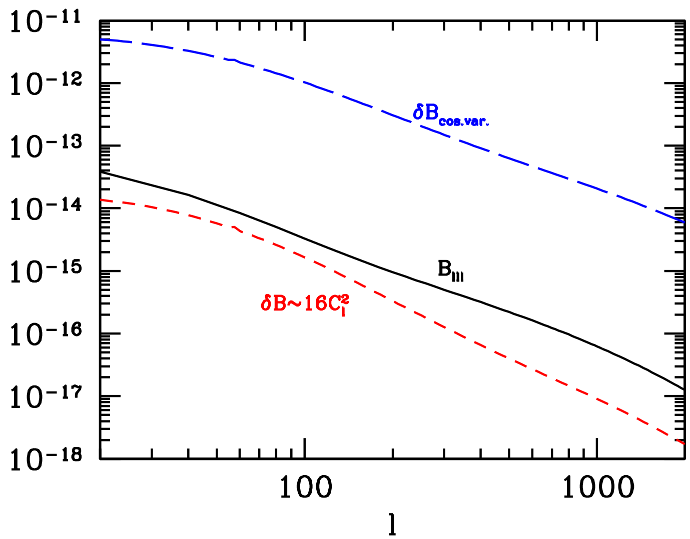


How well do we know the bispectrum?

- In the Gaussian limit, $\langle \epsilon^3 \rangle = 0$ with $\epsilon = \int d\chi W(\chi)\delta$
- Get non-zero result proportional to $B(k)$ since $\delta \neq \delta_{\rm lin}$
- Other contributions Scnheider, van Waerbeke, Jain, & Kruse (1998) from:
  - Reduced Shear: $\epsilon = \gamma/(1-\kappa)$
  - Second Order geodesic corrections: $\epsilon = \int d\chi W(\chi)[\delta + \mathcal{O}(\delta^2)]$

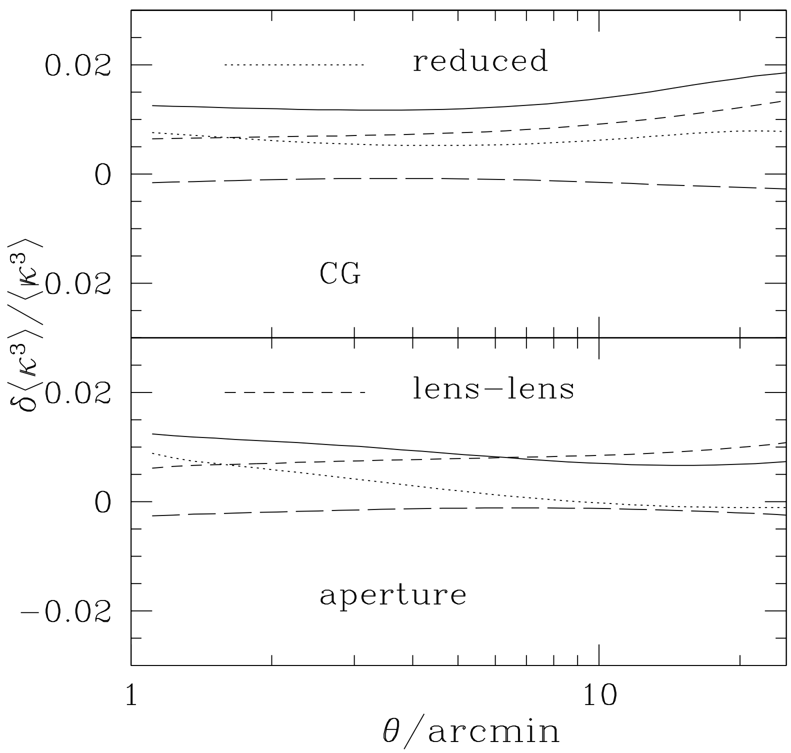
These second order terms are nominally the same order of magnitude as the usual term!

What do we expect?

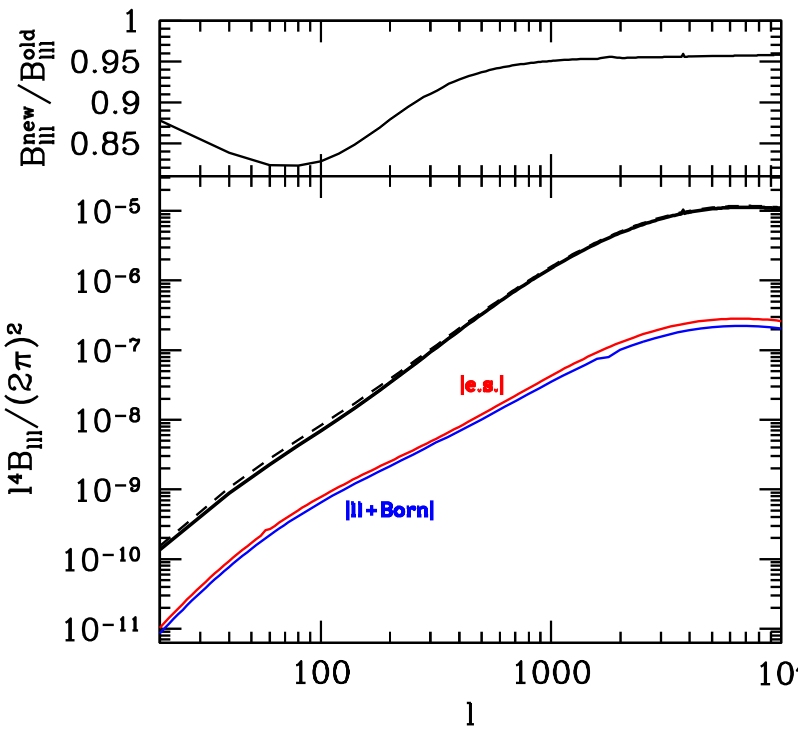


The corrections are of order C_l^2, a little smaller than the nominal term because spatial bispectrum is large. Errors for a single $B_{l_1 l_2 l_3}$ are much larger than signal.

One measure of these effects is the skewness, an integral over the bispectrum. Because of positive and negative contributions, changes are only of order a percent.



Another is to look at specific configuations: the equialteral configuration changes by up to 20% on large scales



Are these corrections important?

- For current experiments/projections, not necessary to include them
- Full sky future experiments: bias induced by neglecting these terms is 15 times bigger than statistical error. Need to get these right to do precision cosmology!

Conclusions

- Will learn about properties of neutrinos and dark energy from lensing C_l and $B_{l_1 l_2 l_3}$
- Much theoretical work needed to reduce theoretical uncertainties below anticipated experimental uncertainties