Cosmology results from weak gravitational lensing in the Dark Energy Survey

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and about 400 collaborators

Einstein Fellows Symposium, Oct 13, 2017
Planck CMB, extrapolated with $\Lambda$CDM

KiDS-450: Hildebrandt+2016

Kilbinger 2015
The Dark Energy Survey

- 5000 sq. deg. survey in grizY from Blanco @ CTIO, 10 exposures, 5 years

- Primary goal: dark energy equation of state

Status:

- Y1 (1500 sq. deg, 40% depth): data processed, results on cosmology today

- Y5 already in progress and going well!
Commemorative slide for O(100) FTE years of work on systematics
Combination of these three two-point functions jointly and robustly constrains cosmology and nuisance parameters


Joint constraints from these three probes in a photometric survey for the first time:

DES Collaboration+ 1708.01530
Joint constraints are best to date:

\[
\begin{align*}
\Omega_m &= 0.301^{+0.006}_{-0.008} \\
S_8 &= 0.799^{+0.014}_{-0.009} \\
w &= -1.00^{+0.04}_{-0.05}
\end{align*}
\]
Planck CMB temperature

$\delta \approx O(10^{-5})$

before

after
Planck CMB temperature

$z=1100$

$\delta \approx O(10^{-5})$

Gaussian random field:

Two-point correlation captures all information

Gravity generates non-Gaussianity on all scales:

PDF not described by second moments
Cosmology from matter/galaxy PDF with counts and lensing in cells

- Step 1: split lines of sight into quintiles of redMaGiC galaxy count – underdense to overdense

DG+ in prep.
cf. DG+ arXiv:1507.05090
Cosmology from matter/galaxy PDF with counts and lensing in cells

• Step 1: split lines of sight into quintiles of redMaGiC galaxy count

• Step 2: measure shear around and mean counts in quintiles – there is an asymmetry / skewness!

20' = radius of aperture for counting galaxies

DG+ in prep.
Cosmology from matter/galaxy PDF with counts and lensing in cells

- Step 1: split lines of sight into quintiles of redMaGiC galaxy count $N$
- Step 2: measure shear around and mean counts in quintiles
- Step 3: model these signals via joint PDF of matter and galaxy density

$$\langle \gamma_t \rangle(N) = \int p(\delta_m|N) \langle \gamma_t \rangle(\delta_m) \, d\delta_m$$

Perturbation theory model: Friedrich, DG+ (in prep.)
Cosmology from matter/galaxy PDF: skewness of matter density

• Counts + lensing in cells jointly constrain:
  - Cosmology
  - Bias + Stochasticity
  - Skewness of matter density: $S_3 \equiv \frac{\langle \delta^3 \rangle}{\langle \delta^2 \rangle^2}$

• Skewness agrees with $\Lambda$CDM prediction at $\sim 20\%$ uncertainty

DG+, which I really need to submit to arXiv right now, so please don't ask too many questions.
Summary

- Wide range of probes from early & late Universe, geometry & structure, agree on fiducial ΛCDM cosmology
- DES has added the most precise measurement of structure in the evolved Universe
  - Control of systematics with improved, independent methods
  - Competitiveness and consistency with Planck CMB in ΛCDM, insignificant offset, but in the direction of other lensing studies
  - Precise joint measurements close to $\Omega_m = 0.30$, $\sigma_8 = 0.80$, $w = -1.0$
- First cosmological constraints from matter density PDF: complementary, consistent, and competitive
- Additional results + much more data (Y3) coming soon!