The Dark Energy Survey and primordial non-Gaussianity

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The Dark Energy Survey

- Study Dark Energy using 4 complementary techniques:
  I. Cluster Counts
  II. Weak Lensing
  III. Baryon Acoustic Oscillations
  IV. Supernovae

- Two multiband surveys:
  **Main**: 5000 deg$^2$ ≈ 5 (h$^{-1}$Gpc)$^3$
  300 million galaxies
  $g, r, i, z, Y$ to 24th mag
  **SNe**: 15 deg$^2$ repeat

- Build new 3 deg$^2$ FoV camera and Data management system in Blanco 4-m telescope
  Survey 2012-2017 (525 nights)
  Camera available for community use the rest of the time (70%)
The DES Collaboration

Fermilab
University of Illinois at Urbana-Champaign/NCSA
University of Chicago
Lawrence Berkeley National Lab
NOAO/CTIO
DES Spain Consortium
DES United Kingdom Consortium
University of Michigan
Ohio State University
University of Pennsylvania
DES Brazil Consortium
Argonne National Laboratory
SLAC-Stanford-Santa Cruz Consortium
Universitats-Sternwarte Munchen
Texas A&M University

Over 120 members plus students & postdocs

Funding: DOE, NSF, STFC, MEC, FINEP, Excellence Cluster, collaborating institutions
Photometric surveys for theorists

- Collect light from galaxies in several broad-band filters in optical and near-IR.
- grizY (DES) + JK (Vista)
- Use flux in each filter to determine:
  - type: star/gal./QSO
  - gal. type: spiral, elliptical, ...
  - (photometric) redshift
- Also have angular and shape information

Terminology:

magnitude = A \(-\log(\text{flux})\)
color = magnitude - magnitude
Observational issues for $f_{\text{nl}}$ measurement

- Artificial correlations can mimic $f_{\text{nl}}$. For $f_{\text{NL}}^{\text{local}}$, separations $>100$ Mpc (several degrees) are crucial.

- Artificial correlations can be due to:
  - photometric calibration
  - photometric redshifts
  - star/galaxy separation

  More relevant for galaxies than clusters

- Clusters have own selection issues (more later ... maybe)
DES Photometric Calibration

- Deal with: telescope/camera, atmosphere, seasons, Moon, Milky Way.
- Multiple overlapping tilings with varying orientations + standard stars + ...
- DES: 2 survey tilings/filter/year
- Need contiguous area that overlaps existing surveys.

**DES Goal:** 1% photometry over all survey area (BaO requirement is 2%).
• Combination DES (optical)+Vista (IR) yields robust photo-zs.
• LRGs have even better scatter.
• Errors need to be modeled carefully, but $f_{NL}$ requirements weaker than WL.
• For clusters $\sigma_z=0.02$.

Rough numbers:
$\Delta z=0.1 \Rightarrow \Delta d_c = 1-2\times10^2 h^{-1} \text{ Mpc over survey redshift range.}$

$100 \text{ Mpc} \approx 3 \text{ deg at } z=1.$
• Distribution of stars is not random. Pronounced variation with latitude.

• Classification using colors (magnitudes)

• BAO requirement:
  – probabilities accurate to 1%
  – stellar contamination and distribution of misclassified galaxies smaller than 9% over all survey (< 2% on scales < 4 degree)

• Good enough for $f_{NL}$?
$f_{NL}$ constraints with DES clusters
Cluster counts-in-cells and sample covariance

About $1.7 \times 10^5$ clusters expected
($M_{\text{th}} = 10^{13.7} \, h^{-1} \, M_{\text{sun}}$)

Cunha, Huterer, Dore 2010
Many cluster systematics under control

<table>
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<th>Nuisance parameters</th>
<th>$M_{obs}$</th>
<th>$\sigma(\Omega_{DE})$</th>
<th>$\sigma(w)$</th>
<th>$\sigma(f_{NL})$</th>
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<td>0.23$^a$</td>
<td>0.77$^a$</td>
<td>18.8$^a$</td>
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</table>

Mass calibration with:
- Weak Lensing
- SZ clusters (South Pole Telescope)
- IR clusters (Spitzer)
- X-Ray clusters

Cunha, Huterer, Dore 2010

With reasonable priors can get $\sigma(f_{NL})$ of a few.
Clusters vs. Galaxies

- Galaxy catalogs will be much bigger but,
- It’s the large halo-halo separations that have the signal.
- Clusters are more directly related to the haloes.
- Clusters can be binned by mass.
- Combination of different tracers potentially very powerful. See N. Hamaus’ talk.
Conclusions

• DES should place tight constraints (better than Planck) using several complementary strategies (WL, galaxies, clusters, QSO’s).

• Cross-check between techniques will be key to controlling systematics.

• Major focus for calibration of photometric surveys has been on BaO and WL constraints for Dark Energy. Need to check what’s happening on larger scales.