Where should we be looking post DESI/LSST

Anže Slosar

Chicago Future Surveys
Introduction

- Parameters will be constrained to some very high precision after CMB S4 + DESI + LSST, but there is more information.
- Getting further is hard, both statistically and systematically.
- So where should we be looking?
- Two basic ways in which experiments can be complementary:
  - observing the same fields and “cross-correlate”
  - observing independently, but with different parameter degeneracy directions ← this talk
Sharing modes

- redshift survey (optical/resolved 21-cm)
- 21-cm intensity mapping
- 21-cm in single dish mode
- Lyman-α forest
- photo-z survey
- low-res survey
- weak lensing (gals/CMB)
Parameter degeneracies

- Some degeneracies easy to understand, some are somewhat counter-intuitive.

- Perhaps easiest to take a “fake experiment” driven approach:
  - given Fisher matrix for CMB-S4 + X, generate cosmological models
  - for each model make prediction for observables for possible future observations
  - if the spread correlates with a parameter of interest, measuring that observable at the sufficient precision will lower that parameter error

- An example . . .
Input Fisher matrices

- Got three Fisher matrices for CMB S4:
  - $\Lambda \text{CDM} + \sum m_\nu$ from Joel Meyers
  - $\Lambda \text{CDM} + \sum m_\nu + N_{\text{eff}}$ from Joel Meyers
  - $w\Lambda \text{CDM}$ from Alessandro Manzotti

- S4 assumes “$1 \mu \text{K-arcmin}, 1 \text{arcmin beam}, f_{\text{sky}} = 0.4$, with Planck high-ell data on an additional 20% of the sky, and an error of .01 on tau from the low-ell Planck data”

- S4 utilizes primary $C_\ell$ is temperature (to $\ell = 3000$) and polarization (to $\ell = 5000$) and 4-point lensing reconstruction

- DESI based off Pat McDonald’s code, assumes whatever is the latest

- LSST based off Pat McDonald and is for LSS and WL only

- For each combination, I drew 1000 models, so extremes are reaching 3-sigma tails

- Last plots were done this morning, so scope for errors is above average...
$m_\nu$, $S_4 + LSST$
$m_\nu$, $S_4 + DESI$
$m_\nu$, $S_4 + \text{LSST} + \text{DESI}$
$N_{\text{eff}}, S_4$
$N_{\text{eff}}$, $S_4 + \text{LSST}$
$N_{\text{eff}}$, $S_4 + \text{DESI}$
$N_{\text{eff}}$, $S_4+LSST+DESI$
$w$ (no $\nu$!), $S_4 + $DESI
$n_s$, $S_4 + \text{DESI} + \text{LSST}$
Other parameters

- Inflationary $n_s$, $\alpha_s$: small-scale measurements of linear power spectrum, e.g. from Lyman-$\alpha$ forest could help, but not in general

- non-Gaussianity: in cross-correlations, potentially huge opportunities of exploiting Dalal effect sans systematics, but no direct degeneracy breaking

- tensor modes: claims in the literature that 21-cm could do very well ($r \sim 10^{-9}$ Book, Kamionkowski and Schmidt)
Conclusions

- It is 2025, deep inside S4+DESI+LSST, you can do one thing before you die, what do you do?

- For $m_\nu$:
  - Measure $\sigma_8$ to sub-percent precision or $f\sigma_8$ to percent precision
  - Measure Hubble parameter to sub-percent precision
  - Measure low-$z$ $D_a$ to sub-percent precision
  - BAO parameters don’t add much, $\tau$ surprisingly doesn’t add much

- For $N_{\text{eff}}$:
  - Measure slope of the power spectrum to sub-percent precision
  - Measure BAO parameters at subpercent precision, $H_0$ would also help
  - $\tau$ helps marginally

- Basic survey observables, BAO and RSD, still seem to have a long way to go in terms of helping others achieve their dreams

- $f\sigma_8$ and $\sigma_8$ about equally useful – which is easier to measure?

- Power spectrum shape is really just one-parameter