Inflation and Neutrinos

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Experiment Stages

Similar language to DETF

- Stage II: (>1K detector elements)
  - e.g: EBEX, SPTpol, BICEP2/Keck, Polarbear, ACTpol...
  - already observing (or about to)
- Stage III: (>10K detector elements)
  - 10x mapping speed over Stage II
- Stage IV: (>100K detector elements)
  - 100x mapping speed over Stage II
  - This is what would come next (deploy ~2020, observe for 5
  - What challenges do we need to overcome?

Inflation

nflation is clearly an exciting and appropriate science goal. While other neasurements will also probe aspects of inflation, such as primordial scalar uctuations, curvature, non-Gaussianity, **only CMB polarization could offer unique "proof" of inflation and constrain its energy scale, and in he process address physics at the GUT scale.**

- It is a compelling mission for a stage IV HEP experiment? Yes, if you think about DM/DE searches. Use case for CMBpol white papers from theorists. Eva Silverstein to lead and coordinate with us. Detection of inflation gravitational modes would be first evidence that gravity is quantized.

- **How deep can we go in r?** How well can we delens? What survey and therefore instrument specs are required to do it. A: this should be done with foreground removal models. For foregrounds, what is the residue noise per pixel estimated after Planck. How do optimize with field/ survey size. Chao-lin and Adrian volunteer to take the next steps

- Non-Gaussianity: Are we done with Fnl from CMB after Planck? Oliver: double the modes again from E-mode, but this will likely be mostly done prior to Stage IV. This is rich field for galaxies surveys. Oliver: mu-T correlations should go to 10^-3 (Zaldarriagga) - what are the practical limits and what measurements would be required. Oliver will write up first draft.

- **What is optimum survey strategy,** including resolution and foreground issues. Need foreground experts (Radek Stompor, Clive Owen, Charles Lawrence)

Inflation 2

- **Ground and space complementary should be stressed** -- both bumps -- and the usual ground first arguments. Case for baselining a ground based experiment. We will still want high-ell for delensing; space for reionization bump.
- Clearly our mission here is to go as low as we can from the ground on high ell bump.
- Running of the spectral index. 21cm surveys and DE surveys constraints: Nikhil to draft curvature.
- GALAXY SURVEY CASE FOR NON-GAUSSIANITY: Kyle Dawson will coordinate this.

Neutrinos 1

Neutrinos are constrained with CMB measurements in two fundamental ways. **First, the measurement of damping scale allows the expansion rate at the time of decoupling, this in turns leads to number of relativistic species.** There is also information in the phasing the acoustic peak There are a lot of degeneracies with the damping scale measurements (helium, running, etc.) , but not so much with the phasing of the peaks.

- What can be done for Neff? What other measurements are needed, i.e., BAO, Ho etc. What can we expect for the extended data sets?
- **Could we get to sigma(Neff) ~ 0.01?** I (Adrian, Josquin). Understand the first second of the universe.
- State what we are really measuring - and we need to make the assumptions clear to HEP particle people. Likewise for the theory. Is it a useful probe for searching for non-standard model physics
- Are there theories for non-integer? Axions? not completely neutrialized steriles? What is the sto from Particle physics theory -- Akito to investigate and Kev; Other connections, e.g., supersymmetry?

ond, CMB lensing and CMB b-modes polarization are itive to the masses of the neutrinos through their impac e scale structure since they switch and also, for the same reason, c (coordinate with CF6)

- What limit can be reached on the neutrino masses for a stage CMB IV mission? **Oliver/Josquin: ultima limit beyond the quadratic estimator sigma ~ 0.01-0.02ev.** Run estimators with min = 0.05 correct (need to verify) then this is compelling, competitive with the from other power spectrum projectio Oliver to investigate *(after CMB lensing 2). Kev and Oliver, others?*

- What if the mass in dominated by one species (think heavy sterile neutrino that goes non-relativistic earlier for Planck's input on whether Neff is ~4). Otherwise we need to treat the cases separately.

- What are the assumptions on other cosmo, e.g, with DE. Can we break degeneracies, using external data

- How do CMB mass constraints compare with constraints from WL surveys, Galaxy surveys? How much d CMB-lensing measurements help the FOM of other LSS constraints, i.e., how important/useful is it the CM integral constraints for calibrating WL and galaxy survey probes. Distance measurements. Manoj Kaplingha CROSS CORRELATION SUBGROUP (Dodelson; David Weinberg , Jason Rhoads - need to work with the

- Can we reframe as test of structure growth, or discovery space if we do not find standard model expectat even if it has been shown from other techniques, say beta-decay results.. Katrin at 0.6 eV, etc.?

- Stress complementarity with other probes. Stress the precision of the mass measurement, assumptions, e should it be trusted? Don't only stress the hierarchy, but also (more importantly) the precision.

Dark Energy

- How much would a stage IV CMB experiment help dark energy constraints for w_0, w_a FOM? I.e by calibration of mass with CMB-lensing? Check of systematics? (Scott, Josh Frieman, CROSS CORRELATION SUBGROUP?) E.g., calibrating counts in LSST. Eduardo?

- NOte CMB lensing measures the linear portion of the spectrum well and with Stage IV goes into t non-linear regime, so we can use it to test the models, validate the models, required to interpret t galaxy WL measurements. ala Uros's comments yesterday on cross correlating with surveys to compare/calibration shear and cmb-lensing to better than 1% (Uros)

Early Dark Energy

- Are there interesting class of models to test? How well do we do? We can instead create a metri of showing deviation from Lambda and the w1,wa parameterization. **Benchmark session cam up with Omega_e.** (Scott; Eric Linder) Ask Eric Linder to write the draft case.

- What measurements are required and how well would we do.

- How about a table with constraints on benchmarks from each probe as well as combined? For the overall report or just to help us write the report.

next meeting

Aim for May 29-30 +/- day to meet at Argonne.

ALL DRAFTS AND TO BE DONE BY MEETING AT END OF MAY

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We also need to connect across other frontiers, in particular instrumentation and ntensity (neutrinos).

Are we going to work from or integrate the KISS report here?

END