Forecast for the PFS Cosmology Survey

Ryu Makiya (Kavli IPMU)
On behalf of the PFS Cosmology working group
The PFS cosmology survey

- Measure the galaxy power spectrum in redshift space at $0.6 < z < 2.4$

- Advantages
  - High galaxy number density, wide redshift coverage
  - Synergy with the HSC

- Science cases
  - The mass hierarchy of massive neutrinos
  - Test the dark energy and modified gravity
  - Test the internal consistency of low-z and high-z LSS data
Massive neutrinos and dark energy

- Both massive neutrinos and cosmic acceleration slow down structure formation and alter the expansion rate
- Wide redshift coverage of the PFS distinguish these effects
Inconsistency within LSS data sets

(Addison et al. 2018)
Parameter Forecast
The PFS forecast

• Bayesian joint analysis of
  • galaxy auto-power spectra in redshift space (PFS)
  • galaxy bispectra (PFS; next talk by N. Sugiyama)
  • lensing auto-power spectrum (HSC; C. Hikage)
  • galaxy-galaxy lensing cross power spectra (PFS x HSC)
  • primordial CMB fluctuation (Planck)+BAO (BOSS)

• Simulations: log-normal simulation suite
  • easy, simple, fast
Log-normal simulation

- **Assumption**: logarithm of matter density fluctuation $\delta$ follows Gaussian distribution

- **Inputs**: matter power spectra and several survey parameters (FoV, redshift range, galaxy number density, galaxy bias)

- **Outputs**: maps of matter density field, velocity field, and galaxy density field
simulated galaxy map

$z = 1.5$, HSC spring field
Galaxy power spectrum (PFS)

Power $kP_0(k)$ [Mpc$^2$/h$^2$]

$z = 1.1$

$z = 2.2$

wave number $k$ [h/Mpc]
Galaxy-galaxy lensing cross power spectra (PFS x HSC)

\[ l^2 C_l \]

- \( z = 0.7 \)
- \( z = 0.9 \)
- \( z = 1.1 \)
- \( z = 1.3 \)
- \( z = 1.5 \)
- \( z = 1.8 \)
- \( z = 2.2 \)

Multipole \( l \)

best-fit
sim.
Theoretical model

Anisotropic galaxy power spectrum

\[ P_{gg}^s(k, \mu) = D_{FoG}(k, \mu, \sigma) [P_{g,\delta\delta} + 2f \mu^2 P_{g,\delta\theta} + \mu^4 P_{\theta\theta}] \]

where (McDonald & Roy 2009; Saito et al. 2014)

\[ P_{g,\delta\delta}(k) = b_1^2 P_{\delta\delta}(k) + 2b_2 b_1 P_{b2,\delta}(k) + b_2^2 P_{b22}(k) \]
\[ P_{g,\delta\theta}(k) = b_1 P_{\delta\theta}(k) + b_2 P_{b2,\theta}(k) \]
\[ P_{\theta\theta} = f^2 P_{\delta\delta} \]
\[ P_{\delta\theta} = f P_{\delta\delta} \]

Fingers-of-God term

\[ D_{FoG} = \exp\{- (f k \mu \sigma)^2 \} \]
\[ -2 \ln L = \sum_{iz} \Delta_{iz}^{T} V_{iz}^{-1} \Delta_{iz}^{p} \] <= galaxy auto+lens cross

+ \Delta_{\text{cosmo}}^{T} V_{\text{HSC}}^{-1} \Delta_{\text{cosmo}} \] <= HSC lens auto (full survey)

+ \Delta_{\text{cosmo}}^{T} V_{\text{bispec}}^{-1} \Delta_{\text{cosmo}} \] <= PFS bispectrum

+ \Delta_{\text{cosmo}}^{T} V_{\text{Planck}}^{-1} \Delta_{\text{cosmo}} \] <= primordial CMB (Planck)

+ \sum_{iz} \Delta_{\text{cosmo}}^{T} V_{\text{zBOSS}}^{-1} \Delta_{\text{cosmo}} \] <= BOSS

\[ \Delta_{iz}^{p} \] : difference between the measured and proposed galaxy power spectra and galaxy-lens cross spectra

\[ \Delta_{\text{cosmo}} \] : difference between the input and proposed cosmological parameters
Covariance matrices

estimated from 300 realizations of LN sim
Covariance matrices

- Bispectrum: Fisher forecasts done by N. Sugiyama
- HSC: MCMC forecasts done by C. Hikage
  - full survey, w/o photo-z error
- CMB: Planck 2018, w/o CMB lensing
- BOSS: Alam et al., including BAO, RSD, AP
M_{nu} = 0.057 +/- 0.019 [eV] (1 sigma), [0.021, 0.097] (95%)
Constraints on neutrino mass ($\Lambda$CDM)

\[ \sum m_\nu [\text{eV}] \]

- Planck
- Planck+BOSS
- Planck+BOSS+HSC
- Planck+BOSS+HSC+PFS
Growth of structure $f\sigma_8$

- Only PFS at $z > 2$!!!
Inconsistency within LSS data sets

PFS can test a consistency of low-z and high-z LSS data sets by itself
Summary

- Performed the parameter forecast for the PFS cosmology by using the log-normal simulation

- PFS is powerful!
  - can reach to $\Sigma m_\nu < 0.1$ eV threshold
  - wide redshift coverage enables us to perform unique test of the internal consistency of LSS data
Next step

- Followings are not yet taken into account
  - Fiber allocation effect
  - redshift misidentification
  - galaxy distribution within a halo
  - velocity PDF of satellite galaxies
  - etc.