Search for Gamma-ray from Luminous Red Galaxies

Masato Shirasaki (NAOJ) with Naoki Yoshida (Univ. of Tokyo, KIPMU) & Sunsaku Horiuchi (Virginia Tech)

2015,6,15 ICM PHYSICS AND MODELING@MPA

Recent progress on Gamma-ray studies The detection of angular correlation of the position of galaxies and gamma-ray maps!

- Correlation between large-scale structure and gamma-rays would be a probe of dark matter (DM) annihilation
 - If DM would annihilate, the high density region in the Universe would be gamma-ray source.
 - The strength of correlation can relate to the production rate of gamma-rays in extragalactic DM halos, or annihilation rate of DM
- Various tracers could be correlated with extragalactic gamma-rays
 - Unresolved blazars, star forming galaxies, radio galaxies



Xia et al. (2015)

Toward the detection of DM annihilation

- We should consider some optimized targets for indirect search for DM annihilation.
- The conditions to be considered
 - they should live in high density regions in the Universe
 - they should be less affected by astro sources
 - their statistical properties should be well constrained
 - it is desirable to know the relation to their host dark matter halos

LRGs seem to be nice, let us examine the case of LRGs!

SDSS DR7 LRG

- Kazin et al 2010, ApJ, 710, 1444
- Passive galaxies used for cosmological analyses (i.e. galaxy clustering & BAO measurement)
- 30272 spectroscopic galaxies
- exist 160 mock catalogs (LasDamas simulations)
- typical halo mass ~ 10¹³⁻¹⁴ M_{sun}/h (derived from g-g lensing and clustering analysis)



use blue one!

Survey region

DEC

- use 3rd year point source catalog
- find 507 sources and use mask with radius of 2 deg
- also remove |b|<20° and Loop-I/bubble regions
- sky fraction of remaining regions ~ 0.052 (corresponding to ~2000 deg²)

point sources



Cross correlation

- use 1-500 GeV gamma-ray intensity
- P7rep ultraclean class
- we have subtracted the galactic component
- use 8944 LRGs (due to additional masking SDSS DR7 sky)
- analysis performed in real space
- the binning in linear spacing as θi = 0.5×i [deg] (i=1-40)
- estimate covariances by using LasDamas Mocks and poisson photon catalog

Stacked image



Cross correlation signal



Modeling of correlation

- HOD modeling based on Ando 2014 (arXiv:1407.8502)
- HOD of LRGs has been studied
- Redshift distribution of LRGs determined by spec-z
- (Almost the only) remaining uncertainty = **boost factor**
 - model A : Gao et al (boost factor~300 for DM halo with mass of 10¹³⁻¹⁴ M_{sun}/h)
 - model B : Sanchez et al (boost factor~30 for DM halo with mass of 10¹³⁻¹⁴ M_{sun}/h)
- PSF effect is also taken into account

Likelihood Analysis 95% confidence level



Systematic error due to modeling of galactic components



repeat the same analysis for different 32 galactic model templates

typical uncertainty $\Delta \chi^2 \sim I$

stat. error ~ 10 times syst. error

It would be important for Euclid!

Possible correlation by star forming in LRG

- already detected the gamma-rays from nearby star forming galaxies
- we examine how large correlations would cause if LRGs form stars with some rate
- Let us consider the simplest case: all the LRGs have the same star forming rate (SFR)
- Using the correlation of L_γ and SFR, we can evaluate the gamma-ray flux of each LRG in our catalog



of each LRG

flux of each LRG

Possible correlation by star forming in LRG



Gamma-rays due to star forming would have less affect on our analysis even in the case of SFR $= 10 M_{sun}/yr$

Summary

- Cross correlation of SDSS DR7 LRGs and Fermi EGB
- LRG is one of the best targets to search for DM annihilation
 - well-studied HOD/typical halo mass
 - passive star forming (less contaminated by astrophysical sources)
 - spec-z is available and they are relatively closer (z=0.1-0.4)
- The main model uncertainty = boost factor <u>only</u> (except for dN/dE)
- Our measurement is consistent with null detection
 - put constraints on DM annihilation for DM halos with mass of 10¹³⁻¹⁴ M_{sun} and redshift of z=0.1-0.4
- impact of model uncertainty of galactic gamma-ray
- One of possible contaminants = Star forming in LRGs
 - gamma-rays by star forming phenomena would have a small influence on our correlation analysis

Check: EGB intensity





Case of small mask



