High precision AGN clustering measurements

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Galaxies cluster!

SDSS DR7

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Outline

- introduction to AGN clustering measurements
- eROSITA AGN sample
- 4MOST & spectroscopic follow-up of eROSITA AGNs
- future results
What are we talking about?

Large-scale clustering of Active Galactic Nuclei

characterize general matter distribution in the universe

galaxy cluster

group of galaxies

field galaxy

void (underdensity)

highest density environment

lowest density environment

NASA, N. Benitez (JHU)

MASIL Imaging Team

ESA & NASA, K.D. Kuntz (GSFC)

Millennium Sim., Springel et al. (2005)

Mirko Krumpe

ESO, September 2012
What drives clustering?

1) Cosmology

2) Galaxy distribution within DMHs

Based on Zheng & Weinberg 2007, Weinberg 2002

NASA, ESA, Jullo, Natarajan, Kneib

National Center for Supercomputer Applications (Kravtsov & Klypin)
AGN clustering measurements: Why?

**Big picture:**
- constrain cosmological parameters
- determine the physical processes in AGN/galaxy co-evolution

(ESO, September 2012)

(test different AGN evolution models by measuring the observed clustering of AGN, ideally as a function of luminosity, redshift, BH mass, accretion rate)

**In specific:**
- host dark matter halo mass
- host galaxy type
- environment
- fuelling mechanism
- AGN lifetime
- central vs. satellite fraction
Galaxy clustering vs. AGN clustering

The most precise clustering measurements by far come from galaxy samples, but ...

AGN outnumber galaxies at $z > 0.5$ and allow us to study the distribution of matter in 80% of the universe with high precision.
eROSITA AGN sample

- most sensitive all-sky X-ray survey (~0.3-10 keV)
- ~3 million AGNs! (RASS, SDSS ~100,000 AGNs)
- launch in 2014

Why X-rays:
- AGNs typically 1-5 magnitudes more luminous than galaxies
- less affected by extinction than optical surveys

- independent selection of AGNs and along with future optical surveys will provide a more complete picture of AGNs in the universe
eROSITA geography

Russian-German Mission

- the sky is divided
- German sky is mainly the southern hemisphere

⇒ accessible from ESO sites!

for constraining AGN clustering measurements redshifts are of utmost importance!

⇒ a future dedicated “redshift-machine” is needed
4MOST – ESO’s next redshift machine

4-meter Multi-Object Spectroscopic Telescope  
(PI: R. de Jong, AIP)

Goal: 20 million public spectra of Gaia, eROSITA and Euclid in 5 years (start 2019)

- currently phase A study; will go on VISTA  
  (~5 deg² FOV, ~2500 fibers, ~400-1000 nm, R~5000, ~20 000 deg²)

- ~80% of all eROSITA AGNs have r < 22 mag

4MOST is THE instrument to enable high-precision AGN clustering measurements
Challenges

Uncertainties of clustering measurements have to be estimated carefully! \( \Rightarrow \) correct interpretation of the results

Future clustering measurements will have challenges:

• for the first time, systematical uncertainties will be dominating over statistical errors
  (currently systematic uncertainties are almost entirely neglected)

• can we use photometric redshifts instead of spectroscopic redshifts
  (What are the involved uncertainties?)
... at ESO’s 60th birthday

- eROSITA compiled the largest AGN sample by far (3 million AGNs)
  - ESO’s new “redshift machine” 4MOST delivered spectra for more than one million AGNs

High precision AGN clustering measurement will:

- measure a BAO signal at a redshift range (z~1) not accessible by any other planned survey ⇒ constrain the nature of dark energy
  - better characterize the interaction between the AGN and its host galaxy
- identify the processes fuelling AGNs over cosmic time
- find new correlations between SMBH and DMH/host galaxy ⇒ identify new physics in AGN/galaxy co-evolution