Clustering Probes

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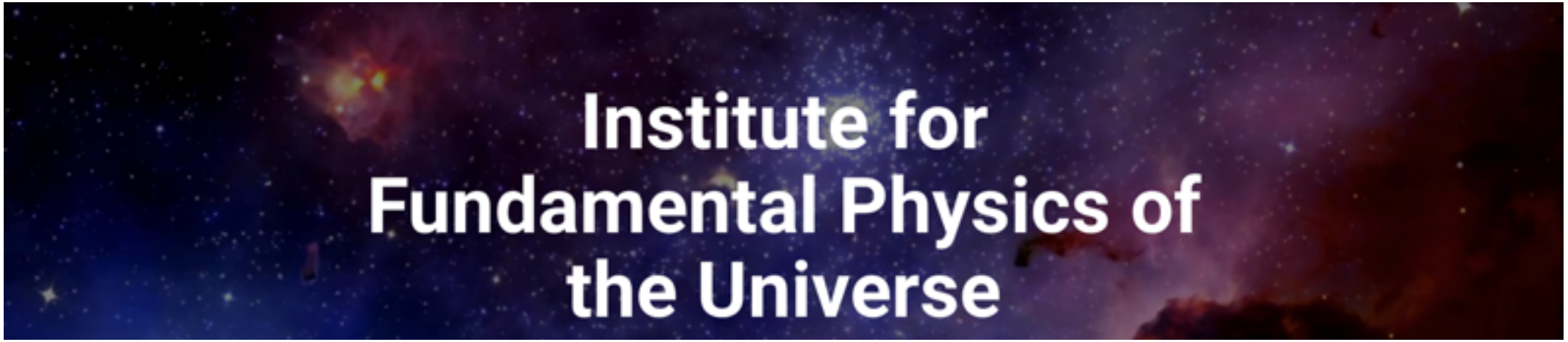


The Institute for Fundamental Physics of the Universe (IFPU) is a joint initiative of the International School for Advanced Studies (SISSA), the Abdus Salam International Centre for Theoretical Physics (ICTP), the National Institute for Astrophysics (INAF) and the National Institute for Nuclear Physics (INFN). The institute aims at hosting and promoting a vigorous and innovative multi-disciplinary research program focused on investigating the fundamental laws of Nature under a Cosmological and Astrophysical perspective.

NEWS

IFPU Colloquia starting on March 21, 2019

The program of Colloquia, Seminars and Journal Clubs at the Institute for Fundamental Physics of the Universe is starting. You can find the calendar and details on IFPU scientific events at the Activities webpage.

ANNOUNCEMENTS

Call for IFPU programs now open

The Institute for Fundamental Physics of the Universe supports and hosts: Focus Week Programs, namely small-scale thematic workshops, and Team Research Programs, namely the activity of small groups developing or finalizing a project. Calls for Read more...

ANNOUNCEMENTS

Applications for long-term visits now open (first deadline: May 1, 2019)

The Institute promotes its internationalization and the development of new research lines through visits of internationally renowned scientists with leading expertise in areas within the scientific goals of the Institute. The next deadline for receiving Read more...

Clustering and clusters

- Growth rate of perturbations: Galaxy clustering (RSD), number density of galaxy clusters and evolution of halo bias, tomography of cosmic shear, Lyman-alpha forest

- Nature of DM (i.e., neutrino masses, free-streaming scale): large-k behaviour of galaxy power-spectrum, Lyman-alpha forest, halo mass function, effect of substructures on strong-lensing features

- Physics of inflation (e.g. non-Gaussianity): scale-dependence of halo bias at the largest scales, detecting and counting the rarest events (e.g. massive high-z galaxy clusters)

- GR effects: whatever traces the largest scales
- Modified gravity effects: same as growth rate of perturbations, comparison between lensing and dynamical mass reconstructions
  - ➔ Among the most interesting questions based on observables tracing the largest scales
  - ➔ It is the regime in which cosmic variance is the limiting factor
  - ➔ Multiple tracers technique to overcome this limitation

Who's doing what in INAF? Key staff in Euclid/LSST, SKA, etc.

Euclid Galaxy Clustering:
F. Marulli (Bologna), G. Guzzo, M. Carbone, B. Granett (Milano), E. Branchini (Roma), S. Camera (Torino), P. Monaco, E. Sefusatti, M. Viel (Trieste)
Not necessarily Euclid-related: N. Bartolo, D. Bertacca, S. Matarrese, M. Peloso (Padova), M. Pietroni (Parma)

Euclid Clusters of Galaxies:
C. Giocoli, L. Moscardini, M. Sereno (Bologna), A. Biviano, S.B., A. Saro (Trieste)
Not necessarily Euclid-related: S. Ettori (Bologna), H. Bourdin, P. Mazzotta, N. Vittorio (Roma-TOV)

Euclid Cosmic Shear:
V. Cardone, R. Maoli, R. Scaramella (Roma)

Euclid Weak and Strong Lensing:
C. Giocoli, M. Meneghetti, B. Metcalf (Bologna)

LSST Galaxy Clusters:
C. Giocoli, L. Moscardini (Bologna), C. Grillo (Milano), P. Rosati (Ferrara), A. Biviano, S.B., A. Saro (Trieste)

SKA HI intensity mapping for LSS:
S. Camera (Torino), M. Viel (Trieste)

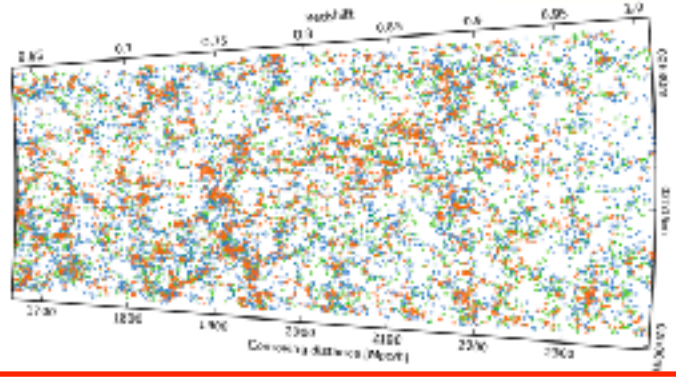
Cosmological Simulations:
S.B., P. Monaco, G. Murante, E. Rasia, L. Tornatore, M. Viel (Trieste), M. Baldi, C. Giocoli (Bologna), C. Carbone (Milano), U. Maio (?)

LSS: Combining imaging & spectroscopy

$$ds^2 = a^2(\tau)\left[-\left(1+\frac{2\Phi}{c^2}\right)c^2 d\tau^2 + \left(1-\frac{2\Psi}{c^2}\right)dl^2\right]$$

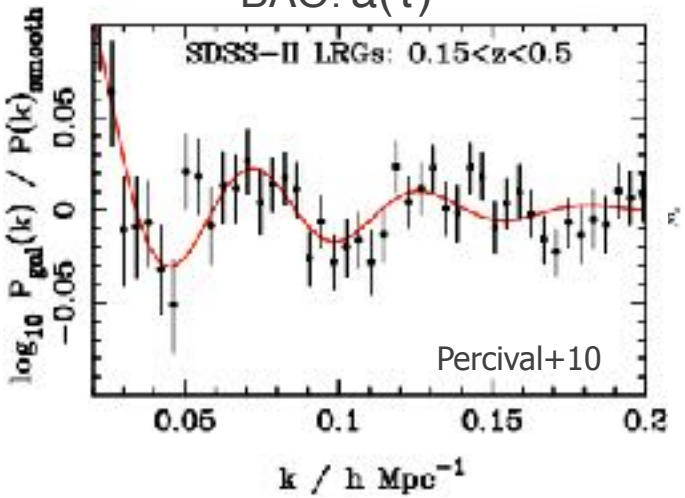
Φ : governs motion of matter

$\Phi + \Psi$: governs motion of light

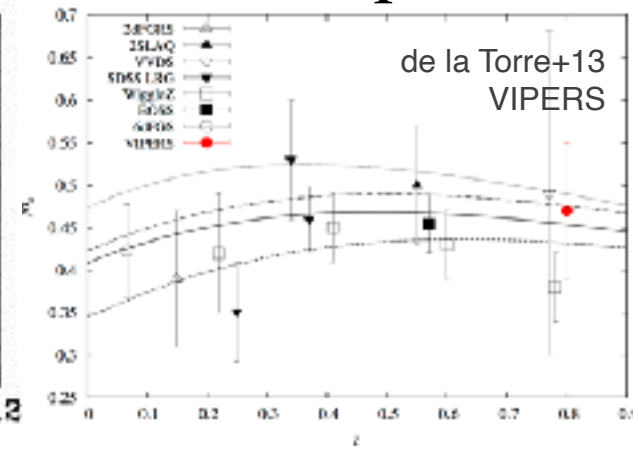


+ Field Equations $\Phi = \Psi$ for GR

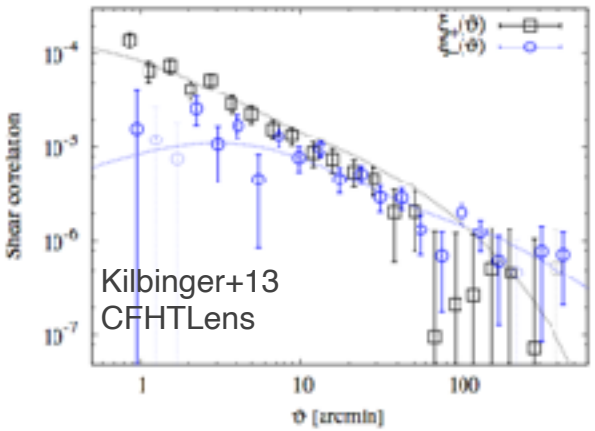
BAO: a(τ)



RSD: Φ

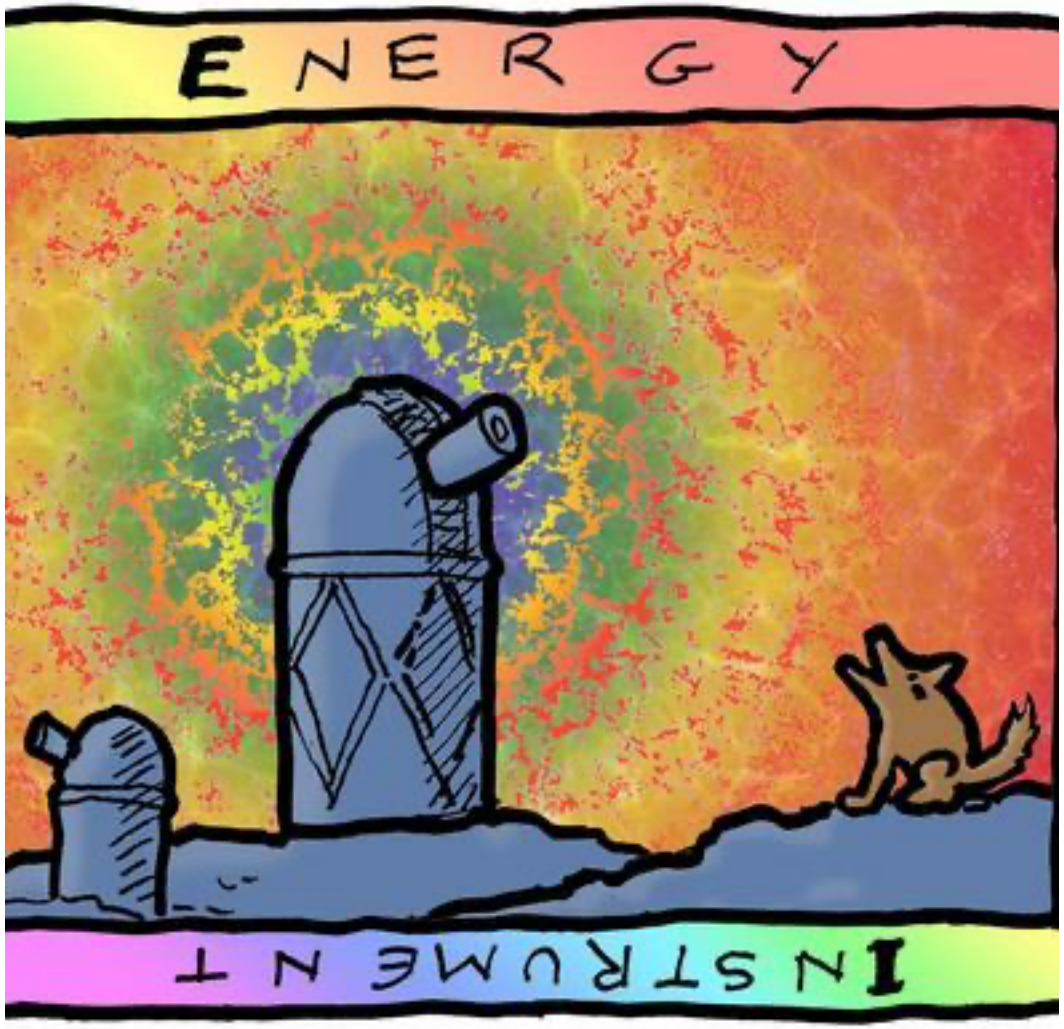


Cosmic shear: $\Phi + \Psi$



The future

DESI



- BAO and RSD using LRG out to z~1 and emission-line (O-II) galaxies out to z~1.7 + QSO/Ly-alpha at 2.1<z>3.5.
- 9k - 14k sq. deg. covered
- 3x 10^7 redshifts in total
- First light in Oct. 2019

➔ NOW ABOUT TO START TAKING DATA

The future

SPT-3G

- 2500 sq.deg.
- ~16,000 receivers (~1000 in SPT-SZ)
- Frequencies: 95, 150, 220 GHz
- ~10^4 clusters to be detected
- Detect clusters out to z~2 and M~10^{14} $M_\odot$

➔ NOW TAKING DATA

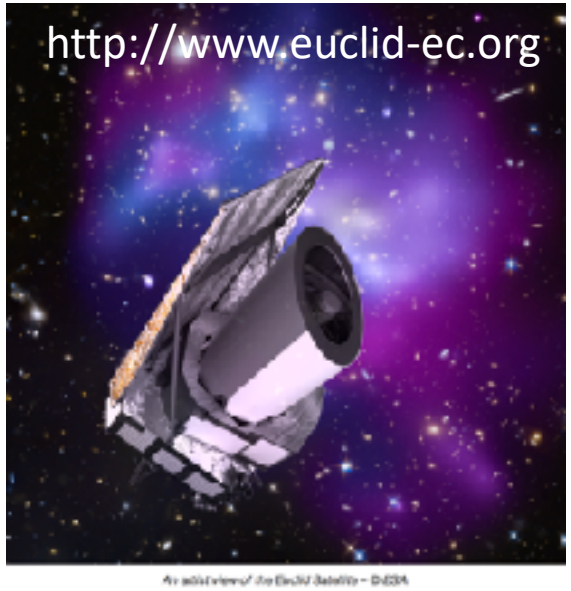
eROSITA

- All sky-survey in X-rays
- Survey speed: 4 times larger than XMM
- PSF: 28” in survey mode
- ~10^5 clusters to be detected
- Secure all clusters > 10^{15} $M_\odot$

➔ NOW TAKING DATA

The future

Euclid



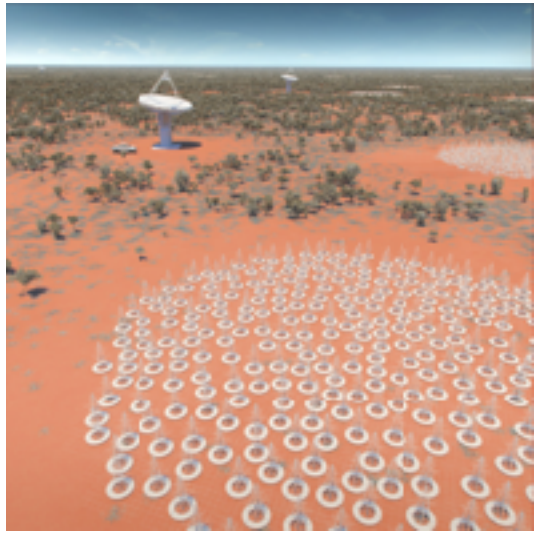
- 1.2m mirror
- Optical imaging
- NIR (YJH) photometry & NIR grism
- 15,000 sq.deg. to be covered
- Launch in June 2022
- Cosmology: Cosmic shear, BAO & RSD, Galaxy clusters, ….

LSST

- 8.4m mirror
- *ugrizy* photometry
- ~18,000 sq.deg. to be covered
- Operations to start in 2023
- Highly complementary to Euclid
- Similar cosmological probes **+ time-domain cosmology** (SN, time-delays)

The future

SKA



1. **HI Intensity Mapping** [BAO, super-horizon, etc.]
   All-sky (3π sr); low-res. >30'; 0<z<3

2. **HI Threshold:** galaxy redshift survey [BAO, RSD]
   SKA1: 5 10^6 gals @ z<0.5
   SKA2: ~10^9 gals @ z<2 (??????)

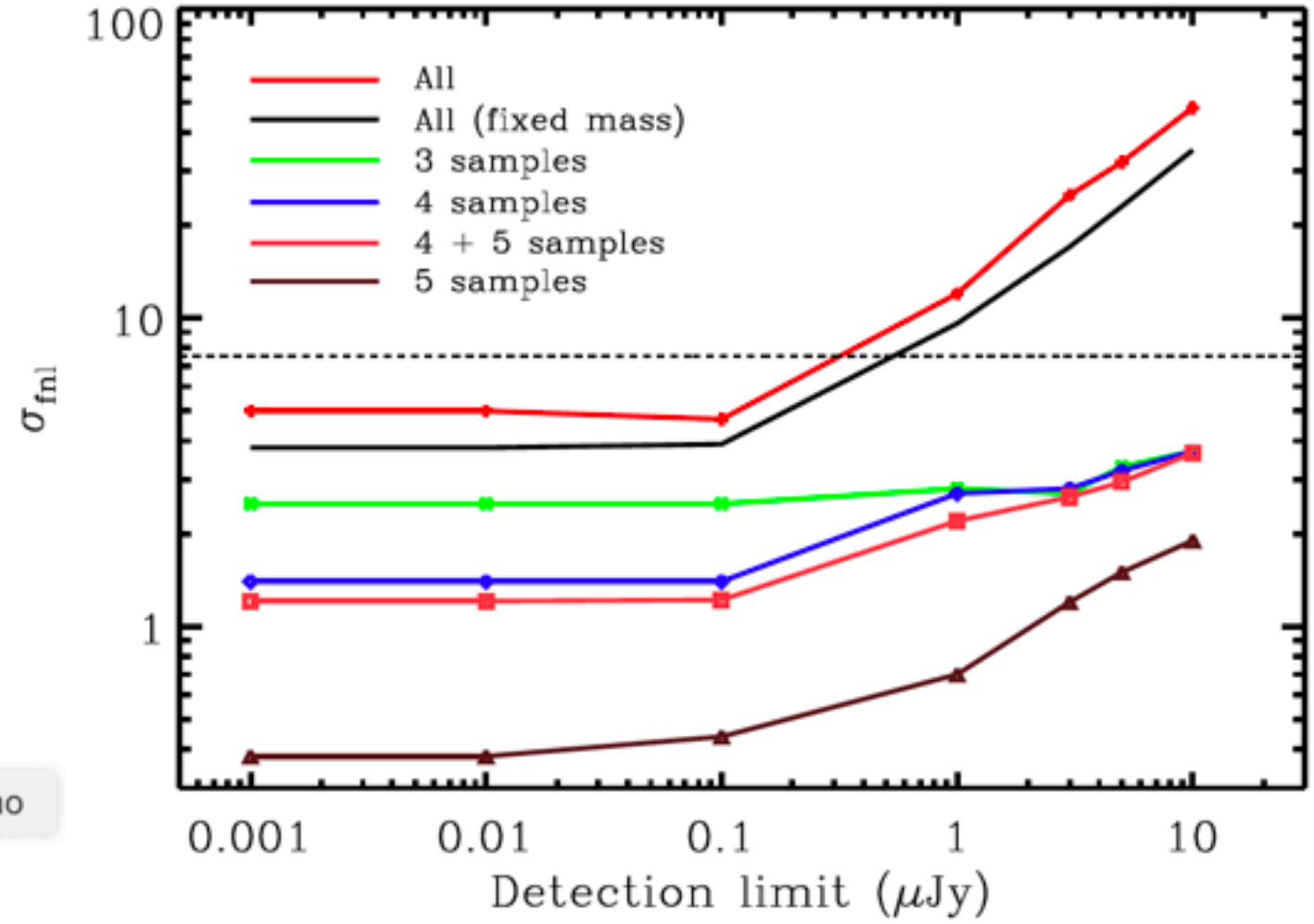
3. **Continuum** [weak lensing, angular clustering, ISW]:
   - → All-Sky Survey (~ 1-2" res.)
   - → Weak Lensing Survey (0.5" res.)

Euclid/LSST + SKA: huge synergies

→ Scientific: beat systematics, complementary constraints, multi-tracers, etc.

→ Programmatics: e.g. simulations, likelihood definitions and coding, etc.

Example: Euclid + SKA through multi tracer method



➔ Large-scale features interesting for Physics of inflation (non-Gaussianity) GR effects (gauge choice)

➔ Large-scale studies limited by cosmic variance

➔ Use multi-tracer technique to factor out cosmic variance (Seljak 2009)

Ferramacho+2014
Use different samples of radio galaxies extracted from a radio survey

Programmatics

1. A unique strategy for cosmological surveys:
   - DESI, Euclid/LSST
   - SKA
   - Follow-up observations (4MOST, MOONS, MSE,…)
   - SPHERE-X, WFIRST

What next?

➔ Cosmological surveys of GW sources (Melita's talk)

2. HPC/storage/network/data exploration: it's part of the experiment! Obvious……

The next cosmological experiment

Combine information from different surveys into a meta-survey!

- Improved characterisation / follow-up of specific classes of objects
- Far beyond the combination of probes within the single experiment
- Detection of tensions and tracing their origin
- Technique of multiple tracers to suppress cosmic variance

➔ Much more than combining likelihoods: Bayesian or AI-based methods?

➔ Need to understand precisely systematics, not to be confused with new physics

- Detailed characterisation of selection functions and covariances