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Testing gravity with galaxy-galaxy lensing and galaxy clustering

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Journée Euclid GC France

The PhD project

What ?

Test of gravity with galaxy clustering and galaxy-galaxy lensing measurements from DESI & Euclid data at small scales

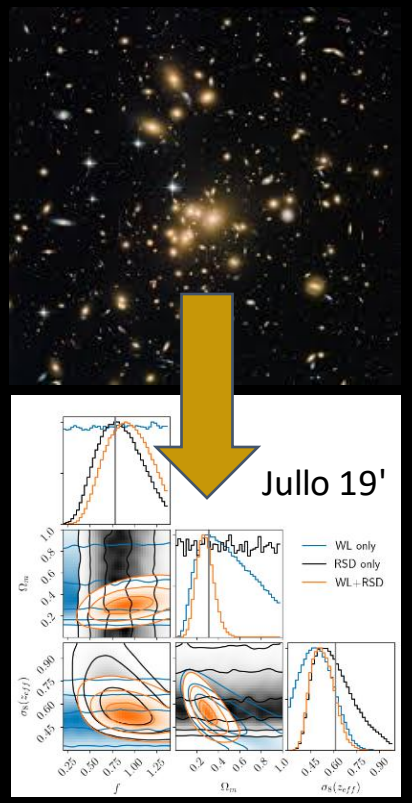
How ?

Build a precise model combining weak lensing and galaxy clustering to constrain cosmological parameters with a modified gravity model extension

Why ?

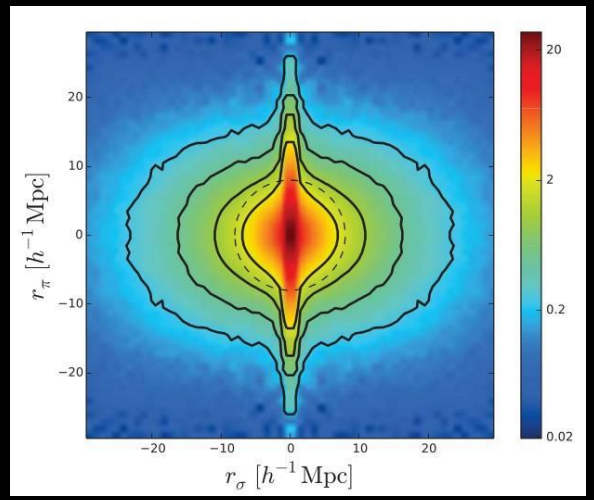
Explain observations and expansion of the Universe:

- Test of dark energy models and find deviation to GR
- Test of modified gravity scenarios at small scales

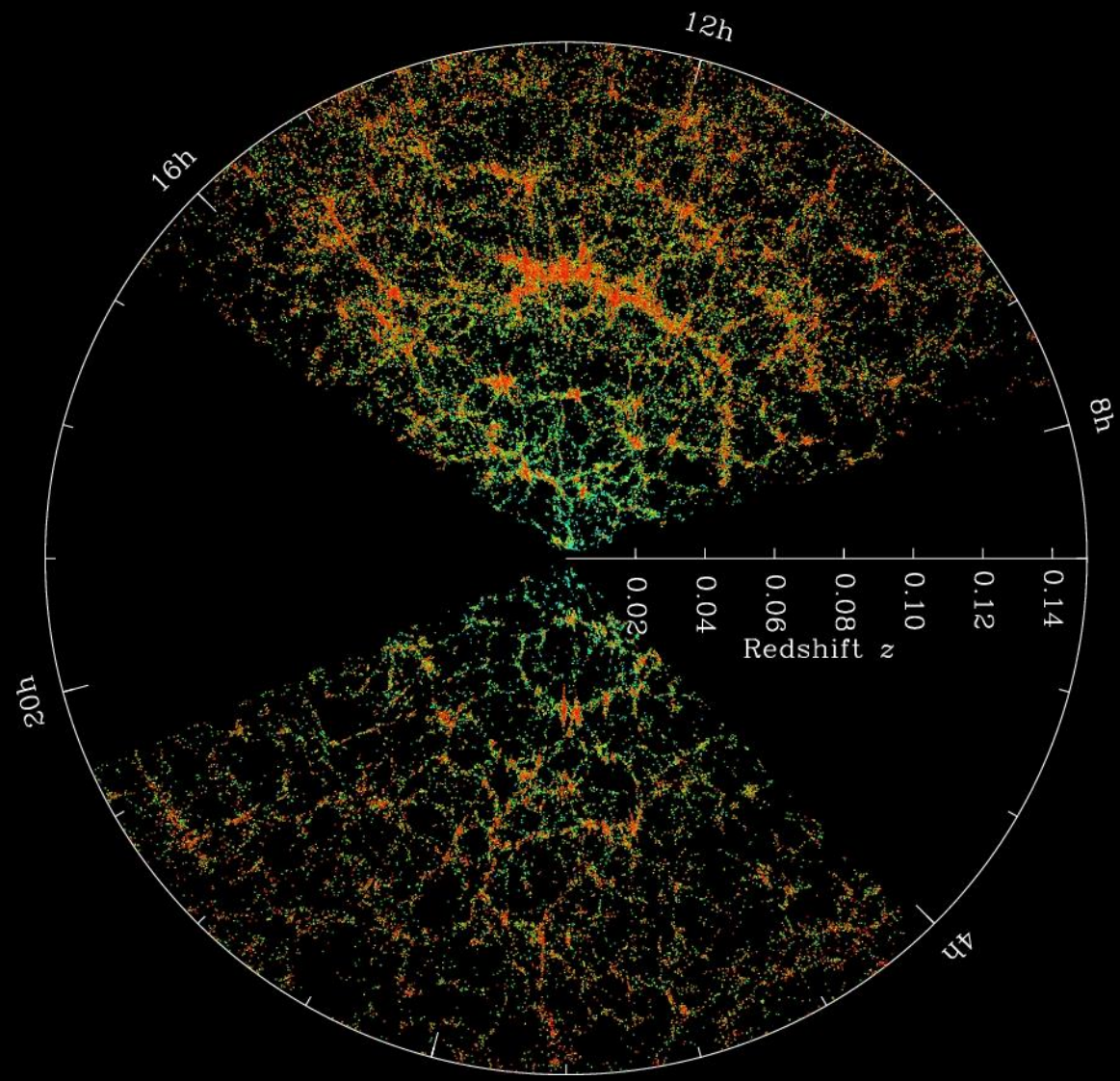


Euclid – Galaxy Clustering

- Probes expansion rate of the Universe (BAO) and clustering history of galaxies induced by gravity (RSD)
- 30 million spectroscopic redshifts over 15,000 deg2



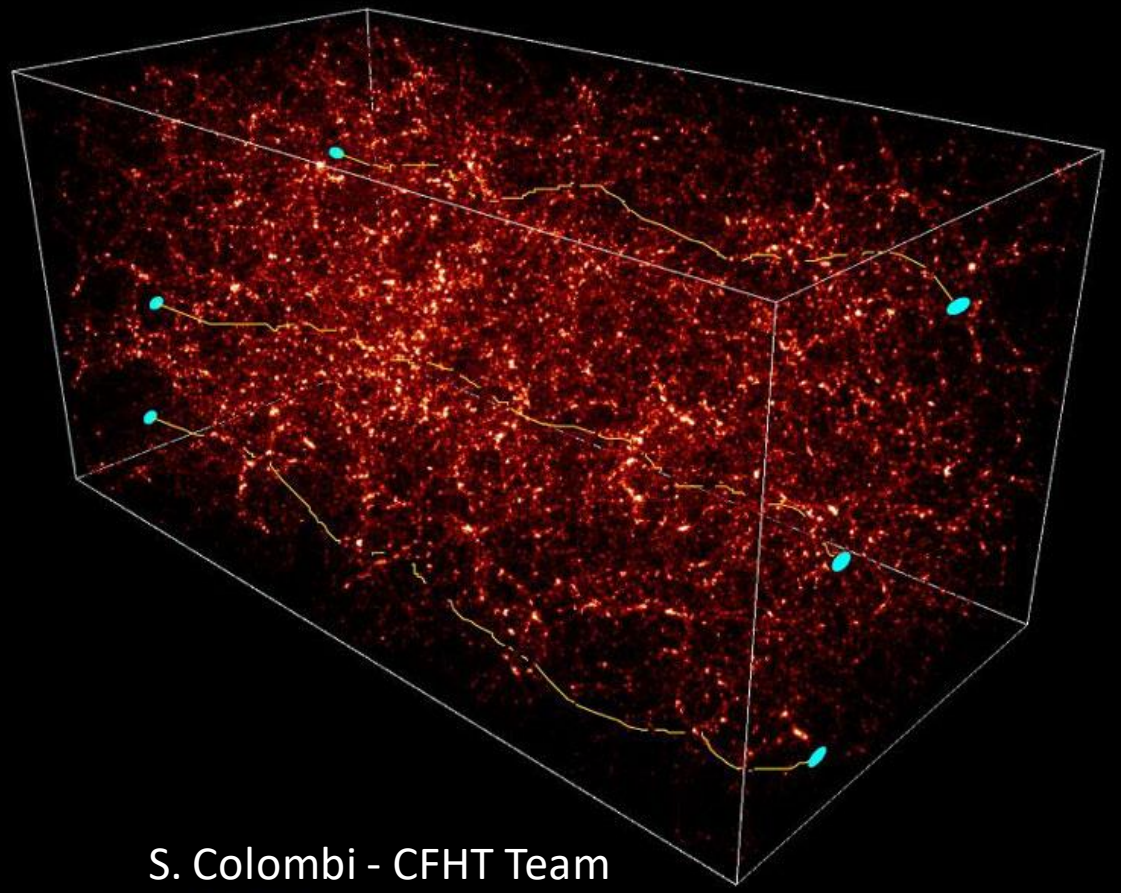
Reid et al. (2014)



Credit: M. Blanton, SDSS

Euclid – Weak Lensing

- Cosmic Shear over 0.2<z<2
- Probes distribution of matter: lensing potential $\phi+\psi$
- Shear amplitude, shape of galaxies
- WL with 1.5 billion galaxies



S. Colombi - CFHT Team

Galaxy bias

b is the bias of tracers of matter (galaxies) as there is a difference between real space and redshift space

density RSD

$$\Delta(z,\mathbf{n}) = b\cdot\delta - \frac{1}{\mathcal{H}}\partial_r(\mathbf{V}\cdot\mathbf{n}) + (5s-2)\int_0^r dr' \frac{r-r'}{2rr'}\Delta_\Omega(\Phi+\Psi)$$

lensing

Bonvin 14'

Weak lensing and galaxy clustering advantages

- GGL and GGC sensitive to b
- RSD probes galaxy-velocity cross-correlation → f (z)
- GGL probes small scale filtered galaxy-matter cross correlation → H(z)

Combining

- put forward independent effect of cosmological parameters (f , σ8,...)
- study of the degeneracies
- increase precision on any deviation to GR (Joudaki ’17; Jullo ’19)

Estimators: lenses and sources

We compare theoretical ensemble average

$$\xi(d) = \langle \Delta(\mathbf{x}) \Delta(\mathbf{x}') \rangle$$

with observational average over pairs:

$$\xi(d) = \sum_{ij} \Delta(\mathbf{x}_i) \Delta(\mathbf{x}_j)$$

Lensing : Tangential shear

$$\gamma_{\rm t}(\theta) = \Sigma_{\rm c}^{-1}(\chi_{\rm l}, \chi_{\rm s})\, \Delta\Sigma(R)$$

(Blake 20')

Clustering :

$$\xi(x,y) = \frac{GG(x,y) - 2GR(x,y) + RR(x,y)}{RR(x,y)}$$

(Jullo 19')

What we are doing regarding DESI

C3 WG lensing mock challenge

1

- From stage 1: compute tangential shear (Fig.1)
- Estimation of the linear galaxy bias with Jullo et al. Code (Fig.2)
- Comparing work with void-lensing (see Renan's work)
- Exploring impact of magnification bias (2011.05771)

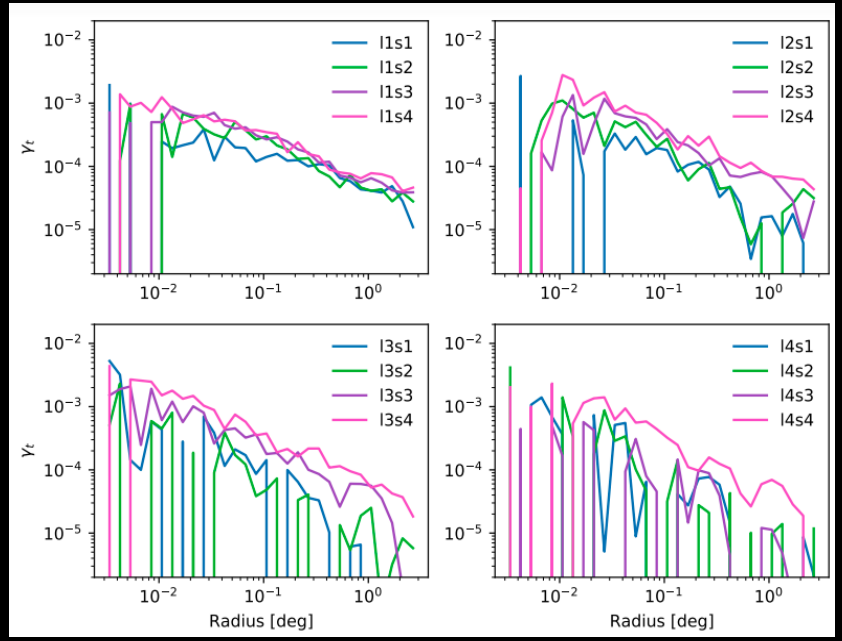


Fig.1

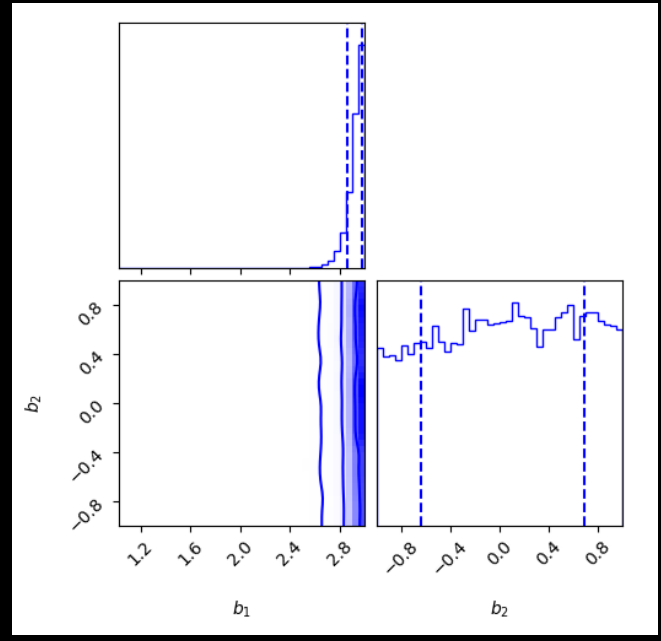


Fig.2

What we are doing regarding Euclid

IST: Likelihood

ISL:NonLinear

2 Developing a code

- Extension from GGL-GC code to systematics
- Taking into account non-linear effects at small scales
- Take relativistic effects into account such as gravitational redshift (Bonvin 14') which can be done by using emulators :
  - gevolution (Adamek 16')
  - Magrathea (Reverdy 14')
  - Raygal (Breton 18')
- Adding lensing and clustering predictions with estimators
- Cosmological likelihood pipeline with MCMC implementation

Testing gravity

3

Extension for modified gravity scenarios

- No parametrisation
- Once metric and theory fixed: calculate power spectrum using EFT Camb or CLASS extension
- Predict MG lensing/clustering signal at small scales with halo model
- **Tests:**

  - Scale-dependance null test (Oliveira Franco 20')
  - Estimators as E_G
  - Anisotropic stress (Sobral Blanco 21')