Title: Modified gravity getting to the one-point clustering statistics

Speakers: Cora Uhlemann

Collection/Series: 50 Years of Horndeski Gravity: Exploring Modified Gravity

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Abstract:

Gravitational collapse shaped the cosmic large-scale structure and created a plethora of different density environments. For optimally probing gravity with galaxy surveys like Euclid and Rubin LSST, we need to dissect different density environments that are lumped together in traditional two-point statistics. I will explain how the one-point probability distribution of dark matter densities can be predicted analytically including signatures of modified gravity that match with cosmological simulations for nDGP and f(R) gravity. I will provide an outlook on how those predictions can be translated to galaxy clustering and weak lensing and observables.

Modified Gravity getting to the One-point clustering statistics

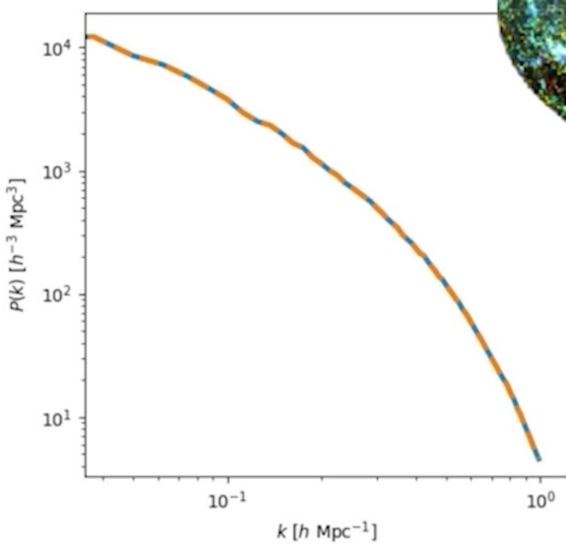
Cora Uhlemann
50y of Horndeski, UoW & PI, July 2024
UNIVERSITÄT BIELEFELD

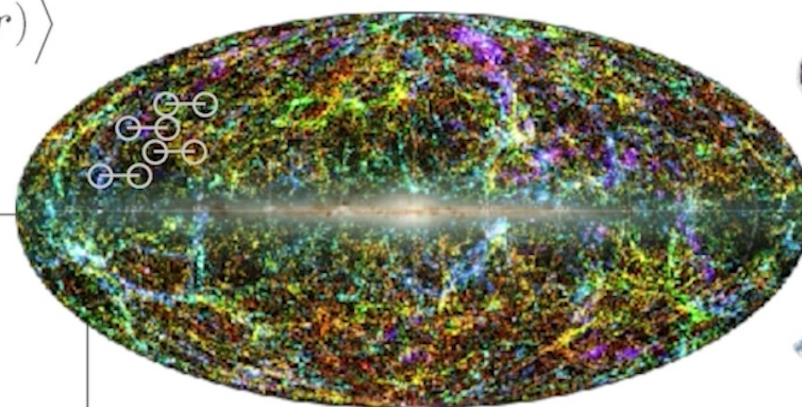
Clustering Statistics

2-point correlation averages over all densities

$$\xi(r) = \left\langle \delta(\boldsymbol{x})\delta(\boldsymbol{x}+\boldsymbol{r}) \right\rangle$$

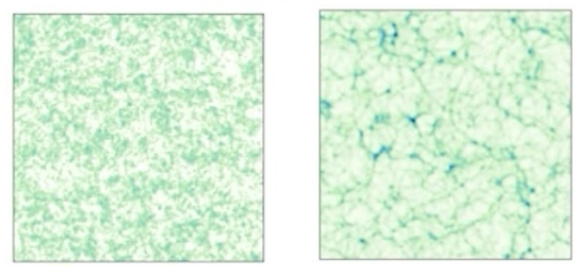
power spectrum





Euclid

Rubin LSST



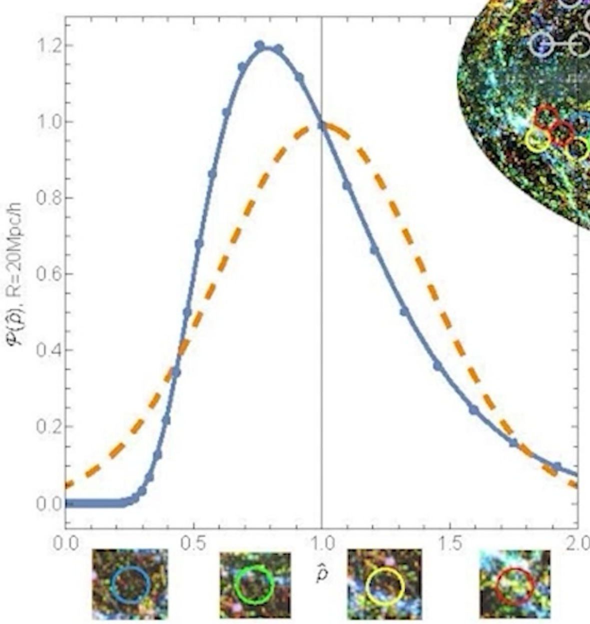
Gaussian Universe

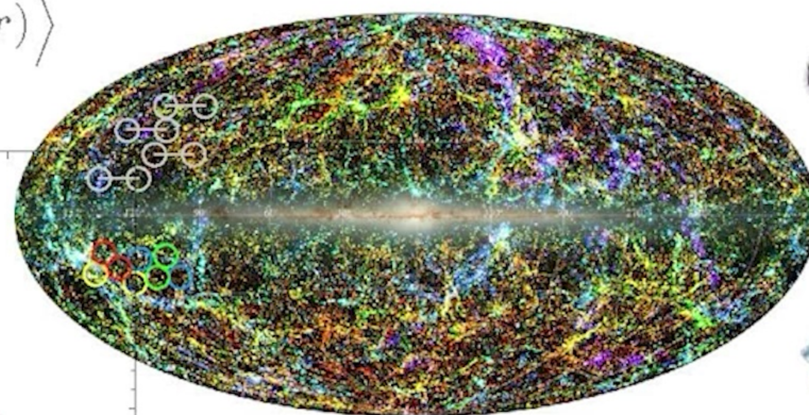
our Universe

Clustering Statistics

2-point correlation averages over all densities

$$\xi(r) = \left\langle \delta(\boldsymbol{x})\delta(\boldsymbol{x}+\boldsymbol{r}) \right\rangle$$





Euclid

Rubin LSST

beyond average 1-point
statistics split density environments

$$\mathcal{P}_R(\delta) \propto \frac{\#\text{coloured cells}}{\#\text{all cells}}$$

One-Point Statistics

Large-deviation statistics

most likely path dominates $\rho = 1 + \delta_{\rm NL}$

spherical collapse

$$\mathcal{P}_{R,z}(\rho) \sim \exp\left[-\frac{\delta_L(\rho)^2}{2\sigma_L^2(z, r(R,\rho))}\frac{\sigma_L^2}{\sigma_{\rm NL}^2}\right]$$

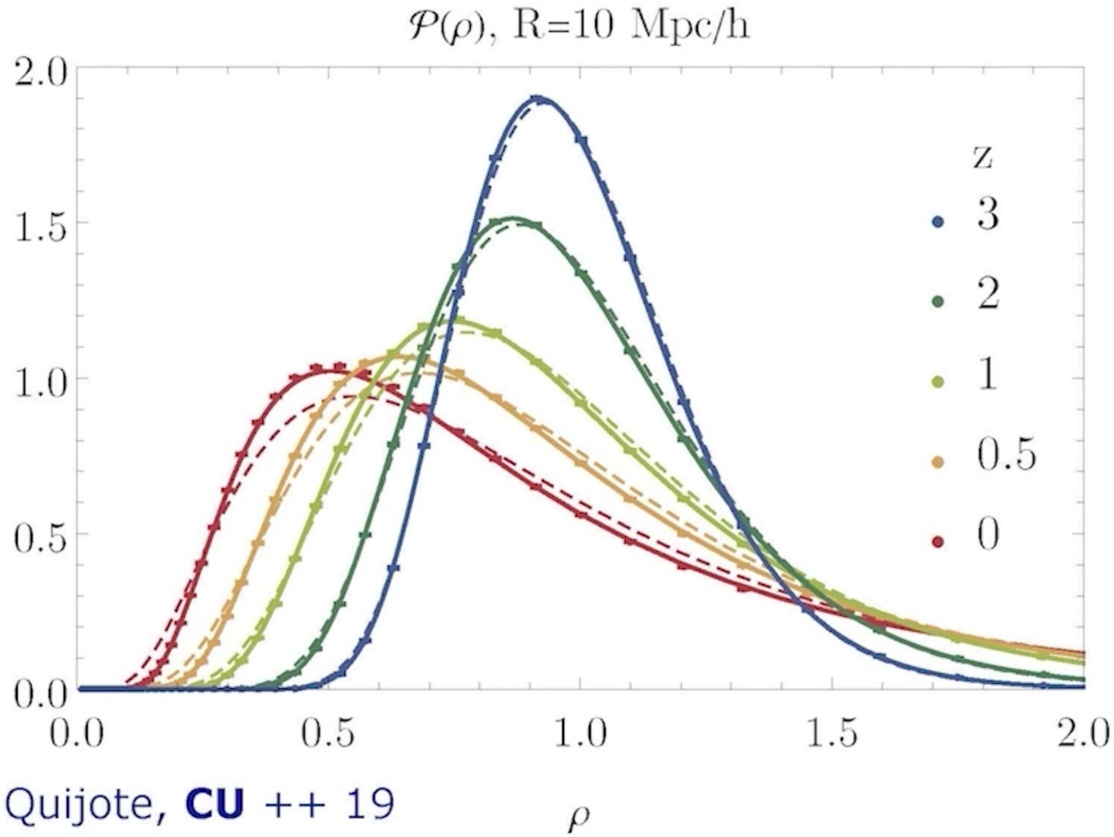
linear variance & growth

nonlinear variance

Bernardeau 94
CU++ 16

One-Point Statistics

accurate PDF predictions beyond lognormal



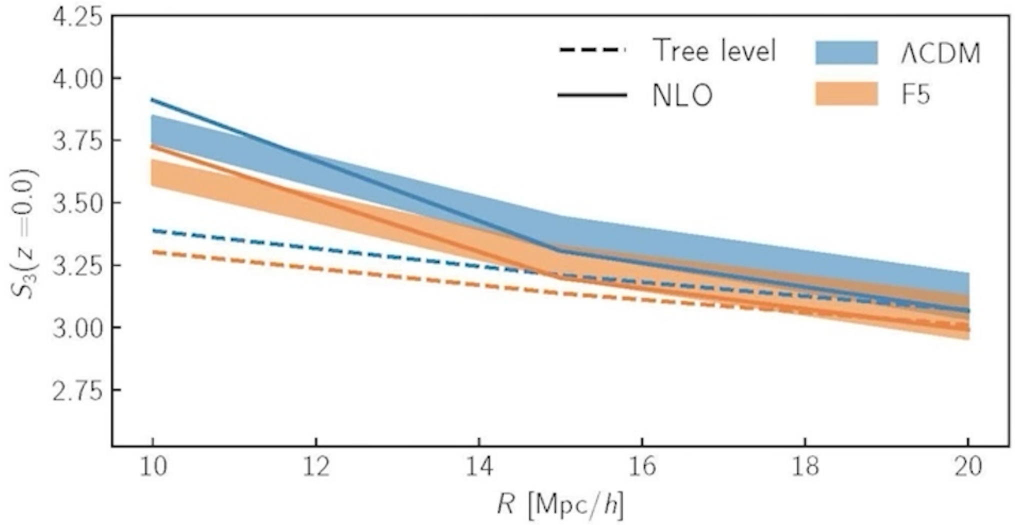
sims: Quijote, **CU** ++ 19

MG @ One-Point Statistics

modified gravity affects nonlinear structure

examples: **nDGP** & **f(R)**

reduced cumulants robust and predictable $S_3 = \frac{\langle \delta^3 \rangle}{\sigma^4}$



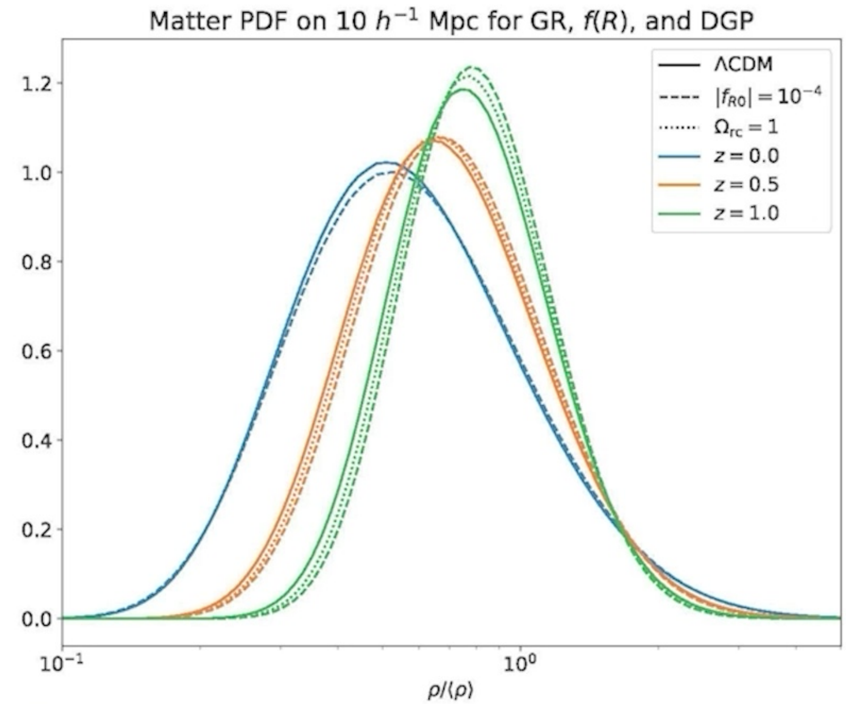
Matteo Cataneo

sims: Durham group

Cataneo, **CU** ++ 21

MG @ One-Point Statistics

modified gravity affects nonlinear structure
characteristic time & density dependence



github: mcataneo/pyLDT-cosmo

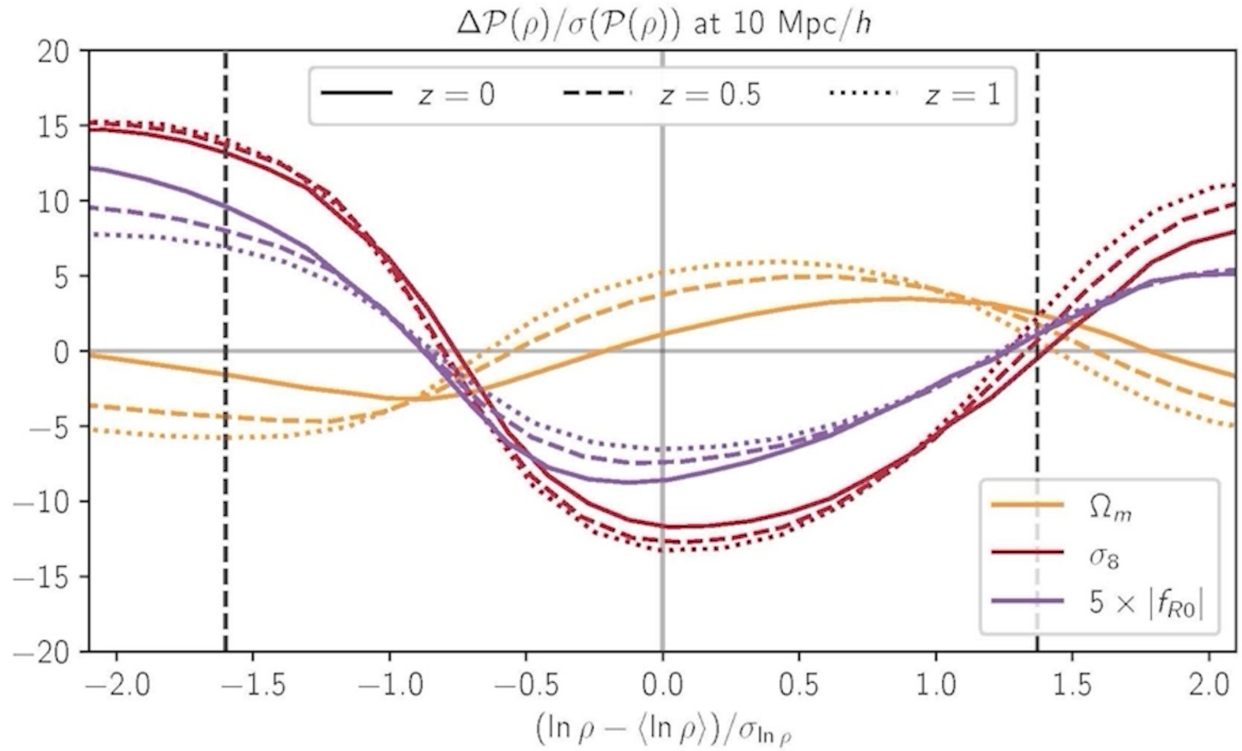
Alex Gough

Gough, CU 21

Cataneo, **CU** ++ 21

MG @ One-Point Statistics

characteristic time & density dependence



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Cataneo, **CU** ++ 21

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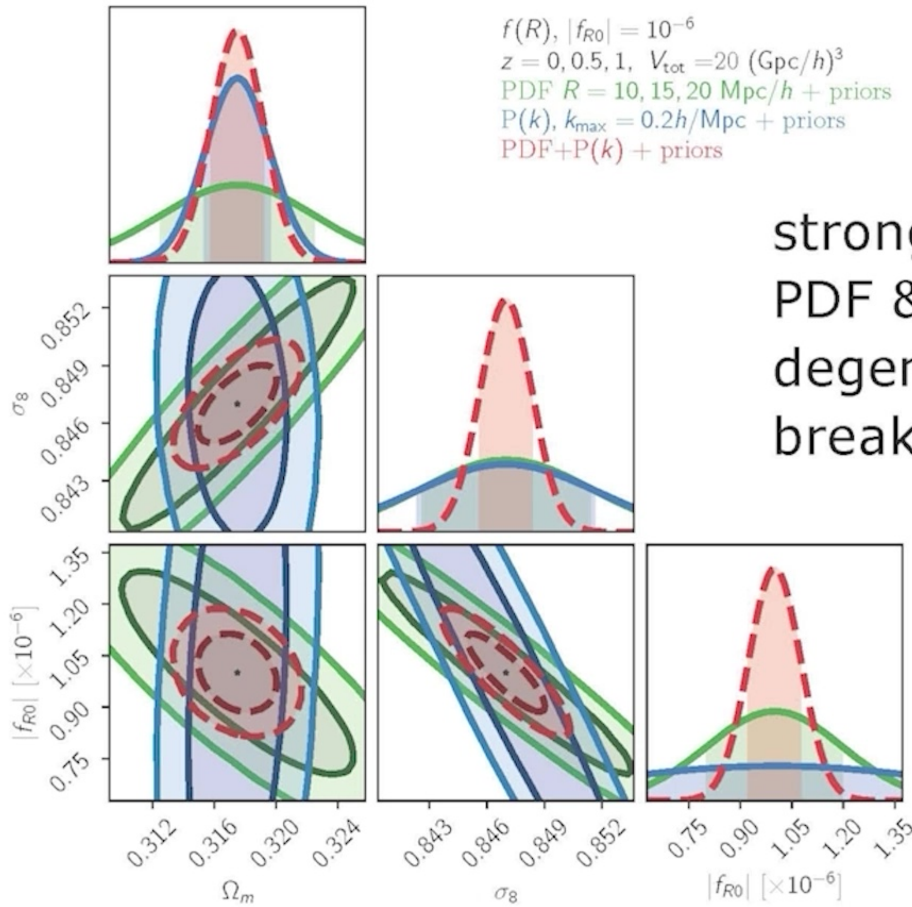


stronger together:
PDF & P(k)
degeneracy
breaking

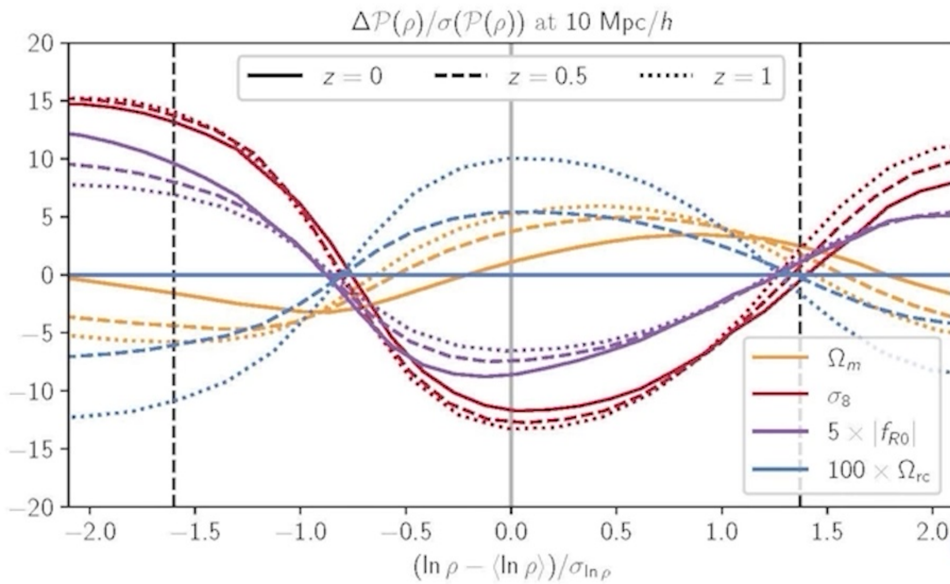
Cataneo, **CU** ++ 21

MG @ One-Point Statistics

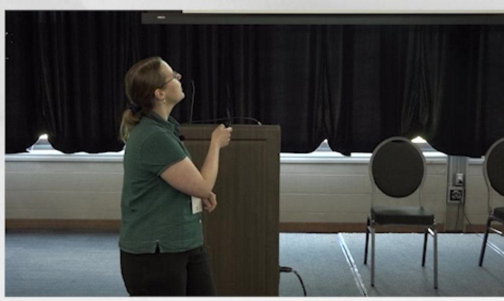
stronger together: PDF & P(k) degeneracy breaking

	F6 detection	DGPw detection
PDF, 3 scales + prior	5.15σ	1.17σ
$P(k)$, $k_{\max} = 0.2\ h/\mathrm{Mpc}$ + prior	2.01σ	2.42σ
PDF + $P(k)$ + prior	13.40σ	5.19σ

matter field



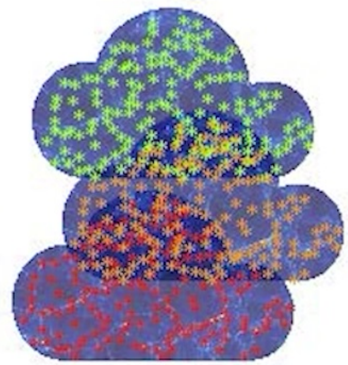
Cataneo, **CU** ++ 21



One-Point to Observables

source galaxies

(dark) matter



galaxies

Postdoc Lina Castiblanco

Euclid

galaxy shapes

convergence κ

galaxy counts

density δ_{g}

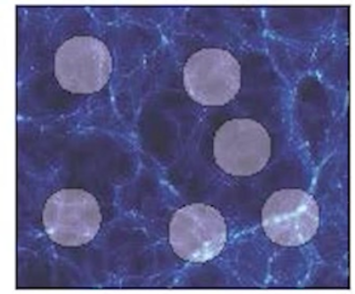
PhD student Beth Gould

MG getting to the One-Point

Powerful non-Gaussian statistics

robust & accurate predictions

different density environments



Matter density PDF

vLCDM, f_{NL} **CU**, Friedrich ++ 19, Friedrich, **CU** ++ 19

dark energy $w_{0,a}$ & MG, Ω_{rc} , f_{R0} Cataneo, **CU**++ 21

Real: weak lensing & galaxy counts PDF

lensing convergence: projection Boyle, **CU**++ 20
Castiblanco, **CU**++ 24

galaxies: galaxy bias & stochasticity Friedrich+(**CU**)+ 21