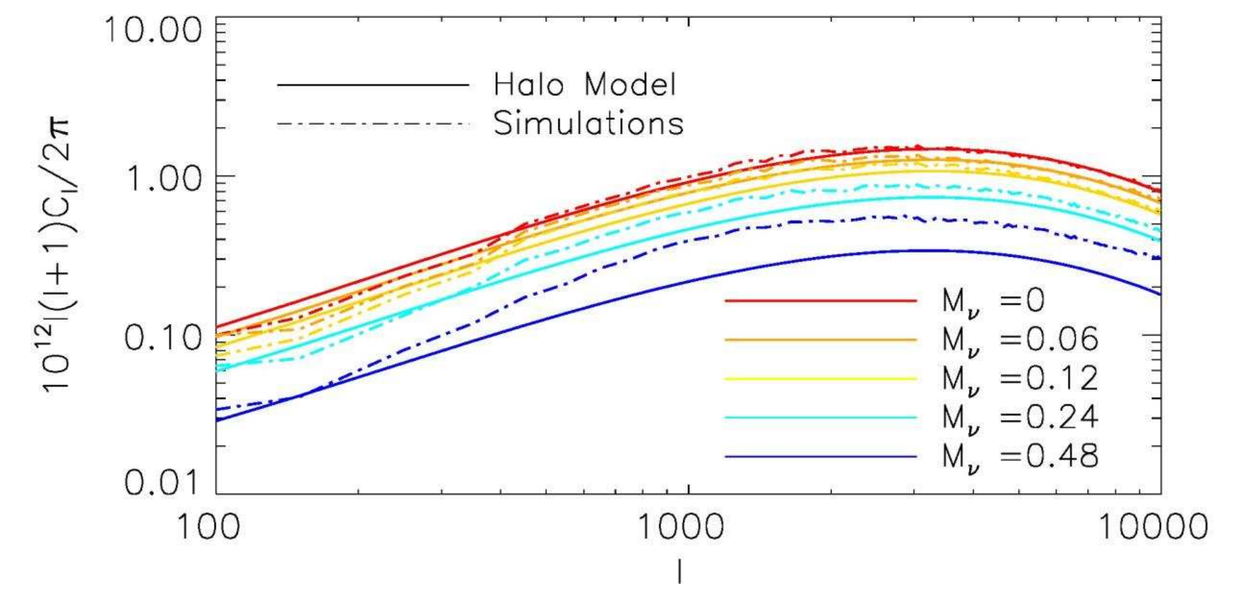
Improving the halo model using hydrodynamical simulations with an eye to cosmological emulators

Alberto Acuto, LJMU

The Halo Model is a versatile, fast and accurate tool that allows us to explore several LSS observables.



oscode: fast solutions of oscillatory ODEs in cosmology

Fruzsina J. Agocs[1,2]

[1]Kavli Institute for Cosmology, Cambridge [2]Astrophysics Group, Cavendish Laboratory, Cambridge

What?

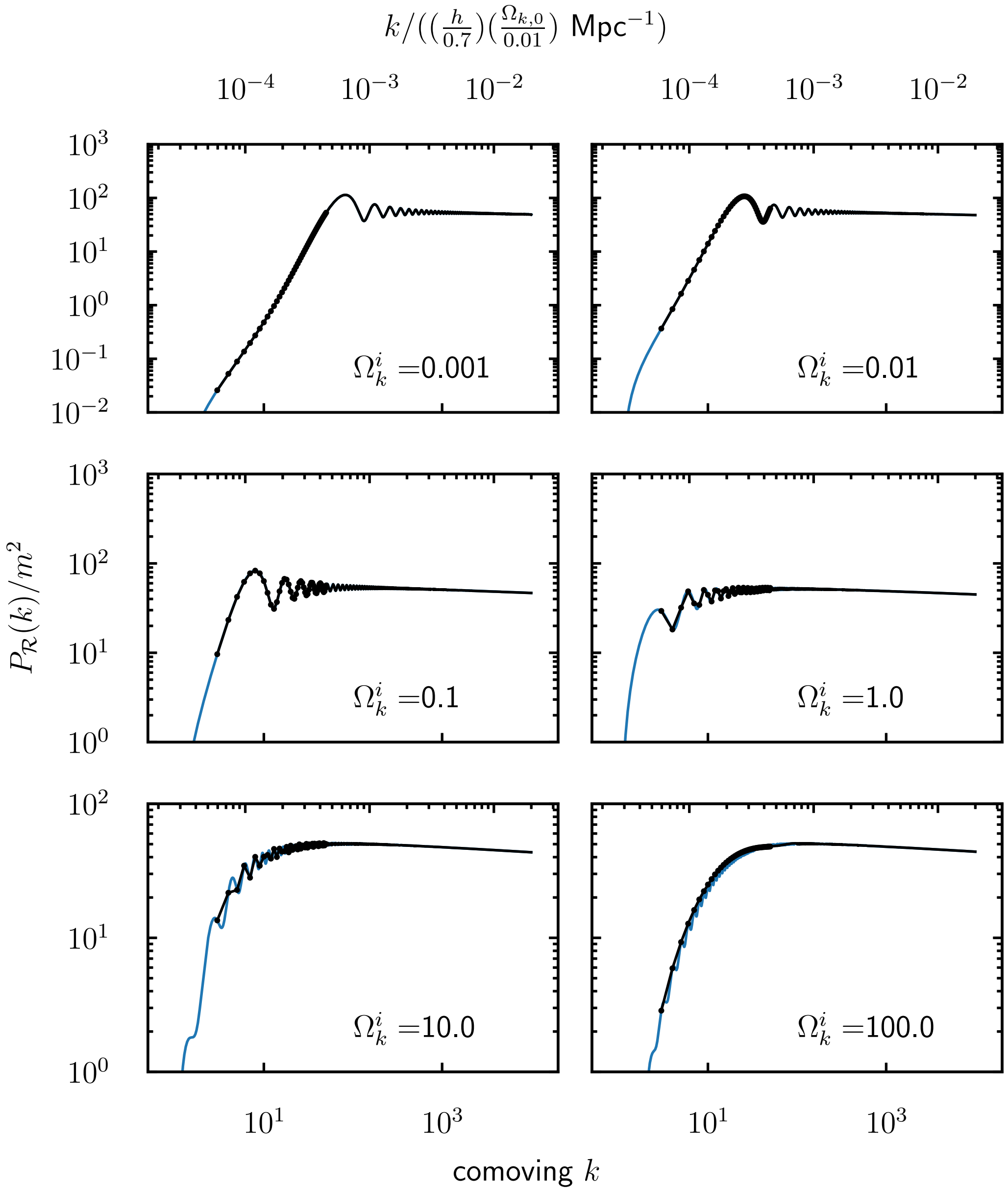
- C++ package with C++ and Python interface
- Solves $\ddot{x}(t) + 2\gamma(t)\dot{x}(t) + \omega^2(t)x(t) = 0$
- ω and γ can be explicit functions of time or array-like containers, storing results of numerical calculations

Why?

- Generalised oscillators extremely common in physics:
- Schrödinger equation, propagation of waves in atmosphere, primordial perturbations, . . .
- Available numerical solvers inefficient at high frequencies, even if frequency varies slowly

How?

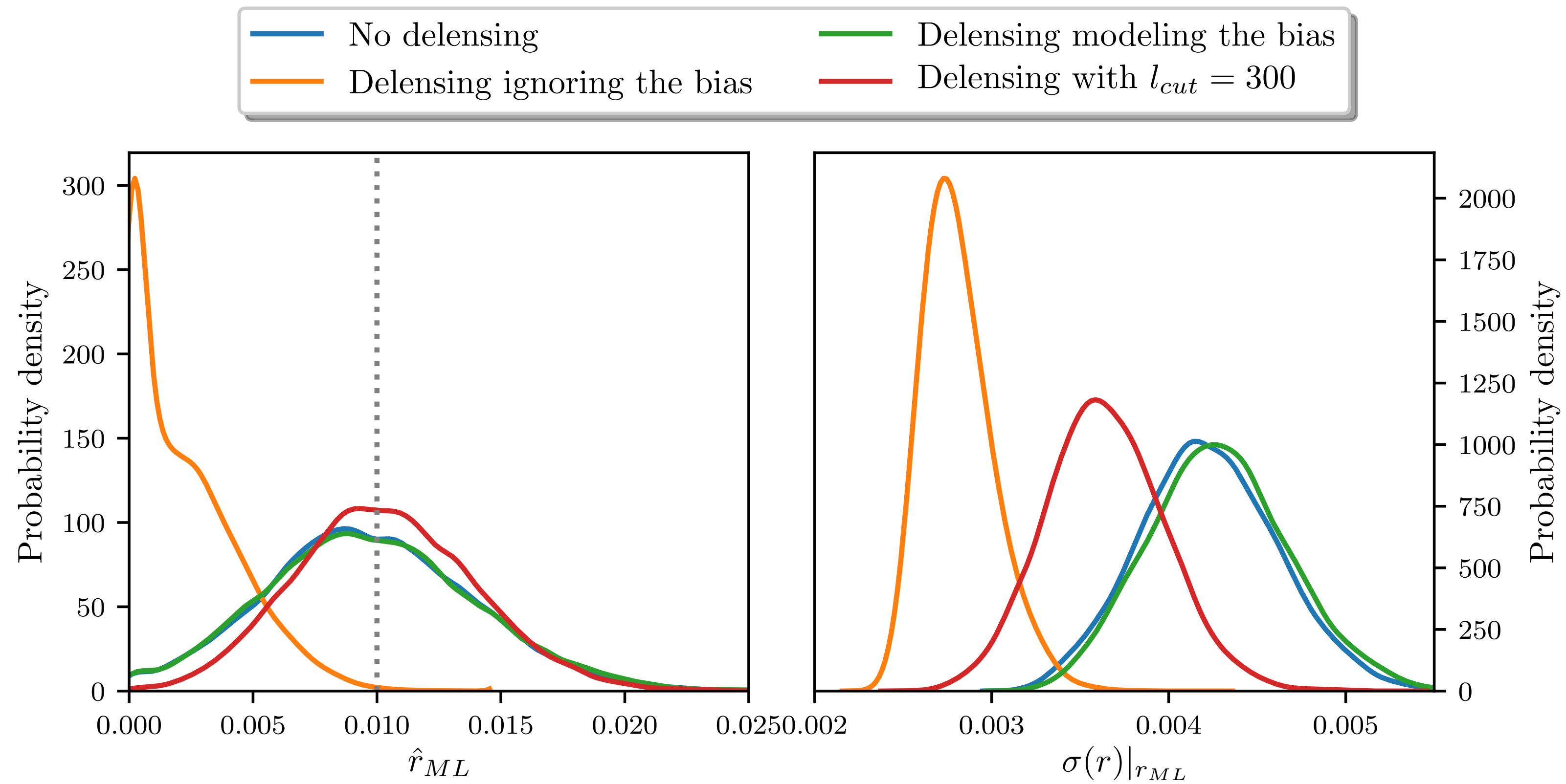
- Problem is poor representation of solution
- Use the Wentzel–Kramers–Brillouin approximation
- This allows **skipping over** highly oscillatory regions



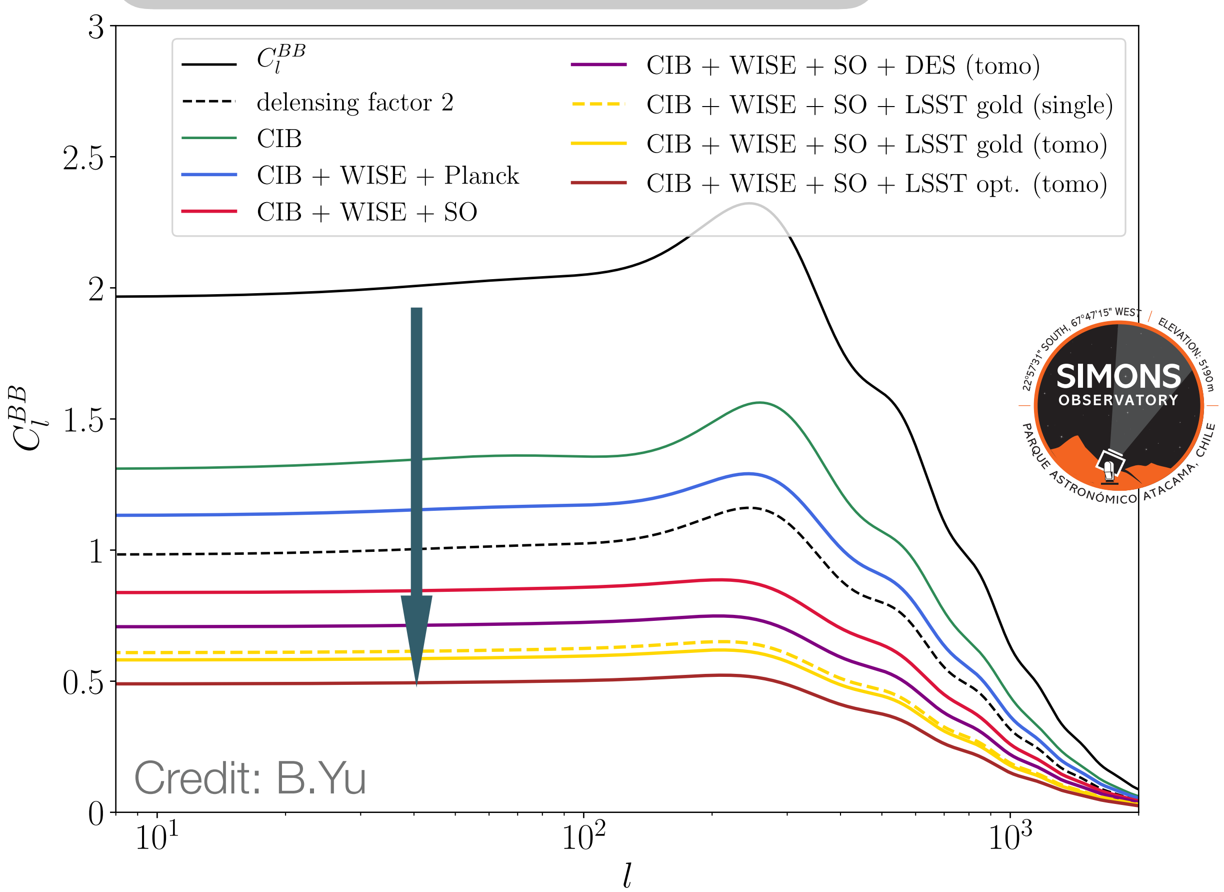
CMB B-mode delensing for the next generation of experiments

Antón Baleato, IoA, Cambridge
with A. Challinor, B. Sherwin, T. Namikawa, B. Yu

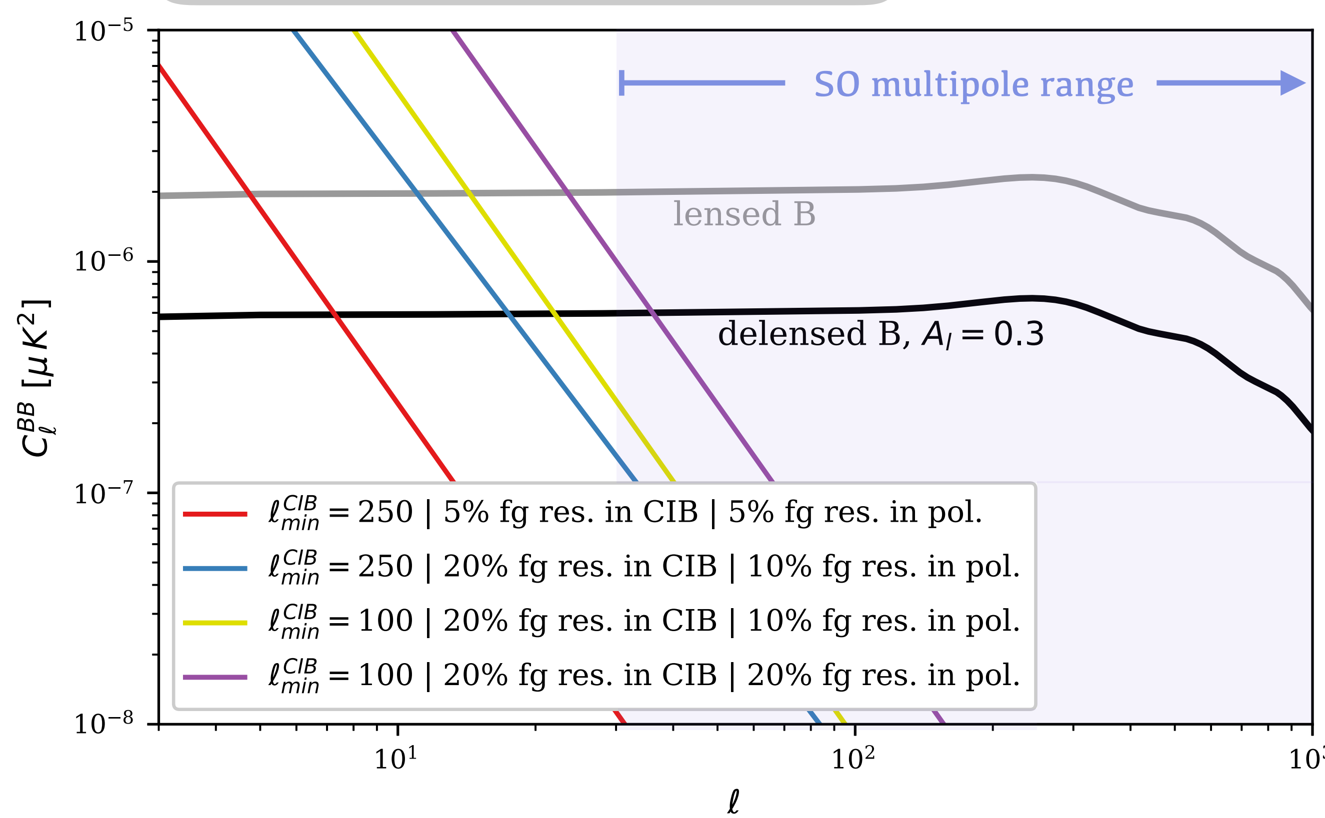
Delensing bias from EB lensing reconstruction



Multi-tracer delensing for SO



Delensing bias from residual galactic dust in CIB maps



THE KAVLI FOUNDATION
UNIVERSITY OF CAMBRIDGE

Dark Radiation from Torsion

Will Barker

A. N. Lasenby, W. J. Handley, M. P. Hobson & Y. C. Lin

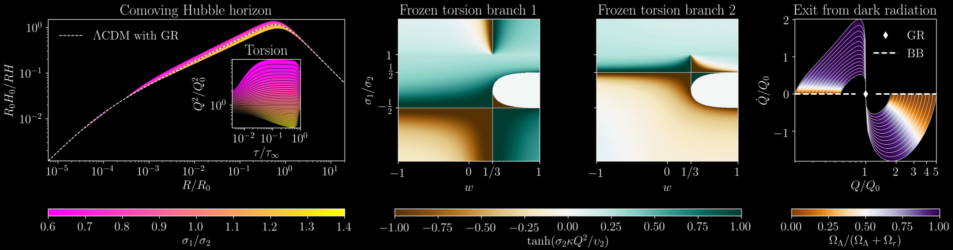
barker_w_1
wevbarker
wb263@cam.ac.uk

Modified 'gauge theory' gravity

- Renormalisable (power-counting)
- Unitary
- Dynamical curvature + torsion
- Action is ~~Einstein-Hilbert~~ Yang-Mills
- Massless $J^P = 2^+$ ~~gravitons~~ tordions

Cosmological phenomenology

- Emergent Friedmann equations
- 'k-screening' (flatness problem?)
- Dark radiation (H_0/σ_8-tensions?)
- Modern universe = attractor state
- Testable torsion ($\Delta N_{\nu,\mathrm{eff}}$, $Q_0 \approx M_\mathrm{P}$)



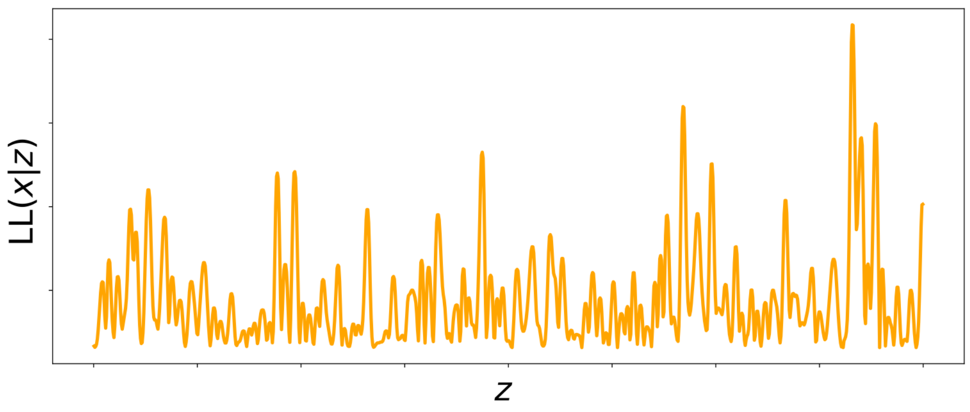
Poster: *Habitable Tordion Worlds*
Paper: *Cosmologically valid gauge gravities: a systematic approach* (in prep for Phys. Rev. D)

The L👀k Elsewhere Effect

BERKELEY CENTER *for* COSMOLOGICAL PHYSICS

Adrian Bayer and Uroš Seljak – (Poster 5)

- **Example:**
  - Exotic model of inflation
  - $P(k|\boldsymbol{z}) = P_{\Lambda\mathrm{CDM}}(k) + \Delta P(k|\boldsymbol{z})$
  - $\boldsymbol{z}$ relatively unconstrained by theory



- **Try:** Maximum likelihood estimation
- **Problem:** Look elsewhere effect – large parameter space will give many spurious peaks.
- **Solution:** Maximise the posterior mass, not the likelihood.
- **Potential uses** in various areas including exoplanets and GWs.

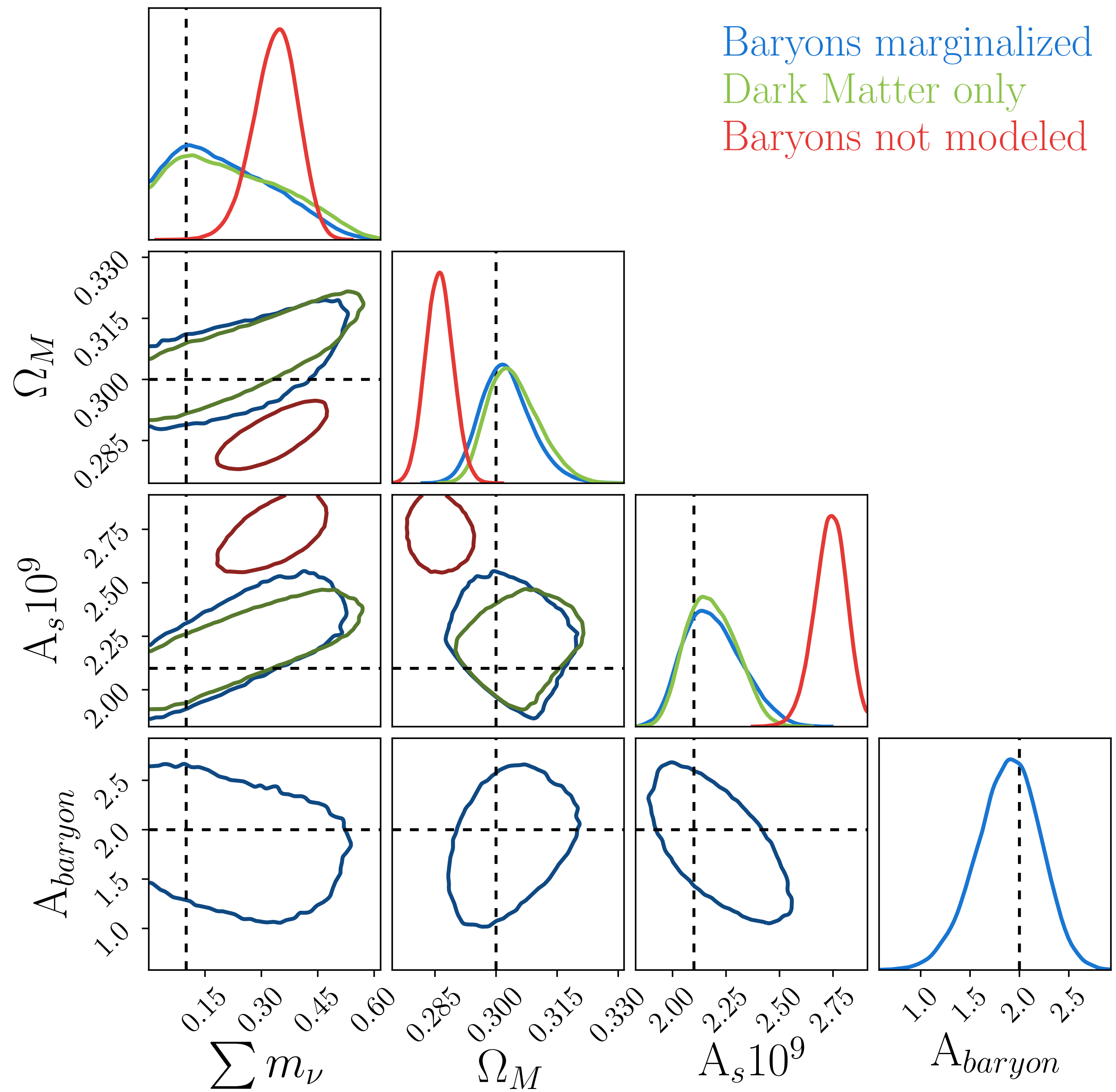
Quantum Bias Cosmology

Luke Butcher, University of Edinburgh.

- **No Dark Energy or Modified Gravity**: Obtain cosmic acceleration "for free", by treating Universe as quantum system.
- **Holographic Foundations**: Testable application of central tenet of quantum gravity.
- **Exact Solutions**: Predicts $a(\tau)$ and $w_{\rm eff}(z)$ from first principles.
- **Falsifiable**: One new free parameter γ; cannot mimic Λ exactly.
- **Passes Preliminary Tests**: Achieves close agreement with ΛCDM at early times, with deviations $O(1\%)$ at present day.
- **Phantom**: Generates $w_{\rm eff} < -1$ acceleration without issue.
- **Fine Tuning**: Inflation provides mechanism for $\Lambda_{\rm obs} \sim 10^{-120}/\ell_{\rm pl}^2$.
- **Future Work**: Compare with actual data! Explore H_0 tension.

Peaks, minima and baryons

Constraints on cosmological parameters from peak counts with and without accounting for baryonic effects



In collaboration with Jia Liu, Ian McCarthy and Ken Osato.

Measuring the Environment of Radio Loud Galaxies using CMB Lensing

from the latest *Planck* data release

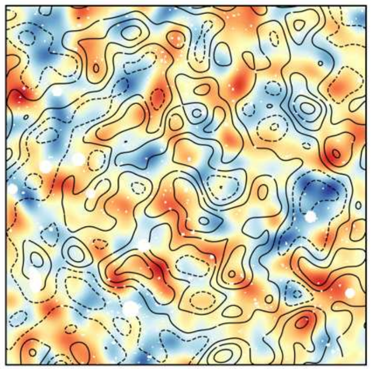
Dr Carolyn Devereux

University of Hertfordshire

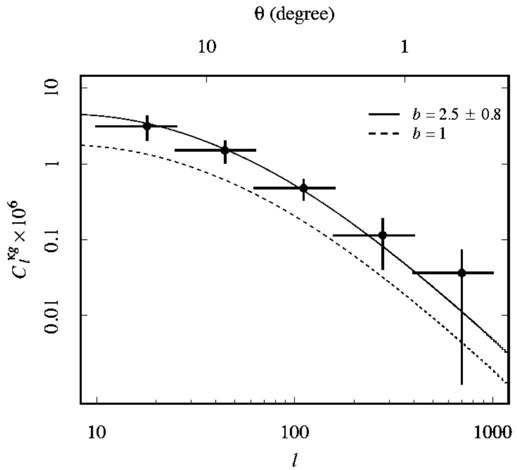
Collaborators: Prof. James Geach, Prof. Martin Hardcastle

MOTIVATION: In what environments do the most powerful AGN reside?

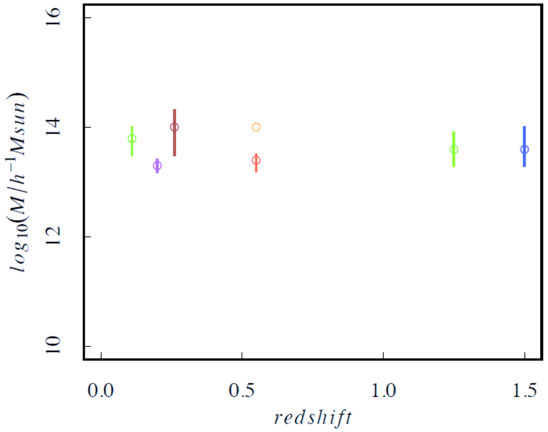
Measure cross-power spectrum of RLAGN density fields with weak lensing maps of *Planck* CMB



Overlay of RLAGN & CMB lensing maps: correlation can be seen by eye



Cross-correlation power spectrum between RLAGN & CMB lensing



Evolution of RLAGN Halo Mass

RESULT

Bias = 2.5 ± 0.8 (at 3.2σ)

Halo Mass = $10^{14.0}$ h^{-1} $M_\odot$

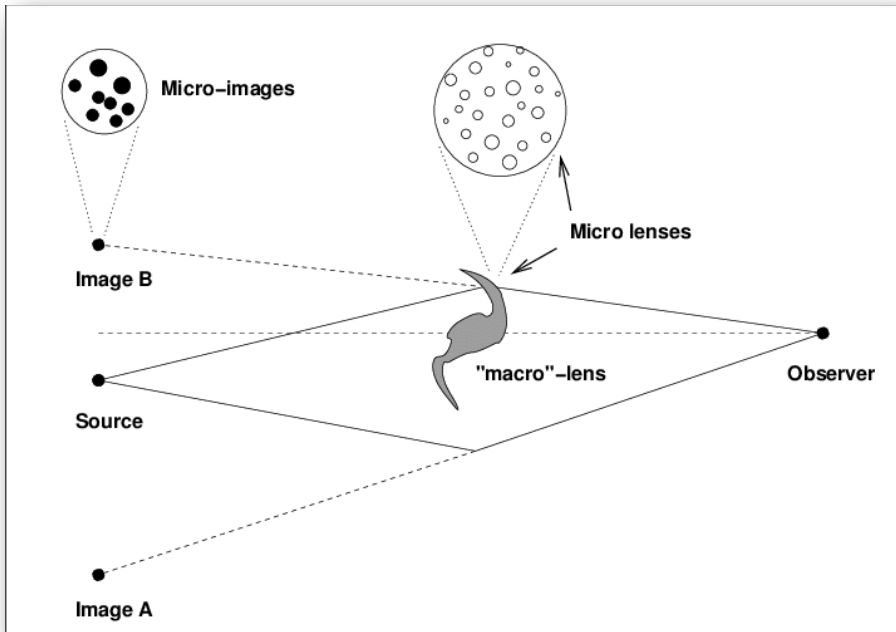
CONCLUSION: Confirms that RLAGN live in rich galaxy groups & clusters

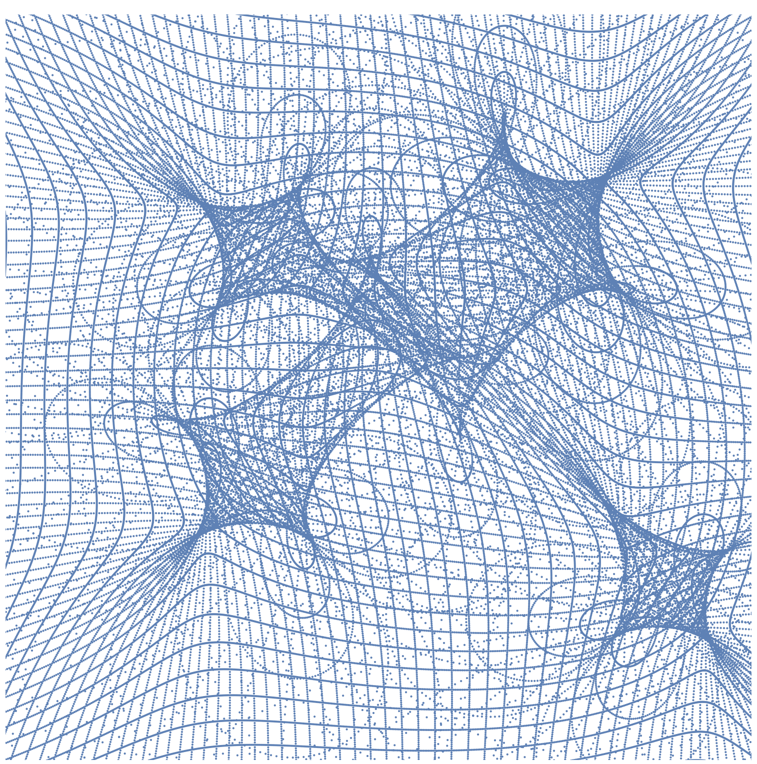
Funded by STFC

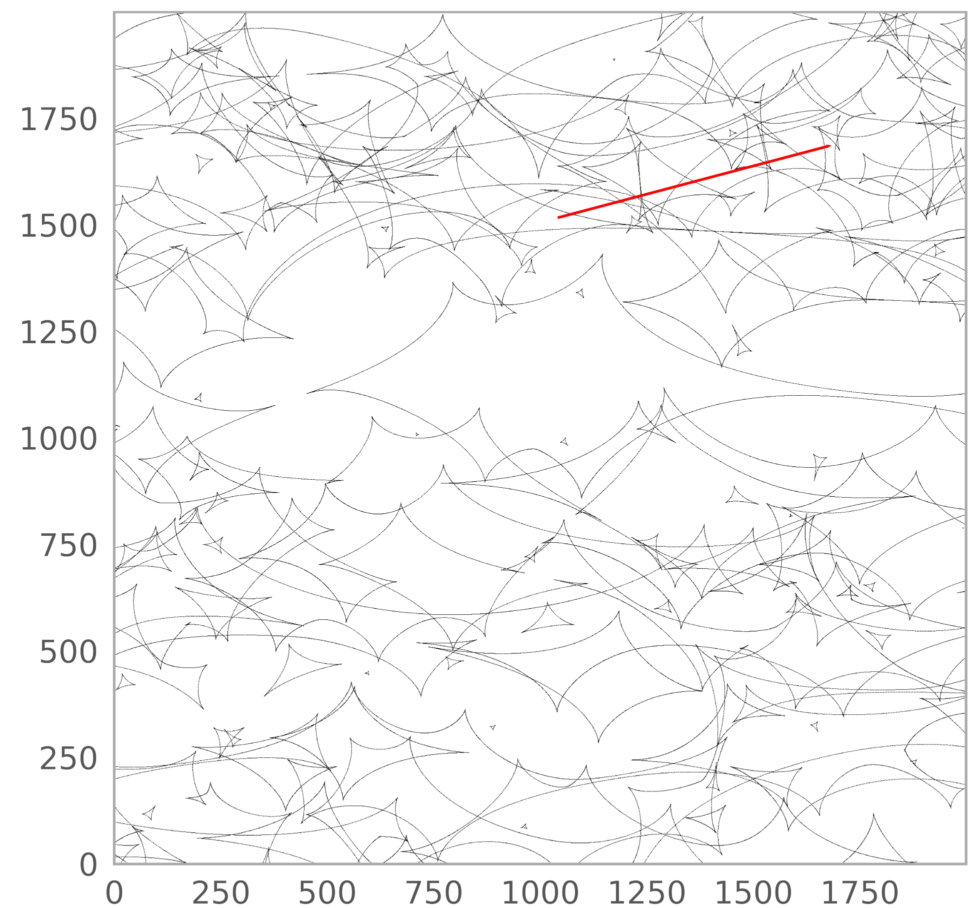
c.devereux@herts.ac.uk

PECULIAR VELOCITIES OF LENS GALAXIES FROM MICROLENSING

A. ESTEBAN GUTIÉRREZ

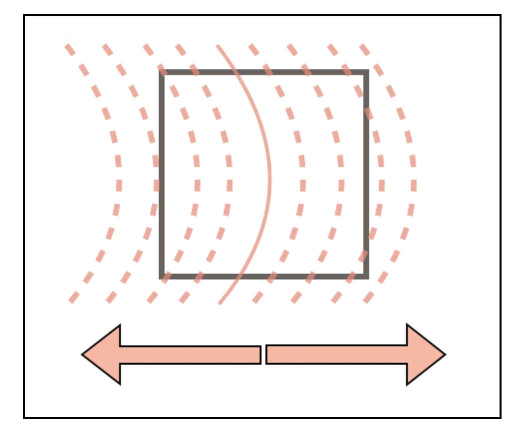






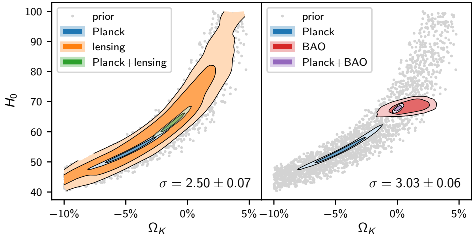
$$\overrightarrow{v} = \overrightarrow{v_{pec}} + \hat{x} v_H$$

$$\frac{v_{eff}}{\sqrt{m}} \propto < n >$$

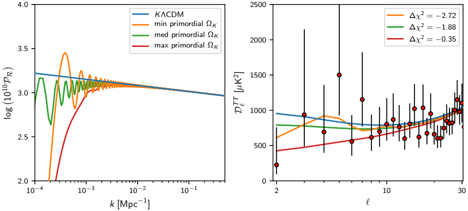


Inflation, curvature (tension) and kinetic dominance

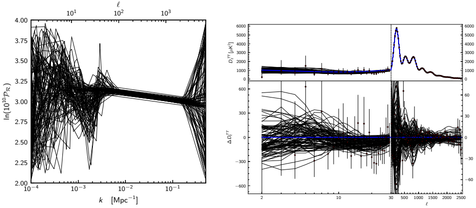
Curvature tension



Primordial power spectra $\Omega_K \neq 0$

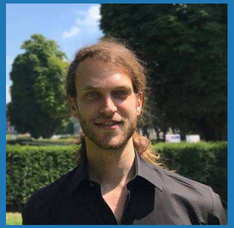


Reconstructed power spectra



- Planck (`plik`) and CMB lensing are in 2.5σ tension for $\Omega_K \neq 0$.
- We should be suspicious of combining BAO, CMB lensing and Planck for curved universe fits.
- `plik` prefers closed universes with odds of 50:1.

Will Handley <wh260@cam.ac.uk>



Lukas Hergt

Kavli Institut for Cosmology
Cavendish Astrophysics
University of Cambridge

lh561@mrao.cam.ac.uk

with
Will Handley, Mike Hobson, Anthony Lasenby

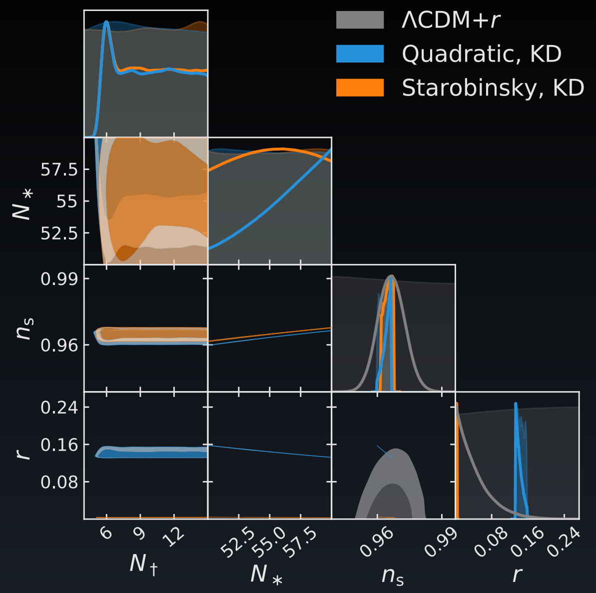
"Case for kinetic dominance initial conditions for inflation",
Phys. Rev. D 100, 023502 (2019),
arXiv:1809.07185

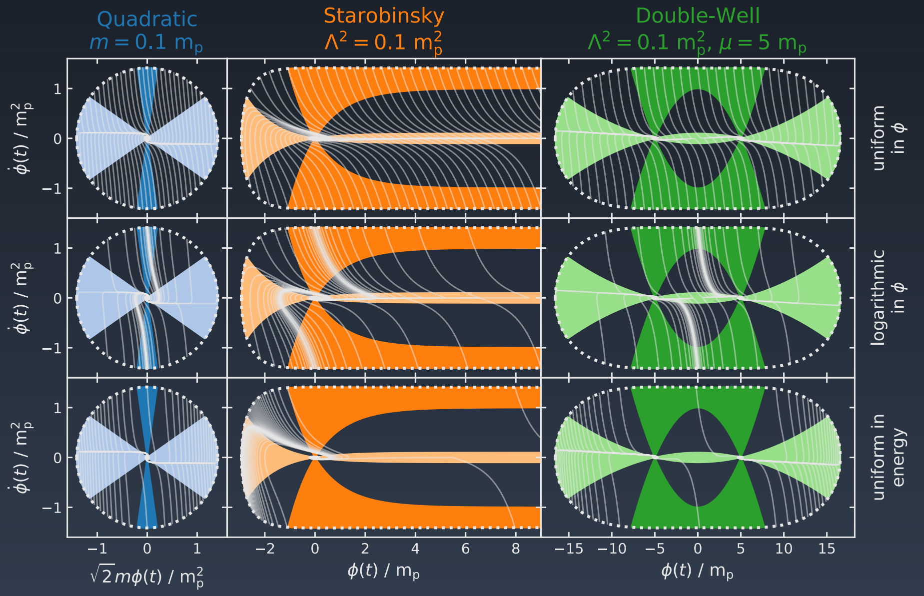
"Constraining the kinetically dominated Universe",
Phys. Rev. D 100, 023501 (2019),
arXiv:1809.07737

with
A. Amara, R. Brandenberger, T. Kacprzak, A. Réfrégier
"Searching for Cosmic Strings in CMB Anisotropy Maps using Wavelets and Curvelets",
JCAP 06 (2017),
arXiv:1608.00004

Kinetic initial conditions for inflation

- generically expected when integrating backwards in time
- cutoff and oscillations in the primordial power spectrum
  - ⇒ candidates for low-ℓ lack of power and/or ℓ=20-30 dip in CMB angular power spectrum
- Bayesian inference
  - Parameter estimation: MCMC (CosmoMC, MontePython, Cobaya)
  - Model Comparison: Nested Sampling (PolyChord)
- next: closed universes
  - ⇒ even *tiny* $\Omega_{k,0}$ has important consequences



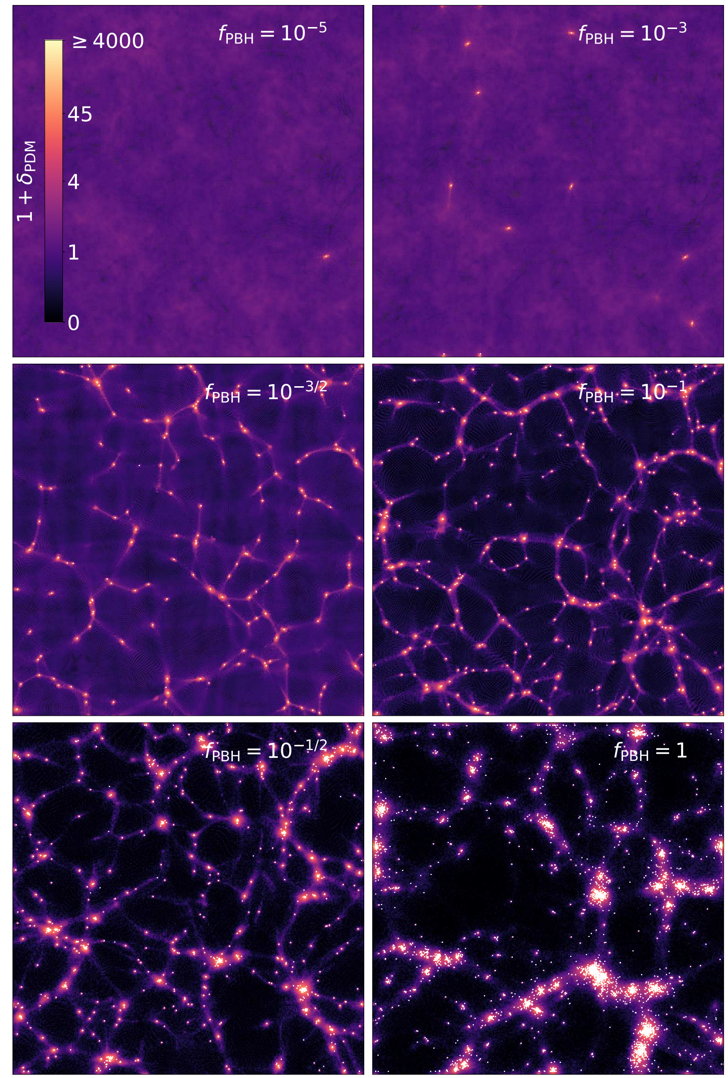


now looking for postdoc position

Early Structure Formation in ΛPBH Cosmologies

Derek Inman, New York University

- PBHs cause small scale structure to be highly nonlinear at $z \sim 1000$
- Study with N-body simulations containing PBHs + "particle dark matter"
- May affect CMB, LIGO, cosmic dawn



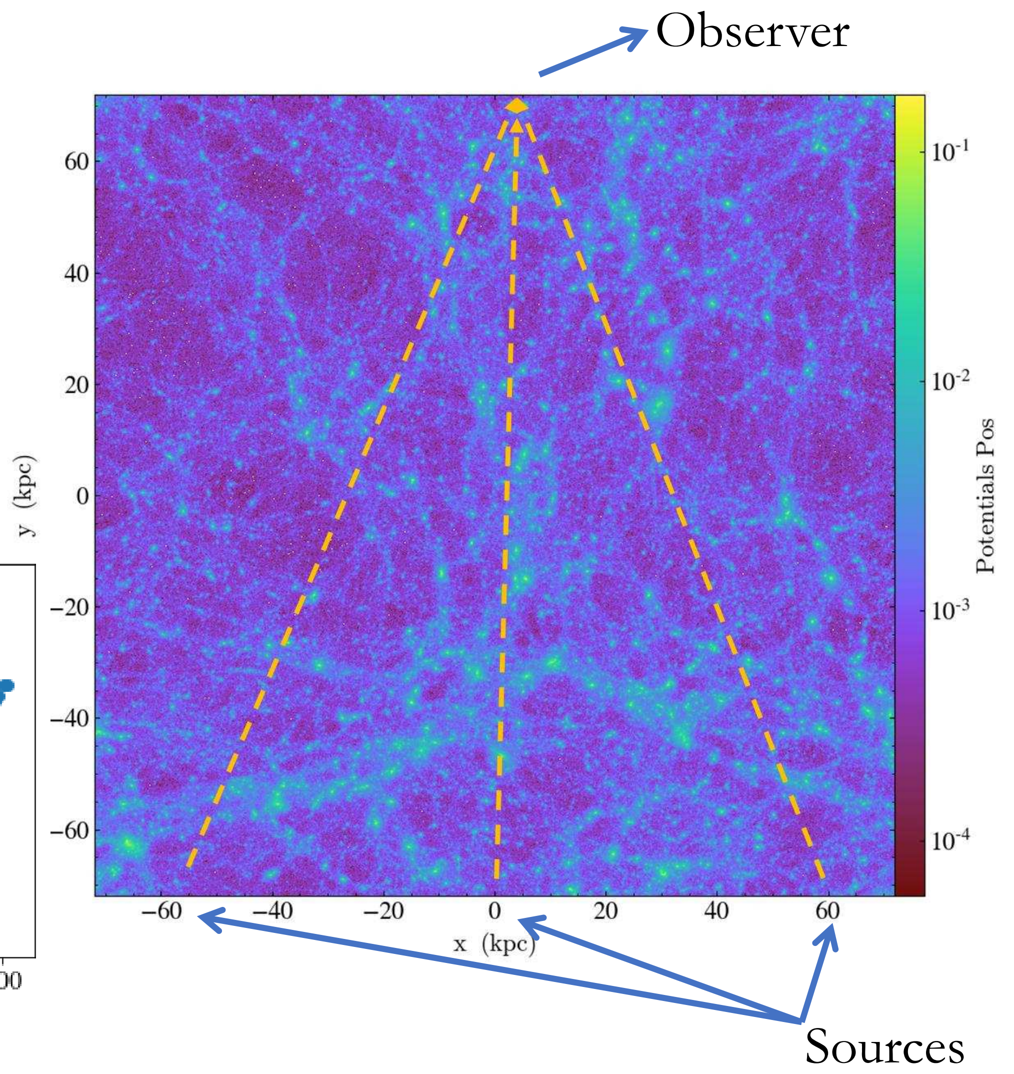
Inman and Ali-Haïmoud (arXiv:1907.08129)

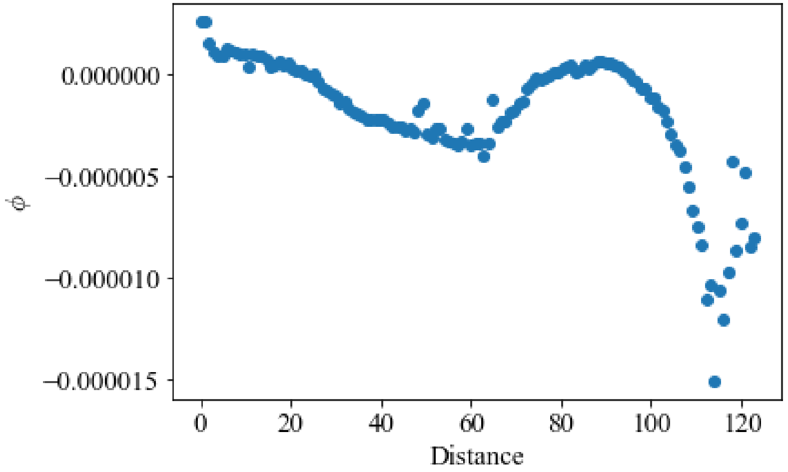
Cosmological Gravitational Wave Propagation through the Clumpy Universe

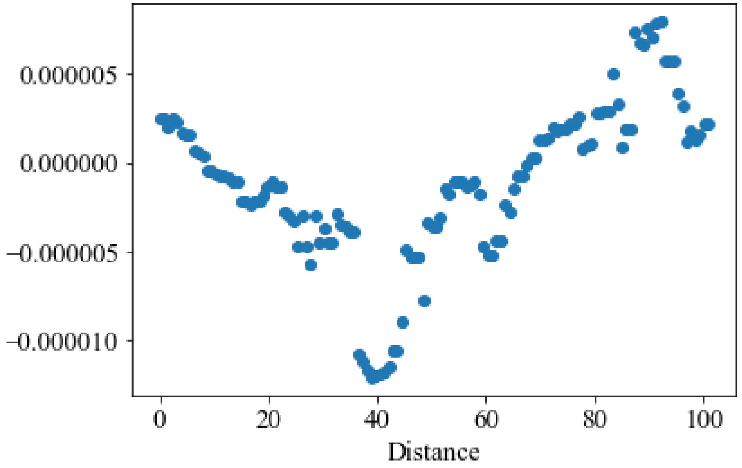
Marios Kalomenopoulos, University of Edinburgh, mariok@roe.ac.uk

Main Goal: Investigate the effects of matter anisotropies in the universe on GWs waveforms. We show preliminary results for:

- Values of the potential $\delta\varphi/c^2$, along random rays in numerical simulations and statistics of time-delays.
- Constraints on inhomogeneity with GW and E/M counterparts.



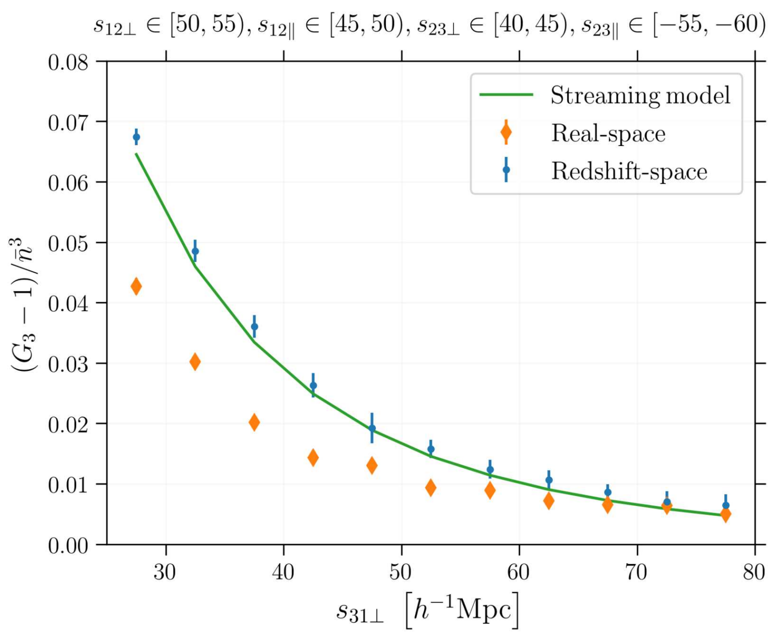


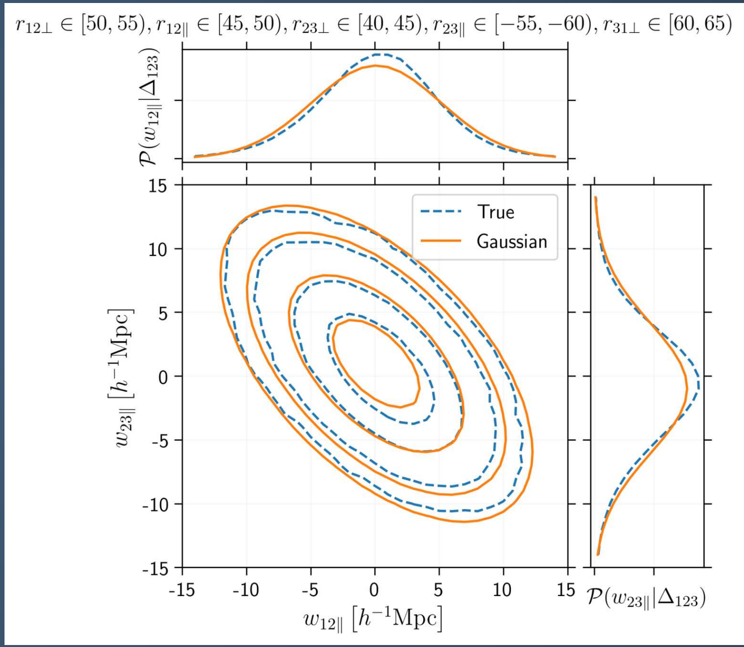


Three-point Gaussian streaming model

Stage IV surveys:

- We introduce the Gaussian streaming model for 3PCF.
- The necessary velocity statistics can be predicted through linear perturbation theory on quasi-linear scales and above.





Stage V surveys:

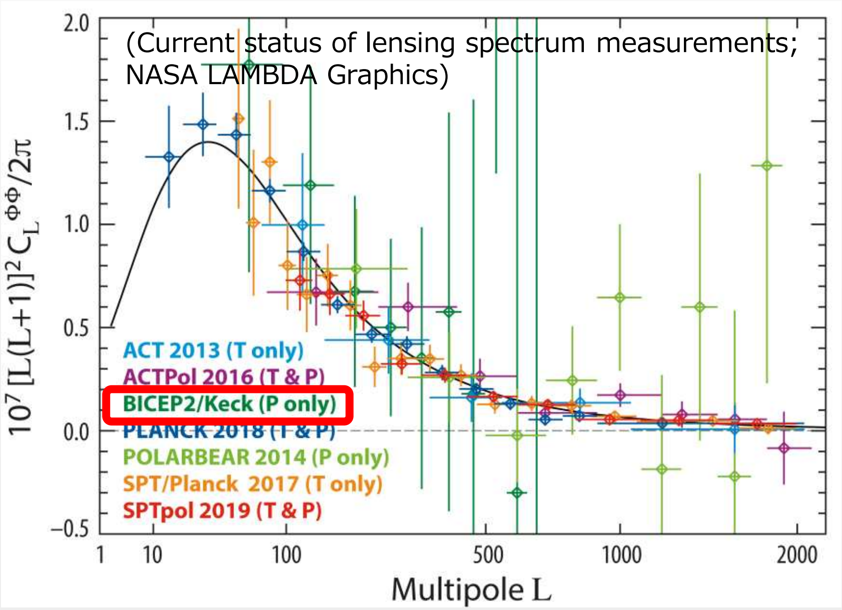
- We developed the exact streaming model framework for n-point clustering statistics.

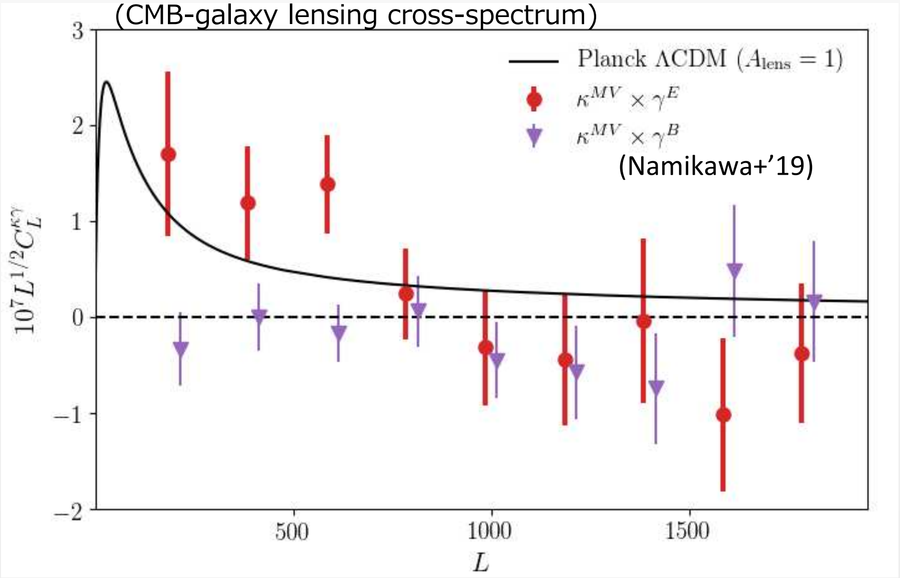
IMPRS astronomy & astrophysics Bonn and Cologne

UNIVERSITÄT BONN

Toshiya Namikawa (The University of Cambridge)

- The poster summarizes my recent works on B-mode analyses + theoretical works





- Quick Summary
  - ❑ Reconstructing lensing map from BICEP/Keck B-modes
  - ❑ Significant improvement on cosmic birefringence constraints from BICEP/Keck
  - ❑ The first evidence of correlations btw CMB polarization lensing and galaxy lensing from Subaru HSC and POLARBEAR
  - ❑ Developing B-mode delensing method for Simons Observatory
  - ❑ Constraining tensor non-Gaussianity from B-mode bispectrum of BICEP/Keck
  - ❑ Derived an optimal estimator for polyspectrum

KiDS + GAMA : **constraints on Horndeski gravity from combined large-scale structure probes**

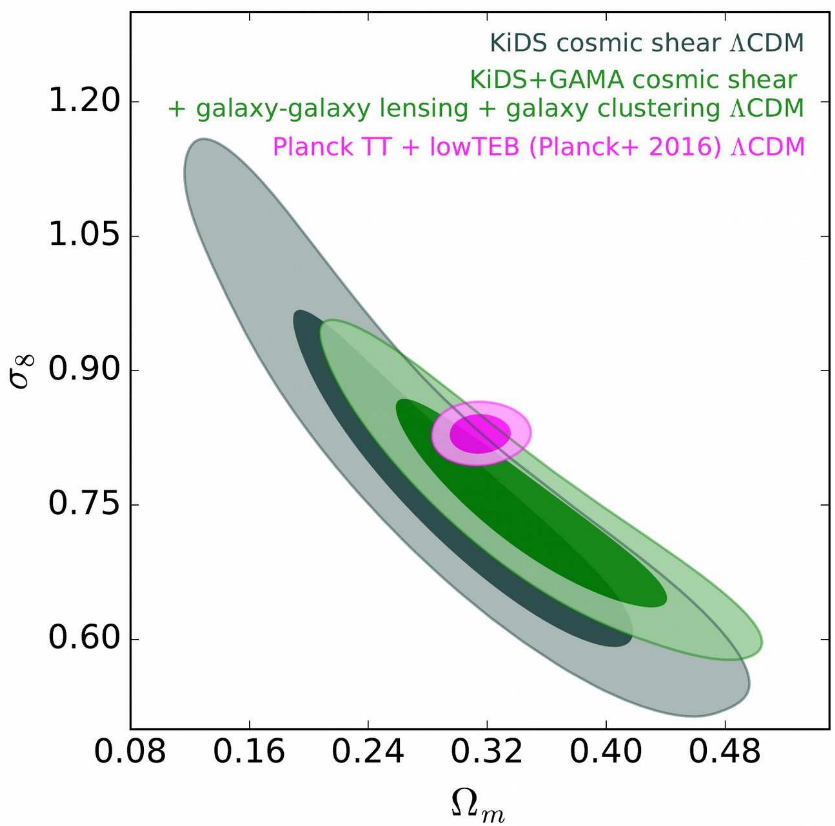
in collaboration with B. Joachimi *and others*

- **3x2pt** analysis of **KiDS + GAMA**, to constrain **Horndeski gravity,** i.e. most general scalar-tensor theory of gravity, covers majority of DE/MG models. First cosmic shear (+ GGL + GC) constraints on Horndeski gravity

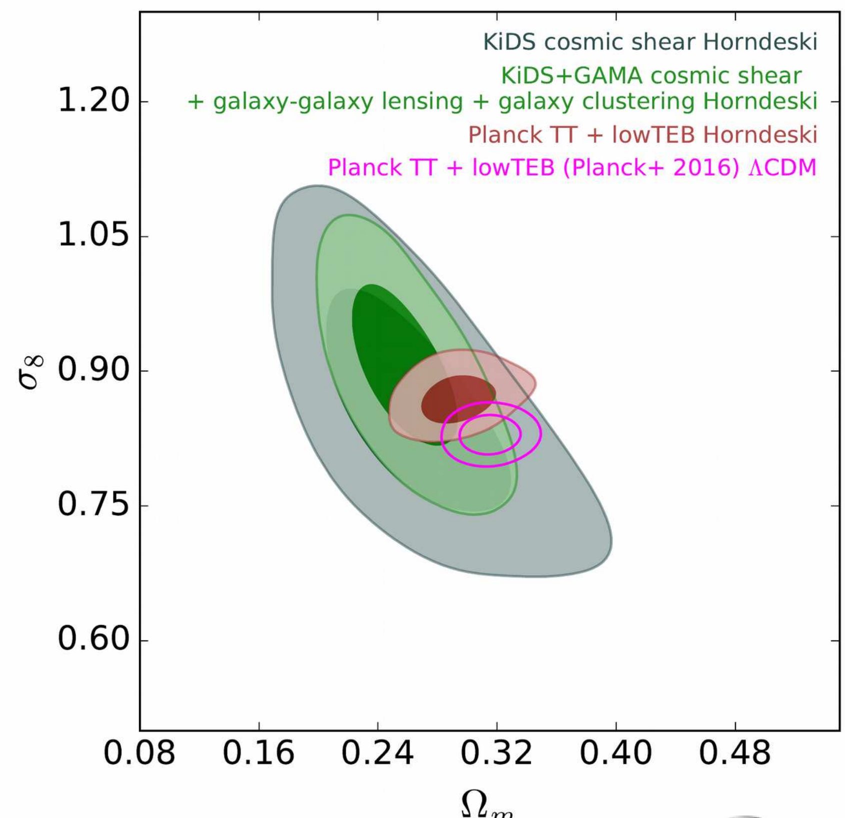
- Modelling of baryon feedback, intrinsic alignments, galaxy bias, screening mechanism. Code publicly available

- Four functions of time fully describe linear perturbations in Horndeski gravity.
  Assume time parameterization ⟶ get constraints on parameters. **Constraints compatible with ΛCDM**

ΛCDM



Horndeski



Alessio Spurio Mancini

ASM et al., arXiv:1901.03686, accepted in MNRAS

THE BAHAMAS PROJECT: EFFECTS A RUNNING SCALAR SPECTRAL INDEX HAS ON LARGE-SCALE STRUCTURE

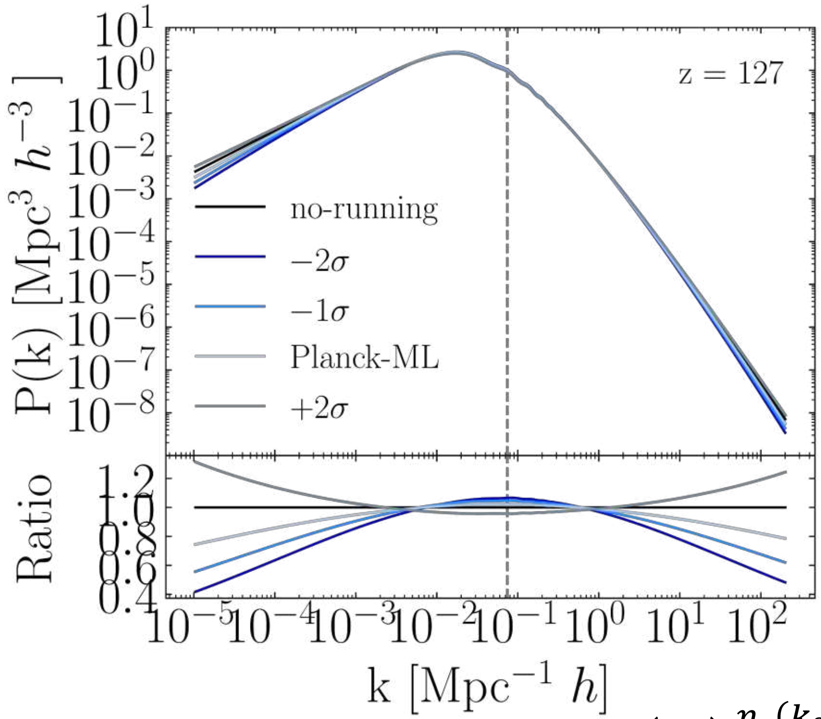
WHAT WAS DONE?

- Extended the BAHAMAS (McCarthy et al. +17) suite of hydrodynamic simulations, with a further 5 which have a running scalar spectral index imprinted into the initial conditions.
- Examined the effects of running on statistics such as:
    - Nonlinear total matter power spectrum
    - Halo mass function
- Explored how separable the effects due to a running scalar spectral index are from baryonic physics.

WHY?

- Hints that the standard model is incomplete (Planck Collaboration XIII +16, Reiss et al. +17)
- Mild evidence for a negative running (Palanque-Delabrouille et al. +15, Planck Collaboration XIII +16)

Effects should be measurable by upcoming LSS surveys such as LSST or EUCLID



$$P(k) = A_s\, k^{n_s} \longrightarrow P(k) = A_s(k_0)\left(\frac{k}{k_0}\right)^{n_s(k_0)-1+\alpha_s'(k)}$$

Here: $\alpha_s'(k) \equiv \frac{\alpha_s}{2}\ln\left(\frac{k}{k_0}\right)$, $\alpha_s \equiv \frac{dn_s}{d\ln(k)}$ = running of the scalar spectral index, k_o = pivot scale (0.05 Mpc^{-1}), A_s= amplitude of power spectrum at k_0.

Sam Stafford

KICC 10th Anniversary Symposium – 16/09 – 20/09 2019

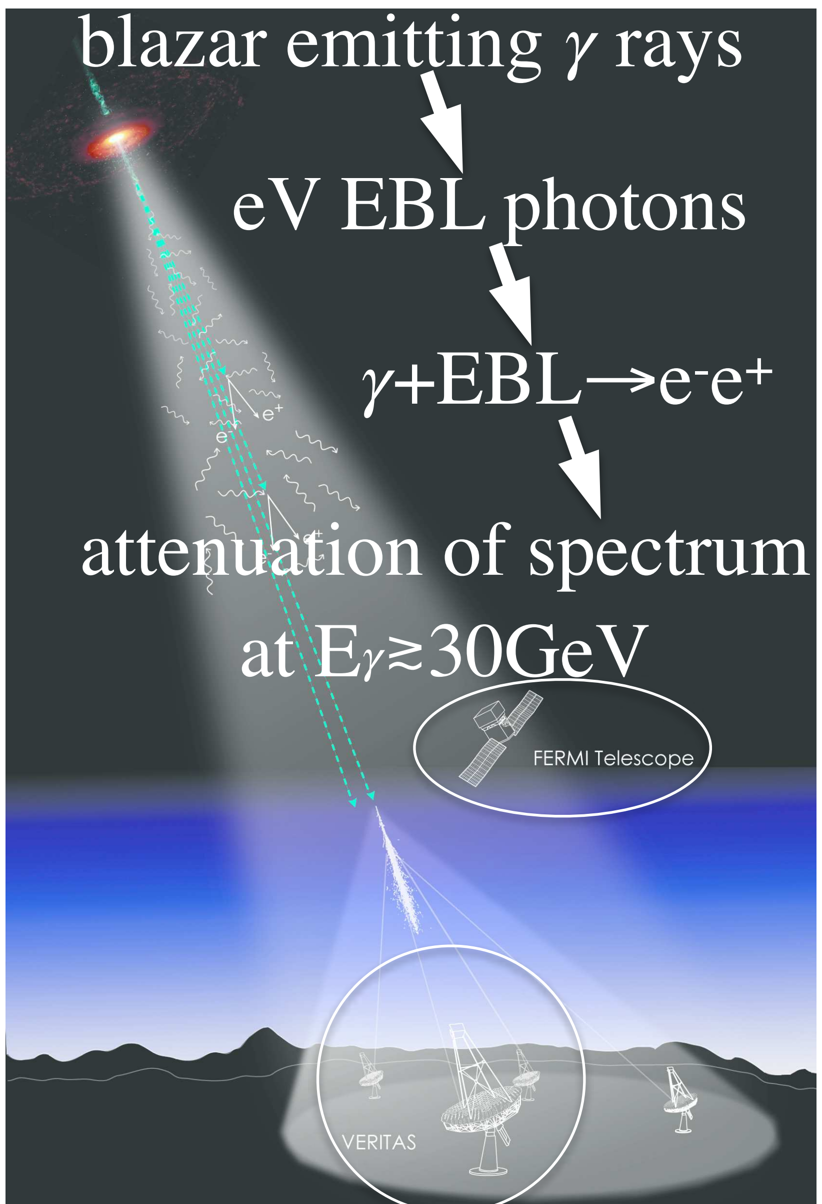
LJMU

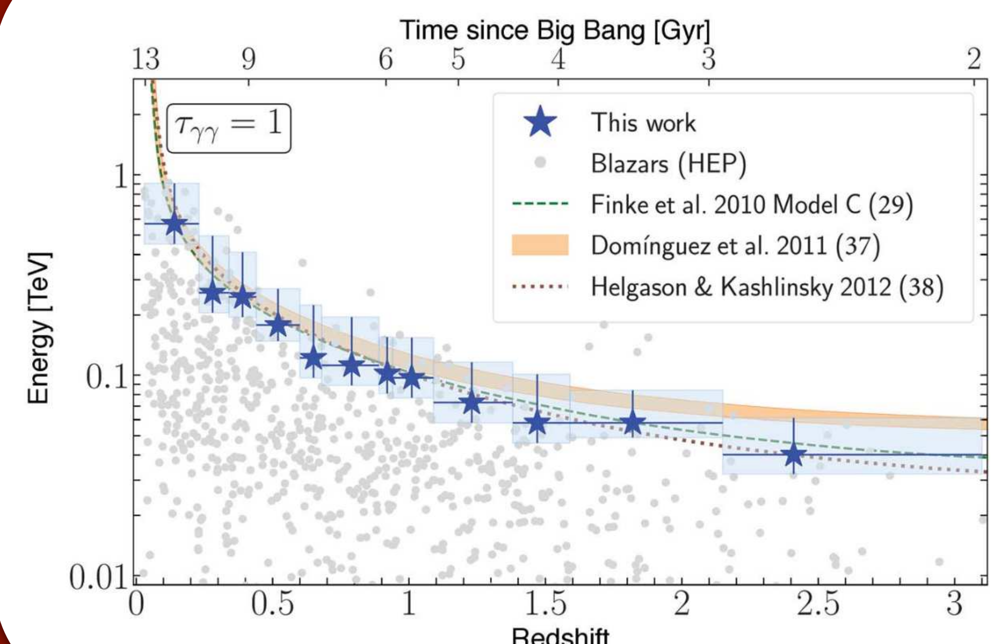
Cosmological constraints from observations of γ-ray attenuation by the extragalactic background light

Radosław Wojtak

DARK, University of Copenhagen

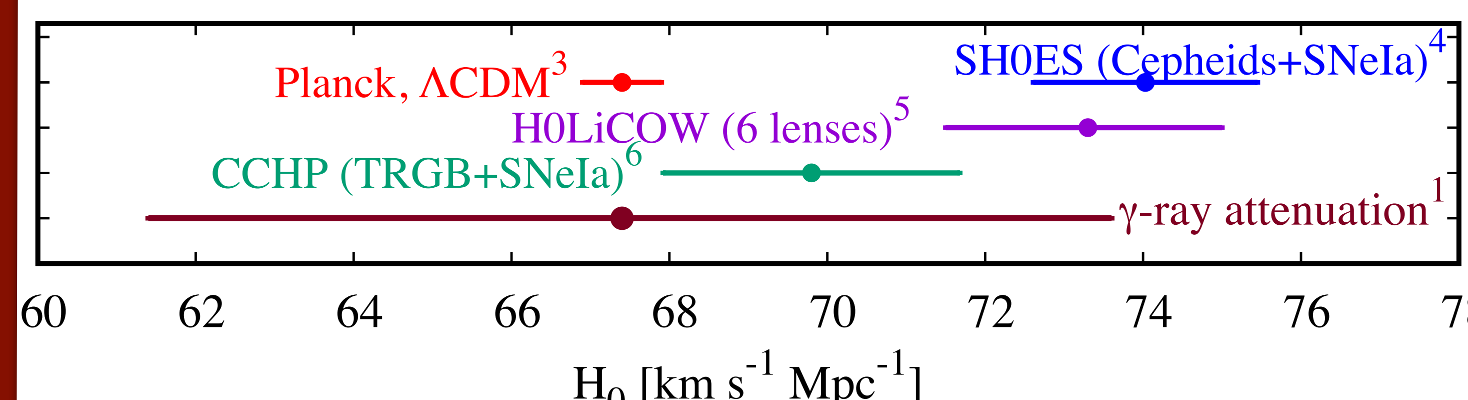
A. Domínguez, J. Finke, M. Ajello, K. Helgason, F. Prada, A. Desai, V. Paliya, L. Marcotulli, D. Hartmann





EBL models + measurements of γ-ray attenuation

cosmological constraints

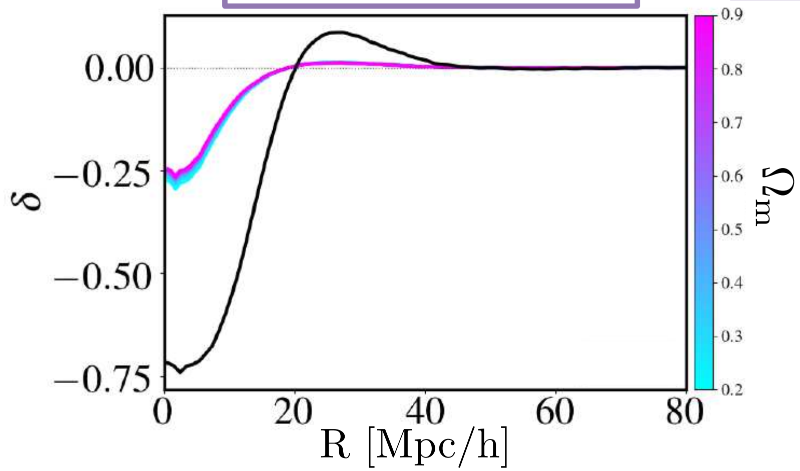


Combine cosmological probes around clusters and voids

Institute for Astronomy

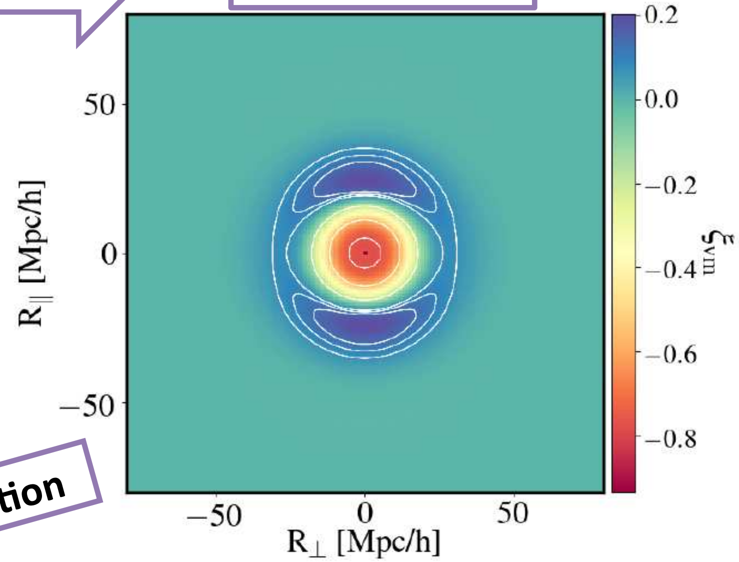
Yan-Chuan Cai, Vasiliy Demchenko
University of Edinburgh

Lensing Observation

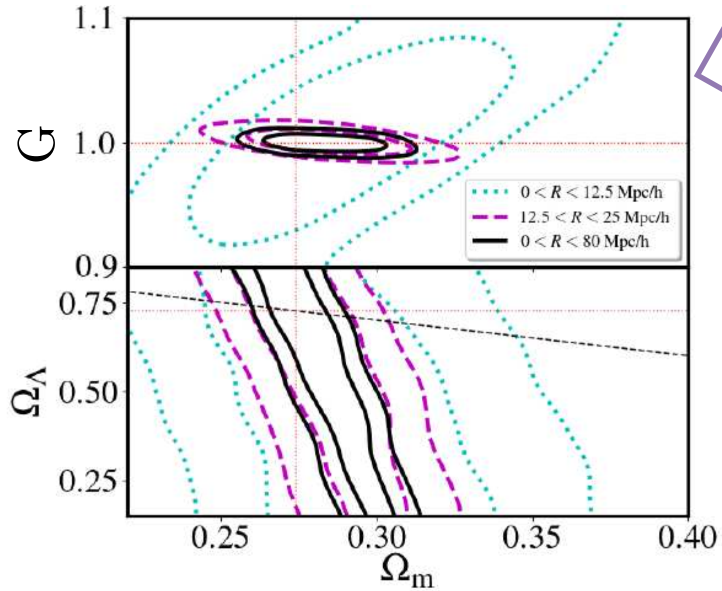


Spherical Dynamics

RSD prediction



RSD Observation



- Lensing and redshift-space distortions combined
- Need spec-z & photo-z survey on the same sky
- No need for initial conditions
- No need for galaxy bias model
- Non-linear regime, small scales

KICC 16-20/09/2019
https://www.kicc.cam.ac.uk/events/kicc-10th-anniversary-symposium-1

THE ROYAL SOCIETY

Cosmological constraints from *Planck* galaxy clusters with CMB lensing mass bias calibration

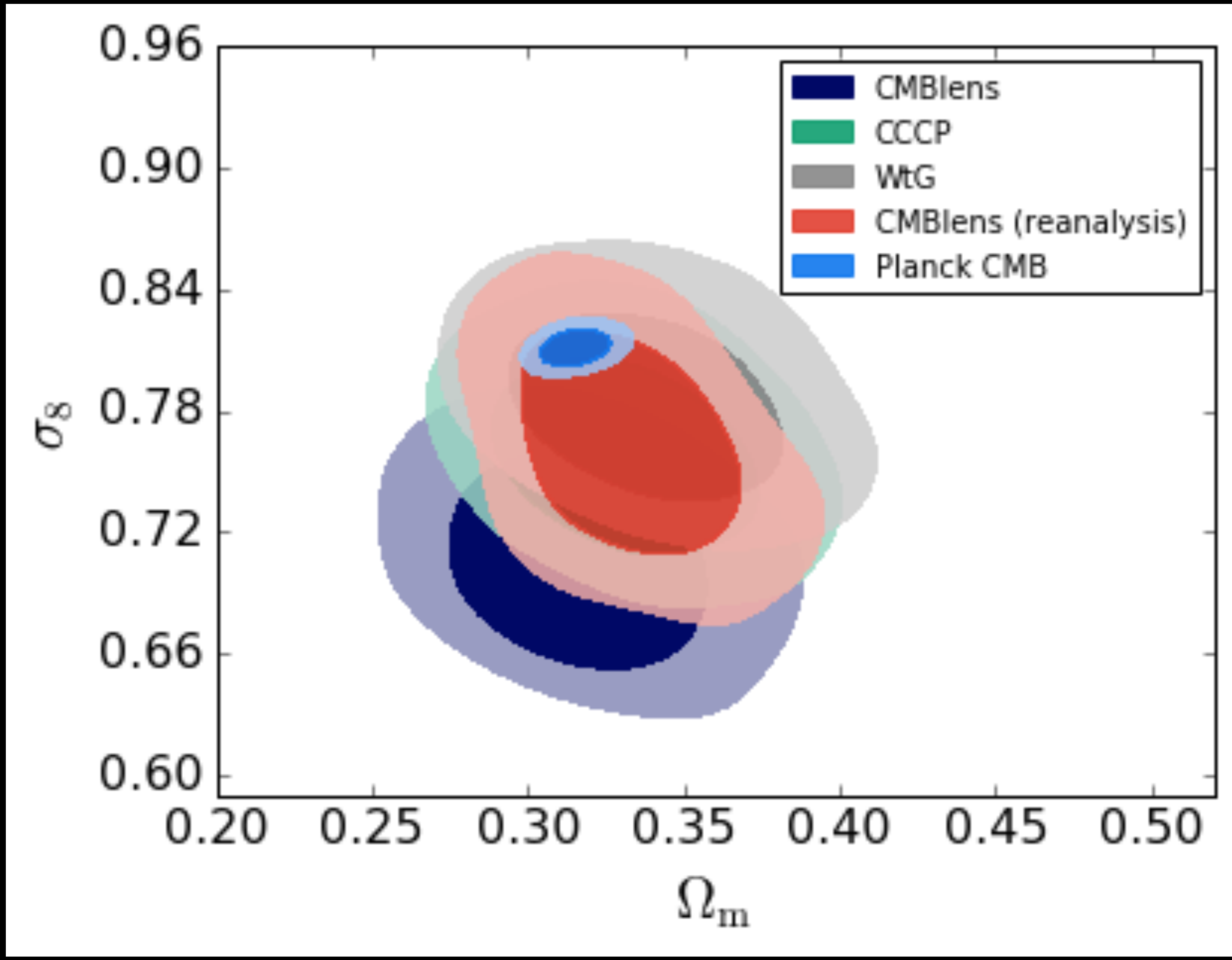
Íñigo Zubeldia & Anthony Challinor
University of Cambridge

Reanalysis of the *Planck* cluster sample (MMF3 cosmology sample), with:

- CMB lensing mass observable less affected by systematics.

- Likelihood analysis that jointly constrains cosmology (Ω_m, σ_8) and the mass bias parameter, 1-b_{SZ}.

We find a significant mass bias, 0.71 ± 0.10, and no evidence for tension with the *Planck* CMB.



IZ & Challinor (2019)
arXiv:1904.07887