Summary of MSSL/UCL Cosmology

Jason McEwen, Tom Kitching & Mark Cropper

UCL DEPARTMENT OF SPACE & CLIMATE PHYSICS
MULLARD SPACE SCIENCE LABORATORY (MSSL)

UCL

MSSL Cosmology

- Mark Cropper head of the Astrophysics Group
- Two (relatively) new cosmology lecturers: Tom Kitching, Jason McEwen
- Strong involvement in Euclid mission
- As part of new injection of people (faculty, postdocs & PhD students) we hope to *enhance existing links* with other London Cosmology groups and *develop new collaborations*

Astrophysics Group Members

- 9 HEFCE-funded staff:
  - Graziella Branduardi-Raymont, Mark Cropper, Ignacio Ferreras, Daisuke Kawata, Tom Kitching, Jason McEwen, Mat Page, Kinwah Wu, Silvia Zane
- 3 STFC-funded research postdocs:
  - Steffano Pasetto, Myrto Symeonidis, *pending*
- 2 EPSRC-funded research postdocs:
  - *Start early 2015* (to be advertised soon)
- 5 UK Space Agency-funded "mission-orientated" science postdocs:
  - Alice Breeveld, Paul Kuin, Sami-Matias Niemi, George Seabroke, Vladimir Yershov
- 8 PhD students
  - Just started: Jennifer Chan, Denis Gonzales, Ellis Owen
  - Jason Hunt, Susan Hutton, Idunn Jacobsen, Alvina On, Megan Whewell
  - Just completed: David Barnes, Rob Grand, Jason Rawlings, Ziri Younsi

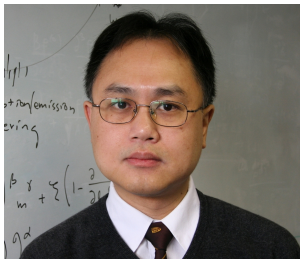
Astrophysics Group Members

Tom Kitching

Graziella Branduardi-Raymont

Mat Page

Mark Cropper



Kinwah Wu

Jason McEwen

Alice Breeveld

Ignacio Ferreras

Daisuke Kawata

George Seabroke

Vladimir Yershov

Megan Whewell

Jennifer Chan

Others…

Sami-Matias Niemi

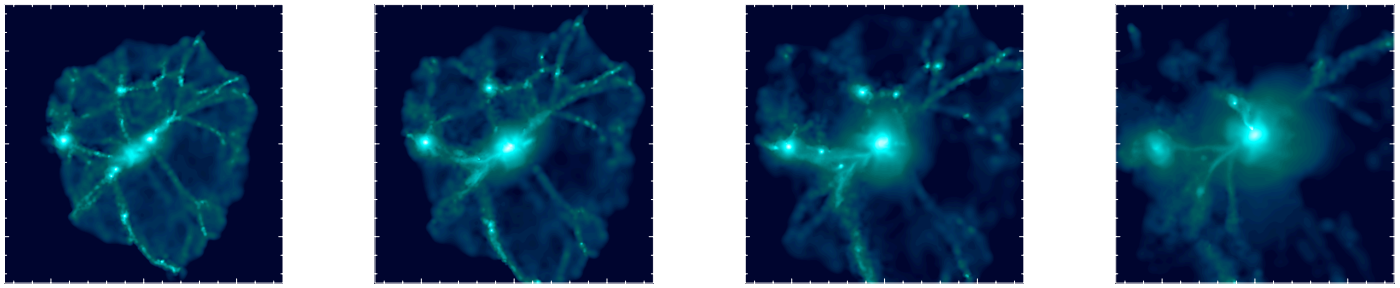
Myrto Symeonidis

Main Science Fields

- Compact Objects
  - Neutron stars
  - Gamma-ray bursts
  - Black holes (supermassive)
- Galaxy Evolution
  - Star formation history and black hole growth in UV, optical and Infrared
  - Galaxy structure, galaxy modelling
  - Radiation Transfer Theory
  - Polarised transfer in highly gravitationally curved regimes (photons, neutrinos)
- Cosmology
  - Origin and evolution of cosmological magnetic fields
  - Nature of Dark Energy and Dark Matter
  - Early Universe Cosmology
  - Radio Interferometry and the Epoch of Reionization

Cosmological Magneto-Genesis

- How large-scale magnetic fields originated and developed and what their roles were in cosmological structural formation are unresolved issues
- A new GCMHD+ code developed for cosmological magnetohydrodynamic simulations
- We investigate how large-scale magnetic fields imprint signatures in sky polarisation and develope a cosmological polarised radiative transfer code and a covariant algorithm to interface it with the GCMHD+ code

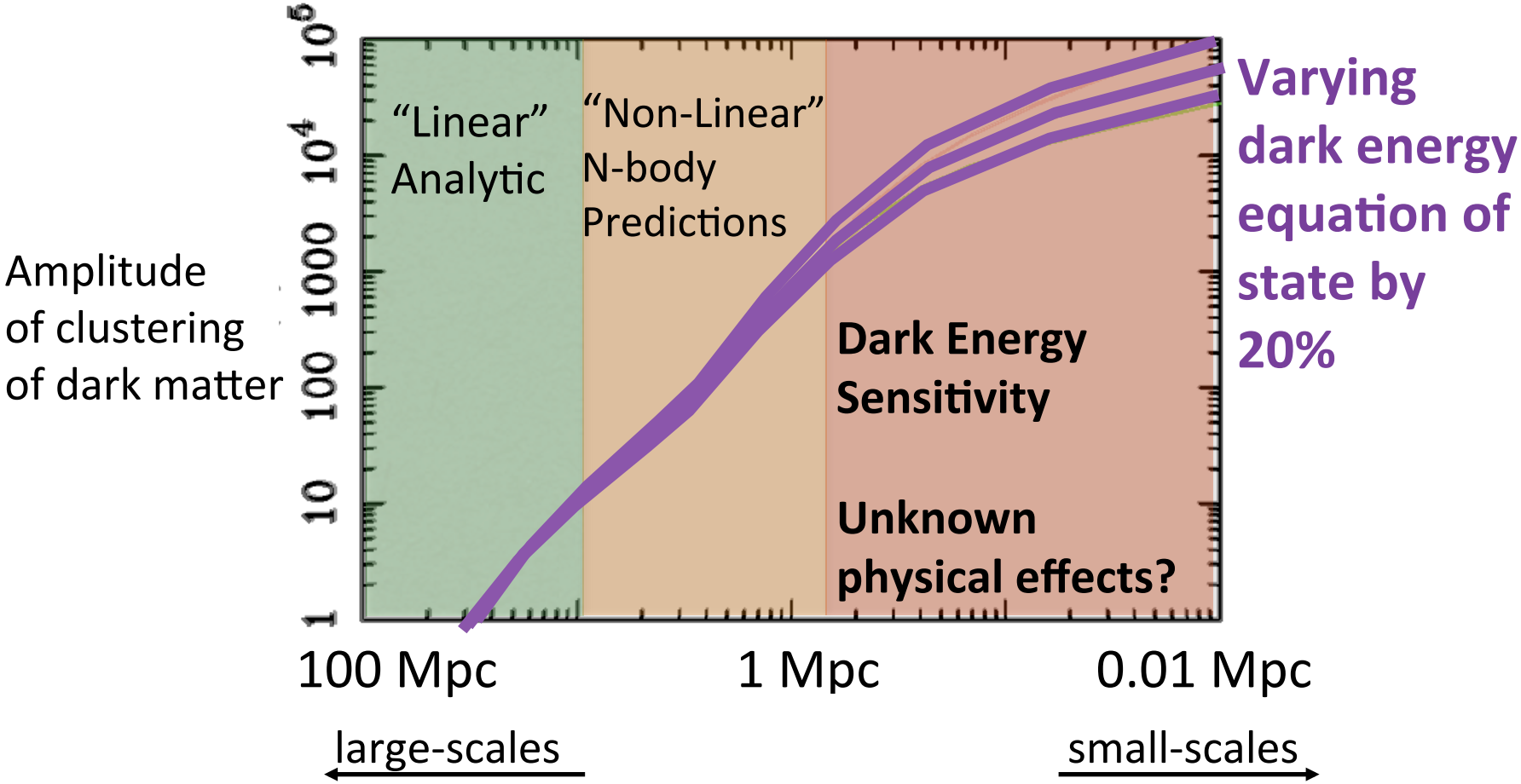


MHD simulations of the evolution of large-scale (30 Mpc^3) magnetic fields from red shifts z = 0.9 to z = 0 (from left to right) using our GCMHD+ code

- Our studies provide a solid framework for the analyses of future MWA and SKA data, give proper interpretations of observations and enable more meaningful comparisons with the predictions of cosmic magnetism models

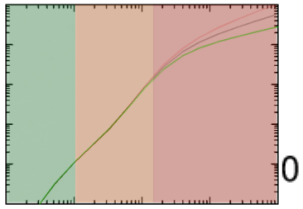
Dark Energy

Most dark energy information comes from small scales:



Dark Energy

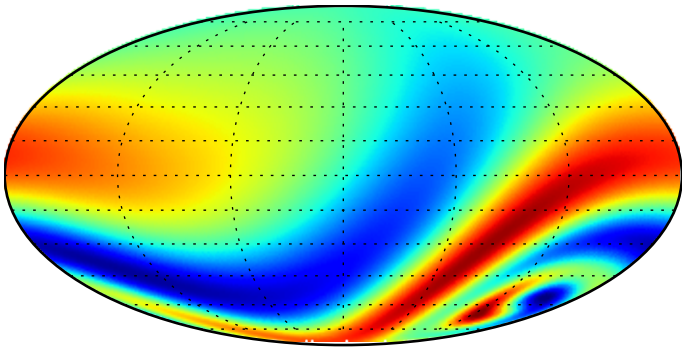
- Linear scales are consistent with LCDM
- Small scales are not consistent with LCDM: either LCDM is wrong or we don't understand small scales



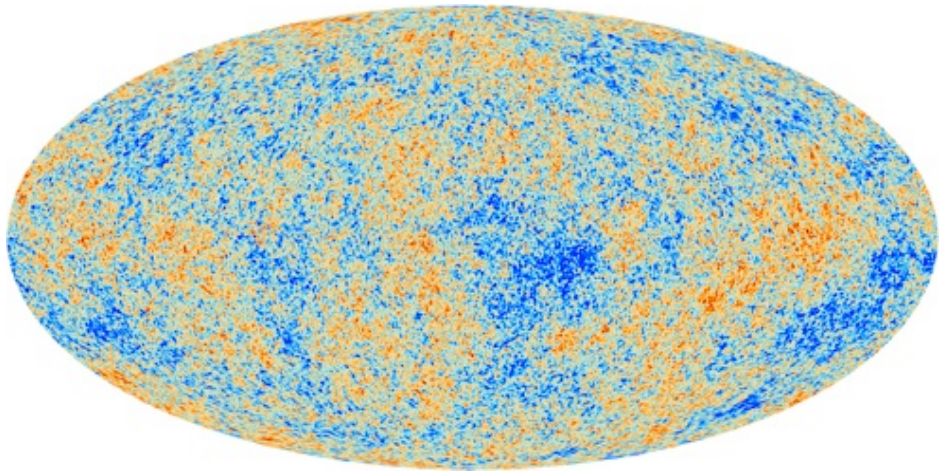
Kitching et al. (2014)

Early Universe Cosmology

- Cosmic microwave background (CMB)
  - Anisotropic cosmologies
  - Topological defects (cosmic strings and textures)
  - Dark energy
  - Inflation and non-Gaussianity



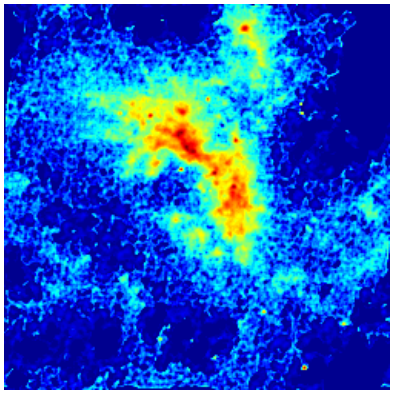
Bianchi models



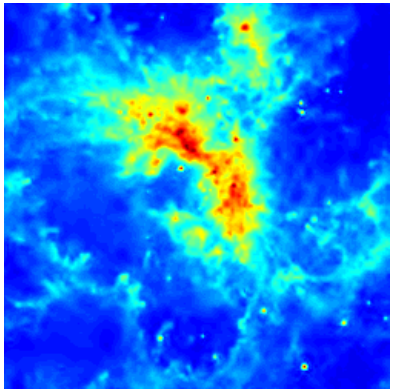
Planck CMB observations

Radio Interferometry and EoR

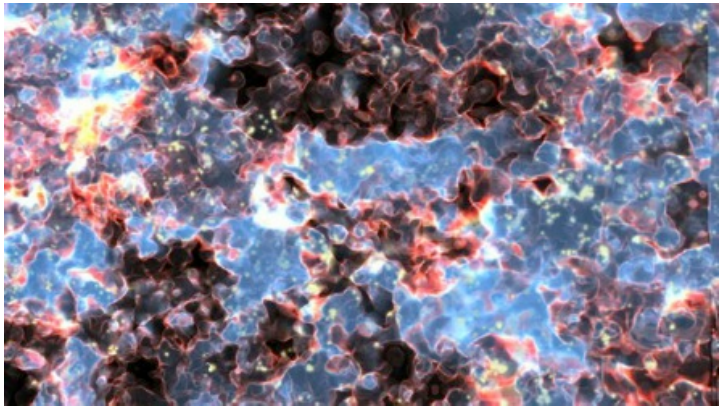
- Square Kilometre Array (SKA)
  - Software Data Processor (SDP) design study
  - Radio interferometric imaging with compressive sensing
  - Observing the Dark Ages and Epoch of Reionization (EoR)



State-of-Art



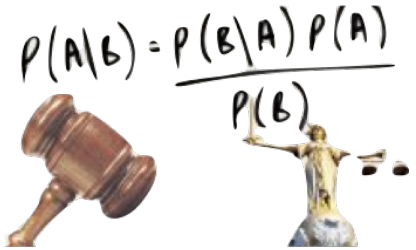
Compressive Sensing



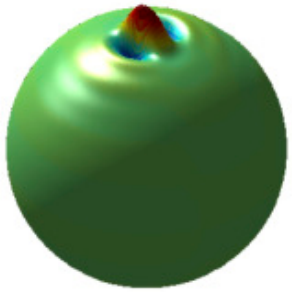
Observing the Epoch of Reionization

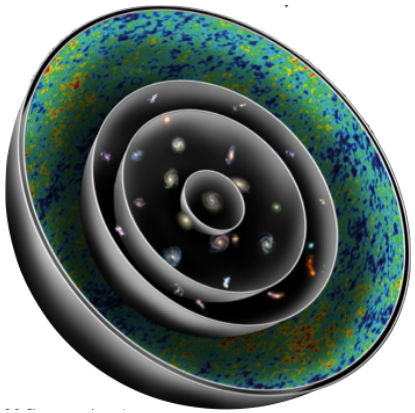
Astrostatistics & Astroinformatics

- Astrostatistics: exploit *statistical approaches* to extract scientific information from observational data
  - Bayesian statistics
  - Path integral methods
  - Machine learning
  - Fast algorithms and big-data



- Astroinformatics: exploit *information theory* to extract scientific information from observational data
  - Wavelets
  - Compressive sensing
  - Machine learning
  - Fast algorithms and big-data

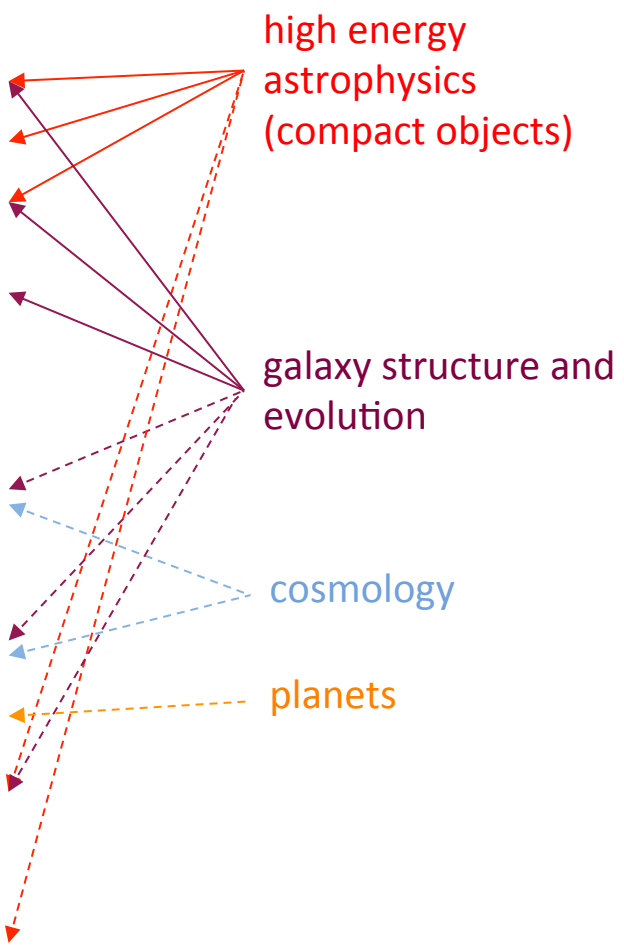




- Cosmological observations live on spherical manifolds
- Connections between astrostatistics and astroinformatics

MSSL Astro Missions

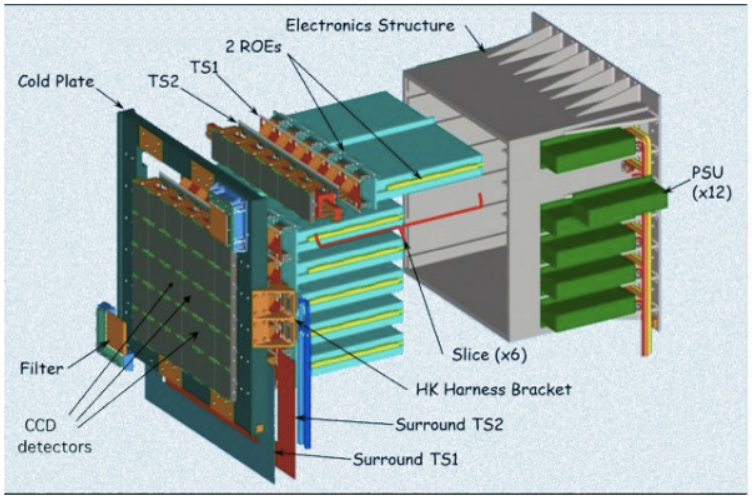
- Science is underpinned with strong links to space instrument teams
  - Operating missions:
    - XMM-Newton (OM and RGS) [1999]
    - Swift (UVOT) [2004]
    - ~~Herschel (SPIRE)~~ [2009]
    - Gaia (RVS) [2013]
  - Awaiting launch:
    - James Webb Space Telescope (NIRSpec) [2018]
  - Under Development
    - Euclid (VIS) [2020]
    - PLATO [2024]
    - Athena+ [2028]
  - Proposed:
    - M4 LOFT [2023]

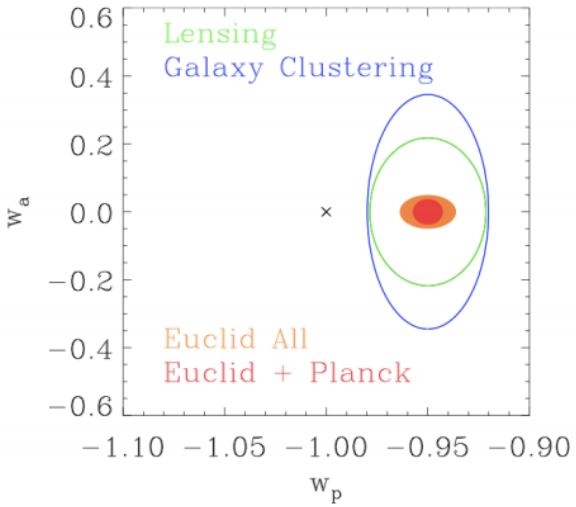


Euclid

- Euclid Weak Lensing major focus of cosmology group long term from now to 2025-2030 (data and post-mission)
- MSSL leads both
  - the Instrument for weak lensing (VIS; Cropper) and Instrument Scientists (Niemi)
  - co-leads science for for weak lensing (Weak Lensing Science Working Group; Kitching)

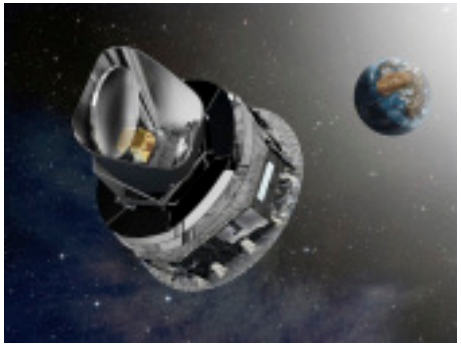
- UCL-MSSL lead of the 2nd-largest imager in space
- Will be the most powerful facility available to study dark energy and dark matter



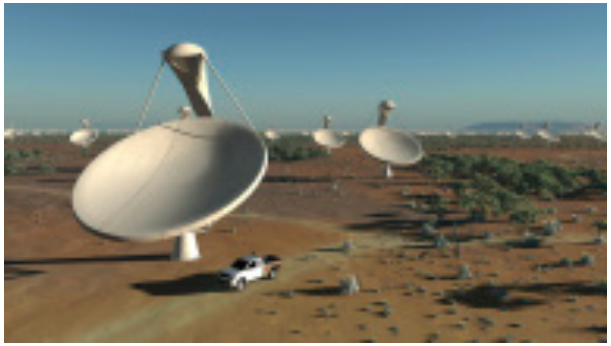


DE constraints from Euclid: 68% confidence contours in the (w_p, w_a).

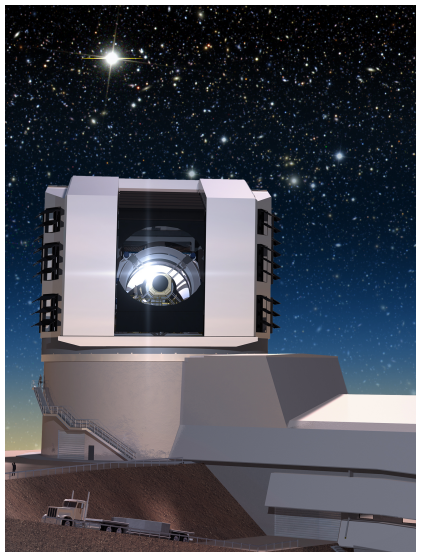
Involvement in External Experiments



Planck



SKA



LSST

CFHTLenS

KiDS

Where to find more

- MSSL Astrophysics: www.ucl.ac.uk/mssl/astro
- Cosmology @ MSSL: www.ucl.ac.uk/mssl/astro/research/cosmology
- MSSL Astro Blog: msslastro.wordpress.com
- Late Universe Blog: lateuniverse.wordpress.com
- Personal Websites: www.thomaskitching.net, www.jasonmcewen.org
- Twitter: @MSSLSpaceLab, @msslastro, @tom_kitching, @jasonmcewen