Abstracts

Prof. Ethan Anderes, University of California, Davis, USA

anderes@ucdavis.edu

Lensing and delensing the cosmic microwave background

One of the major targets for next-generation cosmic microwave background (CMB) experiments is the detection of the primordial B-mode signal. Planning is under way for Stage-IV experiments that are projected to have instrumental noise small enough to make gravitational lensing and foregrounds the dominant source of uncertainty for estimating the tensor-to-scalar ratio r from polarization maps. This makes delensing a crucial part of future CMB polarization science. In this talk we will discuss techniques for estimating this lensing and the more difficult task of removing the lensing from the observations.

Prof. Paolo Baldi, University of Roma "Tor Vergata", Italy

baldi@axp.mat.uniroma2.it

Representation of Gaussian isotropic spin random fields

New information available on the Cosmic Microwave Background includes its polarization that is to be modeled with a realization of a spin random field on the sphere. I shall discuss different approaches to the representation and simulation of spin random fields, with special attention to the case of a sphere and to the Gaussian setting.

Dr Chiaki Hikage, IPMU, Japan

chiaki.hikage@ipmu.jp

Morphological analysis of cosmological random fields using Minkowski Functionals

Minkowski Functionals are a family of functions that uniquely describes the morphology of spatial patterns and has been developed in the mathematical framework of integral geometry. Since Minkowski Functionals incorporate all-orders of correlation functions, they have been extensively applied to cosmic density fields such as Cosmic Microwave Background to measure their non-Gaussian properties. Minkowski Functionals are also generalized to vectorial and tensorial quantities which are sensitive to the anisotropic aspects of spatial structure. I will give a brief review of Minkowski functionals and present recent works.

Prof. Andrew Jaffe, Imperial College London, UK

a.jaffe@imperial.ac.uk

Random Fields in Bayesian Hierarchical Models for Cosmology

I will discuss the way isotropic random fields manifest themselves in the middle levels of Bayesian hierarchical models in cosmology. I will specifically address the recent work of Alsing, Heavens, Jaffe, and Olamaie applying these techniques to weak lensing, using both Gibbs sampling and Hamiltonian Monte Carlo. I will also briefly discuss how random fields in large numbers of dimensions can be used as a tool in building models of inflation, where now the potential is modelled as a random field, and the fields themselves take the place of coordinates.

Prof. Tom Kitching, Mullard Space Sciences Laboratory

tom.kitching@gmail.com

Spin Power Spectra on the Ball

I will discuss the computation of power spectra from spin weighted observables on the Ball. I will cover practical implementation issues and present an application to data. I will also discuss the generation of 3D spin-weighted random fields.

Prof. Anatoliy Malyarenko, Malardalen University, Sweden

anatoliy.malyarenko@mdh.se

Spectral expansions of random sections of spin and tensor bundles

Tiny fluctuations of the Cosmic Microwave Background as well as various observable quantities obtained by spin raising and spin lowering of the effective gravitational lensing potential of distant galaxies and galaxy clusters, are described mathematically as isotropic random sections of homogeneous spin and tensor bundles. We describe the three existing approaches to rigorous constructing of the above objects, emphasizing an approach based on the theory of induced group representations. Both orthogonal and unitary representations are considered in a unified manner. Several examples from astrophysics are included.

Dr Jason McEwen, UCL, UK

jason.mcewen@gmail.com

Wavelet localisation of isotropic random fields on spherical manifolds and cosmological implications

Abstract: Scale-discretised wavelets yield a directional wavelet framework on the sphere where a signal can be probed not only in scale and position but also in orientation. Furthermore, a signal can be synthesised from its wavelet coefficients exactly, in theory and practice. Scale-discretised wavelets are closely related to spherical needlets (both were developed independently at about the same time) but relax the axisymmetric property of needlets so that directional signal content can be probed. I will review directional scale-discretised wavelets on the sphere and discuss their quasi-exponential localisation properties and asymptotic uncorrelation properties for isotropic Gaussian random fields on the sphere. I will briefly present the extension of scale-discretised wavelets to the ball, the space formed by augmenting the sphere with the radial half-line. Finally, I will discuss the application of spin scale-discretised wavelets on the sphere to recover E- and B-mode signals for CMB polarisation and weak gravitational lensing.

Dr Daniela Saadeh, University of Nottingham,UK

daniela.saadeh.13@alumni.ucl.ac.uk

How isotropic is the Universe?

A fundamental assumption of the standard model of cosmology is that the large-scale Universe is isotropic. Because of its centrality, it is essential to test this assumption. Breaking isotropy leads to Bianchi cosmologies, a set of solutions to the Einstein field equations of which only the subset describing rotating universes was previously tested against data.

In this talk, I present a general test of isotropy considering, for the first time, all the degrees of freedom of anisotropic expansion. We analyse cosmic microwave background data from Planck, carrying out the first joint analysis of temperature and polarization data for this purpose. We also show that improved constraints on anisotropy may be obtained by extending the likelihood to high ell.

For the vector mode (associated with rotating universes), we obtain a limit on the anisotropic expansion that is an order of magnitude tighter than previous Planck results using the CMB temperature only. We recover upper limits for all the other modes, with the weakest one arising from the regular tensor modes. We disfavour anisotropic expansion of the Universe with odds of 121,000:1 against.

Dr Jean-Luc Starck, CEA Saclay, France

jstarck@cea.fr

Cosmic Microwave Background Field Estimation

Cosmic Microwave Background (CMB) temperature anisotropies and polarisation measurements have been one of the key cosmological probes to establish the current cosmological model. The ESA PLANCK mission was designed to deliver full-sky coverage, low-noise level, high resolution temperature and polarisations maps. We will briefly review some of the key problem of the PLANCK data analysis, and we will present how adaptive representations can be used to analyze such data set.

Prof. M. D. Ruiz-Medina, University of Granada, Spain

mruiz@ugr.es

Increasing and Fixed Domain Asymptotics for Functionals of Spherical Random Fields

The analysis of spherical random fields is strongly motivated from the analysis of the Cosmic Microwave Background (CMB) radiation data being collected by the NASA mission WMAP. A comparative study is developed, in relation to the asymptotic distribution of certain functionals of spherical random fields, like, for example, The first Minkowski functional, considering two types of asymptotics: (i) Increasing domain asymptotics, (ii) Fixed domain asymptotics or higher frequencies asymptotics (where the corresponding results are in progress).

Prof. Gyorgy Terdik, University of Debrecen, Hungary

terdik.gyorgy@zimbra.inf.unideb.hu; gyorgy.terdik@gmail.com

Estimating the covariance function of isotopic fields on the sphere

Estimating the covariance function of a Gaussian isotropic random field on the unit sphere of the 3D Euclidean space has primary importance. We assume that an observation is given and consider an estimator of the covariance function. We show that this estimator follows a Rosenblatt type distribution. Following results of [Veillette, Taqqu, 2012] the asymptotic distribution of the truncated version of the estimator is also given. One can substitute the usual estimator of the spectrum by estimating the covariance function first then using the Gauss-Legendre quadrature for estimation of the spectrum. The problem of cosmic variance is also considered in accordance with simulations and real data. In practice the observations are given on a high resolution discretized sphere, for instance the Cosmic Microwave Background (CMB) anisotropies data are given on a pixel structure called HEALPix, hence the estimator is approximated in the high accuracy.

Prof. Vicent J. Martínez, University of Valencia, Spain
vicent.martinez@uv.es

Joint constraints on galaxy bias and sigma_8 through the N-pdf of the galaxy number density

We present a full description of the N-probability density function of the galaxy number density fluctuations. This N-pdf is given in terms, on the one hand, of the cold dark matter correlations and, on the other hand, of the galaxy bias parameter. The method relies on the assumption commonly adopted that the dark matter density fluctuations follow a local non-linear transformation of the initial energy density perturbations. The N-pdf of the galaxy number density fluctuations allows for an optimal estimation of the bias parameter (e.g., via maximum-likelihood estimation, or Bayesian inference if there exists any a priori information on the bias parameter), and of those parameters dening the dark matter correlations, in particular its amplitude (Sigma_8). It also provides the proper framework to perform model selection between two competitive hypotheses. The parameters estimation capabilities of the N-pdf are proved by SDSS-like simulations (both, ideal log-normal simulations and mocks obtained from Las Damas simulations), showing that our estimator is unbiased.