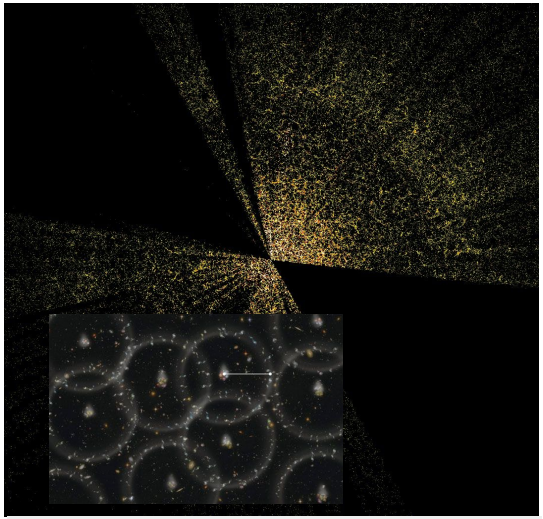
P2: Extracting cosmological information from the large-scale structure signal: Baryon Acoustic Oscillations and Redshift Space Distortions

Background: The BOSS/eBOSS surveys have demonstrated that the Baryon Acoustic Oscillation features (BAO) and Redshift Space Distortions (RSD) can be used to provide robust and precise information about how our Universe has evolved in the last 11 billion years, down to few percent level. Now, the on-going DESI survey will deliver spectroscopic information of more than 40 million extragalactic object over next 5 years, allowing for an unprecedented level of precision, ~0.1%. This data set will revolutionise our understanding of the cosmology and promise to shed light in the nature of Dark Energy and Dark Matter, both pillars of our standard model of cosmology. However, in order to do so, we need to be able to extract and correctly interpret the BAO and RSD information from the DESI galaxy maps with an exquisite accuracy. Doing so, represents one of the major challenges right now for the large-scale structure community.

Project Goal: In the first part of this project we will focus on basic concepts of cosmology such as, what a Gaussian Random Field is, how to generate it and its utility in cosmology; and Monte-Carlo Markov Chains as a way to extract the posterior distribution of our dataset. In the second part of the project we will focus on more practical aspects and will apply the latest techniques to perform the measurement of the power spectrum of DESI/BOSS/eBOSS-like galaxy catalogues and extract information based on the Baryon Acoustic Oscillations (BAO) and redshift-space distortion (RSD) measurements performing Monte-Carlo Markov Chains.



Galaxy maps from a DESI/SDSS like survey, and the graphic representation of the Baryon Acoustic Oscillation information imprinted in the map.

Background resources:
Intro to cosmology by Barbara Ryden (Cambridge, free version)
DESI survey (https://www.desi.lbl.gov)
Cosmology from recent LSS survey (https://arxiv.org/abs/2007.08991)
Statistical Tools for Cosmology Analyses: (https://arxiv.org/abs/0712.3028)
Power Spectrum C-code example (https://github.com/hectorgil/Rustico)
BAO/RSD C-code example (https://github.com/hectorgil/Brass)

Necessary Concepts:
a) Basic Cosmology, Fast Fourier Transforms, power spectrum, BAO, RSD
b) Good understanding of C

Computing need: Analysis can be run on laptops/desktops.

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