

# Master2 Internship proposal at CPT, year 2020-2021

**Research team:**

Cosmology

**Supervisor:**

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**Project title:**

The clustering of matter in a spatially curved universe

**Description:**

“The Cosmic Microwave Background tells us that the universe is almost spatially flat” is a sentence that one often hears during lectures, conferences and seminars. However recently it has been shown by [1] that the CMB alone measures a small but statistically significant amount of curvature (its associated energy density) in the universe.

As a result, it makes sense to study the clustering of dark matter in curved space. Specially one can notice that Baryonic Acoustic Oscillations analysis are pointing toward a zero curvature, however in BAO analysis it is generally assumed that the universe is flat. Thus, one could try to quantify the impact of the flatness hypothesis on BAO measurements.

To do so we can think of creating dark matter density maps with the method described in [2] but which needs to be adapted to non-zero spatial curvature. The basis of the method consists in generating Monte Carlo realisations of the dark matter density field in Fourier space. Indeed, one can show that statistical invariance by translation (homogeneity) imposes that Fourier modes of the matter field are uncorrelated.

The student will first make a true investigation work in order to assess the possibility of generating Gaussian realisations of the dark matter density field in curved space. Depending on the results we will be able to generate some density map in curved space and simulate BAO measurements in order to quantify the impact of the flatness prior. In any case the student will learn a lot about the evolution of matter perturbations in curved space and how to confront them to observations of the large scale structure of the universe.

This work might play a key role in the future analysis of large cosmological surveys such as Euclid.

**References:**

[1] Di Valentino, Melchiorri, Silk, 2019, *Planck evidence for a closed Universe and a possible crisis for cosmology*

[2] Baratta et al. , 2020 *High-precision Monte Carlo modelling of galaxy distribution*

**Specify whether the internship project may naturally lead to a PhD thesis.**

The internship project would naturally lead to a PhD thesis.