

Master 1 or 2 *INTERNSHIP PROPOSAL*

Laboratory name: **Institut d'Astrophysique de Paris**

CNRS identification code: UMR 7095

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Thesis possibility after M2 internship: NO

Shedding light on the dark ages of inflation

According to cosmological inflation, all the structures in the universe arise from microscopic fluctuations that were stretched to cosmological scales during a primordial epoch of accelerated expansion. Inflation predicted the statistical properties of these primordial fluctuations before they were detected, and it has passed stringent observational tests with flying colors. Yet, its physics is still elusive. In particular, while exquisite measurements of the Cosmic Microwave Background give us a detailed knowledge of the early phase of inflation, the physics of the late phase of inflation, also known as the dark ages of inflation, is completely unknown. Fortunately, future observations of stochastic backgrounds of gravitational waves, for instance by LIGO/Virgo, Pulsar Timing Arrays or the LISA mission, offer a new window on this uncharted territory. However, inflationary models relevant for gravitational-wave astronomy often involve violent phenomena and large amounts of particle production that prevent standard perturbative analyses. As a result, theoretical predictions are not yet robust.

In this context, the aim of the internship will be to use the tool of numerical simulations of inflation recently developed in the group to shed light on the properties of inflationary gravitational-waves. The student will use InflationEasy to study two representative classes of inflationary models, with so-called resonant and sharp features. Depending on taste and progress, two key-questions will be addressed. 1. What is the impact of primordial non-Gaussianity on gravitational-wave backgrounds? 2. To which extent realistic inflationary models can lead to distinctive oscillatory patterns in the gravitational-wave spectrum?

Through this internship, the student will discover a large spectrum of the field of theoretical cosmology, from quantum field theory in curved spacetimes to gravitational-wave physics and inflationary cosmology, using both analytical and numerical approaches.

References:

- [1] Oscillations in the stochastic gravitational wave background from sharp features and particle production during inflation, Fumagalli, Renaux-Petel and Witkowski, [2012.02761](#)
- [2] The Inflationary Butterfly Effect: Non-Perturbative Dynamics From Small-Scale Features, Caravano, Inomata, Renaux-Petel, [2403.12811](#)
- [3] InflationEasy: A C++ Lattice Code for Inflation, Caravano, [2506.11797](#)