MAP-fis Essay Proposal, 2016-2017

(*please write in English*)

Supervisor

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Title

Coding the Cosmos

Area

(*Materials, Optics, Condensed Theory, High Energy Theory,....*);

Particle astrophysics, Computational cosmology

Summary of Proposal

Cosmic strings arise naturally in many proposed theories of new physics beyond the standard model unifying the electroweak and strong interactions, as well as in many superstring inspired inflation models. In the latter case, fundamental superstrings produced in the very early universe may have stretched to macroscopic scales, in which case they are known as cosmic superstrings. If observed, these objects thus provide a unique window into the early universe and possibly string theory.

Recent progress in CMB polarization and gravitational wave detection highlights how some of these scenarios can be constrained by high-resolution data. However, they also show that the current bottleneck is the lack of accurate high-resolution simulations of defect networks that can be used as templates for robust statistical analysis. This is expected to be an even bigger problem for next-generation facilities such as CORE and LISA.

This essay will review the current state-of-the-art in the field, both from the astrophysics and from the computational perspectives (with an emphasis on currently available field theory and Goto-Nambu algorithms, and their strengths and weaknesses) outline a roadmap for going significantly beyond the state-of-the-art and developing and implementing a new generation of high-scalability HPC defect codes that will be able to match the sensitivity of ongoing and forthcoming observational searches.

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References

(*to allow students first look at topic*)

The canonical textbook in the area is

Vilenkin & Shellard, Cosmic Strings and Other Topological Defects (Cambridge University Press)

providing a detailed (if slightly out of date) overview of the field. A recent, more focused text is

Martins, Defect Evolution in Cosmology and Condensed Matter: Quantitative Analysis with the Velocity-Dependent One-Scale Model (Springer, 2016).

A sample of recent analytic models and numerical simulations is

Correia et al. (2014) *http://dx.doi.org/10.1103/PhysRevD.90.023521*
Lazanu et al. (2015) *http://dx.doi.org/10.1016/j.physletb.2015.06.034*
Martins et al. (2016a) *http://dx.doi.org/10.1103/PhysRevD.93.043534*
Martins et al. (2016b) *http://dx.doi.org/10.1103/PhysRevD.94.116017*
Vieira et al. (2016) *http://dx.doi.org/10.1103/PhysRevD.94.096005*