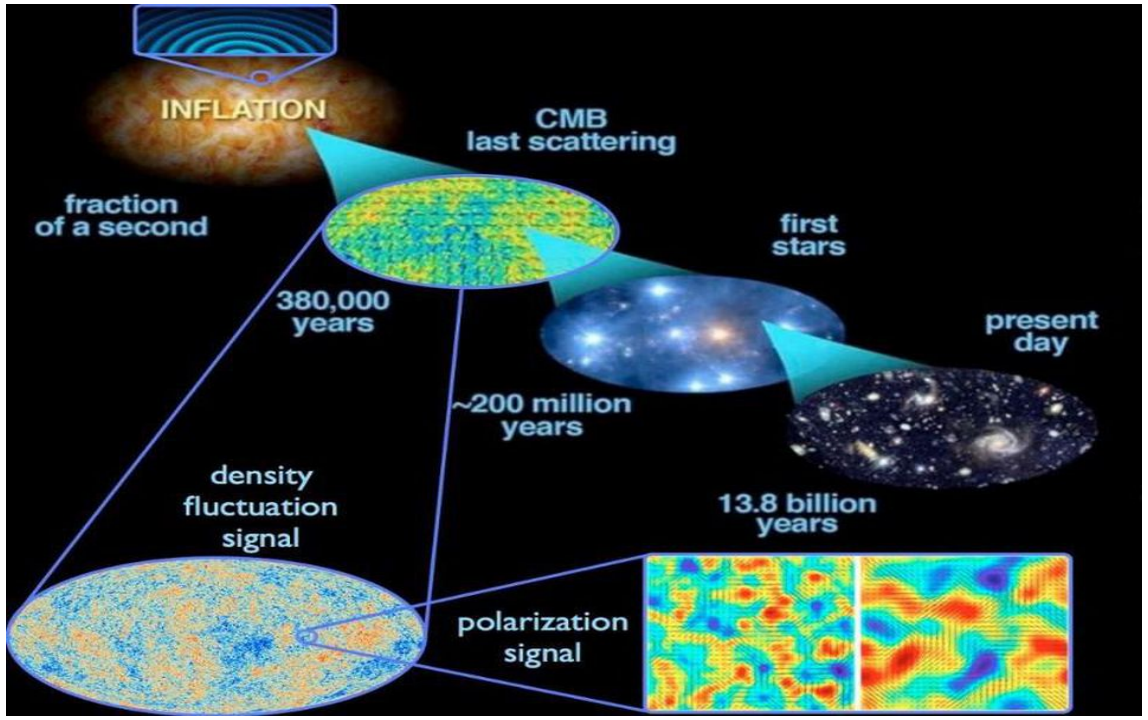
Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

INFLATIONARY MODELS IN THE LHC AND PLANCK ERA



Acronym: INFLALHC

Reader-Friendly Title: Discovering the genesis of the Universe

Scientific Area: NATURAL SCIENCES

Scientific field/s: Physical Sciences; Particles and Fields Physics

Principal Investigator: George Lazarides

Research Team: George Leontaris, Constantinos Pallis, Qaisar Shafi, Nicholas Vlachos and one (more) Postdoctoral researcher

Host Organization: Aristotle University of Thessaloniki

Country: GREECE

Cooperative Organization(s):
University of Ioannina, University of Delaware

Duration: 36 months

Budjet: 196 300 €

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Hellenic Foundation for Research & Innovation

Research Project Synopsis

The utilization of Particle Physics for resolving several problems encountered in modern Cosmology has recently attracted much attention, since observational and experimental data are by now quite precise and place strong restrictions on theoretical models. In this scientific area, called usually Particle Cosmology, Cold Dark Matter (CDM) candidates are identified with certain stable particles, which are predicted by Supersymmetric (SUSY) models, whereas slowly evolving scalar fields can drive inflation. In this proposal we plan to restrict further observationally viable models of inflation combining them with other sectors of the theory related to some open problems of Particle Cosmology, such as SUSY breaking, CDM, and Baryogenesis via leptogenesis with constraints from unstable gravitino and neutrino oscillation parameters. Namely, adopting Induced-Gravity Inflation and unitarity safe versions of non-minimal inflation, we expect to shed light on the mechanism of SUSY breaking in the early universe working in the context of Supergravity and using a global R symmetry. One open possibility is the high scale SUSY which can be analyzed in conjunction with some mitigation of the gauge hierarchy problem, imposing the Veltman condition at a high scale. The stability of the electroweak vacuum for the higgs mass equal to 125.5 GeV will be also checked. In addition, we consider the embedding of non-minimal Higgs inflation in SUSY grand unified theories (GUTs) based on the Pati-Salam or the flipped SU(5) gauge groups and suggest scenaria which allow the activation of non-thermal leptogenesis. Moreover, we connect non-minimal inflation with CDM via ZDM, which is a type of CDM stabilized thanks to an unbroken discrete symmetry which may be remnant of a GUT. The implementation of our research requires model building, quantum field theoretic calculations and numerical and analytic investigation of the dynamical processes in the early Universe.

Project originality

This project aims to address, taking inflation as reference, some of the biggest problems facing modern Astroparticle Physics, such as the Supersymmetry (SUSY) breaking mechanism, the Grand Unification, the origin of baryon asymmetry of the Universe, the neutrino masses, the nature of Cold Dark Matter (CDM) and the High-Scale SUSY. Inflation is an essential ingredient of modern Cosmology, since it overcome the problems of the Standard Big Bang and provides a mechanism for the generation of the observed structure of the universe. We focus on a set of well-motivated inflationary models which are compatible with an R symmetry, such as the F-term Hybrid Inflation, and (chaotic) inflation which requires a non-minimal coupling of the inflaton to Ricci curvature. The R symmetry acts as a junction tool between inflationary models and SUSY breaking sector, not studied in the literature until now. One particularly exciting output of such an analysis would be the high-scale SUSY which requires special attention since it ceases to evade the infamous gauge hierarchy problem and needs a stabilization mechanism of the hierarchy of the mass scales against radiative corrections. The third aim of this project is the embedding of inflation in realistic Grand Unified Theories (GUTs) based on the Pati-Salam gauge group or the flipped SU(5). Although, some of these gauge groups are already employed as framework of the inflationary model building they are not combined until now with the latter of the aforementioned inflationary models. This issue is closely related to our next research objective, which is the establishment of Baryogenesis via non-thermal leptogenesis compatible with relevant available constraints. A by-product from the embedding of inflation in GUTs is the generation of a CDM candidate stabilized by a discrete Z2 symmetry, which could be a remnant of a GUT gauge group. Our models can be probed in current and future experiments, such as the Large Hadron Collider (LHC) and observatories analyzing the Cosmic Microwave Background radiation or detecting primordial gravitational waves -- e.g. the WMAP and Planck satellites, Keck Array/BICEP2 and forthcoming experiments like Keck Array/BICEP3 PRISM and LiteBIRD.

Expected results & Research Project Impact

In this project we aspire to provide a detailed and complete analysis of the cosmological evolution that follows from supersymmetric models valid at high energy scales. We believe that parametrically constraining models of this type by demanding a consistent cosmological history is useful and interesting. The construction of these models is performed by taking into account important theoretical ideas and the relevant experimental and observational data. As a result, we must combine a broad understanding of theory with thorough knowledge of current and future experiments, in order to interact meaningfully with both major branches of science. We expect that our results will have impact for both theory and experiment delineating areas where new ideas are needed. They can help towards the planning of new experiments to test the latest results of theory. In conclusion, achieving the objectives of this research project will expand our understanding of our universe and reveal clues about the nature of physics beyond the weak scale, substantially benefiting, thereby, the scientific community. At the national level, the members of the Physics Departments at the Universities of Thessaloniki and Ioannina will benefit by participating in a state-of-art research, gaining important experience in both the theoretical and experimental domains.

The importance of this funding

This funding is very important since it allows the establishment of a research team which can conduct scientific research at a very high level. In particular,

• It gives the opportunity to the Coordinator and other mature members of the research team to continue their research activity and transmit their experiences to younger researchers;

• It gives the chance to postdoctoral researchers to integrate themselves in a very well-known University in Europe significantly enhancing their chances to find permanent academic jobs;

• It offers the possibility of mobility of the team members, thanks to the available travel budget, facilitating the pursue of domestic and international collaborations and the development of lasting cooperation and collaborations with other countries as well as the attraction of first-class researches;

• It allows the update of the computational facilities, extending thereby the computational tools that the research team has at its disposal for achieving the research objectives.

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