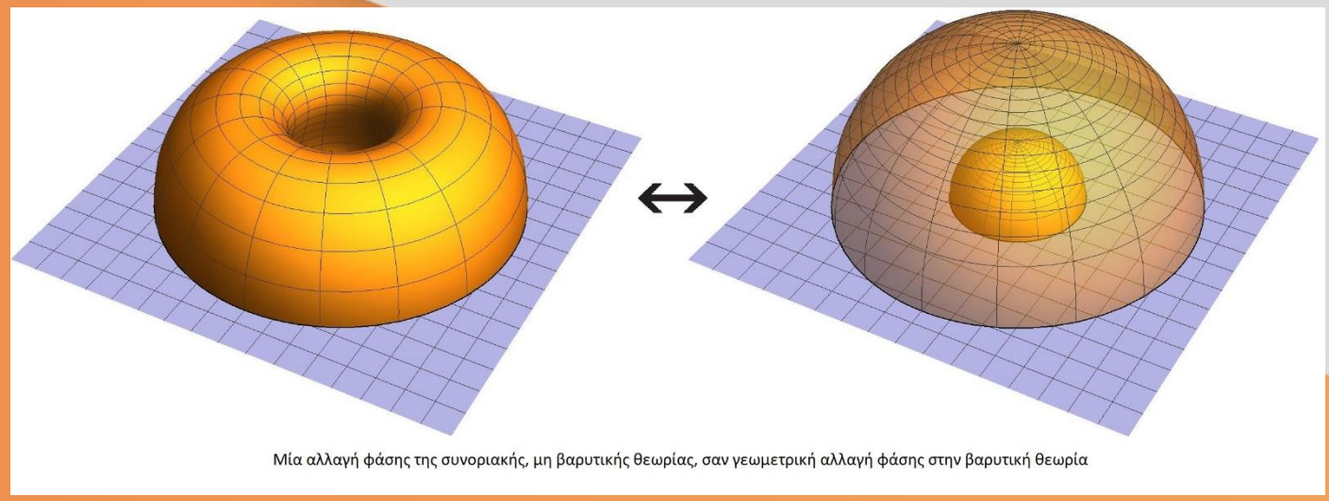
Description of Funded Research Projects
1st Call for H.F.R.I. Research Projects
to support Post-Doctoral Researchers

H.F.R.I.
Hellenic Foundation for
Research & Innovation

Research Project Title:

Holographic Applications of Quantum Entanglement

Principal Investigator:
Georgios Pastras



Μία αλλαγή φάσης της συνοριακής, μη βαρυτικής θεωρίας, σαν γεωμετρική αλλαγή φάσης στην βαρυτική θεωρία

Popular Title:
Quantum Entanglement and Gravitational Theories

Scientific Field:
Natural Sciences, Physics, Theoretical High Energy Physics

Host Institution:
NCSR “Demokritos”

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Physics is full of strongly coupled systems with theoretical interest in classical and quantum physics, such as, turbulence, the confinement problem, the quark-gluon plasma in quantum chromodynamics or the black holes in gravity. Such systems are quite difficult to be studied, since the usual mathematical methods cannot be applied. A fruitful approach for the description and study of such systems is through the establishment of a duality. These are non-trivial correspondences between interconnected pairs of theories with the weakly-coupled phenomena of the one theory being mapped to the strongly-coupled ones of the other and vice versa. A particularly interesting class of dualities is the one of holographic dualities, which connect gravitational theories to non-gravitational conformal field theories, in one less dimension.

Several of the strongly-coupled phenomena under study are purely quantum phenomena without a classical analog (i.e. superconductivity). In such phenomena quantum entanglement, which is a fundamental property of quantum mechanics without a classical analog, plays a radical role. Interestingly enough, the holographic duality connects the quantum entanglement in the non-gravitational theory to geometric properties of the gravitational theory and it suggests that gravity may be a statistical emergent force associated with quantum probabilities.

In our project we will use modern mathematical methods applied to non-linear, but exactly solvable systems (integrable systems). In this way we will extend towards very specific directions the study of the interrelation between quantum entanglement and gravity. Our results will help towards a deeper understanding of gravity as a quantum statistical force. They will moreover facilitate in the description of the quantum strongly coupled non-gravitational theory through its gravitational counterpart, with many potential technological applications (new topological material, high temperature superconductivity, grapheme, and more). Finally, there will be interesting side results in the framework of string theory.

Project Impact on Society

Although the outcomes of theoretical high energy physics are characterized by low technology readiness levels (trl index), their long-term impact in science and technology can be disproportionally large. Our project is not an exception to this rule. The goals are twofold: better understanding of quantum gravity and better understanding of the dynamics of strongly coupled systems. The first mainly serves as a conceptual advancement towards the better understanding of gravity as a fundamental force and its relation to the others, which is probably the most important problem in theoretical physics nowadays. This is necessary for the description of the universe in its initial stages, just after the big bang, as well as of black hole physics, including those at the center of the galaxies, which might be responsible for galaxy formation and evolution. The second goal has many potential technological applications, which include strongly coupled-systems such as quark-gluon plasma, high-temperature superconductors and superfluids.

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To me, H.F.R.I. funding would mean...

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The funding from H.F.R.I. for post-doctoral researchers covers an enduring gap in the support of Greek researchers, from the time they get their Ph.D. until they find a position in an academic institution. This gap obviously became more apparent during the years of the financial crisis, which strongly limited the available positions in Greek academic institutions. Therefore, I believe that H.F.R.I. is of great importance for the research in Greece and for the people, who want to research in Greece, like me, either for personal reasons or because they just want to support their country.

Having experience from abroad, since I returned to Greece in 2011 after 9 years in U.S.A. and Switzerland, I believe that it is very important that this initiative acquires the necessary consistency and continuity over time, so that researchers are able to program their actions based on this, over a sufficient time period.

The Principal Investigator,

Georgios Pastras

Funding

Amount: **182,598 €**

Duration: **24 months**

Foundation: **H.F.R.I.**

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Hellenic Foundation for Research & Innovation

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