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

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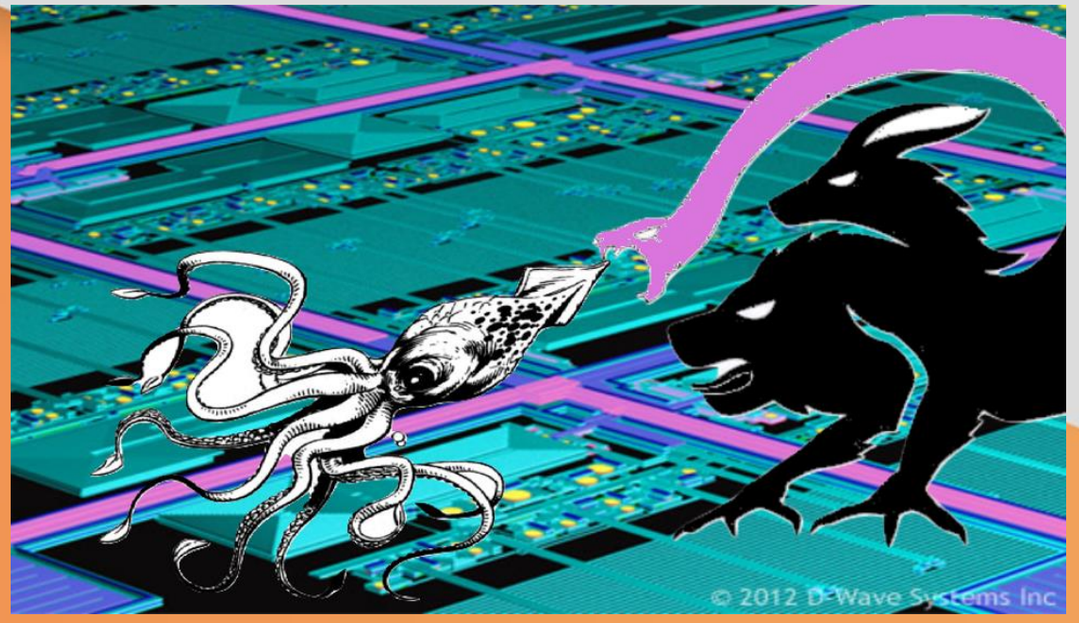
Research Project Title:

SQUID metamaterials: chimera states and spatio-temporal dynamics (acronym: SQUIRREL)

Principal Investigator:
Johanne Hizanidis



Popular Title:
Taming chimeras in SQUID metamaterials

Scientific Field:
Physics

Host Institution:
University of Crete, dep. of Physics

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Research Project Summary

The interplay between nonlinearity and structure is at the center of research on complex systems. In ensembles of coupled oscillators, the synergy between topological features and the underlying dynamics may lead to interesting self-organized phenomena. Within the SQUIRREL project, we will study a system that is capable of exhibiting such complex dynamics: a SQUID (superconducting quantum-interference device) metamaterial, i. e. an artificially structured medium of periodically arranged, weakly coupled SQUIDs, that exhibits extraordinary properties, e. g. negative diamagnetic permeability. The SQUIRREL project will involve theoretical modeling in close interaction with experimental activity. The main focus will be on chimera states, a fascinating counter-intuitive symmetry breaking phenomenon of partially coherent and partially incoherent behavior. The increasing number of studies on chimeras is impressive, ranging from physical and chemical, to biological and technological systems. Works on superconducting systems, however, are still largely missing. In many cases, chimeras are known to be chaotic transients. That makes their experimental verification a challenging task, and the need to control them through various techniques of crucial importance. Moreover, since chimeras have mainly been found in systems of one spatial dimension, there are many open questions concerning higher-dimensional chimera patterns.

To solve these open problems, the SQUIRREL project will focus on five main topics: (1) Exploring complex dynamics of the single constituents of the metamaterial; (2) Taming metastable chimeras in one-dimensional SQUID arrays; (3) Classifying chimeras in two-dimensional SQUID lattices; (4) Modelling of a three-dimensional SQUID structure and fabrication of SQUID stacks; (5) Developing experimental techniques for the detection and imaging of chimeras. Since SQUID metamaterials are the classical prototypes of various superconducting quantum computing settings, the outcome of the SQUIRREL project will have significant impact on applied research related to the design of novel quantum computing devices.

Project Impact on Society

The SQUIRREL project will contribute significantly to the fields of Metamaterials and Nonlinear Dynamics by introducing new research tools and techniques for imaging complex dynamical states. On the theoretical side, the project will generate improved models appropriate for quantitative prediction and modeling of SQUID metamaterials. On the experimental side, new techniques for control will be developed and novel 3D metamaterials will be fabricated.

The outcome of the project will have significant impact on applied research related to quantum computing devices where SQUID qubit arrays serve as “building blocks”, and other novel applications including super-resolution imaging, cloaking, hyperlensing, and optical transformation. Finally, the SQUIRREL project will have an impact on the educational process at the University of Crete, bringing together researchers from Greece and the University of Maryland. Through mutual visits, this collaboration will create an important exchange of know-how which will be valuable for the host institute.

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

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Through the H.F.R.I grant I will be able to advance my research activities from a position of greater independence and responsibility, which are both very important at this stage of my career. At the same time, it will allow me to continue my research at the Physics Department of the University of Crete on even better terms, in an environment where I feel creative, and I am able to interact with excellent colleagues. The H.F.R.I grant will also ensure that the necessary resources and time for a successful collaboration with experimentalists at the University of Maryland are available to me, impacting both on the quality of the research outcome and on the external visibility of the project.

The Principal Investigator,
Johanne Hizanidis

Funding

Amount: **200,000 €**

Duration: **36 months**

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

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CONTACT

127, Vasilissis Sofias Avenue
115 21 Athens, Greece
info@elidek.gr
www.elidek.gr

HELLENIC REPUBLIC
MINISTRY OF DEVELOPMENT AND INVESTMENTS

GSRT
GENERAL SECRETARIAT FOR RESEARCH AND TECHNOLOGY