Electromagnetic Wavefront-shaping Structures for Localization and Powering of Microimplants

Postdoctoral Research Fellowship

Background and Mission

Emerging in-body bioelectronics and biosensors offer powerful capabilities for medicine, clinical research, and basic science. Precision medicine requires precision diagnostics, and biotelemetric microimplants make it possible to yield more precise information than ever before about one's health. Neural interfaces allow us to study the brain *via* mapping, assisting, augmenting, and repairing cognitive or sensory-motor functions. The emerging electroceuticals aim individual nerve fibers or specific neural circuits that regulate the body's organs and processes to treat a range of conditions. Many of required technological advancement is already in place thanks to advances in a variety of disciplines. However, modern microimplants suffer from the compromise between the size of the battery and the duration of the experiment or functionality of the device. Moreover, the battery replacement requires going through surgery. Therefore, the efficient through-body wireless localization and powering became a grand challenge. The qualified candidate will work towards solving the scientific questions in this field. This project builds on the unique scientific and technical expertise of the IETR laboratory (CNRS) in the fields of wave physics, complex radiating structures, and bioelectromagnetics.

The **mission of this project** is to, first, study the fundamental problem of electromagnetic energy exchange between an on-body wavefront-shaping structure and a microimplant in a complex biological environment and, second, to develop novel solutions for localization and adaptive wireless powering. In close collaboration with other team members, the candidate will also contribute to the prototype development, manufacturing, and testing. Last generation of high-performance workstations with GPU accelerators and advanced numerical solvers will be used to handle electromagnetic analysis. State-of-the-art manufacturing and measurement facilities of IETR will help with the prototyping and testing. The final system will be characterized in tissue-equivalent models as well as *in vivo* through established collaborations of our group. Finally, the successful candidate will be expected to present results of the work in high-profile journals and conferences.

Our recent works:

[1] D. Nikolayev *et al.,* "Optimal radiation of body-implanted capsules," *Phys. Rev. Lett.* **122**(10), 2019.

[2] M. Davy and A. Z. Genack "Selectively exciting quasi-normal modes in open disordered systems," *Nat. Commun.* **9**(1), 2018.

[3] P. del Hougne *et al.*, "Precise localization of multiple noncooperative objects in a disordered cavity by wave front shaping," *Phys. Rev. Lett.*, **121**(6), 2018.

Required Background

- Ph.D. (or equivalent) degree.
- Full competence in electromagnetics and wave physics; knowledge of microwave and antenna engineering.
- Solid experience with numerical electromagnetic solvers (e.g., COMSOL, CST, HFSS), skills in programming (Python or MATLAB) and basic measurement equipment (VNA, etc.).
- Fluency in English: the candidate should be conversant and articulate in English and must have strong writing skills. Knowledge of French is not required but would be appreciated.

Advantages

The qualified candidate will be part of a dynamic multidisciplinary team in an international, highly collaborative, and stimulating environment. He/she will have access to state-of-the-art laboratories, workshops, high-performance computing facilities, continuous training and receive a competitive salary.

In addition:

- approx. 7 weeks of annual leave per year + possibility of exceptional leave (moving home, etc.),
- generous statutory benefits: the French national health coverage, unemployment allowances, retirement/pension funds, etc.,
- possibility of subsidized meals and partial reimbursement of public transport costs,
- location in one of the most attractive cities in France for professional and nonprofessional activities (entertainment and culture, sport, gastronomy, etc.). Train connections: 1:25 to Paris and 0:47 to a seaside.

Duration: Initial duration of 18 months. Starting date: as soon as possible.

Location: IETR laboratory of **CNRS** (Rennes, Region of Brittany, France).
Short-term visits to our international collaborators can be arranged as well.

How to Apply

Please send your applications to Dr. Denys Nikolayev (denys.nikolayev@univ-rennes1.fr). Each application should consist of (PDF format):

- a CV (incl. publications),
- contact details of at least three professional references (mail, address, position),
- a motivation letter.

In the motivation letter, the applicant is encouraged to include the following details:

- an explanation of interest in the research we conduct and why he/she believes he/she is suitable for the position,
- short description of graduate and PhD projects,
- details of any relevant work experience (if applicable).