PhD Fellowship

Project Title: STOCHASTIC MICRODOSIMETRY APPLIED TO BIOMEDICAL ELECTROMAGNETICS

Research Fields: microwaves, numerical modeling, electromagnetic dosimetry, exposure assessment, microscale characterization, electromagnetic cell and tissue models.

Research Laboratory: IETR / CNRS, Rennes, France.

Duration: 36 months, expected starting date is Oct. 2021.

Research project

Context

Wireless technologies operating in the upper part of the microwave spectrum are increasingly used for various applications. In particular, they have been used for high data rate communications [> 5 Gb/s], and 26-GHz / 60-GHz technologies are expected to be integrated in the near future in the next generation mobile systems (5 G/ 6G, IoT, smart homes, human-centered communications). Besides, microwaves have a strong potential for numerous biomedical applications, including remote monitoring of wounds, non-invasive detection of glucose level, microwave imaging, thermal ablation, to list just a few. From the exposure assessment and control viewpoint, characterization of frequency-dependent electromagnetic power deposition at the sub-cellular level constitutes a new research challenge in the field of fundamental biomedical electromagnetics, with a potentially strong impact on the environmental safety and future biomedical applications.

Project overview

The main purpose of this PhD research project is to analyze micro-scale electromagnetic field and power distributions at sub-cellular level in order to gain an insight into local micro- and submm-scale phenomena occurring during exposure of the human body. Stochastic approach will be applied to account for the natural variability of physical parameters of biological cells.

The main research axes of this PhD project are threefold:

1. Micro-scale numerical electromagnetic and transient thermal analysis will be performed on cellular models of progressively increasing complexity. To this end, we will consider simplified geometric models of a single cell with sub-cellular organelles and will increase the complexity to realistic stochastic single- and multi-cell models. Electromagnetic (complex permittivity and conductivity) and thermal (heat capacity and conduction) properties will be assigned to these models accounting for the stochastic variability. This will involve characterization of effective electromagnetic and thermal properties of cells and cellular sub-structures (membrane components, cytoplasm, cellular organelles, etc.).
2. The electromagnetic field and absorbed power distributions will be computed using designed cellular models and appropriate numerical solvers (e.g. COMSOL, CST, SIM4LIFE). Stochastic multi-parametric analysis will be performed to assess the variability of the electromagnetic field and power distributions as a function of the geometry, complex permittivity, conductivity and micro-cellular environment. The data on micro-scale electromagnetic field and power deposition will be used as an input to thermal co-simulations.
3. Finally, numerical results will be validated experimentally on cells using *ad hoc* metrological facilities and instrumentation of bioelectromagnetic platform of IETR (i.e. high-resolution dosimetry system based on infrared microscopy), with assistance from experts in cellular and molecular biology.

Research environment

The candidate will join the IETR laboratory of CNRS. Our research activities in biomedical electromagnetics cover a wide spectrum of fundamental and applied research spreading from multi-physics and multi-scale modeling to advanced technologies for body-centric wireless communications. The team was at the origin of pioneering innovations in biomedical electromagnetics, including the first millimeter-wave tissue-equivalent models, novel reflectivity based surface phantom concept, new broadband multi-physics characterization technique for Debye-type materials, innovative millimeter-wave textile antennas for smart clothes, ultra-robust miniature implantable UHF antennas, and the first millimeter-wave reverberation chamber.

Candidate

We seek for highly engaged and motivated candidates with a MS or equivalent degree in electromagnetics, electrical engineering or electronics. The required skills and qualifications are:

- Strong background in electromagnetics, analytical/numerical modeling, and microwave engineering. Knowledge in biomedical engineering / biophysics is welcome but not mandatory.
- Knowledge of numerical modeling and experience with commercial or open-source numerical solvers (e.g. COMSOL, CST, SIM4LIFE), programming skills (e.g. MATLAB).
- Fluency in English: the candidate should be conversant and articulate in English and must have strong writing skills. The successful candidate will be expected to present results of the work in high-profile journals and conferences. Knowledge of French is not required but would be appreciated.

Benefits

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:

- Approximately 7 weeks of annual leave per year + possibility of exceptional leave (moving home, etc.).
- Generous statutory benefits: French national health coverage, unemployment allowances, retirement/pension funds, etc.
- Possibility of subsidized meals, student housing, and partial reimbursement of public transport costs.
- Location in one of the most attractive cities in France for professional and nonprofessional activities [entertainment, culture, sport, gastronomy, etc; 1:25 to Paris by train and 0:47 to a seaside].

Funding: Full-time scholarship provided by the University of Rennes 1.

How to apply

To apply please send your applications to: Maxim Zhadobov (maxim.zhadobov@univ-rennes1.fr).

The application should consist of (in PDF format):

- CV (incl. the contact details of two professional references [mail, address, position])
- Motivation letter (incl. explanation relevance to this PhD research project and why the candidate believes he/she is suitable for the position)
- Copy of PhD diploma
- Reference letters (optional)