MASTER M2 PROJECT 2019

At : Institut Fresnel, Domaine Universitaire St Jérôme Marseille

Biological tissue modeling for non-linear microscopy applications (optics : modelling and data analysis)

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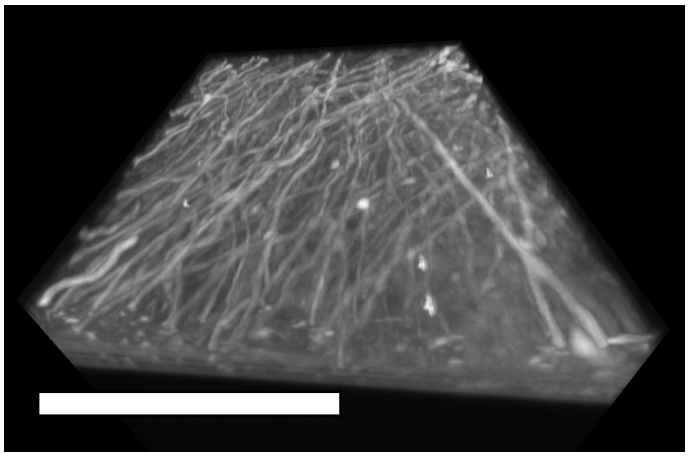
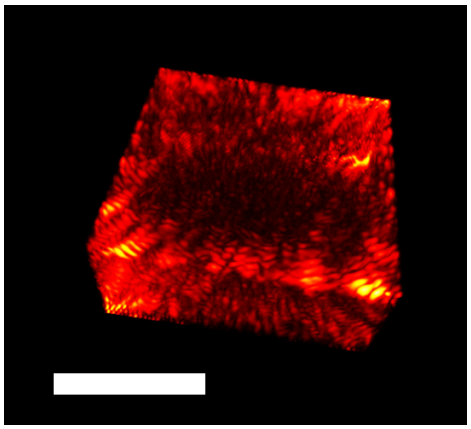
Keywords: electro-magnetic wave propagation simulation; finite-difference time-domain simulation complex media; scattering; python programming.

The MOSAIC team at Institut Fresnel (http://www.fresnel.fr/mosaic) works on various imaging techniques applied in biological research. We aim at developing novel optical microscopy techniques that push the limits of biological imaging beyond the state of the art. Optical microscopy in biological tissues is currently mainly limited by their disordered nature, which cause multiple light scattering. This effect does not allow to focus light deep inside the biological medium and therefore prohibits or nonlinear imaging.



The important aspect of the research is to understand the intrisic properties of the model system (i.e. mouse spinal cord) and to be able to simulate it without need for an actual experiment. We are using finite-difference time-domain approach to model light propagation in the spinal cord tissue. The geometry of the model is based on actual results from non-linear microscopy measurements. The fig 1 depicts 3D spinal cord structure acquired with coherent anti-Stokes Raman microscopy (the scale bar is 50 um). The simulation framework allows to calculate field distribution inside the sample of interest (fig.2 - scale bar 25um) at certain time taking into account multiple scattering. From field distribution various charcteristics can be deduced, e.g. spectral badwidth of the medium, transmission matrix, etc.



The student will contribute to the development (in collaboration with a postdoc fellow) of the model the model and running the numerical experiments with subsequent data analysis.

Required skills and interests: basic knowledge in optics and electromagnetism, in physics of complex systems, image processing and programming (python).

Financial support: 570 € / month

Reference: 1. Oskooi, A. F., Roundy, D., Ibanescu, M., Bermel, P., Joannopoulos, J. D., & Johnson, S. G. (2010). Meep: A flexible free-software package for electromagnetic simulations by the FDTD method. Computer Physics Communications, 181(3), 687–702. https://doi.org/10.1016/j.cpc.2009.11.008

2. Xu, M. (2017). Plum pudding random medium model of biological tissue toward remote microscopy from spectroscopic light scattering, 8(6), 2879–2895. https://doi.org/10.1364/BOE.8.002879