Modelling of signal propagation in nerve axons

Summary

The aim of this project is to understand the role that mechanical and thermal effects play in signal propagation in nerve axons. The proposed study is mostly related to mathematical modelling and numerical experiments.

Research field:	Applied physics and mathematics
Supervisors:	Prof. Dr. Andrus Salupere Dr. Tanel Peets
Availability:	This position is available.
Offered by:	School of Science Department of Cybernetics
Application deadline:	Applications are accepted between October 02, 2023 00:00 and October 23, 2023 23:59 (Europe/Zurich)

Description

Propagation of a nerve pulse is a complex process spiced with nonlinearities. Classically, the nerve function is understood in terms of electrical signals propagating along the nerve axons called the action potentials (AP). Over the past decades, it has become clear that the propagation of an AP is accompanied by mechanical and thermal effects, including a transverse deformation wave of an axon which means changes in axon diameter, a pressure wave in axoplasm and temperature changes.

While it is clear that there is strong experimental evidence about several effects accompanying the propagation of APs, there is no clear understanding whether these effects play important role in axon physiology. However, in terms of axon diameter and biomembrane thickness, these small effects can be significant in neural signalling and can also play an important role in neural pathologies.

Recently, we proposed a mathematical model of nerve pulse propagation including the accompanying effects. The model is based on known equations of mathematical physics which are modified to reflect the physiological effects. The further development of the model must give testable predictions that allow evaluating the importance of the mechanical and thermal effects in nerve signal propagation.

Our research group is focused on mathematical modelling of nonlinear wave processes in advanced materials and performing *in silico* experiments. This beneficial approach gains a better understanding of the underlying physical processes from different viewpoints. The project is financed by a grant from the Estonian Research Council.

Responsibilities and tasks for the PhD student:

- Participation in development of models and performing numerical experiments.
- Publishing obtained results and presenting them at scientific conferences.
- Participation in lab activities (lab seminars, science popularisation, etc)
- Teaching undergraduate students.

The applicant should fulfil the following requirements:

- Must have MSc degree in applied mechanics, physics, applied mathematics, or in a related field
- Must have knowledge in numerical methods
- Must have previous experience in programming using high-level object-oriented programming language
- Must have strong written and oral skills in English
- Must be a highly motivated and proactive individual with excellent communication skills

The following experience is beneficial:

- Knowledge in continuum mechanics
- Latex text preparation system
- Programming in Python and/or Matlab

- Familiarity with following Python modules/packages: numpy, scipy, sympy, matplotlib

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