Institute of Thermomechanics Seminar
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Lecture No. 114

Institute of Thermomechanics, Czech Academy of Sciences

invites you to a lecture within the lecture series **Institute of Thermomechanics Seminar**

Modelling of Complex Signals in Nerves

given by **Prof. Jüri Engelbrecht**
in cooperation with
Dr. Kert Tamm and **Dr.Tanel Peets**

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and
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The propagation of signals in nerves is a fundamental physical process needed for understanding cognitive processes and mental phenomena. It involves not only electrical signals (action potential, ion currents) but also mechanical disturbances in nerve fibres and temperature changes. The modelling of dynamic processes in continua (leaving aside particle physics, astrophysics, etc. where relativity of motion is of importance) is based on the conservation of momentum which is usually known as Newton's Second Law. The thermodynamic effects are modelled by Fourier's law (heat flux is related to temperature gradient) and Joule's law (heat is related to electric current). Traditional models of nerve signals pay more attention to physiology which helps to explain biological phenomena. In order to explain all the phenomena in nerves, a broader view must be elaborated. According to general principles of complex systems, the first step of the bottom-up modelling needs to identify all the basic elements (basic physical processes) and their interactions with each other (couplings) so that many components are united to generate a whole: an ensemble of waves. A possible mathematical model following these ideas is derived. The governing equations for the components of the ensemble correspond either to the modified classical ones for describing the action potentials or are derived from the laws of physics resulting in a consistent system. The interaction of the components of the ensemble is realized by coupling forces. The numerical simulation has shown that the model can grasp the measured effects. The mathematical model generated by authors [1] is an attempt aiming to couple all the measurable effects of the signal propagation in nerves into a system and demonstrates the importance of basic sciences in developing plausible models. This is an interdisciplinary approach at the interface of physiology, physics, and mathematics but it can be said that physics shapes signals in nerves [2]. The ideas are also supported by philosophical analysis [3]. After establishing the sound backbone of the model, further modification of the modelling involving the influence of the internal structure of a fibre (myelin sheath, the cytoskeleton of the axoplasm, etc.) is possible. An example of the modelling of the myelin sheath demonstrates such a possibility [4].

References

[1] Engelbrecht J., Tamm K., Peets T. (2021) Modelling of Complex Signals in Nerves. Springer, Cham
[2] J.Engelbrecht, K.Tamm, T.Peets. (2022) Physics shapes signals in nerves. The European Physical Journal Plus, 137, 696
[3] J.Engelbrecht, K.Tamm, T. Peets. Signals in nerves from the philosophical viewpoint. Proc. Estonian Acad.Sci. (accepted, to appear in 2022)
[4] K.Tamm, T.Peets, J. Engelbrecht. Mechanical waves in myelinated axons. Biomechanics and Modeling in Mechanobiology - BMMB, 2022 (online available)

The lecture will be held on Tuesday, November 8, 2022 at 10:00
in the building of the Institute of Thermomechanics (large lecture room),
Dolejškova 5, 182 00 Prague 8

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