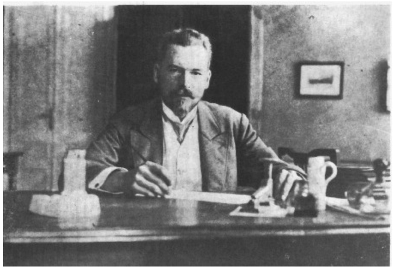

Contribution ID: **37** Type: **Regular Talk**

Quantifying activity in chemically active systems with a stochastic Poisson field theory

Monday, 25 September 2023 11:40 (25 minutes)

Chemically active systems are characterized by the presence of chemical processes which convert energy from the environment to perform activity. Examples are self-propelled particles, active droplets, active gels or molecular motors. The continuous flow of energy, stemming from the chemical reactions, prevents the system to reach thermal equilibrium at molecular scales. For this reason, active matter is known to be intrinsically out of equilibrium. A precise understanding of the non-equilibrium character of active matter remains however a puzzling question. Recent observations in living cells, which are typical examples of active systems in biophysics, even suggest that the local-equilibrium approximation might hold on the spatiotemporal scales related to the formation of condensates.

In this presentation, a framework to quantify activity using fluctuations of heat in the system is introduced. The origin of these fluctuations is of two kinds, either stemming from the active processes or related to the passive thermal fluctuations. The formulation of a field theory with stochastic fluctuating noise and Poisson statistics makes it possible to describe the fluctuations arising from activity. Passive fluctuations, related to the stochasticity in the heat transport at local equilibrium, are described by a stochastic field theory with Gaussian white noise. The dominant contribution in the heat fluctuation provides an indication of the non-equilibrium character of the system. For the length and time scales where the passive thermal fluctuations are dominant, the system might be well approximated by local thermal equilibrium and the relative importance of passive versus active contribution provides a way to quantify the activity.

Reference

J. Mabillard, C. A. Weber, and F. Jülicher, Heat fluctuations in chemically active systems, Phys. Rev. E 107, 014118 (2023).

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Session Classification: Session 3