Proposal for a research internship (M2)

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Thesis possibility after internship: YES
Funding: YES (internship gratification if applicable)

Coupled receptor-scaffold dynamics in the dendritic membrane

Keywords: statistical physics, biophysics, brownian dynamics, neuroscience, synapse

Synapses are highly dynamic structures that constantly assemble and disassemble: on short timescales, neurotransmitter receptors enter and exit the postsynaptic domain; on longer timescales, the postsynaptic scaffolds are themselves subject to turnover and fluctuate considerably in size. Recently, we have described the long-time dynamics and formation of postsynaptic scaffold domains at inhibitory synapses arising from an interplay of scaffold protein turnover and the diffusion of scaffold protein-receptor complexes [1]. In this project, we would like to explore two extensions of that work. In addition to protein-protein interactions within the postsynaptic membrane (receptor-scaffold and scaffold-scaffold interactions), cell adhesion protein-mediated interactions between pre- and postsynaptic domains can physically link neurons at synaptic sites. In a first step, we wish to characterize the influence of such links on the size distribution and fluctuations of postsynaptic scaffold domains via immobilization of the latter. In a second step, we want to explicitly address the short-time dynamics of inhibitory receptors that diffuse in the extrasynaptic membrane and bind transiently to synaptic scaffold domains. The project will involve analytical calculations and computer simulations of the receptor and scaffold protein dynamics in the dendritic membrane. While the project itself is theoretical, we work in close collaboration with the experimental group of Antoine Triller and ample opportunity to interact with experimentalists will exist.

[1] J. Ranft, L. Almeida, P. Rodriguez, A. Triller, and V. Hakim. An Aggregation-removal model for the formation and size determination of postsynaptic scaffold domains. PLoS Comput Biol 13(4):e1005516.

Requirements: solid knowledge in statistical physics, genuine interest in biological problems, basic programming skills in Python & C++