IMPRS on Multiscale Biosystems

Project Title: Probing the effect of electric fields on biomembranes

PIs: Joachim Heberle (Heberle Lab, FU Berlin), Rumiana Dimova (Dimova Lab, MPI)

Project description: Electric fields across biomembranes are involved in essential processes of energy conversion, nerve propagation and signal transduction in living cells. It is the aim of this project to measure the strength of an applied electric field on a local probe located in a membrane protein embedded in a lipid bilayer. FTIR spectroscopy will be used to probe the structural changes that are associated with vibrational changes of the protein backbone and amino acid side chains. These can be as minute as alterations in hydrogen-bonding or protonation changes and are resolved by IR difference spectroscopy. We will employ vibrational Stark effect (VSE) probes like phenylcyanide and thiocyanide, to be judiciously placed in the lipids and in the transmembrane protein. The transmembrane protein is embedded in a lipid bilayer to form a solid-supported membrane. Varying the potential across the biomembrane leads to structural changes in the protein with the field strength monitored by the response of the VSE probe (Fig.1, Heberle lab). Electric field effects on the mechanical and rheological properties of lipid vesides (with and without protein) when adhered to a solid surface and freely suspended will also be monitored by fluorescence and super-resolution microscopy (Fig.2, Dimova lab) and probed with home-built techniques.

Required background: MSc in biophysics, (bio)chemistry, physics or physical chemistry. Strong interest in molecular spectroscopy and interest in interdisciplinary work is required.

Papers to read before the interview:

1. Ataka, K., Stripp, S.T., and Heberle, J. (2013). Biochim. Biophys. Acta. 1828, 2283-2293. http://dx.doi.org/10.1016/j.bbamem.2013.04.026
2. Jiang, X., Zaitseva, E., Schmidt, M., Siebert, F., Engelhard, M., Schlesinger, R., Ataka, K., Vogel, R., and Heberle, J. (2008). Proc. Natl. Acad. Sci. USA 105, 12113-1211. doi.org/10.1073/pnas.0802289105
3. Dimova, R. (2019). Ann. Rev. Biophys. 48, 93-119 DOI: 10.1146/annurev-biophys-052118-115342

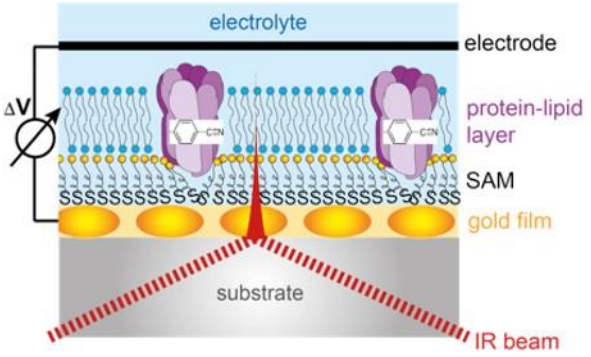

Figure 1: Solid-supported biomembrane with lipid reconstituted transmembrane protein. The gold film serves as an electrode to apply the voltage and as a substrate for surface-enhanced IR absorption (SEIRA) spectroscopy.

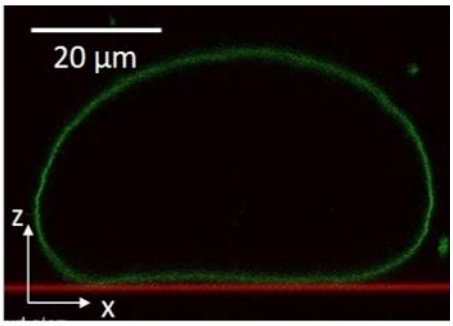

Figure 2: A giant lipid vesicle (fluorescently labeled, green) resting on an electrode (red) and observed via a vertical confocal cross section, see Steinkühler, J., Agudo-Canalejo, J., Lipowsky, R., and Dimova, R. Biophys. J. 111, 1454-1464, 2016.

Contact: JHeberle@zedat.fu-berlin.de, Rumiana.Dimova@mpikg.mpg.de