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Exploring interactions between charged lipid bilayers in a strongly confined geometry : beyond Poisson-Boltzmann theory

The rich and complex behavior of amphiphilic molecules self-assembling into supramolecular structures, such as lipid bilayers in water, is fascinating to physicists. Such thin membranes act as quasi-2D worlds — they are about two molecules thick — evolving in a 3D space, which results in a complex set of interactions. Measuring these interactions at the nanometer scale is challenging and requires precise experiments on controlled model systems.

Our system of choice consists of two bilayers deposited on a solid substrate [1]. The interactions between the membranes are investigated via their spacing and thermal fluctuations, measured using X-ray and neutron scattering techniques, such as specular and off-specular reflectivity. We have shown that this system can be used to study fundamental questions regarding the interactions between highly charged surfaces, using charged lipids with monovalent counterions [2]. Theoretical and numerical studies have indicated the need to go beyond the Poisson-Boltzmann description of electrostatic interactions in such a charged and confined system [3-4]. Our experiments are compared with these strong-coupling theories, indicating a decrease in the water dielectric constant due to a surface charge-induced orientation of water molecules.

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