Phase Behavior of a Charged, Fluid Lipid Bilayer

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Lateral organization of cell membranes is an important problem in Biophysics. A large number of experimental studies points to the existence of lateral domains, sometimes called membrane rafts, and their relation with many biological processes, including signal transduction, membrane trafficking, cell adhesion, membrane fusion etc. Important aspects to consider are: electrostatic interaction, since charged lipids are ever present in biomembranes, the compositional lipid asymmetry and the coupling between the two faces of the membrane. In the present work, we study the lateral phase separation in an asymmetrically charged lipid bilayer consisting of neutral and negatively charged lipids that are in contact with an ionic solution. The two asymmetric monolayers are coupled only trough electrostatic interactions. We have describe the bilayer on the mean-field level by splitting the free energy into non-electrostatic and electrostatic contributions, the former using the Bragg-Williams approximation (random mixing approximation) of a binary lattice gas and the latter using the non-linear Poisson-Boltzmann theory. With the goal of modeling bilayers where only one monolayer tends to phase separate we have assigned different values of non-ideality parameter χ to each one. We calculated the entire phase diagram containing binodal and spinodal lines as a function of the of non-ideality parameter χ and monolayer-monolayer electrostatic coupling. It is shown that the domain formation may be induced or inhibited in the apposed monolayer depending on the location within the phase diagram.