The Electrostatic Contribution to the Line Tension Between Lipid Membrane Domains

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Abstract

The line tension, which characterizes the excess free energy per unit length of the boundary between different lipid membrane domains, is one of the factors that determines domain size and dynamics. Consequently, experimental methods and corresponding modeling studies related to the line tension continue to attract significant interest. Considering a planar binary lipid layer with two domains consisting of neutral and anionic lipids, we calculate the electrostatic contribution to the line tension at the domain boundary using mean-field electrostatics. The influence of lipid mobility in each phase is studied through solutions of the Poisson-Boltzmann equation for different sets of boundary conditions that include fixing the local surface charge density or surface potential, or allowing the lipids to migrate subject to a demixing entropy penalty. We find the electrostatic contribution to the line tension to be negative with magnitudes on the order of piconewton close to physiological conditions. Because this is comparable to experimentally reported values of the total line tension, we conclude that electrostatic interactions generally plays an important role at the boundary between differently charged lipid domains.