Diffusive bending modes in bola lipid membrane of archaea

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We consider new diffusive mode and damping of the bending modes of the archaea membrane. One of the distinct properties of archaea is the presence of a special lipid in their structure - bolalipid. An investigation of the membrane of the archaea is interesting, first of all, because bolalipid membrane is found to be stable in extreme conditions: such as high pressure or high temperature, or very high/low acidity. This opens up potential applications of bolalipid membranes in e.g. medical and catalytic applications. The peculiarity of bolalipid membrane of archea is its intrinsically multi component content: bolalipid molecules can exist in two major configurations: integral shaped (O-forms) and hairpin shaped (U-forms). The U-forms surrounded by the O-forms cause local curvature of the membrane. An ability of bolalipids of the U-shape configuration to move within the bolalipid layer and nonequivalence of their potential energy in the regions of curved and flat membrane cause lateral diffusive flaws of U-forms in the flucruating membrane. For theoretical calculation of the bending modes of bolalipid membrane with small concentration of U-forms we take the energy functional for isotropic elastic thin plate Eq. (1) with dynamic nonzero local spontaneous curvature J_0. Motion of U-forms is described by Fick's laws in the presence of dynamic potential field effectively created by the membrane's bending. The bending is assumed to be small and cylindrical. The resulting system of self-consistent equations is solved by perturbation theory in the long-wavelength limit.

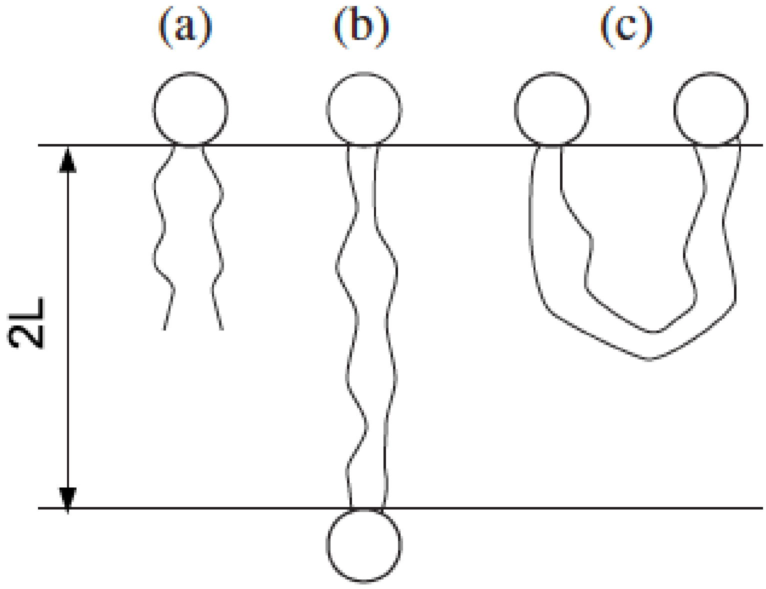

Figure 11: Schematic plot of lipid (a) and bolalipid O-form (b) and U- form (c). 2L is a thickness of hydrophobic region of the membrane. First microscopical model calculations of thermodynamic properties of bolalimid membrane were presented in [1].

$$W = \frac{Eh^3}{24\left(1-\sigma^2\right)} \int \left\{ \left(\frac{\partial^2 \varsigma}{\partial x^2} + \frac{\partial^2 \varsigma}{\partial y^2} - J_0 \right)^2 + 2\left(1-\sigma\right) \left(\left(\frac{\partial^2 \varsigma}{\partial x \partial y} \right)^2 - \frac{\partial^2 \varsigma}{\partial x^2} \frac{\partial^2 \varsigma}{\partial y^2} \right) \right\} \qquad (1)$$

Solving the system of self-consistent dynamic equations for the plate vibration coupled to U-forms diffusion we found two brunches of dispersion: purely diffusive brunch corresponding to U-forms motion and damped bending modes of the membrane's deviations from the flat conformation. Predictions for the spectral intensities of the membrane's fluctuations to be measured by e.g. neutrons scattering technique are presented.

References

[1] Mukhin S.I., Kheyfets B.B.: *Analytical approach to thermodynamics of bolalipid membranes*. Phys. Rev. E, **82**, 051901-9 (2010).