Hydrodynamics in Multicomponent Biomembranes

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Biological membranes typically contain various components such as lipid mixtures, sterols, and proteins that are indispensable to cell functions. Rather than being uniformly distributed in the membrane, there are growing evidences that some intra-membrane components are incorporated in domains arising from lateral lipid segregation in membranes. This phenomenon has attracted great interest in the context of "rafts". Recent researches focus on the dynamical aspect of lateral phase separation in mixed membranes.

We investigate the dynamics of two-component fluid membranes from the theoretical point of view. Since fluid membranes are sandwiched by the surrounding water, a two-dimensional hydrodynamic equation with momentum decay is used. We first discuss the diffusion constant of domains moving in membranes [1]. It is shown that the obtained diffusion constant depends on the domain size logarithmically and algebraically for the weak and strong coupling limits, respectively.

Next we calculate the decay rate of the time-correlation function of the concentration fluctuations by taking into account the effect of hydrodynamic interaction within the membrane [2]. An effective diffusion coefficient is calculated in the entire range of the wave number. In the limit of small wave number q with respect to the correlation length, the decay rate is proportional to q^2 as usual. Here dependencies on the correlation length and the domain size are the same. In the large q limit, however, the effective diffusion coefficient increases only logarithmically with q. Such a weak wave number dependence should be contrasted with that in three-dimensional critical fluids for which the effective diffusion coefficient increases linearly with q in the large q-limit. Our prediction should be checked experimentally.

References

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[2] Seki, K., Komura, S. and Imai, M., 2007. Concentration Fluctuations in Binary Fluid Membranes, J. Phys.: Cond. Matt. 19: 072101.