MAR14-2013-020217

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Measuring membrane rigidity and viscosity: New methods, and new insights

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Lipid membranes are remarkable materials: flexible, two-dimensional fluids whose physical properties guide cellular function. Bending rigidity and viscosity are two of the key mechanical parameters that characterize membranes. Both, however, are challenging to measure. I describe improvements in experimental techniques to quantify the bending modulus and the two-dimensional viscosity of lipid membranes. First, I show that using selective plane illumination microscopy (SPIM, also known as light sheet fluorescence microscopy) to image the thermal fluctuations of freely suspended giant lipid vesicles enables straightforward measurements of membrane rigidity, and also provides insights into changes in rigidity induced by cargo trafficking proteins. Second, I show that tracking both the rotational and translational diffusion of membrane-anchored tracer particles allows quantification of membrane viscosity, measurement of the effective radii of the tracers, and assessment of theoretical models of membrane hydrodynamics. Surprisingly, we find a wide distribution of effective tracer sizes, due presumably to a wide variety of couplings to the membrane. I also provide an example of protein-mediated changes in lipid viscosity.