



Figure S1: Schematic view of the common measurement techniques that probe membrane dynamics. To measure the mechanics of single bilayers in liposomes, the most common technique is video microscopy (orange), which has limit temporal (20-50 ms) and spatial resolution (10 nm). The technique of time resolved membrane spectroscopy (red) as presented in the current work can measure down to $0.2 \cdot 10^{-3}$ nm, with a time resolution of up to 10 μ s. Both, time and spatial resolution are limited by the intensity of the laser and hence by the signal to noise value. In contrast several other methods like X-ray, neutron and NMR methods have been used on stacked multilayer to measure the mechanical properties of stacked membranes with up to ns temporal resolution (green and blue).