Air/water surface rheology probed by thermal capillary wave

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Abstract:

We report on the measurement of the rheology of the air/water interface using an atomic force microscope that probes the thermal fluctuations of the interface. The interface was formed by depositing an air bubble on a solid substrate immersed in a surfactant solution. The thermal capillary fluctuations of the bubble surface were measured using an atomic force microscope cantilever that directly probes the vibration amplitude versus the frequency. The spectrum of the nanoscale thermal vibrations presents several resonance peaks corresponding to the different vibration modes. The resonance frequencies and damping were measured for each mode. Comparing the resonance frequencies measured in surfactant solutions and pure water, the surface tension for each surfactant solutions were obtained. The measured surface tension is in good agreement with the measured one using the Wilhelmy plate method. The dynamic elastic modulus of the bubble surface was also determined by fitting the measured damping using a capillary wave model. The value of the dynamic elastic modulus is much smaller than the static elastic modulus which we hypothesize as due to drag force from the surrounding gas acting on the surfactant molecules at the surface.