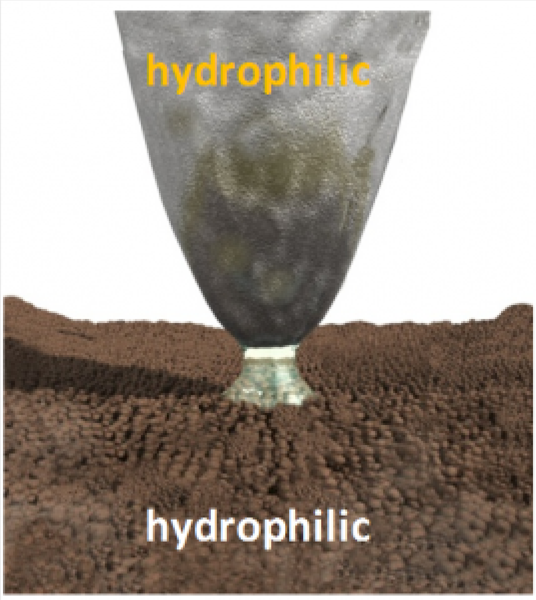
Structural flexibility mapping by bimodal atomic force microscopy in liquids

Wednesday, 7th November 2012. 12:00-13:00



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ABSTRACT:
Bimodal atomic force microscopy is based on the simultaneous excitation of two eigenmodes of the cantilever. Bimodal AFM enables the simultaneous recording of several material properties and, at the same time, it also increases the sensitivity of the microscope.
Here, the excitation of two cantilever eigenmodes in dynamic force microscopy enables the separation between topography and flexibility mapping. We have measured variations of the elastic modulus in a single antibody pentamer of 10 MPa when the probe is moved from the end of the protein arm to the central protrusion. Bimodal dynamic force microscopy enables us to perform the measurements under very small repulsive loads (30–50 pN).
We also develop a model based on fractional calculus to express the frequency shift of the second eigenmode in terms of the fractional derivative of the interaction force. We show that this approximation is valid for situations in which the amplitude of the first mode is larger than the length of scale of the force, corresponding to the most common experimental case. The model allows the measurement of the effective elastic modulus and the contact radius on heterogeneous samples.

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