High-resolution AFM by tracking the resonance frequency of ultrasmall cantilevers

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Ultrasmall cantilevers have been a key element for fast-scanning AFM experiments. They are characterized by their high resonance frequencies and a relatively low thermal noise threshold which determines the ultimate noise floor for AFM. Thus far, ultrasmall cantilevers have been operated in intermittent contact mode but not in the so-called non-contact modes for imaging biomolecules in liquid. These modes rely on tracking shifts in cantilever resonance frequency. With conventional cantilevers, they have been successfully applied to obtain atomic-resolution images in liquid and are increasingly used for high-resolution imaging of biomolecules.

Here we report on high-resolution imaging experiments on a number of benchmark samples, obtained by tracking MHz resonance frequencies of ultrasmall cantilevers. Overcoming a number of experimental obstacles that have thus far prevented this type of experiments, our experimental set-up uses an interferometric detection scheme, optical cantilever actuation, and a customized Vortis controller from JPK Instruments. It has achieved subnanometre-resolution on mica and on the membrane protein bacteriorhodopsin. In addition, it enables us to measure DNA at higher resolution and at significantly lower forces than intermittent contact mode.