Tip-Surface Interaction: The Master Equations of Dynamic AFM

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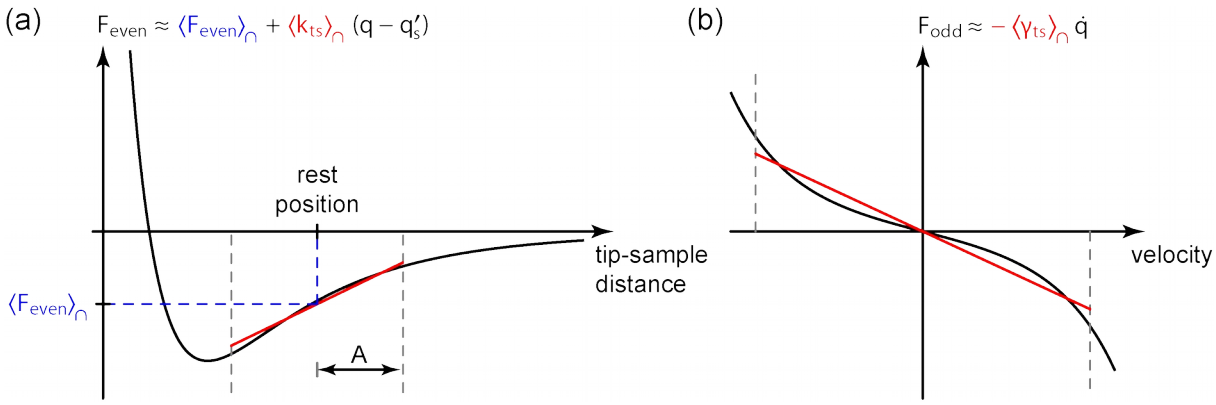
Atomic force microscopy in the dynamic mode has developed into an extremely useful technique in the three decades since the first images with atomic resolution. Today, a wide variety of dynamic atomic force microscopy modes are employed in the field of surface science. These modes are often adjusted to particularly suit the investigation of a specific sample property.
Summarizing the existing literature [1-10] on atomic force microscopy data evaluation, we introduce a general set of three equations [11] to analyse data obtained in any single-frequency operation mode. Hereby, only the harmonic approximation is needed. The resulting **Master Equations of Dynamic AFM** connect the observables excitation force, excitation frequency, amplitude, phase shift and static deflection with the three aspects of the tip-sample force accessible within the harmonic approximation (see figure). This comprehensive set of equations allows for a quantitative determination of the tip-sample force, regardless of the specific mode used. The validity of the harmonic approximation – the most common in modern dynamic AFM data analysis – is checked comparing analytical results provided by the master equations with virtual AFM simulations. We will discuss advantages and limitations of most common dynamic AFM modes. The equivalence of various dynamic AFM modes will be verified by comparing high-resolution data obtained in amplitude modulation and frequency modulation mode.



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