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Theory of Q-Controlled Dynamic Force Microscopy in Liquids
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— The so-called Q-control method allows the active modification of the effective cantilever damping in dynamic force microscopy (DFM) by increasing or decreasing the Q-value of the cantilever. This feature has been used in recent years in numerous experimental studies to improve the apparent imaging capabilities of DFM in liquids. However, it is striking that an in-depth analytic description that would allow a rigorous theoretical explanation of the various features of Q-controlled dynamic force microscopy (QC-DFM) is still missing. Here, we present an analysis of QC-DFM based on the analytical solution of the equation of motion considering a model tip-sample interaction force. Explicit formulas allowing for the calculation of relevant parameters such as amplitude, surface deformation, and maximum forces during an individual oscillation cycle are given. It is found that higher effective Q-factors assist in reducing the maximum tip-sample forces. This helps suppressing unwanted deformations of the sample surface, leading to the reported enhanced image quality. Finally, the results are discussed in relation to the situation in air.

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