Manipulation of single molecules by NC-AFM

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Though the frequency shift of tuning fork force microscopy is primarily related to normal force gradients, there are some examples of experiments, which provide valuable information about lateral forces or energy barriers in the lateral direction. Either 2d- or 3d-frequency data are acquired and transferred into force or energy fields by integration, where instabilities limit the applicability of this method. Alternatively, models are used, where the essential parameters are included to simulate the frequency shift data. An example is given by the pulling of polymeric chains on Au(111) [1], where the detachment of the chain leads to oscillations of the normal and lateral forces. The comparison with the model allows to determine the adhesive energy per subunit of the molecular chain. Lateral manipulation gives insight about the movement of one dimensional chains on surfaces, which is close to the ideal of the Frenkel-Kontorova model.

[1] S. Kawai, M. Koch, E. Gnecco, A. Sadeghi, R. Pawlak, T. Glatzel, J. Schwarz, S. Goedecker, S. Hecht, A. Baratoff, L. Grill, and E. Meyer, Quantifying the atomic-level mechanics of single long physisorbed molecular chains, Proc. Natl. Acad. Sci. USA, 111, (11), (2014), 3968–3972