

Damping Signal in NC-AFM : How to Remove the Contribution of the Instrumentation

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For many *NC – AFM* experiments, the interpretation of the origin of the damping signal remains an open question. Recently, Gauthier et al. [1] have suggested that a coupling between the electronics and the non linearity of the interaction may significantly affect the damping signal. Numerical simulations seem to show that a resonance between the scan speed and the response time of the system can provide a simple explanation for the damping image. Rather than a resonance, we suspect that unexpected high dissipation at the local scale can be induced through instability related to the proportional *P* and integral *I* gains of the *AGC* (Automatic Gain Control) [2].

In this paper, we re-examine the question of the damping signal. Using the principle of least action, or the first harmonic method, we obtain an approximated analytical expression for the damping signal due to the instrumentation : $D_i \approx k_1 \Delta\omega + k_2 \dot{Z}_m + k_3 \Delta\dot{\omega}$, where k_1 , k_2 and k_3 are constants, $\Delta\omega$ is the corrugation of the instantaneous frequency of the loop, $\Delta\dot{\omega}$ its derivative and \dot{Z}_m is the derivative of the amplitude of the oscillation. These quantities are easily deduced from measurements when the time constants of the *AGC* and frequency demodulator are known. The method only uses experimental data, without any assumption concerning the type of interaction between the tip and the surface.

For an ideal machine, $\Delta\omega = \Delta\dot{\omega} = \dot{Z}_m = 0$, but during an experiment these terms are not null and strongly depend on the values of *P* and *I* of the *AGC* and of the *Z*-height regulator. When the setting point of the machine is close to the frontier of the stability domain, and for a particular scan speed, the damping D_i can be strongly enhanced because the term $k_2 \dot{Z}_m$ becomes very large. The Fig. 1 shows typical variations of D_i as a function of the scan speed for three different values of the *P* and *I* of the *AGC*.

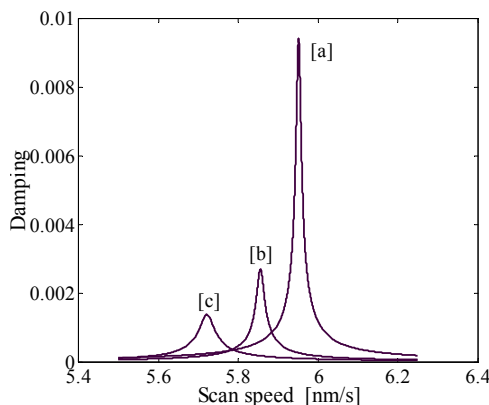


Fig. 1 Damping signal D_i versus the scan speed for three different values of *P* and *I* of the *AGC*. Curve [a] corresponds to a setting point close to the frontier of the stability, curves [b] and [c] corresponds to setting points inside the stability domain.

[1] M. Gauthier, R. Pérez, T. Arai, M. Tomitori and M. Tsukada, *Physical Review Letters*, **89**, 146104, (2002).

[2] G. Couturier, R. Boisgard, L. Nony and J. P. Aimé, *Review of Scientific Instruments* **74**, 2726, (2003).