Wavelets meet multifrequency AFM

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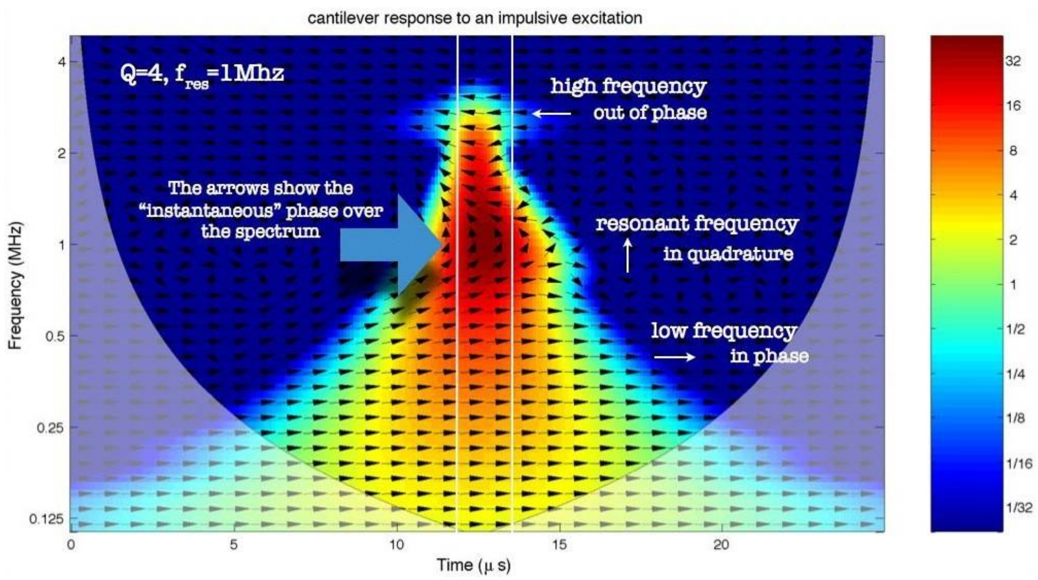
Exciting the cantilever over a frequency band extended the routes that convey measurable information from tip-sample interaction with respect to single frequency imaging modes [1]. Despite progress in the measuring techniques, the employed analytical tool did not evolve at the same pace, Fourier analysis remaining the analytical tool of choice to interpret AFM data. However, when the interaction is mediated by complex excitation pulses, Fourier spectra hinder important information such as the temporal evolution of the frequency components and the associated phases. It is foreseen that future progresses in multifrequency AFM will certainly require new analytical tools. Wavelet analysis is a well established tool for analyzing localized variations of power in a signal evolving in time. By projecting the interacting cantilever motion in time-frequency space, it is possible to follow the evolution of its spectrum [2,3]. Importantly, wavelet cross-correlation can be used to follow in time the "instantaneous" phase shift between the driver and the cantilever response at each frequency, even when the driver is a short single pulse [4] (see figure). The phase information is essential for the characterization of the materials mechanical and chemical properties in biology, polymer science and microelectronics. An analysis of these mathematical tools applied to AFM is timely and useful, especially in view of the ever increasing application of multi-frequency and multi-mode application to a variety of environments (air, liquids) and samples (biological surfaces, thin films, organic compounds).



References

[1] S. Jesse, et al., Nanotechnology 18, 435503 (2007).
[2] Malegori, G. & Ferrini, G. (2010). Tip-sample interactions on graphite studied using the wavelet transform, Beilstein J. Nanotechnol. 1: 172.
[3] Malegori, G. & Ferrini, G. (2011). Wavelet transforms to probe long- and short-range forces by thermally excited dynamic force spectroscopy, Nanotechnology 22: 195702.
[4] Banfi, F. & Ferrini, G. (2012). Wavelet cross-correlation and phase analysis of a free cantilever subjected to band excitation, Beilstein J. Nanotechnol., in press.