Complex dynamics in dynamic atomic-force microscopy

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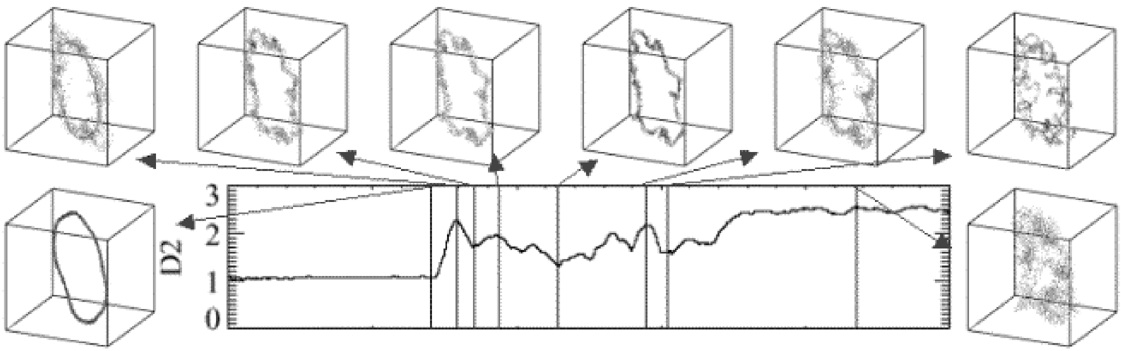
In tapping mode atomic force microscopy (AFM) the highly nonlinear tip-sample interaction gives rise to a complicated dynamics. Apart from the well known bistability under typical imaging conditions the system exhibits a complex dynamics at small average tip-sample distances, which are typical operation conditions for mechanical dynamic nanomanipulation [1]. In order to investigate the dynamics at small average tip sample gaps experimental time series data are analyzed employing non-linear analysis tools and spectral analysis. The correlation dimension [2] is computed together with a the bifurcation diagram, and a Poincaré map. The system under consideration shows features that are typical for a dynamical system with a low number of degrees of freedom in the regular and chaotic regime. Far away from the surface the system is in a regular regime. During the approach a phase jump, a period-doubling regime, and a chaotic regime develop. The analysis reveals a period three behavior. period-doubling, as well as a regime with a positive Lyapunov exponent which indicates a weakly chaotic regime. System characteristics of this type have been observed for the Duffing-oscillator [3] which can serve as a model system for an AFM.



Phase space embeddings for eight different times together with the correlation dimension. The first panel shows the return plot in the regular region. The second panel is located at the phase jump from the attractive to the repulsive mode. The fifth panel shows the period doubled mode. The seventh panel shows a period four mode and the last panel shows the chaotic regime.

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