Swift Engineered Equilibration: towards quicker and reliable AFM measurements?

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Shortcut To Adiabaticity techniques appeared in a quantum mechanical formulation less than ten years ago. They consist in driving a system to assist a transformation between two equilibrium states and then perform it much quicker than the usual adiabatic path. Very recently, Shortcut To Adiabaticity procedures have been successfully transposed to thermal systems (Engineered Swift Equilibration), allowing some members of our team to accelerate up to a hundred times the equilibrated compression of a colloidal particle.

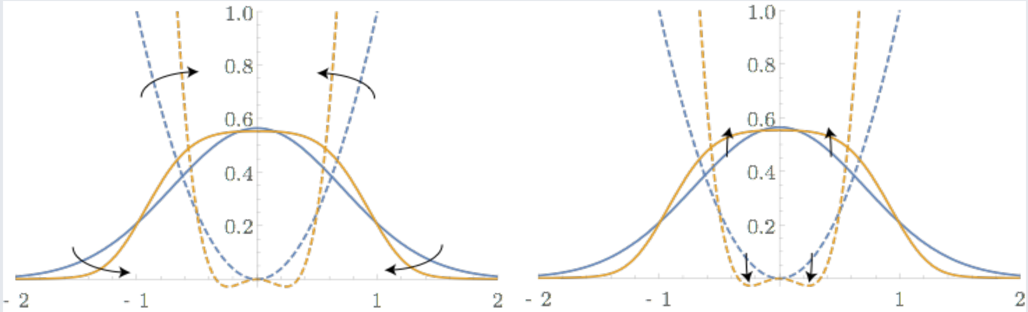

Figure: Fine-tuned evolution of the potential (dashed lines) to convert a Gaussian equilibrium state (in blue) into a quartic one. The orange curve shows an intermediate time, characterised by a bistable potential. The left graph shows the sharpening of distribution tail, and the right graph shows the broadening of the central part.

From a theoretical perspective, this line of research is in its infancy, while experimental attempts have barely started. We designed adiabatic quick transformations, as well as minimised work input for a given target state, manipulated non-Gaussian states (see Figure for the potential required to transform a Gaussian state into a quartic state), and addressed the case of practical implementation of decompression assisted by temperature. We also plan to combine these tools and devise a micro thermal engine. This work is developed in collaboration with colleagues from Toulouse, Lyon and Marseille.

Finally, we are currently developing a new aspect of Engineered Swift Equilibration that concerns underdamped systems, such as an Atomic Force Microscope cantilever, using our standard protocol as a probe to measure the atomic force field. Our goal is to develop a cutting-edge Atomic Force Microscopy technique, both faster than usual techniques and still reliable. A patent has been filled in this direction.

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