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Gleaning signals from noise for probing matter at the molecular scale

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Abstract— **Thermal noise has a significant effect on the functionality of the processes and matter at the molecular and smaller scales. Rational control and interrogation of matter at such small scales necessitates devices which have exquisite resolution to discern the signals where the measurement noise introduced cannot overwhelm the thermal response of matter. In this tutorial, methods that have evolved for rational control and interrogation of matter at the small scale will be explained with specific emphasis on the use of flexure probes and optical forces. In particular biological molecules will be used as a case study with emphasis on motor-proteins based transport inside cells and protein folding and unfolding experiments using flexure probes. Modern control theory and related perspectives hold significant promise in meeting the resolution and bandwidth needs for interrogation and manipulation of matter at the small scale. In the tutorial, examples on how such methods have overcome perceived limitations will be emphasized. Moreover, the tutorial will highlight avenues for future research and will outline outstanding challenges. The tutorial will be apt for researchers with background in controls; no expertise will be assumed on molecular scale aspects.**

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