Noisy business: How biological nanomachines make use of thermal fluctuations

Cells contain a variety of complex nanoscale machines. They share a number of common properties with macroscopic machines, such as their ability to produce directed motion and to generate forces. However, a fundamental difference is imposed by thermal fluctuations that significantly influence the operation of nanoscale machines.

It is becoming more and more clear that biomolecular machines not only cope but even exploit fluctuations to full-fill their functions. Here I will exemplify this concept at the example of CRISPR-Cas enzymes, a recently discovered machinery that is currently revolutionizing genome engineering applications in biotechnology. I will show how such enzymes make use of fluctuations to find and verify a certain DNA target sequence and how they can speed up the target search process by a simple kinetic proofreading mechanism. In parallel I will also introduce and explain the techniques that we develop in the laboratory to study with high spatio-temporal resolution the behavior of enzymes and enzyme systems at the single molecule level.

Furthermore, my laboratory tries to use the understanding about biomolecular machines to develop artificial nanoscale systems. This employs self-assembled DNA nanostructures, which are used as rigid 3-dimensional building blocks. As an example, I will demonstrate how such structures can be used to dictate the growth of inorganic nanoparticles, which is an important step towards the biomimetic fabrication of nanoelectronic devices.