Driving a Single Nanoparticle Inside Optical Tweezers with Electric Field (M.Sc. Project)

Research question:

How fast the electric double layer around a single nanoparticle reacts to an external electric field?

Project Description:

Most surfaces, nanoparticles, and biomolecules become electrically charged in contact with water. This charge will be screened by the ions solvated in water. The ions form the so-called electric double layer (EDL), which is often only a few nanometers thick. The interactions of the particle with its environment, however, will greatly depend on this cloud of ions. The processes inside the EDL determine the reactivity and assembly of these charged objects and. Understanding the EDL properties is important for a variety of biological and industrial processes, from how the kidneys function and neurons communicate to how an e-reader works.

When an external electric field is applied, the charged nanoparticle will be pulled in one direction and the shell of ions around it will be pushed in the opposite direction. The particle thus will start to drift in the liquid, due to the viscosity of the media and interaction with the cloud of ions. It takes time for the particle to start moving with a constant velocity and this time depends on how quickly the ions can diffuse around the nanoparticle and the double layer.

The fast response of the EDL is very hard to probe by only using conventional method of electrophoretic measurement. But combining electrophoresis with optical tweezers opens up a great avenue of possibilities. By studying the high-speed motion of the nanoparticle to the electric field we can study the properties of the EDL and how the surface chemistry of the nanoparticle changes these properties.

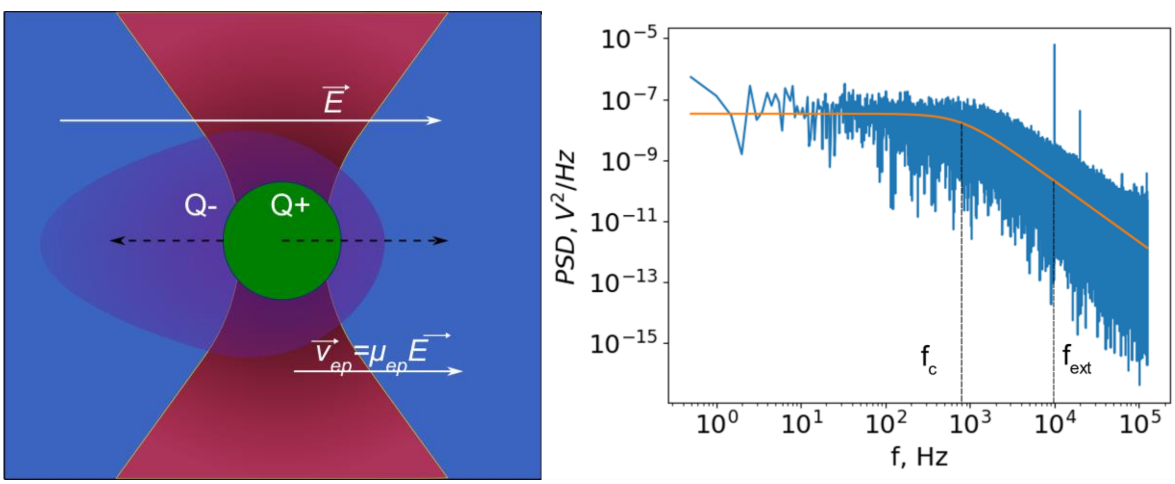

Figure 1. Electrophoretic response of a charged nanoparticle and its electric double layer to external electric field

In this project you take part in the developing new experimental methods for measuring the electrophoretic mobility of a nanoparticle trapped with optical tweezers with a temporal resolution of a few microseconds. You will also learn about high-bandwidth data acquisition, fabrication of microfluidic devices, and signal processing in Python.

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