Diffusion and Surface Charge of Nanoparticles obtained by an ABELtrap

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Monitoring the Brownian motion of individual nanoscopic objects is key to investigate their transport properties and interactions with their close environment. Most techniques rely on transient diffusion through a detection volume or immobilization, which restrict observation times or motility. We have built an Anti-Brownian Electrokinetic trap (ABELtrap, developed by A. E. Cohen and W. E. Moerner at Stanford University, [1-2]) using FPGA-based feedback controls and simultaneous data recording by time-correlated single photon counting [3]. Employing a laser pattern generated by fast electro-optical beam deflectors focused in a flat microfluidic chip, the scattering objects are detected and localized by single photons. Their estimated Brownian motion in the field-of-view and based on the particle's current position is cancelled by electrokinetic forces in real time with microsecond feedback algorithms. Therefore, observation times of single structures in solution are achieved up to seconds. Determined diffusion coefficients obtained by the ABELtrap are compared to results from conventional fluorescence correlation spectroscopy (FCS). Several nanostructure types, such as spherical silver or gold particles and fluorescent beads are studied regarding their diffusion properties and surface charge. In the case of plasmonic particles, new insights on the quality of often needed biofunctionalization protocols or ligand exchange reactions might be accessible on single particle level in contrast to techniques that rely on averaged signals from ensembles of particles, such as Zeta potential measurements. Additionally, morphologically anisotropic nanostructures or DNA-particle constructs are studied by extension of the existing setup with a polarization sensitive multichannel detection path.

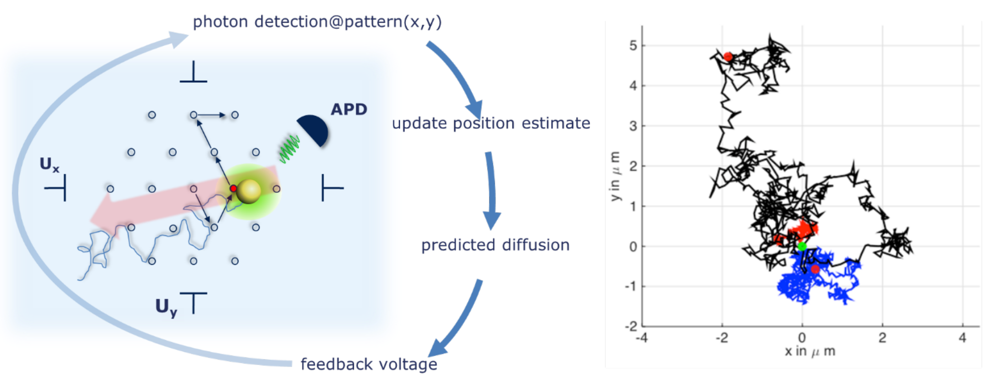

Fig. 1: (left) - Depiction of the general ABELtrap detection scheme. By detection of a photon at the laser pattern position (x,y), the Kalman position estimate is updated and a corresponding feedback-voltage pulse is applied to counteract Brownian motion and trap the nanostructure.
(right) – retraced of the Browian motion of different trapped particles (black, blue, red) by reconstruction of the recorded optical and electrical feedback signals.

[1] Cohen, A.E.; Moerner, W.E., Applied Physics Letters (2005), 86, 093109
[2] Cohen, A.E.; Moerner, W.E., Optics Express (2008), 16, 6941
[3] Dienerowitz, M.; Dienerowitz, F.; Börsch M., Journal of Optics (2018), 20, 034006