

NanoTracker: Force-Sensing Optical Tweezers for Quantitative Single-Molecule Nanomanipulation

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In the past decade, experiments involving the manipulation and observation of nanostructures with light using optical tweezers methodology have developed from proof-of-principle experiments to an established quantitative technique in fields ranging from (bio)physics to cell biology. With optical tweezers, microscopically small objects can be held and manipulated. At the same time, the forces exerted on the trapped objects can be accurately measured.

JPK Instruments has developed a quantitative optical tweezers platform, the NanoTracker. This platform allows the controlled trapping and accurate tracking of nanoparticles, suspended either in a microfluidic multichannel flow chamber or even in a temperature-controlled open Petri dish. With its 3D detection system, particle displacements in the trap can be recorded with nanometer precision. Moreover, dynamic forces acting on the particle (e.g. exerted by motor proteins) can be measured with more than piconewton resolution on a sub-millisecond time-scale.

Here, we detail these and further features of the NanoTracker platform. Several successful biophysical applications will be demonstrated. In particular, we show how one of the hallmarks of single-molecule biophysics, the overstretching transition of DNA, can be studied in a versatile manner and used for protein-DNA interaction mechanics. Moreover, on the lower side of the force range the other benchmark single-molecule biophysics, kinesin's 8-nm steps and stall forces, are shown to be measurable.

With the NanoTracker, optical tweezers finally transcend from the labs of self-building scientists who helped the technique mature, to a turn-key system able to serve a much wider community of researchers in the life sciences.