MagneticTwister™ Option for NanoTracker™ 2 Optical Tweezers

The NanoTracker™2 optical tweezers system comes with a large number of translational degrees of freedom allowing the user to manipulate the stage, sample chamber and optical traps independently with high precision. With the MagneticTwister™ option, an additional rotational degree of freedom becomes available. The three-dimensional manipulation possibilities provided by the optical trap are complemented by the ability to apply torque and rotate magnetically sensitive particles in defined steps.

Torque Application and Twisting of Magnetic Particles

The custom-designed magnets in the MagneticTwister™ generate a homogeneous field of 700 mT at a distance of 1 mm in the sample chamber. Depending on the particle's size and susceptibility, forces in the Piconewton range can be applied. Both magnet-sample distance (and thus field strength) and rotation of the magnetic field can be adjusted via the NanoTracker™ 2 control software.

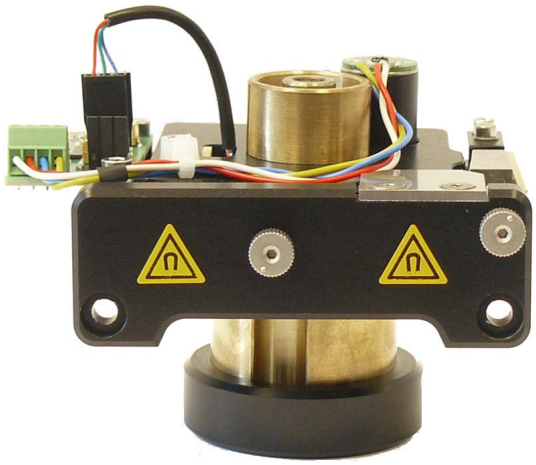

Fig. 1: *Image of the unmounted MagneticTwister™option. It replaces the detection objective holder and is easily aligned with the trap and camera optics. Controlled by an electric stepper motor, the magnets can be rotated 360° with an accuracy of 4° using the provided control software.*

Undisturbed Bright Field and Fluorescence Microscopy

Due to the tubular design, camera-assisted bright field microscopy remains available for the localization of the particle throughout the experiment. Being fully compatible with the approved modular design of the NanoTracker™ 2, no optical ports are obstructed. Thus, all fluorescence techniques that can be routinely combined with JPK's NanoTracker™ 2 (Epifluorescence, CLSM, TIRF) can also be used in combination with the MagneticTwister™ option.

Single Molecule Torsion

By the use of functionalized chamber and magnetic bead surfaces, single molecules like DNA or chromatin can be manipulated and held in a fixed configuration by the optical trap(s) provided by the NanoTracker™ 2. Rotation of the magnets will simultaneously apply a torque to the trapped bead which is transferred to the clamped molecule. This will alter its mechanical pre-tension which, in the case of DNA, has profound effects on the molecule's ability to coil [1] or to interact with enzymes and other molecules [2]. In order to optically evaluate the orientation of the magnetic handle, functionalized nanorods with attached superparamagnetic beads can be bound to the molecule of interest [3] and then be exposed to the rotating magnetic field.

Literature

[1] W. Li, „Impact of DNA Twist Accumulation on Progressive Helical Wrapping of Torsionally Constrained DNA“, *Phys. Rev. Lett.*, Bd. 109, Nr. 21, 2012.

[2] F. Kouzine, S. Sanford, Z. Elisha-Feil, und D. Levens, „The functional response of upstream DNA to dynamic supercoiling in vivo“, *Nature Structural & Molecular Biology*, Bd. 15, Nr. 2, S. 146–154, Jan. 2008.

[3] A. Celedon, I. M. Nodelman, B. Wildt, R. Dewan, P. Searson, D. Wirtz, G. D. Bowman, und S. X. Sun, „Magnetic Tweezers Measurement of Single Molecule Torque“, *Nano Letters*, Bd. 9, Nr. 4, S. 1720–1725, Apr. 2009.