Fiber-optical light-force trap - *optical stretcher:*

A stable three–dimensional light-force trap can be build using two single mode optical fibers (Fig. 1). The trapping forces can be resolved into two components:

- ✓ the ***scattering force***, which pushes particles in the direction of the laser propagation, and
- ✓ the ***gradient force***, which pushes particles in the direction of increasing intensity.

The gradient force provides the capture of the particle in the directions x and y, whereas stable trapping in the z direction is provided by the counterpropagating laser beams, where the scattering forces of the two beams equal each other at a certain z-position. (Fig. 2 a)

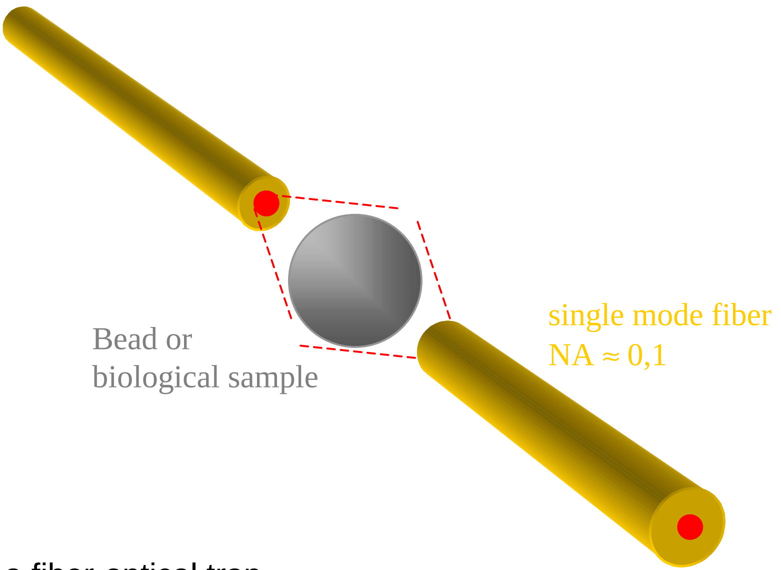

Fig. 1: Set-up of a fiber-optical trap

Advantages of this fiber-optical trap compared to the common optical tweezers:

- ✓ the trap is decoupled from the microscope objective, allowing a greater freedom in viewing the samples
- ✓ the trap is simple and inexpensive (no filters, beamsplitters, dichroic mirrors, telescopes are required)
- ✓ no focus is needed for stable trapping, so the light power for similar laser beam intensities can be two or three orders of magnitude greater than in optical tweezers
- ✓ a conventional optical microscope can be used

The fiber-optical implementation is simple, but there are several types of ***fiber misalignment***:

- ✓ a ***translational displacement*** (Fig. 2 c) (leadind to an oscillation back and forth between the fiber faces and finding no stable trapping) and
- ✓ a ***rotational disalignment*** (Fig. 2 d) (stable trapping is possible) and
- ✓ ***both types*** of misalignment at the same time

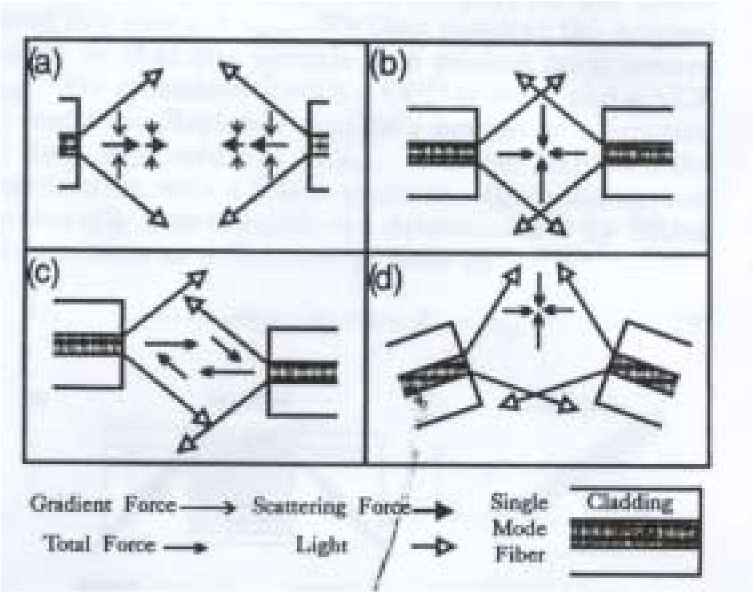

Fig. 2: Taken from Ref. 1

→ → Special application

Introduction to optical deforming forces:

Beside the possibility to confine particles using a fiber-optical trap, this implementation, using two counterpropagating laser beams, can be used to significantly stretch soft particles, e.g. cells. The deforming forces, acting on the surface between the object and the surrounding medium, are considerably higher than the trapping forces on the object. One might expect that the scattering forces from the two beams might compress the cell, but exactly the opposite occurs. The cell is stretched along the z-axis. This is due to the change of momentum if light is entering or exiting a particle with a higher (or lower) index of refraction. The forces arising act on the surface, away from the particle.

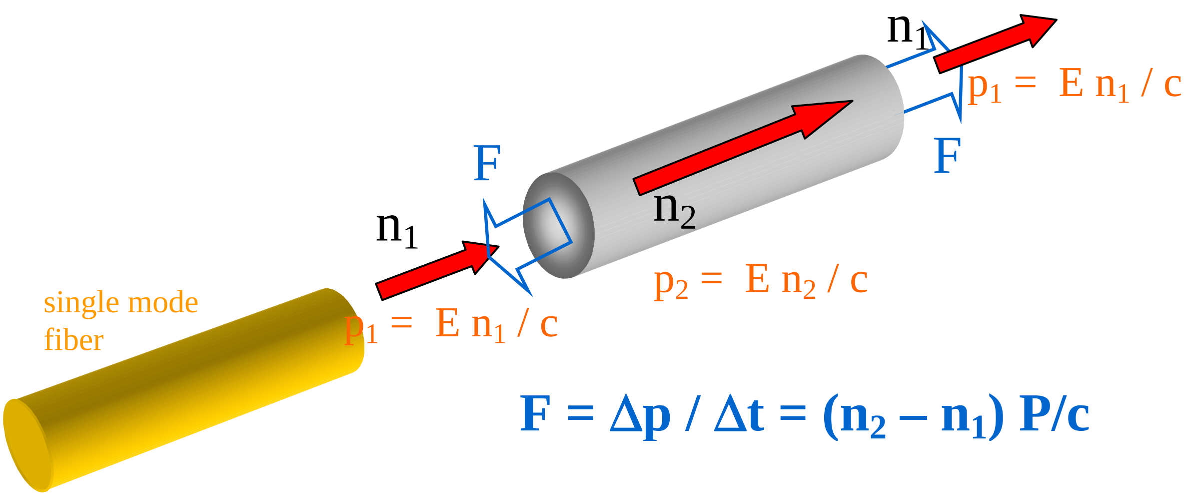

Fig. 3: Principle of Optical Stretching (if one single mode fiber is present)

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