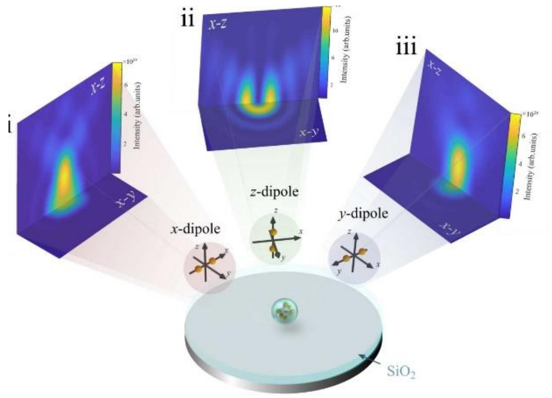
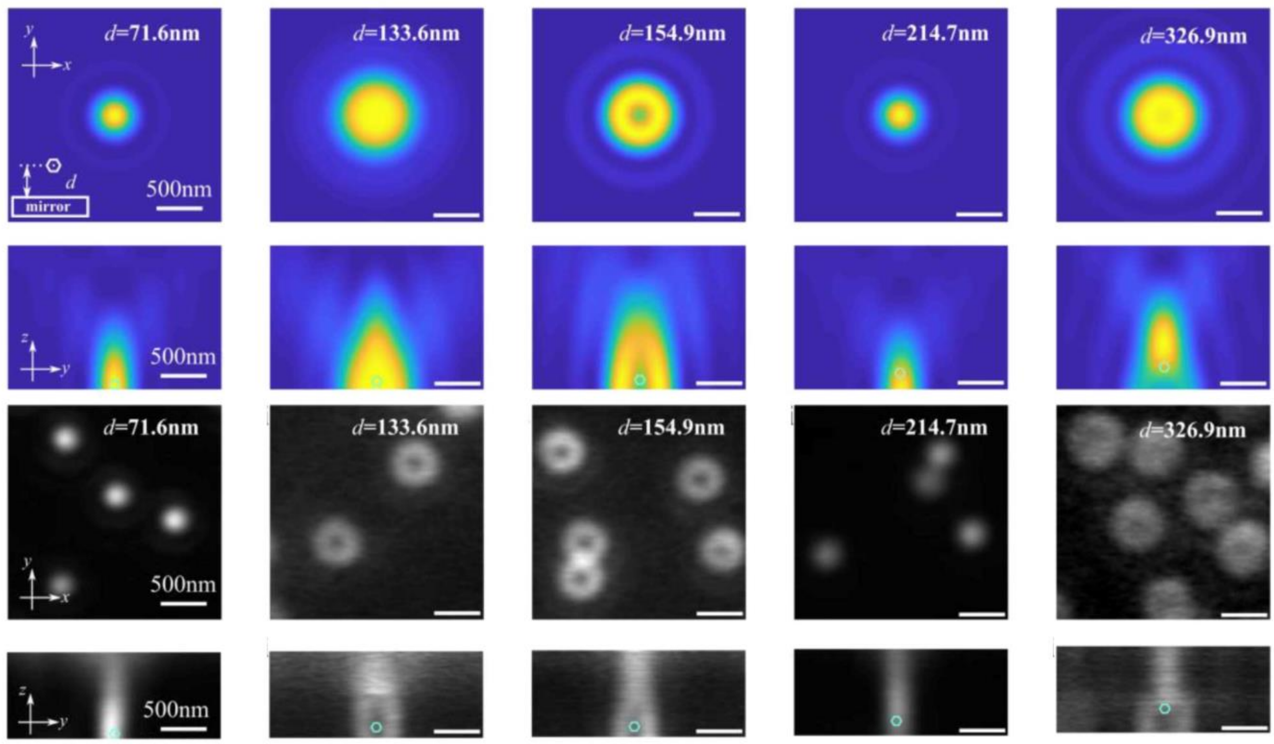
Real-time optical distance sensing of up-conversion nanoparticles with a precision of 2.8 nanometers

Sub-diffraction limited localization of fluorescent emitters is a major goal of microscopy imaging. It is of key importance for so-called super-resolution, a technique that was awarded the Nobel Prize in Chemistry in 2014. A cooperation of researchers in Australia, China, the USA and **IRIS Adlershof** have now demonstrated ultra-precise localization and tracking of fluorescent nanoparticles dispersed on a mirror. The many randomly oriented molecular dipoles in such up-conversion nanoparticles (UCNPs) interfere with their own mirror images and create unique, bright and position-sensitive patterns in the spatial domain.



Calculated self-interference of a single nanoparticle placed on a mirror substrate with a silica layer as the spacer. (i), (ii) and (iii) show different cuts through the far-field patterns of oriented dipoles oscillating along the x, y and z-axis, respectively

The pattern can be detected in the far-field by a sensitive camera and was compared to a detailed and quantitative numerical simulation. In this way it was possible to localize individual particles with an accuracy of only 2.8 nm, a value which is smaller than 1/350 of the excitation wavelength.



Simulated (topmost two rows) and experimental (bottommost two rows) far-field self-interference emission patterns.
The particle- to-mirror distance in- creases from the left to the right column from 72nm to 327nm. All scale bars are 500 nm.

The localization can be performed rapidly, and a single particle can be followed with a 50Hz frame rate. This is much faster than other self-interference-based methods based on mapping of the fluorescence spectrum. A special benefit of UCNPs is their high photo-stability and sensitivity, e.g. to temperature and PH. Therefore, the novel technique may be used for high-resolution multimodality single-particle tracking and sensing.

Axial Localization and Tracking of Self-interference Nanoparticles by Lateral Point Spread Functions

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