

# Far-field optical nanoscopy: principles and recent advancements

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Throughout the 20<sup>th</sup> century it has been widely accepted that, at the end of the day, a light microscope relying on conventional lenses (far-field optics) cannot discern details that are finer than about half the wavelength of light (> 200 nm). However, in the 1990s, it was discovered that overcoming the diffraction barrier is realistic and that fluorescent samples can be resolved virtually down to molecular dimensions. Here we discuss the simple yet powerful principles that allow neutralizing the resolution-limiting role of far-field optical diffraction<sup>1,2</sup>. In a nutshell, features residing closer than the diffraction barrier are prepared in different molecular (quantum) states so that they are distinguishable for a brief detection period. As a result, the resolution-limiting role of diffraction is overcome, and the interior of transparent samples, such as living cells and tissues can now be imaged non-invasively at the nanoscale using focused light in 3D.

Besides discussing basic principles, we will show most recent advancements. In particular, we demonstrate massive parallelization of RESOLFT and STED recording using simple patterns of light, by more than 100,000 fold<sup>3</sup>. Likewise, we demonstrate the relevance of emerging 'far-field optical nanoscopy' to various areas, especially to the life and the material sciences.

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2. Hell, S.W. Microscopy and its focal switch. *Nature Methods* **6**, 24-32 (2009).
3. Chmyrov, A. et al. Nanoscopy with more than 100,000 'doughnuts'. *Nature Methods* (2013).