Axial Colocalization of Single Molecules with Nanometer Accuracy Using Metal-Induced Energy Transfer

Sebastian Isbaner[1], Narain Karedla[1,2], Izabela Kaminska[3,4,6], Daja Ruhlandt[1], Mario Raab[3,5], Johann Bohlen[3,5], Alexey Chizhik[1], Ingo Gregor[1], Philip Tinnefeld[3,5], Jörg Enderlein*[,1,2], Roman Tsukanov*[,1]

[1] Third Institute of Physics – Biophysics, Georg August University, Göttingen, Germany

[2] DFG Research Center "Nanoscale Microscopy and Molecular Physiology of the Brain" (CNMPB), Göttingen, Germany

[3] Institute for Physical and Theoretical Chemistry, Braunschweig Integrated Centre of Systems Biology (BRICS), and Laboratory for Emerging Nanometrology (LENA), Braunschweig University of Technology, Braunschweig, Germany

[4] Institute of Physics, Faculty of Physics, Astronomy, and Informatics, Nicolaus Copernicus University, Torun, Poland

[5] Department of Chemistry and Center for NanoScience, Ludwig-Maximilians-Universität München, München, Germany

[6] Current address: Institute of Physical Chemistry of the Polish Academy of Sciences, Warsaw, Poland

Email: roman.tsukanov@phys.uni-goettingen.de

Keywords

Single-molecule fluorescence, super-resolution microscopy, plasmonics, DNA origami, MIET microscopy, fluorescence lifetime, DNA-PAINT

Super-resolution microscopy today is able to resolve structures on the order of a few nanometers, far below the optical diffraction limit. In particular, single-molecule localization methods are used routinely to resolve biomolecular structures by making use of fluorophore blinking or, alternatively, binding events of agents carrying fluorophores to the pre-designed docking cites. However, there exists a rather large discrepancy between lateral and axial localization accuracy, the latter typically three to five times worse than the former. Here, we present a new method to localize several emitters along the optical axis with nanometer precision. The core principle behind this is the distance-dependent fluorescence quenching of an emitter close to a metal surface, which we term Metal-Induced Energy Transfer (MIET) [1,2]. We use MIET to colocalize multiple single emitters attached to a DNA origami structure at known heights with an accuracy of 5 nm [3]. Furthermore, we show that by combining MIET with DNA Point Accumulation for Imaging in Nanoscale Topography (DNA-PAINT) technique, it is possible to collect an in principle unlimited amount of photons from each binding site, then enabling to improve the axial resolution even further.

[1] Chizhik, A. I.; Rother, J.; Gregor, I.; Janshoff, A.; Enderlein, J., *Nat Photon* 2014, 8 (2), 124-127.
[2] Karedla, N., Chizhik, A. I., Gregor, I., Chizhik, A. M., Schulz, O., Enderlein, J., *ChemPhysChem* 15(4), 705-711 (2014).
[3] Isbaner, S., Karedla, N., Kaminska, I., Ruhlandt, D., Raab, M., Bohlen, J., Chizhik, A., Gregor, I., Tinnefeld, P., Enderlein, J., Tsukanov, R., *Nano Lett*. 18, 2616–2622 (2018).