ÚFE Institute of Photonics and Electronics
The Czech Academy of Sciences

PRESS RELEASE

Prague, February 10, 2021

Flickering shadows of the fine skeleton of a cell

New light-microscopy method enabled high-speed imaging of the protein choreography and dynamics.

Scientists have, for the first time, directly imaged fluctuations in the shape of single macromolecular species using a rather simple optical microscope. “Ever since super-resolution microscopy revealed nanoscopic details about where in the cell specific single biomolecules do their job, we have dreamed about seeing the dynamics of the protein machinery, which keeps life ticking,” says Marek Piliarik from the Institute of Photonics and Electronics in Prague.

Light microscopy offers an invincible insight into the dynamics of biological matter. However, the level of spatial details is intrsically limited by the diffraction limit of light. Therefore the shape of sub-diffractional species can not be optically resolved. In the work just published in Small Methods [1], Vala et al. introduce a new microscopy toolbox to discern the shape of protein structures. They employed the new method to visualize a series of individual conformational changes confined deep below the diffraction limit of light that characterize the dynamics of single disassembling microtubules essential for cell function.

Microtubules are among the most dynamical cellular structures that perpetually grow and shrink, enabling vital processes in cells including division or motility. The presence of nanometer-sized curved structures at the tip of a disassembling microtubule observed on static electron micrographs have puzzled scientists for decades. However, to date, no time-resolved data has allowed them to gain an insight into the disassembly process. Now, the group of authors from Prague have discerned the changes in the light scattering of protein structures owing to fluctuations in their immediate shape even though these transient segments are normally hidden in the diffraction-blurred edge of the microtubule. They were able to capture the choreography, rate, amplitude, and spatiotemporal displacement of transient structural changes at the tip of disassembling microtubules. Zdenek Lansky from the Institute of Biotechnology adds a biological perspective to the work “The unprecedented resolution of the method enables us to better understand the dynamic changes in the structure of microtubules — elusive mechanisms that underpin essential biological processes, such as cell division.”

To achieve this, researchers adopted one of the most sensitive light microscopy techniques, recently coined as interferometric scattering microscopy, which is ultimately capable of imaging single unlabeled proteins. The team from two institutes at the Czech Academy of Sciences pushed the limits of the technology beyond just detecting the light extinction signal cast by a structure of one or a few protein molecules in a split of a millisecond. The variation in a specific fraction of its signal allowed the scientists to resolve changes in the immediate shape of the protein structures. “The fact that we can see protein-sized structures changing shapes only milliseconds before they break apart still amazes us. When considering the method’s capability of non-invasive imaging with up to MHz repetition rates, we believe it has significant potential to become a new window into cell machinery. The concept of seeing geometrical details of objects hidden in the diffraction blurr is a great opportunity for the whole field of optical microscopy”, predicts Milan Vala, the first author of the publication. Marek Piliarik shares his vision “We believe that our technique will open a whole new field of applications similar to super-resolution microscopy that do not rely on a fluorescent probe to light up but simply resolve a particular conformation of natural protein structures.”

Reference:

[1] M. Vala, L. Bujak, A.G. Marin, K. Holanova, V. Henrichs, M. Braun, Z. Lansky, M. Piliarik, Nanoscopic Structural Fluctuations of Disassembling Microtubules Revealed by Label-Free Super-Resolution Microscopy, Small Methods, DOI: 10.1002/smtd.202000985

Contact information:

Corresponding author:
Marek Piliarik, Ph. D.
Phone: +420 777 012 991
E-mail: piliarik@ufe.cz
Institute of Photonics and Electronics of the Czech Academy of Sciences
Chaberská 1014/57, Prague 182 51, Czech Republic

Public relations coordinator:
Petra Palečková, MSc.
Phone: +420 266 773 429
E-mail: paleckova@ufe.cz
Institute of Photonics and Electronics of the Czech Academy of Sciences
Chaberská 1014/57, Prague 182 51, Czech Republic

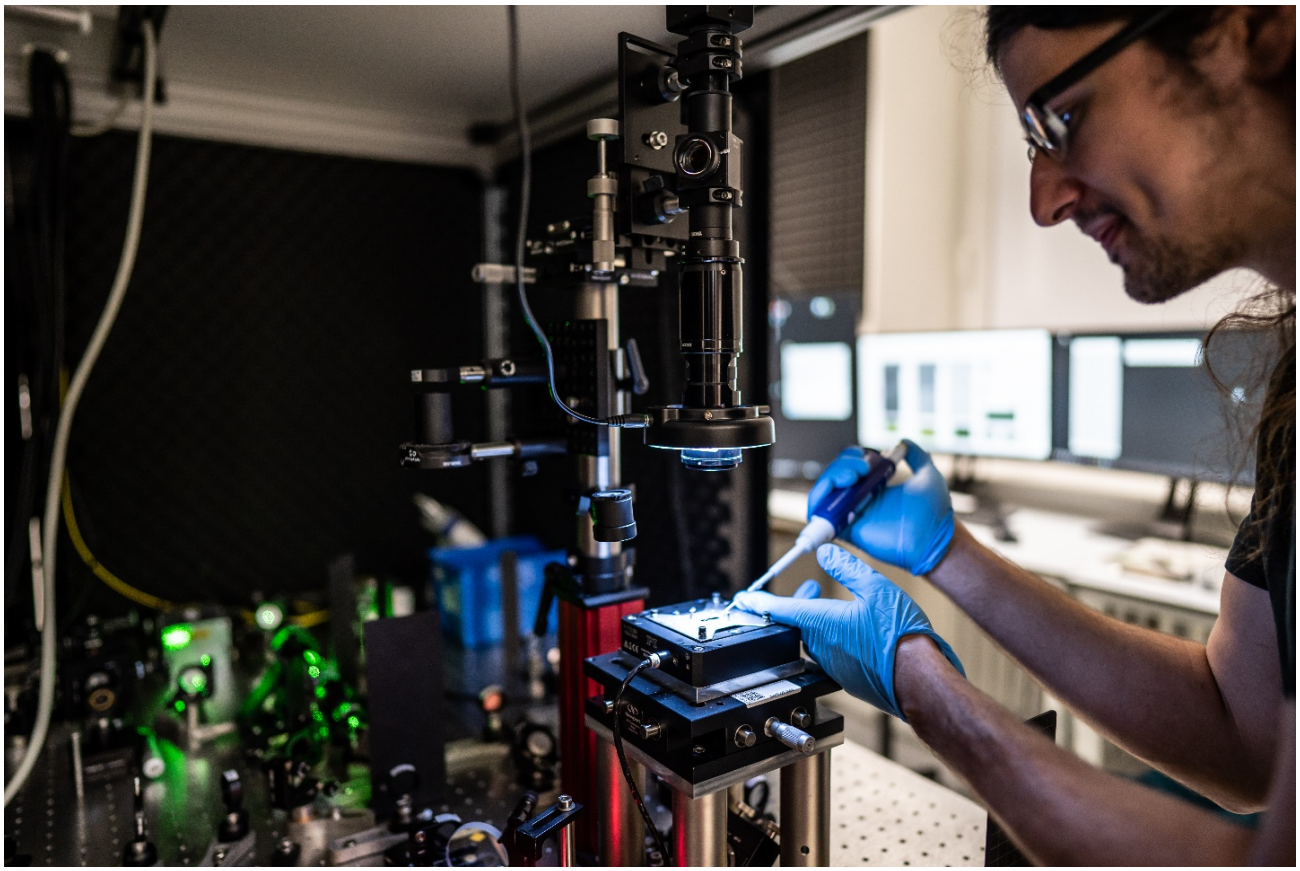

Image credits: Institute of Photonics and Electronics

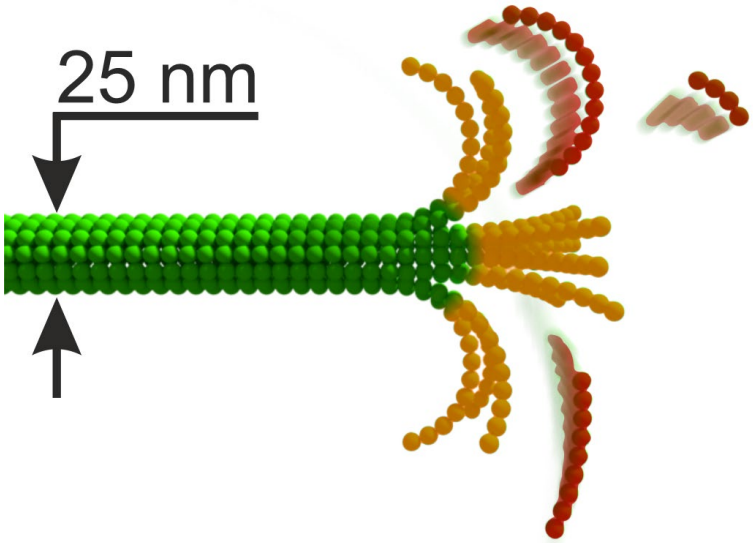

Fig: Illustration of a disassembling microtubule. The new microscopy method allows researchers to discern the microtubule shaft from the curved structures at the microtubule tip as well as the momentarily disassembled protein segments.