Materials Research Seminar

Texas Center for Superconductivity at the University of Houston

Center for Integrated Bio and Nano Systems

Mapping cellular function using 3D single-molecule tracking and super-resolution microscopy

November 22, 2024

Face to Face: 10:00 am

Location: HSC 102

Prof. Anna-Karin Gustavsson

Department of Chemistry,

Rice Unviersity

Abstract:

Cellular function is governed by the molecular organization and interactions at the nanoscale. In this talk I will demonstrate our recent developments for improved 3D single-molecule tracking of dynamics and super-resolution imaging of nanoscale structures throughout mammalian cells and showcase applications of our approaches for cellular imaging. First, I will describe soTILT3D, an imaging platform that consists of a steerable, dithered, single-objective tilted light sheet for optical sectioning to reduce fluorescence background, photobleaching, and the risk of photodamaging sensitive samples, together with a novel 3D nanoprinted microfluidic chip for environmental control and for reflection of the light sheet into the sample. By combining these approaches with point spread function (PSF) engineering for nanoscale localization of individual molecules in 3D; deep learning for analysis of overlapping emitters; active 3D stabilization for drift correction and long-term imaging; and Exchange-PAINT for sequential multi-target imaging without chromatic offsets, we showcase whole-cell multi-target 3D single-molecule super-resolution imaging with improved accuracy, precision, and imaging speed. Next, I will demonstrate a versatile multimodal illumination platform that integrates the optical sectioning capabilities of light sheet illumination with uniform, flat-field epi- and TIRF illumination, resulting in more precise and accurate quantitation of single-molecule data. Finally, I will discuss how novel long axial-range double-helix PSFs offer stitching-free, 3D super-resolution imaging of whole mammalian cells, simplifying the experimental and analysis procedures for obtaining volumetric nanoscale structural information. Furthermore, we show that deep learning-based analysis drastically improves the achievable imaging speed and resolution with these PSFs. These imaging approaches are versatile and can be utilized to study molecular dynamics, nanoscale structures, and molecular mechanisms to address a wide range of chemical, biological, and biomedical questions related to cellular function and pathogenesis.

Bio: Dr. Gustavsson joined the faculty at Rice University in 2020 as a CPRIT Scholar in Cancer Research and the Norman Hackerman-Welch Young Investigator Chair. Her research group strives to gain detailed information about cellular nanoscale structures, dynamics, and molecular mechanisms by developing and applying innovative and versatile single-molecule tracking and super-resolution imaging tools. Dr. Gustavsson received her PhD in Physics from the University of Gothenburg, Sweden, before joining the group of Nobel Laureate W. E. Moerner at Stanford University as a Postdoctoral Fellow in 2015. She founded the Center for Nanoscale Imaging Sciences in 2024. Her work has been recognized with multiple honors, including the FEBS Journal Prize for Young Scientists, the Swedish Research Council International Postdoc Fellowship, the PicoQuant Young Investigator Award, the NIH K99/R00 Pathway to Independence Award, the CPRIT Recruitment of First-Time Tenure-Track Faculty Members Award, the Scialog: Advancing Bioimaging Fellowship, and the Edward S. and Fofo Lewis Chemistry Research Award.