

Lecture 6: Wednesday, July 3

High-speed and high-resolution imaging of brain activity

Na Ji

University of California, Berkeley

Abstract

To understand computation in the brain, one needs to understand the input-output relationships for neural circuits and the anatomical and functional relationships between individual neurons therein. Optical microscopy has emerged as an ideal tool in this quest, as it is capable of recording the activity of neurons distributed over millimeter dimensions with sub-micron spatial resolution. I will describe how we use concepts in astronomy and optics to develop next-generation microscopy methods for imaging neural circuits at higher resolution, greater depth, and faster speed. By shaping the wavefront of the light, we have achieved synapse-level spatial resolution through the entire depth of primary visual cortex, optimized microendoscopes for imaging deeply buried nuclei, and developed a video-rate (30 Hz) volumetric imaging method. We apply these methods to understanding neural circuits, using the mouse primary visual cortex as our model system.

References:

1. Lu R, Sun W, Liang Y, Kerlin A, Bierfeld J, Seelig J, Wilson DE, Scholl B, Mohar B, Tanimoto M, Koyama M, Fitzpatrick D, Orger MB, Ji N, "Video-rate volumetric functional imaging of the brain at synaptic resolution." *Nature Neuroscience* (2017) 20, 620-628.
2. Sun W, Tan Z, Mensh BD, Ji N, "Thalamus provides layer 4 of primary visual cortex with orientation- and direction-tuned inputs." *Nature Neuroscience* (2016) 19, 308–315.
3. Wang C, Liu R, Milkie DE, Sun W, Tan Z, Kerlin A, Chen T, Kim DS, Ji N, "Multiplexed aberration measurement for deep tissue imaging in vivo." *Nature Methods* (2014) 11, 1037–1040.

BIOGRAPHICAL SKETCH

Na Ji studied chemistry and physics as an undergraduate in the University of Science and Technology of China and later a graduate student at the University of California, Berkeley. In 2006, she moved to Janelia Research Campus, Howard Hughes Medical Institute, and worked with Eric Betzig on improving the speed and resolution of in vivo brain imaging. She became a group leader at Janelia in 2011. In 2017, she moved to the Department of Physics and Department of Molecular & Cell Biology at the University of California, Berkeley as the Luis Alvarez Memorial Chair in Experimental Physics. She is also affiliated with the Bioengineering, Biophysics, and Vision Science Graduate Programs, Helen Wills Neuroscience Institute, and serves as a faculty scientist at the Lawrence Berkeley National Laboratory. In addition to imaging technology development, her lab also applies the resulting techniques to outstanding problems in neurobiology.