UCLA College | Physical Sciences
Physics & Astronomy

Physics and Astrophysics Special Seminar

Monday, March 15, 2021
2:00 p.m.

Cracking neural circuits of a simple brain

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How do brains compute? The *Drosophila* (fruit fly) larva is a small, semi-transparent crawling organism with about 10,000 neurons, compared to 100 billion in humans and 100 million in mice. Despite this simplicity, the larva carries out information-processing tasks, including navigation – moving towards a favorable location based on information from its senses. A century of genetic work in *Drosophila* combined with recent innovations in protein engineering allow us to use light to directly activate specific neurons in the larva. For instance, we can engineer larvae with light-activable neurons in their “noses.” When presented with red light, these larvae perceive an odor and respond by attempting to find its source. Using sophisticated light patterns and analysis methods, we developed an assay that allowed us to quantify how the larva makes decisions based on multiple sources of sometimes conflicting information.

Advances similar to the ones that allow us to activate neurons using light allow us to measure thought patterns using light microscopes. Because the larva is almost clear, it has been a long-standing goal to use a microscope to “read the larva’s mind” as it navigates its surroundings. However, the 3D brain movements generated by the larva’s complicated locomotion have prevented optical recording of neural activity in behaving larvae. We developed a two-photon microscope capable of tracking single neurons moving rapidly in 3D while monitoring their activity in real time without motion artifacts. To record from many neurons we added a second beam that scans the volume around the tracked neuron to enable motion-corrected volumetric imaging in a freely-behaving animal. This allowed us to image correlated activity of motor and pre-motor neurons from a significant portion of larva’s “spine” in a completely unrestrained crawling animal. I will use these techniques to follow information flow through the larva’s circuits during sensory-motor transformations and achieve a neuron-level understanding of how a simple brain implements fairly complex calculations.

Mirna Mihovilovic Skanata is a Postdoctoral Associate in the Center for Soft Matter Research at New York University. To understand how brains process information and make decisions, Mirna has developed a two-photon microscope that enables her to image neural activity with single-cell resolution in a freely moving model organism. By reading out the activity while the animal receives stimulus and makes decisions, Mirna aims to achieve a circuit-wide understanding of how a tiny brain of a fruit fly larva implements complex computations. Mirna received her PhD in Physics from Brown University, where her experimental work straddled the border between biophysics and nanotechnology. She created solid state nanopores, artificial nanometer-scale ionic channels that can thread long DNA polymers. These single-molecule detectors helped address fundamental questions of polymer physics and inspired technological applications. Throughout her career, Mirna has developed novel technologies to tackle questions at the interface of physics and life.