

Chen Institute Symposium 2021

Speakers: Larry Abbott and Gaby Maimon

Title: How brains add vectors

Abstract: Many cognitive computations rely on the nervous system estimating mathematical vectors, but aside from computer models, how brains represent vectors or perform vector operations remains unknown. In this talk, we will describe how the *Drosophila* brain performs vector arithmetic. Specifically, we will show that fly brains have explicit neural signals that track the direction in which their body is traveling in reference to external cues, like the sun. These new signals differ from previously characterized neurons in *Drosophila* and mammals that track heading (e.g., head-direction cells) and they begin to illuminate how the sense of space is properly updated when traveling and heading angles differ. We will then provide evidence that *Drosophila*'s world-referenced traveling direction signal is constructed via a neural circuit that rotates, scales, and adds four input vectors that track the fly's traveling angle referenced to its own body axis. By combining these newly described traveling-direction signals with traveling speed, and integrating over time, it becomes sensible to imagine the mechanics of how insects form spatial memories as they navigate. The central features of this vector calculator may generalize to other nervous systems and other cognitive domains beyond navigation where vector operations or reference-frame transformations are required.