Elad Harel

Title: Optical Pulse Trains - From Tracking Viruses to Directing Material Synthesis

Abstract: Optical pulse trains offer unprecedented opportunities to interrogate and control matter with high spatial and temporal precision. In this talk, I will describe how structured sequences of light may be used both to measure the vibrational dynamics of single viruses and to direct the crystallization of metal halide perovskite materials.

In the first part, I will introduce *BioSonics*, an all-optical approach that leverages ultrafast spectroscopy to detect long-lived acoustic vibrations in individual virions under ambient conditions. These vibrational signatures, spanning frequencies in the ultralow GHz range, encode information about virus morphology, protein interactions, and environmental coupling at the single-particle level. This capability opens a new window for tracking the mechanical properties of complex biological systems without the need for external labels.

In the second part, I will present a novel method for light-induced crystallization (LIC), in which temporally sequenced optical pulses are used to initiate and control perovskite crystal growth at nanoscale nucleation sites. This pulse-train approach enables deterministic, site-selective crystallization far-from-equilibrium conditions, allowing for spatiotemporal programming of crystal structure and morphology.  Using high-speed spectroscopy and imaging, we capture real-time phase transitions, revealing transient metastable states, molecular cluster attachment, and critical nucleation events.