



**The Chinese University of Hong Kong  
Department of Biomedical Engineering**



**Graduate Seminar – PhD Oral Defence**

**Student** : Mr. ZHU Hongfei  
**Supervisor** : Prof. ZHOU Renjie  
**Date** : 15 January 2026 (Thursday)  
**Time** : 10:30 am  
**Venue** : Room 1122, William M W Mong Engineering Building, CUHK

**Title: Three-dimensional Multimodal Optical Microscopy with Ultrahigh Spatial-temporal Resolution for Biomedical Imaging Applications**

Light microscopy is fundamental to studying life processes across scales. Diverse biological applications have driven the development of specialized modalities such as confocal, light sheet, and super-resolution microscopy, each optimized for specific performance parameters like resolution, speed, field of view and penetration depth. However, inherent trade-offs among these metrics preclude a universally optimal design, often making a single microscope inadequate for comprehensive studies. Consequently, laboratories typically employ multiple instruments, a practice that introduces operational complexity and impedes true correlative imaging of the same specimen across scales. Therefore, an integrated multimodal platform is critically needed to address broader biological questions. Furthermore, existing techniques struggle to meet the demanding requirements of certain specific scenarios. A prime example is the long-term live-cell imaging of organelle interactions, which necessitates the simultaneous achievement of three-dimensional (3D) super-resolution, high speed, and minimal photodamage. Tackling such challenges requires innovative imaging paradigms that transcend conventional performance trade-offs.

In this talk, we will present our recent progress on 3D multimodal optical microscopy. We will first present the developed multimodal platform based on a commercial microscope framework, achieving label-free modalities, ultrafast 3D light-field microscopy (LFM), and multiple super-resolution methods, including structured illumination microscopy (SIM) and single molecule localization microscopy (SMLM). Next, we will describe DAO-MBS, a label-free tomographic phase imaging technique enhanced by digital adaptive optics (DAO), which delivers high-fidelity, aberration-free performance in complex biological settings. We will also show how the DAO module has been extended to LFM, resulting in our HiFi-sLIM method for deep-tissue and in vivo imaging. Subsequently, we will demonstrate how combining complementary modalities enables novel imaging paradigms. Through the integration of SIM and SMLM, we developed SMILE, a 3D modulation-enhanced localization microscopy method that achieves spatially invariant 10 nm resolution for analyzing ultra-fine cellular structures. Lastly, by merging SIM with LFM, we realized S<sup>2</sup>LIM—an ultrafast 3D super-resolution approach ideally suited for long-term live-cell imaging studies.

**\*\*\* ALL ARE WELCOME \*\*\***

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