The Chinese University of Hong Kong
Department of Biomedical Engineering

Graduate Seminar – PhD Oral Defence

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Date	**:**	27 May 2025
Time	**:**	2:00 pm
Venue	**:**	Room 1122, William M W Mong Engineering Building, CUHK

Title: Pushing the Spatial Resolution Limit of Quantitative Phase Microscopy

The 2023 International Roadmap for Devices and Systems (IRDS) highlights the critical demand for metrology tools capable of atomic-scale characterization to advance semiconductor technologies beyond complementary metal-oxide semiconductor (CMOS) limits. However, existing techniques lack sufficient accuracy and throughput in ambient conditions. Concurrently, in life sciences, real-time observation of ultrathin subcellular structures of living cells in their native and unlabeled states is of great significance for studying biological processes such as cell migration and motility, while the weak signals generated by such thin structures limit the imaging contrast, thereby reducing the resolvability.

Quantitative phase microscopy (QPM), a label-free coherent imaging method, has been widely applied to material metrology and bioimaging applications. Spatial resolution, determining the smallest structures that can be resolved, is a key performance factor in optical imaging. However, existing resolution criteria for intensity-based incoherent imaging techniques cannot be directly applied to QPM, since the resolution capability of coherent imaging is phase-dependent. Furthermore, the practical resolution limit is inextricably tied to the signal-to-noise ratio (SNR). To enhance the SNR, numerous noise suppression strategies have been proposed, while the phase noise is ultimately limited by the photon-shot noise and background surface undulations, restricting the accuracy to the Ångstrom level. Therefore, we develop innovative strategies to improve SNR and push the spatial resolution limit in QPM and demonstrate new applications.

In this talk, I will first present Phase Amplification microscopy (Φ-Amp) as a paradigm shift from phase noise suppression to signal enhancement, enabling femtometer-level accuracy for quantifying subatomic features. Then, I will introduce a substrate-enhanced QPM technique leveraging the principle of Φ-Amp, which achieves high-SNR imaging of ultrathin subcellular structures in living cells. Building on these advancements, I will present our quantitative investigation of the influence of SNR on spatial resolution and propose strategies to push the spatial resolution limit in experiments. Finally, I will introduce our development of a high-resolution QPM method with second harmonic generation and structured illumination to achieve a fourfold resolution enhancement.

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

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