The Chinese University of Hong Kong
Department of Biomedical Engineering

Graduate Seminar – PhD Oral Defence

Student : Ms. NIE Yujie
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Date : 4 July 2022 (Monday)
Time : 3:00 pm
Zoom Link : https://cuhk.zoom.us/j/97539344794?pwd=eVJaZW1WcTR0YjRlZGtackxnd0xEdz09
Meeting ID : 975 3934 4794
Password : 742444

Title: Pushing Phase Sensitivity Limit of Quantitative Phase Microscopy for Nanometrology and Label-Free Bioimaging

Quantitative phase microscopy (QPM) is an emerging label-free imaging technique that has many applications in biomedical investigations and material metrology. Phase or optical pathlength difference (OPD) sensitivity, determining the lowest phase or OPD level that can be detected, is an important merit of a QPM system. Phase sensitivity affects the phase image quality and can be characterized in both time and space domains. The temporal phase sensitivity of current off-axis interferometry-based QPM methods (or simply referred to as off-axis QPM methods) is mostly limited to a few milliradian (or ~ 1 nm in OPD). Further improvements in phase sensitivity will open new potential avenues in nanometrology and bioimaging. Therefore, we propose to develop innovative strategies to push the phase sensitivity limit in off-axis QPM and demonstrate new applications. I will first present our development of new strategies to beat the temporal phase sensitivity limit. This development is based on a theoretical framework that links the temporal phase sensitivity to the camera effective full-well-capacity (EFWC) and effective pixel number under the shot-noise limited detection condition. Spatiotemporal filtering and frame summing algorithms are further developed to beat the temporal phase sensitivity limit to 2 picometers. In the second part of the talk, I will present a thin film thickness profiling method based on our high sensitivity QPM method, termed Transmission-Matrix Quantitative Phase Profilometry (TM-QPP). In TM-QPP, accurate thickness determination is realized by developing a transmission-matrix model that accounts for the multiple refractions and reflections of light at sample interfaces. TM-QPP not only maps the thickness of 2D materials (e.g., MoS_2, $MoSe_2$ and WSe_2) in a wide field but also determines the number of layers in space, while the measurements are conducted in a contact-free manner within a few milliseconds. In the third part of the talk, I will present a label-free bacterial viability analysis method based on our high sensitivity QPM method. The viability of bacteria is critical in determining food safety and water quality. To improve the efficiency and accuracy of classical methods, we propose a high sensitivity diffraction phase microscopy (HS-DPM) method to analyze *E. coli* cell biophysical parameters under different experimental conditions. To foster viability assessment, we applied machine learning to our detection method. The results show that label-free HS-DPM can differentiate *E. coli* viability more precisely than the culture method, thus demonstrating the potential of our approach for more accurate and rapid prediction of the microbial risk of pathogens. Finally, I will conclude the talk and discuss the future work.

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

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