澳門大學
UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU

應用物理及材料工程研究院
INSTITUTO DE FÍSICA APLICADA E ENGENHARIA DE MATERIAIS
INSTITUTE OF APPLIED PHYSICS AND MATERIALS ENGINEERING

IAPME Seminar

First-principles method to study radiative heat transfer and a unified theory for photon transport in the nonequilibrium regime

05 September 2024

Prof. Tao ZHU
Tiangong University
Venue: N23-4018
Time: 10:10 – 11:30

Abstract:
Near-field radiative heat transfer, due to its ultra-high energy transfer efficiency, shows significant potential for application in various emerging technological fields. Currently, the main theoretical frameworks for studying near-field radiative heat transfer problems include the traditional fluctuation electrodynamics (FE) theory and the recently proposed non-equilibrium Green's function (NEGF) method. In both methods, the radiative heat flux between objects depends on calculating the response function of the objects to external electromagnetic fields. This report introduces methods for calculating near-field radiative heat flux between objects at different temperatures based on first-principles methods of density functional theory. It provides calculation formulas that include local field effects for both FE and NEGF approaches. Using two-dimensional materials such as graphene as examples, we present the relationship between near-field radiative heat flux and the distance between objects, as well as the radiation energy spectrum. Then we systematically compare the effects of first-principles methods and traditional theoretical models on response functions such as graphene polarizability. Finally, I will introduce pioneering work on a unified theory of energy, momentum, and angular momentum transfer caused by photon-electron interactions under completely non-equilibrium conditions.

Biography:
ZHU Tao, Associate Professor at Tiangong University, graduated from the Department of Applied Physics at Xi'an Jiaotong University in 2014 and obtained his Ph.D. in Physics from the National University of Singapore in 2019. He has long been engaged in fundamental theoretical research and computation of excited-state properties of materials and photon transport problems. Proposed and established first-principles research methods for near-field radiative heat transfer problems based on the fluctuational electrodynamics (FE) theory and the non-equilibrium Green's function (NEGF) scalar field theory, and developed related computational software. For the first time, unified the propagation of energy, momentum, and angular momentum caused by photon transport into the same theoretical framework. Regarding published achievements, in the past five years, more than 15 papers have been published in well-known domestic and international journals such as Nature Communication, Physical Review B, and Physical Review Applied. Prof. Zhu also serves as the principal investigator on a project funded by the National Natural Science Foundation of China (Grant No. 12204346) and participates in one National Key R&D Program project under the Ministry of Science and Technology of China (Grant No. 2022YFA1204000).

Enquiry: Prof. Pan (huipan@um.edu.mo)