DEPARTMENT OF PHYSICS AND ASTRONOMY
COLLOQUIUM IN-PERSON ONLY EVENT

Nanoscale Understanding of Chemical Heterogeneity and Light-Matter Interactions

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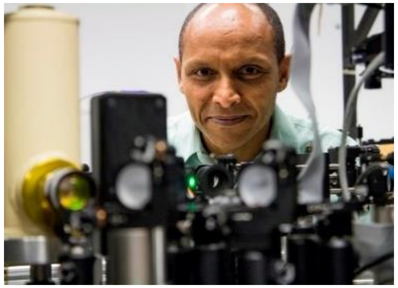
Many physical and chemical phenomena that influence device performance occur at the nanoscale, but these can be hidden in diffraction-limited optical microscopy and spectroscopy. A nanoscale understanding of these phenomena can lead to advancements in various technological applications, including display devices, photocatalysis, sensors, and quantum technologies. In this talk, I will discuss recent results from two related research areas based on tightly localized electromagnetic near-field effects. The first part of the talk will focus on the role of chemical heterogeneities in the directional self-assembly of nanoscale organic materials and on the molecular-level understanding of structures in solid films of colloidal nanoparticles with surface ligands. Using scattering-type scanning near-field optical microscopy (s-SNOM), we reveal diverse structural information and chemical identities in both organic and inorganic materials. The second part will highlight plasmon-vibration coupling effects as a function of laser-plasmon detuning, along with precise resonance tuning achieved by exploiting the photothermal response of polyelectrolytes (PEs). Raman scattering signals from CH bond vibrations in PEs within plasmonic nanocavities are significantly enhanced when laser-plasmon blue detuning aligns with the vibrational frequency. These findings support molecular optomechanics theory, which predicts vibrational mode amplification and increased Raman sensitivity when plasmon resonance overlaps with Raman emission. Furthermore, precise plasmon resonance tuning is achieved through the photothermal response of PEs, which dynamically adjust their thickness at the picometer scale under laser illumination and undergo phase transitions. This tunability enables control over gap-dependent photophysical processes, such as optomechanical Raman enhancement, electron tunneling, and charge transfer plasmons, opening new avenues for nanophotonic applications.



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