ICFO

PhD THESIS DEFENSE: Tailoring the Direction and Polarization of Mid-Infrared Thermal Emission with van der Waals Materials

MICHAEL THOMAS ENDERS

September 29, 2025
14:00
ICFO Auditorium and Online (Teams)

The mid-infrared spectral region holds signi?cant potential for applications in energy harvesting and waste-heat recovery, radiative cooling, spectroscopy, sensing, thermal camou?age and night vision, among others. Conventional approaches to controlling mid-infrared (mid-IR) radiation with metamaterials and metasurfaces often rely on intricate fabrication methods. Commercial components for mid-IR photonics rely on materials that limit their scalability and accessibility. In this thesis, we explore how van der Waals (vdW) heterostructures, with their intrinsically anisotropic optical properties and deeply subwavelength thicknesses, enable unprecedented manipulation of thermal emission in terms of directionality, polarization, and chirality.

We ?rst introduce a straightforward far-?eld method to extract the complex dielectric function of microscopic exfoliated ?akes, facilitating accurate characterization of highly dispersive polar materials without sophisticated near-?eld instrumentation. We demonstrate how ultrathin ?akes of ?-molybdenum trioxide (?-MoO?) can serve as deeply subwavelength phase retarders in the mid-IR, enabling e?cient polarization control at spectral regions inaccessible to conventional bulk optical components. Moreover, we show that by simply twisting two anisotropic ?akes, intrinsic mid-IR chirality can be engineered, resulting in circular dichroism in both absorption and thermal emission, e?ectively transforming inherently incoherent blackbody radiation into circularly polarized emission.

Finally, we develop structures based on anisotropic dielectric spacers within Salisbury screen con?gurations, enabling simultaneous control over the azimuthal and zenithal angles of emitted thermal radiation. Through analytical and numerical analysis, clear design principles are derived and validated using realistic materials. The results presented here establish vdW materials and their heterostructures as versatile platforms for advanced mid-infrared photonic applications, signi?cantly enhancing our capability to precisely tailor thermal radiation across a broad range of practical applications.

Monday September 29, 14:00 h. ICFO Auditorium
Thesis Director: Prof. Dr. Georgia Papadakis
Hosted by: Academic Affairs