Alexander Swinton McLeod

Graduate Institution: University of California - San Diego

Graduate Discipline: Infrared Spectroscopy

Hometown: Vallejo, CA

Relevant SC Research: Basic Energy Sciences

Research Interest:

My primary research interest lies in the theory and application of scanning near-field infrared microscopy and broadband near-field spectroscopy to the study of collective surface modes in materials. This technique uses a conducting AFM tip to locally scatter a focused beam of laser light to a detector, resolving optical contrast along a sample surface at the scale of tens of nanometers. A key challenge facing this novel technique is the development of a quantitative description of the physics at play in the optical tip-sample interaction. New theories now provide the means to numerically extract nano-resolved optical constants from measurements of crystalline, heterogeneous, and thin-film solids. I'm currently applying this technique to study low temperature transitions in correlated oxides, charging mechanisms in lithium matrix crystals, surface modes in topological insulators, tunable graphene plasmons, and spectroscopy of crystal phases in cometary and interstellar grains. I also follow the development of broadband infrared and terahertz laser sources, and study tip-based methods to image low-energy excitations in high-Tc superconductors.

About Me:

Presently I'm a PhD student working in the infrared spectroscopy laboratory of Dimitri Basov at UC San Diego. Coming from an undergraduate background in astrophysics and cosmology, I first become interested in optics and condensed matter theory as a summer student, developing numerical techniques for plasmonics and photonics at Lawrence Berkeley Laboratory's Molecular Foundry. After briefly stepping away from academia to work with the Naval Nuclear Propulsion Program in Washington DC, I returned to LBL as site-lead for the NSF-funded Network for Computational Nanotechnology program, where I directed the development of online simulation tools in topics ranging from photonic crystals to many-body perturbation theory. I specialized particularly in finite-difference time-domain and finite-element modeling of plasmonic nano-structures for applications in light manipulation and tip-enhanced Raman spectroscopy.

Working closely and establishing career-long ties with experimental collaborators, I must have become envious of their toys they called instruments. I hatched a scheme to change gears and focus on hands-on experiments in disciplines I'd heretofore only ever simulated. Working with tip-based near-field infrared imaging and spectroscopy techniques, enabling unrivaled resolution of optical phenomena across a rich energy range, I now forge ties with a spectroscopy community avidly probing the signatures of exploitable many-body physics in next-generation materials, such as graphene and high-Tc superconductors. Among these ranks, my career goal is to establish the merits and theoretical picture of near-field microscopy as a quantitative spectroscopy technique, and to extend it across the energy and temperature regimes necessary for probing phase transitions and correlated excitations down at the natural length scales where they live. With a newly completed high-vacuum cryogenic near-field microscope, and experiments underway, these aspirations are already at the brink of realization.

I like to think of myself as a condensed matter theorist masquerading as an experimentalist, often poring over texts and review articles in valiant attempts to understand the innumerable yet exciting many-body phenomena exhibited in condensed matter systems. With a flair for numerical calculation, I'm constantly reminded there are few physical questions that can't be addressed by some thoughtful coding and a powerful CPU (or two). Outside the lab, I'm an avid runner, hiker, photographer, and keyboardist, with an overly eclectic passion for music and coffee.