Towards unveiling optical excitations and magnetism in 2D materials at the atomic and nanometer scale

Juan Carlos Idrobo

Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, Oak Ridge, TN 37831 USA

The introduction of aberration-correction in scanning transmission electron microscopy (STEM) has allowed the realization of Richard Feynman's long sought dream, atom-by-atom structural and elemental identification of materials, by simply looking "at the thing".

In this talk, I will present our results on two-dimensional materials, including graphene, boron-nitride and dichalcogenides, studied using a combination of monochromation and aberration-corrected scanning transmission electron microscopy with first-principles calculations. In particular, I will show examples of how is possible to study point and extended defects in two-dimensional materials with unprecedented spatial resolution. How one can reveal the bonding characteristics of individual impurities in graphene, the optical response of monolayer graphene with and without impurities, and how the optical response changes as a function of twisted angle in bilayer graphene.

I will also show that chiral signals, such as magnetic dichroism, are the new frontier where aberration-correction STEM can have a significant impact, revealing information that is physically out of reach in X-ray and neutron synchrotrons. I will discuss current and future limitations in the experiments, and what is required to reveal different chiral signals, *i.e.*, magnetic moments (orbital and spin) of individual atoms and the conditions required to produce two-dimensional dilute magnetic semiconductors.
.

This research was supported by the Center for Nanophase Materials Sciences, which is a Department of Energy Office of Science User Facility, and instrumentation within ORNL's Materials Characterization Core provided by UT-Battelle, LLC under Contract No. DE-AC05-00OR22725 with the U.S. Department of Energy.