Shedding Light on Atomically Thin Crystals

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Atomically thin crystals have been studied because of their unique physical properties and possible applications in electronic and optical devices. Light scattering techniques, such as Raman and photoluminescence spectroscopy, have become essential tools to characterize atomically thin crystals. By careful investigation of such spectra, we can further elucidate the intrinsic physical properties of crystals. In this presentation, I will discuss the development of optical methods to extract physical properties of few-atom-thick materials, which are difficult to measure via other techniques. First, low-frequency polarized Raman spectroscopy can be used to determine almost all the mechanical constants of layered materials. By utilizing volume holographic Bragg filters, the Raman spectrum in the low-frequency range (5 to 100 cm^{-1}) can be measured, which allows the study of interlayer vibrations in layered crystals. The coupling between in-plane uniaxial strain and interlayer sliding is observed, and the unexplored off-diagonal components of the elasticity tensor for MoS_2 can be obtained. Secondly, the magnetic ordering in atomically thin crystals is studied by temperature dependent Raman spectroscopy. Antiferromagnetic ordering in the atomically thin limit is challenging to measure because of the inherently small net magnetic moment. Due to the zone-folded Raman modes resulting from the antiferromagnetic ordering, an Ising-type antiferromagnetic ordering in iron phosphorus trisulfide ($FePS_3$) is observed down to the monolayer limit. Finally, a tunable photoluminescence imaging system has been developed and applied to investigate large-area, atomically thin materials synthesized via metal-organic chemical vapor deposition. Photoluminescence and absorption images of samples can be obtained from the micron- to wafer-scale with short acquisition times under wide-field illumination.