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**Ultrafast laser spectroscopy of two-dimensional materials and their heterostructures**

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Monolayer transition metal dichalcogenides are new two-dimensional materials beyond graphene. Recently, extensive studies have revealed several unique properties of these materials and their potential applications in electronic and renewable-energy technologies. Furthermore, it is possible to use these atomic layers as building blocks to fabricate new van der Waals heterostructures with emergent properties. In this talk, I will report our recent ultrafast laser studies of several types of two-dimensional transition metal dichalcogenides and their heterostructures. First, we studied several nonlinear optical processes, such as second harmonic generation, which allows detection of the crystal orientation and symmetry of $MoS_2$ monolayers, and two-photon absorption, which was used to measure the bandgap and exciton binding energy of $WSe_2$ monolayers. Second, we used a transient absorption microscopy technique with high spatial resolution to study exciton dynamics in these materials, and measured their exciton lifetime, diffusion coefficient, and ballistic transport. Third, by performing transient absorption measurements with polarization resolution, we studied spin and valley dynamics of excitons in monolayer $MoSe_2$ and deduced a spin relaxation time of about 9 ps at room temperature. Finally, we used the transient absorption technique with layer selectivity to study heterostructures of graphene-$WS_2$, $MoS_2$-$MoSe_2$, and $WS_2$-$MoSe_2$. We observed ultrafast and efficient charge and exciton transfer across the van der Waals interface in all these structures. The formation of spatially indirect excitons in the transition-metal-dichalcogenide heterostructures was also studied. Furthermore, we found that the optical properties of $WS_2$ can be effectively tuned by carriers in graphene in the graphene-$WS_2$ heterostructure.