Probing Confined Water Monolayer via Excitonic Sensor in Transition Metal Dichalcogenides

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Water under confinement exhibits phase dynamics and properties that differ significantly from those of bulk water [1], yet at the nanoscale it remains challenging to characterize experimentally. In this work, we investigate a monolayer of water intercalated between muscovite mica and 2D materials [2], specifically transition metal dichalcogenides (TMDC), which are excellent hosts for excitonic physics. Through tracking the optical response of excitons, in particular the excited Rydberg states that are highly sensitive to changes in its local dielectric environment [3], we are able to measure the effective screening of 2D water in a cryostat from 4K to 295K non-invasively. In combination with Raman spectroscopy, this study fingerprints the temperature-dependent characteristics of hydrogen-bonding networks, and dielectric response of water monolayer, offering insights into its rich phase and structural characteristics under confinement.

References

[1] Kapil, V. et al. Nature, 609 (2022) 512-516
[2] Xu, K. et al. Science, 5996 (2010) 1188-1191
[3] Xu, Y. et al. Nature, 581 (2020) 241-218

Figures

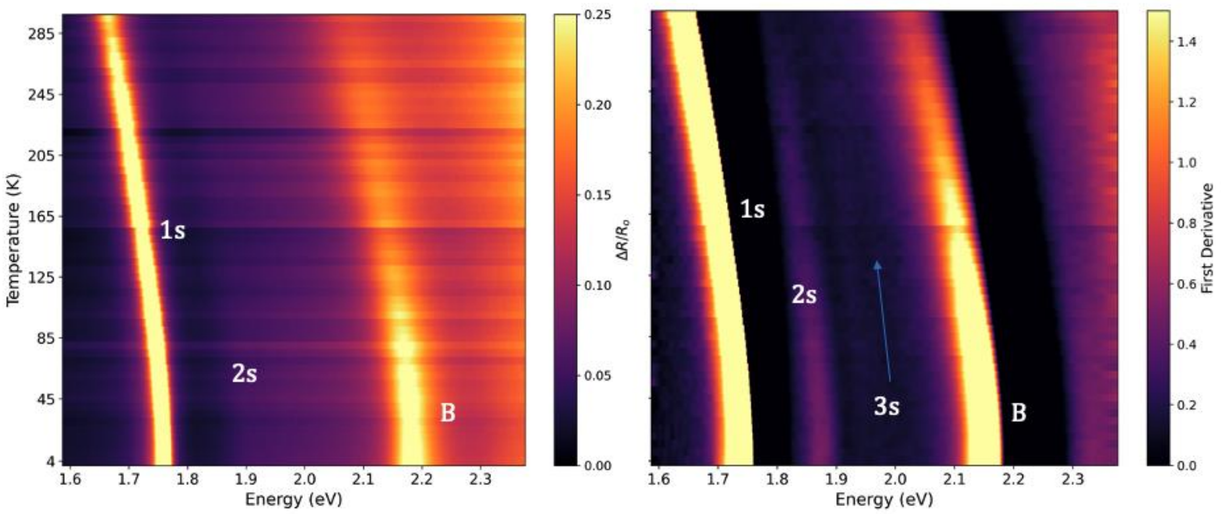

Figure 1: Differential reflectivity and its first derivative of monolayer tungsten diselenide (WSe_2) on mica with a monolayer of water intercalated in between. The spacing among the first (1s), second (2s), and third excited states (3s) of the neutral A exciton reveals effective screening by a monolayer of water across temperatures. The first excited state of the neutral B exciton (B) due to emission from the higher spin split conduction band is also brightly visible on the spectra.