Studying Thermal Transport in 2D Materials using Pre-Time-Zero Spatiotemporal Pump-probe Microscopy

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Understanding heat transport in 2D materials is of great importance to fundamental and applied science. Successful exploitation of the remarkable electronic, optical, and mechanical properties of 2D materials will require an in-depth knowledge and control of their thermal properties. [1] Therefore, there is great interest in the development of techniques to study thermal transport in 2D materials. However, there currently lacks a technique that combines minimal sample fabrication, no required material input parameters, and high sensitivity to small temperature changes.

Recently, [2] we have developed a technique that meets these requirements, based on spatiotemporal pump-probe microscopy. In particular, our technique allows for quantifying thermal diffusivity in nanometer thick 2D materials by exploiting the spatial profile at *pre-time-zero* pump-probe delay, i.e. when probe pulses arrive *before* pump pulses. In this configuration the probe is sensitive to residual heat created by previous pump pulses from the pulse train of the laser source. We apply our technique to the study of heat diffusion in thin suspended films of transition metal dichalcogenides, obtaining a thermal diffusivity of 0.19±0.01 cm^2/s for $MoSe_2$ and 0.53±0.14 cm^2/s for WSe_2 in good agreement with literature values. [3]

This technique is applicable well beyond thermal transport, as it is capable of quantifying diffusion of any specie that lives longer than the time between pump pulses, for example, charge carriers, excitons, phonons, etc.

References

[1] X. Gu et al, Rev. Mod. Phys, 90 (2018) 041002
[2] S. Varghese, J. D. Mehew et al, *in preparation*
[3] P. Jiang et al, Adv. Mater. 29 (2017) 1701068

Figures

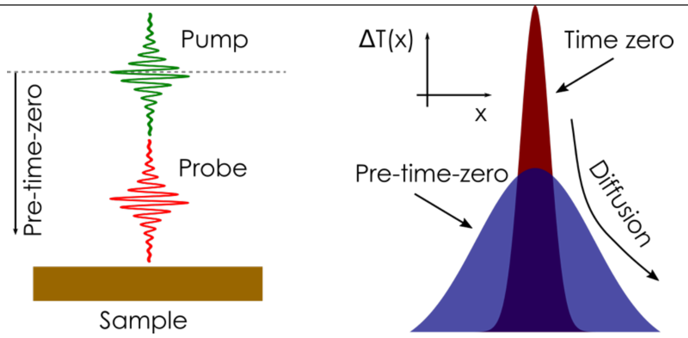

Figure 1: Schematic of the concept behind the pre-time-zero technique