The thermal conductivity of the Dirac fluid at room temperature

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Graphene displays highly exciting fundamental properties, while enabling a range of promising applications, in particular related to the field of optoelectronics, where hot carriers often play a crucial role [1]. Here, we will show recent results [2], where we have studied the flow of electronic heat in graphene, carried by hot carriers, using a novel technique (see Fig. 1). Owing to hydrodynamic behavior – where carrier-carrier interactions are faster than momentum relaxation – we obtain a giant electronic heat diffusivity up to 70,000 cm^2/s. The diffusivity is particularly large upon approaching the Dirac point, where the system enters the quantum-critical Dirac fluid regime. In this regime, theory predicts a diverging thermal conductivity [3], and indeed we find a thermal conductivity up to 40,000 W/m/K. This is an order of magnitude larger than the already extremely high thermal conductivity of the phonon system of graphene [4]. This result is likely relevant for thermal management applications requiring ultrafast heat dissipation from small hot spots.

REFERENCES

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FIGURES

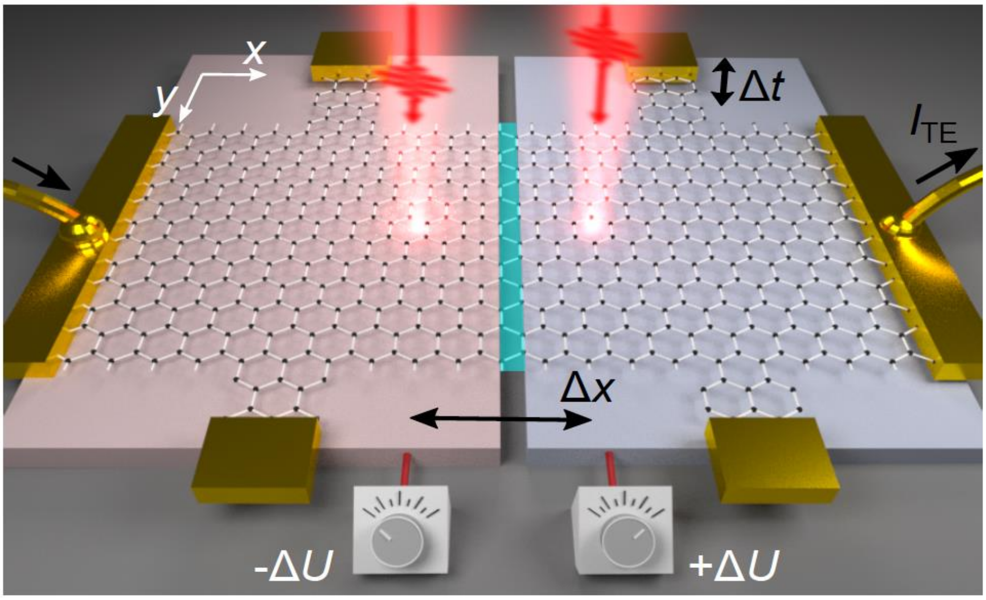

Figure 1: Schematic representation of spatiotemporal thermoelectric microscopy with two spatially (Δx) and temporally (Δt) displaced ultrashort laser pulses that are incident on a graphene device with two backgates at respective gate voltages of $-\Delta U$ and $+\Delta U$. This creates a *pn*-junction (cyan-colored region), where photocurrent is generated. By systematically varying Δx and Δt and measuring the photocurrent generated by interacting heat from the two pules, we obtain the diffusivity of heat carried by the electronic system. This thermal diffusivity becomes extremely high – up to 70,000 cm^2/s – when examined in the hydrodynamic time window, where Δt is smaller than the momentum relaxation time (~350 fs for our device). This is especially the case when ΔU is small, *i.e.* close to the Dirac point, when the system is in the quantum-critical Dirac-fluid regime. See Ref. [2].