How electronic heat in graphene spreads and cools

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The special properties of electronic heat in graphene [1] provide the foundation on which several key optoelectronic device concepts are based, including photodetectors and transceivers for data communication applications [2]. It is thus crucial to understand the heating-cooling dynamics of hot carriers in graphene.
We have studied the cooling dynamics in two high-quality graphene systems which a mobility above 15,000 cm^2/Vs: WSe_2-encapsulated graphene and suspended graphene. Our ultrafast pump-probe measurements, combined with theory, indicate that the cooling time at room temperature is intrinsically limited by the coupling of electrons to optical phonons, which form an efficient heat sink even for electrons with initially insufficient kinetic energy for optical phonon emission [3].
We have also studied heat spreading of hot carriers in graphene, using a novel spatiotemporal thermoelectric microscopy technique with femtosecond temporal and nanometer spatial control [4]. When tuning to the hydrodynamic time window before the occurrence of momentum relaxation, and under Dirac-fluid conditions, we observe a giant thermal diffusivity up to 70,000 cm^2/s. Moreover, the thermal conductivity of the electron system can be larger than the already record-high thermal conductivity of the phonon system of graphene. This result is relevant for thermal management applications.

References

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