Enhanced photoenergy harvesting and extreme Thomson effect in hydrodynamic electronic systems

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The electric and thermal transport properties of graphene-based devices are a topic of great interest, especially for their potential for real-world applications.

The simultaneous presence of carriers of opposite polarities whose density can be tuned by electrostatic gating or by changing the temperature, creates a rich scenario of transport behaviours. A particularly interesting one has recently been observed in a single layer of ultra-clean graphene near the charge neutrality point. There, the thermal resistivity vanishes while the electric resistivity remains finite because electrons and holes, moving in opposite directions under the action of an electric field, exert mutual friction on each other. The result is that the Wiedemann-Franz ratio between the electric resistivity and the thermal resistivity is enhanced well above the standard value.

Motivated by these interesting findings, we investigate thermoelectric transport in AB-stacked bilayer graphene.

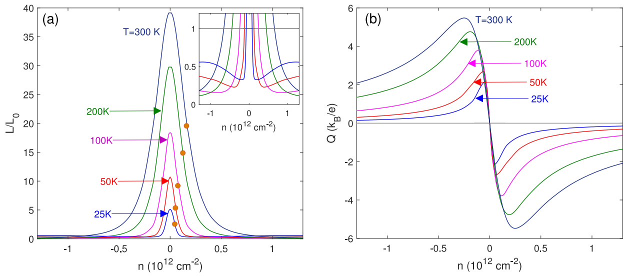

Figure 1: Wiedemann-Franz ratio (a) and Seebeck coefficient (b) of bilayer graphene

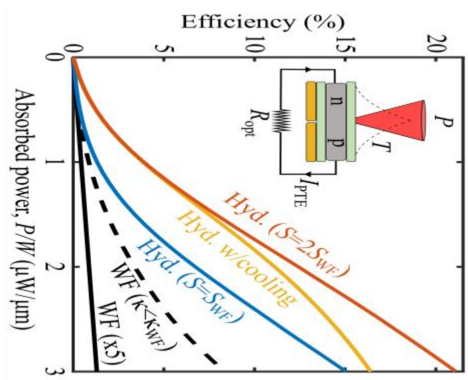

Figure 2: enhanced thermoelectric efficiency in the hydrodynamic regime

It should be noted that the behaviour at the charge-neutrality point is diametrically opposite to what one expects and observes in heavily doped graphene. In the degenerate hydrodynamic regime, the thermal conductivity is reduced and becomes a *decreasing* function of the electronic temperature. This results in *reduction* of the Wiedemann-Franz ratio.

We show how this peculiar temperature dependence gives rise to new striking thermoelectric phenomena. These include an 80-fold increase in thermoelectric efficiency compared to the WF regime, dramatic qualitative changes in the steady state temperature profile, and an anomalously large Thomson effect. In graphene, which we pay special attention to here, these effects are further amplified due to a doubling of the thermopower.

References

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Figures