Thermoelectric Spin Voltage in Graphene

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Spin-caloritronics, a field that exploits the interaction between spin and heat currents in solid-state devices, has spawned a vast literature in recent years, complete with beautiful and elaborate experiments [1]. Amongst the most intriguing phenomena is the spin Seebeck effect [2], in which a thermal gradient in a ferromagnetic material gives rise to spin current. Non-magnetic materials are also relevant for spin caloritronics. Graphene, for example, exhibits efficient spin transport, energy-dependent carrier mobility and a unique density of states, which make it an ideal platform for the observation of novel spin-caloritronic effects. However, decisive observations of the spin-heat interaction in graphene are scarce to non-existent.
In this talk I will present our recent prediction and experimental evidence that a carrier thermal gradient in a graphene lateral device leads to a large increase of the spin voltage around the graphene charge neutrality point [3]. This increase results from a thermoelectric spin voltage (TSV), analogous to the voltage in a thermocouple, which can be further enhanced by the presence of hot carriers generated by an applied current [4]. These results could prove crucial for graphene spintronic devices, in particular to sustain pure spin signals with thermal gradients and tune the remote spin accumulation by varying the spin injection.

References

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Figures

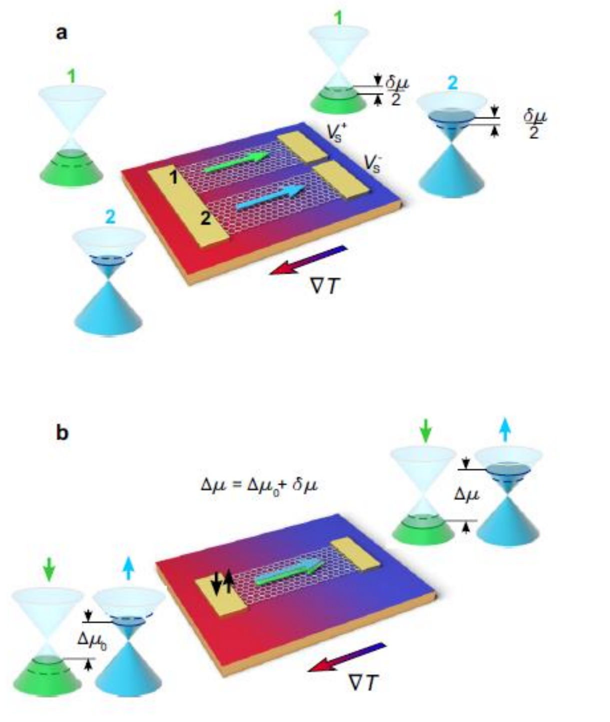

Figure1: **a**, Conventional thermocouple comprising two graphene sheets, 1 and 2. A thermoelectric voltage $V_S = V_{S+} - V_{S-} = -(S_2 - S_1)\Delta T$ is built up due to the temperature difference ΔT between the cold and the hot sides. The flow direction of the majority of the carriers in 1 (holes) and 2 (electrons) is shown with green and blue arrows, respectively. **b**, Carriers with opposite spins belong to two independent transport channels. When the spin accumulation $\Delta\mu_0 \neq 0$, S becomes spin-dependent. A thermoelectric effect analogous to that in Fig 1.a leads to a TSV and a remote increase (decrease) of the spin accumulation $\Delta\mu = \Delta\mu_0 + \delta\mu$ at the cold end. For simplicity, the $n_\downarrow = -n_\uparrow$ case is shown. The flow direction of the carriers for spin-down and spin-up sub-bands is shown with green and blue arrows, respectively.