




Thermoelectric Spin Voltage in Graphene






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Graphene 2018, Dresden, June 26-29, 2018

Spin and Hot Carrier Transport

Characteristics lifetimes

Low spin-orbit coupling

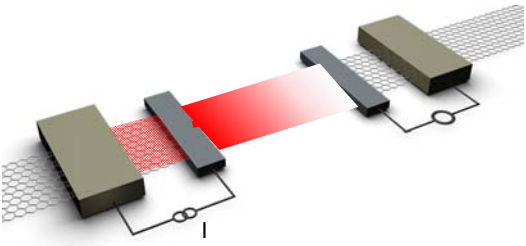
Spin Transport

Spin lifetimes: 0.1-10 ns
Spin relaxation length 1-30 μm

Weak electron-phonon interaction


Hot Carrier Transport

Carrier cooling times: 0.01-1 ns
Cooling length 0.1-10 μm



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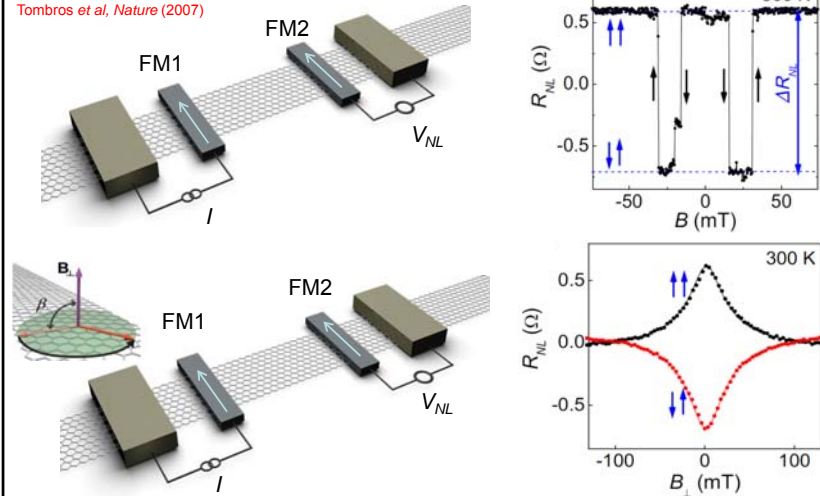
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Graphene Spintronics

Spin signal

Johnson and Silsbee (1985); Aronov (1976)
Tombros et al. *Nature* (2007)



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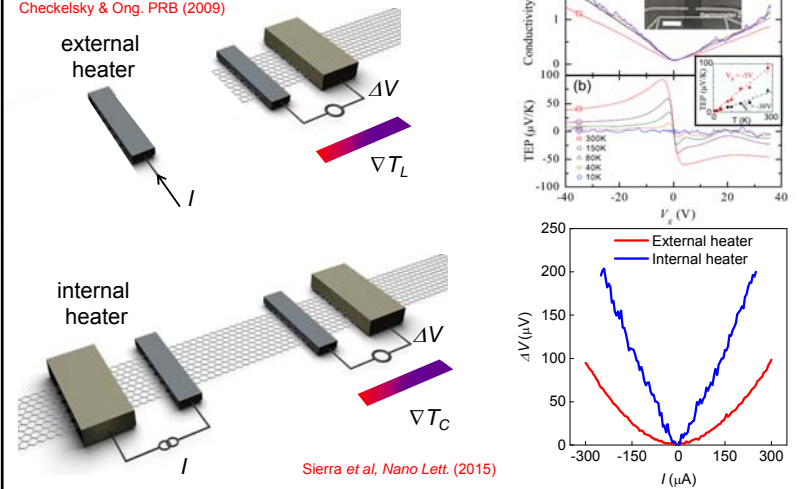
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Thermoelectricity in Graphene

Thermoelectric Signal

Zuev, Chang & Kim PRL (2009)
Wei et al. PRL (2009)
Checkelsky & Ong. PRB (2009)



Sierra et al. *Nano Lett.* (2015)

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Spin and Hot Carrier Transport

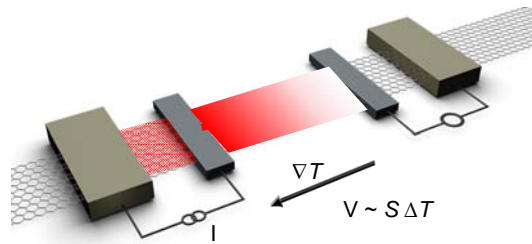
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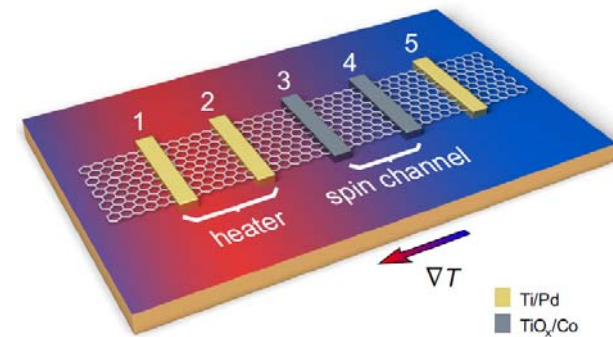
Carrier temperature $T_C \gg$ Lattice temperature T_L

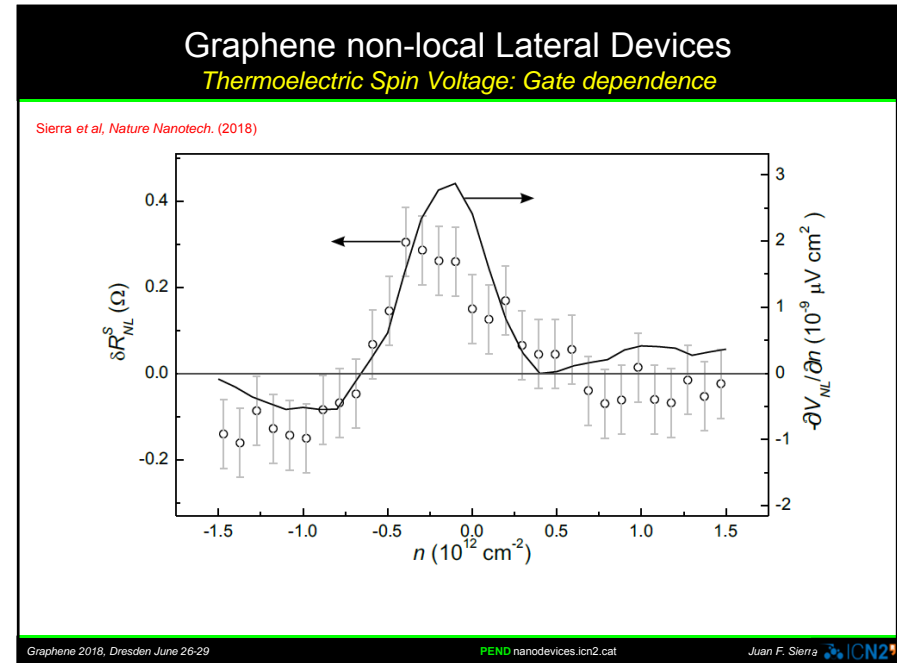
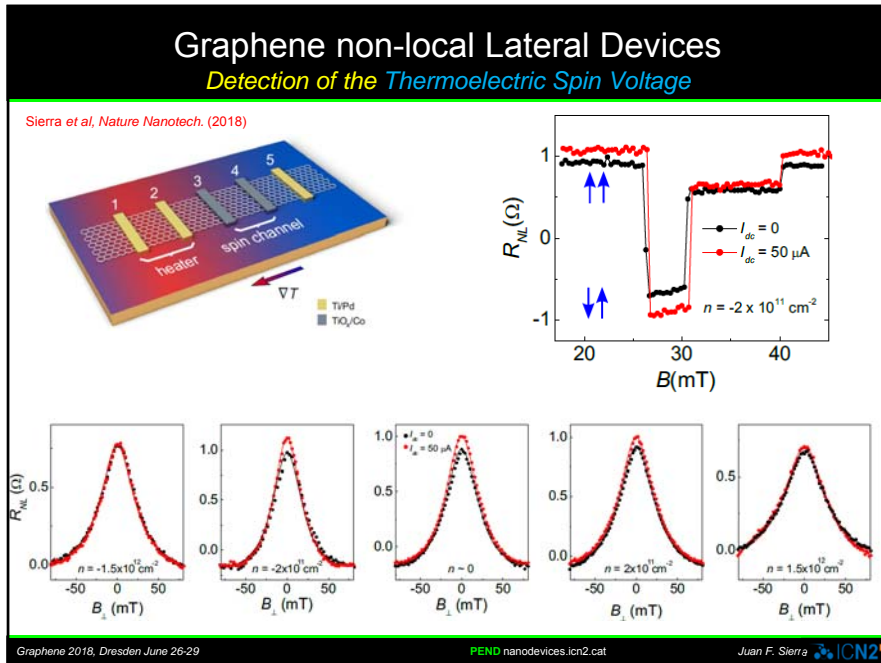
Large ∇T in the hot-carrier regime

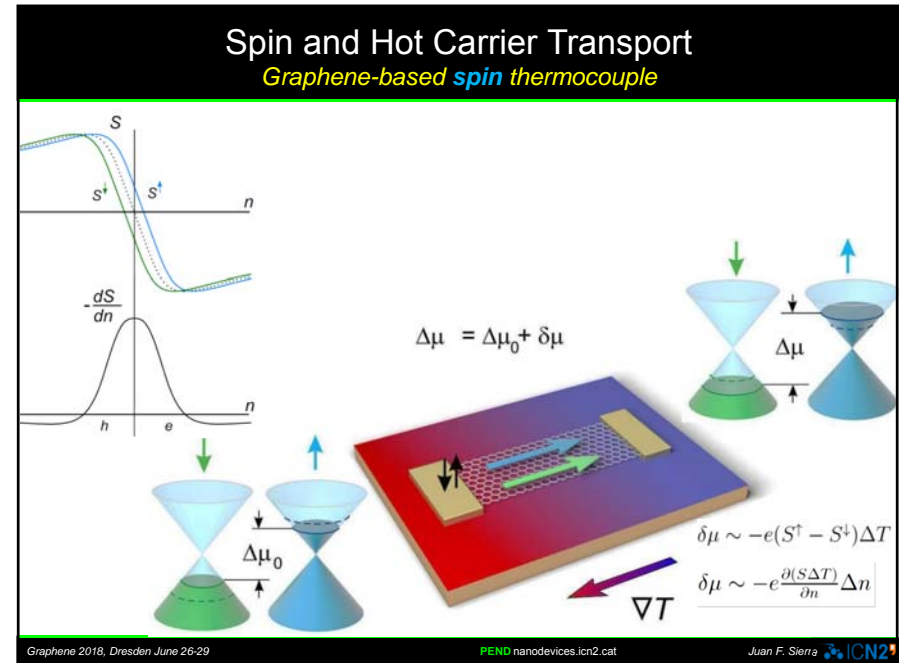
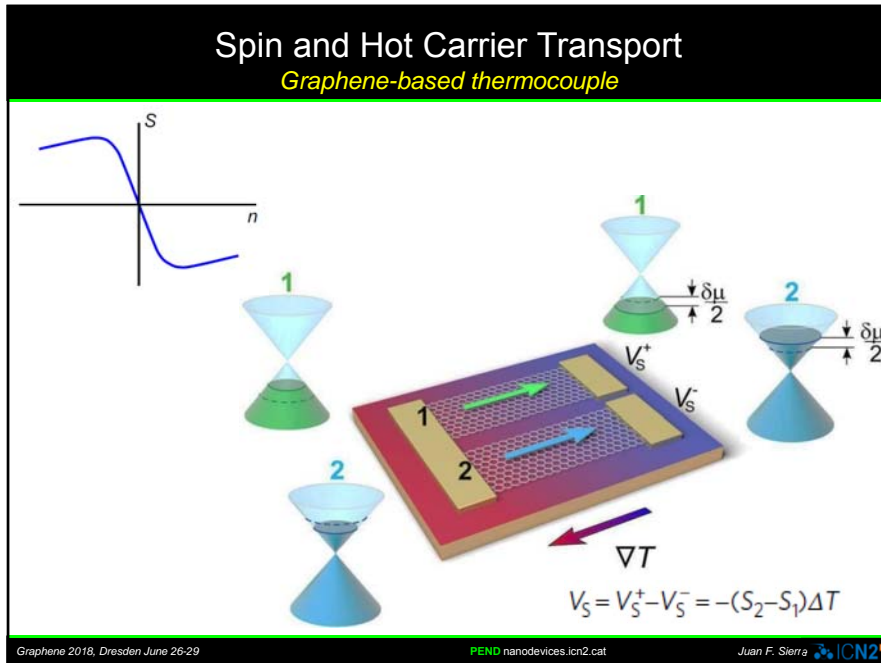
Spin and Heat Transport

Device design

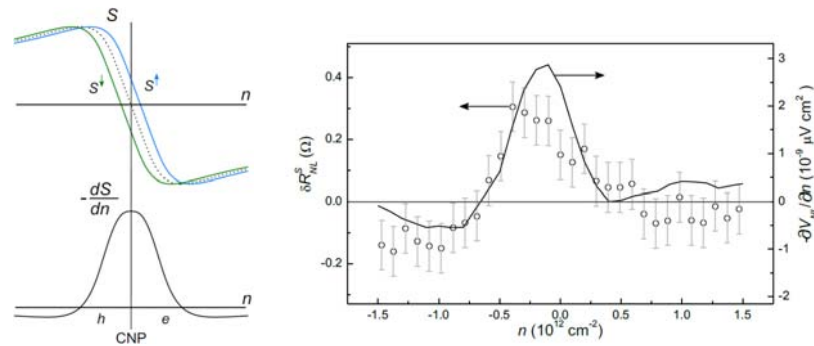
DC-heater current \Rightarrow Constant temperature gradient
AC-spin injection current \Rightarrow AC spin splitting







Graphene non-local Lateral Devices Thermoelectric Spin Voltage: Gate dependence



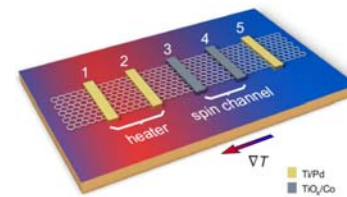
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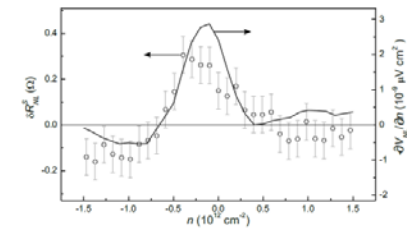
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Conclusions

- Electrical injection/detection of hot-carriers in graphene using non-local techniques (graphene used as part of the electrical heater).
- Hot-carriers create large thermal gradients which can sustain and enhance spin currents in graphene.
- Large increase of spin voltage near to the graphene charge neutrality point.



Sierra et al., Nature Nanotech. 13, 107 (2018)



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