1D-1D Coulomb Drag Signature of a Luttinger Liquid

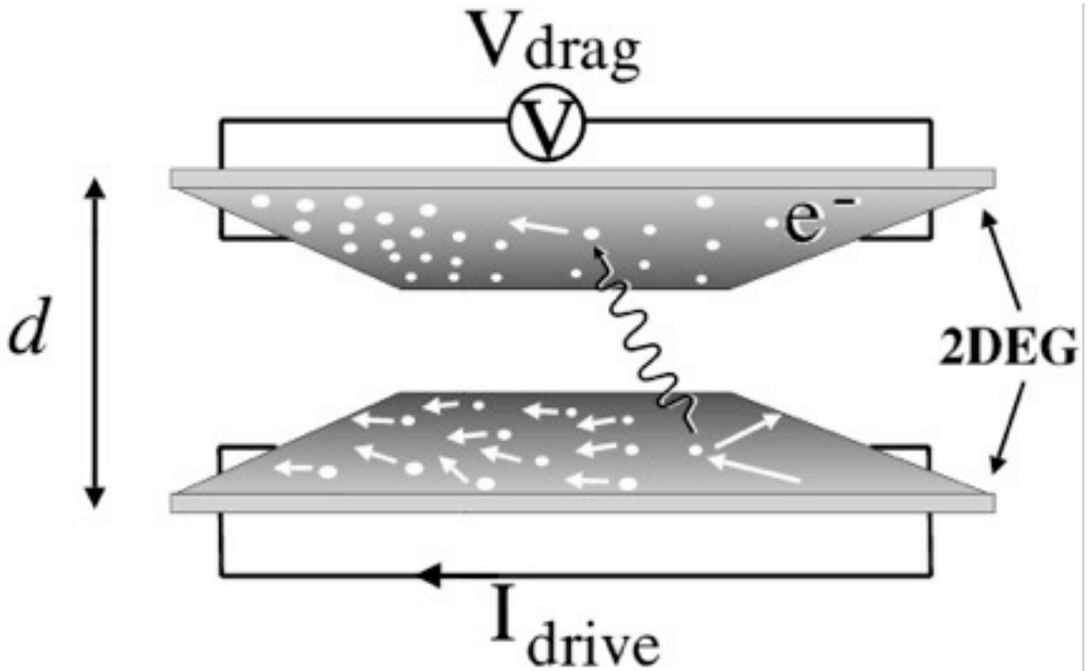
D. Laroche, G. Gervais, M. P. Lilly, J. L. Reno

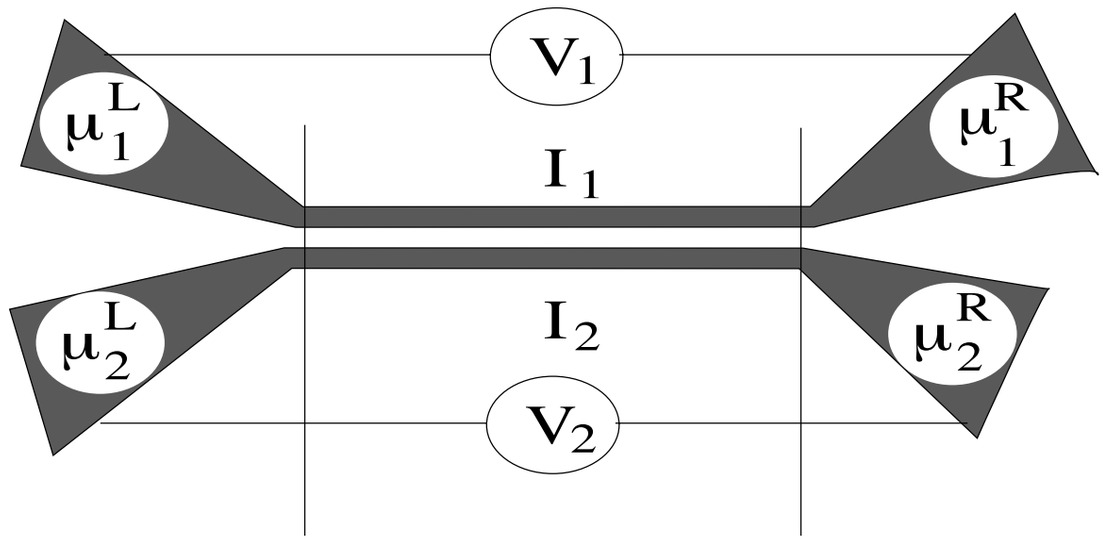
Science **343**, 631 (2014)

Diego Rainis

Journal Club 18.02.2014

Coulomb drag





$$R_{\mathrm{D}} \equiv -\frac{V_{\mathrm{drag}}}{I_{\mathrm{drive}}}$$

Coulomb-interaction-induced current (or voltage) induced in one system (*drag*) when a current is driven in a nearby system (*drive*)

Coulomb drag in 3D-2D-1D

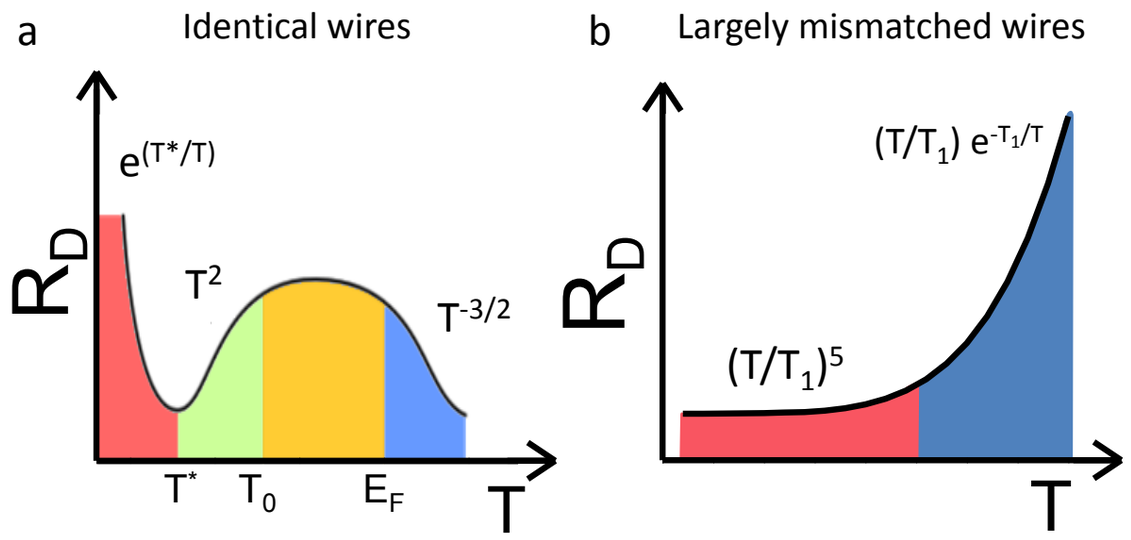
3D-2D:

Fermi liquid theory, phase space arguments give

$$R_{\mathrm{D}}(T) \propto T^2$$

1D:

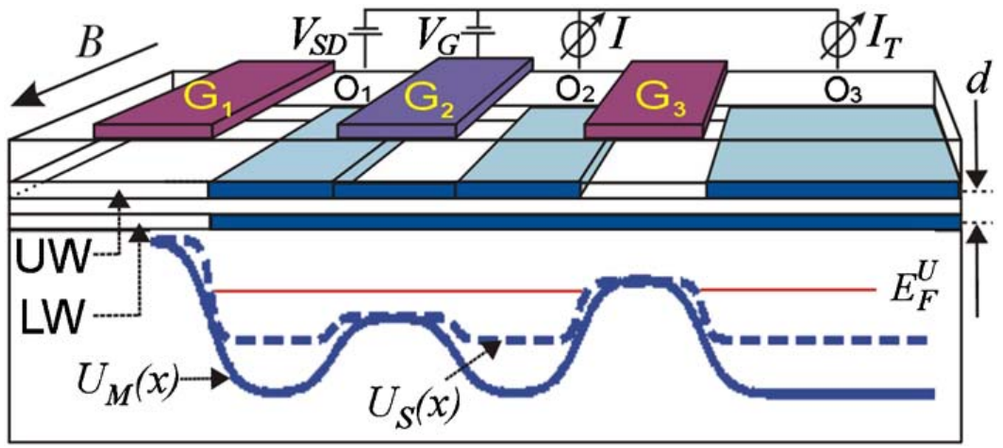
Fermi liquid theory breaks down, Luttinger liquid paradigm.
Simplest model: linearized bands, Tomonaga Luttinger Liquid (TLL)
+ Corrections due to finite curvature (forward scattering)



Dominique Laroche, PhD Thesis, McGill University (2013)
&
M. Pustilnik, E.G. Mishchenko, L.I. Glazman, and A.V. Andreev, PRL **91**, 126805 (2003)
[with partial correction by D. Rainis, M. Polini, M.P. Tosi, and G. Vignale, PRB **77**, (2008)]

Experimental Situation so far

Vertically-coupled Qwires (without independent contacting)



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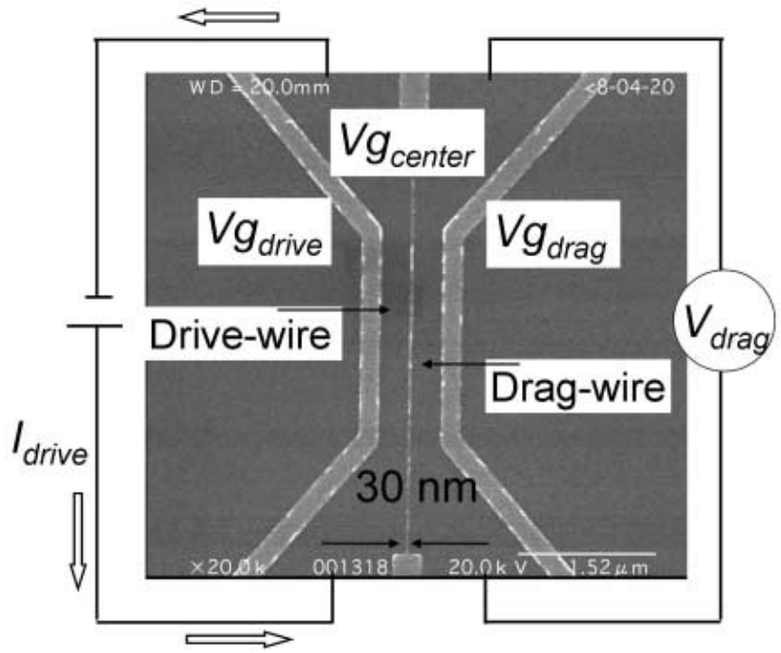
Laterally-coupled Qwires



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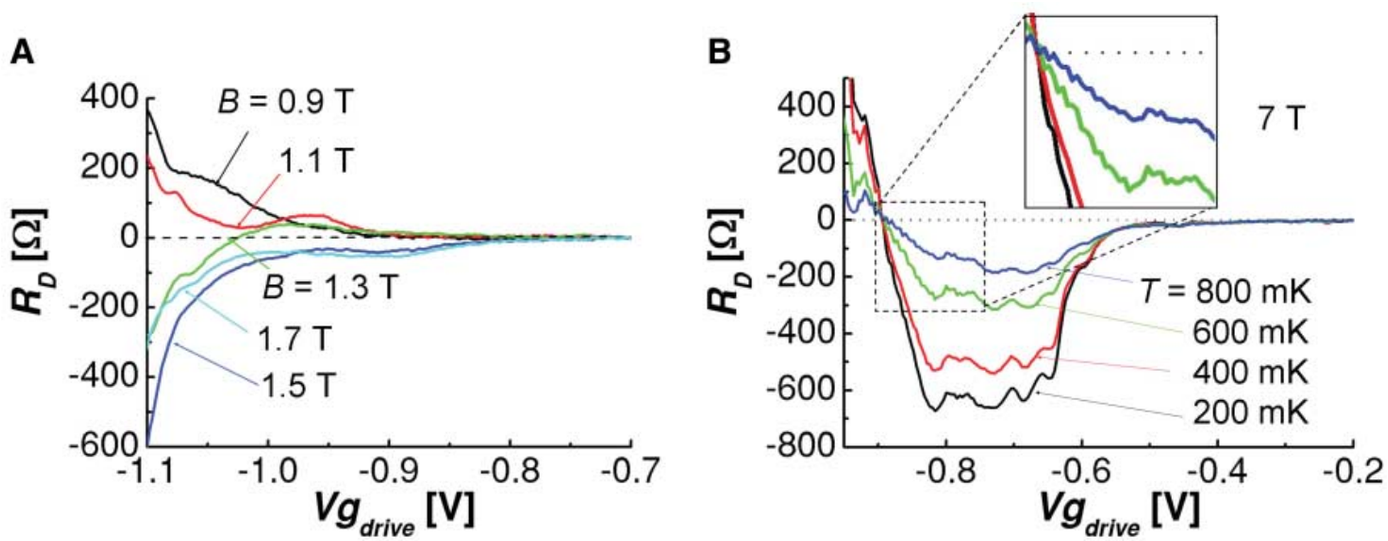
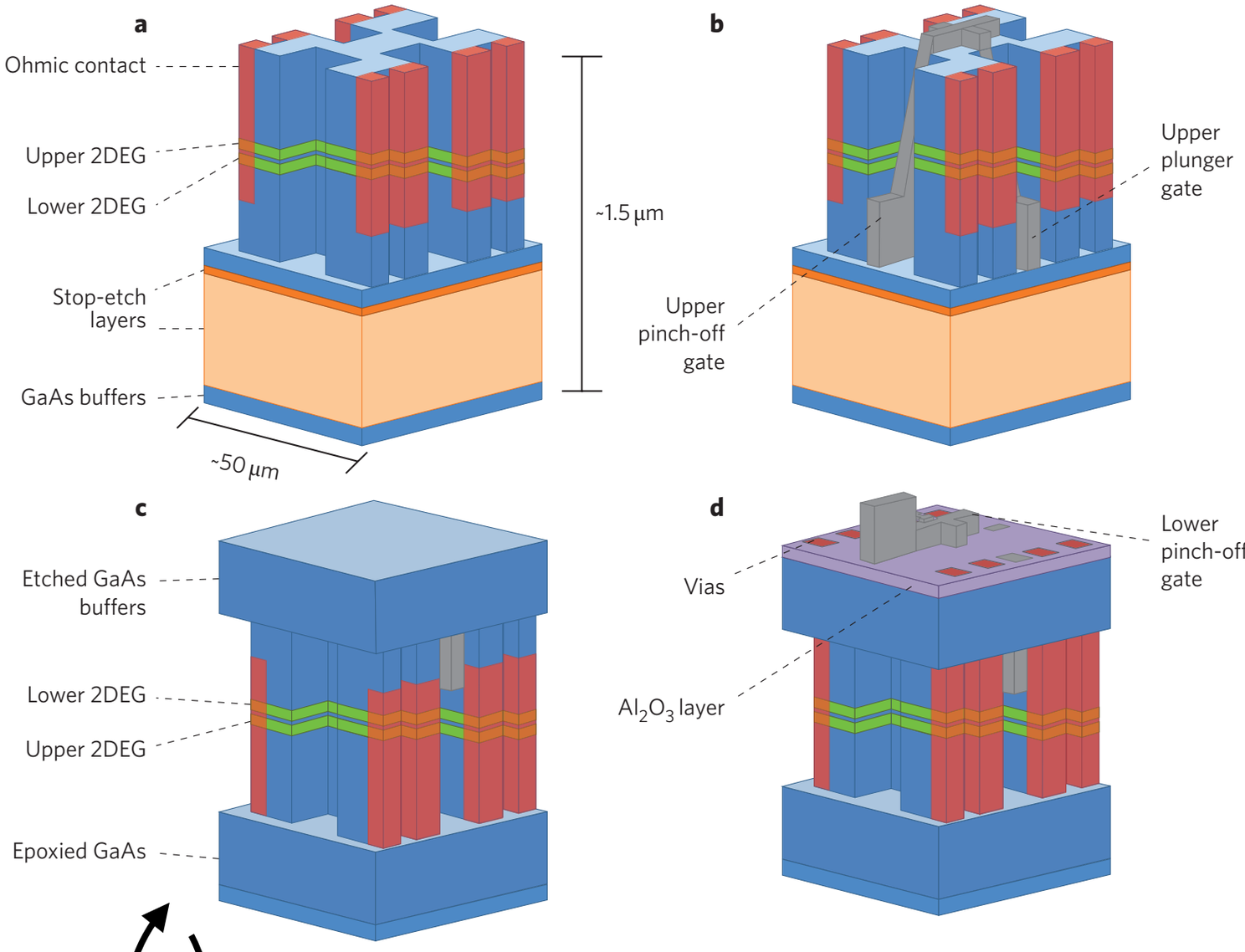
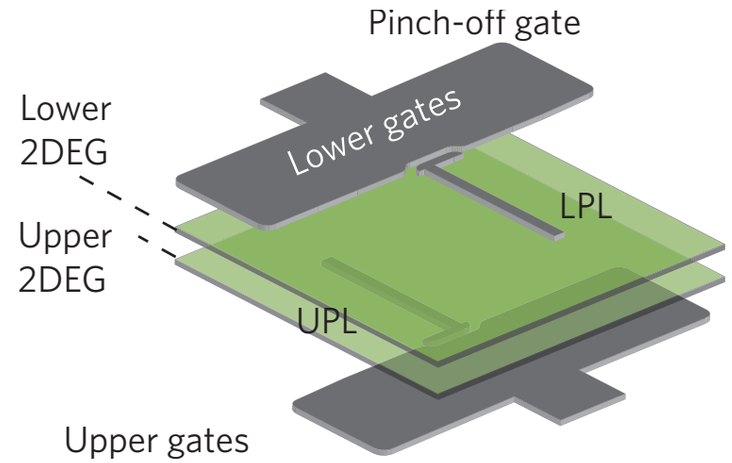
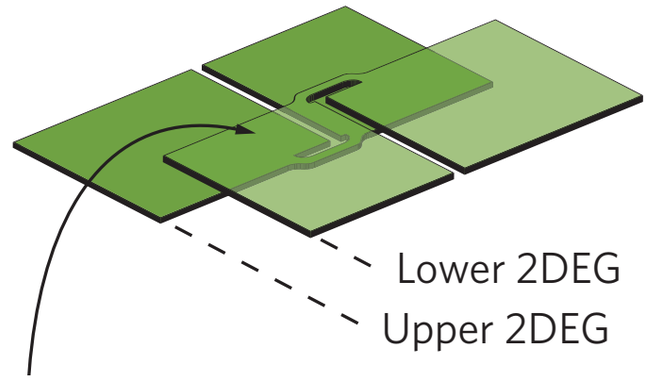
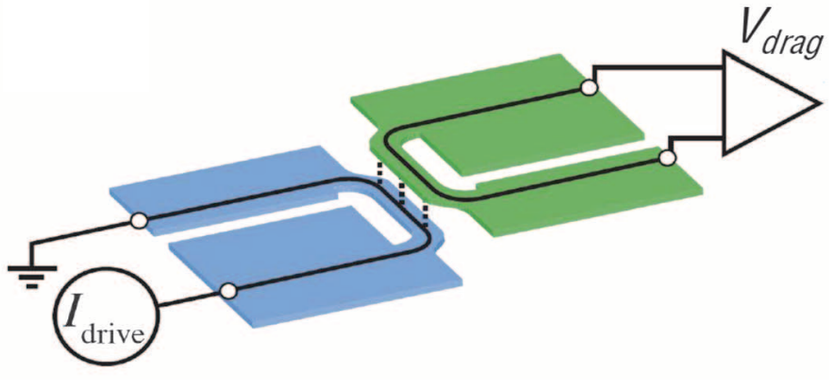


Experimental Breakthrough:
Vertically Coupled 1D Wires & Independent Contacting



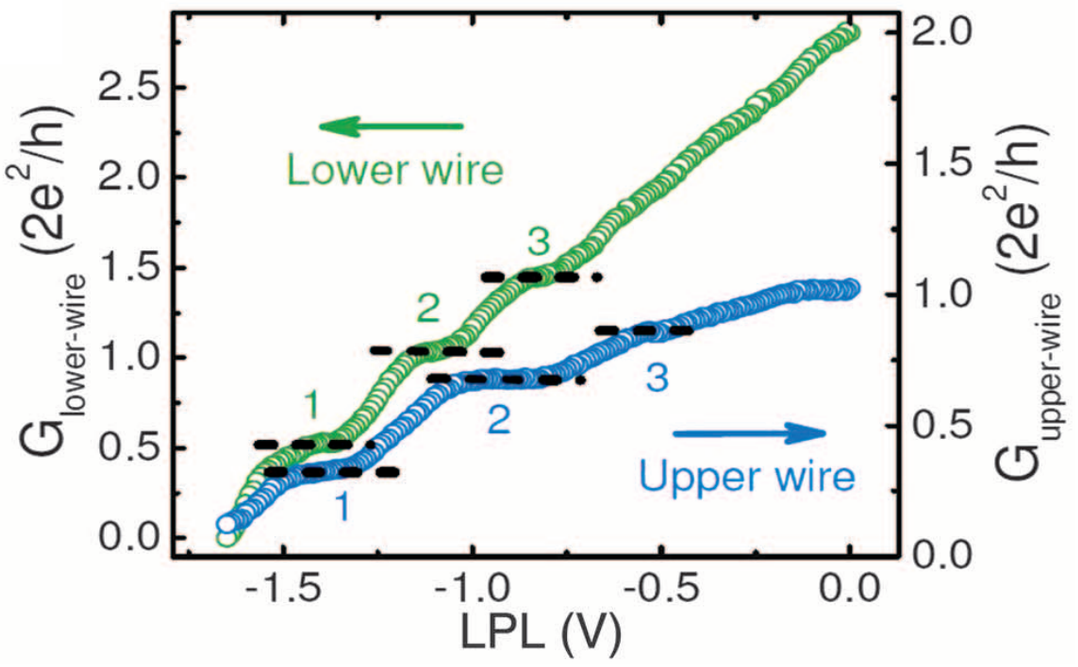


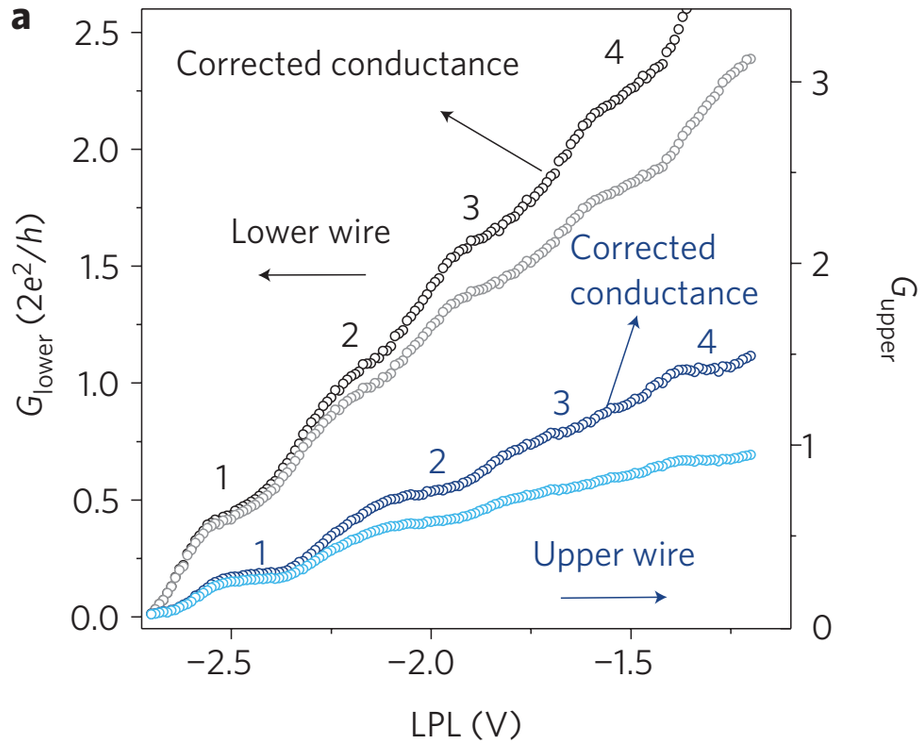




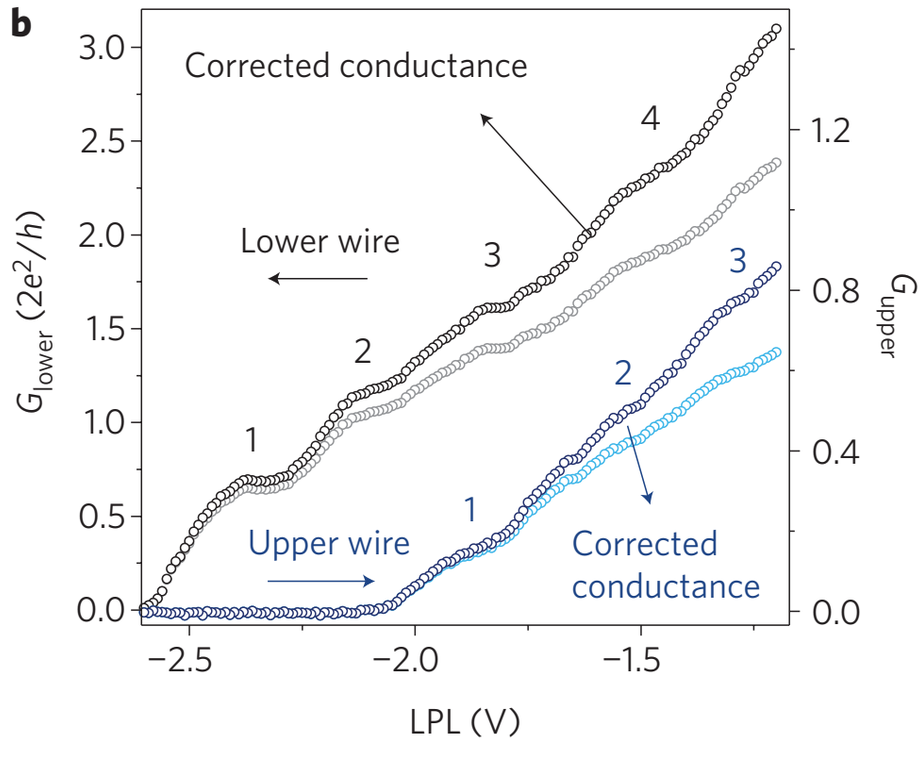
D. Laroche, G. Gervais, M.P. Lilly, and J.L. Reno,
Nat. Nano. **6**, 793 (2011)

Results I:
Demonstration of independent control of the wires



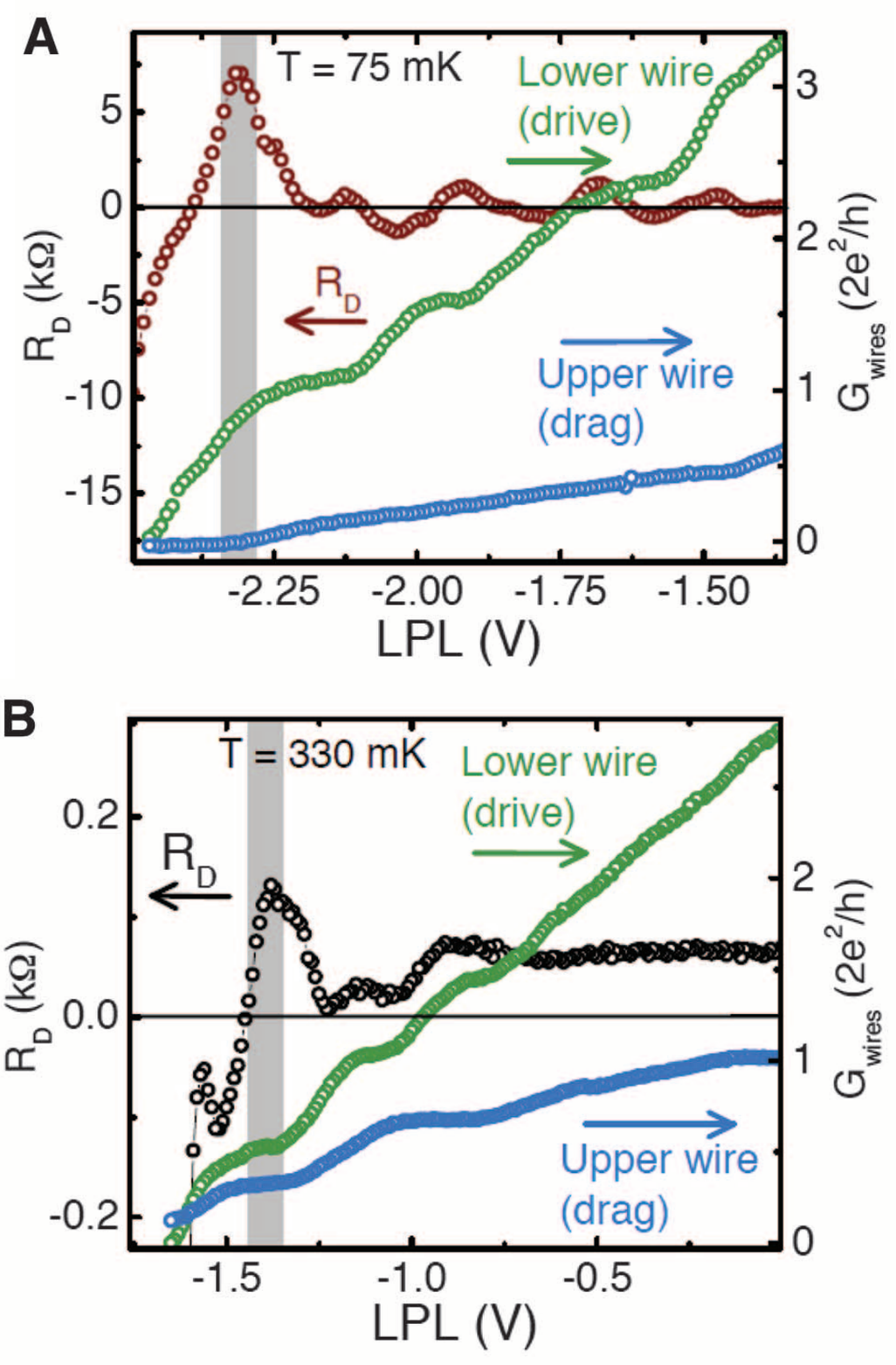


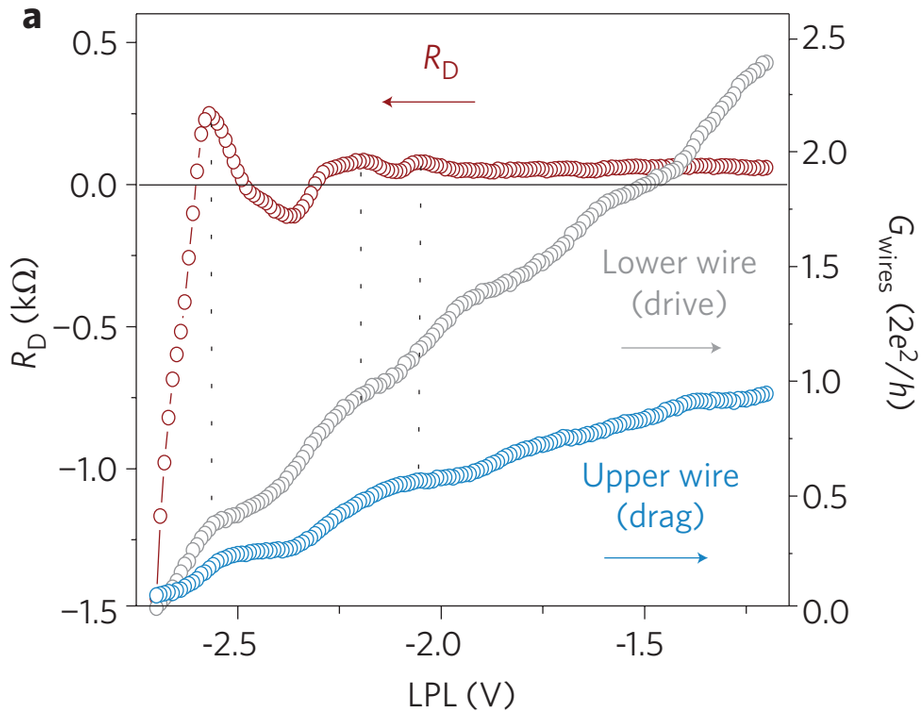
UPL=-0.23 V

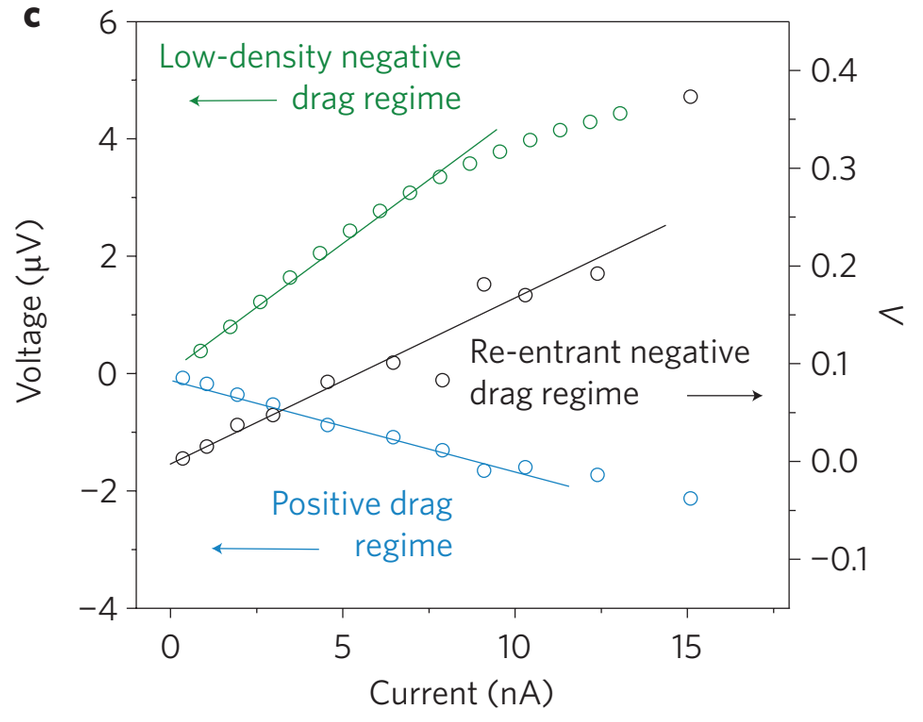


UPL=-0.34 V

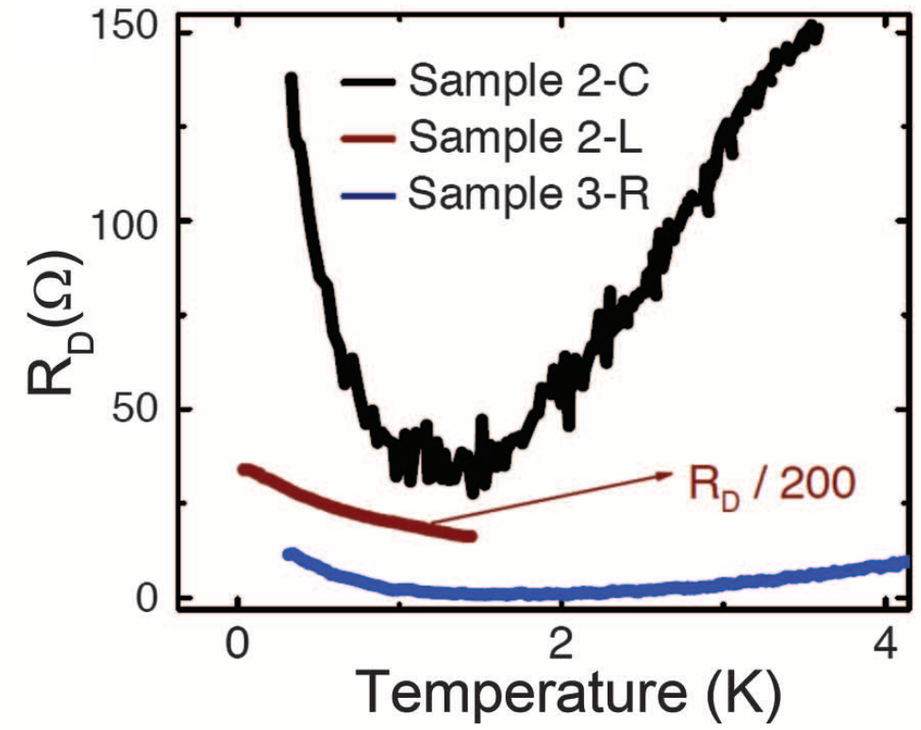
Results II:
Drag resistance

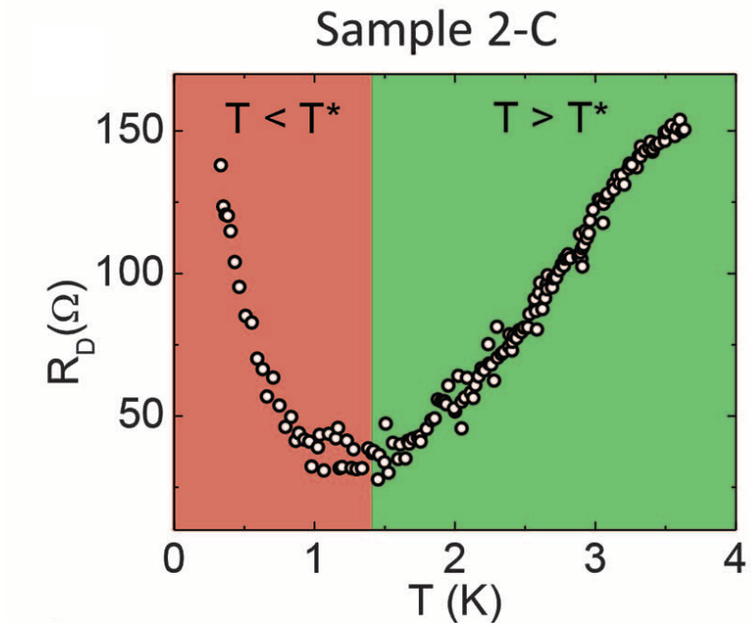


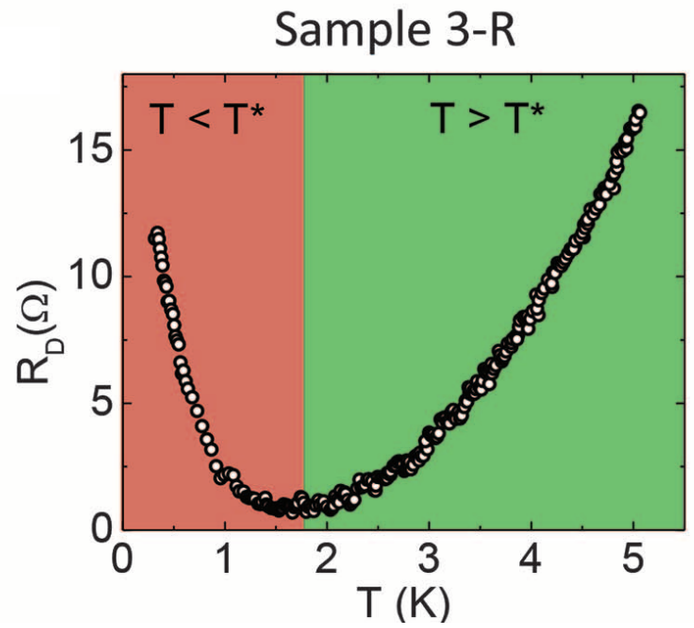


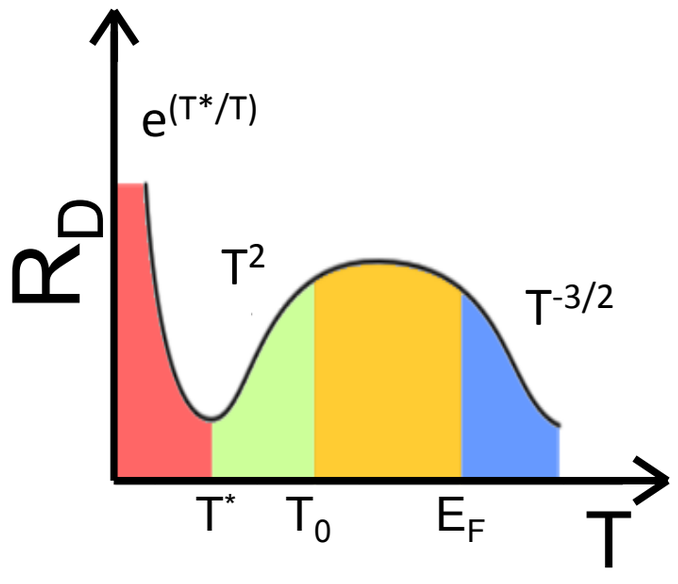


Results III:
Temperature dependence

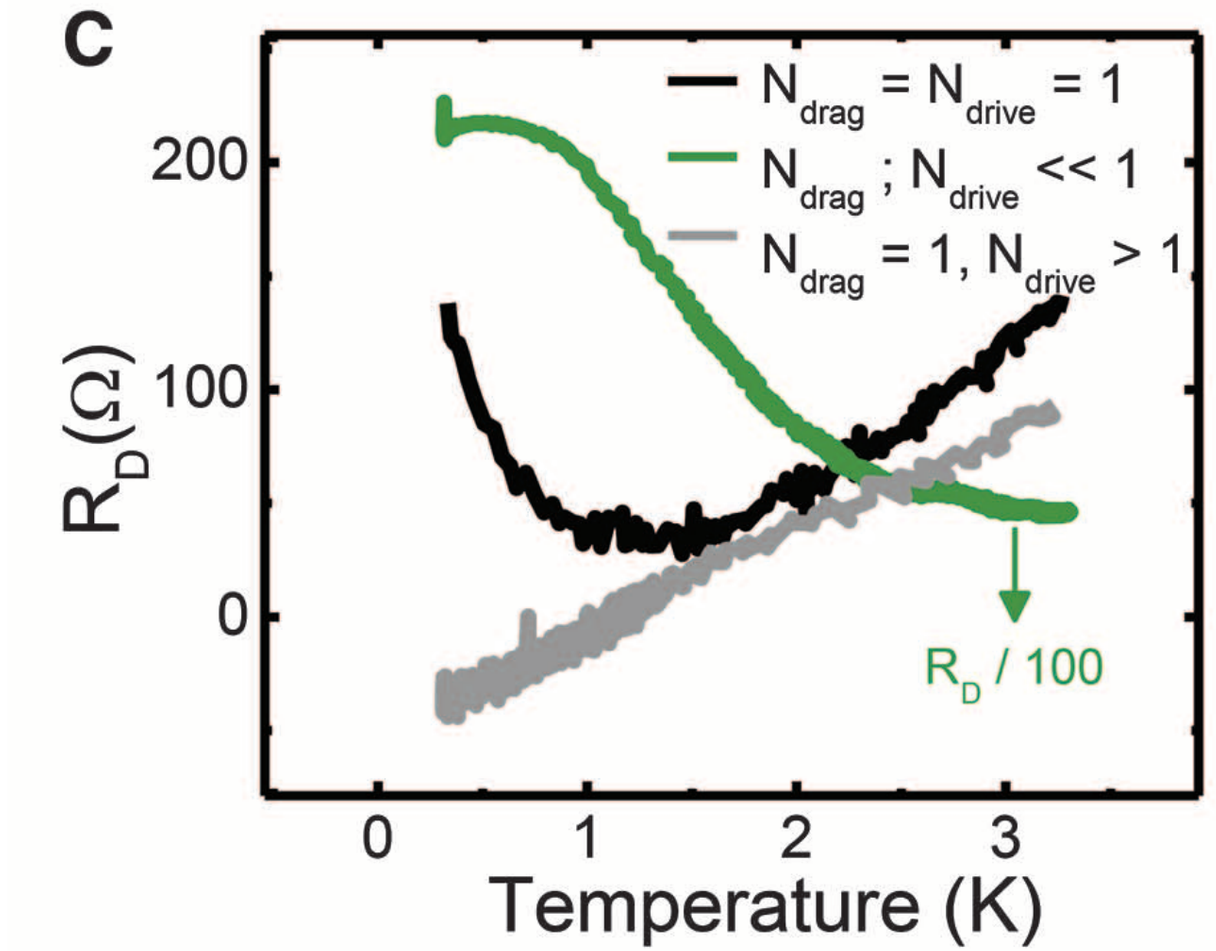








Results IV:
Subband occupancy dependence



Subband occupancy plays a crucial role!

!

26. J. Peguiron, C. Bruder, B. Trauzettel, *Phys. Rev. Lett.* **99**, 086404 (2007).

Such devices might also be used to determine the existence of a nuclear spin helix, a recently predicted novel quantum state of matter (*29*).

29. B. Braunecker, P. Simon, D. Loss, *Phys. Rev. B* **80**, 165119 (2009).

of Energy (DOE). This work was performed, in part, at the Center for Integrated Nanotechnologies, a U.S. DOE, Office of Basic Energy Sciences, user facility. Sandia National Laboratories is a multiprogram laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. DOE's