SAND2021-2571C

Magneto-transport of electrons in near surface InAs quantum wells in contact with NbTiN

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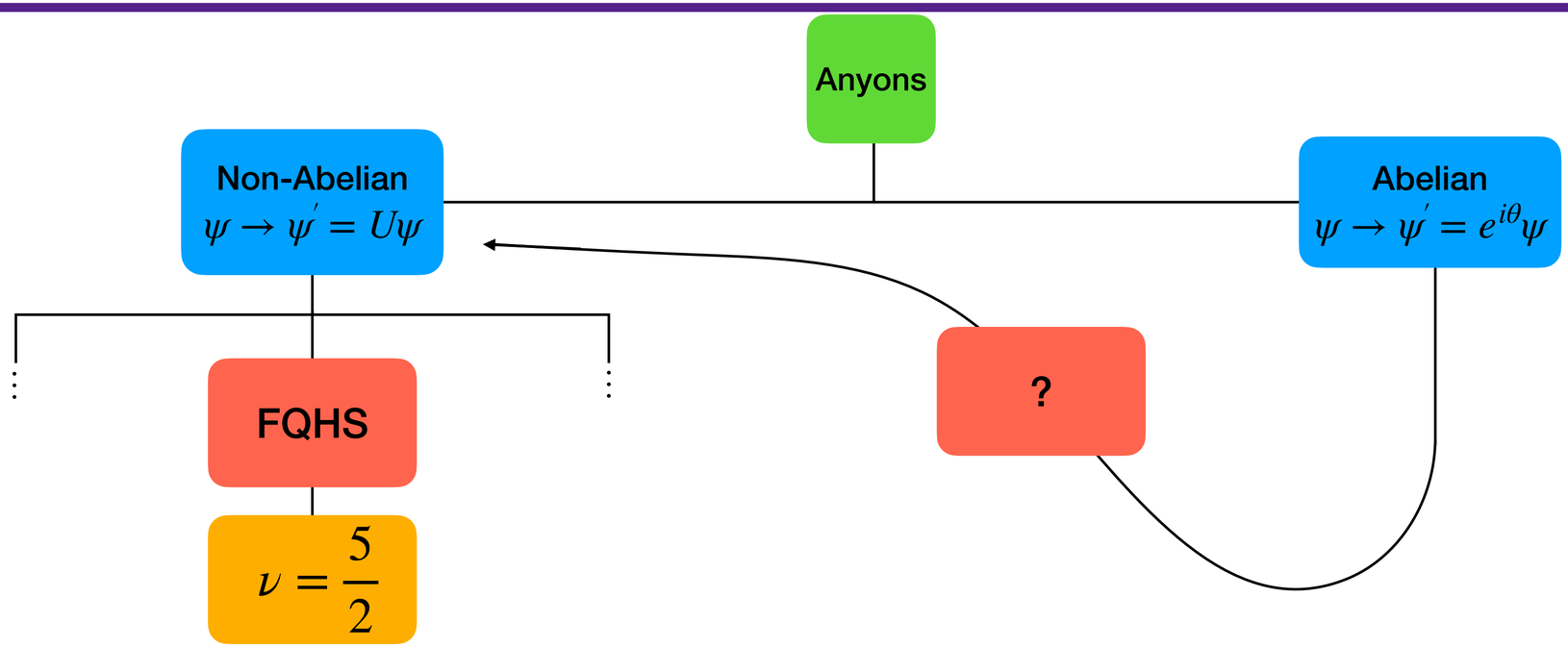
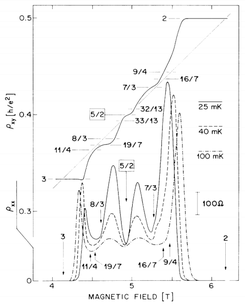
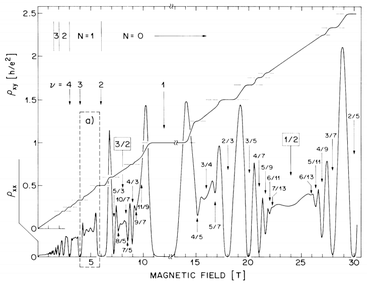
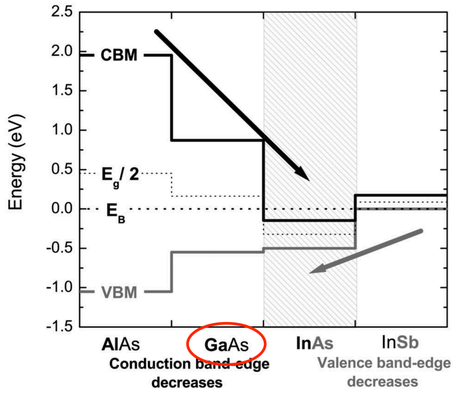
Motivation









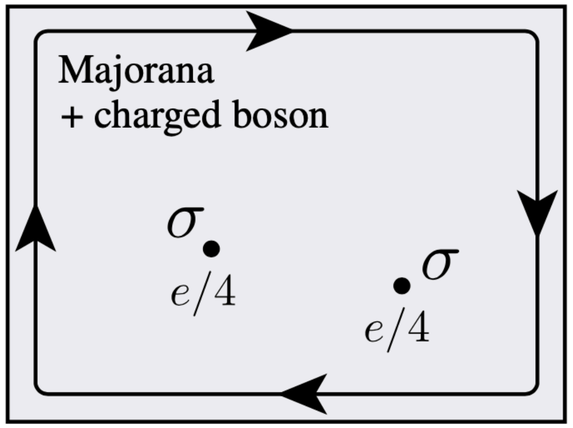
Requires $\mu \approx 30{,}000{,}000 \frac{cm^2}{Vs}$

R. Willett et al. PRL (1987)

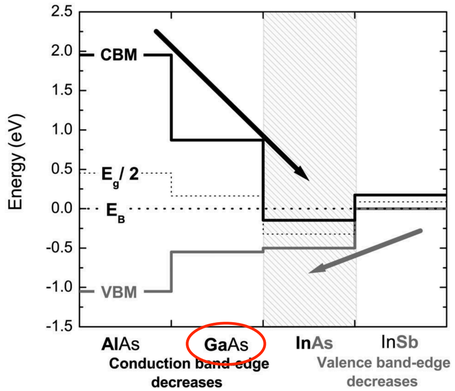
L. F. J. Piper et al. PRB (2006)

Motivation

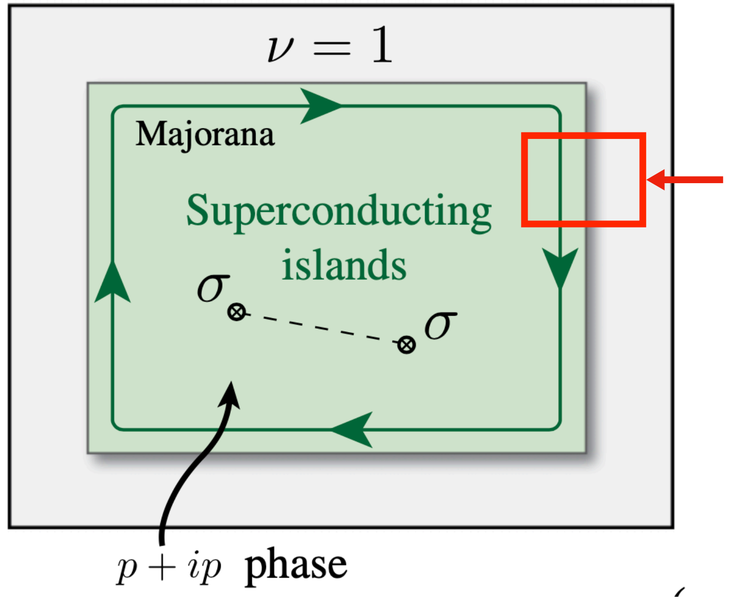
$\nu = 5/2$ Moore-Read



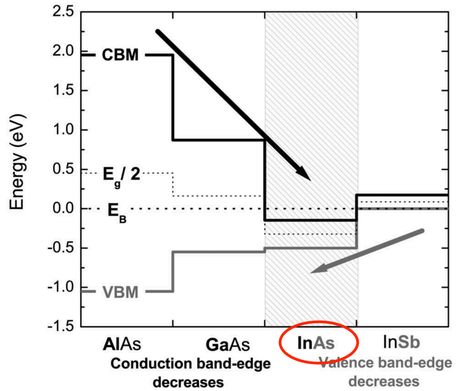
$\mu = 30{,}000{,}000 \frac{cm^2}{Vs}$



$\sim$



$\mu \approx 10{,}000 \frac{cm^2}{Vs}$, $\nu = 1$ **+Superconductivity**

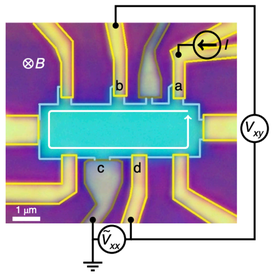


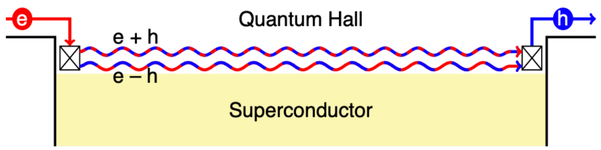
ROGER S. K. MONG et al. PHYS. REV. X 4, 011036 (2014)

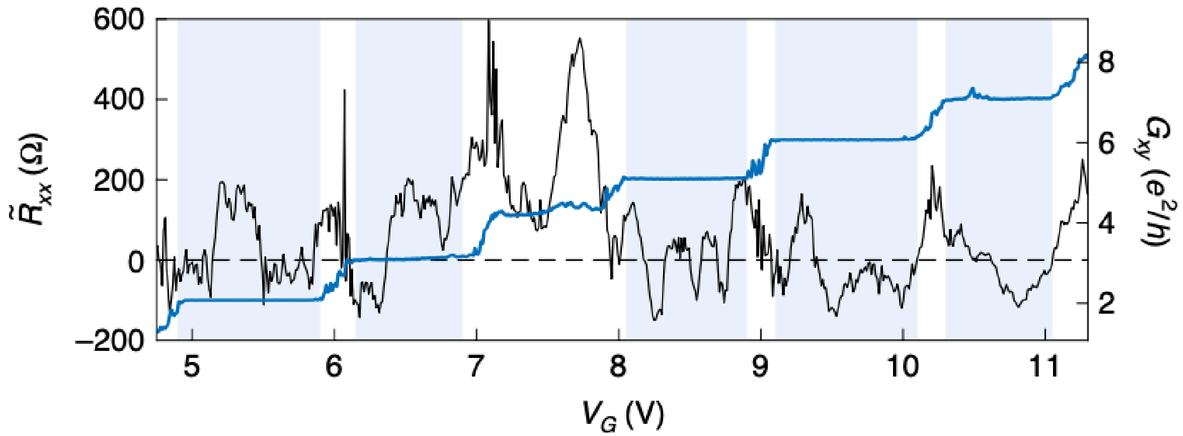
Wan et al., Nature Communications, **6**, 7426 (2015)

Literature Review

Graphene/MoRe

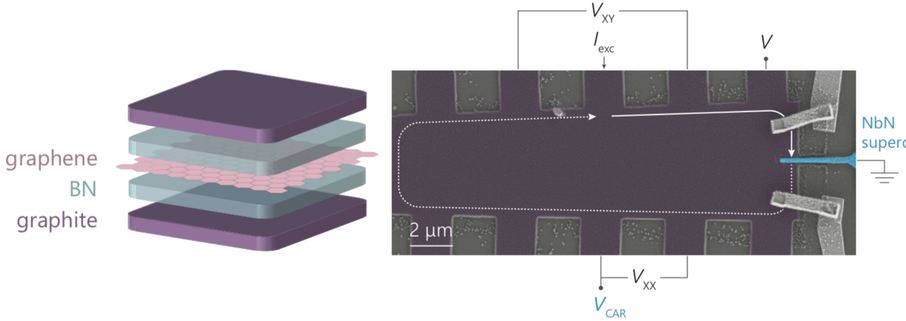


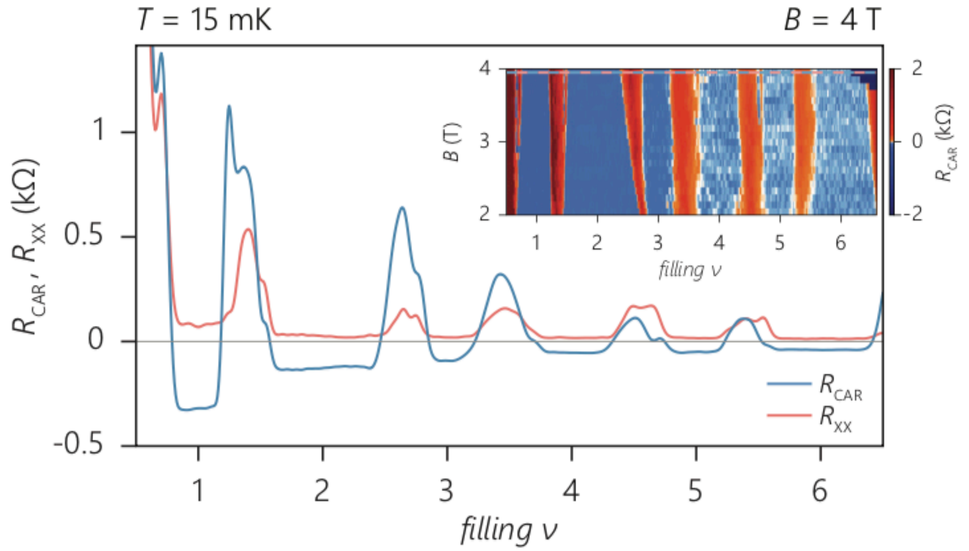




Chiral Andreev Edge States (CAES)

Graphene/NbN



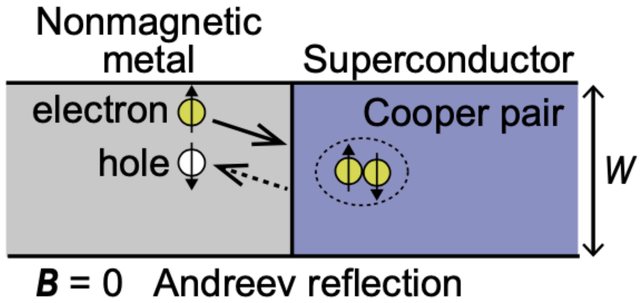


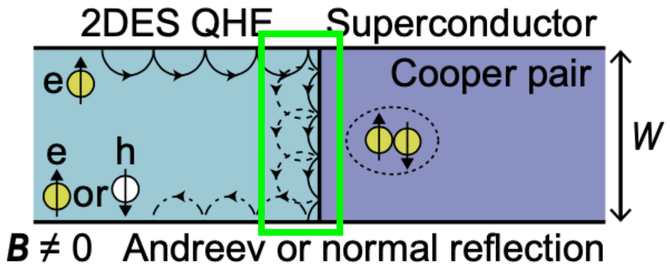
Cross Andreev Reflection (CAR)

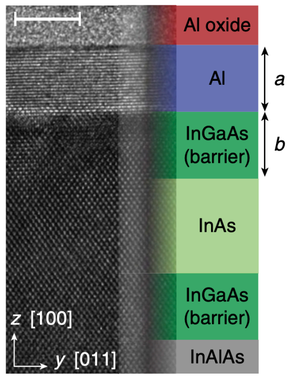
Lingfei Zhao et al. Nature Physics (2020)

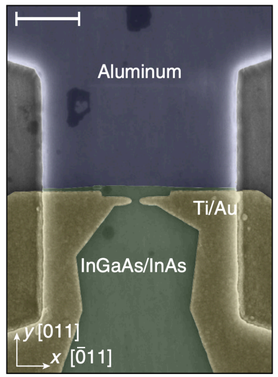
Önder Gül et al. arXiv:2009.07836 (2020)

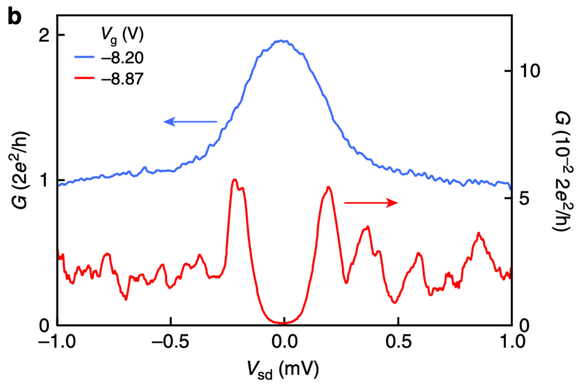
Andreev Reflection











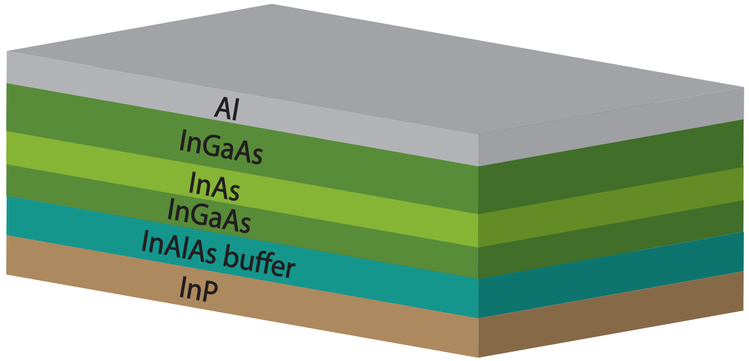
$$G_{ns} = 2G_0 \frac{G_{nn}^2}{(2G_0 - G_{nn})^2},$$

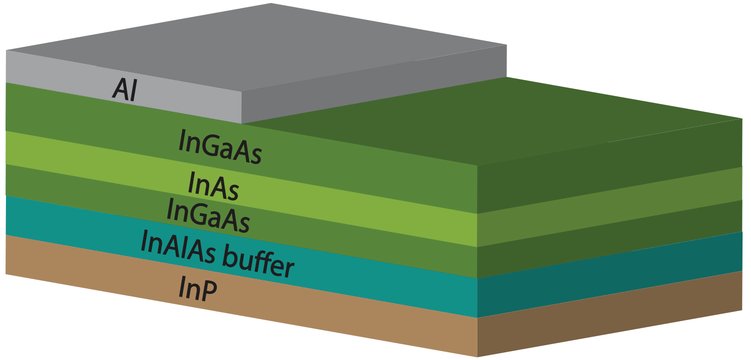
Focus of our study

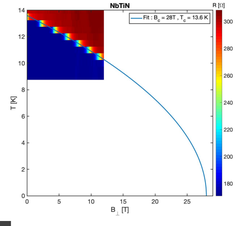
Y. Kozuka et al. JPS (2018)

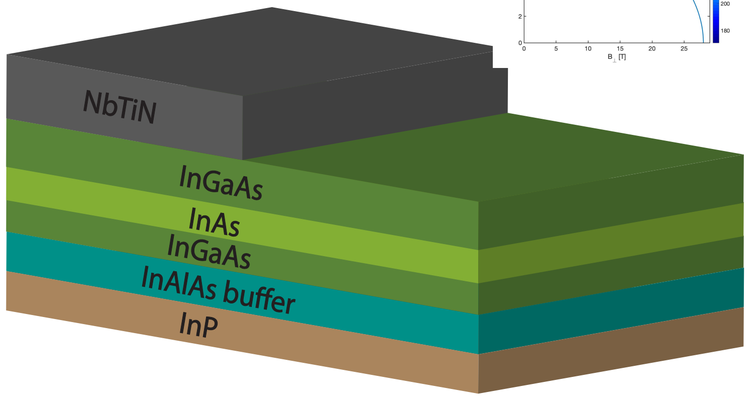
M. Kjaergaard et al. Nature Communications (2016)

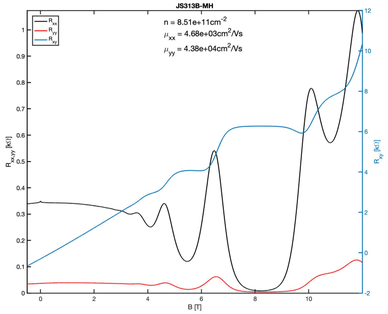
Device Fabrication

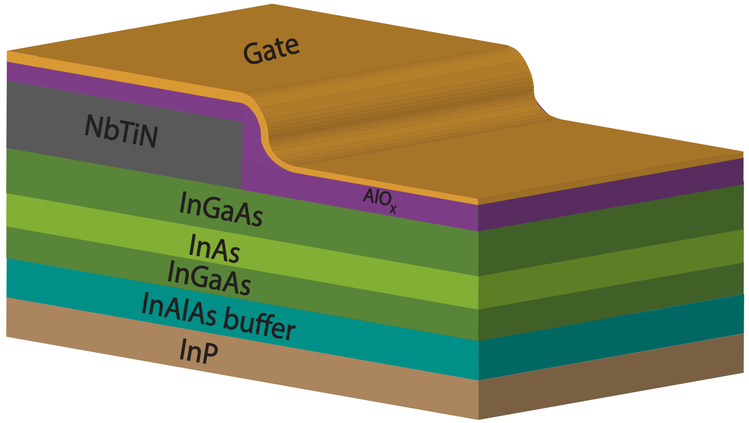


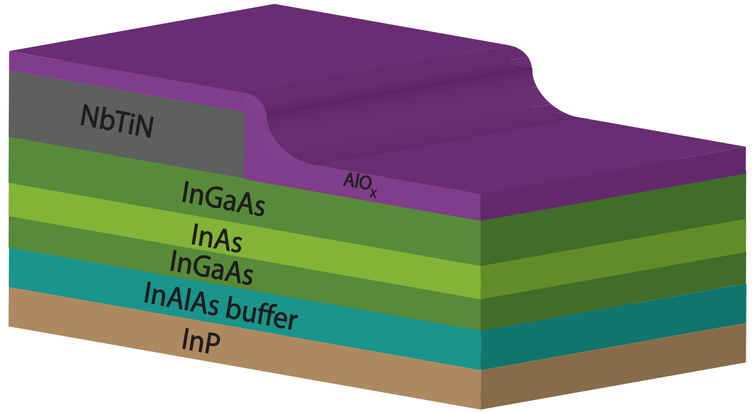




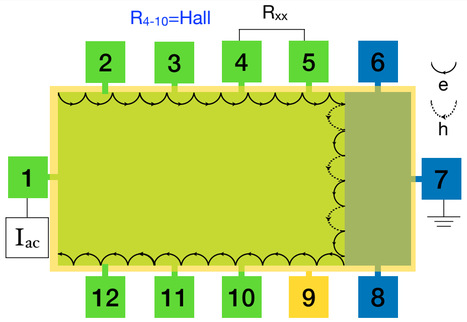


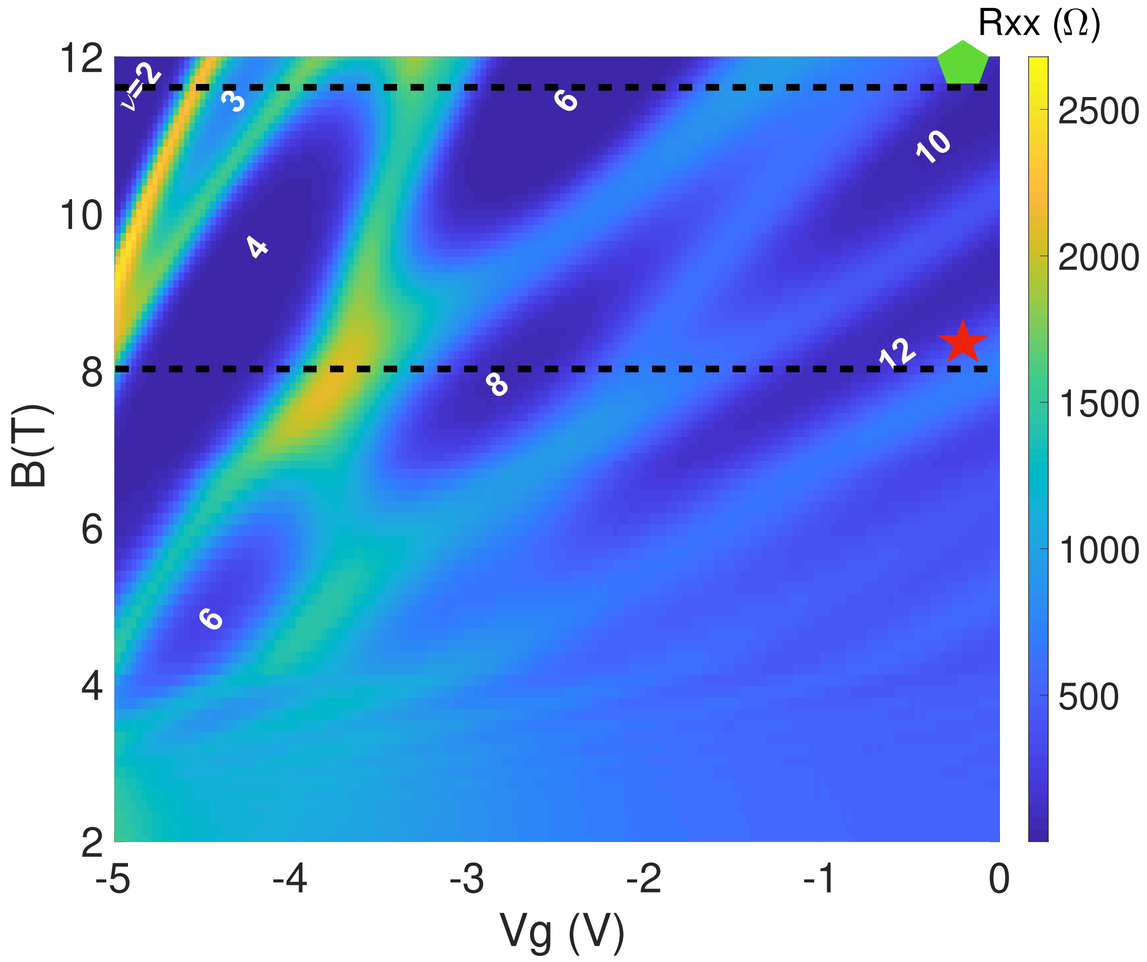


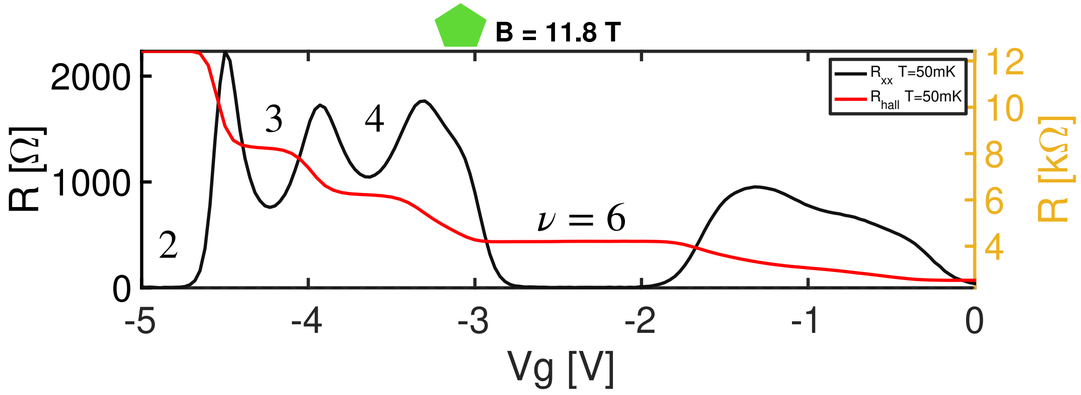


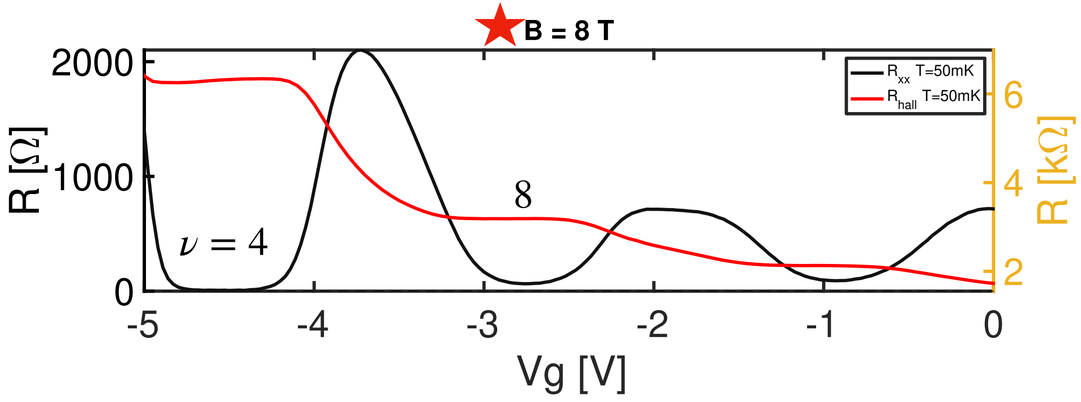


2DEG Characterization

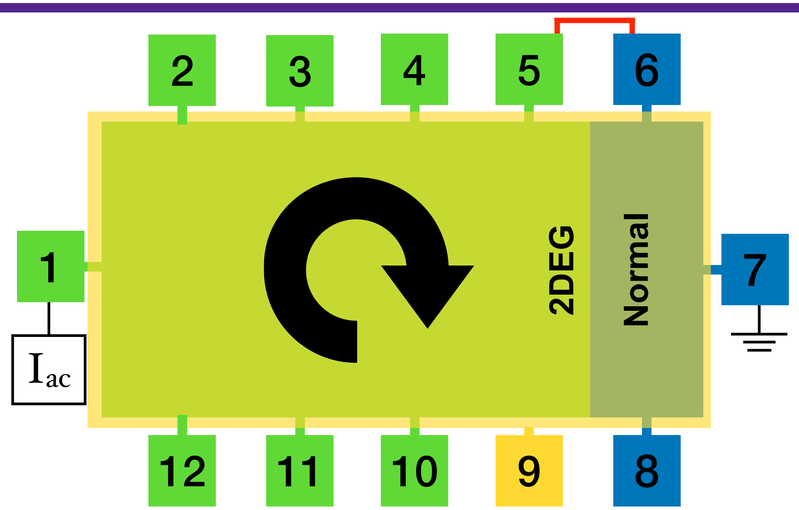


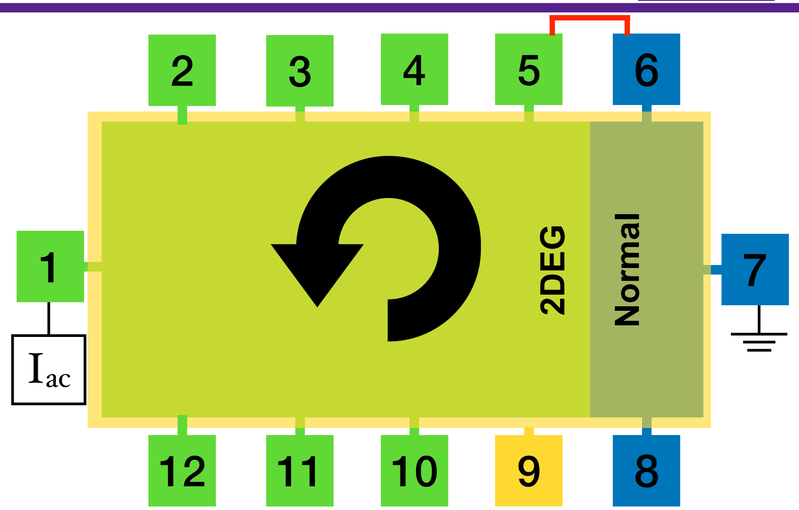






Interface(2DEG/Normal) resistance





$+B$

$$R_{5-6} = \frac{h}{e^2}\frac{R}{NT}$$

$-B$

$$R_{5-6} = \frac{h}{e^2}\frac{1}{NT}$$

Ideal interface:
R=0, T=1 ➡

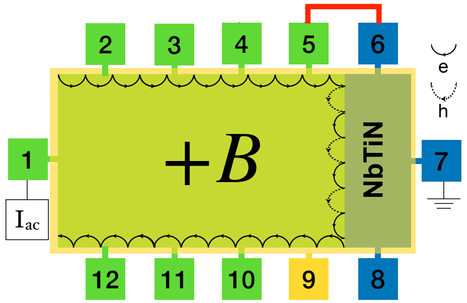
$$R_{5-6} = 0$$

$$R_{5-6} = R_{Hall}$$

Superconductor?

M. Buttiker, PRB(1988)

Interface(2DEG/Superconductor) resistance



Normal

$$R_{5-6} = \frac{h}{e^2}\frac{R}{NT}$$

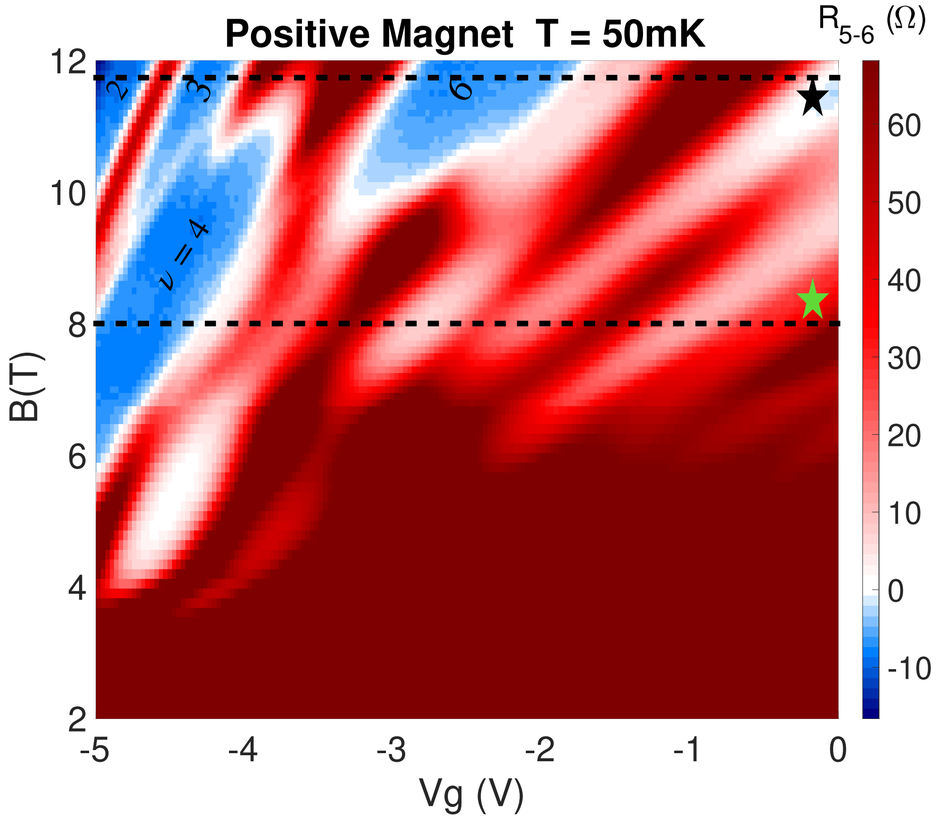
Superconductor

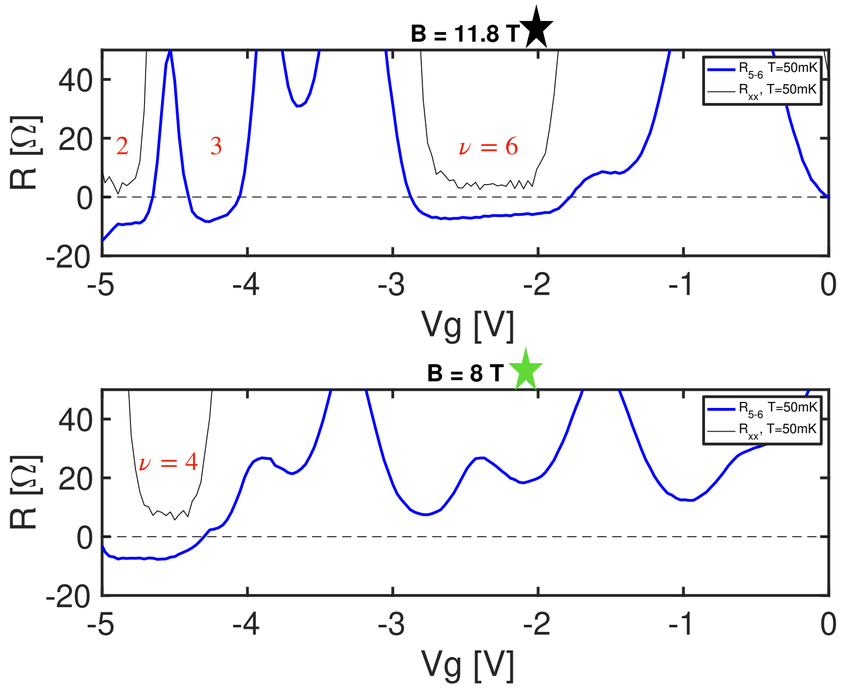
$$R_{5-6} = \frac{h}{e^2}\frac{R-A}{N(T+A)}$$

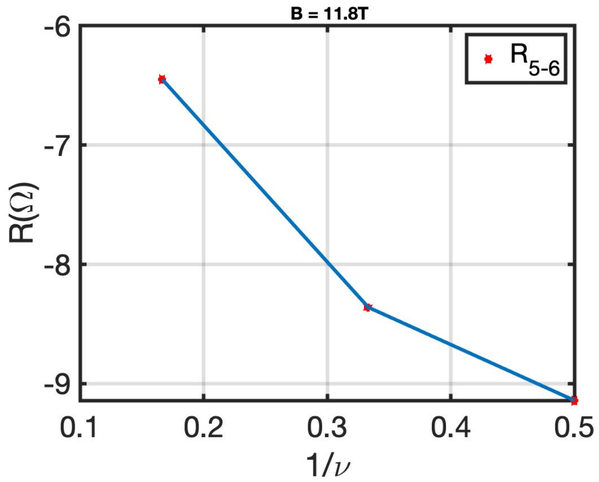
If $A > 0$ → $R_{5-6} < 0$

Ideal interface: $A = 1$

(A: andreev reflection contribution)







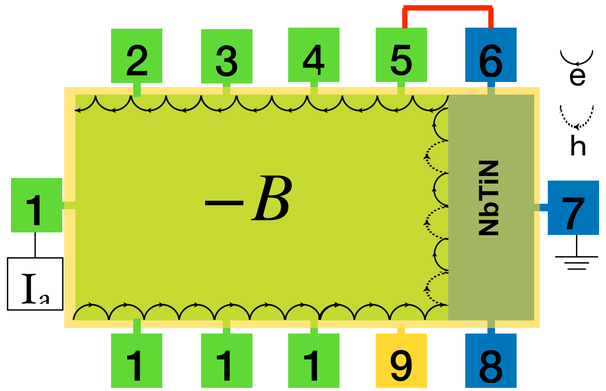
$$\frac{R-A}{(T+A)} = -3.2 \times 10^{-4}$$

Önder Gül et al. arXiv:2009.07836 (2020)

G.' E. Blonder et al. PRB (1982)

M. Buttiker, PRB(1988)

Chirality matters!



Normal

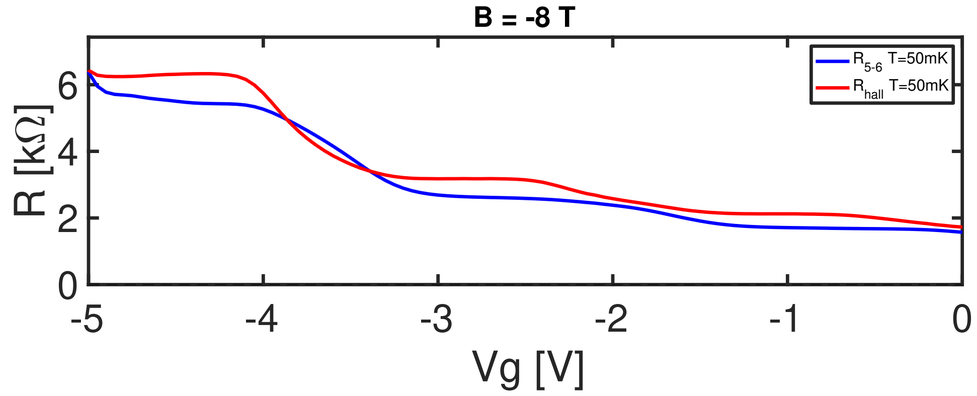
$$R_{5-6} = \frac{h}{e^2}\frac{1}{NT}$$

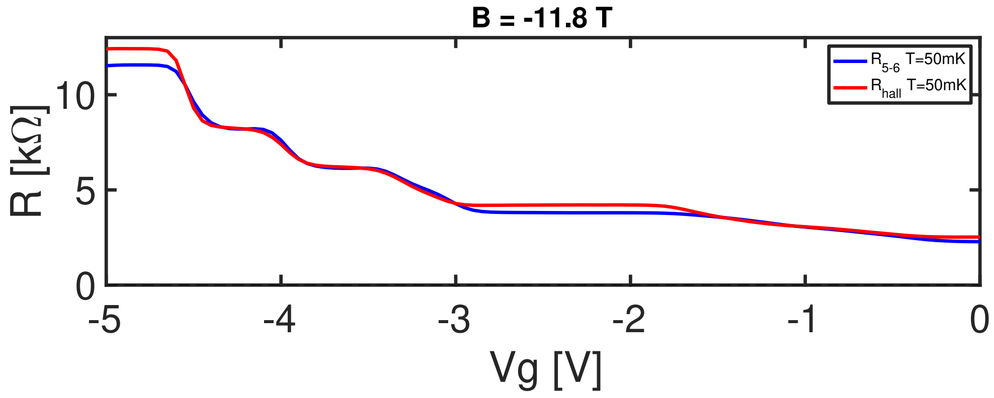
Superconductor

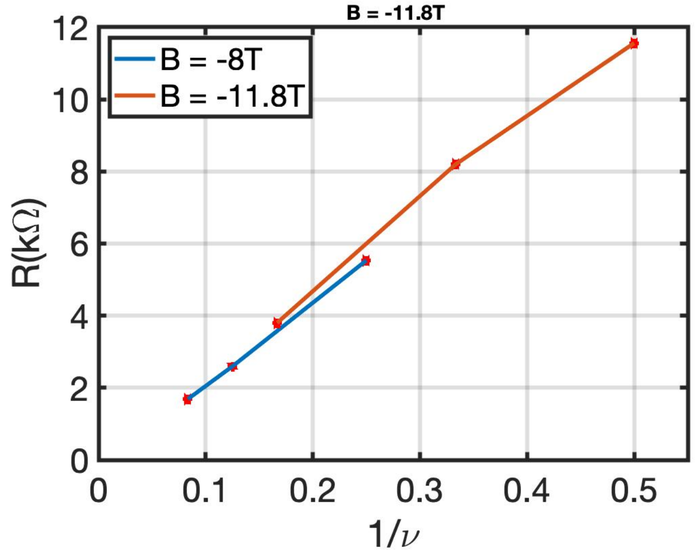
$$R_{5-6} = \frac{h}{e^2}\frac{1}{N(T+A)}$$

(A: andreev reflection contribution)

If $A > 0$ → $R_{5-6} < R_{Hall}$



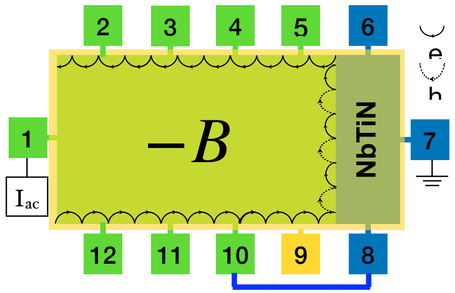


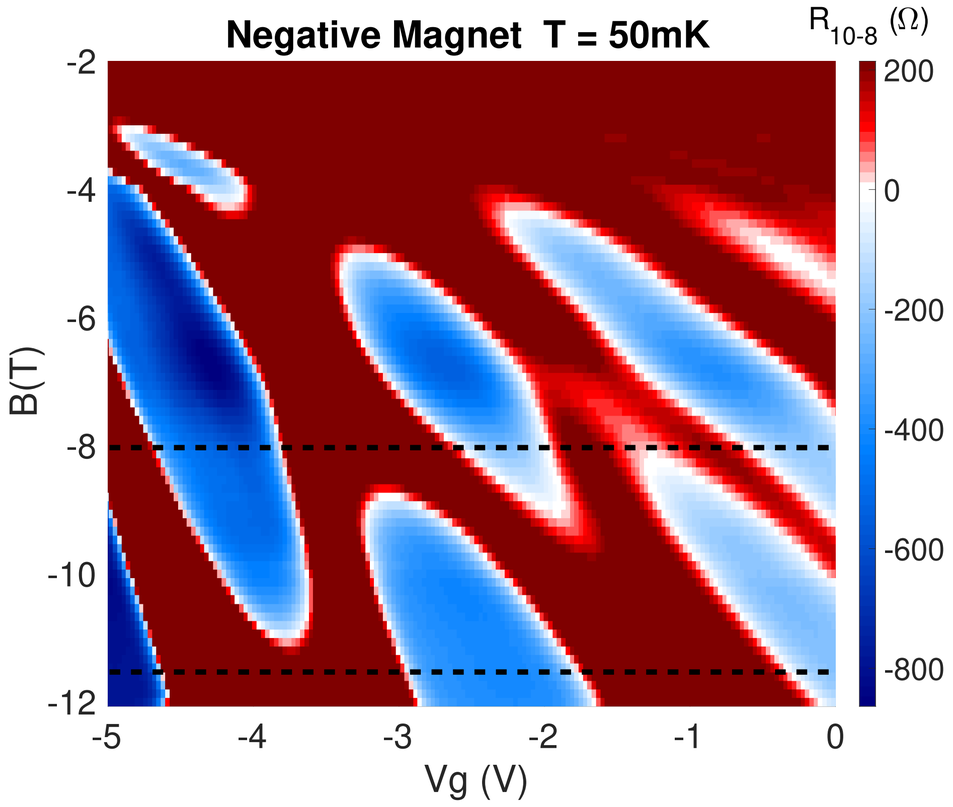


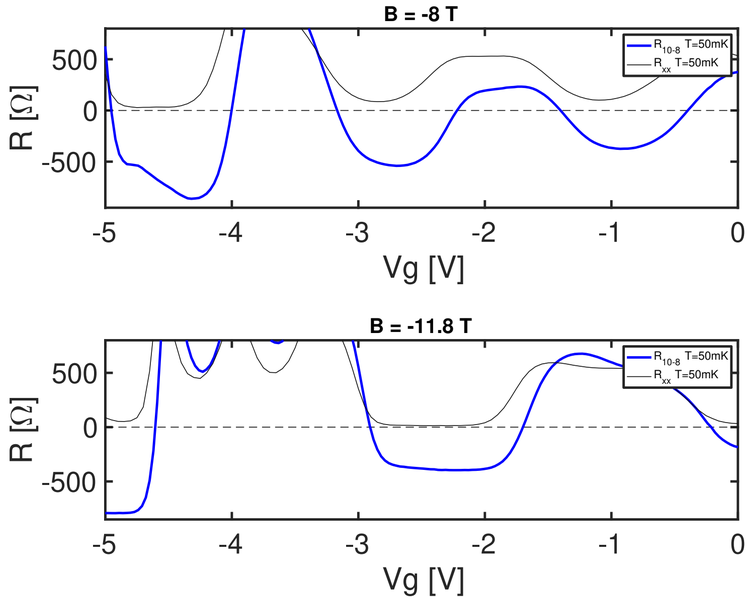
From -11.8T : $T + A = 1.1088$

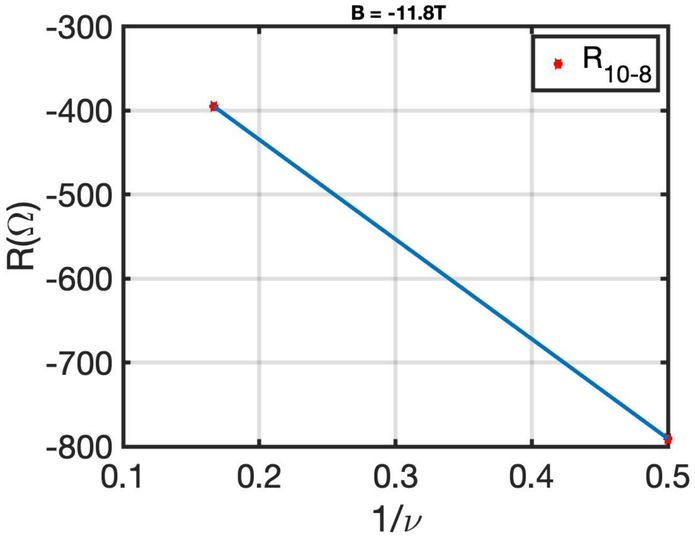
From -8T : $T + A = 1.1136$

Interface resistance









$$\frac{R-A}{(T+A)} = -0.04$$

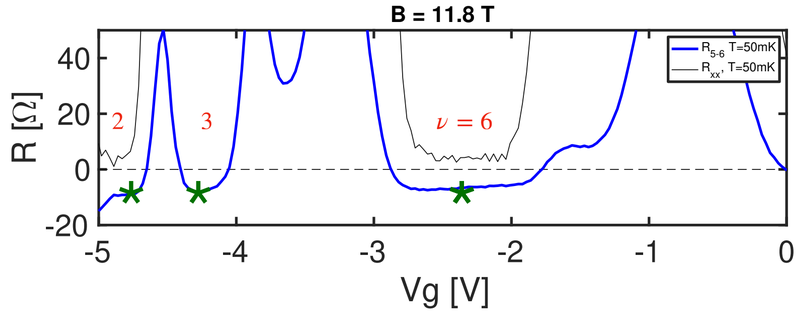
Z calculation

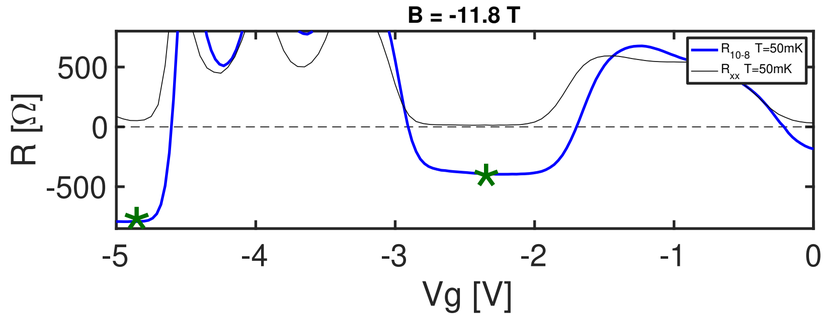
$$R_{5-6 or 10-8} = \frac{h}{2\nu e^2}((1+2Z^2)^2 - 2)$$

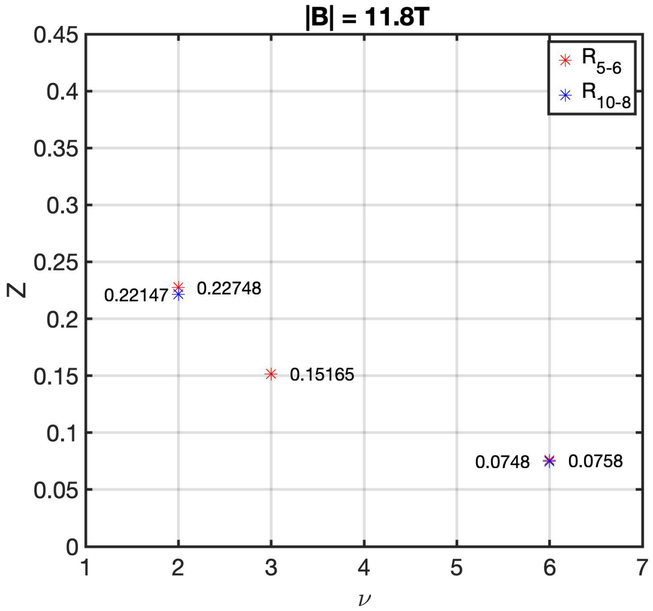
Ideal interface: $Z = 0$

$Z_c = 0.45$

If $0 < Z < Z_c = 0.45$ → $R_{5-6} < 0$







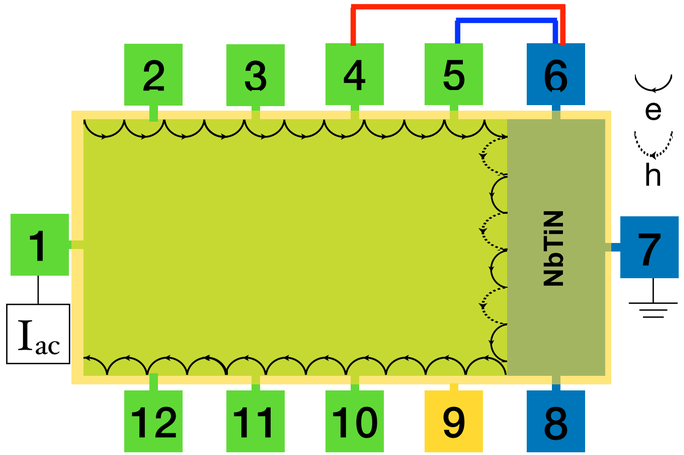
$0.075 < Z < 0.227$

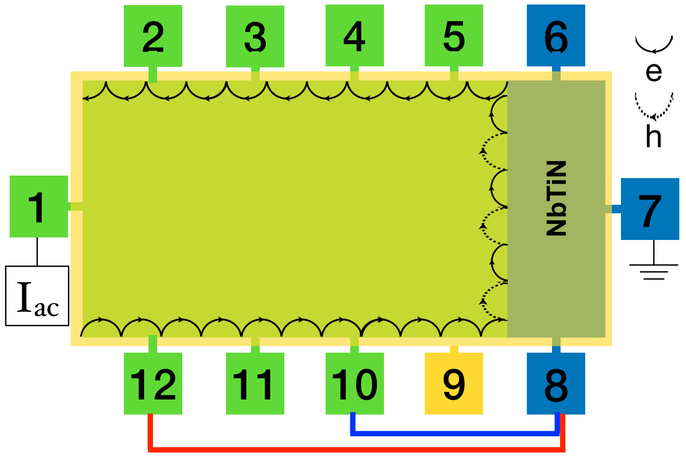
Önder Gül et al. arXiv:2009.07836 (2020)

G.' E. Blonder et al. PRB (1982)

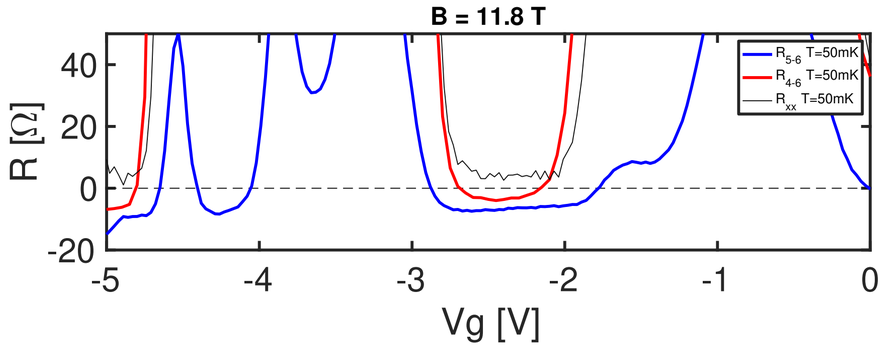
M. Buttiker, PRB(1988)

Distance dependence of interface resistance

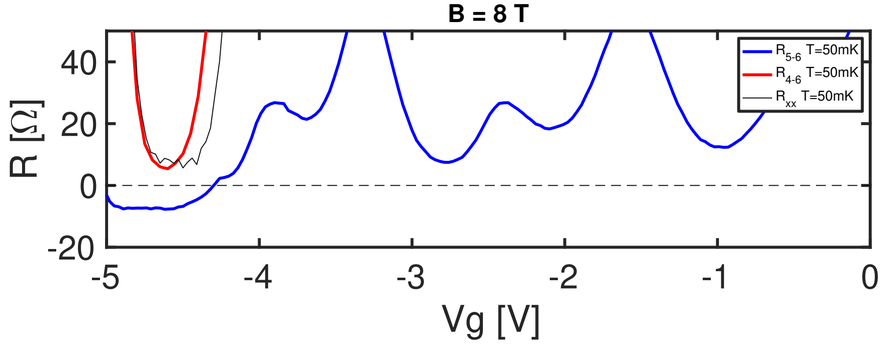




(a)

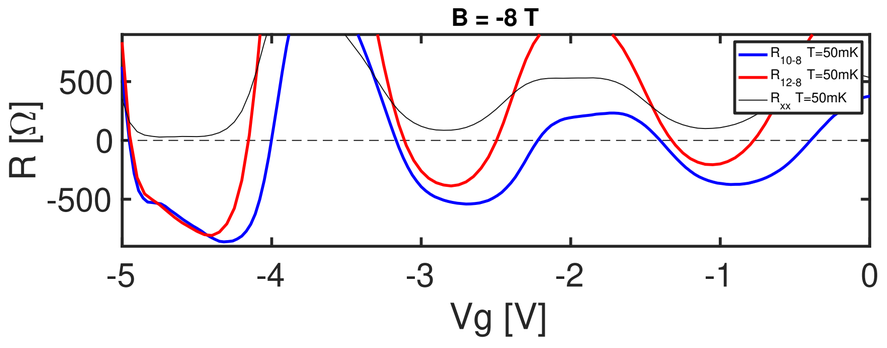


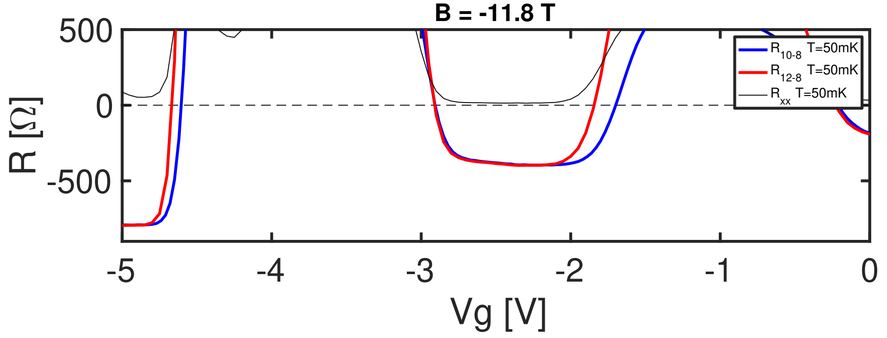
(b)



(c)

(d)





Summary

- Fabrication of gate controlled InAs/NbTiN Hall-bar
- Negative resistance observation at 2DEG/Superconductor interface in IQHS
- Andreev reflection at 2DEG/Superconductor interface up to ~10%

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This work was performed, in part, at the Center for Integrated Nanotechnologies, a U.S.~DOE, Office of BESs, user facility.
This paper describes objective technical results and analysis.
Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. DOE or the United States Government.