Extreme Sensitivity of the Spin-Splitting and 0.7 Anomaly to Confining Potential in One-Dimensional Nanoelectronic Devices

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Their Motivation

• Spintronics
  – Create Spin polarized current
  – Use QPC and magnetic field
  – High g* as an advantage

• Study 0.7 anomaly
  – Many body effect
  – Unresolved for almost two decades

→ Study both in dependence of density
Our motivation

• Nuclear Spin Ordering in GaAs
  – RKKY type of interaction
    → strongly interacting e\(^{-}\) and hyperfine coupling
  – nuclear Curie T ~ mK (r\(_S\) ~ 2 - 5), tunable with gate!
  – Use QPC as a detector

Simon, Braunecker, Loss, PRB, 2008
Devices

- Bow Tie (BT) and polyimide (PI) geometry
- 2DEG 90nm deep
- 300 nm long, 500 nm wide QPC
- Use positive bias for PI device → PI-375
g* measurement

- Extract leverarm, Zeeman splitting and subband spacing

\[ \Delta E_z = e \left[ \frac{dV_g}{dV_{sd}} \right]^{-1} \times \frac{dV_g}{dB_{||}} = e \frac{dV_{sd}}{dB_{||}} \]
• Decreasing $g^*$ with $m$ on average
• For $m>1$, $g^*$ increases with decreasing $n$
• $g^*$ of 2.8 is observed at $m=1$
• Trends for individual devices, but no general trend
QPC characterization

- Subband spacing increases with increasing $n$
- For PI devices $\Delta E$ similar
- For BT $\Delta E$ higher
- $g^*$ uncorrelated?
  $\rightarrow$ Depends on overall potential
Spin gap model

- Spin gap model predicts gap opening proportional to $\Delta E_{1,2}$

- The bigger the gap the closer $G_{0.7}$ to $e^2/h$

- Both samples are consistent with this

- In BT data another feature is prominent at low $n$

Riley et al., PRB, 72, 2005
0.7 anomaly vs. density

- $G_{0.7}$ changes with density
- At high $n$, $G_{0.7}$ decreases, as predicted
- Different samples show different trends
  → Overall potential is crucial
Two different mechanisms?

Thomas et al., PRB, 61, 2000

K. S. Pyshkin et al., PRB, 62, 2000

Riley et al., PRB, 63, 2001
TML data

\[ \frac{dV_{sd}}{dV_g} = 0.0057 \]

\[ \Delta E (mV) \]

\[ V_{tg} = -200 \text{ mV} \]

\[ \frac{dE}{dB} \]

\[ g \text{-factor} \]

\[ n \left( 10^{11} \text{ cm}^{-2} \right) \]

TML, unpublished, 2012
Conclusion

• $g^*$ of 2.8 is observed, dependent on QPC overall potential

• Appearance of the 0.7 plateau is also linked to the overall potential (disorder?)

• Density dependence is consistent with density dependent spin gap model

• Spin polarized current at low density could have been observed