Gate-Tunable Quantum Acoustoelectric Transport in Graphene

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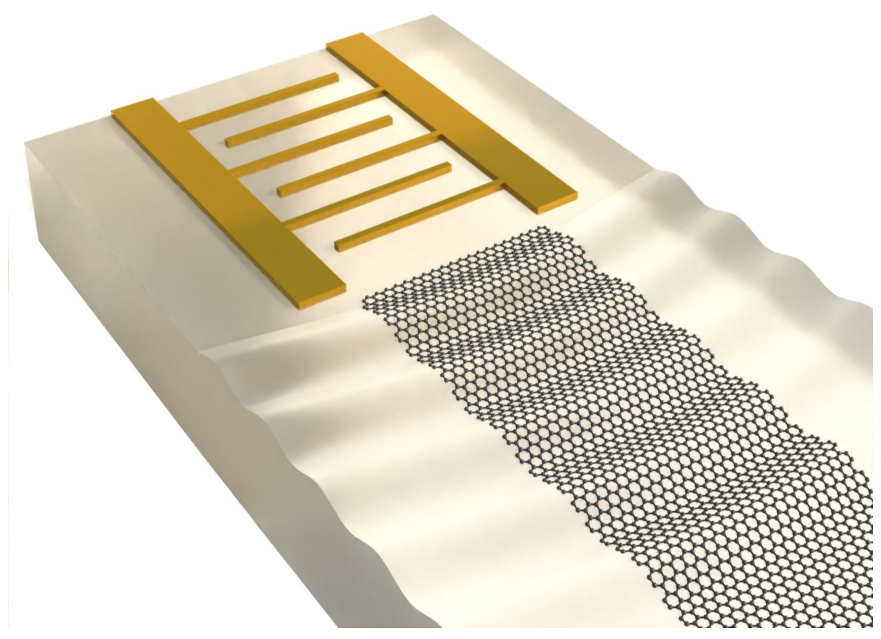
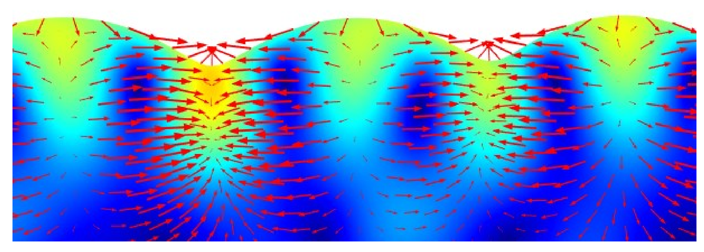
1. Surface acoustic wave & Acoustoelectric effect

Surface acoustic wave (SAW) is a special acoustic wave that only propagates on the surface of a solid, which could be generated by interdigital transducer (IDT).

SAWs could interact with mobile carriers via piezoelectric field and induce a d.c. current in conductors lying on the substrate named as acoustoelectric (AE) effect.



Electric field distribution:



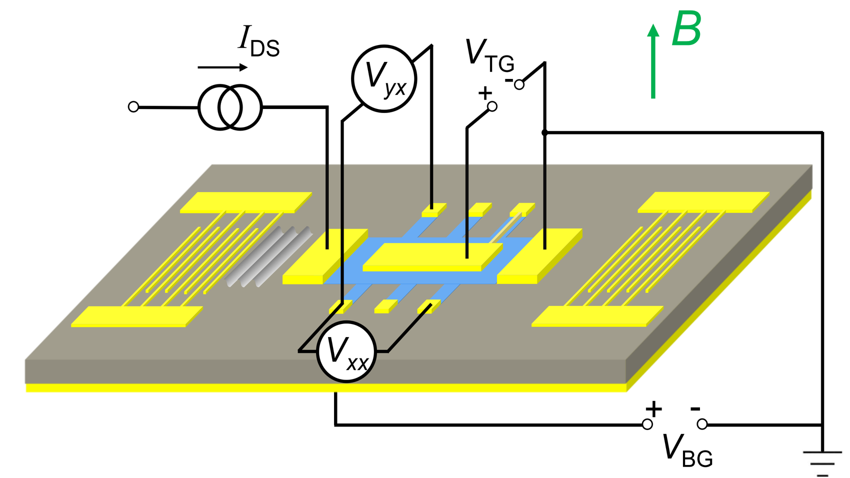
$$j_{\alpha x}^{AE} = -\frac{1}{e}\frac{\partial \sigma_{\alpha x}}{\partial N_S}\cdot\frac{I_{SAW}\Gamma}{v_{SAW}}$$

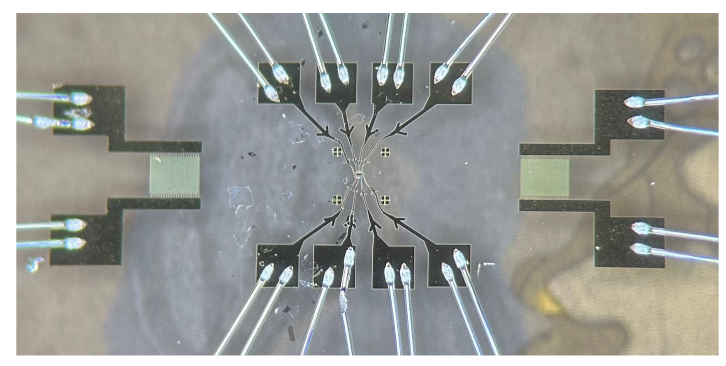
$$\Gamma = \frac{K^2}{2} q \frac{\sigma_{xx}/\sigma_m}{1+(\sigma_{xx}/\sigma_m)^2}$$

2. Device setup

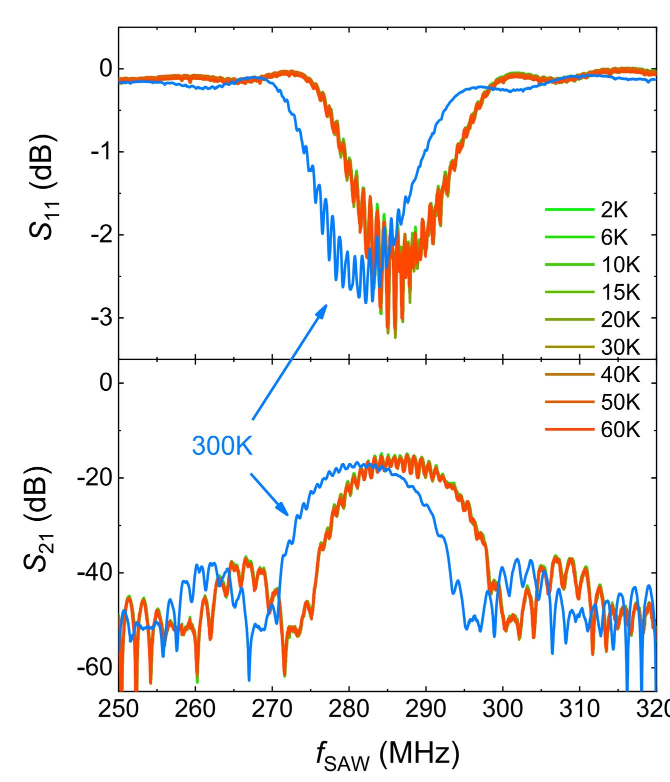
BN-encapsulated graphene FET devices between a pair of IDTs on piezoelectric $LiNbO_3$ substrate.

We measure AE voltages as SAWs propagate under various conditions.





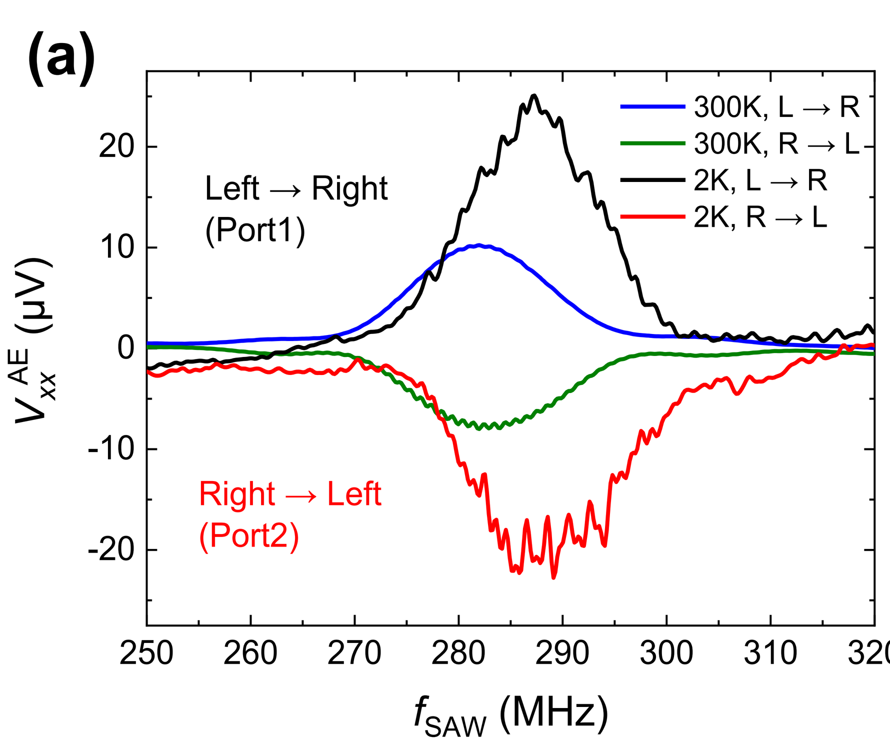
***S*-parameters of IDTs:**

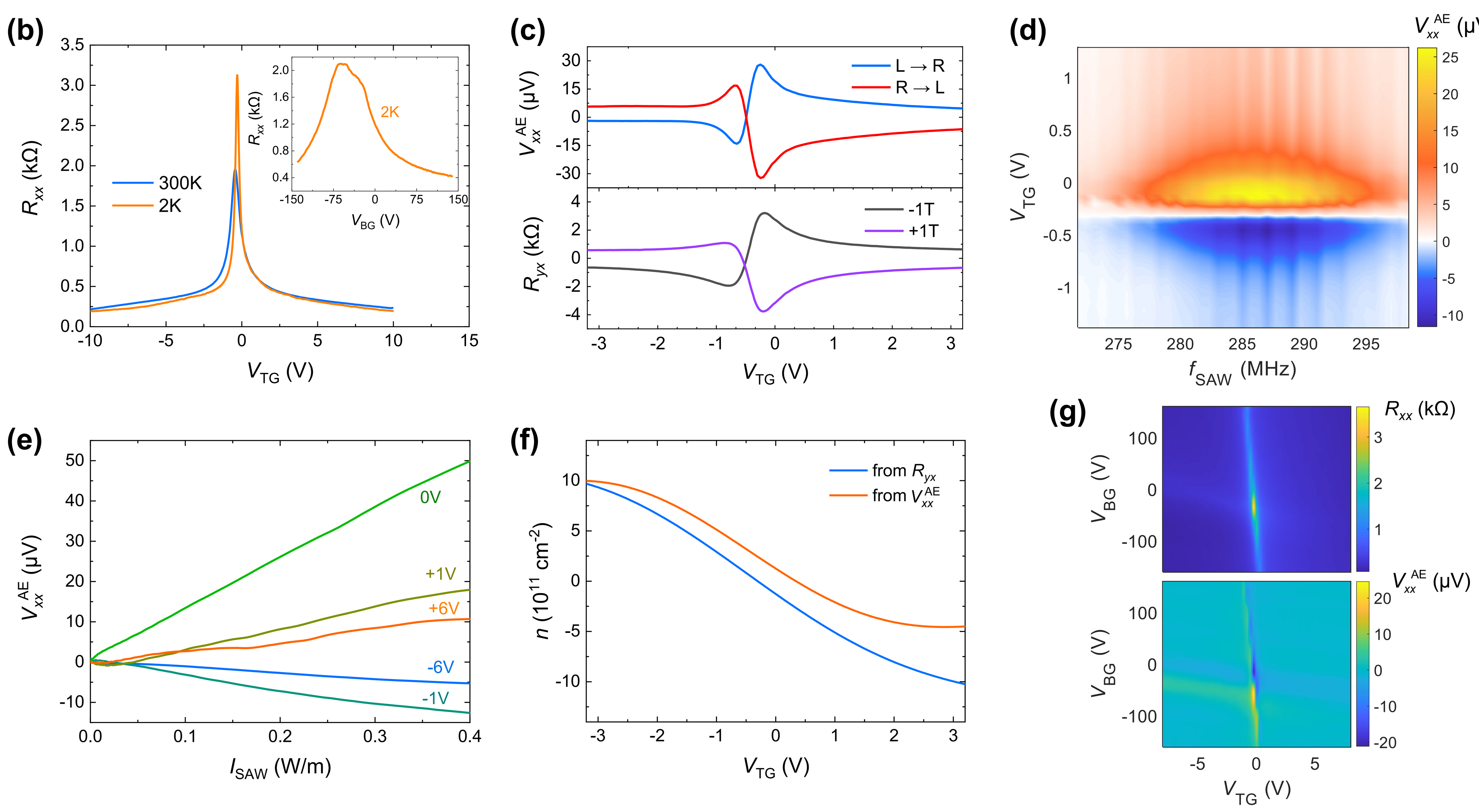


3. Gate-tunable longitudinal AE effect at zero field

We're able to extract carrier density without the need of magnetic field.

(a)-(g): zero-field V_{xx}^{AE} vs SAW frequency, gate voltage, SAW intensity.

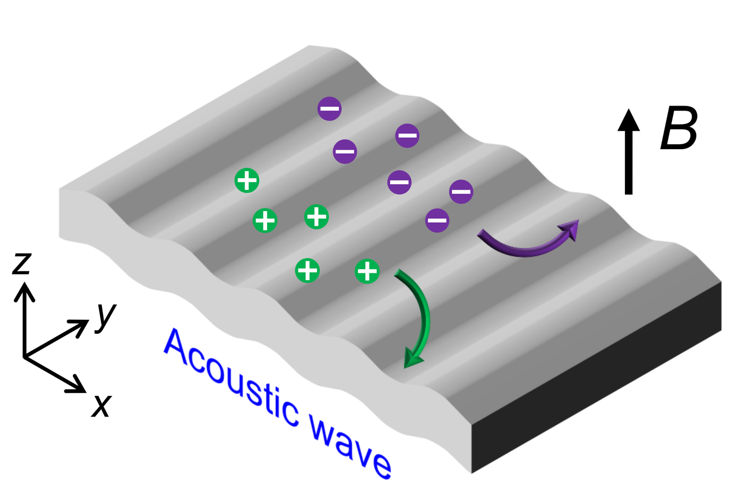


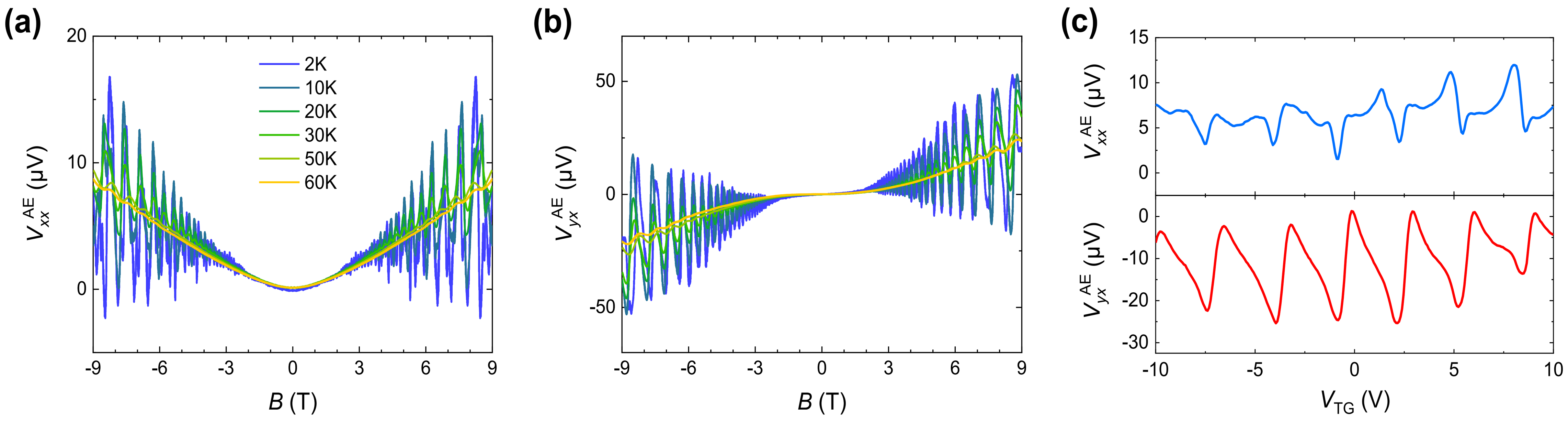


4. Quantum oscillations on AE voltages

With magnetic fields, transverse AE voltage appears. At large fields, clear quantum oscillations were observed on AE voltages in both direction.

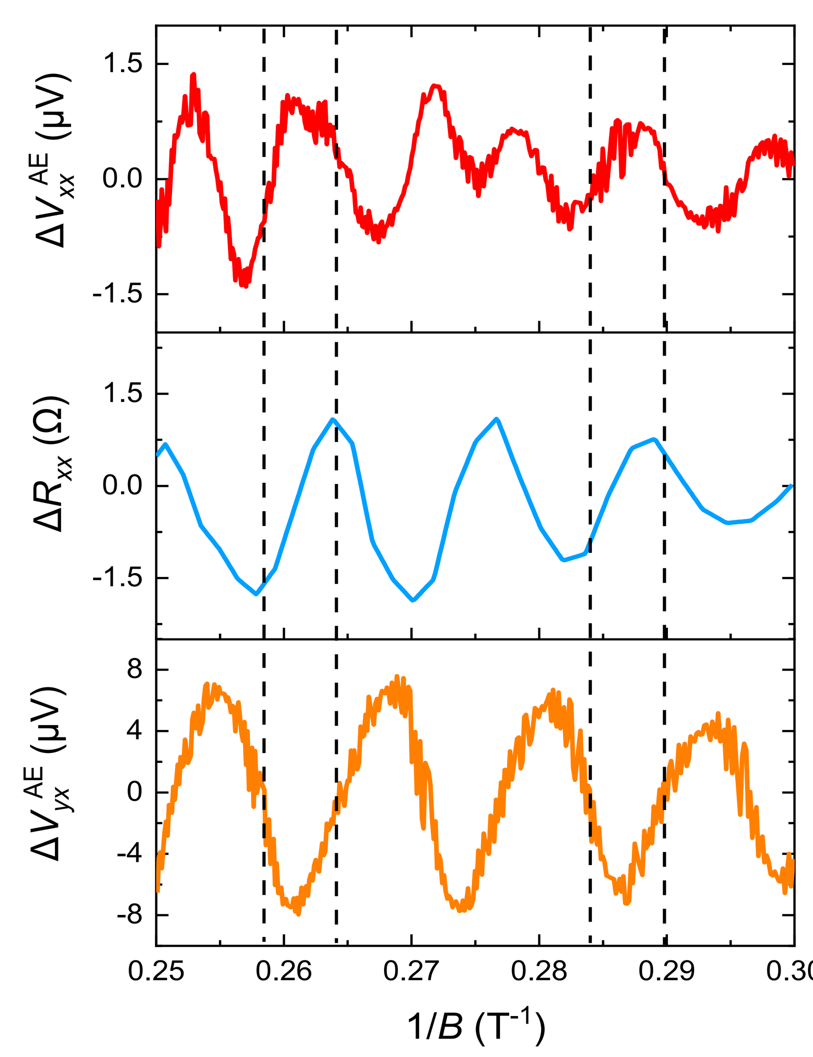
(a): V_{xx}^{AE} vs B; (b): V_{yx}^{AE} vs B; (c): V_{xx}^{AE} and V_{yx}^{AE} vs gate voltage.





5. Comparison to electric transports

Quantum oscillations on ΔR_{xx} and ΔV_{xx}^{AE} have $\pi/2$ phase difference.



6. Conclusions & Highlights

(1) We establish a simple design of AE transport device with gate tunability.

(2) We demonstrate a new way to extract carrier concentration without the need of magnetic field as in Hall effect.

(3) AE transport can probe Landau quantization and quasiparticle properties.

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