communications physics

ARTICLE

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Observation of nonlocal Josephson effect on double InAs nanowires

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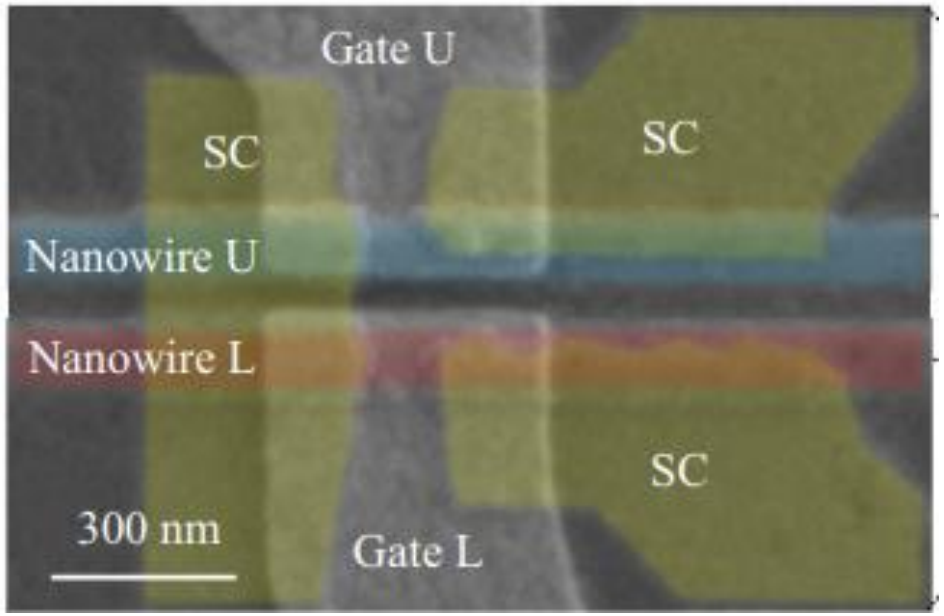
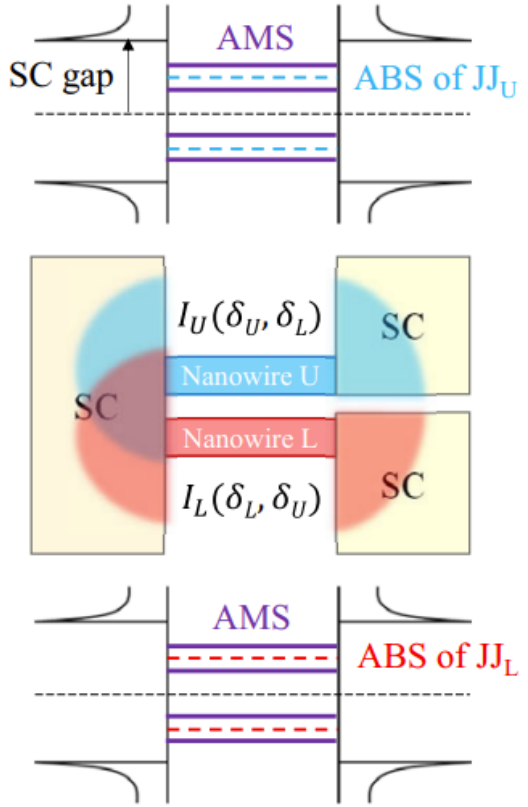
Outline

- Motivation
- Devices
- Local, Non-local Control
- Conclusion



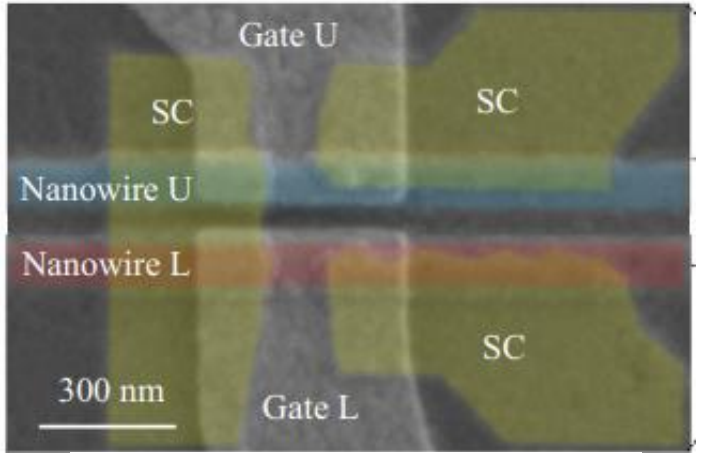
Motivation

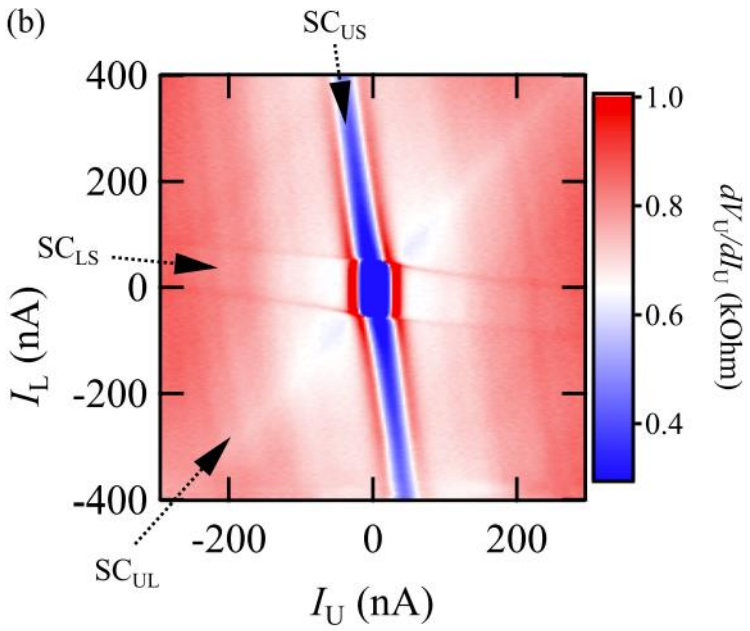
- Study of JJ physics key for SC circuits
- Interesting/exotic states of matter in hybridized systems (CAR, AMS, etc.)
- Control supercurrent in one JJ non-locally by manipulating the other
- Claim multi-terminal JJ can be a platform for topological physics

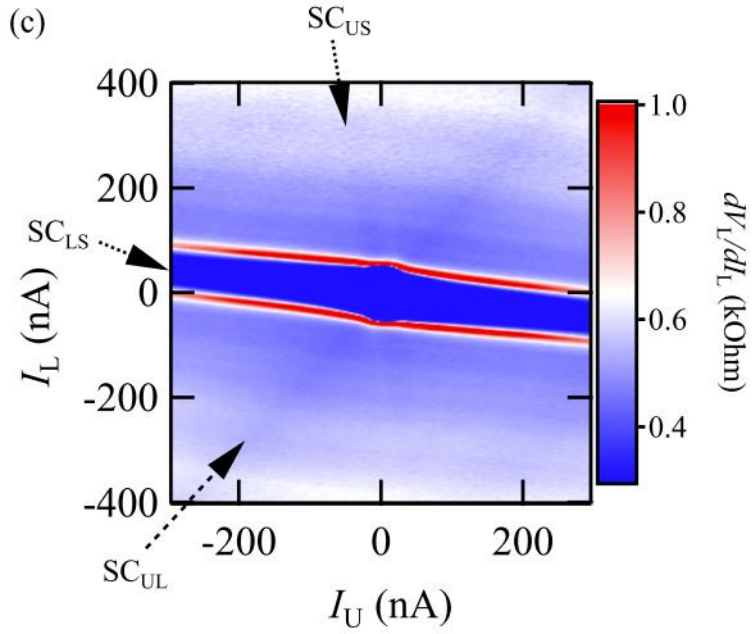


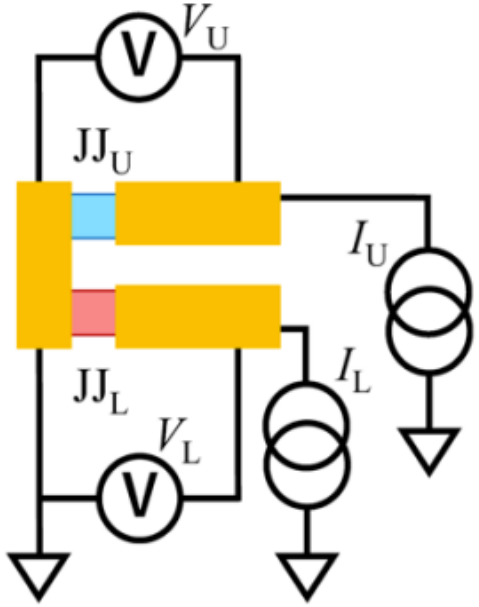
Device 1

- SAG InAs [100] double NW with 10 nm in-situ epitaxial aluminum (both devices)
- 80 nm wide NW with 60 nm separation
- All measurements at 10 mK
- Device 1 used to confirm SC correlation between any two SC electrodes



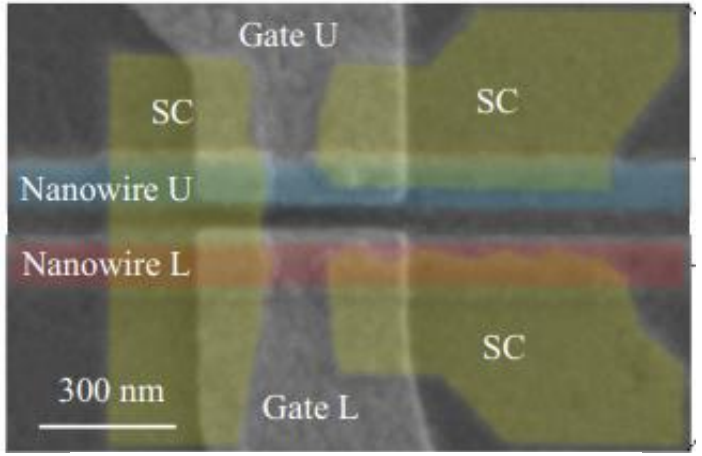


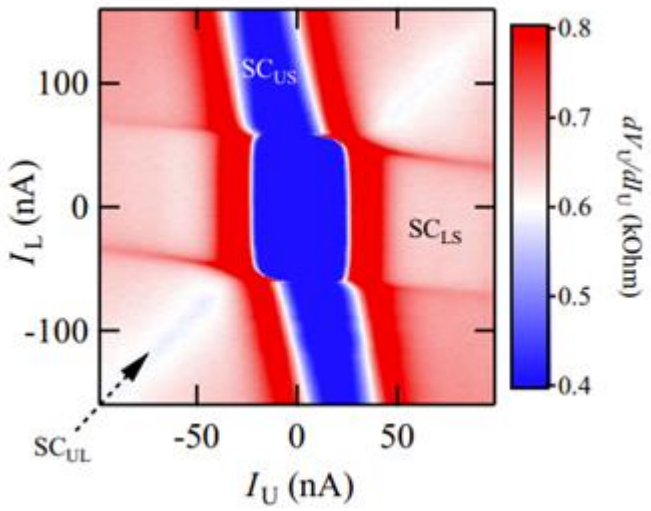


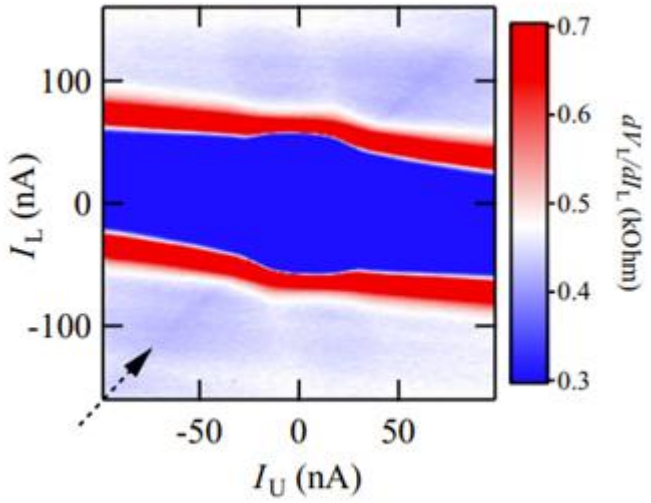


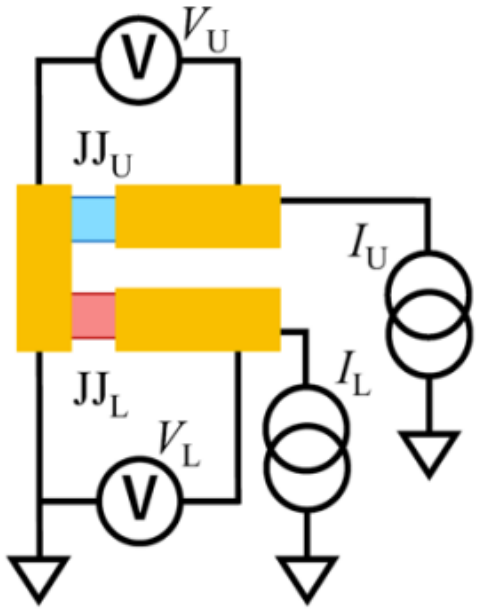
Device 1

- Switching current ~30 (60) nA in JJU (JJL)
- Finite SC due to Joule-heating
- Tilts of SC regions due to cotunneling
- SC_{UL} fist indication of non-local SC correlation









Device 2

- Device 2 used to demonstrate non-local control of DC Josephson effect
- Use gates and magnetic flux

$$I_s = I_C \sin\phi$$

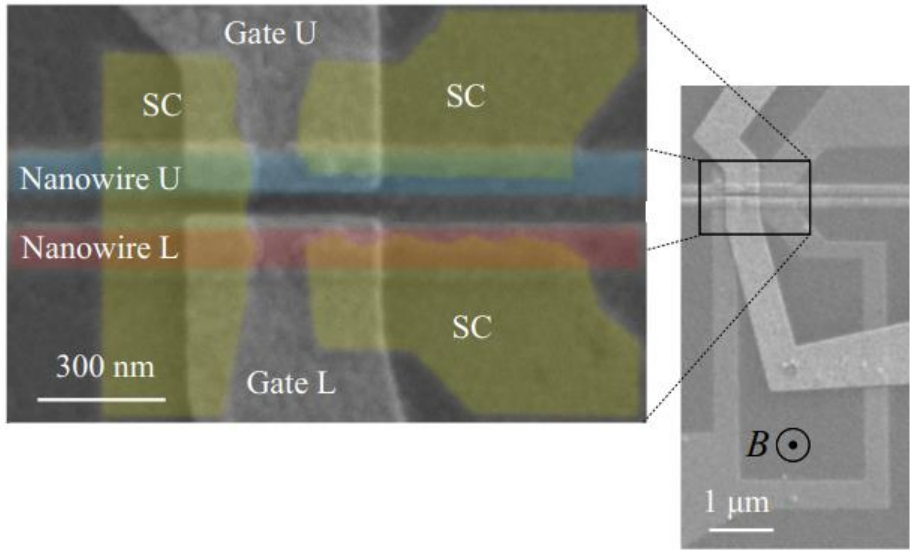
DC Josephson effect

$$2eV = \frac{\hbar \partial \phi}{\partial t}$$

AC Josephson effect

$$f_J = \frac{2eV}{h}$$

Josephson frequency

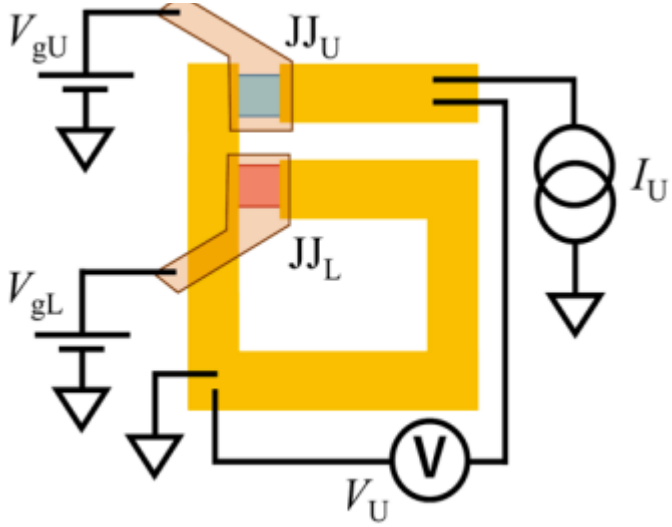


$$W = \int I_S V dt = \frac{\hbar}{2e} \int I_s d\phi$$

Free energy: integral over phase diff.

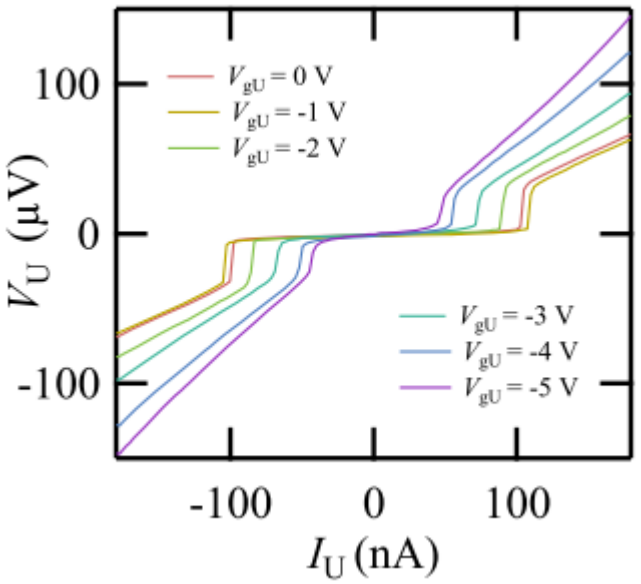
$$I_S = \frac{2e\partial W}{\hbar \partial \phi}$$

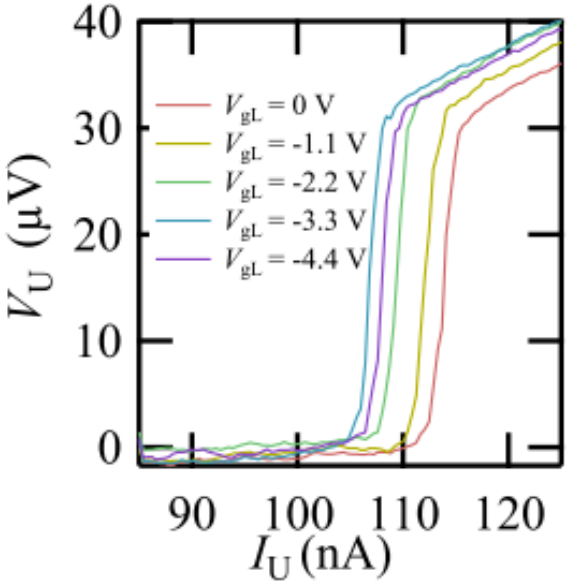
SC prop. to energy change wrt phase



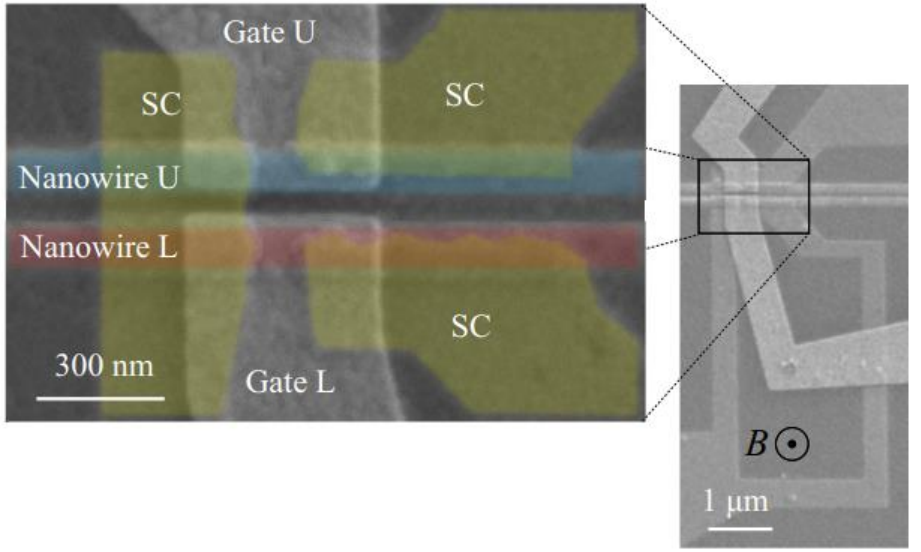
Device 2

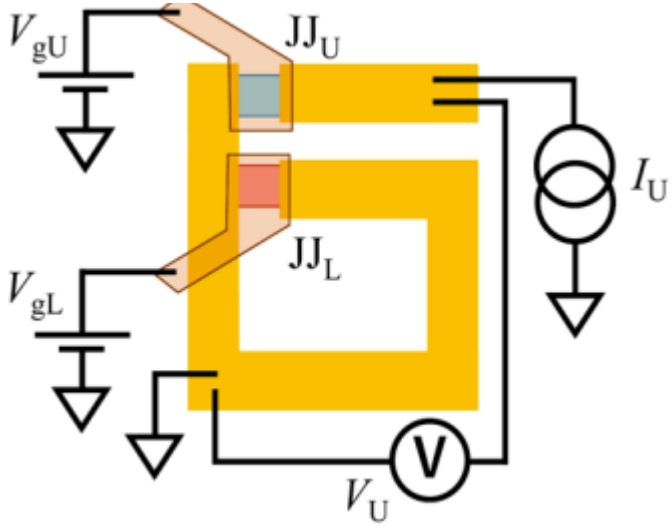
- Switching current modulated by gates





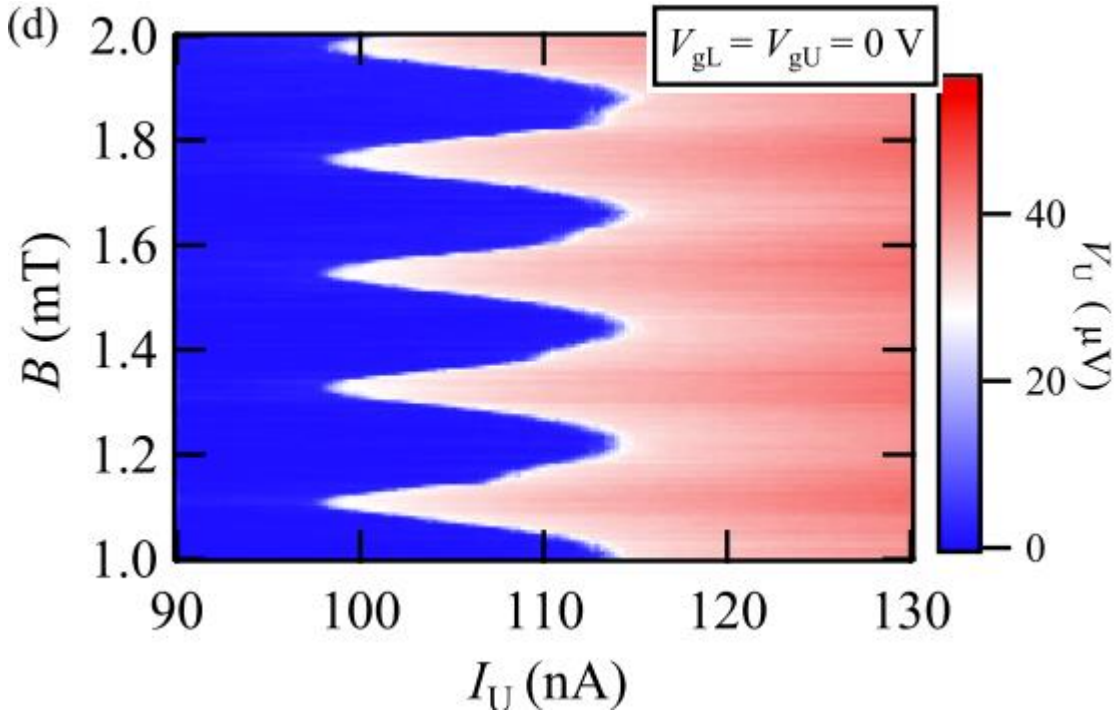
$B = 1.9$ mT

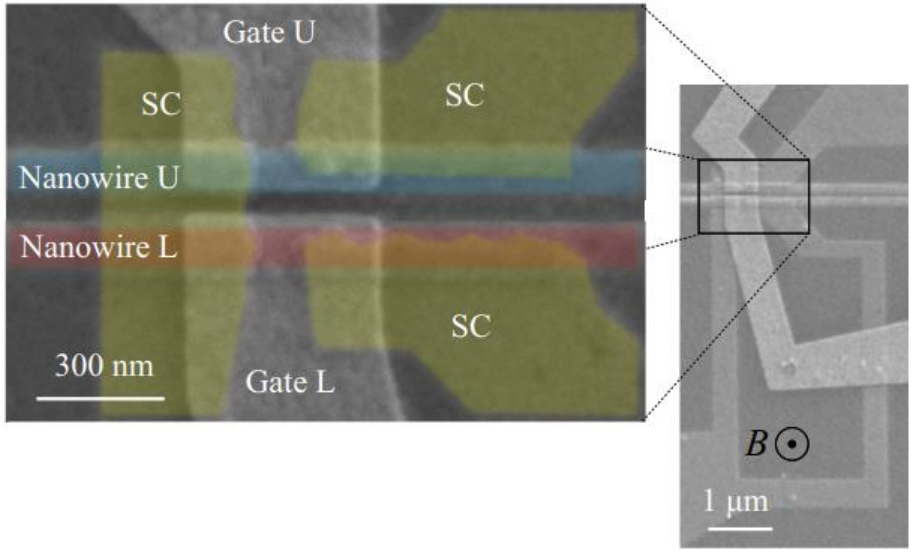


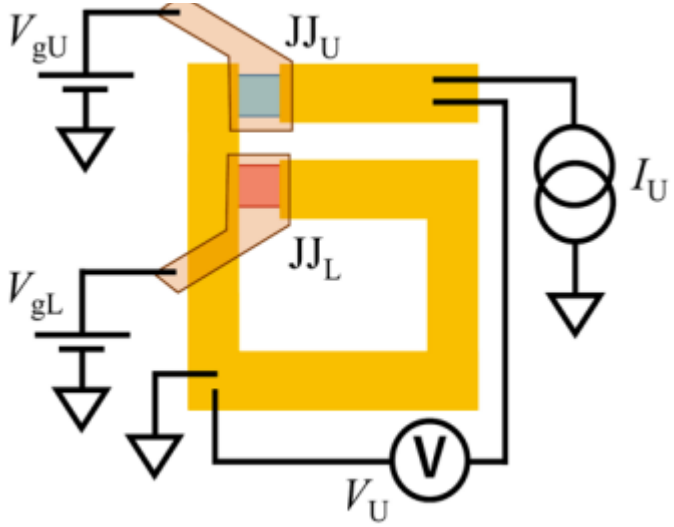


Device 2

Oscillation period: 0.22 mT
Calculated: 0.3 mT (A_{loop} = 6.88 μm^2)

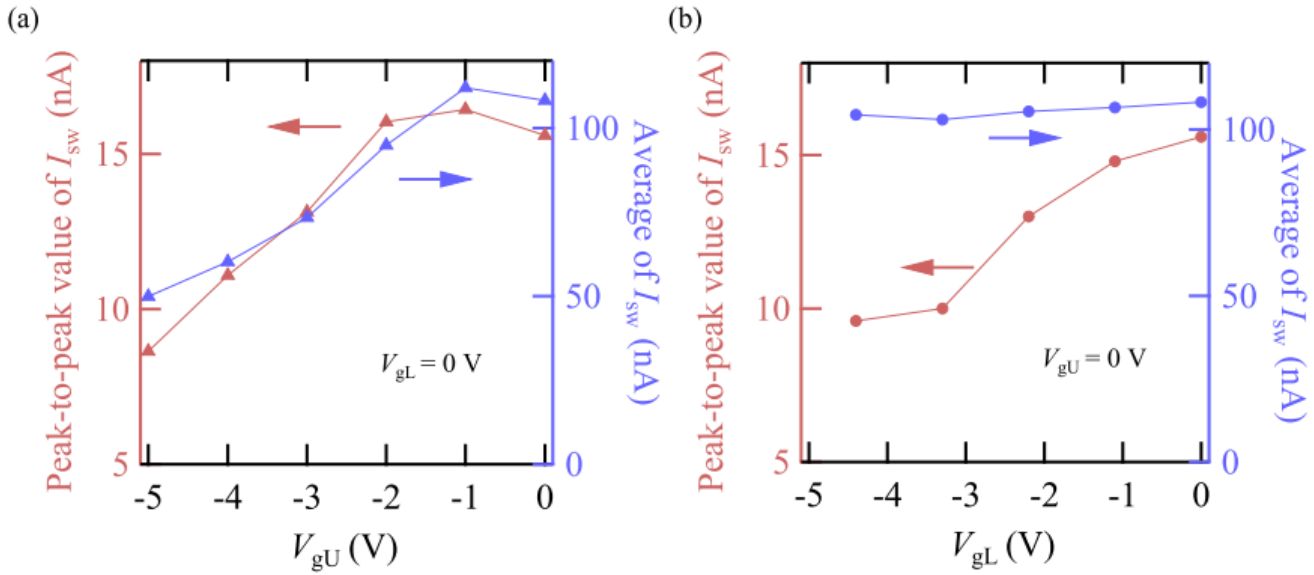


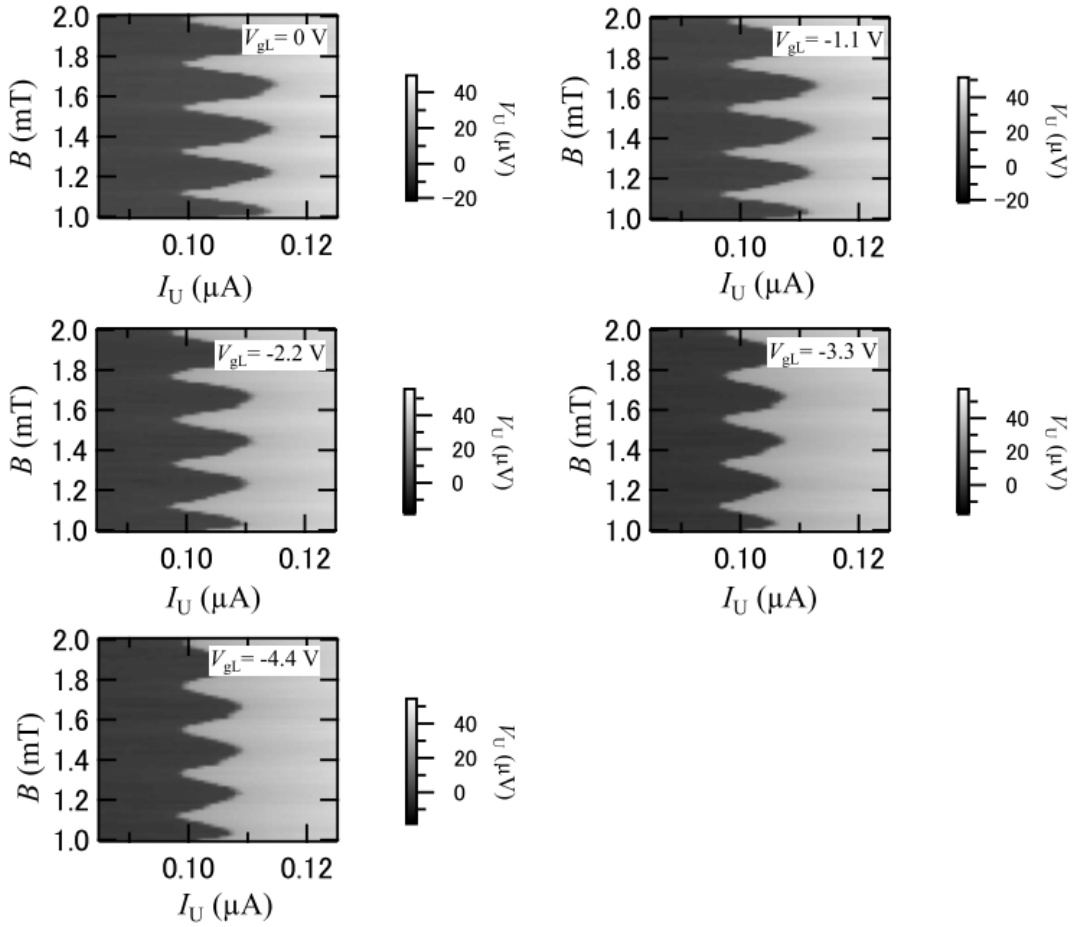




- B-field should change only ϕ_L
  → only non-local SC correlation between JJU and JJL should affect I_{switch}

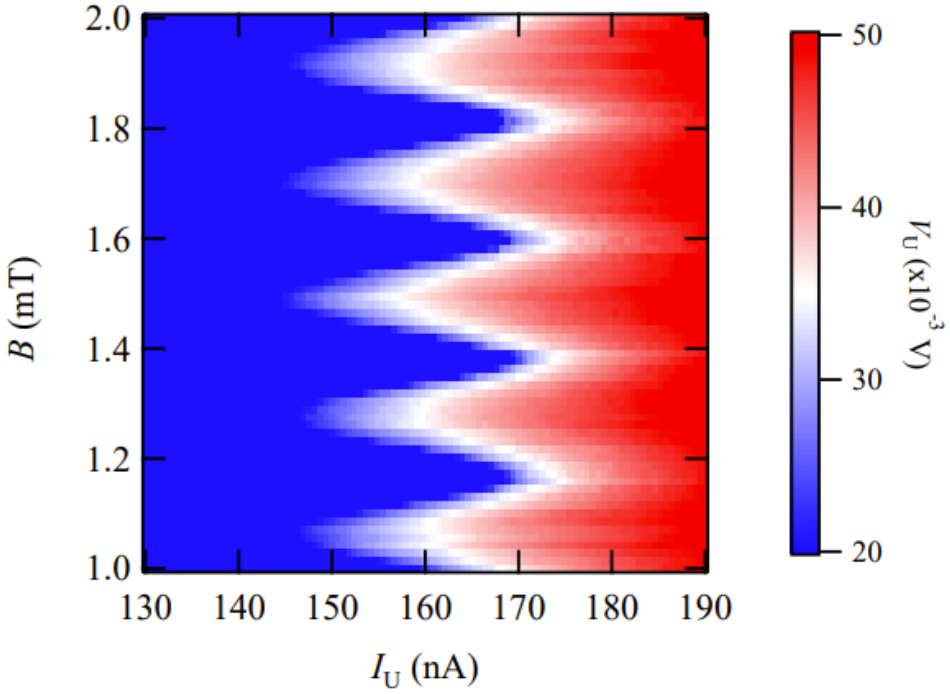
Local, non-local control



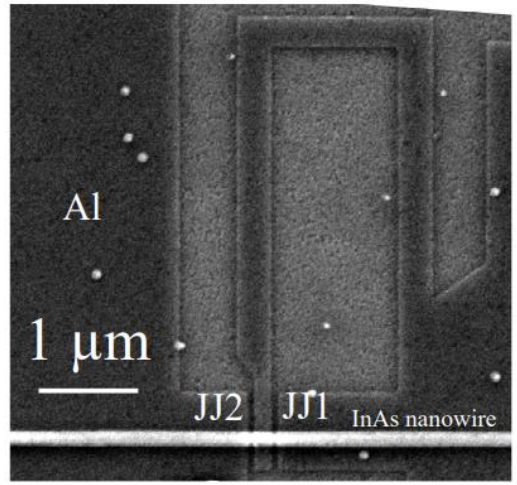


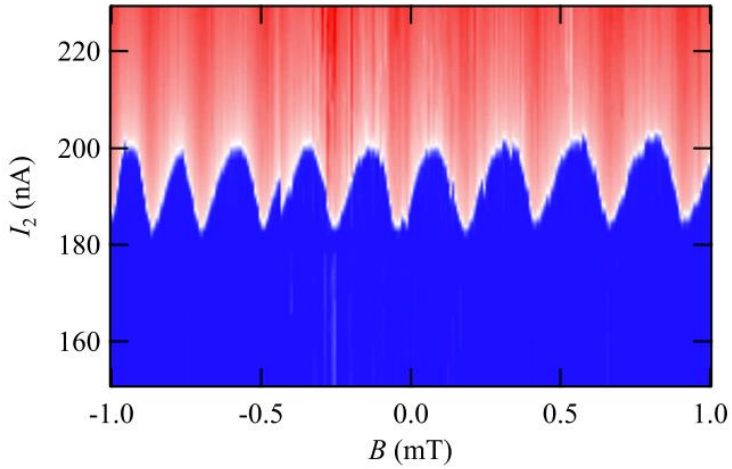
Avg only affected by local gate
→ oscillation due to coherent coupling between JJU & JJL

Reproducible



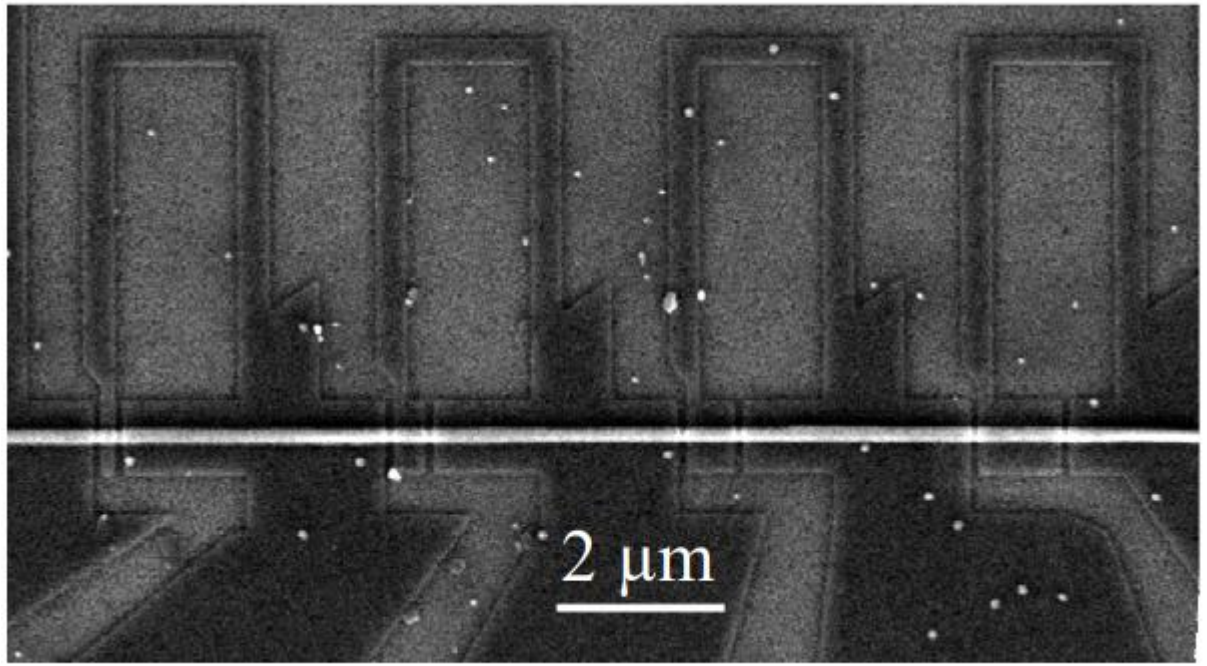
Sample 3

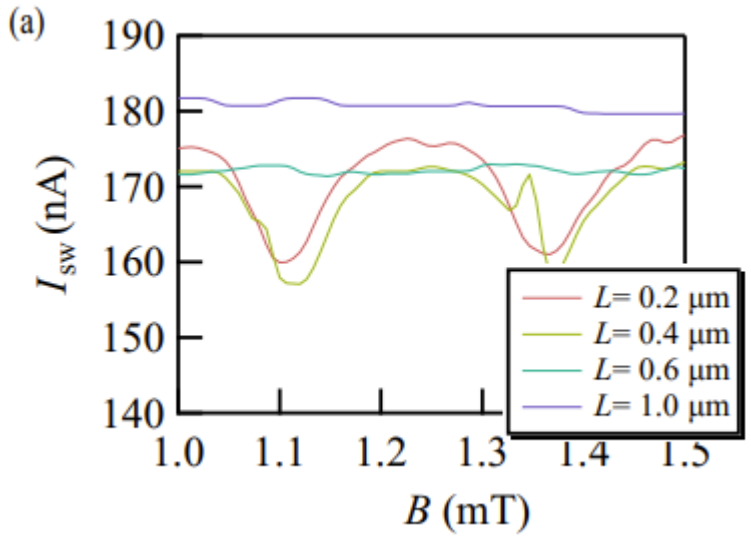




On single wires!

Function of length





Conclusion & Outlook

- Observation of non-local Josephson effect in switching current
- Need to evaluate the current phase relation
- Results explained without SOI playing a role

Thanks for listening!