

Family of magnetic field-boosted superconductors in rhombohedral graphene

From Knowledge to Competitiveness

Portugal-US Partnerships 2026 Summit

Mit Portugal Program

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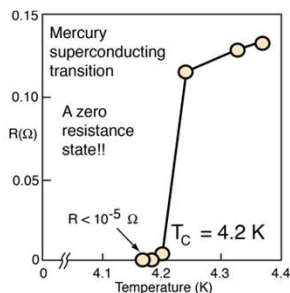
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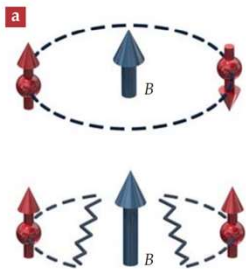
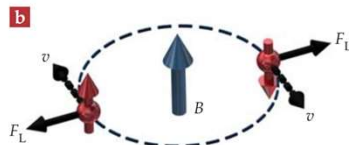
Chips/Nanotechnology

Are magnetic field-boosted SCs possible?

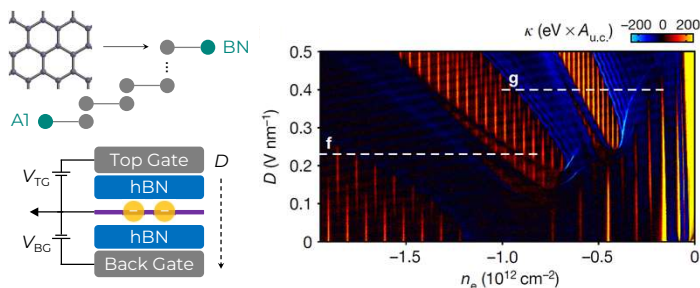


- **Superconductivity (SC):** The electrical resistance goes to perfectly zero [1].
- Lots of applications in **energy technology** (no resistive loss), **imaging** (MRI, etc.), and **quantum computing** (SC qubit, topological quantum computation).
- SC originates from two electrons paired up together → Copper pair.
- Copper pairs in most materials are from two opposite spins [2]. → SC is killed by a magnetic field.

- Can we make SCs that are robust or even enhanced by a magnetic field?



Rhombohedral N-layer graphene (RNG)

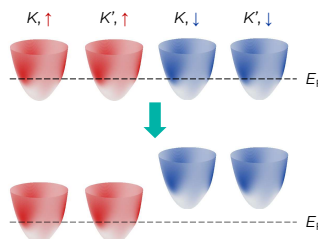


- RNG: Atomically thin carbon sheet with a rhombohedral stacking order.

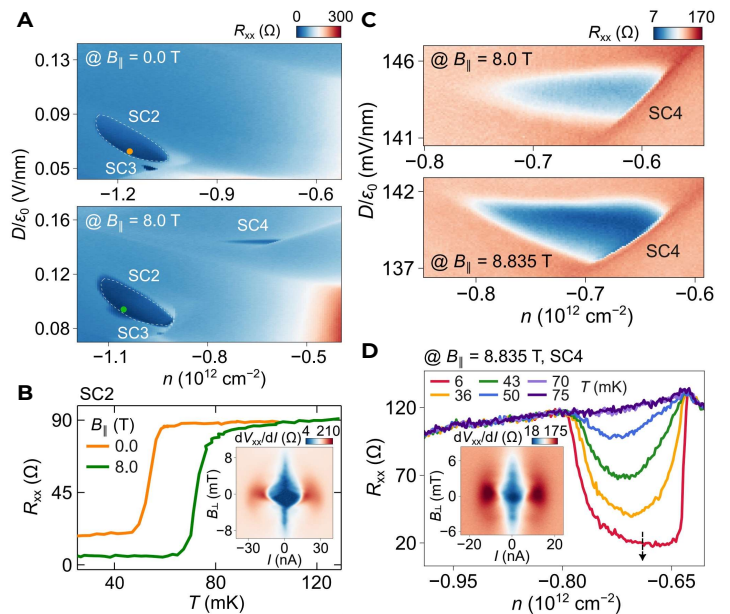
- Make it into a **transistor**: Can control the electron density n and vertical electric field D/ϵ independently.

- Tuning n and D → Can find a region where **only a single direction of spin is allowed** [3], due to strong electron correlation effects.

- Will this become SC as cool down?

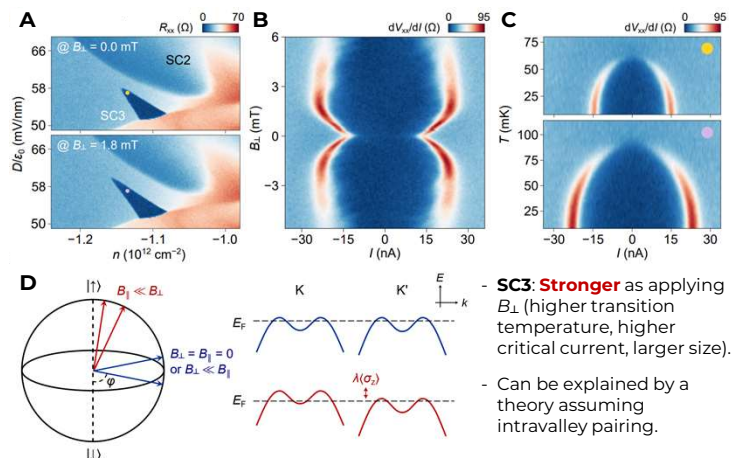


SC enhanced & induced by in-plane field $B_{||}$



- **SC2: Stronger** as applying $B_{||}$ (higher transition temperature, larger size).
- **SC4: Induced** by $B_{||}$ (no analog at zero $B_{||}$).

SC enhanced by out-of-plane field $B_{\perp}$



- **SC3: Stronger** as applying $B_{\perp}$ (higher transition temperature, higher critical current, larger size).
- Can be explained by a theory assuming intravalley pairing.

Future outlook

- Understanding the **microscopic origin** of the observed superconductors.
- Engineering **non-Abelian quasiparticles** with approximations to QAH states for fault-tolerant topological quantum computing [4].

References:

- [1] H. K. Onnes, *Commun. Phys. Lab.* **12**, 120 (1911). [2] A. de Visser, *Phys. Today* **73**, 44 (2020).
[3] H. Zhou et al. *Nature* **598**, 429 (2021). [4] N. H. Lindner et al. *Phys. Rev. X* **2**, 041002 (2012).

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