

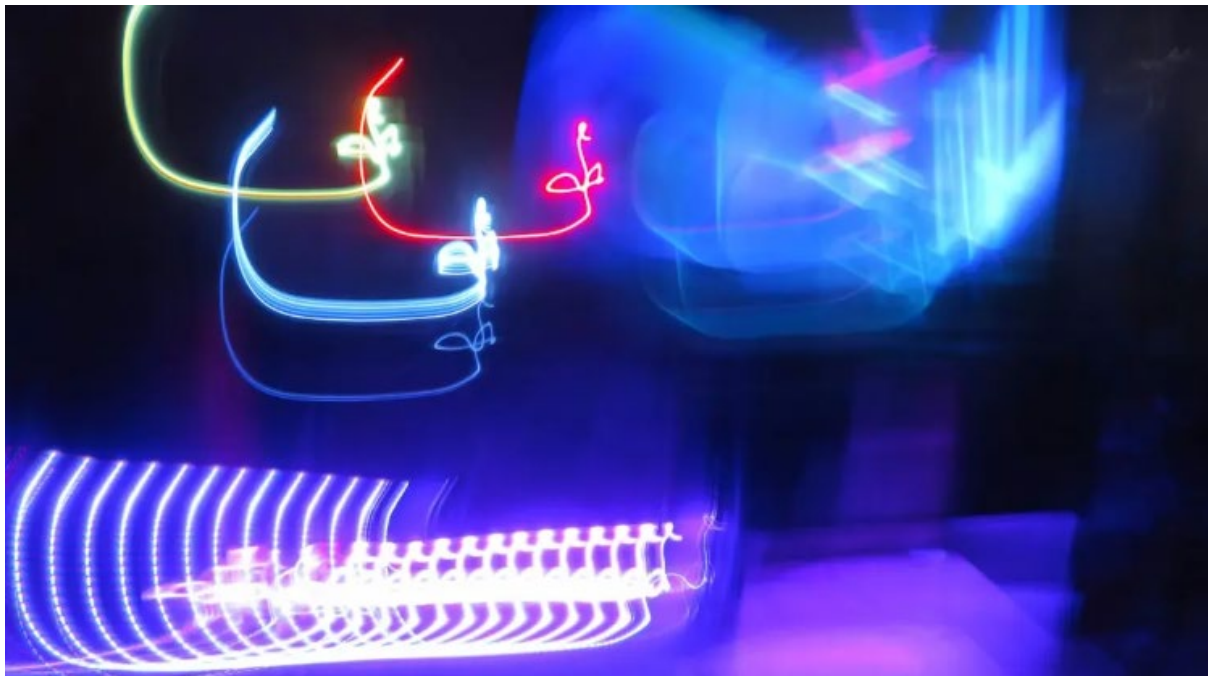
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NTU Scientists Solve Long-Standing Challenge: Controlling Free-Flowing Electric Currents with Light Using Magnetic Fields

Revolutionizing Quantum Electronics at Nanyang Technological University

Unlocking the Future of Electronics: NTU's Groundbreaking Light-Controlled Currents



In a pioneering achievement, scientists at Nanyang Technological University (NTU) in Singapore have demonstrated the ability to precisely control 'free-flowing' electric currents using light to manipulate magnetic fields in advanced quantum materials. This breakthrough addresses a persistent challenge in materials science: directing dissipationless electron flows without resistance, which typically generate wasteful heat in conventional electronics.

The innovation promises transformative impacts on low-power computing, quantum technologies, and energy-efficient devices, aligning perfectly with Singapore's ambitious push in quantum research under the S\$37 billion Research, Innovation and Enterprise (RIE) 2030 plan.

The Science Behind Free-Flowing Electric Currents

Free-flowing electric currents refer to dissipationless edge states in topological materials, where electrons travel along the material's edges without scattering or losing energy, akin to vehicles on a one-way highway protected from collisions. This phenomenon stems from the quantum Hall effect, first observed in 1980, where strong magnetic fields induce quantized conductance and chiral edge modes.

In modern contexts, moiré Chern ferromagnets—ultrathin layers of materials like graphene or transition metal dichalcogenides stacked with a slight lattice mismatch—create periodic 'moiré' patterns. These induce Chern insulators with spontaneous magnetization, enabling these edge currents at zero external field. However, controlling their direction has been elusive due to the fixed magnetization orientation.

NTU's Innovative Method: Light as a Magnetic Switch

Led by Prof. Gao Weibo, Chair of NTU's School of Electrical and Electronic Engineering and Director of the Quantum Science and Engineering Centre, the team used circularly polarized light—a beam rotating like a corkscrew—to flip the magnetization in the moiré Chern ferromagnet. Here's the step-by-step process:

Step 1: Fabricate ultrathin moiré superlattice, creating insulating bulk with conductive edges.

Step 2: Apply circularly polarized light (dimmer than a flashlight) to induce torque on magnetic moments.

Step 3: Magnetization reverses from 'up' to 'down,' instantly switching edge current direction from clockwise to counterclockwise.

Step 4: Measure transport properties confirming precise, reversible control without external magnets.

Dr. Cai Xiangbin, first author and Presidential Postdoctoral Fellow, noted: "Our breakthrough opens doors to programmable electrical circuits with greatly reduced power consumption."

Experimental Breakthrough and Validation

The experiments utilized a chip-scale moiré Chern device, where light pulses achieved ultrafast switching. Published in *Nature* (DOI: 10.1038/s41586-025-10048-4), the work confirms reversible control at room temperature, a feat previously requiring cryogenic conditions.

Key metrics: Switching time under femtoseconds, energy efficiency surpassing electrical gates, and scalability to integrated circuits. Collaborators Dr. Pan Haiyang

highlighted its potential for quantum information processing via associated superconductivity.

Implications for Quantum Computing and Electronics

This control enables 'wireless' routing of currents, ideal for topological quantum bits (qubits) protected from decoherence. Applications include:

Ultra-low-power AI chips, reducing data center cooling costs (projected \$100B+ globally by 2030).

Fault-tolerant quantum computers, leveraging edge states for robust information transfer.

Programmable matter for sensors and spintronics.

With the global quantum computing market forecasted at \$5B+ by 2026 growing to \$20B by 2030, NTU's advance positions Singapore as a leader.

Singapore's Quantum Ambitions and NTU's Pivotal Role

Singapore's Budget 2026 allocates S\$37B to RIE2030, with quantum as a strategic pillar—including Quantinuum's Helios system arrival and S\$300M investments. NTU's CQT@NTU and QUASAR lab, under Prof. Gao, drive this ecosystem.

NTU ranks top globally in materials science, fostering spin-offs and attracting talent. For aspiring researchers, explore higher ed jobs at NTU via university jobs listings.

Stakeholder Perspectives and Challenges

Prof. Gao emphasized: "Optical control directs electricity without wires—precise, fast, no bulky gear." Industry experts see synergies with Singapore's semiconductor hub status.

Challenges: Scaling to practical devices, integrating with silicon fabs, and mitigating light absorption losses. Solutions involve hybrid photonic-electronic chips.

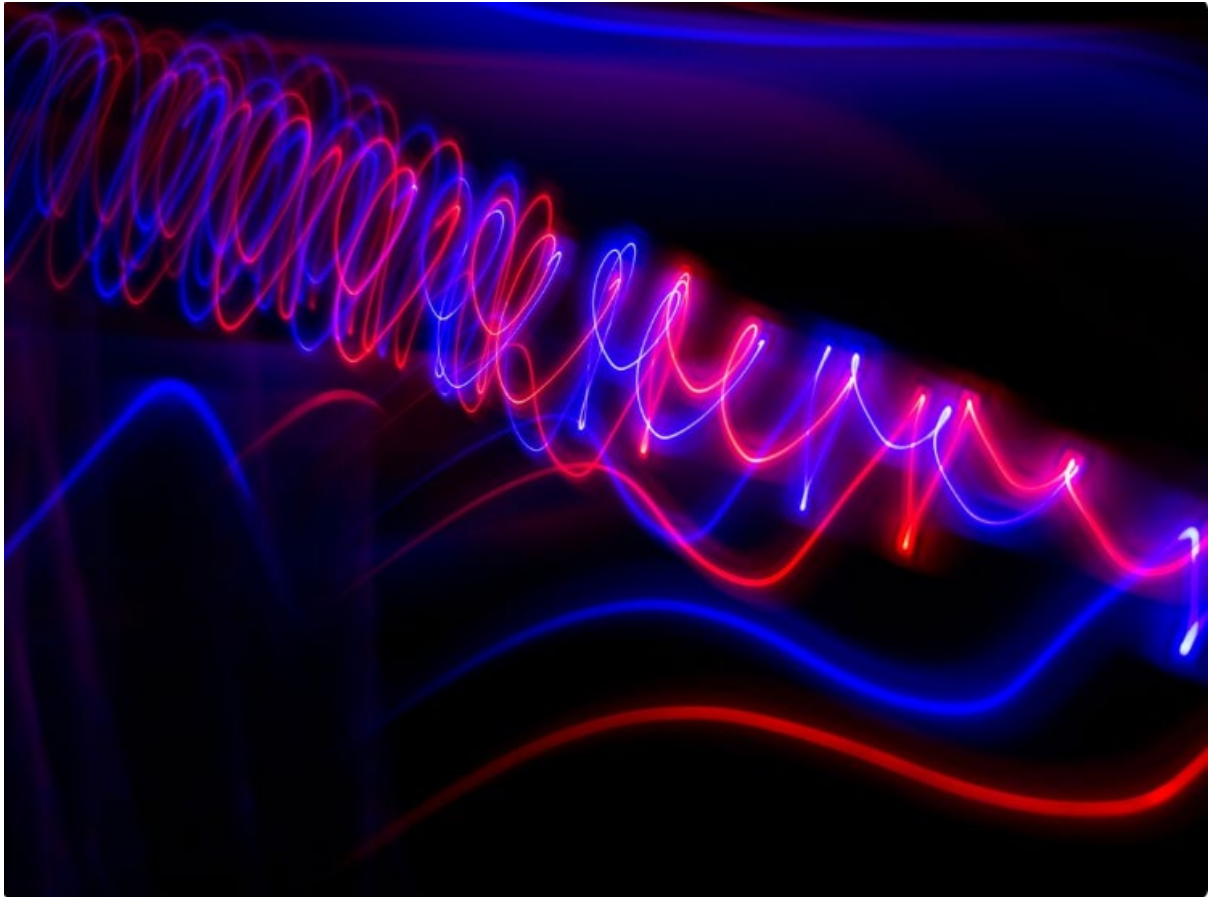
Future Outlook: From Lab to Marketplace

Next: Superconductivity in these materials for hybrid quantum circuits. Timeline: Prototypes by 2028, commercialization 2030+. Singapore's quantum strategy forecasts ecosystem growth to \$1B+ by 2030.

Actionable insights: Researchers should skill in moiré materials; students rate profs like Gao on Rate My Professor for guidance.

Career Opportunities in Singapore's Quantum Sector

NTU's breakthrough boosts demand for quantum engineers. Check faculty positions, postdoc roles, and career advice. Singapore offers scholarships via scholarships page.



Conclusion: Pioneering a Quantum Future

NTU's light-controlled currents mark a quantum leap for Singapore's higher education and tech landscape. Stay updated via higher education news and pursue opportunities at higher ed jobs, rate my professor, and higher ed career advice.

<https://www.academicjobs.com/sg/research-publication-news/ntu-light-controlled-electric-currents-breakthrough-or-academicjobs-sg-9128>