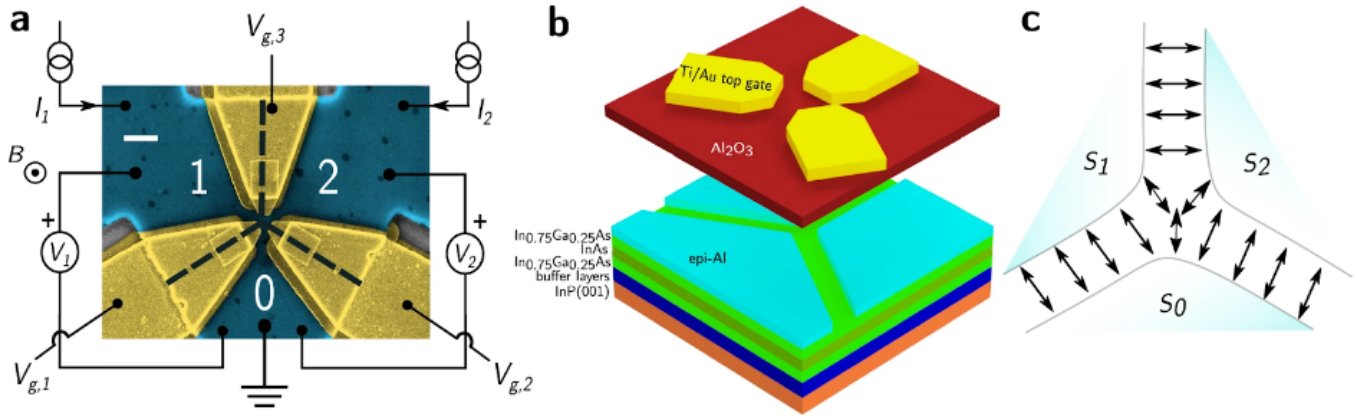
UNIVERSITY OF MINNESOTA
Driven to Discover℠

Superconducting diode effect in a three-terminal Josephson device

A superconducting quantum device for scalable and gate tunable realization of the Josephson diode effect

Technology No. 2022-286



IP Status: US Patent Pending; 18/335,417

Applications

- Quantum Computing
- Cryogenic Control Circuitry

Key Benefits & Differentiators

- **Scalable:** Device is material agnostic and does not require non-standard fabrication techniques.
- **Reconfigurable:** Gate tunability enables change of diode polarity.
- **Multi-signal integrations and rectification:** Device can be used to rectify signals from multiple inputs or to deliver rectification of a signal as a nonlinear function of another signal applied to the device.
- **Long coherence time:** Gate tunability enables use as a building block for topologically protected qubits.

- **Compact device configuration:** Triangular configuration of Josephson junctions has a small form factor and is compatible with existing industry fabrication practices.

Technology Overview

Quantum computing has received tremendous attention in recent years and is expected to grow significantly due to the promise of exponentially faster computing and fundamentally new computing approaches. One of the major drivers behind this growing industry is the high degree of versatility that quantum computing can offer across many industries. The Achilles heel of quantum computers is decoherence (loss of information), which occurs at a rapid rate and prevents the scaling of the number of qubits. One approach for increasing the coherence time is the use of topologically protected qubits, which have well-separated states akin to digital in comparison to analog. To date, there has not been a compact and/or practical approach, e.g. avoiding the use of exotic materials, for doing this.

Researchers at the University of Minnesota have developed a superconducting quantum device for scalable and gate tunable realization of the Josephson diode effect which may serve as building blocks in designing topologically protected qubits. The three-terminal device is based upon InAs quantum well two-dimensional electron gas proximitized by epitaxial aluminum and exhibits diode efficiency that can be tuned by a small out-of-plane magnetic field and electrostatic gating. Researchers have further shown that this diode effect is a generic property of multi-terminal Josephson devices, making this technology material agnostic and therefore scalable and amenable to standard fabrication approaches relative to existing technologies that rely on exotic materials. The use of standard materials and fabrication approaches is expected to result in increased reliability and efficiency while providing longer coherence times in a compact device configuration. Additionally, this device could be used for neuromorphic circuits and AI because it enables nonlinear intermodulation and rectification of multiple signals and the ability to electrostatically tune the weight of each of these signals.

Phase of Development

TRL: 3-4
Working prototype- Multiple devices have been demonstrated that exhibit non-reciprocal critical current behavior

Desired Partnerships

This technology is now available for:

- License
- Sponsored research
- Co-development

Please contact our office to share your business’ needs and learn more.

Researchers

- **Vlad Pribiag, PhD** Associate Professor, School of Physics and Astronomy

References

Mohit Gupta, Gino V. Graziano, Mihir Pendharkar, Jason T. Dong, Connor P. Dempsey, Chris Palmstrøm & Vlad S. Pribiag, https://www.nature.com/articles/s41467-023-38856-0, Nature Communications