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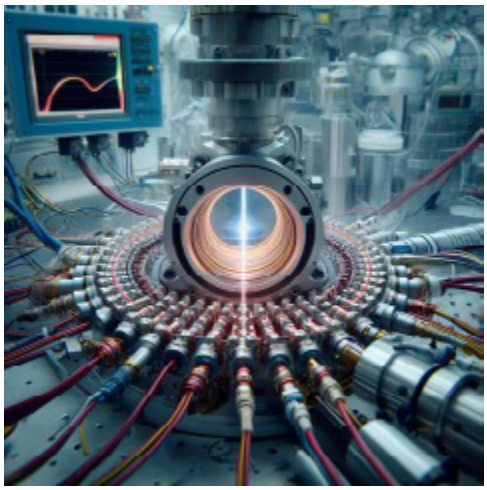
Passive Single-Photon Detector

Chapman Case #2023-006



Market Need

In sectors like quantum computing, space exploration, and precision scientific instrumentation, there is a growing market demand for highly sensitive, ultra-low-temperature detection and energy harvesting technologies. A specific need has emerged for more efficient and sensitive thermoelectric devices that can operate effectively at sub-Kelvin temperatures. The global cryogenic equipment market, which includes devices such as cryogenic detectors and superconducting systems, is projected to grow to $30 billion by 2027, driven by innovations in space missions, quantum technologies, and high-precision scientific research.

Chapman Solution

Dr. Andrew Jordan of Chapman University's Institute for Quantum Studies and Dr. Francesco Giazotto of Instituto Nanoscienze-CNR have together designed a novel single-photon detector based on the thermoelectric response of superconducting fluxons. In the current state of the art, thermoelectric devices using conventional materials, such as semiconductors, achieve limited efficiency and are constrained by their reliance on higher temperatures and particle symmetry. Superconducting technologies, such as superconducting nanowire detectors and bolometers, have already revolutionized low-temperature detection in fields like quantum computing and space exploration. Yet, the proposed single-photon detector, goes further by exploiting the particle-hole asymmetry in type-II superconductors at quantum limits, leading to a giant thermoelectric response that is significantly more sensitive and efficient than current models. Furthermore, the figure of merit (ZT) for this technology can reach values above 3, particularly in Scanning Tunneling Microscope (STM)-based configurations centered at the vortex core; compared to the current state of the art where ZT values typically hover around 1 or below.

Applications

- Bolometers for low-energy photon detection that can be used in infrared astronomy, space exploration, and scientific research for detecting minute temperature changes caused by low-energy photons.
- Thermocouples for ultra-low temperatures used in precision thermal management in environments such as space missions or quantum computing setups.
- Diodes for ultra-low temperatures such as superconducting-based diodes used in quantum computing.

Key Publication

"Giant Thermoelectric Response of Fluxons in Superconductors", May 2024.

Stage of Development

- Demonstrated proof of concept.
- Available for further research collaborations.

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