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Perspectives on Broadband Quantum-Limited Traveling-Wave Microwave Parametric Amplifiers for Fundamental Physics Measurements

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Ultra-sensitive detection schemes at microwave frequencies play a central role in many advanced applications, including quantum sensing, quantum computing, and fundamental physics searches. In many of these applications, the necessity of reading a large array of devices (e.g. detectors, cavities, qubits) calls for large bandwidth amplifiers with the lowest possible noise. Solid-state amplifiers offer exceptional gain but fall short of the quantum noise limit. Traveling Wave Parametric Amplifiers (TWPAs), especially Kinetic Inductance TWPAs (KITs), present a compelling solution. KITs are simpler to fabricate than traditional TWPAs based on Josephson junction, boast a high dynamic range, magnetic field resilience, and potential operation at higher temperatures (4 K).

National research groups, such as the Italian Institute of Nuclear Physics and the US National Institute of Standards and Technology, are working to enhance the performance of KIT amplifiers. These efforts focus on applications for the readout of highly sensitive detectors used in particle physics and astrophysics applications such as Transition Edge Sensors (TESs), Microwave Kinetic Inductance Detectors (MKIDs), Metallic Magnetic Calorimeters (MMCs), and resonant cavities. These amplifiers are also crucial for advancing quantum technologies, facilitating qubit readout, quantum key distribution, and microwave quantum illumination. In this presentation, I will provide an overview of the current developmental progress of KIT amplifiers, explore potential future enhancements, and discuss applications in detector and qubit readout. The advancements discussed underscore the pivotal role KITs can play in pushing the boundaries of quantum technologies by demonstrating enhanced performance and versatility in highly sensitive systems.

Collaboration

Role of Submitter

I am the presenter

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