

Josephson Photonics Devices for BREAD

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Josephson photonics refers to the physics of Josephson junctions biased at a DC voltage V below the superconducting gap, interacting with electromagnetic radiation. In this regime, Cooper pairs tunnel inelastically through the junction, exchanging their potential energy $2eV$ with the electromagnetic environment in the form of photons. Because the junction has no inductance in this voltage state, Josephson photonics devices are not limited by the plasma frequency that constrains most Josephson junction technologies to about 30 GHz. This opens the door to much higher operational frequencies.

We are developing two Josephson photonics devices that could be useful for BREAD:

1. Inelastic Cooper Pair Tunneling Amplifier (ICTA), a linear, quantum-limited amplifier [1]. I will present our latest progress in extending ICTA bandwidth to an octave [2] and discuss our roadmap toward ICTAs operating in the W-band (75 to 110 GHz).
2. Photon-Number Amplifier, a device multiplying the photon number in an incoming mode into n photons in an outgoing mode [3]. Ideally, this process adds no photon noise, enabling detection far below the standard quantum limit. I will share recent experimental results and describe two readout strategies: time-resolved photon counting [4] and spectral resolution.

[1] Near-quantum-limited amplification from inelastic Cooper-pair tunnelling, S. Jebari, F. Blanchet, A. Grimm, D. Hazra, R. Albert, P. Joyez, D. Vion, D. Estève, F. Portier, M. Hofheinz, *Nat Electron* 1, 223-227.

[2] DC-powered broadband quantum-limited microwave amplifier, N. Nehra, N. Bourlet, A. H. Esmaeili, B. Monge, F. Cyrenne-Bergeron, A. Paquette, M. Arabmohammadi, A. Rogalle, Y. Lapointe, and M. Hofheinz, to appear on arXiv.

[3] Microwave Photon-Number Amplification, R. Albert, J. Griesmar, F. Blanchet, U. Martel, N. Bourlet, M. Hofheinz, *Phys. Rev. X* 14, 011011.

[4] Amplification and Detection of Single Itinerant Microwave Photons, L. Danner, M. Hofheinz, N. Bourlet, C. Padurariu, J. Ankerhold, B. Kubala, arXiv:2510.08030v1.

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