Graphene Josephson junctions to realize quantum noise-limited amplifiers and broadband bolometers

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2D materials offer the ability to combine contrasting functionalities. The core of quantum information processing involves preparing, manipulating, and efficiently detecting quantum states. In cQED architecture, probing quantum systems in a single-photon regime is challenging. Hence, amplification with the least added noise is crucial before signal processing at room temperature. The Josephson parametric amplifiers (JPA) are the routinely used devices for low-noise amplification of quantum signals, which improves the signal-to-noise ratio significantly. The existing JPAs use Al-AlOx-Al tunnel junctions where magnetic flux is the control knob for biasing the devices. Our recent work demonstrates the implementation of a gate tunable JPA using a graphene Josephson junction (gr-JJ), where we change the device bias using electrostatic gating [1]. Electrostatic control is advantageous over magnetic flux control in cQED devices as it causes less interference.

The graphene JJ architecture can also be extended to make novel sensors like bolometers by leveraging the non-linearity. This results in state-of-the-art broadband bolometer, with NEP of 500 aW/sqrt(Hz), and fast response [2].

[1] J. Sarkar *et al*., Quantum noise limited microwave amplification using a graphene Josephson junction, Nature Nanotechnology 17, 1147–1152 (2022).

[2] J. Sarkar *et al.*, Kerr non-linearity enhances the response of a graphene Josephson bolometer, arXiv:2502.04911