Quantum Amplification using Superconducting Nanowires

UCL Lead department: London Centre for Nanotechnology

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Project Summary:

Amplifiers are a key component in any solid-state quantum technology. Conventional semiconductor amplifiers, even at cryogenic temperatures, are not sufficiently low-noise for this application. Parametric amplification techniques have therefore established themselves as the technology of choice for low-noise amplification of quantum devices in the milliKelvin temperature range. Both the lumped-element Josephson parametric amplifier (JPA) and the distributed-element Josephson travelling-wave parametric amplifier (J-TWPA) represent the current state-of-the-art. In particular the J-TWPA enables scaling to the 100-qubit level (for quantum simulation and other near-term applications) and beyond (for fault-tolerant quantum computation) since its high bandwidth allows many signals to be multiplexed on a single channel.

The building-block of both the JPA and the J-TWPA is the Josephson junction (JJ). The JJ is a device whose *current* depends on the sine of *magnetic flux*, giving it the non-linearity which is required for amplification – in this case a non-linear inductance. The coherent quantum phase-slip nanowire (QPS-NW) is the dual of the JJ: the *voltage* across it depends upon the sine of the *charge* on it, giving it non-linear capacitance. The Warburton group at UCL has recently demonstrated both incoherent QPS effects in superconducting NbN nanowires and coherent coupling between a QPS-NW qubit and a superconducting resonator. These experimental proofs-of-principle demonstrate that applications exploiting the QPS phenomenon in superconducting nanowires are now within reach.

This project forms part of a partnership between Paul Warburton's group at UCL and Jonathan Williams and Asem Elarabi at NPL, with the goal of developing a prototype parametric amplifier based on superconducting nanowires. Fabrication will take place at the cleanroom in the London Centre for Nanotechnology at UCL. Measurements will be undertaken at 10 mK in an existing dilution refrigerator set-up with low-noise radio-frequency characterisation tools.

The ideal candidate will be an experimentalist with an MSc, MEng or MSci degree (or equivalent) in physics or electrical engineering or materials science.