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Detecting µeV photons and meV phonons via inelastic charge tunneling across Josephson junctions

Thursday, 22 August 2024 10:00 (30 minutes)

Superconducting quantum devices usually operate Josephson junctions in the superconducting state as nonlinear inductors to form anharmonic oscillators. In this talk I will show that Josephson junctions can also yield useful quantum measurement devices when operated in the voltage state. In this configuration, called Josephson photonics, Cooper pairs tunnel inelastically through a junction biased at a voltage V below the gap, by transferring their energy 2eV into one or more photons in the harmonic modes of the circuit in which the junction is embedded. In Josephson photonics, the junction, therefore, acts as a nonlinear drive and has very low inductance. This allows Josephson photonics devices to operate more easily at high frequencies which we expect to be only limited by the superconducting gap, corresponding to 100 GHz (400 µeV) for Aluminium and 900 GHz (3.7 meV) for Nb, the two most commonly used materials in superconducting circuits.

I will discuss two Josephson-photonics devices we are developing, a quantum-limited amplifier and a single photon detector which could help enable QCD axion search experiments in mass ranges that are currently difficult to access.

I will also briefly discuss some preliminary ideas on how tunneling of quasiparticles across voltage-bias Josephson junctions could be used to measure energy deposited in a substrate in the form of phonons with meV resolution. In this regime inelastic Cooper-pair tunneling constitutes a background signal which must be carefully avoided.

Presenter: HOFHEINZ, Max (U Sherbrooke)