

Physics

Lancaster
University



Research Associate in superconducting qubits with moveable junctions

JOB DESCRIPTION

Job vacancy:

Job Title: Research Associate	Present Grade: 6
Department/College: Physics	
Directly responsible to: Prof. Edward Laird and Dr Jon Prance	
Supervisory responsibility for: Partial responsibility for graduate and MPhys students	
Other contacts	
Internal: members of the Physics Department	
External: Other scientific collaborators	

We are seeking a committed researcher to integrate mechanical resonators into superconducting qubits.

Coupling between a mechanical resonator and a qubit is a key to controlling single phonons, to creating ultra-sensitive detectors for force and displacement, and ultimately to studying mesoscopic quantum superpositions of millions of nucleons. However, it is difficult to make the coupling strong enough to overcome decoherence. In this project, we will study the ultimate limit of strong coupling, by incorporating the moving element into the qubit itself. We will do this using Josephson junctions made from vibrating carbon nanotubes and graphene, which are optimal for strong coupling because they have very low mass and high quality factor. The ultimate aim is to create a matter-wave interferometer according to the scheme outlined in [1]. Along the way are a host of exciting experimental possibilities that come from strong coupling between mechanics and superconductivity, including phonon lasers, mechanical Shapiro steps, mechanical parametric amplifiers, and ultra-sensitive SQUID-based force sensors.

This project takes advantage of newly purchased equipment and will use the nanofabrication facilities of the Quantum Technology Centre, the electronic and cryogenic facilities of the Low Temperature Physics group and a vibration-isolated laboratory in the IsoLab facility at Lancaster. For more information about this research area see

<http://wp.lancs.ac.uk/laird-group/>

<https://www.lancaster.ac.uk/physics/isolab/>

<https://www.lancaster.ac.uk/physics/about-us/people/jonathan-prance.>

Our recent high-profile papers in this field include

[1] Khosla, K. E., Vanner, M. R., Ares, N. & Laird, E. A. Displacement electromechanics: how to detect quantum interference in a nanomechanical resonator. *Phys. Rev. X* 8, 21052 (2018).

[2] Wen, Y. et al. A coherent nanomechanical oscillator driven by single-electron tunnelling. *Nature Physics* 16, 75 (2020).

[3] Thompson, M et al. Graphene-based tunable SQUIDs, *Appl. Phys. Lett* 16 162602 (2017)

[4] M Ben Shalom et al. Quantum oscillations of the critical current and high-field superconducting proximity in ballistic graphene, *Nature Physics* 12 p318 (2016)

This post is initially funded until the end of February 2025.

Major Duties:

- Fabricate graphene and/or carbon nanotube mechanical resonators.
- Incorporate them into superconducting circuits to realise Josephson junctions, SQUIDS, and qubits.
- Detect mechanical vibrations via the superconducting device, characterize the coupling between the mechanical and superconducting degrees of freedom, and study how each affects the other.
- Realise, if possible, the displacement protocol for creating a matter-wave interferometer on a chip.
- Analyse data and publish results in peer-reviewed journals.
- Disseminate project results including presenting to project partners and at conferences.
- In liaison with your line managers, support the production of arising IP.
- In liaison with your line managers, support students working on quantum electronics and nanomechanics.