



The University of Manchester

Quantum Technologies at Manchester & the Manchester Axion Novel Cavity eXperiment (MANCX)

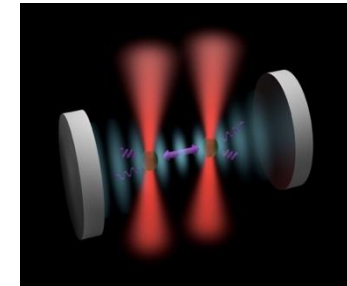
Jamie McDonald
University of Manchester

QTFP Community Meeting
21-22 Jan 2025, Glasgow

1. Centre for Quantum Science and Engineering (CQSE)



2. Quantum Technologies for Fundamental Physics (QTFP) @ Manchester



3. Manchester Axion Novel Cavity eXperiment (MANCX)



Centre for Quantum Science and Engineering

The Centre was launched in 2024 to promote, co-ordinate, and lead quantum science and engineering at Manchester:

- Over 50 research groups focussing on quantum science, spanning physics, chemistry, materials, maths, computer science, electrical and electronic engineering
- Facilities spanning three institutes – Advanced Materials, Photonics, and 2D Materials
- First cohort of 5 Quantum-specific PhD students recruited in 2024
- 3 tenure-track Dame Kathleen Ollerenshaw Fellowships



Royce Institute for Advanced Materials



Photon Science Institute



The National Graphene Institute



The University of Manchester

Centre for Quantum Science and Engineering



THEME 1
Information, Computation and Physical Foundations

Lead: Thomas Elliott (PHYS)

THEME 2
2D Materials & Condensed Matter

Lead: Artem Mishchenko (PHYS)

THEME 3
Spins & qubits

Lead: Alice Bowen (CHEM)

THEME 4
Quantum photonics

Lead: Jayadev Vijayan (EEE)

THEME 5
Materials for quantum
Lead: Maddison Coke (TECH)

THEME 6
**Quantum Technologies for
fundamental physics**
Lead: **Jamie McDonald** (PHYS)

Centre for Quantum Science and Engineering

New Posts!

Professors (x3) in Applied Quantum Technologies - Physics, Maths, Computer Science:

<https://www.jobs.manchester.ac.uk/Job/JobDetail?JobId=31138>

Lecturer in Applied Quantum Technologies - Physics:

<https://www.jobs.manchester.ac.uk/Job/JobDetail?JobId=31139>

(Senior) Lecturer in Maths (cryptography, including quantum and post-quantum):

<https://www.jobs.manchester.ac.uk/Job/JobDetail?JobId=30869>

Contact chris.parkes@manchester.ac.uk



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QTFP @ Manchester

(Th, Exp, Astro, Cosmo, Nucl)

Quantum levitated sensors to target
dark matter high frequency gravitational waves

[Updated HFGW review on arXiv this morning!!](#)

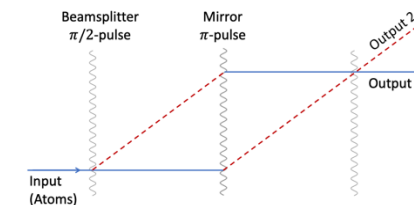
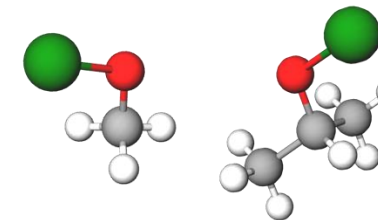
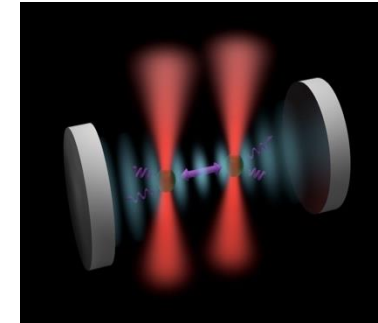
Manchester Axion Novel Cavity eXperiment (MANCX)

Cold atoms and molecules, CP violation

[ERC Advanced Grant](#)

5th force tests of dark sectors, dark energy/modified gravity,

Terrestrial Very Long Baseline Atom Interferometry
(TVLBAI) MoU signed



Axions

Solve strong CP problem in QCD

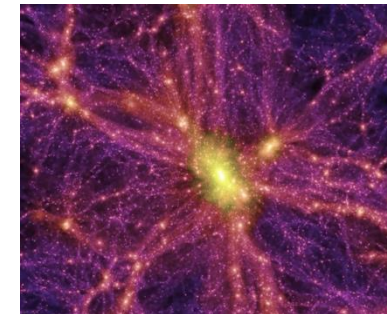
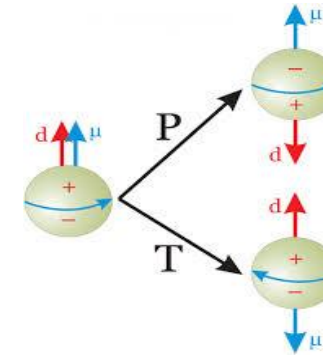
(why neutron EDM so small?)

Peccei & Quinn (1977)

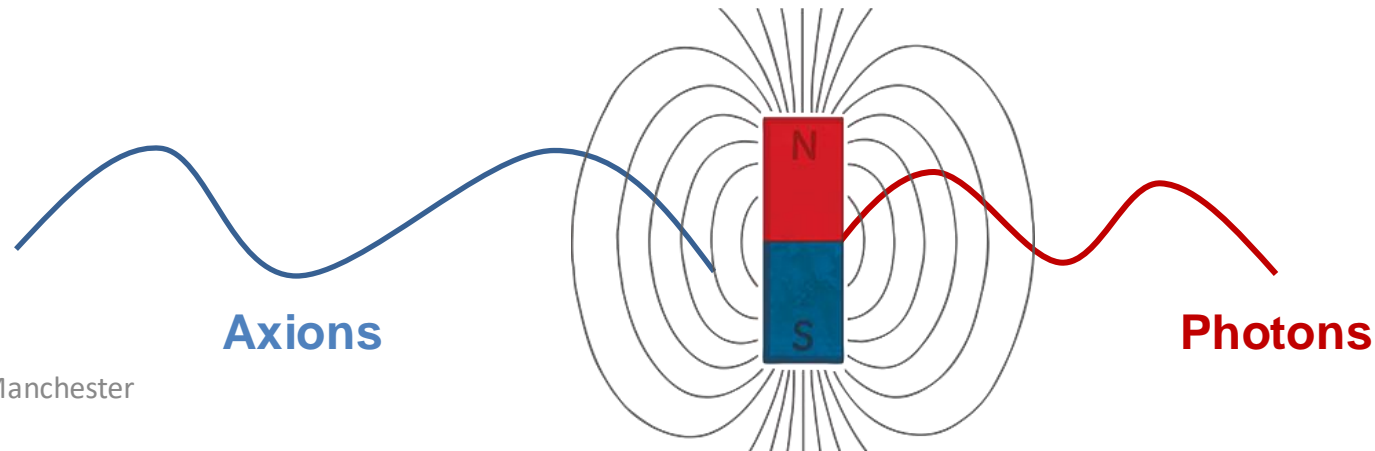
Leading candidates to explain dark matter

($m_{DM} \sim 10^{-6} \text{eV} \ll \text{GeV}$)

Dine & Fischler (1983), Abbott & Sikivie (1983), Preskill, Wise & Wilczek (1983).

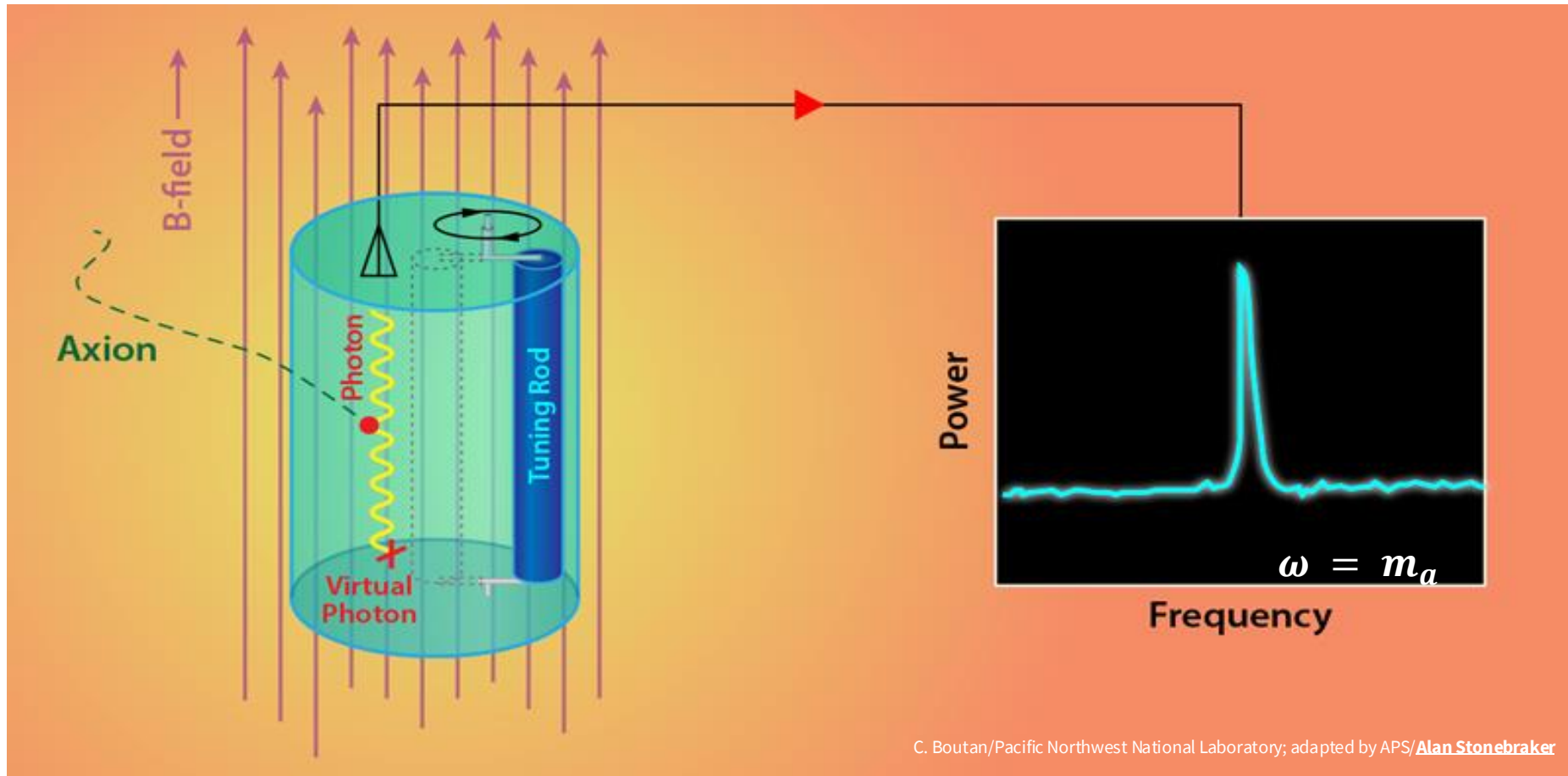


$$\mathcal{L} = g_{a\gamma\gamma} a F_{\mu\nu} \tilde{F}^{\mu\nu} = g_{a\gamma\gamma} a E \cdot B_{lab}$$



Axions

$$\mathcal{L} = g_{a\gamma\gamma} a F_{\mu\nu} \tilde{F}^{\mu\nu} = g_{a\gamma\gamma} a \mathbf{E} \cdot \mathbf{B}_{lab}$$



C. Boutan/Pacific Northwest National Laboratory; adapted by APS/Alan Stonebraker

Axions

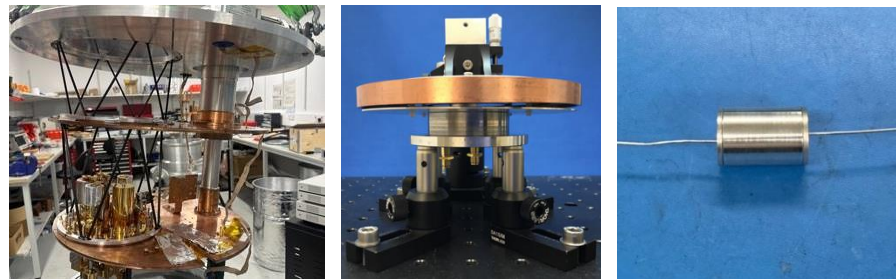
Plot: C. O'Hare



Manchester Axion Novel Cavity eXperiment (MANCX)

Ades, Battye, Buck, Feasby, Gilles, Gramellini, Marchitelli, **JM**, McCulloch, Lancaster, Mohammadian, Piccirillo, Preston, Qureshi, Upward, Wystemp.

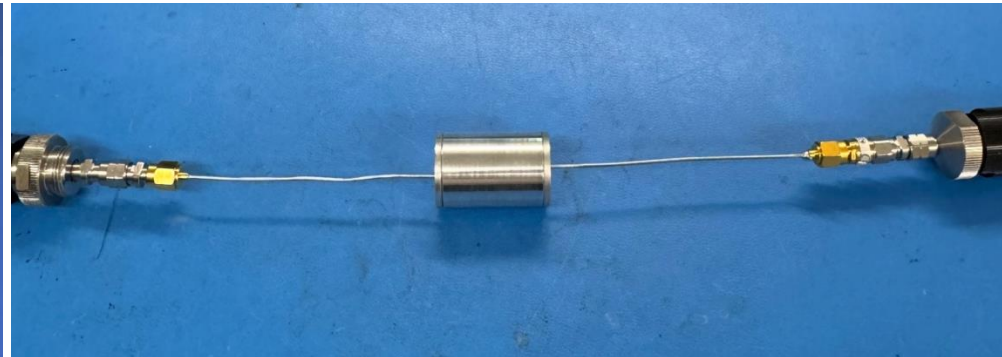
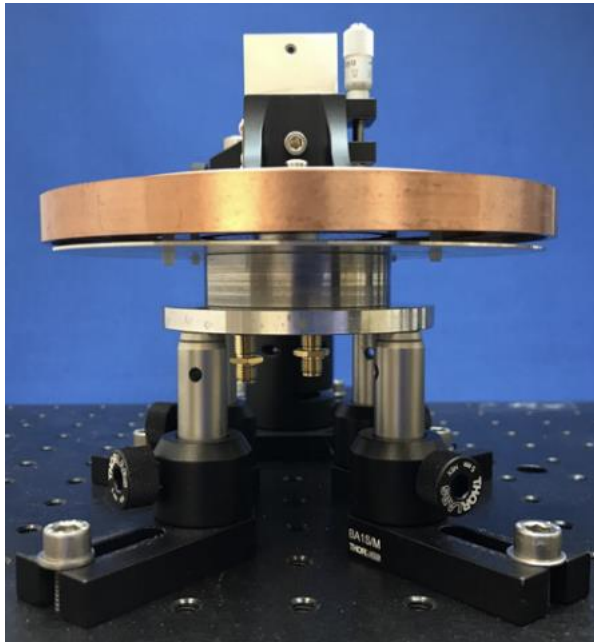
- Manchester has extensive expertise in **microwave/radio** + low-temp physics (Jodrell Bank) and **experimental particle physics** (LHC, Neutrinos, Dark matter)
- MANCX: prototype experiment to target axions above 10 GHz ($m_a > 40 \mu eV$) (working on compensating for small volume, tuning mechanisms, increasing Q factor)
- 6 MPhys students, 4 PDRAs, 3 Academic Staff + engineers/technical support
- Collaboration across Particle Physics, Jodrell Bank Center for Astrophysics and Daresbury Laboratory



Manchester Axion Novel Cavity eXperiment (MANCX)

Cavity development and superconducting thin films

- Superconducting test cavities machined + coated @ Daresbury in 2025
- Further prototyping and RF testing underway, 2 prototypes made
- Testing on cryostat planned



Science & Technology Facilities Council

Daresbury Laboratory

Manchester Axion Novel Cavity eXperiment (MANCX)

Cryogenics

Finalising setup: hope to soon reach target
Temperature of $T = 50\text{mK}$ by mid 2025



Magnets

Small ~ 5 Tesla test magnets (x2) recently delivered from
Wisconsin–Madison in USA

Quantum Noise Limited Amplifiers

Under development using facilities at the
National Graphene Institute.



The National Graphene Institute

Outlook

- **Manchester keen to support QTFP projects (e.g. QSHS) please reach out!**
- **MANCX technology demonstrators in 2025/26**
- **First papers on cavities and amplifiers coming soon!**
- **First MANCX PhD position opening – please apply!**

[FSE Bicentenary PhD] Search for dark-matter particles using novel quantum technologies
Department of Physics and Astronomy

PhD Research Project Competition Funded Students Worldwide

Prof Mark Lancaster, Dr Elena Gramellini

Application Deadline: Applications accepted all year round

[View Details](#)

<https://www.se.manchester.ac.uk/study/postgraduate-research/fees-and-funding/search-for-funding/bicentenary-phd-studentships/>