EPSRC

RESEARCH PROPOSAL

EPS(RP)

Engineering and Physical Sciences Research Council
Polaris House, North Star Avenue
Swindon SN2 1ET

You should read the separate notes for guidance and the funding guide before completing any research proposal. The form EPS(RP) must be accompanied by a case for support. The EPSRC will reject research proposals which are not complete.

1 DETAILS OF PROPOSAL

Organisation where grant would be held

Organisation	University of Strathclyde
Division or Department	Department of Physics
Address	16 Richmond St, Glasgow G1 1XQ

Investigators

Total number of investigators: 3

Please give details of each investigator below. Continue on a separate sheet if necessary.

Details	Principal Investigator	Co-investigator 1	Co-investigator 2
Title/Initials	Dr. K	Dr. L	Dr. C
Surname	Benedek	Russell	Iakovou
Post held	Professor	Senior Lecturer	Research Assistant (Postdoc)
Organisation	University of Strathclyde	University of Strathclyde	University of Strathclyde
Division or Department	Department of Physics	Department of Physics	Department of Physics
Telephone	0712378987	07123456789	09124356789
Fax	N/A	N/A	N/A
E-mail	k.benedek@strath.ac.uk	l.russell@strath.ac.uk	c.iakovou@strath.ac.uk
Hours per week on project	25	35	40
First EPSRC proposal?	YES ☐ NO ☒	YES ☐ NO ☒	YES ☒ NO ☐
Change in organisation?	YES ☐ NO ☒	YES ☐ NO ☒	YES ☐ NO ☒

Co-authors

Give the name and organisation of the individuals other than investigators on this project who are co-authors of the proposed research.

Dr. Chang Li - Tsinghua University

Scheme

Indicate if proposal is

☒ First Grant Scheme ☐ Link ☐ Overseas Travel

Related proposals

a. If this proposal is a resubmission, please give previous research grant proposal Ref no. GR/

b. If there is more than one organisation submitting an EPS(RP) for this project, please give details of the investigator(s) and project title(s).

c. If this proposal has been submitted in response to a specific call for proposals please give title of call.

Title of Research Project *(Please do not exceed 150 characters, including spaces)*

"Mitigating the Joule Expansion in Multicell Atomic Quantum Memories"

Summary of EPSRC Resources Required for Project

a. Financial resources required

	Total £
Staff	173,433.00
Travel and subsistence	17,500.00
Consumables	13,748.00
Exceptional items	0
Equipment	77,793.30
Large Capital	0
PCTF	0
Sub-total	282,424.00
Indirect Costs	86,717.00
Total	369,141.00

b. Summary of staff effort requested

	Months
Post Graduate	0
Post Doctoral	36
Project Students	0
Technician	24
Other	5.4
Visiting Fellows	12
Total	77.4

c. Services and HPC total

Start date and Duration

a. Proposed start date: 2022/09/01

b. Duration of the grant (months): 36

Research Councils/MoD Joint Research Grant scheme (JGS)

If MoD/Dstl have indicated that they are prepared to provide support for this proposal if successful, please indicate the percentage level of this support and MoD/Dstl contact name.

Percentage level of support: %

Name of MoD/Dstl contact:

Public Communication Training Funds (PCTF)

Do you wish to apply for Public Communication Training Funds? YES ☐ NO ☒

Objectives

- Build the multicell atomic quantum memory (MAQM) experimental set-up with optical tweezers array trap.
- Achieve the current state-of-the-art memory lifetime of 1 ms.
- Surpass the current state-of-the-art lifetime by 2 - 3 order of magnitude, i.e., 0.1 – 1 second of memory lifetime.
- Participate in R&D with M2Lasers industrial partner, investigating scalable solutions of MAQM for potential commercialisation.
- Organise international outreach workshops on quantum hardware with Chinese collaborators.

Summary

Quantum information technologies, promise unparallel computational speeds and quantum communication protocols guarantee unbreakable encryption with respect to their current market-dominant classical counterparts. A key component in realising quantum communication systems is the quantum memory or “qRAM”. Analogous to classical RAM, “qRAM” is responsible for the retrieval of quantum states to be read at a later time. However, inherent quantum mechanical effects such as atomic free expansion make it difficult to distribute entanglement over long distances and for a useful amount of time.

Herein, we propose an experiment to realise a quantum repeater node based on multicell atomic quantum memory (MAQM) as demonstrated by Li et al. (2021), a co-author of this proposal and contributor, however by utilising optical tweezers to trap and manipulate atomic ensembles instead of magneto-optical traps (MOTs). Optical tweezers arrays, which use highly focused laser beams on microscopic atomic ensembles are promising candidates in increasing the memory lifetime of the memory cells by mitigating the atomic free expansion of the ensembles. Thus, demonstrating longer lifetime per memory cell, entanglement between nodes is maintained for longer times. This will constitute an important step towards goals such as the quantum internet and scalable quantum computing components.

Beneficiaries

- This research is aligned with the UK’s £ 150 million investment portfolio in novel quantum technologies.
- Maintain as a nation a leading role in academia and remain at the forefront in the global race for useful quantum computing.
- Promote ground-breaking international collaboration.
- The realisation of a long-lived quantum memory cell, *i.e.,* order of magnitude greater of milliseconds, marks an important step towards long distance quantum networks, and controlled production of entangled states at the interaction of light and matter.
- Quantum communication is of transformational importance for the underlying infrastructure in many sectors like finance, business, and government.
- Collaboration with local industrial stakeholders carries potential impact on the Scottish job market for the long run.

Staff

Name and grade	Starting point on spine	Increment date	EFFORT ON PROJECT			Basic starting salary £	London allowance Y/N	Gross annual salary £	Total cost on grant £
			Appointment date	Duration of appointment	% of Full time				
RESEARCH STAFF									
i) Existing Staff									
ii) New Appointées									
C. Iakovou	25	2023/09/01	2022/09/01	36 months	100 %	29,614.00	N	38,966.00	120,528.00
iii) Project Students									
TECHNICAL STAFF									
D. Weber	19	2023/09/01	2022/09/01	24 months	30 %	24,871.00	N	33,043.00	19,826.00
OTHER STAFF									
M. Smith	10	2023/09/01	2022/09/01	36 months	15 %	19,623.00	N	26,062.00	11,728.05
VISITING FELLOWS									
N. Hempler			2024/01/02	12 months	100 %	53,348.00		71,173.00	21,351.90
								Total £	173,433.00

Visiting Fellows

Details	Nominated Fellow
Title/Initials	Dr. N
Surname	Hempler
Post held	General Manager
Home Organisation	M Squared Lasers
Division or Department	Quantum Research and Systems
Country	Scotland, United Kingdom
Telephone	07135546645
Fax	None
E-mail	n.hempler@m2lasers.com

Financial Details of Nominated Fellow

a. Will Fellow be supporting dependants? YES ☐ NO ☒

b. What annual salary would host organisation pay staff of the Fellow's status? 71,173 £

c. If salary contribution required from EPSRC, state:

(i) percentage of normal salary being received from any other source 70 %

(ii) normal salary if less than given above

Travel and Subsistence

Destination and purpose	Total £
IEEE International Conference on Quantum Computing and Engineering, Singapore 2024	4,500.00
Workshop in Advances in Quantum Hardware (WAQC '25), Glasgow 2025 (as organisers)	5,000.00
Workshop in Advances in Quantum Hardware (WAQC '25), Beijing 2025 (as organisers)	8,000.00
Total £	17,500.00

Consumables

Specify	Total £
Laboratory electricity consumption of 7000kWh per annum (20.772p per kWh) + daily standing charge	5,200.00
4g Rubidium @ 99.9% purity + FedEx Rate – Goodfellow Cambridge Ltd.	848.00
2 Desktop Towers + Peripherals	3,500.00
Electronic Components, cables, and micro-controllers	500.00
Publication costs	3,700.00
Total £	13,748.00

Exceptional Items

Specify	Total £
Total £	

Equipment (single items under £100,000)

Description of items and country of manufacture	Basic price £	Import duty £	VAT £	Total £
Single Photon Detector (6 in total), UK	3,566.28 (x1)	0	713.2 (x1)	25,675 (x6)
Zero-Order Half-Wave Plate (8 in total), UK	355.22 (x1)	0	71.04 (x1)	3,410.1 (x8)
Mounted Achromatic Quarter-Wave Plate (8 in total), UK	666.75 (x1)	0	133.4 (x1)	6,400.8 (x8)
2x2 Multimode Coupler 50:50 Split (4 in total), UK	255.88 (x1)	0	51.2 (x1)	1,228.2 (x4)
Mounted Polarizing Beam splitter (2 in total), UK	253.72 (x1)	0	50.7 (x1)	608.9 (x2)
EO Phase Modulators (7 in total), UK	2,025.00 (x1)	0	405.00 (x1)	17,010 (x7)
Thorlabs Optical Table (1 in total), UK	7,599.00 (x1)	0	1,519.8 (x1)	9,118.8 (x1)
100x Mitutoyo Plan NIR Microscope Objective (2 in total), UK	4,441.25 (x1)	0	888.3 (x1)	10,659 (x2)
Mirrors and lenses, UK	2053.00	0	410.6	2463.6
Colour Camera CCD (1 in total)	1,015.75	0	203.2	1,218.9 (x1)
			Total £	77,793.3

Large Capital (single items £100,000 and over)

Description of items and country of manufacture	Basic price £	Import duty £	VAT £	Total £
			Total £	

Services and HPC

Give details of any proposed usage of EPSRC-supported services required together with the cost that will be incurred. Please complete a separate service form if necessary.

Service	Instrument(s)	Units	Cost £
	Total		

Other Support

Give details of any support sought or received from any source for this or related research in the past three years (minimum £10,000).

Source	Brief title of research proposal	Amount sought £	Amount awarded £

Collaboration

Please give details of collaborators and their contributions to the research. These contributions should be in addition to resources identified in pages 3 to 5. If there are more than two collaborating bodies, please continue on a separate sheet.

Details	Collaborator 1		Collaborator 2	
Name of contact	Dr. Chang Li			
Name of collaborating body	Tsinghua University			
Address of collaborating body	Haidian District, Beijing, China			
Telephone	+123456789			
Fax	None			
E-mail	c-l15@mails.tsinghua.edu.cn			
Type of organisation	Academic Institution - SME			
Number of employees	0			
Main business area and SIC code if applicable	N/A			
Direct contribution to project	**Description**	**Value £**	**Description**	**Value £**
a. cash				
b. equipment/materials	3-year loan of M-Squared SolsTiS Rainbow laser system from Tsinghua University.	28,800		
c. secondment of staff	Three-year Stay at Strathclyde. Annual contribution to salary of 50% at spinal point 32	74, 459		
d. other				
Sub-Total		103,259		
Indirect contribution to project				
a. use of facilities/equipment				
b. staff time				
c. other				
Sub-Total				
Total Contribution				
		Total Value (including contributions from additional collaborators)		103,259

Declaration

In completing this research proposal, we confirm that:

a. we have read the funding guide;
b. if a grant is offered we will accept the EPSRC Terms and Conditions;
c. we have not entered into any obligations which may conflict with these.

	Signatures	Name in BLOCK CAPITALS	Date
Principal Investigator	Prof. Kata Benedek	KATA BENEDEK	2022 / 01 / 11
Coinvestigator(s)	Dr. Christoforos Iakovou	CHRISTOFOROS IAKOVOU	2022 / 01 / 11
	Dr. Lewis Russell	LEWIS RUSSELL	2022 / 01 / 11
Head of Department	Prof. Stefan Kuhr	STEFAN KUHR	2022 / 01 / 11
Administrative Authority (Position held)			

2 OTHER INFORMATION

This information will NOT be circulated to referees or panels.

Referees

Please give details of three expert referees whom the EPSRC may approach for assessment of this research proposal.

Referee 1

Name	Dr. Daniel Oi
Position held	Senior Lecturer
Organisation	Computational Nonlinear & Quantum Optics Group, University of Strathclyde
Address	JA 7.12, Department of Physics, University of Strathclyde, 107 Rottenrow, Glasgow, G4 0NG, U.K
E-Mail	daniel.oi@strath.ac.uk

Referee 2

Name	Dr. Thomas Jennewein
Position held	Associate Professor
Organisation	Institute for Quantum Computing, University of Waterloo
Address	Mike & Ophelia Lazaridis Quantum-Nano Centre, QNC 3317
E-Mail	thomas.jennewein@uwaterloo.ca

Referee 3

Name	Dr. Immanuel Bloch
Position held	Professor for experimental physics
Organisation	Faculty of Physics, Ludwig-Maximilians University (LMU)
Address	Schellingstrasse 4 / 1. & 2. Stock, 80799 Munich
E-Mail	immanuel.bloch@physik.uni-muenchen.de

Personal Information

The EPSRC aims to encourage equal opportunities. If you are willing to do so, please provide information on your own and your colleagues' age, sex and ethnic origin. We will NOT use this information in the assessment of this research proposal, but only for internal and statistical purposes.

Please give details for each investigator below. Continue on a separate page if necessary.

	Principal Investigator	Co-investigator 1	Co-investigator 2
Date of birth	1981/06/04	1985/06/24	1993/11/28
Sex	Female	Male	Male
Ethnic origin (see below)	White	White	White

Ethnic origins

White	**Black-African**	**Black-Caribbean**	**Black-Other**	**Indian**
Pakistani	**Bangladeshi**	**Chinese**	**Other**	