welcome to the European Microkelvin Collaboration

Application Form for MICROKELVIN Transnational Access Project

1. General Information

Project number	**AALTO08**	
Project Title:	**VORTEX MOTION AND DISSIPATION AT VERY LOW TEMPERATURES IN 3He-B**	
Project Acronum:		
Lead scientist:[1]	**Title:**	**Dr.**
	First name:	**Paul**
	Last name:	**Walmsley**
	Birth date:	**16th June 1977**
	Research status/Position:	**Research Associate**
	New User:[2]	**Yes**
	Scientific Field:	**Superfluid hydrodynamics and turbulence**
	Home institution:	**School of Physics and Astronomy, The University of Manchester, Manchester M13 9PL, UK**
	Home institution is MICROKELVIN partner:	**Yes** ☐ **No X**
	Business address:	Condensed Matter Physics Group, School of Physics and Astronomy University of Manchester
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	Curriculum vitae (18 lines max): 2003 – Present : Research Associate, University of Manchester. 2003 : Ph.D., University of Manchester, 'Textures, vortices and persistent currents in a slab of superfluid ^{3}He-A.' 1999 : Mphys(Hons.) Physics (First class), University of Manchester. Dr. Paul Walmsley's main achievements have been in performing experiments on homogeneous quantum turbulence in superfluid ^{4}He at very low temperatures and also in understanding the nature of quantized vortices and other topological defects in confined superfluid ^{3}He-A. His experimental expertise is in performing ultra-low temperature experiments on the Manchester rotating cryostat. Since 2003, he has given 7 invited talks including a recent plenary talk at QFS2009. He has published a total of 17 papers and has been the lead author on 12 of these papers, including 4 Physical Review Letters.	

[1] The lead scientist indicated here is expected to participate in the campaign as a user of the infrastructure.
[2] Indicate 'Yes' only if the user has never visited the infrastructure before this specific project, otherwise write 'No'.

	Five most recent publications:		
	1) A.I. Golov and P.M. Walmsley, Homogeneous turbulence in superfluid ^{4}He in the low temperature limit: experimental progress, J. Low Temp. Phys. **156**, 51 (2009).		
	2) P.M. Walmsley, A.I. Golov, H.E. Hall, W.F. Vinen, and A.A. Levchenko, Decay of turbulence generated by spin-down to rest in superfluid 4He, J. Low Temp. Phys. **153**, 127 (2008).		
	3) V.B. Eltsov, R. de Graaf, R. Hanninen, M. Krusius, R.E. Solntsev, V.S. L'vov, A.I. Golov and P.M. Walmsley, Turbulent dynamics in rotating helium superfluids, chapter 2 in: Progress in Low Temperature Physics (vol. 16): Quantum Turbulence, ed. by M. Tsubota (Elsevier Science, 2008).		
	4) P.M. Walmsley and A.I. Golov, Quantum and quasiclassical types of superfluid turbulence, Phys. Rev. Lett. **100**, 245301 (2008).		
	5) P.M. Walmsley, A.I. Golov, H.E. Hall, A.A. Levchenko, and W.F.Vinen, Dissipation of quantum turbulence in the zero-temperature limit, Phys. Rev. Lett. **99**, 265302 (2007).		
Other participating scientists:[3]	**Name:**	**Position:**	**New User:**[2]
	1- Andrei Golov	professor	yes
	2-		
	3-		

[3] Please list all participating user group members. Expand the table, if necessary.

2. Project Information

Name of host infrastructure:	Low Temperature Laboratory, Aalto University			
Access provider / Infrastructure Director:	**Name:** Prof. Matti Krusius		**E-mail address:** krusius@cc.hut.fi	
	Prof. Mikko Paalanen		paalanen@neuro.hut.fi	
Planned project dates:	**Start date:**	25/04/2010	**Completion date:**	22/05/2010

Project description (12 lines max):

SUPERFLUID DYNAMICS IN THE QUANTUM VACUUM LIMIT $T \rightarrow 0$

The characteristics of vortex flow in the $T \rightarrow 0$ temperature limit are of central interest in the quantum fluids research group at the University of Manchester and in the ROTA group of the Low Temperature Laboratory. In Manchester the measurements are concerned with superfluid ^{4}He while in Helsinki they are performed with ^{3}He-B. In both cases there are strong expectations that new progress in this area can be achieved at this time.

To investigate the dynamic response of vortices in a rotating cryostat, the time-proven method is to record the spin up or spin down of the superfluid component after a sudden step-like change in the rotation velocity. The spin-down response has been found to be laminar down to temperatures ~ 0.20 Tc in a smooth-walled cylinder filled with 3He-B when surface pinning is absent. This result has been confirmed both experimentally and numerically in vortex filament calculations [1]. The spin-up process is more complicated because of the energy barriers and critical velocities associated with vortex formation. However, aside from this difficulty, vortex motion in the interior of the cylinder is also laminar during spin up. In contrast, if axial rotation symmetry is severely broken by obstructing the flow paths with measuring sensors located inside the measuring volume, such as quartz tuning fork oscillators, for instance, then the responses become turbulent.

Interestingly it turns out that if one of the end plates of the cylinder is replaced by the AB interface, then both the spin-up and spin-down properties change and show more complicated behavior. So far only a first quick look at these changes has been carried out. To understand the dynamics at the AB interface, when vortices either extend through the interface or cover the interface as a vortex layer, we need to perform systematic measurements as a function of rotation velocity, temperature, and magnetic field. These studies are related to earlier work on the superfluid Kelvin-Helmholtz instability of the AB phase boundary [2], but the new spin-up/spin-down results should also be compared to similar measurements in the absence of the AB interface.

Spin up and spin down in the present experimental setup generate also strong thermal signals which can be monitored and calibrated with quartz tuning fork sensors [3]. So far these measurements are few and there is no understanding how to explain the origin of these signals. This is a second area of problems where systematic measurements are required. These studies will hopefully teach us about quasiparticle kinetics and possibly about dissipation in vortex motion.

References:

[1] ***Super stability of laminar vortex flow in superfluid He;*** V.B. Eltsov, R. de Graaf, R. Hänninen, M. Krusius, and V.S. L'vov, manuscript in preparation; Annual report of the Low Temperature Laboratory - 2008, Rota Group, https://ltl.tkk.fi/wiki/LTL/Annual_reports

[2] ***Dynamics of vortices and interfaces in superfluid ^{3}He;*** A.P. Finne, V.B. Eltsov, R. Hänninen, N.B. Kopnin, J. Kopu, M. Krusius, M. Tsubota, and G.E. Volovik, Rep. Prog. Phys. **69**, 3157-3230 (2006), arXiv:cond-mat/0606619.

[3] **Annual report of the Low Temperature Laboratory - 2009**, Rota Group, https://ltl.tkk.fi/wiki/LTL/Annual_reports

Scientific objectives of the project (12 lines max):

Dr. Paul Walmsley has performed spin-up and spin-down measurements in a container with the shape of a cube. This container filled with superfluid ^{4}He displays turbulent responses. Thus it will be of interest to compare the properties of vortex flow in the two superfluids in the $T \rightarrow 0$ temperature limit in different geometries.

Technical description of work to be performed (20 lines max):

Dr. Paul Walmsley is an expert in ultra-low-temperature research, with extensive experience of torsional oscillator measurements on vortices and soliton-like domain boundaries in superfluid ^{3}He-A and ion transmission measurements on turbulent vortex flow in superfluid ^{4}He. The present one-month visit has been planned to allow him to familiarize himself with two additional measuring techniques which have proven

useful in the investigation of vortex dynamics in the T → 0 temperature limit: 1) NMR measurement of vortices and vortex-free flow and 2) measurement of the density of quasiparticle excitations with quartz tuning fork oscillators. A further new area for him to learn about are the different ways in which rotating states with vortex-free superflow or with a cluster of known number of rectilinear vortex lines can be formed at different temperatures.

3. Joint Proposals / Funding

Is this project in collaboration with other (concurrent) projects at the infrastructure?	**Yes ☐ No X**
Specify: Part of general effort to understand quantum turbulence in the zero temperature limit	

Is this proposal submitted to any funding programmes?	**Yes ☐ No X**
If yes, please specify:	**Only to MicroKelvin collaboration**

The completed application form should be submitted to the MICROKELVIN Management Office