welcome to the European Microkelvin Collaboration

CAPACITIES

Application Form for MICROKELVIN Transnational Access Project

1. General Information

Project number:	AALTO24	
Project Title:	Biot-Savart tree-algorithm together with smooth wall boundary conditions at different geometries	
Host scientist:[1]	**Title:**	Dr. (Tech)
	First name:	Risto
	Last name:	Hänninen
	Home institution:	O.V. Lounasmaa Laboratory, Aalto University
Lead scientist:[2]	**Title:**	Prof.
	First name:	Carlo
	Last name:	Barenghi
	Home institution:	Newcastle University, UK
Project scientist:[3]	**Title:**	Dr.
	First name:	Andrew
	Last name:	Baggaley
	Scientific Field:	Fluid Dynamics
	Home institution:	Newcastle University
	Is your home institution MICROKELVIN partner?	No
	Business address:	School of Mathematics and Statistics
	Street:	Herschel Building
	PO Box:	
	City:	Newcastle Upon Tyne
	Zip/Postal Code:	NE1 7RU
	Country:	UK
	Telephone:	0191 2225371
	Fax:	
	E-mail:	a.w.baggaley@ncl.ac.uk
	Curriculum vitae (18 lines max): - Education - 2006–2009 Ph.D. Flux rope dynamo, Newcastle University - 2002 – 2006 MMath. First class with Hons., Newcastle University - Employment - 2010-present Post-doctoral research associate, Newcastle University - Research Interests - Quantum and classical turbulence - Magnetohydrodynamics and dynamo theory - Population dynamics applied to the Neolithic epoch	
	Five most recent publications:	
	1- Quasiclassical and ultraquantum decay of superfluid turbulence, PRB 85 (2012)	
	2- Tree Method for Quantum Vortex Dynamics, JLTP 116 (2012)	
	3- Quantum turbulent velocity statistics and quasiclassical limit, PRE 84 (2011)	
	4- Vortex-density fluctuations in quantum turbulence, PRB 84 (2011)	

1 The lead scientist indicated here is expected to participate in the campaign as a user of the infrastructure.
2 The host scientist is supervising the work of the visiting project scientist at the infrastructure.
3 The project scientist is the person who will be visiting the infrastructure.

	5- Spectrum of turbulent Kelvin-waves cascade in superfluid helium, PRB 83 (2011)		
Other participating scientists:[4]	**Name:** Andrew Baggaley	**Position:** post-doctoral research associate	**New User:** yes
	Prof. Carlo Barenghi		no

4 Please list all participating user group members. Expand the table, if necessary.

2. Project Information

Name of host infrastructure:	Aalto University			
Access provider / Infrastructure Director:	**Name:** Matti Krusius, prof.		**E-mail address:** mkrusius(at)neuro.hut.fi	
Planned project dates:	**Start date:**	2 weeks	**Completion date:**	April - May, 2012

Project description (12 lines max):

The dynamics of quantized vortices is an important topic in the Microkelvin work programme. The direct visualization of vortices and their dynamics in the zero temperature limit $T \to 0$ has not yet been accomplished. Instead numerical vortex filament calculations with Biot-Savart integration along the line vortex is used to acquire a broader overall understanding of experimental results which often answer only very specific questions. At the lowest temperatures with exponentially vanishing mutual friction dissipation the correspondingly growing long computing time becomes a severe limitation in the calculations. Improved numerical routines need to be developed. The results from calculations with such codes can be experimentally tested by comparing to specific straightforward examples of vortex configurations and their dynamic responses, as measured with NMR in a rotating cryostat. We propose to exploit this possibility to test new numerical procedures applicable in the $T \to 0$ limit.

Our goal is to implement a numerical code that can model the vortex dynamics and quantum turbulence using external boundary conditions that are experimentally realistic. The numerical code has to be fast enough such that it can be run using parameters that are typical for present day experiments. The complexity of a typical Biot-Savart implementation is of order N^2, where N is the number of points used to model the line vortices in helium superfluids. With the help of the tree-algorithm (see publication [2]) this can be reduced to N*log(N). In order to simulate a variety of physical problems, we will combine the new tree-algorithm with feasible boundary conditions by taking into account the geometry.

Scientific objectives of the project (12 lines max):

With the help of the new and faster algorithm the primary task is to mimic and interpret various experiments, first in simple rotating cases where the results can be tested. Later more complex applications will be included, where the direct visualization of quantized vortices is typically difficult. Such experiments are, for example, the propagation of the vortex front in a rotating cylinder or the decay of a vortex tangle after a sudden stop of rotation. It is expected, that the results obtained help us to better understand quantum turbulence. We are most interested in the zero temperature limit, where energy dissipation should occur at length scales shorter than the inter-vortex distance. Therefore a faster code is needed, in order to cover a wider range of scales. Within this filament formulation we can then also search for improved methods to identify possible coherent structures and to probe the cascade of Kelvin waves on the vortex.

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

The primary goal is to use the vortex filament model and combine two pre-existing numerical codes such that we can exploit the benefits from both programs. The tree-algorithm code by A. Baggaley, which is N*log(N) method (versus the standard N^2 method), allows a considerable speed-up and makes possible to use vortex line densities larger than before. So far this code is limited to periodic boundary conditions. Using the tree-algorithm as a basis, a new code will be implemented where experimentally feasible boundary conditions are taken into account. This will be done by using the code by R. Hänninen, where the geometry, i.e. a cube and a cylinder, are already implemented. During this first short visit our task is to discuss how to combine these two approaches so that a working code can ultimately be composed.

3. Joint Proposals / Funding

Is this project in collaboration with other (concurrent) projects at the infrastructure?	**No**
If yes, please specify:	

Is this proposal submitted to any funding programmes?	**No**
If yes, please specify:	

The completed Application Form should be submitted to MICROKELVIN Management Office
(**Sari.Laitila@aalto.fi**, fax +358-9-47022969)