welcome to the European Microkelvin Collaboration

CAPACITIES

Application Form for MICROKELVIN Transnational Access Project

1. General Information

Project number:	**TKK 03**	
Project Title:	Dissipation in vortex motion	
Project acronym:		
Lead scientist:[1]	**Title:**	Professor
	First name:	Victor
	Last name:	L'vov
	Birth date:	
	Research status/Position:	Professor
	New User:[2]	No
	Scientific Field:	Superfluid hydrodynamics
	Home institution:	Department of Chemical Physics The Weizmann Institute of Science
	Home institution is MICROKELVIN partner:	**Yes** ☐ **No X**
	Business address:	
	Street:	
	Street No.:	
	PO Box:	
	City:	Rehovot
	Zip/Postal Code:	76100
	Country:	Israel
	Telephone:	+972 (8) 934-3750
	Fax:	+972 (8) 934-4123
	E-mail:	Victor.Lvov@weizmann.ac.il http://lvov.weizmann.ac.il
	Curriculum vitae (18 lines max): Professor Victor L'vov is a senior member of the permanent staff at the Weizmann Insitute and a widely known expert of hydrodynamic theory in both the viscous and superfluid states. He comes from the Institute of Thermodynamics in Novosibirsk (Russian Academy of Sciences) from where he moved to the Weizmann Institute in the early nineties.	
	Five most recent publications (on superfluids):	
	V.S. L'vov, S.V. Nazarenko and L. Skrbek, Energy Spectra of Developed Turbulence in Helium Superfluids, J. Low Temperature Physics, **145**, 125 - 142 (2006).	
	V. S. L'vov, S. V. Nazarenko, O. Rudenko, Bottleneck crossover between classical and quantum superfluid turbulence, *Phys. Rev. B* **76**, 024520 (2007). DOI: 10.1103/PhysRevB.76.024520.	
	V.B. Eltsov, A.I. Golov, R. de Graaf, R. Hanninen, M. Krusius, V.S. L'vov, and R.E. Solntsev Quantum turbulence in propagating superfluid vortex front, *Phys. Rev. Letts*, **99**, 265301 (2007); DOI :10.1103//PhysRevLett.99.265301	
	V. S. L'vov, S. V. Nazarenko and O. Rudenko, Gradual eddy-wave crossover in superfluid turbulence, *J. of Low Temp. Phys*. **153**, 140-161 (2008). DOI: s10909-008-9844-0	

[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'.

	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, ***Progress in Low Temperature Physics***, XVI pp. 46-146 (2009), DOI: 0.1016/S0079-6417(08)00002-4 Also arXiv:0803.3225

Other participating scientists:[3]	**Name:**	**Position:**	**New User:**[2]
	Sergey V. Nazarenko	professor University of Warrick, UK	yes
	Oleksii Rudenko	Ph.D. student The Weizmann Institute, Il	yes

2. Project Information

Name of host infrastructure:	Low Temperature Laboratory Helsinki University of Technology		
Access provider / Infrastructure Director:	**Name:** prof. Matti Krusius prof. Grigory Volovik		**E-mail address:** mkrusius@neuro.hut.fi volovik@boojum.hut.fi
	prof. Mikko Paalanen		paalanen@neuro.hut.fi
Planned project dates:	**Start date:** 06/08/2009		**Completion date:** 29/08/2009
Project title :	**Dissipation in quantum turbulence in zero temperature limit**		

Project description (12 lines max):

Dissipation from the motion of quantized vortices at the very lowest temperatures is of great current interest in the study of coherent quantum systems. At higher temperatures the source of dissipation is the friction and damping in vortex motion known as mutual friction. It arises from the scattering of normal excitations from a vortex which moves with respect to the reference frame provided by the normal fluid. This mechanism of dissipation approaches zero in the zero temperature limit, when the cloud of normal excitations becomes more and more rarefied. In a rotating cryostat one can explore the motion of vortices by changing the rotation velocity and by comparing the responses when different boundary conditions or different initial conditions are imposed. The question is then how do vortices couple to changes in the externally imposed reference frame when the density of normal excitations is approaching zero? From measurements on both helium superfluids and Bose-Einstein condensed cold atom clouds so far we know that the superfluid with its vortices appears to remain coupled. What provides this coupling: are there new dissipation mechanisms which govern the superfluid dynamics in the zero temperature limit?

The MicroKelvin collaboration provides an opportunity to study these questions experimentally in the fermion superfluid 3He-B by means of a rotating cryostat. With this apparatus 3He-B is cooled to below 0.2 Tc in rotation which can be controlled to within $\pm$1 circulation quantum. Measurements on the spin-up and spin-down of the superfluid component under varied conditions have shown that vortices do respond to changes in the rotation velocity down to very low densities of normal excitations, where their mean free path is much longer than the sample dimensions. However, dissipation strongly depends on vortex polarization, i.e. on the presence of inter-vortex and intra-vortex reconnection processes.

Scientific objectives of the project (12 lines max):

Professor L'vov has studied (together with his student Oleksii Rudenko and his colleague Sergey Nazarenko) the free decay of superfluid turbulence. In particular, they have paid attention to the cross-over regime from the hydrodynamic Richardson – Kolmogorov energy cascade to Kelvin waves propagating on single vortex lines. They find that a bottleneck will arise in the energy transfer between the two branches with increasing vortex polarization. His new work will concentrate on the mechanisms of dissipation and the coupling to the reference frame at vanishing quasiparticle densities, taking into account realistic temperature dependences.

The visit takes place at the time when also new measurements are starting. Here the spin-up of the

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

superfluid component is studied at constant externally controlled conditions. This measurement monitors the propagation of a vortex front along a rotating column in stationary state conditions, whereby outside interference is minimized and it might become possible to measure the small increase in the density of quasiparticle excitations, which the vortex dissipation is expected to give rise to. This measurement of the conversion of vortex dissipation to heat is a continuation of the studies in Ref. [1], while the mechanism for the new zero temperature dissipation is assumed to be associated with quasiparticle emission from 1-dimensional vortex core states [2].

References:

[1] ***Quantum turbulence in a propagating superfluid vortex front;*** V.B. Eltsov, A.I. Golov, R. de Graaf, R. Hänninen, M. Krusius, V.S. L'vov, and R.E. Solntsev, Phys. Rev. Lett. **99**, 265301 (2007).

[2] **The Universe in a Helium Droplet**; G.E. Volovik (Clarendon Press, Oxford, 2003).

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

The three-week visit is used for discussions on how to proceed in the new studies and on how results from previous measurements should be interpreted. These measurements were concerned with the spin down of the superfluid component in two different geometries and showed that the decay time can differ by an order of magnitude below 0.2 Tc, depending on polarization.

3. Joint Proposals / Funding

Is this project in collaboration with other (concurrent) projects at the infrastructure?	**Yes X No ☐**
If yes, please specify: Study of quantum turbulence in zero temperature limit	

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

The completed Application Form should be submitted to MICROKELVIN Management Office (**leena.meilahti@tkk.fi**, fax +358-9-4512969)