welcome to the
European Microkelvin Collaboration

CAPACITIES

Report on the Transnational Access Activity carried out within MICROKELVIN

The eligibility of transnational access to a MICROKELVIN TA site implies the submission of the following:

1) The Certification of visit

The form "Certification of visit" must be completed and signed by the access provider in charge of the infrastructure and the leader of the project.

2) A TA project report

The form for the TA project report is contained within this document. It should be completed after project end by the group leader of the project. You must respect the limited number of words specified, longer descriptions will be rejected. Figures/tables may be attached at the end of the document. The document must be submitted in an editable format (doc, rtf).

3) A User group questionnaire

To enable the Commission to evaluate the Research Infrastructures Action, to monitor the individual contracts, and to improve the services provided to the scientific community, each project leader of a user-project supported under an EC Research Infrastructure contract is requested to complete a "user group questionnaire". The questionnaire must be submitted once by each user group to the Commission as soon as the experiments on the infrastructure come to end.

The user group questionnaire is not part of this document and must be completed on-line. It is accessible at:

http://cordis.europa.eu/fp7/capacities/questionnaire_en.html.

► **Please note that any publications resulting from work carried out under the MICROKELVIN TA activity must acknowledge the support of the European Community:**

> **"The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 228464 (MICROKELVIN)."**

.

MICROKELVIN Transnational Access Project Report

1. General information

Project number:	AALTO27	
Project Title:	Dynamics and dissipation in vortex motion in the zero-temperature limit in rotating superfluid 3He-B	
Lead scientist:[1]	**Title:**	prof.
	First name:	Victor
	Last name:	L'vov
	Home institution:	Weizmann Institute of Science, Rehovot, Israel
Host scientist:[2]	**Title:**	prof.
	First name:	Matti
	Last name:	Krusius
	Home institution:	O.V. Lounasmaa Laboratory, Aalto University
Project scientist:[3]	**Title:**	prof.
	First name:	Victor
	Last name:	L'vov
	Birth date:	
	Passport number:	
	Research status/Position:	
	New User:[4]	No
	Scientific Field:	hydrodynamics, turbulence, superfluids
	Home institution:	Weizmann Institute of Science
	Is your home institution MICROKELVIN partner?	No
	Business address:	
	Street:	
	PO Box:	
	City:	Rehovot
	Zip/Postal Code:	76100
	Country:	Israel
	Telephone:	+972(8)9343750
	Fax:	+972(8)9344123
	E-mail:	Victor.Lvov@gmail.com http://lvov.weizmann.ac.il

[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.

[4] Indicate 'Yes' only if the user has never visited the infrastructure before this specific project, otherwise write 'No'.

2. Project information

Please, give a brief description of project objectives: (250 words max)	The dynamics of quantized vortices at the lowest temperatures is a central topic in the Microkelvin program (Joint Research Activity package 3 Task 1 – Investigation of quantum vortices as model cosmic strings). Measurements on superfluid vortex motion have been ongoing for several years in the rotating cryostat of the Low Temperature Laboratory of the Aalto University. Different processes have been studied, in particular the interplay of laminar and turbulent vortex flow. One of the main challenges is to understand the sources of dissipation in vortex motion in the limit $T \to 0$, which corresponds to the vacuum limit for quasiparticle excitations, i.e. the normal component. This is the regime in which bulk hydrodynamics is expected to break down since the density of the ballistic quasiparticle cloud will be too sparse to support a tight coupling between the superfluid and normal components via the mutual friction damping in vortex motion. The motion of cosmic strings could be expected to take place in this same regime today, if cosmic strings are found to exist. At higher temperatures mutual friction in the bulk volume provides the coupling of the superfluid vortices to the external reference frame, both with respect to energy and angular momentum transfer. Mutual friction arises from the scattering of normal excitations from a vortex which moves with respect to the reference frame provided by the normal fluid. With decreasing temperature mutual friction dissipation vanishes exponentially, as the density of normal excitations approaches zero. However, current measurements show that in turbulent vortex motion dissipation does not extrapolate to zero in the $T \to 0$ limit. What are these mechanisms which govern superfluid dynamics at the lowest temperatures? One of the processes which have been employed for such studies is the motion of a turbulent vortex front in a long rotating cylinder. Measurements of the azimuthally rotating and axially advancing front have been performed since 2005 in the rotating cryostat. The front divides the cylinder in two sections: Ahead of the front there is vortex-free rotating counterflow ($v_s = 0$, $v_n = \Omega R$), while behind the front there is a bundle of twisted vortices at some value Ω_s of solid-body-rotation density ($v_s \approx \Omega_s R \leq \Omega R = v_n$). Turbulence concentrates in the front itself, where reconnections occur continuously at a steady rate while the front is moving. The first results [1] on the axial velocity of the front were obtained with NMR techniques and were interpreted assuming that the dissipation is primarily produced by the turbulent front motion. Subsequent thermal studies [2] of the axially moving transition from vortex-free counterflow to the rotating equilibrium vortex state (at constant rotation velocity Ω) showed that with decreasing temperature in the limit $T \to 0$ an increasing fraction of the total dissipation arises from the laminar part of the vortex flow. Although this result was opposite to what was generally expected, it is consistent with measurements of the spin-down response [3] of the equilibrium vortex state after a sudden stop of the rotation drive. **References:** [1] V.B. Eltsov, A.I. Golov, R. de Graaf, R. Hänninen, M. Krusius, V.S. L'vov, and R.E. Solntsev, *Quantum turbulence in a propagating superfluid vortex front;* Phys. Rev. Lett. **99**, 265301 (2007).

	[2] V.B. Eltsov, R. de Graaf, J.J. Hosio, P.J. Heikkinen, R. Hanninen, M. Krusius, V.S. L'vov, and G.E. Volovik, *Superfluid vortex front at T -> 0: Decoupling from the reference frame*, *Phys. Rev. Lett.* **107**, 135302 (2011). [3] V.B. Eltsov, R. de Graaf, P.J. Heikkinen, J.J. Hosio, R. Hänninen, M. Krusius, and V.S. L'vov, *Stability and dissipation of laminar vortex flow in superfluid 3He-B*, arXiv:1005.0546v1, Phys. Rev. Lett. **105**, 125301 (2010).
Technical description of work performed: (250 words max)	There are unresolved questions concerning the correct interpretation of different dynamic measurements at the lowest temperatures. If we want to make use of the helium superfluids as laboratory model systems of coherent quantum matter in the vacuum $T \to 0$ limit, the dynamics should be understood better. In superfluid turbulence the kinetic energy flows via the Richardson – Kolmogorov cascade to ever smaller length scales when the temperature is reduced. Finally, at the inter-vortex distance it has to be bridged from larger eddies consisting of bundled vortices to Kelvin waves propagating on single vortex lines. With further temperature reduction more and more of the dissipation occurs in the Kelvin wave cascade. New results are currently accumulated both in laboratory measurements as well as in high-resolution numerical calculations as a function of temperature, rotation velocity, and the radius of the rotating cylinder. Both sets of data appear to emphasize the importance of the Kelvin wave cascade. Comparing the results, we expect to construct an empirical model which provides a unified explanation. Hopefully this model will guide the way to a physical understanding of the Kelvin wave cascade and its dissipation.
Project achievements (and difficulties encountered):[5] (250 words max)	During his 3-week visit in the Low Temperature Laboratory, prof. L'vov discussed and analyzed results from vortex front measurements. He prepared a report which describes a phenomenological model and its fit to the experimental data when the superfluid component starts to lose increasingly its coupling to the rotating reference frame of the container walls with decreasing temperature. The model provides a perfect fit but unfortunately not all details about the basis for this model are currently known.
Expected publications and dates:	in 2012
Submission date:	19 September, 2012

Completed Project Reports should be returned to MICROKELVIN Management Office (Sari.Laitila@aalto.fi, Fax: +358 9 47022969).