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)."**

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CAPACITIES

MICROKELVIN Transnational Access Project Report

1. General information

Project number:	AALTO14	
Project Title:	**Vortex front propagation and the axially moving transition from the vortex-free Landau state to the equilibrium vortex state**	
Lead scientist:[1]	**Title:**	Professor
	First name:	Victor
	Last name:	L'vov
	Home institution:	Weizmann Institute of Science, Rehovot, Israel
Project scientist:	**Title:**	Prof.
	First name:	Victor
	Last name:	L'vov
	Birth date:	
	Passport number:	
	Research status/Position:	
	New User:[2]	No
	Scientific Field:	Turbulence in superfluids and viscous fluids
	Home institution:	Weizmann Institute of Science
	Is your home institution MICROKELVIN partner?	No
	Business address:	Israel
	Street:	+972(8)9343750
	PO Box:	+972(8)9344123
	City:	Rehovot
	Zip/Postal Code:	76100
	Country:	Israel
	Telephone:	+972(8)9343750
	Fax:	+972(8)9344123
	E-mail:	Victor.Lvov@gmail.com
	Web page:	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] 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 very lowest temperatures is a central topic in the Microkelvin programme (Joint Research Activity package 3 Task 1 – Investigation of quantum vortices as model cosmic strings). One of the challenges is to understand the sources of dissipation in vortex motion at the lowest temperatures, in the limit $T \rightarrow 0$. This is the regime in which the motion of cosmic strings could be expected to take place today, if they are found to exist. At higher temperatures dissipation is known to be caused by 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. Mutual friction dissipation vanishes as the density of normal excitations approaches zero at the lowest temperatures. However, currently it is believed that in turbulent vortex motion dissipation does not appear to extrapolate to zero in the limit $T \rightarrow 0$. Are there thus new mechanisms which govern superfluid dynamics at the lowest temperatures? One of the phenomena which have been employed for such studies is the motion of a vortex front axially along a long rotating cylinder. The front divides the cylinder in two regions: ahead of the front is vortex-free rotating counterflow and behind the front a twisted bundle of vortices. Measurements of the azimuthally precessing and axially advancing front have been performed in the rotating cryostat of the Low Temperature Laboratory with the fermion superfluid 3He-B using noninvasive NMR techniques. One of the tasks is to investigate the front propagation velocity $V_f(\Omega,T)$ as a function of rotation velocity Ω and mutual friction dissipation $\alpha(T)$. The front velocity can be used as a measure of dissipation and can thus provide the key to the understanding of the dynamic properties of vortices at the lowest temperatures.
Technical description of work performed: (250 words max)	New results are currently accumulated both in laboratory measurements as well as in high-resolution numerical calculations on the axial velocity and the azimuthal precession of the propagating vortex front as a function of temperature and rotation velocity. This data is expected to provide a better understanding of the consistency between measurement and calculation. Also the explanation for the unexpected dependences of the front velocity in different temperature regimes should emerge from these studies. The extrapolation of the data to $T \rightarrow 0$ should ultimately reveal the mechanisms which control the axially propagating transition from the vortex-free Landau state to the equilibrium vortex state at the lowest temperatures. Prof. L'vov has studied extensively the decay of homogeneous and isotropic superfluid turbulence via the Richardson – Kolmogorov hydrodynamic energy cascade which ultimately at sufficiently low mutual friction dissipation and small length scales (comparable to the inter-vortex distance) couples to Kelvin waves propagating on single vortex lines. It is important to understand to how these theories apply

	to the turbulence in the propagating vortex front. During his 1-month visit in the Low Temperature Laboratory prof. L'vov has participated in the front velocity measurements and in the numerical calculations. He has spent a great deal of effort on the analysis of the results. His conclusions are still waiting for further confirmation until the data accumulation can be regarded as completed.
Project achievements (and difficulties encountered):[5] (250 words max)	The front velocity measurements (similar to earlier thermal measurements) show that there is a characteristic temperature of 0.3 Tc where a transition occurs from the mutual-friction-dominated regime at high temperatures to the low-temperature regime where the decoupling of the superfluid from the reference frame of the normal component starts and vortex tension wins in importance. In this latter regime V_f (Ω, T) decreases more slowly than mutual friction $\alpha(T)$ and its extrapolation, when $T \rightarrow 0$, displays a non-zero intercept. The detailed properties of the front velocity in this regime are still under discussion.
Expected publications and dates:	"Superfluid vortex front at T -> 0: Decoupling from the reference frame", J.J. Hosio, V.B. Eltsov, R. de Graaf, P.J. Heikkinen, R. Hänninen, M. Krusius, V.S. L'vov, and G.E. Volovik, Phys. Rev. Lett. **107**, 135302 (2011) [doi:10.1103/PhysRevLett.107.135302] A follow-up publication with an explanation of the vortex front velocity as a function of rotation velocity and mutual friction dissipation is in preparation.
Submission date of user group questionnaire:	3 October, 2011

Completed Project Reports should be returned to MICROKELVIN Management Office (laitila@neuro.hut.fi, Fax: +358 9 47022969).