Application Form for MICROKELVIN Transnational Access Project

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]	**First name:**	Victor
	Last name:	L'vov
	Birth date:	
	Research status/Position:	Prof.
	New User:[2]	No
	Scientific Field:	Turbulence in helium superfluids
	Home institution:	Weizmann Institute of Science, Rehovot, Israel
	Home institution is MICROKELVIN partner:	No
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	Curriculum vitae (18 lines max): Prof. L'vov is a senior member of the permanent staff at the Weizmann Institute and a widely known expert of hydrodynamic theory in both viscous and superfluid flow. He comes originally from the Institute of Automization in Novosibirsk (Russian Academy of Sciences) from where he moved to the Weizmann Institute in the early nineties.	
	Five most recent publications (on helium superfluids):	
	1) *Temperature suppression of Kelvin-wave turbulence in superfluids,* Laurent Boué, Victor L'vov, Itamar Procaccia, arXiv:1205.0461	
	2) *Energy Spectra of Superfluid Turbulence in 3He,* Laurent Boué, Victor L'vov, Anna Pomyalov, Itamar Procaccia, Phys. Rev. B **85**, 104502 (2012), arXiv:1112.5979	
	3) *Kelvin-wave turbulence in superfluids*, Laurent Boué, Ratul Dasgupta, Jason Laurie, Victor L'vov, Sergey Nazarenko, Itamar Procaccia, Phys. Rev. B **84**, 064516 (2011), arXiv:1103.5967	
	4) *Superfluid vortex front at T -> 0: Decoupling from the reference frame*, J.J. Hosio, V.B. Eltsov, R. de Graaf, P.J. Heikkinen, R. Hanninen, M. Krusius, V.S. L'vov, G.E. Volovik, Phys. Rev. Lett. **107**, 135302 (2011), arXiv:1102.4284	
	5) *Energy Spectra of Quantum Turbulence: Large-scale Simulation and Modeling*, Narimasa Sasa, Takuma Kano, Masahiko Machida, Victor S. L'vov, Oleksii	

[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'.

	Rudenko, Makoto Tsubota, Phys. Rev. B **84**, 054525 (2011), arXiv:1008.3050		
Other participating scientists:[3]	**Name:**	**Position:**	**New User:**[2]
	1 - Sergey V. Nazarenko	professor University of Warwick, UK	yes
	2 - Oleksii Rudenko	post-doctoral researcher Technische Universiteit, Eindhoven, Netherlands	yes

2. Project Information

Name of host infrastructure:	Low Temperature Laboratory, Aalto University, Espoo, Finland			
Access provider / Infrastructure Director:	**Name:** Prof. Matti Krusius Prof. Grigory Volovik		**E-mail address:** mkrusius@neuro.hut.fi volovik@boojum.hut.fi	
Planned project dates:	**Start date:**	11/8/2012	**Completion date:**	1/9/2012

Project description (12 lines 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 have been ongoing in a rotating cryostat on different dynamic processes for several years. They are now approaching their final phase. One of the main challenges is to understand the sources of dissipation in vortex motion in the limit $T \to 0$. 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 caused by the 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. Mutual friction dissipation vanishes 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 dynamic processes which have been employed for such studies is the motion of a vortex front axially along 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 ($v_s = 0$), while behind the front there is a bundle of twisted vortices at some value of solid-body-rotation density ($v_s \le v_n$). 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).

Scientific objectives of the project (12 lines max):

There are unresolved questions concerning the correct interpretation of the different dynamic measurements at the lowest temperatures. If we want to make use of the helium superfluids as laboratory model systems of

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

coherent quantum matter in the vacuum $T \rightarrow 0$ 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 s 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.
Technical description of work to be performed (20 lines max): During his 3-week visit in the Low Temperature Laboratory, prof. L'vov will participate in further measurements on the propagating vortex front. These are expected to provide the missing details needed to compare adequately to simulation calculations. In particular, more data is needed on the vortex density behind the front, which declines with decreasing temperature, but does not appear to fit within a common model for experiment and numerical calculation. The goal is to arrive at an adequate understanding about the basic data in the regime where the superfluid component starts to lose increasingly its coupling to the rotating reference frame of the container walls with decreasing temperature.

3. Joint Proposals / Funding

Is this project in collaboration with other (concurrent) projects at the infrastructure?	**No**
Specify:	

Is this proposal submitted to any funding programmes?	**No**
If yes, please specify:	**None**

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