Application Form for MICROKELVIN Transnational Access Project

1. General Information

Project number:	**LANCASTER13**	
Project Title:	**Analysis of data on quantum diffusion in Helium-4 Crystal**	
Lead scientist:[1]	**Title:**	Dr.
	First name:	Igor
	Last name:	Todoshchenko
	Home institution:	O.V. Lounasmaa Lab, Aalto University, Finland
Host scientist:[2]	**Title:**	Prof.
	First name:	Shaun
	Last name:	Fisher
	Home institution:	Lancaster University
Project scientist:[3]	**Title:**	Dr.
	First name:	Igor
	Last name:	Todoshchenko
	Scientific Field:	Quantum Liquids and Solids
	Home institution:	O.V. Lounasmaa Lab, Aalto University, Finland
	Is your home institution MICROKELVIN partner?	Yes
	Business address:	O.V. Lounasmaa Lab, Aalto University
	Street:	Puumiehenkuja 2B, Otaniemi
	PO Box:	15100
	City:	Espoo
	Zip/Postal Code:	00076 AALTO
	Country:	Finland
	Telephone:	+358 44 5458 422
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	E-mail:	todo@boojum.hut.fi
	Curriculum vitae (18 lines max): **Current Position**: 1999-present, Senior Researcher, Lounasmaa Lab, Aalto University, Finland. **Resarch Interests**: **Solid Helium-4:** Equilibrium shapes, Topological defects in the bulk and on the surfaces, Anisotropy, Supersolidity, Thermodynamics. **Solid Helium-3:** Faceting transitions, Surface kinetics, Surface magnetism **Quantum Interfaces:** Surface fluctuations, Superfluid surface bound states **Graduate Students:** 2 students graduated, 2 students currently in the lab **Publications:** 26 papers in refereed Journals, (30 Letters) **Invited talks at conferences: 6**	

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.

	Five most recent publications:		
1	I. A.Todoshchenko, H. Alles, H. J. Junes, M. S. Manninen, A.Ya.Parshin, Devil's staircase of facets on the surface of ^{4}He crystals Phys. Rev. Lett., v. **101**, p. 255302 (2008).		
2	M. S. Manninen, H. J. Junes, J.P. Kaikkonen, A.Ya.Parshin, I. A.Todoshchenko, and V. Tsepeli, Experimental setup for the observation of crystallization waves in ^{3}He Journal of Physics: Conference Series, v. **150**, p. 012026 (2009).		
3	I. A.Todoshchenko, H. Alles, H. J. Junes, M. S. Manninen, A.Ya.Parshin, Nuclear spin ordering on the surface of a ^{3}He crystal: magnetic steps Phys. Rev. Lett., v. **102**, p. 245302 (2009).		
4	I. A.Todoshchenko, M. S. Manninen, A.Ya.Parshin, Anisotropy of c facets of ^{4}He crystal Phys. Rev. B, v. **84**, p. 075132 (2011).		
5	M. Reivinen, E.-M. Salonen, I. Todoshchenko, V.P. Vaskelainen, Equilibrium crystal shapes by virtual work J. Low Temp. Phys., v. **170**, p. 75–90 (2013).		
Other participating scientists:[4]	**Name:**	**Position:**	**New User:**
	1-		
	2-		
	3-		

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

2. Project Information

Name of host infrastructure:	**Lancaster University**			
Access provider / Infrastructure Director:	**Name: Prof. S.N. Fisher**		**E-mail address: s.fisher@lancaster.ac.uk**	
Planned project dates:	**Start date:**	**25.03.13**	**Completion date:**	**02.04.13**

Project description (12 lines max):

The project will be devoted to the analysis of the data obtained on the plastic flow of helium-4 crystals in Lancaster in the end of the year 2012. The essence of the experiment was observation of the motion of a thin wire through the bulk helium-4 crystal due to (Lorentz) force applied to the wire and the flow of vacancies (interstitials) in the crystal near the wire. At low driving forces (stresses) the velocity of the wire depends linearly on the stress, which is the indication of the diffusive flow of vacancies around the wire, while the concentration of the vacancies remains constant. We will analyze the dependence of the linear coefficient both on temperature and on the quality of the crystals which should provide understanding of the diffusion coefficient of vacancies and their concentration under different conditions. At high stresses, the velocity-stress dependence becomes non-linear, and we are going to analyze this regime at different conditions to clarify what are the physical processes behind it. The jump-like motion of the wire was never observed before in helium crystals. We will analyze the statistics of these jumps and hope to get an idea of their nature.

Scientific objectives of the project (12 lines max):

We aim to demonstrate a crossover from the thermal diffusion of vacancies to the quantum one. In the classical case the diffusion of vacancies is thermally activated and falls down exponentially when the temperature decreases below the activation energy of vacancies (10K for hcp helium-4 crystal). At low enough temperatures vacancies de-localize due to the high probability of quantum tunnelling in the absence of short-wave-length phonons, and their diffusion coefficient becomes temperature-independent. We will try to show the crossover by analysing the mobility of the wire at low stresses. The nature of higher power of the velocity-stress dependence will be clarified as well. We are going to demonstrate that the term is cubic, as the preliminary analysis shows, and in that case the creation of vacancies by the applied stress should be involved. We are also going to show that the macroscopic jumps of the wire could have quantum nature and might occur due to overlap of several de-localized vacancies (vacancions) into clouds. Such clouds are interesting objects where vacancions may Bose-condense at low enough temperatures.

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

The preliminary data on the mobility of the wire at low stresses show a large scatter at temperatures below 1.5 K but seem to be lying between the theoretical value for classical (thermal) diffusion from the bottom and the constant value roughly corresponding to the thermal diffusion at 1.5 K. We will analyse these points more accurately to be sure that they indeed correspond to the linear regime and will pay attention to the crystal quality and history. Most probably, the scatter reflects different quality of the crystal samples, and we are going to find out which kind of crystals show the diffusion much faster than the thermally activated one, and thus are more promising for the observation of Bose condensation of vacancies. It will be also very interesting to compare the crystals showing fast diffusion of vacancies with the crystals where the wire often jumped a macroscopic distance, because the correlation would certainly indicate that the de-localized vacancies are responsible for both processes. We will compare the data on jumps with the model of usual creep followed by the destruction of the material. Hopefully the creep will be excluded as typically there must be several stages (like the increase of the density of vacancies) preceding the disruption due to creep which were not observed. We also plan to analyse carefully the high order term in the velocity-stress dependence. Supposedly it corresponds to the creation of vacancies on the surface of the wire due to applied stress. The probability of creation of a vacancy is proportional to the square of the stress, and the velocity of an individual vacancy is linear with stress, thus the velocity of the wire is proportional to the third power of the stress, in agreement with the preliminary analysis. In the view of possible Bose-condensation of vacancies, it is important to demonstrate that a significant amount of vacancies can be created by the stress because of the damage of the crystal.

3. Joint Proposals / Funding

Is this project in collaboration with other (concurrent) projects at the infrastructure?	**Yes**
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)