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)."

welcome to the
European Microkelvin Collaboration

CAPACITIES

MICROKELVIN Transnational Access Project Report

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
	Birth date:	25 June 1971
	Passport number:	51N4746853
	Research status/Position:	Senior researcher
	New User:[4]	No
	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
	PO Box: City:	15100 Espoo
	Zip/Postal Code:	00076 AALTO
	Country:	Finland
	Telephone:	+358 44 5458 422
	Fax:	+358 9 470 22969
	E-mail:	todo@boojum.hut.fi

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 project focussed on performing the final experiments and analysing our previous data obtained in Lancaster on the plastic flow of helium-4 crystals. The experiments involved a thin wire moving through bulk helium-4 crystals due to the Lorentz force applied to the wire. At low speeds, the velocity of the wire is proportional to the driving force (stress) and the motion of the wire is due to the diffusive flow of vacancies present in the solid. The driving force applied to the wire induces a stress field in the solid, and vacancies move from the regions of less dense solid behind the wire to the regions of more dense solid ahead of the wire. The wire mobility is thus proportional to the concentration of vacancies and to the mobility of a single vacancy. We have analyzed the dependence of the wire mobility on temperature and on the history of the crystal sample and found that the concentration of vacancies varies a lot from sample to sample. High quality crystals show a small concentration of vacancies while samples which were thermally cycled could have more than an order of magnitude larger concentration of vacancies. These additional vacancies may be induced by the stress in the solid due to the change in melting pressure. At higher drives, we find that stress-induced vacancies are created by the wire.
Technical description of work performed: (250 words max)	The data on the mobility of the wire at low stresses show a large scatter at temperatures below 1.5 K. We have paid special attention to be sure that the data has been taken in the linear regime and thus the scatter reflects real variability in the crystal quality which depends on the sample history. We have applied a model of diffusive motion of vacancies around the wire to show that the lower boundary of the mobility is due to thermally activated vacancies as expected for high quality crystals. In this model the diffusion coefficient of a single vacancy is proportional to the tunnelling frequency, or to the width of the energy band of vacancies. Samples with low mobility were freshly made and were measured at the same temperature at which they were grown. These good quality samples have only thermally activated vacancies. After changing the temperature of the sample the mobility of the wire becomes much larger indicating that the vacancy concentration may be increased by more than one order of magnitude. We suggest that additional vacancies appear due to stresses in solid when changing the melting pressure (temperature). Vacancies can also be created by the wire at high drives, which results in a cubic term in the velocity-stress dependence of the wire.
Project achievements (and difficulties encountered):[5] (250 words max)	We have shown that the flow of vacancies is responsible for the plastic motion of a wire through solid helium 4. The lowest observed values of the mobility of the wire are in good quality crystals and these agree well with a model based on the diffusion of thermally activated vacancies. By fitting the low mobility data we can infer the width of the energy band of vacancies. To our knowledge this is the first measurement of the band width of vacancies and the measured value is in the good agreement with theoretical expectations. The higher values of the wire mobility are attributed to the flow of

	vacancies created by the stresses in solid. Stresses in our samples have two origins. First is stress due to the change in melting pressure as the temperature is varied. Second is stress induced by the wire itself at high drives. We find that the concentration of additional vacancies in both cases is similar, about 10^{-3} for stresses close to the ultimate tensile stress of 10-20 mbar. We thus show that a finite concentration of vacancies can be introduced in bulk solid helium 4 by applying stress to the sample. This may be useful for future studies of the potential exotic behaviour at very low temperatures. For instance, the maximum observed concentration of the stress-induced vacancies corresponds to a Bose-condensation temperature of around 30 mK.
Expected publications and dates:	A draft version of a paper has been written and is currently under discussion, we hope this will be published within a few months.
Submission date of user group questionnaire:	16 April, 2013

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