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:	**Lancs12**	
Project Title:	**Quantum diffusion of vacancies 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]	Yes
	Scientific Field:	Quantum Liquids and Solids
	Home institution:	O.V. Lounasmaa Lab, Aalto University, Finland
	Is your home institution MICROKELVIN partner?	Yes
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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)	This project is devoted to measurements on the plastic flow of helium-4 crystals at low temperatures with a range of driving forces. A metallic wire inserted into solid helium can move due to the flow of vacancies or interstitials in the surrounding stress field. The project objectives are to investigate plastic flow by studying the dynamic properties of the wire as a function of temperature, the quality of the crystal, and the applied force. The project will probe many interesting aspects, some of which are outlined below. We expect the plastic properties to change dramatically on varying the temperature and the crystal quality. In the bcc phase, defects can move quite easily along many 'easy' planes. In the hcp phase, defect motion is far more restricted. At high temperatures, vacancies are thermally activated. While at low enough temperatures, vacancies are predicted to delocalize with the formation of quasiparticles (vacancions). Vacancies have an activation energy of the order of 10 Kelvin, so that the equilibrium density of vacancies will rapidly fall with decreasing temperature below 1 Kelvin. However, non-equilibrium vacancies can be introduced in the solid by changing the density of the crystal at constant volume. Furthermore, at sufficiently large vacancy densities and at low enough temperatures, vacancies may Bose-condense into a single ground state. This system might then display superflow, mass flow without dissipation, which should have a dramatic effect on the wire response.
Technical description of work performed: (250 words max)	We investigated the plastic flow with a superconducting wire in the shape of a rectangular loop. The wire was placed in a strong vertical magnetic field, and a DC current through the wire produces a transverse Lorentz force. A small AC current (approx. 30 kHz) is superimposed on the DC current to induce a voltage on nearby pick-up coils. The amplitude of the induced voltage depends on the position of the wire. The absolute position of the wire can be extracted after calibrating the response in liquid He or in vacuum. We were able to nucleate the He crystal by applying heat to the cell locally, or by simply pressurizing the cell slowly. Crystals were prepared in many different ways. Slow growth at almost constant temperature and pressure produces better quality crystals. Fast cooling or warming produces crystals with a lot of defects. We grew crystals of very poor quality by inducing a very rapid pressure and temperature change by briefly driving the wire normal with a large DC current. The measuring cell also contained two pressure sensors and a set of small tuning forks which were used to monitor the position and size of the crystal in the cell.

Project achievements (and difficulties encountered):[5] (250 words max)	We have made many measurements of the wire response in different crystals and over a wide range of temperatures. We measured the velocity of the wire as a function of driving force (stress) in various crystals of different qualities. The data are currently being analysed. Our preliminary findings indicate that below 1.4 K the mobility of the wire depends strongly on the crystal quality. Perfect crystals showed only very slow motion, consistent with thermally excited vacancies whose density decreases rapidly with decreasing temperature. In contrast, crystals of poor quality appeared to show much faster plastic flow. The results suggest that there are two channels of plasticity, one is generated by thermally-activated vacancies and another may be generated by disorder-activated vacancies. At high drives the velocity-stress relationship of the wire becomes non-linear, possibly with cubic velocity dependence, probably due to the self-generation of vacancies by the moving wire. We have also observed fast jumps of the wire position with amplitudes as high as 0.5 mm. The velocity of the wire during such jumps was as fast as 1 mm/s. These jumps never happened with crystals of good quality. We speculate that the jumps might be associated with 'cloud bursts' of vacancies of very high density. Such cloud bursts might be ideal to investigate the possible Bose condensation of vacancions.
Expected publications and dates:	We are currently analysing the data. We hope to publish the results in the next few months.
Submission date of user group questionnaire:	02.01.2013

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