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:	Lancs11	
Project Title:	**Study of Plastic flow in solid Helium-4**	
Lead scientist:[1]	**Title:**	Prof
	First name:	Emil
	Last name:	Polturak
	Home institution:	Technion-Israel Institute of Technology
Host scientist:[2]	**Title:**	Prof
	First name:	Shaun
	Last name:	Fisher
	Home institution:	Lancaster University
Project scientist:[3]	**Title:**	Prof
	First name:	Emil
	Last name:	Polturak
	Birth date:	9.7.1948
	Passport number:	10134584
	Research status/Position:	Prof
	New User:[4]	Yes
	Scientific Field:	Quantum solids
	Home institution:	Technion-Israel Institute of Technology
	Is your home institution MICROKELVIN partner?	No
	Business address:	Department of Physics, Technion-Israel Institute of Technology,
	Street:	
	PO Box:	
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	Country:	Israel
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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 aimed to study plastic flow in solid Helium-4 over a broad range of temperatures, from around 1.5 K to well below 10 mK. In particular, the objective was to study the motion of a wire through the solid under an applied force. The device was developed in an earlier TNA project. It was previously used to study quantum turbulence in superfluid 4He over a wide range of temperatures, from the superfluid transition temperature (~2K) to below 3mK. Here, we wish to use the device (and the same cell) to study solid 4He. The experiments will be performed on the Lancaster Advanced Refrigerator. The project will investigate the plastic properties of solid helium, including plastic flow (creep) at low drive forces, the yield stress and the plastic response at higher driving forces. We are particularly interested in what happens at lower temperatures where there has been a great deal of recent interest in possible "super-solid" and/or "quantum plasticity" behaviour. Substantial amounts of data, analysis and modelling will be required to interpret the experiments. The project scientist has much experience in similar experiments at higher temperatures.
Technical description of work performed: (250 words max)	To study the plasticity of solid 4He we used a wire which was formed into a square loop. A sideways driving force on the wire arises from the Lorentz force exerted when a current is passed through the wire in a vertical magnetic field. The position of the wire was measured using two near-by pick-up coils. A high frequency (~30kHz) probe current was superimposed on the drive current. This induced voltages in two nearby coils. The magnitude of the voltage depends on the wire position. The position measurements were calibrated by measuring the elastic displacement of the wire in liquid 4He. In the solid phase at high temperatures the wire was found to move slowly and steadily through the solid. Here, the resultant plastic flow of the solid around the wire is thought to be facilitated by the diffusion of vacancies – an effect previously investigated by the project scientist at higher temperatures. We also found non-linear behaviour at higher driving forces, presumably due to the motion of defects. In addition we found some unexpected behaviour at higher driving forces. The wire was found to move in a stepwise fashion. The size of the steps increased with the driving force, and high velocities (of order 1 mm/s or more) occur at the step itself. Work is on-going to understand this behaviour, and we will extend the measurements to lower temperatures (so far, no steady motion has been observed at low mK temperatures).
Project achievements (and difficulties	The project has revealed some very interesting results. For the first time we have observed slow steady motion of a wire through hcp solid 4He at tem-

encountered):[5] (250 words max)	peratures below the bcc region of the phase diagram. At low driving forces the velocity is linear in the applied force, but becomes non-linear at higher forces (the velocity varies approximately as the 4th power of the force). These properties can probably be understood on the basis of vacancy diffusion as was investigated previously by the project scientist at higher temperatures. A quantitative comparison is on-going. At higher forces, unexpected behaviour is observed. The wire position changes in a step wise fashion, with increasing step size at larger driving forces. During the step the wire moves at high velocities (of order 1 mm/s or more). Further work is on-going to try to understand this. One difficulty is that the wire occasionally becomes normal which heats the cell and locally melts the solid, but there is no sign of the wire becoming normal during the steps.
Expected publications and dates:	Publications will follow after the new phenomena have been better quantified and understood (work is on-going).
Submission date of user group questionnaire:	7 November, 2012

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