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).”**

MICROKELVIN Transnational Access Project Report

1. General information

Project number:	**AALTO 26**	
Project Title:	**Superconducting Graphene Resonators**	
Lead scientist:[1]	**Title:**	Lecturer
	First name:	Saverio
	Last name:	Russo
	Home institution:	University of Exeter, School of Physics, Centre for Graphene Science
Host scientist:[2]	**Title:**	Professor
	First name:	Pertti
	Last name:	Hakonen
	Home institution:	OVLL, Aalto University
Project scientist:[3]	**Title:**	Mr
	First name:	Daniel
	Last name:	Cox
	Birth date:	21.01.1990
	Passport number:	461907995
	Research status/Position:	Graduate student
	New User:[4]	No
	Scientific Field:	Nanophysics
	Home institution:	
	Is your home institution MICROKELVIN partner?	No
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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)	Graphene is a unique two-dimensional, gapless semiconductor: the conduction and valence bands touch in two inequivalent K points, the Dirac points, where the density of states vanishes. However, the conductivity at the Dirac point remains finite. Indeed, it has been theoretically shown by M. Katsnelson and J. Tworzydlo et al. in 2006 that, in perfect graphene, the conduction occurs only via evanescent waves at the Dirac point. Mechanical graphene resonators have been actively investigated during the last few years. We have adopted capacitive measurement methods for detection of nano-mechanical motion. Dissipation at high measurement frequencies is one of the unknown factors in employing these capacitive techniques for graphene resonators. One way to go around this problem is to employ proximity-induced superconductivity to reduce electrical losses. In this project we plan to develop superconducting graphene resonators and investigate their electrical and mechanical characteristics.
Technical description of work performed: (250 words max)	List of work to be performed: 1. preparation and characterisation of monolayer graphene samples with superconducting contacts, 2. releasing the graphene sheets using an appropriate method, for example vapour-phase HF-etching, 3. characterization of the samples at DC at room temperature, 4. selection of good samples for low temperature measurements, 5. measurements in a dilution refrigerator, 6. obtain data on conductivity, supercurrents, and shot noise, 7. detect mechanical resonance using FM detection methods, 8. investigate coupling between mechanical motion and superconducting electrical transport, 9. compare FM detection to supercurrent resonance detection. Of the above work list, items 1-2 will be performed using Micronova facilities, while items 3-9 will be carried out at LTL of Aalto University.
Project achievements (and difficulties encountered):[5] (250 words max)	Two sets of graphene samples were fabricated. One consisted of exfoliated sheets on traditional Si/SiO_2 and contacted with superconducting aluminium leads and then etched with gas phase HF etching. The other set was exfoliated graphene on top of LOR resist, which negates the need to use HF etching, and instead allows the use of organic solvents and more exotic materials; aluminium contacts were also fabricated on these samples. So far only normal state conducting properties of these samples have been examined. Two experiments were performed – one looking at interference effects in graphene and the other concerned with high DC

	bias electron-phonon coupling – both of which require high quality suspended samples. To examine interference phenomena in our ballistic samples, conductance measurements were used to probe the electronic Fabry-Pérot resonances that arise from reflections at the sample edges and contacts. Shot noise measurements were successfully taken to validate the multimode nature of these interferences. Shot noise measurements were also employed for in-situ thermometry in graphene in order to probe the electron-phonon coupling. Here a high DC bias was applied, and AC conductance along with shot noise were measured simultaneously. Accordingly, the heating power vs. electronic temperature was obtained which could be analysed in terms of the coupling between acoustic phonons and electrons; strong indications for the dominance of double phonon processes were found.
Expected publications and dates:	▪ *Flexural Phonons and Shot Noise in Suspended Graphene* – M. Oksanen, A. Laitinen, D. J. Cox, S. Russo and P. Hakonen (2013) ▪ *Multimode Fabry-Perot Interference in Suspended Graphene* – M. Oksanen, A. Uppstu, A. Laitinen, D. J. Cox, A. Harju, S. Russo and P. Hakonen
Submission date of user group questionnaire:	30 April, 2013

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