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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MICROKELVIN Transnational Access Project Report

1. General information

Project number:	**AALTO16**	
Project Title:	**Shot noise on suspended graphene at mK temperatures**	
Lead scientist:[1]	**Title:**	Prof.
	First name:	Saverio
	Last name:	Russo
	Home institution:	University of Exeter
Host scientist:[2]	**Title:**	Prof.
	First name:	Pertti
	Last name:	Hakonen
	Home institution:	Low Temperature Laboratory, Aalto University
Project scientist:[3]	**Title:**	B.Sc.
	First name:	Daniel
	Last name:	Cox
	Birth date:	21/01/1990
	Passport number:	461907995
	Research status/Position:	Research assistant
	New User:[4]	Yes
	Scientific Field:	Condensed matter (graphene)
	Home institution:	University of Exeter
	Is your home institution MICROKELVIN partner?	☐ Yes ☒ No
	Business address:	Centre for Graphene Science, School of Physics, University of Exeter
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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)	1. To investigate electrical transport in suspended graphene sheets, 2. To measure shot noise of ballistic graphene, 3. To verify basic models for electrical transport in graphene on the basis of shot noise and conductivity (I: evanescent modes, II: weak electron-phonon coupling), and 4. To investigate the coupling of mechanical motion to electrical transport.
Technical description of work performed: (250 words max)	**Preparatory phase at the University of Exeter:** 1. preparation and characterisation of monolayer/few layer graphene samples, 2. releasing the graphene sheets using an appropriate method, for example HF-etching 3. characterization of the samples at DC at room temperature 4. selection of good samples for low temperature measurements **Measurements at LTL:** 1. Measurements were performed in a dilution refrigerator with high frequency wiring and a cooled preamplifier. 2. The experiments concentrated on high-frequency conductivity and shot noise of graphene sheets 3 The results obtained were analysed using the current theoretical models for graphene. 4. Preliminary measurements on the coupling of mechanical modes and electrical transport were done.
Project achievements (and difficulties encountered)**:**[5] (250 words max)	At low bias voltage, we find that, in accordance with earlier experiments, the Fano factor ($F=S_I/2e\langle I\rangle$) measured at the charge neutrality point is close to F = 1/3, which is theoretically expected for graphene samples. At high bias, we observe that electron-phonon scattering is enhanced and this leads to inelastic electron relaxation that causes suppression of shot noise. According to diffusive theory, as long as the inelastic scattering length is longer than the elastic mean free path, there is a direct connection between the Fano-factor and the temperature: $T=FeV/2k$. We have employed this dependence to obtain $T(V)$ from the measured shot noise. As a consequence, we may estimate the

	conductivity $G(T(V))$ without optical phonon scattering using the measured or theoretical conductance $G(T)$. From the additional suppression of G, we can determine the electron scattering time from optical phonons. In suspended monolayers, we find that the Fano-factor goes via a minimum around 1 V as a function of the bias voltage. Using diffusive theory, the voltage at the minimum can be related directly to the electron - optical phonon scattering, provided that this scattering is the dominant inelastic mechanism. The reason for the increasing shot noise at very large bias is that the ability of electron–phonon scattering to suppress noise starts to diminish as the maximum energy absorbed by one phonon is less than an eV, and, in principle, for very large V, F approaches 1/3 again.
Expected publications and dates:	▪ Abstract sent to Graphene Week 2012 conference ▪ Publication planned later
Submission date of user group questionnaire:	23 February, 2012

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