welcome to the
European Microkelvin Collaboration

CAPACITIES

# Application Form for MICROKELVIN Transnational Access Project

## 1. General Information

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| **Project number:** | **CNRS16** | |
| **Project Title:** | **The electron Glass in Semiconductors** | |
| **Lead scientist:**[1] | **Title:** | Professor |
| | **First name:** | Aviad |
| | **Last name:** | Frydman |
| | **Home institution:** | Bar Ilan University, Israel |
| **Host scientist:**[2] | **Title:** | Dr. |
| | **First name:** | Thierry |
| | **Last name:** | Grenet |
| | **Home institution:** | Neel Institute, CNRS, Grenoble |
| **Project scientist:**[3] | **Title:** | Professor |
| | **First name:** | Aviad |
| | **Last name:** | Frydman |
| | **Scientific Field:** | Condensed matter physics, experiment |
| | **Home institution: :** | Bar Ilan University, Israel |
| | **Is your home institution MICROKELVIN partner?** | Yes |
| | **Business address:** | |
| | Street: | Department of Physics, Bar Ilan University |
| | PO Box: | |
| | City: | Ramat Gan |
| | Zip/Postal Code: | 52900 |
| | Country: | Israel |
| | Telephone: | 972-3-5318102 |
| | Fax: | |
| | E-mail: | aviad.frydman@gmail.com |

**Curriculum vitae (18 lines max):**

**Academic Background:**

1987-1990 B.Sc. (cum laude), Physics and Mathematics, Hebrew University

1990-1992 M.Sc. (cum laude), Physics, Hebrew University of Jerusalem.
Thesis: “The Influence of Film Thickness on the Electric Transpo
Disordered Insulators”. Supervisor: Prof. Zvi Ovadyahu.

1992-1996: Ph.D. (distinction), Physics, Hebrew University of Jerusalem.
Thesis: “Quantum Mechanical Tunneling in the Presence of
Intermediate States.” Supervisor: Prof. Zvi Ovadyahu.

**Experience:**

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| 1992-1996 | Teaching assistant | Hebrew University, Jerusalem |
| 1996-1999 | Post Doctoral Researcher | University of California, San Diego |
| 1999- 2005 | Senior Lecturer | Bar Ilan University |
| 2005-2006 | Visiting professor | Yale university |
| 2006-present | Associate Professor | Bar Ilan University |

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.

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| | **Five most recent publications:** |
| | 1. "Coexistence of Coulomb blockade and zero bias anomaly in a strongly coupled nanoparticle" , L. Bitton, D.B. Gutman, R. Berkovits and A. Frydman, Phys. Rev Lett. **106**, 016803 (2011). |
| | 2. "Disorder induced superconducting ratchet effect in nanowires", S. Poran, E. Shimshoni and A. Frydman**,** Phys. Rev. B 84, 014529 (2011). |
| | 3. "A Superconducting Gap in an Insulator", D. Sherman, G. Kopnov, D. Shahar and A. Frydman, Phys. Rev. Lett. **108**, 177006 (2012). |
| | 4. "The Electron Glass", M. Pollak, M. Ortuno and A. Frydman, Cambridge University press (2012). |
| | 5. "Zero bias anomaly in a two dimensional granular insulator", N. Ossi, L. Bitton, D.B. Gutman, and A. Frydman, accepted to Phys. Rev. B |

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| **Other participating scientists:**4 | **Name:** | **Position:** | **New User:** |
| | 1- | | |

## 2. Project Information

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| **Name of host infrastructure:** | **Institut Néel, Grenoble France** | | | |
| **Access provider / Infrastructure Director:** | **Name: Henri Godfrin** | | **E-mail address:** Henri.Godfrin@grenoble.cnrs.fr | |
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| **Planned project dates:** | **Start date:** | **1/6/2013** | **Completion date:** | **31/8/2013** |

**Project description (12 lines max):**

The electrical conductivity in highly disordered electronic systems, in which transport is governed by hopping and is subject to strong electronic interactions, exhibits glassy phenomena such as slow relaxation to equilibrium, memory effects, and aging (an "electron glass"). So far electron glass properties have been seen only in highly disordered metals or metal-like materials exhibiting hopping transport and having charge carrier densities larger than $n=10^{20}cm^{-3}$. No clear signs for memory effects or slow relaxations after a rapid cool-down have been observed in semiconductors. It has been proposed that an electron glass requires a hopping system characterized by a large number of charge carriers within a localization length. A standard semiconductor has a relatively small charge carrier density. Hence, in order to fulfill the above requirement one would need a relatively high doping degree in order to increase the localization length and very low temperatures, so that transport in the semiconductor is dominated by hopping conductivity. We plan to explore the electron glass phenomena in silicon and diamond samples at ultra-low temperatures (down to a few tens of mK).

**Scientific objectives of the project (12 lines max):**

Despite decades of research, many aspects of the electron glass are not understood. No statistical or thermodynamic theory of non-ergodic systems exists and therefore there is no full understanding of any glasses, less so of the electron glass that may be a special case of a "quantum glass". The fact that the effect has not been observed in semiconductors raises a number of questions:

1. Does the electron glass indeed require many electrons in a localization volume?
2. Can single crystal materials be electron glasses?
3. Does the electron-electron interaction energy determine the glass properties such as glass temperature and characteristic energy of the so called "memory dip"?

We trust that the information gained by exploring the electron glass in doped semiconductors samples will provide useful information for a deeper understanding of the processes responsible for glassines in low dimensional electronic systems.

4 Please list all participating user group members. Expand the table, if necessary.

**Technical description of work to be performed (20 lines max):**

The first stages of the project will be dedicated to identifying the correct samples. We will measure transport properties of different degrees of doping of silicon samples in order to identify samples which will have the correct parameters at our base temperature, i.e. (1) hopping conductivity and (2) more than 10 electrons per localization volume. A series of doped diamond samples, provided by a group in Institut Néel, will also be investigated. Owing to its high critical dopant concentration, this system is a good candidate to offer high numbers of electrons in the localization volume.

Once the correct doping is found we will study the electron glass properties. We will measure the relaxation to equilibrium following three types of excitations: rapid thermal change, gate voltage and high electric field. The temperature dependence of the relaxation will be studied in order to identify whether the glass is "classic" or "quantum" and the measurements will be supplemented by "aging" experiments, i.e. relaxation following different excitation times.

## 3. Joint Proposals / Funding

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| **Is this project in collaboration with other (concurrent) projects at the infrastructure?** | **No** |
| **If yes, please specify:** | |

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| **Is this proposal submitted to any funding programmes?** | **No** |
| **If yes, please specify:** | |

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The completed Application Form should be submitted to MICROKELVIN Management Office (Sari.Laitila@aalto.fi, fax +358-9-47022969)