



# COLLOQUE DE PHYSIQUE

24, QUAI ERNEST-ANSERMET, CH-1211 GENÈVE 4

**Lundi 18 septembre 2017, 12h30**  
Ecole de Physique, Auditoire Stueckelberg

« **Nanoscale thermal imaging of dissipation in quantum systems** »  
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**Abstract:**

Energy dissipation is a fundamental process governing the dynamics of physical systems. In condensed matter physics, in particular, scattering mechanisms, loss of quantum information, or breakdown of topological protection are deeply rooted in the intricate details of how and where the dissipation occurs. Despite its vital importance, direct imaging and microscopy of dissipation in quantum systems is currently impossible because the existing thermal imaging methods lack the necessary sensitivity and are unsuitable for low temperature operation

We developed a scanning nanoSQUID with sub 50 nm diameter that resides at the apex of a sharp pipette [1] that can act simultaneously as nanomagnetometer with single spin sensitivity and as nanothermometer providing cryogenic thermal imaging with four orders of magnitude improved thermal sensitivity of below  $1 \mu\text{K}/\text{Hz}^{1/2}$  [2]. The non-contact non-invasive thermometry allows thermal imaging of minute energy dissipation down to the fundamental Landauer limit of 40 fW for continuous readout of a single qubit at 1 GHz at 4.2 K. In addition, by varying the potential between the SQUID-on-tip and the sample a nanoscale spectroscopic analysis of the dissipation process can be attained. These advances enable observation of changes in dissipation due to single electron charging of individual quantum dots in carbon nanotubes. Our thermal imaging study of hBN encapsulated graphene reveals a fascinating dissipation mechanism due to resonant localized states providing the first visualization of inelastic electron scattering from individual atomic defects, opening the door to direct imaging and spectroscopy of dissipation processes in quantum matter.

**References**

- [1] Vasyukov *et al.*, *Nature Nanotech.* **8**, 639 (2013).
- [2] D. Halbertal, J. Cuppens, M. Ben Shalom, L. Embon, N. Shadmi, Y. Anahory, H. R. Naren, J. Sarkar, A. Uri, Y. Ronen, Y. Myasoedov, L. S. Levitov, E. Joselevich, A. K. Geim, and E. Zeldov, *Nature* **539**, 407 (2016).

Une collation en compagnie du conférencier sera offerte après le colloque.

Prof. Dmitry Abanin