Project 4.26. Thermodynamics of nanostructures at low temperatures

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Background:
Investigations of thermal processes in mesoscopic systems demand fast thermometry that can be easily integrated with a structure. One approach to boost the temporal resolution of a thermometer is to embed a temperature sensor in a microwave or rf resonator. A change in the magnitude and phase of the transmitted or reflected signal provides information about the thermal dynamics of the system. The method circumvents the problem of unavoidable stray-cabling capacitance, offering a typical bandwidth of 10 MHz. The need to use a resonator increases the sensor complexity and inhibits a higher level of integration (microwave on-chip resonators are millimeter-sized structures). In an effort to explore thermal processes at significantly faster rates, we have developed a completely different strategy: we use a hysteretic superconducting weak link probed with fast current pulses for its switching threshold as a temperature-sensing element. Our thermometer is capable of measuring temperature transients with unprecedented temporal resolution falling into single nanosecond range. The ease of integration, true nanometer size, and simplicity make our thermometer a good choice for investigating thermodynamics of nanocircuits

1. *Nanosecond Thermometry with Josephson Junctions*, **M. Zgirski**, M. Foltyn, A. Savin, K. Norowski, M. Meschke, and J. Pekola, **Phys. Rev. Applied** 10, 044068 (2018)
2. *Flipping-Coin Experiment to Study Switching in Josephson Junctions and Superconducting Wires*, **M. Zgirski**, M. Foltyn, A. Savin, and K. Norowski, **Phys. Rev. Applied** 11, 054070 (2019)
3. *Gambling with Superconducting Fluctuations* , M. Foltyn, M. Zgirski, **Phys. Rev. Applied** 4, 024002 (2015)

Aim:
The project will take an extensive use of a superconducting Josephson junction (JJ) as a temperature-sensing element delivering nanosecond resolution. Successful implementation of a JJ-based thermometer should lead to establishing a new approach to calorimetry and bolometry at the nanoscale. It will make it possible to dynamically test thermodynamical properties of nanostructures, involving measurements of heat capacity and thermal conductivity as well as mechanisms of heat exchange at low temperatures (hot electron diffusion, electron-phonon coupling, photon radiation). Fast thermometry will provide direct access to the temporal evolution of effective temperatures under nonequilibrium conditions and the energy relaxation rates, thus contributing to a complete understanding of the thermodynamics of mesoscopic systems.

Candidate requirements:
- RESPONSIBILITY for the specific tasks in the project,
- strong interest in the proposed research (beyond usual working hours),
- background in Experimental Solid State Physics, Nanoscience, Nanotechnology or Electronics,
- good technical skills,
- good communication skills, candidate should work in harmony with the rest of researchers,
- low-noise transport measurements experience will be of an advantage,
- capable of using programming languages i.e. LabView, Mathematica, Matlab