TT 89: Cryotechnique: Refrigeration

Time: Thursday 16:45–17:45 Location: HSZ/0103

TT 89.1 Thu 16:45 HSZ/0103

Twin low frequency stirling type Pulse Tube Cryocoolers driven by a single metal bellows compressor — •Xaver O. Herrmann[1,2], Jack-André Schmidt[1,2], Bernd Schmidt[2], Jens Höhne[3], and André Schirmeisen[1,2] — [1]Instiute of Applied Physics, Justus-Liebig University, Giessen, Germany — [2]TransMIT-Center for Adaptive Cryotechnology and Sensors, Giessen, Germany — [3]Pressure Wave Systems GmbH, Taufkirchen, Germany

GM-Type Pulse Tube Cryocoolers (PTC) offer cooling power at temperatures down to 2.2 K with ^{4}He as a working fluid[1]. With increasing reliability of PTCs, they have become a dependable and cost-effective option for cooling sensitive sensors[2] to temperatures even below typical LHe bath cryostats. In contrast to conventional GM cryocoolers, PTC require only one moving part: the rotary valve. For critical applications with "high demand" for reliable and continuous cooling, GM-type PTC offer service intervals in excess of 3 years. In order to increase the service interval further as well as to reduce losses within the rotary valve, omitting this valve is the most effective option. In this contribution we present our current status of development of a pair of small low frequency Stirling-type PTC, derived from the two stage GM-type PTC SUSY, both driven by one metal bellows compressor.

[1] N. Jiang et al., Cryogenics 44 (2004) 809.
[2] R. Güsten et al., Nature 568 (2019) 357.

TT 89.2 Thu 17:00 HSZ/0103

Adiabatic demagnetization refrigeration to below 100 mK with frustrated Gd^{3+} compounds — •Tim Treu, Marvin Klinger, Felix Kreisberger, Anton Jesche, and Philipp Gegenwart — Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg

Adiabatic demagnetization refrigeration (ADR) is becoming increasingly important for achieving temperatures below 1 K as the global supply of helium-3 continues to tighten. Although ADR in this temperature range has long relied on paramagnetic hydrated salts, recent work shows that frustrated rare-earth oxides provide greater entropy densities and practical benefits, particularly their stability against heating and vacuum exposure [1]. In this study, we present the structural, magnetic, and thermodynamic characteristics of frustrated Gd^{3+} compounds. We evaluate their excellent ADR performance to below 100 mK and compare the results with existing literature. Also, we demonstrate on these compounds how the ADR measurement itself can be used to gain information about the heat capacity, phase transitions, phase boundaries and magnetic interactions below ^{3}He temperatures.

The work was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research 298 Foundation), Grants No. 514162746 (GE 1640/11-1) and No. TRR 360-492547816.

[1] T. Treu et al., J. Phys. Condens. Matter 37, 013001 (2025).

TT 89.3 Thu 17:15 HSZ/0103

Cooling of electrons via superconducting tunnel junctions and their arrays exhibiting nodal lines — •Linus Aliani and Viktoriia Kornich — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

Condensed matter physics demands experimental control over a systems' temperature. This is usually achieved by the use of commercial dilution refrigerators. However cooling to temperatures below mK is still an issue and usually phonons are cooled down instead of electrons. We therefore propose a setup, which cools *electrons via electrons*.

We consider theoretically a small current running from an electron bath through a setup based on superconducting tunneling junction(s). We employ tunneling junctions with a π phase difference in order to host nodal lines. These nodal lines and their surrounding spectrum depend on external parameters. Thus the setups' entropy is adjustable via its' dependence on their nodal lines. The high entropy of the setup forces electrons entering it to increase their entropy, thereby removing heat from the electron bath. We demonstrate the working principle of this approach by first studying the entropy of a simple superconductor-insulator-superconductor (SIS) junction and compare it to the free electron gas at chemical potential. Subsequently we modify the setup in various ways in order to introduce opportunities for fine tuning for possible experimental uses. For this we investigate superconducting tunnel junctions with a ferroelectric insulator and an array of such junctions with ferroelectrics in-between.

TT 89.4 Thu 17:30 HSZ/0103

Optomechanical Cooling without Residual Heating — Suranganga Sengupta[1], Björn Kubala[1,2], Joachim Ankerhold[1], and •Ciprian Padurariu[1] — [1]Institute for Complex Quantum Systems and IQST, Ulm University — [2]German Aerospace Center (DLR), Institute of Quantum Technologies, Ulm

Resolved-sideband cooling is a standard technique in cavity optomechanics enabling quantum control of mechanical motion, but its performance is ultimately limited by quantum backaction heating. This fundamental effect imposes a limit on the minimum achievable mechanical phonon number, establishing a finite-temperature floor regardless of the applied cooling strength. We generalize the semi-classical model for optomechanical cooling to describe universal cavity Hamiltonians incorporating both passive and active nonlinearities. As a concrete demonstration, we analyze the simplest circuit optomechanical system that implements a nonlinear drive via a Josephson junction. Our analysis reveals that this active nonlinear drive can eliminate the residual heating backaction, thereby comparing favorably with alternative optomechanical cooling schemes based on passive nonlinearities [1]. By successfully overcoming the finite-temperature floor that limits conventional schemes, our method paves the way for unprecedented quantum control over mechanical systems and establishes the experimental viability of zero-heating optomechanical cooling.

[1] D. Zoepfl et al., Phys. Rev. Lett. 130, 033601 (2023).