INSTITUT NEEL Grenoble

Development of a Continuous Nuclear Demagnetization Refrigerator

Context:

Cryogen-free ("dry") dilution refrigerators have become popular in recent years because of their large experimental space, their automated operation and the cost of helium. The advantages of dry dilution fridges have allowed a large community to reach temperatures as low as ~10 mK. However, several fields of research require still lower temperatures. For example, ultra-coherent nanomechanical drums, which could be used as compact quantum memories, are expected to reach one second coherence times upon cooling below 1 mK.

Sub-mK temperatures in condensed matter systems are achieved using adiabatic nuclear demagnetization refrigerators (NDR), which usually include liquid helium baths and have a relatively small experimental space. At present, these system do not operate continuously and must eventually be re-magnetized at 10 mK.

We are developing a continuous nuclear demagnetization refrigerator (CNDR), which would allow ultra-low temperature researchers to take full advantage of cryogen-free technology. We have demonstrated the necessary components to construct a CNDR in recent publications, including a heat switch with ultra-high thermal conductance[1] and aluminum refrigerant with low eddy current heating[2] (see figure). These innovations will lead to a (relatively) enormous cooling power of 40 nW at 0.6 mK.

1. J. Butterworth *et al. Review of Scientific Instruments* (2022) https://doi.org/10.1063/5.0079639
2. M. Raba *et al. Phys. Rev. Applied* (2024) https://doi.org/10.1103/PhysRevApplied.22.024027

The candidate will contribute to work toward demonstrating the CNDR as well as industrializing the fabrication process. We are laying the groundwork to commercialize the CNDR, possibly by creation of a start-up.

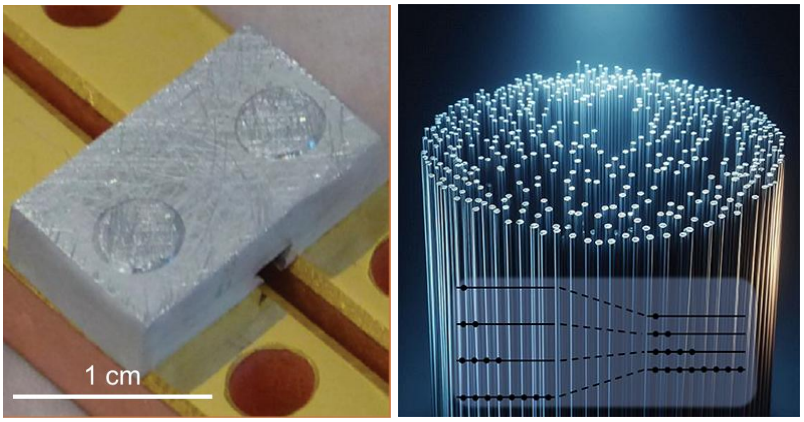

Figure: (left) A superconducting heat switch with ultra-high thermal conductance in its normal state and a switching ratio greater than 10^6. (right) Artist's impression of the aluminum refrigerant.

Candidate profile:

Expertise in one or more of the following areas is desirable: cryogenic wiring, cryogen-free refrigerators, dilution refrigerators, vibration isolation, measurement and data processing with Python, commercial strategy, industrial processes (e.g. aluminum welding), low temperature physics.

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Foreseen start for the position: June/July 2025
Gross Salary: commensurate with the experience level of the candidate
Duration : at least 1 year

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