Alliance 6: New Frontiers in Cryogenics

Research axes and facilities

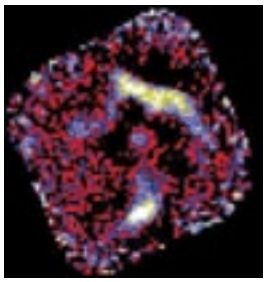
Cryogenics plays a crucial role in many fields. New opportunities are indeed opened up by low temperatures, either through specific phenomena such as superconductivity, or through the ultimate sensitivity of detectors due to the suppression of thermal noise. LANEF builds on Grenoble's international expertise in cryogenics, which itself is deeply rooted in its strong position in both fundamental and applied low temperature physics. The partners of LANEF are studying or using the behavior of cold matter, from record sub-millikelvin temperatures achieved at the Microkelvin facility up to several tens of kelvins (hydrogen, nitrogen). They are involved in many fundamental developments using helium as a model system of classical or quantum fluids. LANEF partners address many cryogenic challenges, ranging from the quest for ultra-low temperatures as a benchmark for quantum mechanics, to the production of very low temperatures for spatial or remote applications, or for large facilities (ILL, CERN, future particle accelerators). LANEF partners also develop new, cutting-edge, cold detectors for different fundamental and applied purposes. The LANEF framework strengthens the cooperative actions between its partners, and allows them to draw the best benefit from their complementary strengths.

Actions within LANEF

New refrigeration methods for new constraints. Such constraints are the present ^{3}He supply crisis, the possible future exhaustion of ^{4}He and the need to develop larger cooling systems for spatial applications. We develop new dilution systems using less ^{3}He, cryogen-free dilution refrigerators, and continuous adiabatic demagnetization refrigerators.

Easycool refrigerator funded by LANEF in 2012.

For higher temperatures (4 K to 140 K), pulse tube coolers have a huge potential of application, and very high frequency coolers are developed for small size applications. Application of pulsating heat pipes (PHPs) to cryogenic purposes are studied, exploiting our expertise in cryogenic visualization. Nanometric-sized refrigerators based on superconducting junctions are developed as a possible solution for cooling nanosystems down to the 100 mK range.

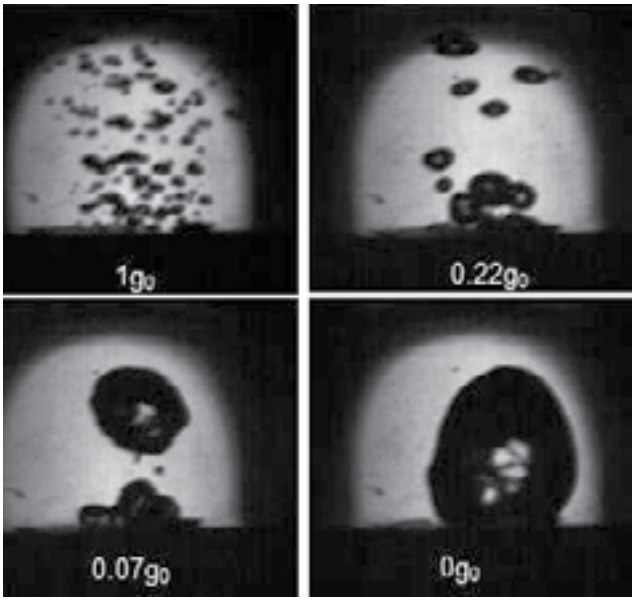


Left: Millimeter wave image of the Horsehead nebulae recorded in 2012 using the NIKA (New IRAM KIDs Arrays) 100 mK camera at the 30 m IRAM telescope at Pico Veleta, in Spain.

Right: cryogenic test of the NIKA2 camera

Large detector arrays. Unique sensors, based on superconducting technologies and developed with the support of space agencies, offer new opportunities to build ultra-sensitive cameras for challenging applications (small dose medical imaging using superconducting single photon detectors, mm-wave astrophysics using Kinetic Inductance devices – KIDs).

New probes and experiments for advanced turbulence studies. Helium offers an unique platform to study fully developed classical turbulence at the laboratory scale, and to compare it to (quantized) superfluid turbulence. The different scales of normal of superfluid helium flows are analyzed with new micrometric sensors exploiting the excellence of LANEF in nanotechnologies, or by advanced visualization means. Visualization means are also used for other applications, such as exploring the behaviour of cryogenic liquids (ebullition crisis, flow in porous media, ..) in the absence of gravity, an issue for space applications.



Effect of gravity on the ebullition of liquid oxygen. Effective gravity is varied through magnetic levitation. Similar experiments with liquid hydrogen were performed at LNCMI in the framework of a CNES/INAC collaboration.

Key figures: **35 Permanent scientists from INAC and NEEL**
20 PhD students & postdocs
R&D and industry: CNES, ESA, Air Liquide, Absolut Systems, Cryoconcept

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