Group of Cryogenics & Superconductivity

Department of Magnetic Resonance & Cryogenics

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area

– Cryogenics
– Low temperature physics
– Fluid dynamics, turbulence
– Applied superconductivity

Excellence

– Characterization of thermal-radiative properties of materials at low temperatures
– Experimental study of near-field effect at low temperatures
– Basic research in fluid dynamics – Rayleigh-Bénard convection
– Design and optimization of cryogenic systems

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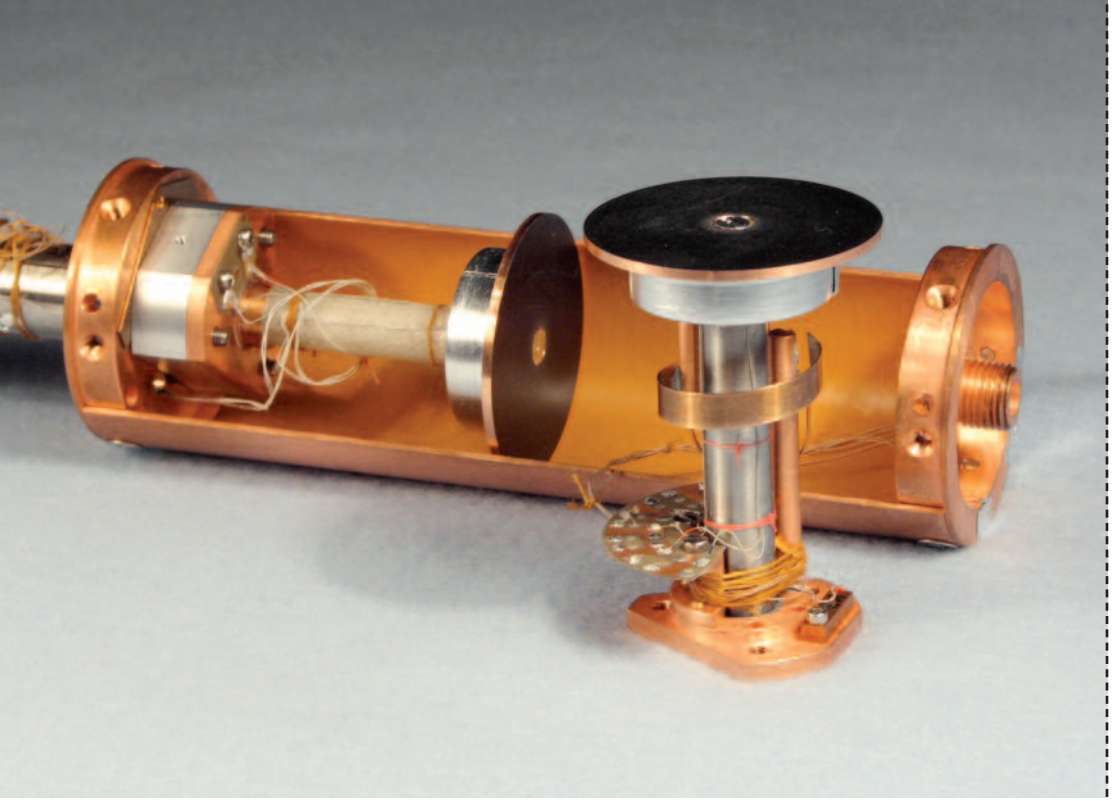
Cryostat for study of natural convection in cold helium gas



Apparatus for measurement of thermal radiative properties

Mission

– Elucidation of natural turbulent convection in cryogenic experiments considering the fact that a general theory of turbulence is still absent
– Broadening of our unique database of thermal-radiative properties of materials used in cryogenics
– Validation of theoretical model of the near-field effect at low temperatures for different materials

DEVELOPED TECHNOLOGIES

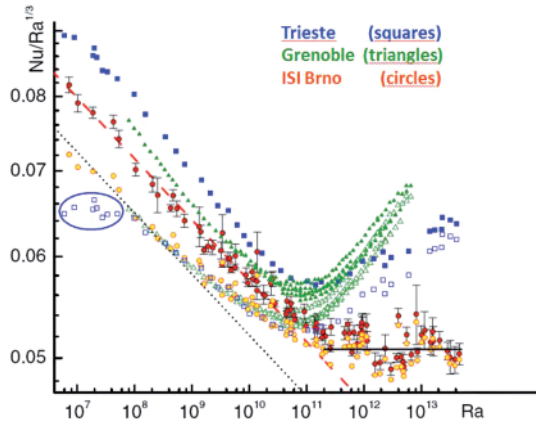
Content of research

– Experimental study of the dependence of the Nusselt number (Nu) on the Rayleigh number (Ra) up to Ra ≈ 10^{15}
– Experimental study of large scale circulation and coherent structures in cryogenic helium gas
– Study of near-field effect at low temperatures over 6 orders of magnitude of heat transfer
– Characterization of materials and multilayer insulation (MLI) from the viewpoint of reduction of parasitic heat transfer at low temperatures
– Experimental study of ultra-clean pumping using helium cryopump and elimination of cryogenic liquids losses
– Design of sample cooling for low temperature scanning probe microscope (SPM)
– Vacuum instrumentation for cryogenic systems
– Low temperature thermometry

Main capabilities

Basic research

– Study of Rayleigh-Bénard convection using cold helium gas
– Methods of loss reduction in cryogenic systems
– Study of material surfaces used in cryogenics
– Study of near-field effect at low temperatures



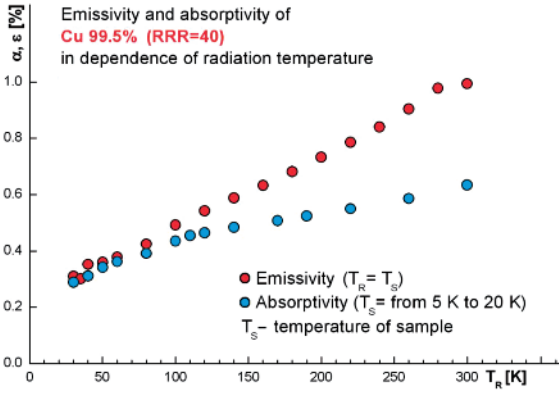
Different results for Ra over 10^{11}

Applied research

– Measurement of thermal-radiative properties of materials
– Advanced microscopy and spectroscopy platform for research and development in nano- and microtechnologies: UHV SEM/SPM modular system for in situ fabrication and characterization of nanostructures and surface analysis at variable substrate temperatures (5–700 K)
– Design of cryogenic systems by the KRYOM 3.1 program developed in the Group of Cryogenics & Superconductivity
– Design of superconducting magnet systems with a defined shape of magnetic field

Fields of research results application

Materials science (study of materials used in cryogenics)
Special measuring instruments
Space research
Nuclear magnetic resonance and imaging



Emissivity and absorptivity of Copper

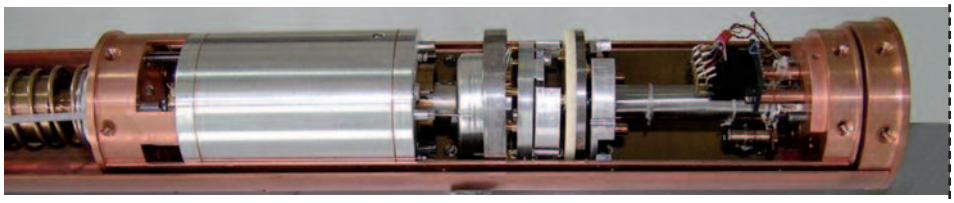
KEY RESEARCH EQUIPMENT

– Helium liquefier L1410 (Linde Process Plants), 18 l of liquid helium per hour, complete helium recovery system for helium gas savings.
– Helium Dewars with neck diameter up to 50 mm and volumes from 30 l to 100 l of liquid helium
– Precise NMR magnetometer PT 2025 (Metrolab Instruments), measurement range from 0.7 to 13.7 Tesla
– Low temperature controllers (3 pcs) Model 340 (LakeShore) for precise measurement of (low) temperature with different types of sensors
– Helium leak detector ASM 310 (Adixen Vacuum Products)
– Mass spectrometer PrismaPlus (Pfeiffer Vacuum) up to mass number A=100
– Container (500 l) for liquid nitrogen storage (Chart Ferox)

ACHIEVEMENTS

Development of unique experimental system for observation of near-field effect at low temperatures and pilot experimental measurements

– Králík, T.; Musilová, V.; Hanzelka, P.; Zobač, M.; Fořt, T. and Horák, M.; *Strong Near-Field Enhancement of Radiative Heat Transfer between Metallic Surfaces.* Phys. Rev. Lett. 109, (2012) 224302



Apparatus for the measurement of the radiative heat transfer by the near field

Elucidation of natural turbulent convection using our original experimental apparatus

– Urban, P.; Hanzelka, P.; Králík, T.; Musilová, V.; Srnka, A. and Skrbek, L.; *Effect of boundary layers asymmetry on heat transfer efficiency in turbulent Rayleigh-Bénard convection at very high Rayleigh Numbers.* Phys. Rev. Lett. 109, (2012), 154301
– Urban, P.; Musilová, V.; Skrbek, L.; *Efficiency of heat transfer in turbulent Rayleigh-Bénard convection.* Phys. Rev. Lett. 107, (2011), 014302

Characterization of thermal-radiative properties of materials at low temperatures using original measurement system of in-house design

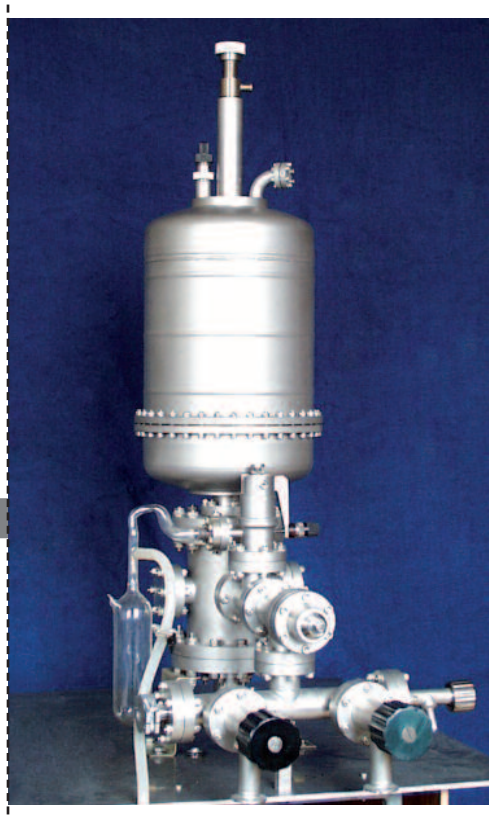
– Musilová, V.; Hanzelka, P.; Králík, T.; Srnka, A.; *Low temperature radiative properties of materials used in cryogenics.* Cryogenics 45, (2005), 529–536

Design and manufacturing of wiggle-free helium bath cryopump suitable for electron optical devices

– Musilová, V.; Dupák, J.; Hanzelka, P.; Králík, T.; Urban, P.; *Economical helium bath cryopump: design and testing.* Vacuum 74, (2004), 77–83

Design of unique custom-made cryogenic systems

– Urban, P.; Hanzelka, P.; Králík, T.; Musilová, V.; Skrbek, L.; Srnka, A.; *Helium cryostat for experimental study of natural turbulent convection.* Review of Scientific Instruments. 81, n. 8, (2010), 085103



Ultra high vacuum helium bath cryopump

MAIN COLLABORATING PARTNERS

Collaboration with academic partners

– Charles University (Praha, CZ)
– Brno University of Technology (Brno, CZ)
– CERN (Geneva, Switzerland)
– Polytechnic Institute of New York University (New York, USA)
– University of Vienna (Vienna, Austria)
– International Centre for Theoretical Physics (Trieste, Italy)

Collaboration with companies

– RUAG Space (Vienna, Austria)
– Acktar (Kyriat-Gat, Israel)
– Delong Instruments (Brno, CZ)
– SHM Plasma (Brno, CZ)
– První brněnská strojírna Velká Bíteš, a.s. (Velká Bíteš, CZ)

EXPECTATIONS

Offers

– Properties of materials at low temperatures
– Thermal shielding of cryogenic systems
– Calculation of cooling capacities of different liquid gases
– Design of special cryogenic systems for physics experiments
– Low temperature measurement and its accuracy
– Vacuum in cryogenic systems
– Calculation of parasitic heat flows at cryogenic temperatures
– Measurement of parasitic heat flows at cryogenic temperatures
– Expertise in cryogenic safety, training in cryogenic safety

Requirements

– Partners for EU research projects in the field of cryogenic helium turbulence
– Co-operative research and development of new materials for the thermal insulation of cryogenic systems
– Collaboration with industrial partners on common projects dedicated to applied science in the field of cryogenics (e.g. special cryogenic devices)

Measurement of thermal dependence of the emissivity and absorptivity of materials at low temperatures.