

# Cryocoolers, dilution refrigerators, and superconducting motors

Four lectures by A.T.A.M. de Waele



Prof. Dr. Alphons (Fons) de Waele is a renowned expert in the field of cryogenics. After a PhD on Josephson effect and thermoelectric effects in superconductors, he joined the Eindhoven University of Technology, where he worked successively on dilution refrigerators, cryocoolers, in particular pulse-tube coolers down to 1.2 K, and thermoacoustics refrigeration.

As a co-organizer and teacher of the European Cryoschool for PhD students, he is well known for his lectures on thermodynamics of open systems and cryogenic technologies.

Since his retirement, he is an active advisor in the field of cryogenic technology in particular related to superconducting motors.



LANEF's cryogenic alliance is pleased to announce a series of four lectures by Professor De Waele (see back of page for program).

## Thermodynamics

(Wednesday, November 22nd, 14h-16h)

## Cryocoolers

(Thursday, November 23rd, 10h-12h)

## Dilution Refrigerators

(Friday, November 24th, 14h-16h)

## Superconducting Motors

(Monday, November 27th, 14h-16h)

These lectures are open to everybody interested. They are recognized by two doctoral training programs (EDPhys and IMEP2). Lectures will be held at Institut Néel, CNRS, Grenoble. Access to CNRS requires an authorization (see back of page).

## DETAILED PROGRAM

### Thermodynamics

- Mathematical formulation of the first and second laws of thermodynamics for inhomogeneous open systems
- Introduction of concepts like enthalpy flow, entropy flow, entropy production, and dissipation
- Application to motors and coolers and the equivalence with other formulations
- The third law is formulated mathematically. The equivalence with the unobtainability of absolute zero will be critically discussed

### Cryocoolers

- The operation principles of AC coolers like Stirling coolers, pulse-tube coolers, GM coolers are discussed from the perspective of thermodynamics and gas dynamics
- The Joule-Thomson liquefiers and coolers treated mainly using hT-diagrams. The concept of pinch points will be introduced
- The working principle of the Collins liquefier and the reverse Brayton cooler
- Based on scatter diagrams some general properties and challenges of cryocoolers will be addressed

### Dilution refrigerators

- Introduction of the relevant  $^3\text{He}$ - $^4\text{He}$  properties
- The operation of wet and dry Dilution Refrigerators (DR)
- The limiting temperature of DR's
- The Planck dilution refrigerator (if time allows)

### Superconducting motors

- Types of superconducting motors
- Properties of high-Tc superconducting tapes

## Location of lectures

### Institut Néel-CNRS-25 Avenue des Martyrs-Grenoble

Wednesday, November 22nd, 14h-16h, D420

Thursday, November 23rd, 10h-12h, E424

Friday, November 24th, 14h-16h, D420

Monday, November 27th, 14h-16h, E424

**Due to Vigipirate regulations, people with no CNRS badge wishing to attend the lectures have to send an e-mail at least 48 h in advance to :**

**[cryo@grenoble-lanef.fr](mailto:cryo@grenoble-lanef.fr)**

This e-mail should include your name, address, institution, and electronic address.

