# Kyushu University
# Low Temperature Center


*Kyushu University*

*Low Temperature Center*


Ito Branch

Hospital Branch

# Helium Liquefier System

In 1908, Heike Kamerlingh Onnes from Leiden University succeeded in the liquefaction of helium for the first time. He was later awarded the Nobel prize in 1913. His discovery on liquid helium has led to various applications such as superconductors.

***The latest high performance helium liquefier system was installed and launched in the Low Temperature Center. This system provides a strong support for educational and research activities requiring cryogens.***

## Specifications

**＜Liquefaction & Refrigeration＞**

・Helium liquefier/refrigerator
*LindeKryotechnik AG* LR280
Liquefier capacity 235 L/h
Refrigerator capacity: 1440 W @20 K 1550 W @50 K
・Compressor for helium liquefier
*Kaeser Kompressoren* ESD441 1503 $Nm^3/h$

**＜Recovery & Purification＞**

・Compressor for recovery and purification
*GreenField Engineering Co.* C5U217GPEX
*Bouer Co.*IK25.0-NI
Recovery capacity: $100Nm^3/h×2$
・High pressure external purifier
*Koike Sanso Kogyo Co., Ltd*
Purify capacity: 100 $Nm^3/h×5$ h×2
・Gasbag
*Koike Sanso Kogyo Co., Ltd*
Volume: 50 $m^3×1$, 60 $m^3×1$

**＜Storage＞**

・Liquid helium storage
*Jecc Torisha Co., Ltd* CH-2000
Capacity: 2000L × 2
・Clustered cylinders for pure gas
*Koike Sanso Kogyo Co., Ltd* Maximum capacity: 2,255 $m^3$
・Clustered cylinders for impurities gas
*Koike Sanso Kogyo Co., Ltd* Maximum capacity: 4,511 $m^3$

**＜Analysis & Hydrogen remove system＞**

・Gas analysis system *LindeKryotechnik*
・Hydrogen remove system Peak Laboratories Co., Ltd.


Outdoor clustered cylinders for pure and impurity gases


Helium liquefier/refrigerator

External purifier


Compressor for helium liquefier/refrigerator

Compressor for recovery and purification

Helium gas analysis system

Hydrogen remove system

If a gas is expanded freely into an open space through a valve or a throttling device, the temperature of the gas can be slightly decreased. This phenomenon is known as the Joule-Thomson (JT) effect, which is used in the final stage of the helium liquefier. Due to the weak intermolecular interaction of helium gas, this effect can be exploited at temperatures below 40 K. Therefore, helium gas is first cooled down to 20 K or less by another method (expansion engine) before applying the JT effect.

The operation process of helium liquefier is as the following. First, a high pressure (HP) gas is prepared by the compressor. Then, the HP gas is cooled down through the heat exchanger, and some of the gas flows through the expansion engine, in which an efficient turbine-type engine is recently employed. When the gas rotates the turbine in the expansion engine, work is done. As a result, the temperature and pressure of the gas decrease. This process is known as the adiabatic expansion in the Carnot's cycle for an ideal gas system (equi-entrophy process), which is different from a JT expansion for a real gas system (equi-enthalphy process). Since the turbine should rotate smoothly even at low temperatures, an advanced technique is required. The resultant cold gas with a temperature of about 10 K is used to refrigerate the main HP gas at below 40 K. Finally, the cold HP gas is expanded to atmospheric pressure through the JT valve and is liquefied.


## Liquid $N_2$ Cold Evaporator

## CE10000-M

**Japan Chemical Engineering & Machinery Co., Ltd.**

**Storage capacity: 10000 L**

**<Liquid nitrogen>**

The boiling point of liquid nitrogen ($LN_2$) is about 77 K. $LN_2$ has various uses because of its low cost. $LN_2$ is relatively safe and is easy to handle, however, a constant supply of oxygen is essential during use.

**<Support>**

$LN_2$ is supplied by the LowTemperature Center.

Users should attend the seminar on safe handling techniques of cryogens prior to using $LN_2$.

# Utilization of liquid helium in Ito campus

Liquid helium is used in various fields such as the development and characterization of new functional materials or superconductors for applications and fundamental research in condensed matter physics.

## Nuclear Magnetic Resonance (NMR) Spectrometers; JNM-ECX500(Left panel) and JNM-ECZ400(Right panel)

The Center of Advanced Instrumental Analysis was established in 1982 to facilitate advanced instrumental analyses and high grade specimen preparation for research and education. At present, the center manages 18 and 30 instruments, respectively, at the Chikushi and Ito campuses. Use of the instruments is available to all members of Kyushu University.

The center located in Ito Campus manages two NMR spectrometers. One is the JNM-ECX500 and another is the JNM-ECZ400. Both of them have been renewed recently. These instruments are useful for structure analysis, sample identification and so on. These instruments need liquid helium to cool the superconducting magnet coil. Therefore, we have been using the helium recovery system since 2010.



*Center of Advanced Instrumental Analysis*

## Magnetic Property Measurement (System Quantum Design, Inc. mpms-5S and mpms-XL)

It's possible to measure the magnetic properties with several mg of samples by easy operation. Magnetic properties can be measured with 0–5 kOe of external magnetic field. These machines equip two temperature control modes of step-by-step mode and sweep mode with temperature range of 1.9-400 K. A photo-magnetic properties using various wave length of light can be measured by introducing an optic fiber into a sample room of equipment. Recently, We have found and reported some interesting molecular magnetic materials such as photo-responsive nano magnets[1] and molecular nanocages with giant spin[2] etc. Furthermore, these equipment can be used as temperature control unit easy to handle. We are studying about the multi-electronic properties, for example, electronic conductivities, photo-responsive conductivities and dielectric properties by coupling appropriate equipment with mpms.

[1] T. Liu, O. Sato et al., *Nat Commun* **2013**, *4*, 2826. [2] S. Kang, O. Sato et al., *Nat Commun* **2015**, *6*, 5955.

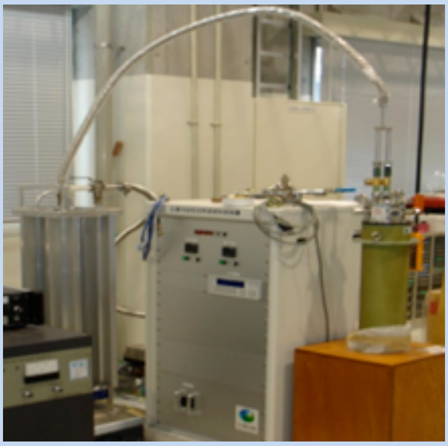
*Institute for materials chemistry and engineering*

## Continuous Flow Helium Cryostat

The system continuously provides a wide temperature range from 3 K to 300 K with a high stability. The cryostat is set in the electromagnet, which generate a strong magnetic field around 1.2 Tesla. Since this cryostat is very flexible, one can measure any physical properties, such as electrical and magnetic properties. At the moment, we have the sample holders for static and dynamical transport measurements.

*Faculty of Science*

## Compact-type variable and modulate temperature apparatus

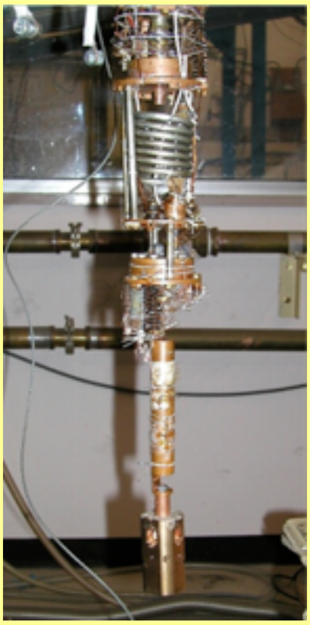


This apparatus provides a stable test field containing helium gas, which is hold at a fixed temperature ranging from 20 K to 70 K.

Various performance tests of superconducting wire and coil are done in such environment.

*Research Institute of Superconductor Science and Systems.*

## Dilution refrigerator equipped with a superconducting magnet



The refrigerator can go down to a temperature of 50 mK and go up to a magnetic field of 8 T.

The rear black panel is a $^3He$-$^4He$ gas handling system.

*Faculty of Engineering.*

## Measurement system for normal propagation phenomena in a high Tc superconducting wire

Liquid helium can be transferred easily from a 250-L vessel to the system using a transfer tube.

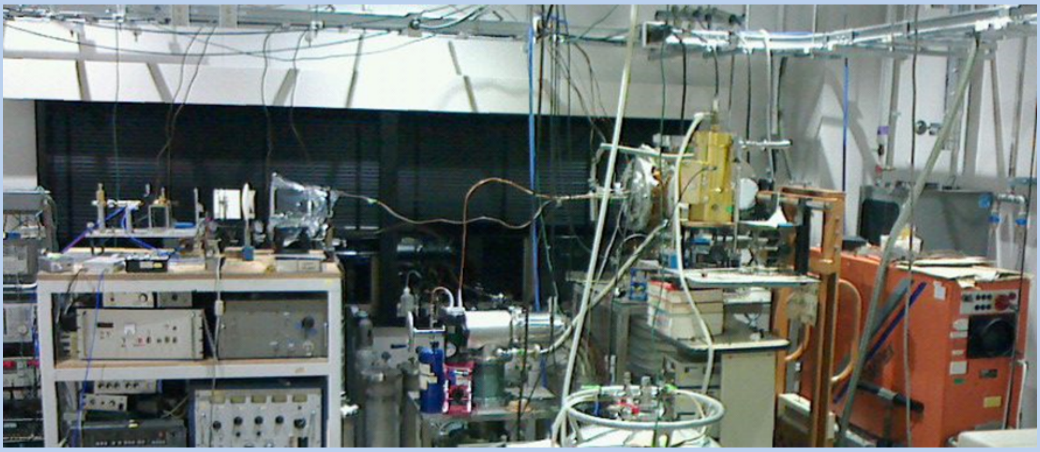
The relation between normal propagation and cooling effect is investigated in this system.

*Research Institute of Super-conductor Science and Systems.*

## Millimeter Wave Spectrometer with Multi-reflection Optical Path

In millimeter wave region, a sensitive detection technique of the absorption spectrum with multi-reflection optical path is not easily applicable because of big diameter of the millimeter wave beam. We have developed confocal multi-reflection optical path for the millimeter wave experiment. Using ten round trip optical path, transient molecules and molecular complexes have been detected sensitively. The extremely fast *ortho-para* conversion of the vinyl radical has been detected with this apparatus [1]. The van der Waals band of the He-HCN complex, which is quite weakly bound with a binding energy of 9 $cm^{-1}$, has been also detected almost near to the dissociation limit [2].

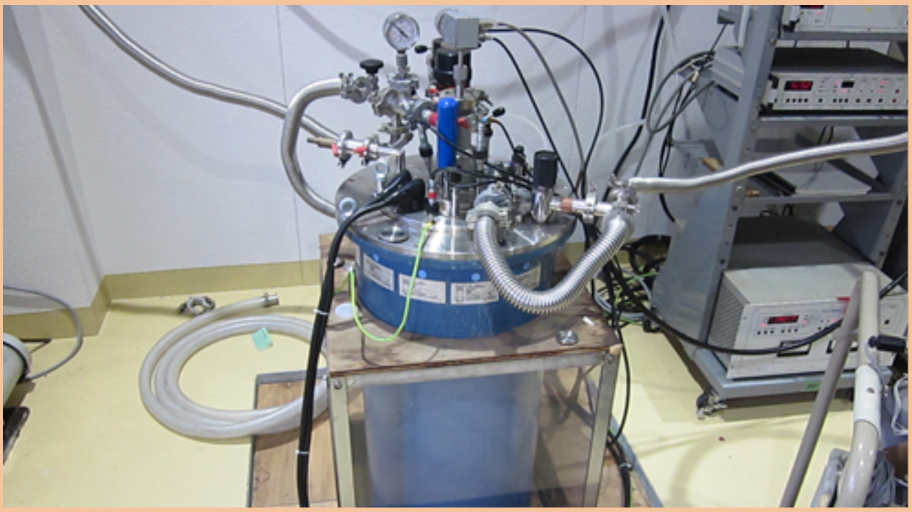
[1] Mol. Phys. 108, 2289 (2010) **Invited Article**.　[2] J. Chem. Phys., **117**, 7041-7050 (2002).



*Faculty of Science*

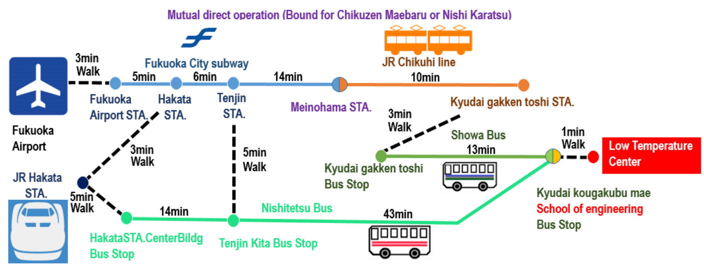
## Physical property measurement apparatus under multiple extreme conditions.

We can measure such physical properties as electrical resistivity,　thermal expansion, magnetoresistance, hall resistivity and magnetization under multiple extreme conditions (high pressure up to ~2.5GPa,high magnetic field up to 14T and low temperature down to 1.5K).The sample, which is put into a pressure cell, are inserted into a superconducting magnet.　Mainly, we investigate itinerant magnetic materials and rare-earth-based valence fluctuating compounds.



*Faculty of Science*

# Ito Branch

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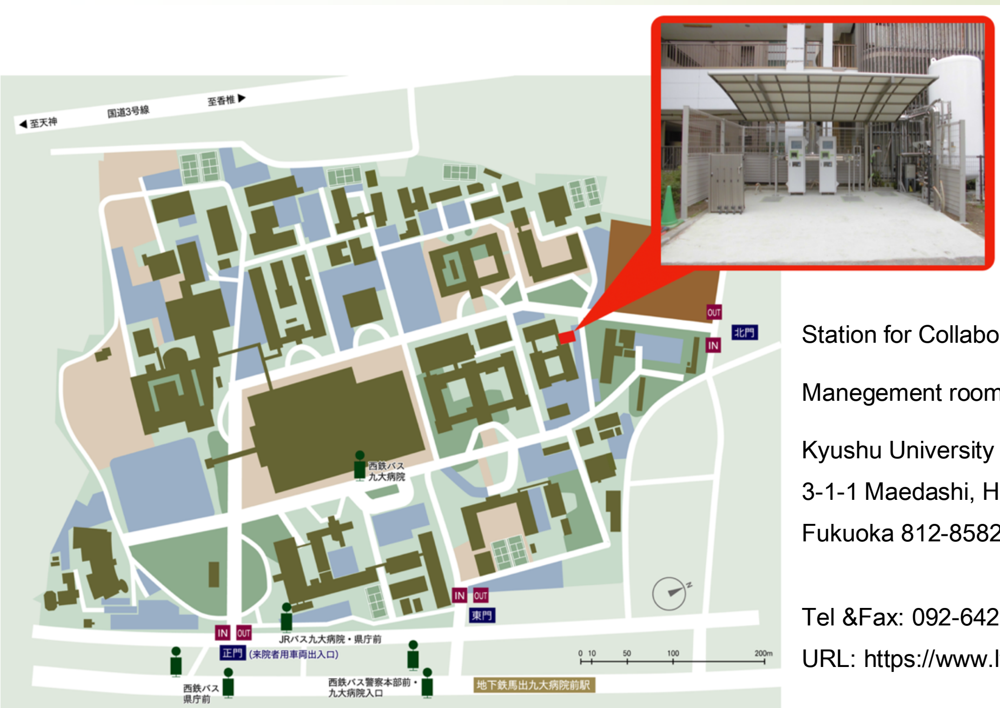

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