Facilities for High Quality Research

The internationally lauded accomplishments of Kyoto University's researchers owe a great deal to its unique approach to promoting education and research — an approach which encourages the creativity essential for groundbreaking innovation and discoveries. Another key element is the university's state-of-the-art laboratories and research facilities, which provide students and researchers with the hands-on practical experience vital to their development as world-class scientists and scholars.

Aerial view of the MU radar

Middle and Upper Atmosphere Radar in Atmosphere and Ionosphere Research

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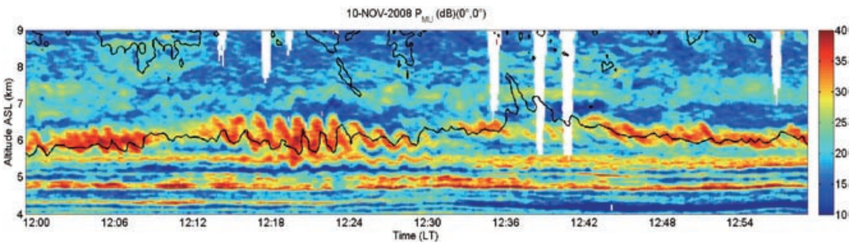
WEB www.rish.kyoto-u.ac.jp/mu/en/

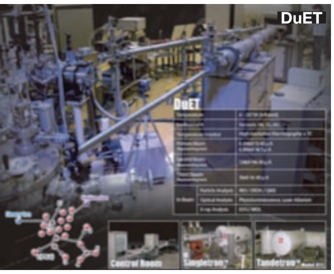
The Middle and Upper Atmosphere Radar (MU Radar) is a giant atmospheric radar that was installed at Shigaraki in Shiga Prefecture, Japan (34.85°N, 136.10°N), to study the middle (10-100 km altitude) and upper atmosphere (100-500 km), including the ionized atmosphere (ionosphere, 60-500 km) and the troposphere (0-10 km) at fine temporal and spatial resolutions. It is one of the most powerful and multifunctional VHF-band atmospheric radars in the world, and is operated by the Research Institute for Sustainable Humanosphere (RISH) of Kyoto University.

Since its establishment in 1984, the radar has been operated as part of an interuniversity collaborative program developed to study variability in the Earth's atmosphere, ranging from meteorology, middle atmosphere dynamics to ionosphere physics. The operational frequency of the MU radar is 46.5 MHz, and its peak output power is 1 MW. It is composed of 475 crossed three-element Yagi antennas and an equivalent number of solid-state transmitter–receiver (TR) modules. Each Yagi antenna is driven by a TR module with peak output power of 2.4 kW. This system operates as an active phased array radar to enable very fast and almost continuous beam steering. The MU radar is capable of continuously monitoring three-dimensional winds, waves, turbulence, and atmospheric instability over the wide altitude range found in the Earth's atmosphere. Moreover, its temporal resolution of approximately 1 min and altitude resolution of approximately 100 m are unequalled by conventional instruments such as radiosondes, making it possible to quantitatively investigate the small-scale atmospheric gravity waves that are considered to play important roles in the dynamics of the Earth's atmosphere.

In 2004, the MU radar imaging observation system was installed to enhance the performance of the MU radar, making it possible to conduct three-dimensional imaging of small-scale structures associated with atmospheric phenomena. In response to the positive results achieved by the MU radar, a more sophisticated 47-MHz radar system, known as the Equatorial Atmosphere Radar (EAR), was established at the equator in West Sumatra, Indonesia (0.20°S, 100.32°E) in 2001.



Detailed atmospheric structure at very fine temporal and vertical resolutions obtained using the MU radar imaging observation system〔H. Luce et al., *Geophys. Res. Lett.*, **39**, L04807, 2012〕



Dual Ion Beam Accelerator Accurately Controls Irradiation Conditions

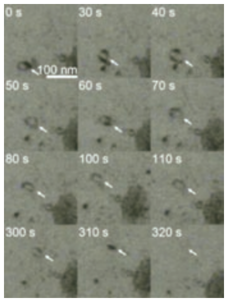
Leader: **Dr. Akihiko Kimura**

Professor, Institute of Advanced Energy

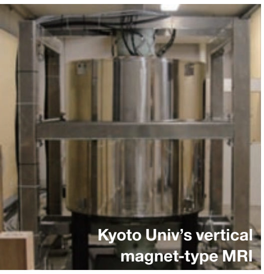
WEB www.iae.kyoto-u.ac.jp/ksoshiki/storage.html

The Dual-Beam Facility for Energy Science and Technology (DuET) is equipped with two beam lines of a 1.7MeV tandetron accelerator and a 1MeV single end accelerator, which enables the simultaneous irradiation of materials with different ions. The DuET was developed for fundamental materials research for future advanced energy systems, and is one of the main research facilities of the Laboratory for Complex Energy Processes in the Institute of Advanced Energy of Kyoto University. It is capable of irradiating and/or implanting a variety of ions, including Fe, Si, Ni, Cu, C, and He ions. This capability has enabled research on irradiation effects on steel to be performed in highly controlled experimental conditions. Precise control of irradiation conditions is essential for basic research on materials' response to irradiation and the effects of implantation on material properties and functions. The irradiation temperature ranges widely from about 10 K to 1800 K, using a helium cryostat for low temperature irradiation and a heating holder for elevated temperature irradiation, which makes the DuET to be the characteristic irradiation facility in the world.

One of the recent results obtained with the DuET concerns a fundamental study on atomistic motion of the lattice defect structures generated in ferritic model alloys by iron-ion irradiation. Nono-scaled lattice defect structures, which are dislocation loops of about 5 nm diameter, can be induced by the irradiation. Understanding the behavior of lattice defects is important in characterizing the materials properties and performance. Ion implantations are effective in modifying the surface of materials. The DuET facility can be used for magnetization and improvement of corrosion resistance by implantation.



A sequence of direct transmission electron microscope observations of a shrinking defect cluster (indicated by the arrow) that was induced by ion-irradiation (Submitted to *Phys. Rev. Lett.*, 2013)



Kyoto Univ's vertical magnet-type MRI

3 Tesla High-Temperature Superconducting Magnet MRI

Team Leader: **Dr. Hidenao Fukuyama**

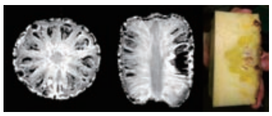
Professor/Director, Human Brain Research Center, Graduate School of Medicine

WEB hbrc.kuhp.kyoto-u.ac.jp/ResearchField.html

Superconductive conditions usually occur at 0°K. There is no loss of electricity in such circumstances. This condition is established by liquid helium using Niobium-Titanium. Until now, there has been no effective industrial application of super-conduction, with the exception of magnetic resonance imaging (MRI). Japan has created materials for super-conduction at high temperatures of 20-100°K and led the world in this field.

Professor Fukuyama and his colleagues constructed an MRI with a high temperature superconducting magnet made of a bismuth compound of Bi-2223, which is the first MRI of this type to be successfully produced. The machine operates at 20°K which is the temperature of liquid hydrogen. Furthermore, this machine does not require liquid helium, and it is operated with electricity or liquid hydrogen. Liquid helium is currently in short supply all over the world, and it is predicted that its production will decrease in the future.

Images of a monkey brain



MR image of pineapple
Damaged area is disclosed as dark area on the right side of pineapple.

Images produced by their MRI are at a similar level to those of commercially available 1.5 tesla MRI. Although certain aspects of the machine are still in the process of refinement, its images will be improved to match the quality of conventional 0°K superconducting MRIs.

Advancements in the development of high-temperature superconducting materials will enable the operation of MRIs at higher temperatures (around 170°C, 100°K) in the future. Those MRIs will be operated with liquid nitrogen, which is easily obtained, and they will be able to depict brains and other organs with liquid nitrogen or electric power only.

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