Advanced Research Center for Beam Science
– Particle Beam Science –

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Assoc Prof
IWASHITA, Yoshihisa
(D Sc)

Techn Staff
TONGU, Hiromu

Researcher (pt)
KATAYAMA, Ryou

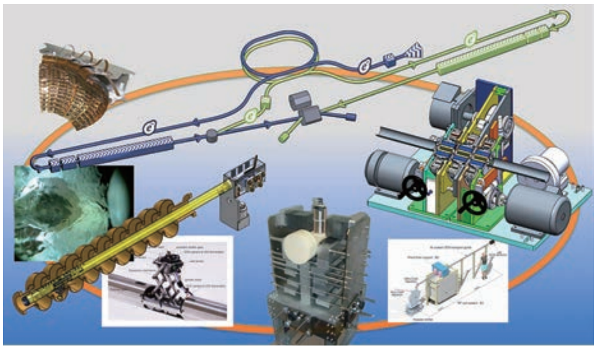
Lect (pt)
SAEKI, Takayuki (D Sc)
High Energy Accelerator Research Organization

Students
KITAHARA, Ryunosuke (D3)
MIYAWAKI, Eisuke (M2)
DENG, Weichao (M1)
TAKEUCHI, Yusuke (M1)
YAMAZAKI, Yuki (M1)

Guest Scholar
JAMESON, Robert A. (Ph D) Goethe University, Frankfurt Germany, 2–15 October

Scope of Research

We are studying particle beam science which includes particle beam generation, acceleration and manipulation for fundamental sciences as well as for practical applications, such as new materials and cancer therapy. We also concentrate on electromagnetics design such as Neutron Optics, including neutron beam focusing to highly enhance their efficiency for advanced measurements. We are the first in the world to demonstrate active neutron acceleration in order to seek the neutron Electric Dipole Moment. In addition, we contribute to advanced fault detection techniques for the International Linear Collider project superconducting accelerating cavities.



KEYWORDS
Beam Physics
Accelerator Physics
Neutron Optics
Phase Rotation
International Linear Collider

Selected Publications

Conway, Z. A.; Ge, M.; Iwashita, Y., Instrumentation for Localized Superconducting Cavity Diagnostics, *Supercond. Sci. Technol.*, **30,** 034002 (2017).

Fuwa, Y.; Iwashita, Y., Performance Evaluation of a Klystron Beam Focusing System with Anisotropic Ferrite Magnet, *Prog. Theor. Exp. Phys.*, **2017-2**, 023G01-1-14 (2017).

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Kubo, T.; Iwashita, Y.; Saeki, T., Radio-frequency Electromagnetic Field and Vortex Penetration in Multilayered Superconductors, *Appl. Phys. Lett.*, **104,** 032603 (2014).

Evaluating the Multi-Layer Thin-Film Superconductor Using the Third Harmonic Voltage Method

The superconducting accelerating cavity has an advantage of storing electromagnetic energy efficiently and achieving a high gradient accelerating electric field for charged particles easily. In general, the maximum accelerating gradient is limited by the critical magnetic field because the superconductive state cannot be maintained when the magnetic field induced by the accelerating electric field becomes larger than it. Today, niobium is generally widely used as the de-facto standard for the base material of the superconducting acceleration cavity, and the critical magnetic field is 200 mT. However, in recent years, it is pointed out that the critical magnetic field can be increased more by coating inner surfaces with multilayer-thin film superconductor and insulator.

As an example, Figures 1 and 2 show contour plots of the maximum permissible magnetic field that can maintain the superconducting state in the case that NbN or Nb3Sn is assumed for the superconducting single layer. The vertical axis represents the film thickness of the superconducting layer, the horizontal axis represents the film thickness of the insulating layer, and the numerals in the figure represent the maximum permissible magnetic field [mT]. If it is possible to realize the technology to optimize the performance as shown in Figures 1 and 2, the acceleration gradient can be increased up to several times higher than the conventional gradient. Thereby, we can aim at the physics of multi TeV, which is impossible at the present for the next generation electron-positron collider experiments. Hence, it is desirable to study the feasibility of this technique in detail.

In order to prove the above prediction, we constructed a dedicated system in Uji, Kyoto University, to measure the lower critical magnetic field H_{c1}, which is the indicator that can maintain the superconducting state. The third harmonic voltage induction method was adopted to determine H_{c1}. In this method, the AC magnetic field is applied while changing the temperature of the sample, and the temperature dependence of H_{c1} can be clarified from the rise of the inductance nonlinear component generated in the coil. In this study, the inductance of the coil is derived by dividing the third harmonic voltage by the current. Figure 3 shows the schematic diagram of the third harmonic system. The sample and a coil and a heater can be set in a stage, and the stage is installed inside the cryostat filled with the liquid helium. The stage is actually suspended from above and is partially immersed in liquid helium. A coil is fixed on the stage at a distance from the sample, and the magnetic field can be controlled by applying a current.

The temperature of the sample is adjusted by using the heater and the liquid helium. Applying voltage and current to the coil are read out by the four-terminal method, and the third harmonic component of the voltage induced in the coil extracted by using a high-pass filter. Finally, after conversion from the analog value to the digital value, the voltage and the current are recorded in the PC.

Figure 4 shows the preliminary result of the H_{c1} dependence on the temperature for a sample consisting of one insulating layer and one superconducting thin NbN film layer and a silicon substrate. The vertical axis is H_{c1} of the sample, and the horizontal axis is the temperature of the sample of the superconducting thin film. From this measurement, it is found that H_{c1} at 0 K becomes 7.2 mT. This is the temperature dependence of H_{c1} clarified by this measurement, which is expected to provide a solid basis for comparison of the above mentioned theoretical model.

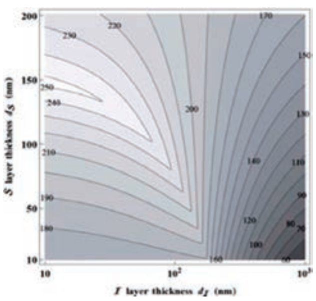

Figure 1.

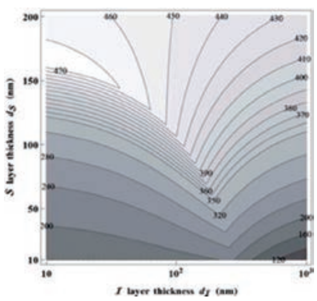

Figure 2.

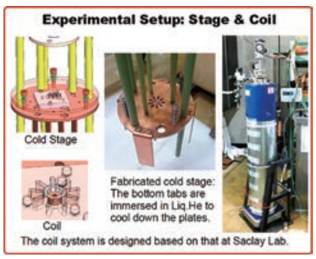

Figure 3.

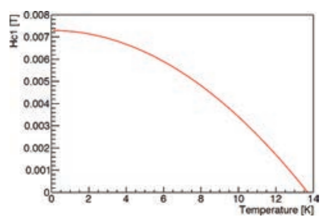

Figure 4.