Division of Transdisciplinary Sciences

Department of Advanced Materials Science

Laboratory	Faculty	Introduction of research activities and laboratory	Key words	Projects or activities summer program students can participate
Arima-Tokunaga Laboratory	Prof. Taka-hisa ARIMA Assoc. Prof. Yusuke TOKUNAGA	We are interested in transition-metal oxide compounds which show novel physical responses like 1) control of electric polarization of matter with a magnetic field, 2) change in shape of matter with a magnetic field, 3) control of magnetism of matter with an electric field, 4) control of optical property with a magnetic or electric field, and 5) directional birefringence/dichroism. All of these physical responses are related to the simultaneous breaking of more than one symmetry operation, referred to as 'multiferroicity'. We design multiferroic materials which are expected to host such novel responses, grow crystals, measure their physical properties, and investigate the origin of the physical responses from the microscopic point of view. We also utilize synchrotron and neutron facilities to reveal the symmetry breaking.	Multiferroics; Magnetism; Ferroelectrics; Crystal Growth; X-ray Diffraction;	Summer-program students can participate in crystal growths of some transition-metal oxide compounds by a floating zone method, flux method, or chemical vapor transport method. They can perform measurements of x-ray diffraction to characterize the obtained crystals and to analyze the crystal structure. They can experience measurements of dielectric properties, magnetic properties, and optical spectra at low temperatures as well as room temperature.
KIMURA (Tsuyoshi) Laboratory	Prof. Tsuyoshi KIMURA Asst. Prof. Kenta KIMURA	The research subject of our laboratory belongs to the field of "Materials Physics" which deals with the understanding of materials' properties based in quantum mechanics, the exploration for state-of-arts functional materials based on synthetic chemistry, and the development of cutting-edge measurement systems of materials properties. Especially, we explore multi-functional electronic materials in which various electric and magnetic properties are entangled and induce unexpected materials functionalities. For this purpose, we design and synthesize various transition-metal compounds, and carry out measurements of their electric and magnetic properties under various environmental conditions in terms of temperature, pressure, and electric and magnetic fields. "Multiferroics" are one of such functional materials and are defined as materials in which multiple order parameters such as ferromagnetic, ferroelectric, and ferroelasitic orders coexist and couple each other. We aim	Physics and chemistry; Multi-functional materials; Crystal growth; Electronic properties; Magnetic and electric fields	In this summer program, you will learn how to investigate multi-functional electronic materials such as multiferroics in which their electronic properties respond to both magnetic and electric fields. Electronic properties of materials are strongly dominated by their constituent elements and crystal structures. Thus, you will begin with the synthesis of the materials from chemicals, and have an experience of crystal growth. The obtained specimens will be characterized by structural analyses such as an x-ray diffraction measurement which reveals the crystal structures of the specimens. Subsequently, you will characterize their magnetic, mechanical, and electric properties under various environmental conditions such as low temperatures and high magnetic and electric fields. By comparing the results of several compounds,

		to explore new types of mutiferroic couplings and orders such as magnetic monopole, magnetic toroidal, magnetic quadrupole, and chiral orders, which lead to unconventional control of electronic properties in materials, and hopefully which will be used for future electronic devices.		you will find the required conditions to achieve materials with (multi-)functional properties.
Nakatsuji Laboratory	Prof. Satoru NAKATSUJI Dr. Takahiro TOMITA Dr. Akito SAKAI Dr. Tomoya HIGO	Material innovation has made various breakthroughs in basic science and applications. Recent research has shown that magnetic materials have great potential when they have topologically nontrivial electronic structures. To advance our understanding of novel and potentially useful electronic and magnetic materials, our research utilizes a combination of high quality single crystal growth, thin film growth and measurements under extreme conditions (low temperature, high magnetic field, and high pressure). One of our primary aims is to search for new materials that exhibit exotic topological properties, which are currently a flourishing field in condensed matter physics. Recently, a large anomalous Hall effect, which has been seen only in ferromagnet, was discovered in an antiferromagnet at room temperature in our group. This striking phenomenon indeed come from topological structure called the Weyl points in the momentum space. Such novel properties in topological magnets can be potentially useful for spintronics application such as high-density non-volatile memory devices in smartphones and computers, and energy harvesting for the internet of things.	Topology; New materials; Condensed matter; Superconductor; Spintronics	We are planning to perform the following studies in the summer program. (1) Probing the Fermi surface of materials through quantum oscillation in their transport properties and magnetization in high fields up to 16 T and at low temperatures using the dilution and Helium-3 refrigerators. Students will learn the basics of high magnetic field and low temperature measurements, and how these conditions can be utilized to study the structure of the Fermi surface of quantum materials. (2) Searching for room temperature energy harvesting materials through a combination of single crystal growth and electrical and thermal transport measurements. Students will learn how to grow single crystals using various techniques and the method for measuring their electrical and thermoelectric properties. Students may choose one of these for their program, and we will guide them accordingly.