Condensed Matter Research Center

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The Condensed Matter Research Center (CMRC) was established on April 1, 2009, in the Institute of Materials Structure Science (IMSS). The objective of the CMRC is to pursue cutting-edge research on condensed matter science through the comprehensive use of multi-probes supplied by the IMSS, such as synchrotron light, neutrons, muons, and slow positrons. The CMRC has four research groups: the correlated electron matter group, the surface/interface group, the matter under extreme conditions group, and the soft matter group. The research subjects of these groups are matched with the areas of excellence on which the IMSS focuses attention. The groups in the CMRC promote the following six projects.

1. Hybridized orbital ordering project: The ordered states of the electronic degrees of freedom play very important roles in strongly correlated electron systems. In particular, the hybridization effect of the electronic orbitals has been a central issue in this field. In this project, both the hybridized orbital ordering between localized and itinerant electrons and the charge/spin/orbital orderings will be studied under high pressure or a strong magnetic field. Resonant hard/soft X-ray and neutron scattering techniques are used complementarily.

2. Geometrical correlation project: Geometrical frustration often produces novel phenomena in strongly correlated electron systems, such as the heavy fermion state in which anomalous mass enhancement occurs. The objective of this project is to determine a characteristic correlation time for fluctuation in itinerant systems with strong electron correlation under the influence of geometrical frustration using muons, neutrons, and synchrotron X-rays, which have different probing-time scales.

3. Molecular crystal project: In this project, electronic correlation in molecular crystal systems will be investigated to elucidate novel phenomena such as superconductivity, magnetism, ferroelectricity and charge ordering. We will analyze the crystal structure under high pressure using a pressure cell developed specifically for molecular crystals to elucidate the mechanism of superconductivity. The charge ordering state of molecular crystal systems is sometimes destroyed under an electric field. The transient behavior from charge ordered to disordered state will be investigated using structural analysis by synchrotron X-rays.

4. Surface/interface project: Crystal structures and electronic structures at the surface and interface of magnetic thin films and multilayers are studied through depth-resolved magnetic circular dichroism (MCD)/X-ray absorption spectroscopy (XAS), resonant X-ray scattering (RXS), and neutron reflectivity. This research is important for developing materials for new electronics, called “spintronics,” as well as for basic surface and interface science.

5. Extreme conditions project: The targets of this project are compounds in the Earth’s core/mantle as well as light element minerals. We are studying changes in the crystal structures, electronic structures, spin states, valence states, and chemical bonding of these compounds to understand changes in density and in elastic, geological, transport, and chemical properties. We will use diffraction and spectroscopy techniques employing synchrotron X-rays and neutrons.

6. Soft matter project: This project has three research objectives: spontaneous motion under non-equilibrium conditions, hierarchical structure of a soft matter complex resulting from self-organization, and functional soft matter interfaces for industrial applications. We are conducting basic studies of these three fields by complementary use of synchrotron X-rays, neutrons, and muons.