4 Condensed Matter Research Center

The Condensed Matter Research Center (CMRC) was established in the Institute of Materials Structure Science (IMSS) on April 1, 2009. The mission of CMRC is to pursue cutting-edge research on condensed matter science by comprehensive use of multi-probes (synchrotron light, neutron, muon, and slow positron). CMRC is also expected to be a center of excellence in the field of materials structure science through close collaboration with researchers of universities and other institutes around the world.

Figure 1 shows the organization chart of CMRC (Director: Y. Murakami). The advisory committee is set up to give scientific advice and consists of five academic experts. CMRC has 27 inside-members of IMSS, which consists of eight professors, six associate professors, two vice associate professors, seven assistant professors, and four postdoctoral fellows. Sixty-two researchers from the outside of IMSS are now collaborating with the IMSS members of CMRC to execute the following research projects.

CMRC has four research groups: correlated electron matter group (Group Leader (GL): R. Kadono), surface/interface group (GL: K. Amemiya), matter under extreme condition group (GL: T. Kondo), and soft matter group (GL: H. Seto). The research subjects of these groups are matched with areas of excellence on which IMSS focuses attention. The groups in CMRC are promoting the following six projects, which include cross-sectional research among these groups. The correlated electron matter group has three projects (1-3) and each other group has a project (4-6).

1. Hybridized orbital ordering project (Project Leader (PL): H. Nakao): The ordered states of electronic degrees of freedom (charge, spin, and orital) 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 for a long time. In this project, the hybridized orbital ordering between localized and itinerant electrons as well as the charge/spin/orbital orderings will be studied under high pressure or strong magnetic field. The resonant hard/soft X-ray scattering and inelastic neutron scattering techniques are utilized complementarily.

2. Geometrical correlation project (PL: R. Kadono):

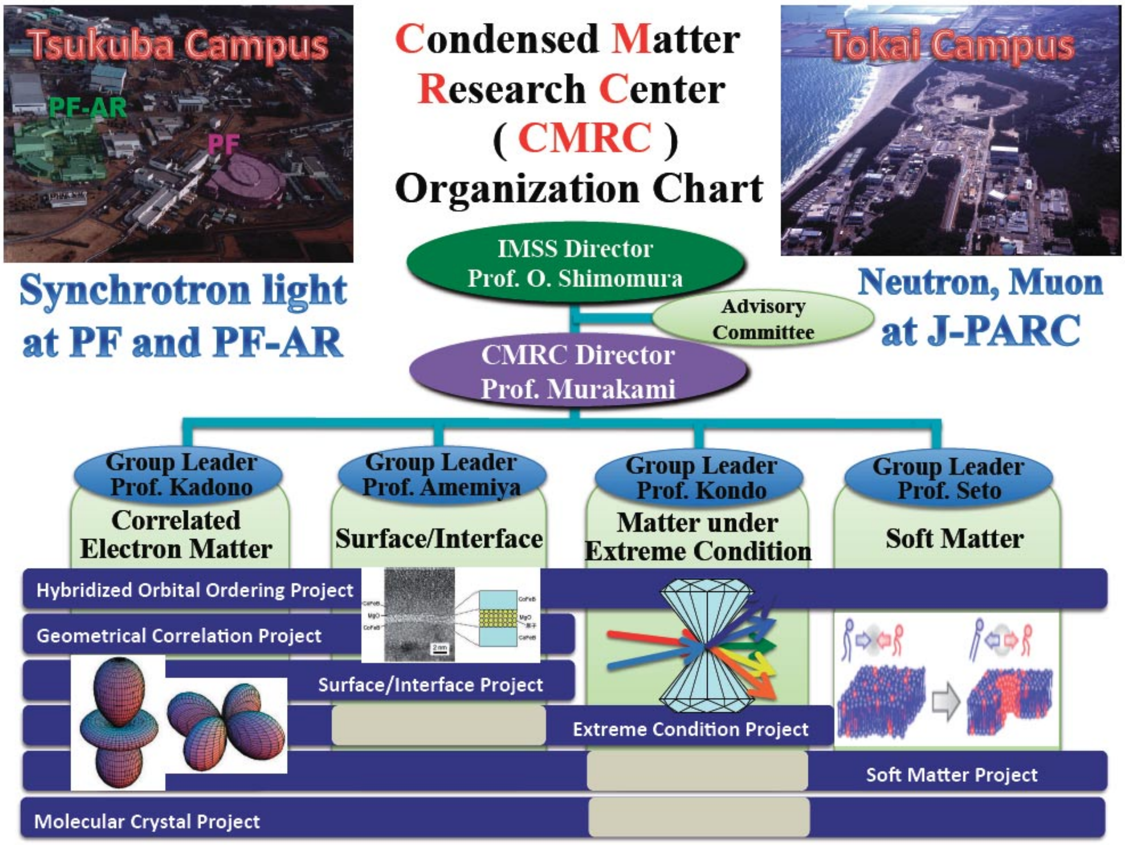

Figure 1
Organization chart of the Condensed Matter Research Center

The geometrical frustration often produces novel phenomena in strongly correlated electron systems such as heavy fermion state in which anomalous mass enhancement occurs. The goal of this project is to determine a characteristic correlation-time of fluctuation in itinerant systems with strong electron correlation under the influence of geometrical frustration using muon, neutron, and synchrotron, which have different observation-time scales.

3. Molecular crystal project (PL: R. Kumai): In this project, electronic correlation in molecular crystal systems will be investigated to elucidate novel phenomena such as superconductivity and charge ordering. We will analyze the crystal structure under high pressure using a pressure cell specially developed for molecular crystals to elucidate the mechanism of superconductivity. The charge ordering state of molecular crystal systems is somtimes destroyed under electric field. The transient behavior from charge ordered to disordered state will be investigated using structure analysis by synchrotron X-ray.

4. Surface/interface project (PL: K. Amemiya): Crystal structures and electronic structures at the surface and interface of magnetic thin films and multilayers are studied by 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 basic science of surface and interface.

5. Extreme condition project (PL: T. Kondo): The target matters of this project are compounds in earth's core/mantle and light element minerals. We study change of crystal structures, electronic structures, spin states, valence states, and chemical bonding of these compounds to know change of density, elastic properties, geological properties, transport properties and chemical properties. The diffraction and spectroscopy techniques of synchrotron X-ray and neutron will complementarily used.

6. Soft matter project (PL: H. Seto): This project has three research targets: spontaneous motion under non-equilibrium conditions, hierarchical structure of soft matter complex due to self-organizaiton, and functional soft matter interfaces for industrial applications. We conduct basic studies of these three fields by complementary use of synchrotron, neutron, and muon.

We are carrying out these studies using synchrotron beamlines (BL) of Photon Factory (PF) and Photon Factory Advanced Ring (PF-AR) at the Tsukuba campus and neutron and muon BL of J-PARC at the Tokai campus. BL-8A and 8B of PF are used to analyze the crystal structure; super-high-resolution powder diffractometer (super-HRPD) of J-PARC is useful for the crystal and magnetic structures analyses. BL-3A and 4C of PF are frequently used to examine the orders of electronic degrees of freedom such as charge, spin, and orbital orders under high pressure and strong magnetic field. BL-16A of PF is used for the measurements of MCD, RXS, XAS; resonant soft X-ray scattering diffractometer is installed in 2009. The experiments of high pressure are carried out at PF-AR beamlines: NE1A for the diamond anvil cell with laser heating and NE7 for the large press. The chopper spectrometer (HRC) of J-PARC makes it possible to conduct high-resolution experiments of inelastic neutron scattering, while experiments using the muon BL of J-PARC provide information about local magnetization.

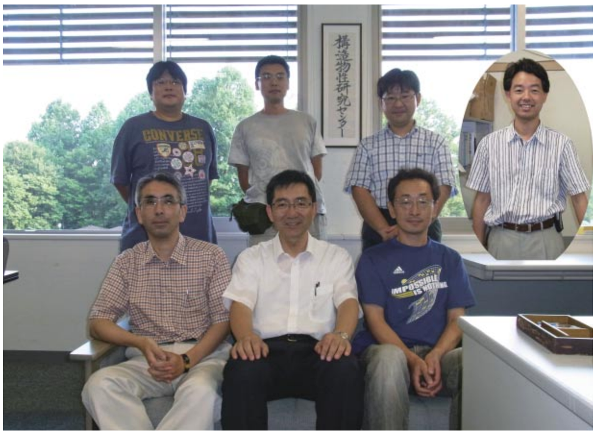

Figure 2
CMRC director and project leaders of the Condensed Matter Research Center, from left to right in the front row: R. Kadono, Y. Murakami, H. Seto, from left to right in the back row: R. Kumai, H. Nakao, T. Kondo, K. Amemiya.