Charge Dynamics in (ω, Q)-Space Studied by Inelastic X-ray Scattering (IXS)

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Concerning physical properties and functions of materials, the excited states of electrons in materials play the major roles. The basic nature of the electronic excited states in materials has both single-particle and many-body aspects, and it is therefore directly concerned with experimentally obtaining information which theorists in materials science regard as fundamental to our understanding materials. Recent progress and development of synchrotron X-ray sources like that realized at SPring-8 have encouraged the realization of sophisticated inelastic X-ray scattering (IXS) experiments, which has become powerful tool for investigating momentum- and energy-dependent charge and lattice dynamics. Since X-rays directly interact with an electron charge, one can investigate dynamical dielectric functions (DDF) and particle-hole excitations in momentum and energy (ω, Q) space. There are two kinds of IXS methods: nonresonant IXS (NIXS) and resonant IXS (RIXS). NIXS is known to provide directly DDF which reflects the information on transitions between occupied and unoccupied one electron state, and on the correlated motion of the electrons in (ω, Q) space. On the other hand, since RIXS yields two-particle (electron-hole) excitation from which both occupied and unoccupied states are elucidated, the interpretation of its spectra is thought generally to be rather complicated. However, Ishii et al. showed that the spectral shape of the intraband excitation in RIXS applied to the electron-doped cuprate, $Nd_{2-X}Ce_XCuO_4$, is similar to the dynamical density response function. [(1)]This gives an important message such that RIXS is a good tool for measuring energy-and momentum dependent DDF in strongly correlated metallic systems.

Although the NIXS spectrum is directly related to the DDF, in a reality it is very difficult to obtain the DDF in the ~100 meV energy region experimentally, where phonons are located. We would like to discuss a way how the DDF in such an energy region could be obtained in the talk.

Another electric charge dynamics can be studied in (*t*, Q)-space. The dynamics of non-equilibrium transition, for instance, should be investigated in a (t, Q) space rather than in a (ω, Q) space. Pump-Prove type experiments focus on this type of experiments, and have been recently carried out with a few tens of fs. time resolution.[(2)] By considering the direction of future development of SR and related X-rays, the dynamics in (*t*, Q)-space will become more popular than now. Therefore, this type of experiments will be also discussed in the talk.

(1) K. Ishii et al., Phys. Rev. Lett. **94** (2005) 207003.

(2) D. Polli et al., Nature Materials **6** (2007) 643.