What can we see with intense X-rays?

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Intense, short, and coherent pulses form X-ray free-electron lasers (XFEL), such as LCLS [1] and SACLA [2], open up new opportunities for spectroscopic and structural studies. Now many groups report on fs-time resolved measurements and damage-free protein crystallography. At the same time, it also becomes possible to investigate nonlinear optics in the hard X-ray region. Recently, we succeeded in measuring X-ray two-photon absorption (TPA) [3]. The selection rule for TPA is different from the usual one-photon absorption (OPA). X-ray TPA can access directly the 3d orbitals of transition metals, and can become a powerful spectroscopic tool. However, we also find severe damage of sample due to intense X-rays. To estimate the TPA cross section, we need to simulate the population dynamics of the electronic configuration under intense X-ray pulses. X-ray nonlinear optics treats the interaction between intense X-rays and materials, and is not completely unrelated to the various XFEL applications. When one focuses XFEL beam to measure a small sample, the inner shell of most atoms may be photo-ionized. Since the pulse duration is in the fs range, the excitation occurs simultaneously. So, the signal one measures may come from highly excited atoms far from the ground state. In fact, we observed X-ray fluorescence from a krypton atom with a K hole [4]. Although the lifetime of the K hole in krypton is only 0.17 fs, the existence of the K hole cannot be ignored. The creation of the K hole is expected to modify the X-ray property of atoms, shifting the photon energy of the K edge and changing the scattering factor [5]. Understanding of such effects is necessary to analyze data measured with intense X-rays.

In this talk, we will discuss the interaction with intense X-rays and atoms, and the analysis of X-ray TPA.

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