Femtosecond X-ray diffraction applications to biology and solid-state physics

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X-ray diffraction temporally resolved on the femtosecond time scale is a strong instrument for studying ultrafast processes in all the fields of scientific interest, from biology to physics and chemistry. The development of the laser-plasma source for producing femtosecond X-ray flash has given rise to the first applications of this technique to follow dynamical processes [1]. Here we report our last results on two parallel topics of our field of interest. First, we present an experimental result in which we realize for the first time a Laue diffraction pattern from a protein crystal (lysozyme) by using the femtosecond X-ray source. This represents a key step toward ultrafast dynamics study on biological samples. In fact, to resolve the dynamics of complex systems such as protein, many diffraction spots need to be detected at the same time. Standard Laue method consists in using a polychromatic and collimated beam, and the diffraction pattern is detected behind the sample. In our case, we use a different geometry, which takes into account the features of laser-plasma source: monochromatic and divergent. Because of the divergence, the reciprocal space is investigated by the different wave vectors available and therefore many different reflections are allowed for diffraction. Note that the interest on this geometry is amplified by the fact that new generation source of ultrafast X-ray pulse like the X-FEL is strongly monochromatic, and therefore divergence is needed to detect many diffraction peaks at the same time. The goal is of course to follow the full dynamics by detecting a Laue pattern for each time delay between the excitation pulse and the X-ray pulse.
The second topic concerns solid-state physics application of femtosecond X-ray diffraction. Our goal is the detection of high frequency vibrational modes (optical phonons) in condensed materials. We show theoretical results of dynamical simulation of the rocking curve perturbed by optical phonon for some particular interesting materials. These simulations show some specific features that are a necessary guide to perform the real experiment.

[1] C. Rischel et al., *Nature* **390**, 490 (1997).