A series of measurements of the Fourier components of the valence electrons together with phase retrieval algorithm [33] can be used to reconstruct the valence electrons distribution.

Our work suggests that the DFG process we describe here would lead to higher efficiencies than sum/difference frequency mixing of X-ray and optical pumping beams. This is because the efficiency of the X-ray and optical mixing process depends on the intensity of the optical laser, thus limited by the optical damage threshold. On the other hand, the efficiency of the DFG process depends on the intensity of the X-ray lasers. Since the damage threshold at X-ray wavelengths is several orders of magnitude higher than the optical damage threshold, the intensity used for the pumping beams in DFG can be much higher than in X-ray and optical mixing. In addition, since the delay between the two pumping beams is controllable, it is possible to use DFG into optical wavelengths to probe the dynamics of processes, which are associated with valence electrons with temporal resolution determined by the duration of the X-ray pumping beams. With the present specifications of XFELs, the possible temporal resolution is a few of tens of femtoseconds. Another possible application is as a cross-correlator for the inspection of ultrashort X-ray pulses.

Acknowledgments

This work was supported by the Israel Science Foundation (under Grant No. 1038/13).

#226995 - $15.00 USD Received 17 Nov 2014; revised 10 Feb 2015; accepted 12 Feb 2015; published 13 Mar 2015