CFEL SCIENCE

Max Planck Research Department for Structural Dynamics

SEMINAR

January 27th, 2011 - 14:30

Seminar Room 108, DESY Bldg. 49

Luca Poletto

CNR-Institute of Photonics and Nanotechnologies, Padova, Italy

Spectral Selection of Ultrashort Pulses in the Extreme Ultraviolet

The time response of grating monochromators for extreme-ultraviolet femtosecond pulses, such as those produced through high-order laser harmonics or free-electron lasers, is here analyzed. The use of gratings for the spectral selection intrinsically introduces a broadening in the output pulse because of diffraction: each ray that is diffracted by two adjacent grooves is delayed at first order by one wavelength.

As an example, let us consider a 200-gr/mm grating illuminated on an area of 20mm by 30nm wavelength: the number of grooves involved in diffraction is 4000, giving a total delay of 400fs at 30nm, that is obviously unacceptable for femtosecond time resolution. The monochromator is defined to be time-preserving if the temporal duration at the output is close to the Fourier limit for a given spectral bandwidth. Once the resolution R at the output of the monochromator has been defined, the minimum number of grooves that have to be involved in the diffraction to support such a resolution is N=R. The corresponding time broadening is close to the Fourier limit for a given bandwidth. Therefore the single-grating design can be adopted for ultrashort pulses without altering in a significant way the pulse duration, provided that the number of illuminated grooves is equal to the resolution.

Two possible configurations for single-grating time-preserving monochromators are compared: the classical-diffraction mount (CDM) and the off-plane mount (OPM). I will show that the classical mount is suitable for monochromators with time response in the 100-200fs range, while the off-plane mount is suitable for ultrashort responses in the 10-50fs range. Furthermore, the OPM gives higher grating efficiency in the extreme-ultraviolet.

The design, realization and characterization of the single-grating OPM monochromator realized for the beamline ARTEMIS at CLF-RAL (UK) for the spectral selection of high-order harmonics are discussed. A sub-30-fs time response at the output of the monochromator has been measured trough the yield of Kr^{2+} with harmonic 23rd pump (35.7eV) and 800nm probe. Monochromators that do not alter the temporal duration of the pulse in the femtosecond time scale are realized by using two gratings in subtractive configuration, so that the second grating compensates for the temporal and spectral spread introduced by the first one. Since two gratings are required, it is essential to adopt a design with maximum efficiency. Again, the OPM is the preferred choice.

The realization of a double-grating monochromator with gratings in the OPM for the spectral selection of high-order laser harmonics is discussed. A 8fs duration at harmonic 23rd has been measured at the output of the monochromator through XUV-IR cross-correlation. The experimental results confirm the advantages the off-plane configuration to realize time-preserving monochromator in the extreme-ultraviolet.

Host: Andrea Cavalleri, Condensed Matter Division, MPSD, CFEL