XUV Free Electron Laser based Nonlinear Optics

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The recent advent of Free Electron Lasers (FELs) allowed to push experimental techniques peculiar of table top pulsed laser towards much shorter wavelength allowing to probe dynamical processes with an unprecedented time-space resolution. Within the portfolio of FEL based experimental methods we will discuss the new opportunities offered by the extension of non-linear spectroscopies in the vacuum ultraviolet to soft X-ray energy range. Pioneering wave mixing experiments have been successfully carried out at the FERMI FEL, signifying that second harmonic generation and four wave mixing experiments are now possible at nanometer wavelength. These results pave the way to a new class of experiments like investigation of heat transfer at the nanoscale or energy transfer in light harvesting devices.