Coherent X-rays From Ultrafast Lasers, and Applications - Attosecond Science Meets Nonlinear Optics

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The technology of bright coherent x-ray generation using tabletop-scale ultrafast lasers has opened up many new opportunities. To date, most experiments that use light from high harmonic generation have been limited to the EUV spectral region at ~50-100 eV. The grand challenge for extending bright HHG to higher energy is the development of new phase matching techniques for efficient HHG at high photon energies. The past two years have seen rapid progress in this area, essentially solving the high-harmonic phase matching problem. By employing mid-infrared driving pulses, bright phase-matched HHG should extend even into the hard x-ray region of the spectrum above 1 keV. Quasi phase matching techniques can also be implemented employing interference with counterpropagating light pulses. This coherent control process represents a useful manipulation of electronic wave function on attosecond time-scales. By combining these phase matching techniques, coherent tabletop x-ray sources with carefully engineered source properties will be possible. At the same time, the use of HHG sources to study dynamics in atomic, molecular, materials, and engineered systems has expanded rapidly. I will briefly discuss recent experiments in our group in observing molecular "radiation femtochemistry," high-resolution imaging, ballistic heat transport in nanoscience, and ultrafast studies of magnetism dynamics.