Zepler Institute

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"X-ray lasers" on a tabletop: New science and new opportunities for technology

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Abstract

The ability to generate coherent laser-like beams of ultrashort-pulse x-rays using the process of high-order harmonic generation (HHG) of a femtosecond laser provides fundamentally new capabilities in x-ray science, as well as making many applications previously possible only at large-scale synchrotrons now broadly accessible. Recent work in our group demonstrates the ability to image with sub-wavelength resolution, and to probe, using a tabletop setup, the fastest charge, spin and energy transport processes in materials. Recent applications include probing the dynamics of the quantum exchange interaction fundamental to magnetic materials; clocking the fastest excited-state decay (τ~200 as), for energetic electrons in a material; the use of coherent HHG light for tabletop nanoimaging with resolution approaching 10 nm; and studies of the physical limits of energy flow and materials properties at the nanoscale. The HHG process provides an unprecedented degree of control over the coherent characteristics of the light generated-attosecond pulse trains with complex circular polarization, narrow-band or broadband light, and the use of ultrafast mid-IR lasers to generate coherent x-rays with $h\upsilon$ >1.5 keV are all recent examples. Industrial applications in nanotechnology are also on the horizon, and we commercialized this technology to make it accessible for both scientific and industrial applications. Further work will continue to expand the utility of these HHG sources, even likely into the hard x-ray region of the spectrum.

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Biography

Henry C. Kapteyn is a Professor of Physics and ECE at the University of Colorado at Boulder, and a fellow of JILA, a Research Institute joint between the University of Colorado and NIST. He and his wife and long-term collaborator, Margaret Murnane, are well known for their research in femtosecond lasers, and for understanding how to coherently upconvert this light to make a "tabletop x-ray laser" that generates ultrashort bursts of short-wavelength light. In recent years, they have this applied source to pioneering studies of atomic, molecular, and material studies at short length- and time-scales. Henry has published more than 200 papers and was elected to the US National Academy of Sciences in 2013. His awards include the R.W. Wood Prize, the Arthur Schawlow Prize and the Willis Lamb Award in Quantum Electronics.

Monday 3 April 2017, 14:00 - 15:00, B53 4025 Highfield Campus