Harnessing high harmonic sources for real-time functional imaging

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X-ray science has undergone a revolution in the past decade. More than 50 years after the demonstration of the visible laser, it is finally possible to produce coherent light at wavelengths substantially shorter than the ultraviolet. Large- and small-scale coherent X-ray sources, including X-ray free electron lasers (XFELs) and high harmonic generation (HHG) sources, have demonstrated a broad range of applications. The past 8 years in particular have seen breakthrough advances – in the HHG source itself, in the development of new laser technologies, as well as in new experimental methodologies and applications.[1-5] Moreover, light science when combined with engineering has resulted in a tunable tabletop X-ray laser with femtosecond-to-attosecond pulse duration. The extreme quantum coherence of high harmonic (HHG) light sources makes it possible to control x-ray light using visible lasers, to the extent that it is now possible to produce short wavelength waveforms with controlled spectrum, temporal shape, polarization state, orbital and spin angular momentum and torque. This is important since most advanced applications of lasers require precise control over light. Longer wavelength mid-IR lasers promise directed beams of soft and hard X-rays.

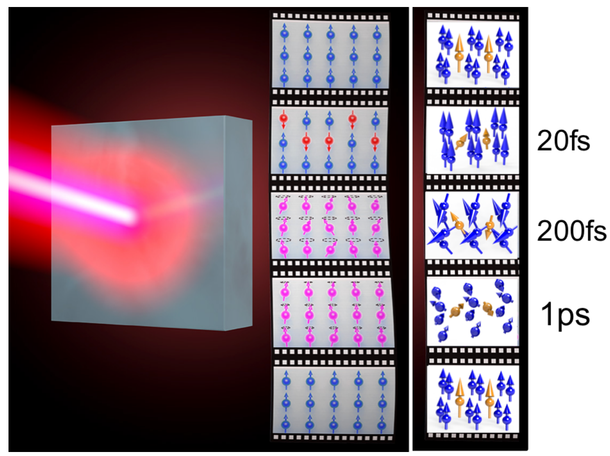

Fig. 1: If electrons in a ferromagnet are heated above the Curie temperature by a femtosecond laser, the spin system also absorbs sufficient laser energy within ~20fs to subsequently undergo a magnetic phase transition.[3]

This talk will present recent advances in high harmonic light sources, with many applications in materials science and imaging. Exciting applications include imaging and spectroscopy of quantum materials, chemical and energy systems, as well as metrology in support of next-generation nanotechnologies. Exciting new capabilities include the ability to implement spatial-, interfacial- and depth-resolved maps of layered materials, the ability to find hidden phases with new properties in quantum materials, the ability to probe thermal and elastic properties at the nanoscale, and the ability to directly manipulate spin polarization in magnetic materials using light on few-femtosecond timescales.

References

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