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GENERATION OF FEMTOSECOND PULSES OF SYNCHROTRON RADIATION: A NEW TOOL FOR ULTRAFAST X-RAY SCIENCE

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An important frontier in ultrafast research is the application of femtosecond x-ray pulses to investigate structural dynamics associated with phase transitions in solids, chemical reactions, and rapid biological processes. The fundamental time scale for such processes is an atomic vibrational period, ~100 fs, which is nearly three orders of magnitude beyond the present capabilities of synchrotrons. We have recently generated femtosecond synchrotron pulses from the Advanced Light Source (ALS) using ultrashort laser pulses[1], and are developing a bend-magnet beamline with 100 fs time resolution for ultrafast x-ray science.

A femtosecond laser pulse is used to create femtosecond time structure on a 30 ps electron bunch by co-propagating with the stored electron bunch through a wiggler. The field of the laser pulse effectively modulates the energy of the underlying electrons as they traverse the wiggler. The modulation is several times larger than the rms beam energy spread and is applied only to an ultrashort slice of the electron bunch. The femtosecond slice is then spatially separated from the rest of the electron bunch (in a dispersive bend) by a transverse distance that is several times larger than the rms transverse size of the electron beam. Finally, by imaging the synchrotron x-rays from the displaced beam slice to the experimental area, we are able to separate out the femtosecond radiation originating from the offset electrons.

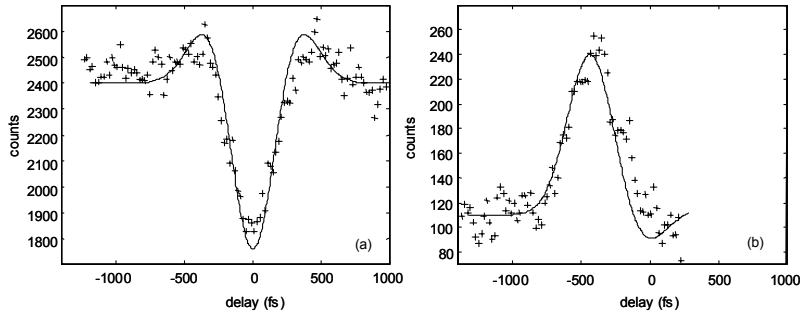

Figure 2: (a) femtosecond dark pulse from on-axis radiation, (b) femtosecond pulse from off-axis radiation. Solid lines are from a model calculation.

Femtosecond synchrotron pulses are directly measured by cross-correlating the visible light from a bend-magnet beamline with the synchronized laser pulses. Figure 2a shows the femtosecond "dark" pulse that appears as a narrow hole in the main pulse, and originates from the central core of the sliced electron bunch. Figure 2b shows the ~300 fs synchrotron pulse originating from the displaced electrons. A new beamline is currently under construction at the ALS which will provide x-ray pulses of <100 fs duration for ultrafast x-ray science.

Reference

[1] R.W. Schoenlein et al., *Science*, (in press), 2000.

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