New Scientific Opportunities with VUV and Soft X-ray Free Electron Lasers

A workshop, hosted by the University of Wisconsin-Madison and its Synchrotron Radiation Center, will bring together researchers to discuss how the availability of such FEL light sources could revolutionize the study of elementary processes in Chemistry, Physics, Materials Science, and the Life Sciences. It will be held on Wednesday and Thursday, October 18th and 19th, 2006 at the Pyle Center of the UW-Madison.

Topical Sessions

Femtochemistry
  Coordinator: John Wright, UW-Madison

Atmospheric And Intergalactic Gases
  Coordinator: Nora Berrah, Western Michigan University

Pump-Probe Experiments
  Coordinator: David Reis, University of Michigan

Biological Systems
  Coordinator: Robert Austin, Princeton University

Exotic Materials, Clusters And Nanostructures
  Coordinator: Paul Evans, UW-Madison

Resonant Inelastic X-Ray Scattering
  Coordinator: Peter Abbamonte, University of Illinois

Time Resolved Imaging And Coherent Scattering
  Coordinator: Steve Kevan, University of Oregon

Registration

Registration is free, but will be limited to 100 participants.

For registration and workshop information and program, see www.src.wisc.edu/meetings/fel2006/

Organizing Committee

Hartmut Höchst (SRC)
David Moncton (MIT)
Joseph Bisognano (SRC)

Contact Hartmut Höchst @ 877-2000 or hhochst@wisc.edu for additional information.

Synchrotron Radiation Center
UW-Madison

3731 Schneider Drive
Stoughton, WI 53589-3097
Concept for a Wisconsin X-ray Laser User Facility

VUV Hall

- 30 – 300 nm
- 10 – 100 nm
- 3 – 30 nm

Undulators

- All undulators operate simultaneously at repetition rate up to 1 MHz each.
- Total number of undulators set by budget.
- Facility lasers and RF components synchronized to ~10 fs.
- FEL synchronized to <100 fs.

Soft X-ray Hall

- 1 – 10 nm

Seed lasers

- Master laser oscillator

Injector laser

RF power supplies

1-1.5 GeV

2.5 GeV

SRF Linac

Fiber link synchronization

Space for future upgrade to hard x-ray laser
Session Overview

• 13:30-14:00  
  Ultrafast Science Directions of the Argonne Atomic, Molecular, and Optical Physics Group  
  Bertold Krässig, Argonne National Laboratory

• 14:00-14:30  
  Spin and Orbital Moment Dynamics in Magnetic Materials  
  Andreas Scholl, Lawrence Berkeley National Laboratory

• 14:30-15:00  
  Femtosecond X-ray Diffraction Using Random Sampling  
  David Reis, University of Michigan

• 15:30-16:00  
  Ultrafast X-ray Absorption  
  Christian Bressler, EPFL-Laussane
Ultrafast Photography 1878
Optical Pump-Probe

Accelerator-based

- Resolution limited by the bunch duration (or the timing jitter)
- Arbitrary pump-probe delay (NOT limited by bunch separation)

D.A. Reis et al.
Example:
Resonant core excitation of laser ionized krypton atoms

Tunnel ionization: $4p \rightarrow$ continuum

Variable delay $\delta t = 100$ ps

$1s \rightarrow 4p, np, continuum$

0.2 fs

Fluorescence x ray out

X ray in
Result: X-rays selectively probe Kr⁺ ions

Young et al. PRL 2006
Low-Spin $\rightarrow$ High-Spin Transition (and back)

$[\text{Fe(bpy)}_3]^{2+} (\text{aq})$
static absorption

$\Delta t = 50 \text{ ps}$

$700 \text{ ps}$

$c = 25 \text{ mM/l}$
(1, 6 and 100 mM/l ok)
$\rightarrow$ Fluorescence Detection
Condensed Phase Dynamics

$t < 0$

$R(I^- - O) = 350$ pm

$0 < t < 1$ ps

CTTS - $e^-$

Inertial Response?

$t >> 1$ ps

$R(I^0 - O) = 300$ pm (?)

$e^-_{solvated}$

C. Bressler
Resolution limited by the bunch duration (or the timing jitter)
Arbitrary pump-probe delay (NOT limited by bunch separation)
Time-Resolved X-ray Experiments

Time-resolved X-PEEM
- 70 ps temporal resolution.
- 50-100 nm spatial resolution.
(5 nm possible in the future.)

X-ray streak camera
- Sub ps temporal resolution
- No spatial resolution
 (~100 fs possible)
Time-Resolved XMCD at Fe L$_3$ Edge

60fs pump pulse

Transmitted x-ray intensity

Dichroism

dichroic contrast is lost in a few pico-seconds

A. Scholl
What can we learn about interatomic potential through ultrafast optical and x-ray experiments?

D.A. Reis et al.
Using the jitter for random sampling

D.A. Reis et al.
Ultrafast Laser pump X/VUV Probe

• Application to wide class of nonequilibrium dynamics in Atomic, Molecular, Chemical, Biological and Condensed Matter systems.

• XAS, Photoemission, Dichroism, Imaging, Raman, …

• Must match repetition rates of pump and probe. Could FEL be pump?

• Synchronization can pose limits