Scientific Opportunities and Priorities for XPCS at NSLS-II
XPCS : The “REAL” 12 years of history in the hard X-ray regime


- Visible Raman
- Visible Brillouin
- X-ray Raman
- RIXS
- INS
- IXS
- X-ray PCS
- Visible PCS
- Compton

A. ROBERT, SLAC, V1, Jan 2008

XPCS @ NSLSII
Jan 2008

PHOTON SCIENCE at STANFORD LINEAR ACCELERATOR CENTER

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XPCS at 3rd generation Synchrotron Sources
XPCS Instruments: Current Status

- 2 Dedicated Storage Rings Instruments:
  - ID10 (ESRF) & 8-ID (APS)
  - Recent indications of XPCS activities at Spring-8 (March 2007)

- Dedicated FEL Instruments in construction:
  - 1 at LCLS (Stanford)
  - 2 at XFEL (1 soft- and 1 hard X-ray) (Hamburg)
  - 1 at SCSS (Hyogo)

- Dedicated Storage Rings instruments in construction:
  - 1 at SLS (Villingen)
  - 1 at Petra III (Hamburg)
  - 1 at Diamond (UK)
Increase of Brilliance from the Synchrotron Source
- Beneficial for weekly scattering samples
- Use of higher energy X-ray
- Allow to probe faster dynamics and/or at larger wavevectors

Optimized Optical design (which preserve the coherent flux and symmetries the coherence length of the beam):
- Vertical focusing (increase flux and reduce the large vertical coherence length)
- Horizontal collimation and monochromatization:
  - Increase horizontal coherence length
  - Multiplexes the beam?
  - Defines longitudinal coherence length.
- Ability to tune the beam size at the sample
- Beam Damages
  - High Energy
  - Microfluidics technology (for fluid samples) or translating the sample
- Energy Tunability?
- Beam stability issues
Scientific Opportunities

- Nanoscale Dynamics in Colloids and Polymer systems
- Glassy Dynamics
- Hard Condensed Matter (Phase transitions, Critical phenomena,…)
- Grazing Incidence XPCS
- Near Field Speckle
Scientific Opportunities: Nanoscale Dynamics of Colloidal Systems

- Larger brilliance useful for smaller objects:
  - Small $\Rightarrow$ scatters less: \textbf{Intensity} $\propto R^6$

- Small $\Rightarrow$ faster:
  \[
  \tau_c = \frac{1}{D_0 \cdot Q^2} \propto R
  \]

- Small $\Rightarrow$ Larger interesting Q’s $\Rightarrow$ faster and scatters less:
  \textbf{Intensity typically} $\propto Q^{-4}$
  \[
  \tau_c = \frac{1}{D_0 \cdot Q^2} \propto Q^{-2}
  \]

- Small $\Rightarrow$ Biological systems
Scientific Opportunities: Nanoscale Dynamics of Colloidal/Polymer Systems

Figure 9
The figure compares the experimental $D_{\text{ex}}(Q) = \bar{\Gamma}(Q)/Q^2$ of Taq polymerase by NSE (open squares) with those from different dynamic models. The horizontal dashed line is $D_{\text{ex}}(Q)$ of a rigid-body model of Taq polymerase. The red line is the $D_{\text{ex}}(Q)$ calculated using the dynamic model that parses Taq polymerase into two domains, the 5' nuclease and the Klentaq domains. The blue line is the $D_{\text{ex}}(Q)$ calculated assuming three domains.
Scientific Opportunities: Glassy Dynamics (1)

- GD is complex i.e. several dynamical processes involved:
  - β-relaxation
  - α-relaxation (with non-ergodicity issues)
Scientific Opportunities: Glassy Dynamics (2)

- GD is complex i.e. several dynamical processes involved:
  - “aging”: non-equilibrium dynamics (XTRC/2-times)

![Graph showing aging dynamics](image)

\[ \tau \]

\[ \text{Age } t_w [\text{s}] \]

\[ 0.05 \]

\[ 0.04 \]

\[ 0.03 \]

\[ 0.02 \]

\[ 0.01 \]

\[ 0 \]

\[ 10^1 \]

\[ 10^2 \]

\[ 10^3 \]

\[ 10^4 \]

\[ \tau [\text{s}] \]

\[ 13094 \]

\[ 6128 \]

\[ 4041 \]

Scientific Opportunities: Glassy Dynamics (3)

- GD is complex i.e. several dynamical processes involved:
  - Intermittent dynamics ($\chi_4$ 4th order correlation function)

Investigation of $q$-dependent dynamical heterogeneity in a colloidal gel by x-ray photon correlation spectroscopy

V. Trappe, E. Pitard, L. Ramos, A. Robert, H. Bissig, and L. Cipelletti

Requires as well the ability to change the illuminated volume
Scientific Opportunities in Hard Condensed Matter: Critical Fluctuations, Phase Transitions

Direct measurement of antiferromagnetic domain fluctuations


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Scientific Opportunities in Hard Condensed Matter: Critical Fluctuations, Phase Transitions

X-Ray Intensity Fluctuation Spectroscopy Studies on Phase-Ordering Systems

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(Received 16 September 2004; published 9 February 2005)
Scientific Opportunities: Grazing Incident XPCS

Two-Dimensional Dynamics of Metal Nanoparticles on the Surface of Thin Polymer Films Studied with Coherent X Rays


PHYSICAL REVIEW LETTERS
PRL 98, 047801 (2007)

week ending 26 JANUARY 2007

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Capillary Waves at the Transition from Propagating to Overdamped Behavior

A. Madsen,¹,* T. Seydel,² M. Sprung,³ C. Gutt,³ M. Tolan,³ and G. Grübel¹
Scientific Opportunities: Near Field Speckles

X-ray near field speckles: a new approach to small angle static and dynamic scattering

To be published in Nature Physics

R. Cerbino¹, L. Peverini², M.A.C. Potenza¹, A. Robert³, P. Bösecke², M. Giglio¹

Measured with Near Field Speckles

Measured with Classical XPCS

Still unclear what are the potential scientific application of NFS as the Q-range is restricted to very small angle

_wavevector q (nm⁻¹)

_τ (s)

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Scientific Opportunities: Detector Issues

- **2D Detector Program**
  - Small pixel size
    - 20 x 20 microns or more/less?
  - Frame Rate
    - Kilo Hertz
    - Mega Hertz?
  - Noise levels
  - Number of pixels
    - 1k x 1k?
    - more?
    - tiling capability?
  - Built in correlator in each pixel?

- **1D Detector** ...
  - APD-type + correlator
  - Linear array of them?