Scientific Opportunities and Priorities for XPCS at NSLS-II

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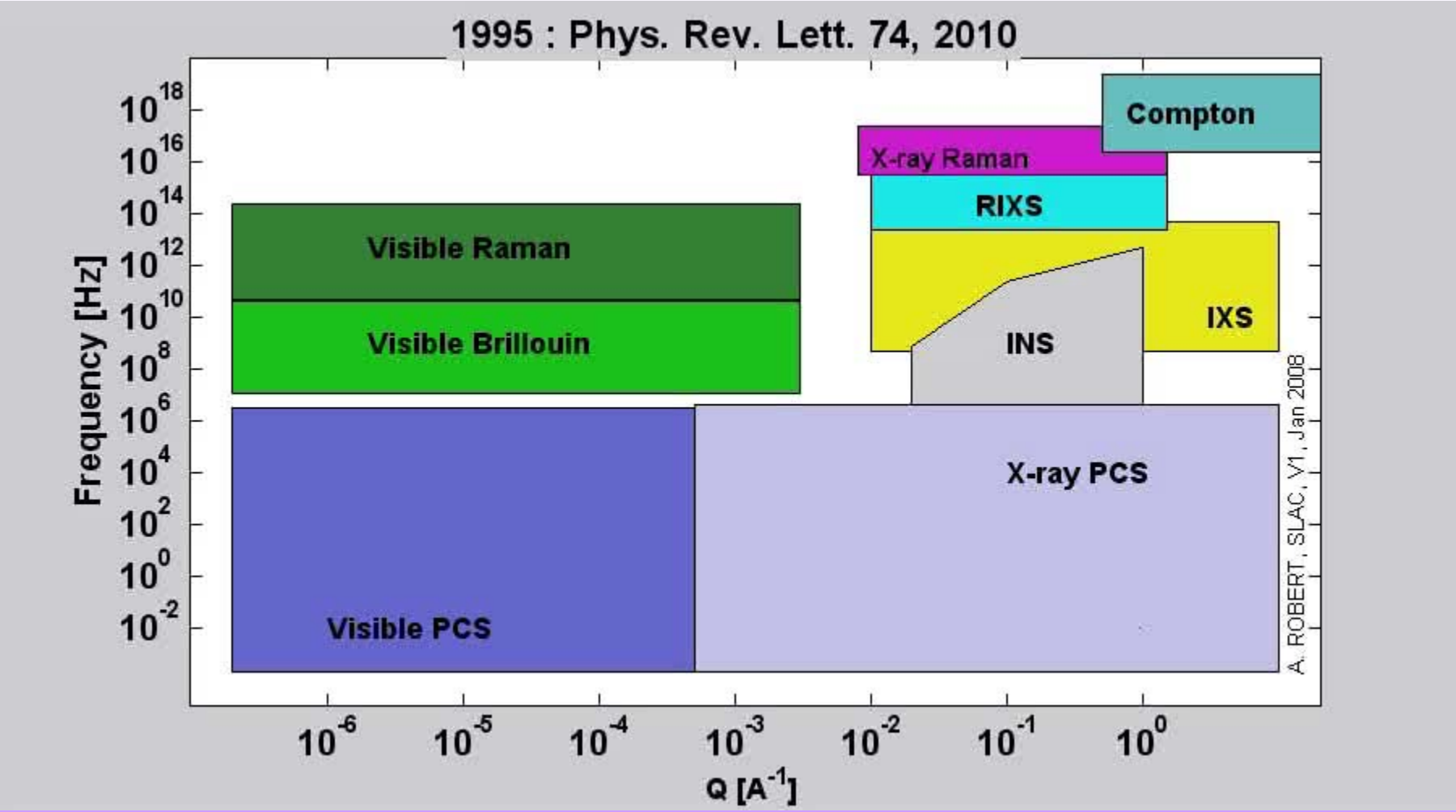
XPCS : The "REAL" 12 years of history in the hard X-ray regime



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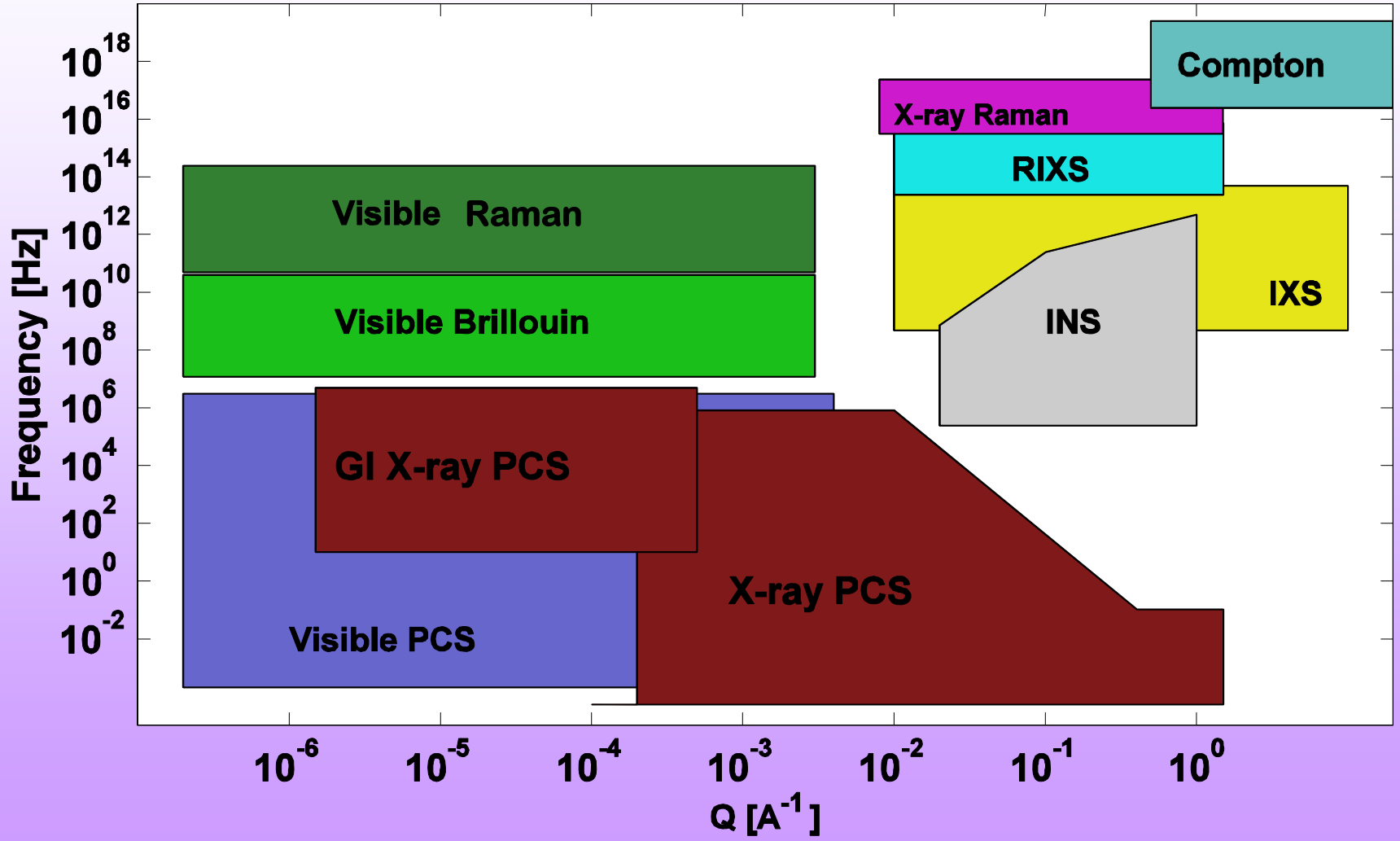
XPCS at 3rd generation Synchrotron Sources



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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)

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XPCS @ NSLS II

- 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

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Scientific Opportunities

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

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Scientific Opportunities : Nanoscale Dynamics of Colloidal Systems

- Larger brilliance useful for smaller objects :
  - Small ➔ scatters less : **Intensity** $\propto \mathbf{R^6}$
  - Small ➔ faster : $$\tau_C = \frac{1}{D_0 \cdot Q^2} \propto R$$
  - Small ➔ Larger interesting Q's ➔ faster and scatters less :
    Intensity typically $\propto Q^{-4}$

$$\tau_C = \frac{1}{D_0 \cdot Q^2} \propto Q^{-2}$$

  - Small → Biological systems

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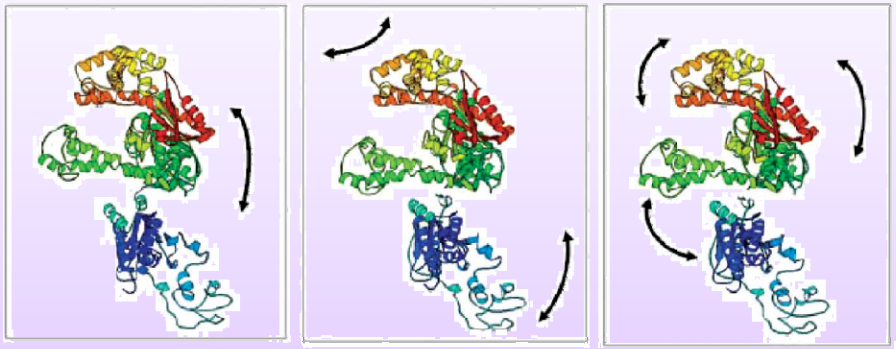
Scientific Opportunities : Nanoscale Dynamics of Colloidal/Polymer Systems



Richter, J. Appl. Cryst (2007) **40**, s28

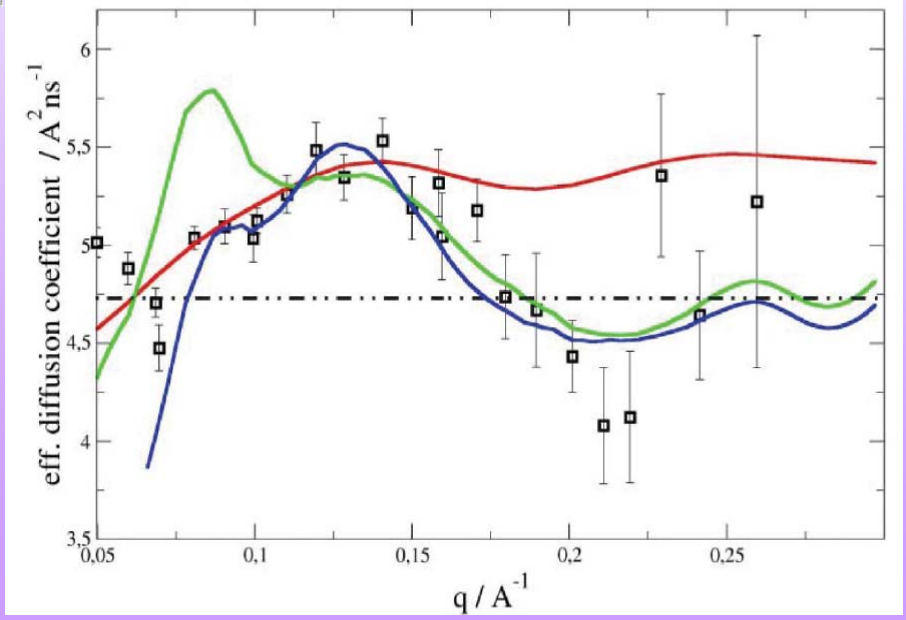


Figure 9
The figure compares the experimental $D_{eff}(Q) = \bar{\Gamma}(Q)/Q^2$ of *Taq* polymerase by NSE (open squares) with those from different dynamic models. The horizontal dashed line is $D_{t,DLS}$. The black solid line is the $D_{eff}(Q)$ of a rigid-body model of *Taq* polymerase. The red line is the $D_{eff}(Q)$ calculated using the dynamic model that parses *Taq* polymerase into two domains, the 5′ nuclease and the Klentaq domains. The blue line is the $D_{eff}(Q)$ calculated assuming three domains.

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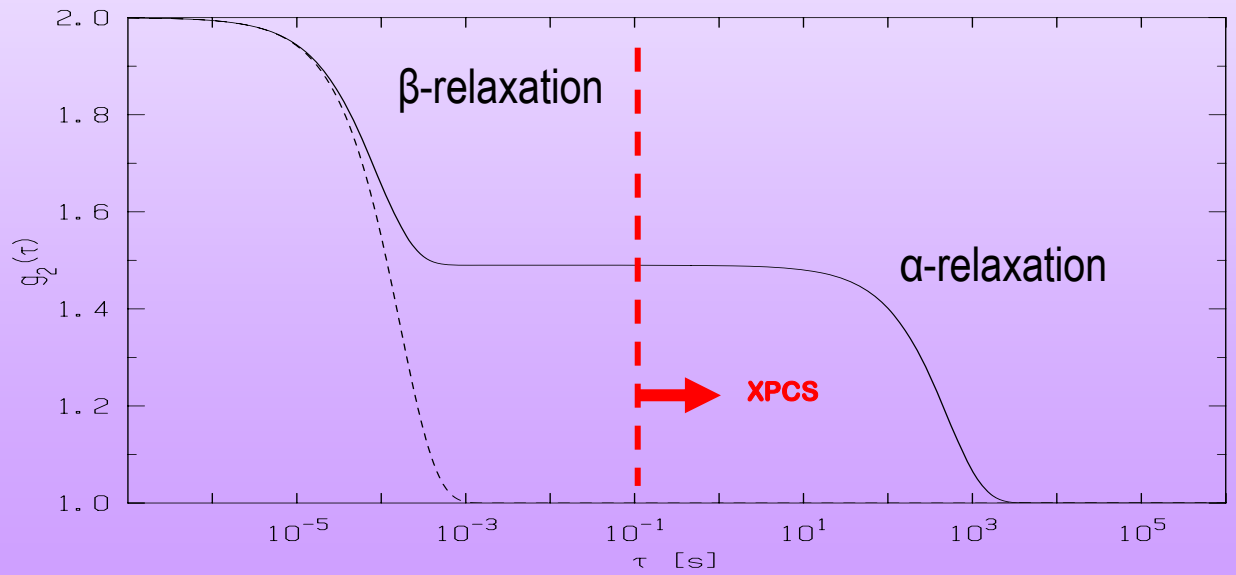
Scientific Opportunities : Glassy Dynamics (1)

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



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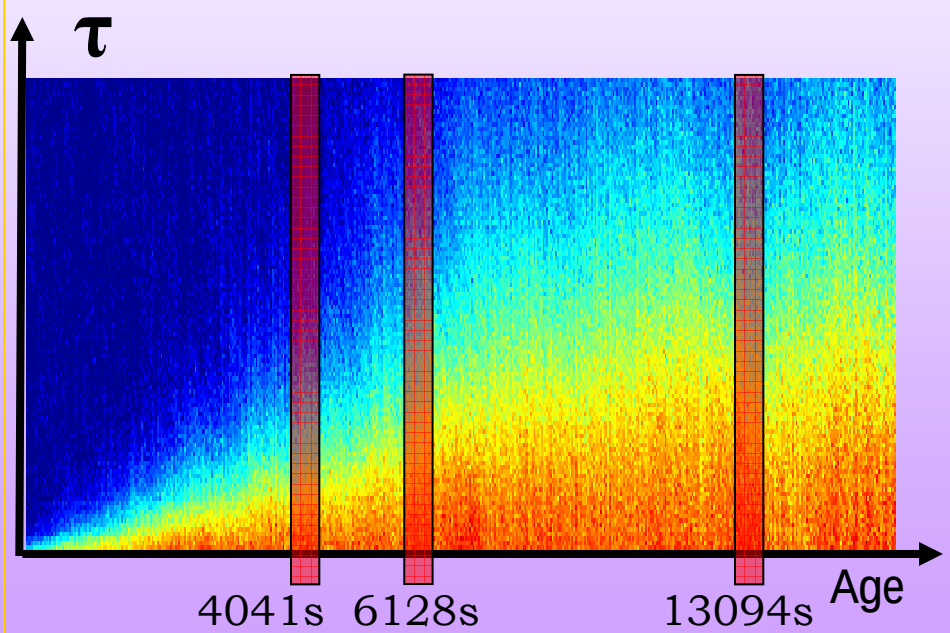
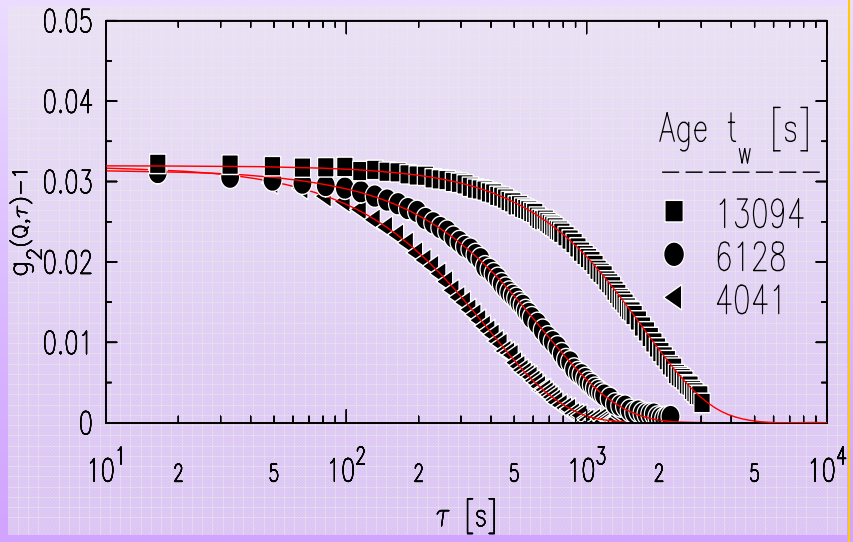
Scientific Opportunities : Glassy Dynamics (2)

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





Europhys. Lett., **75** (5), pp. 764–770 (2006)

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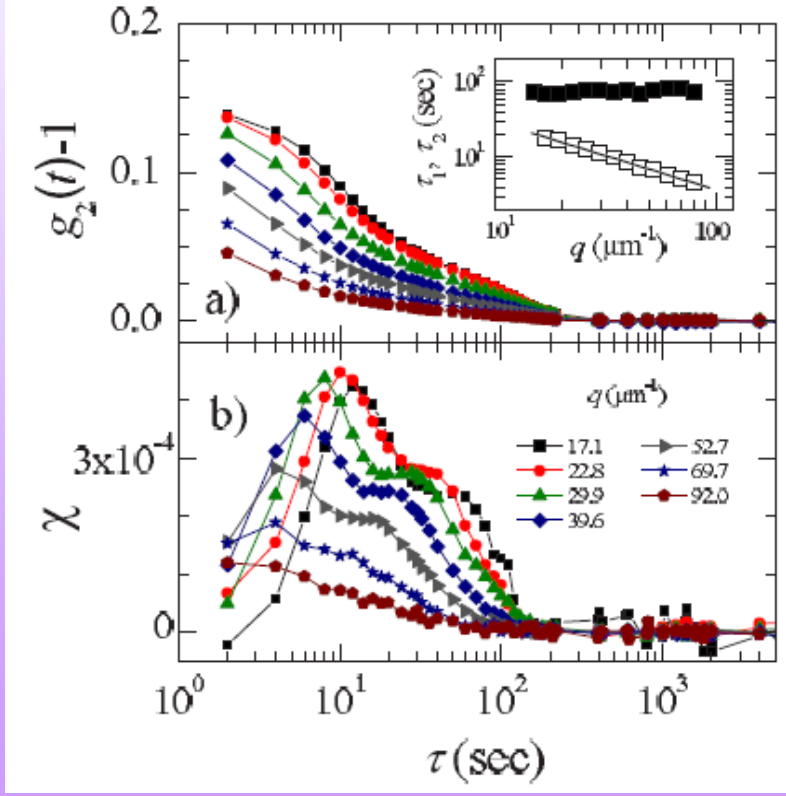
Scientific Opportunities : Glassy Dynamics (3)

- GD is complex i.e. several dynamical processes involved :
  - Intermittent dynamics (χ_4 4th order correlation function)

PHYSICAL REVIEW E 76, 051404 2007

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

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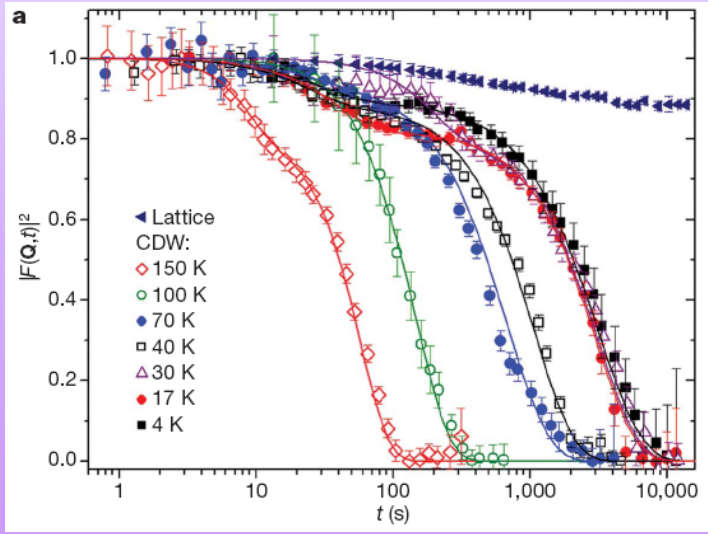
Scientific Opportunities in Hard Condensed Matter: Critical Fluctuations, Phase Transitions

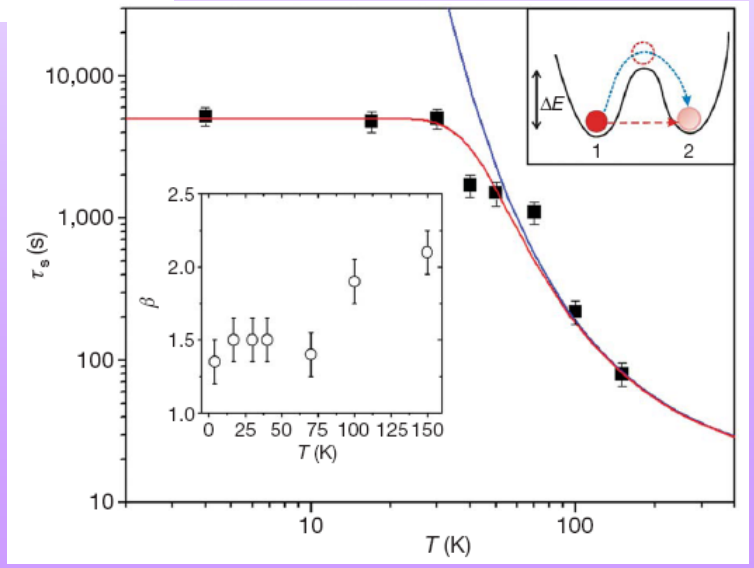
nature Vol 447|3 May 2007|doi:10.1038/nature05776

LETTERS

Direct measurement of antiferromagnetic domain fluctuations

O. G. Shpyrko[1], E. D. Isaacs[1,3], J. M. Logan[3], Yejun Feng[3], G. Aeppli[4], R. Jaramillo[3], H. C. Kim[3], T. F. Rosenbaum[3], P. Zschack[2], M. Sprung[2], S. Narayanan[2] & A. R. Sandy[2]





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

PRL 94, 055501 (2005) PHYSICAL REVIEW LETTERS week ending 11 FEBRUARY 2005

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

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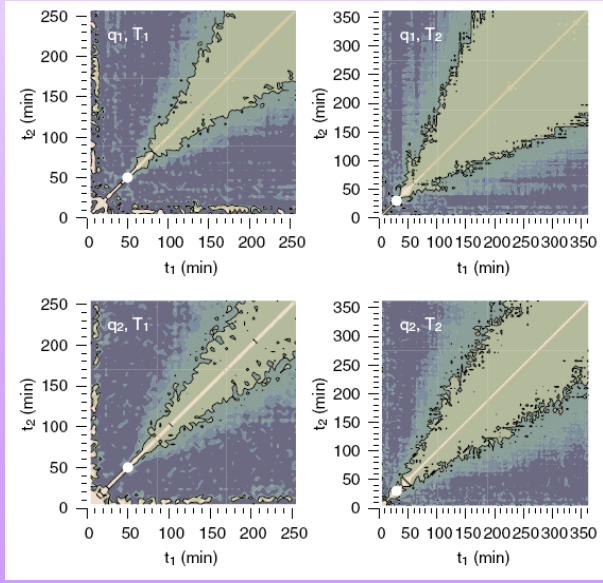
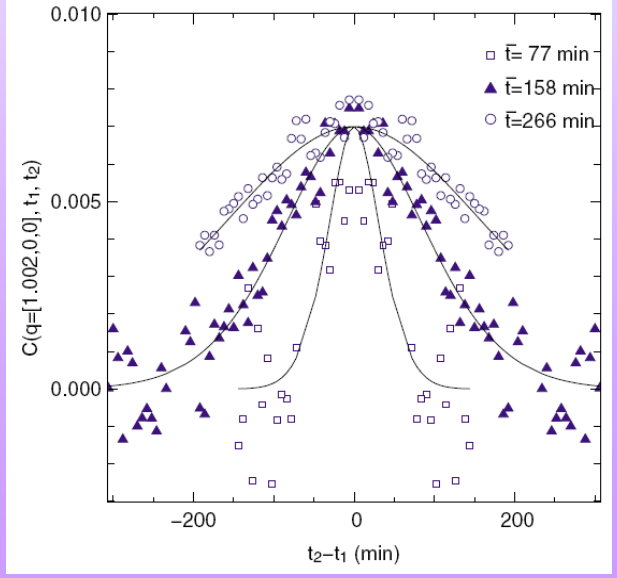
(Received 16 September 2004; published 9 February 2005)



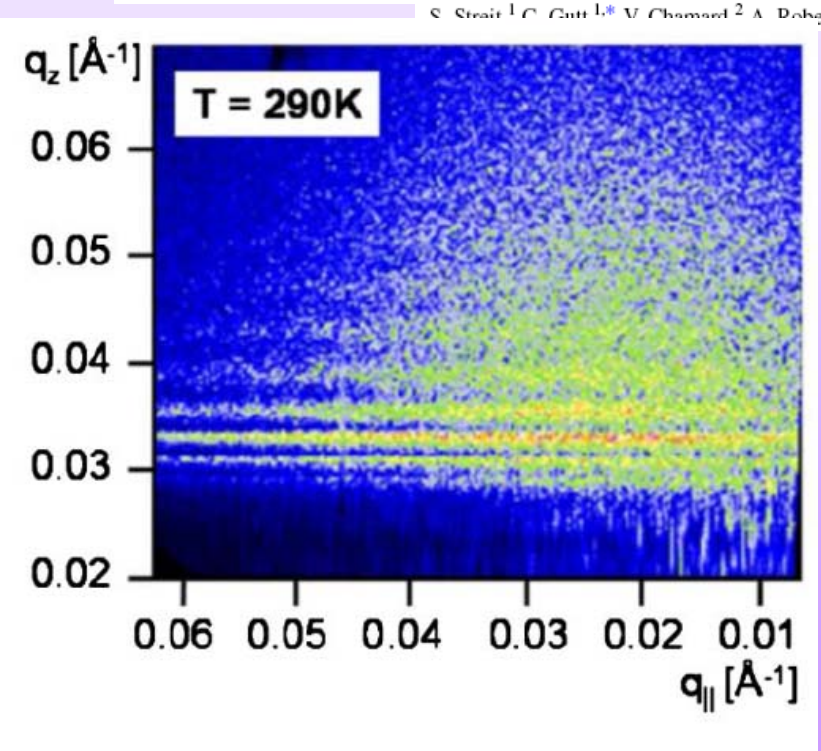


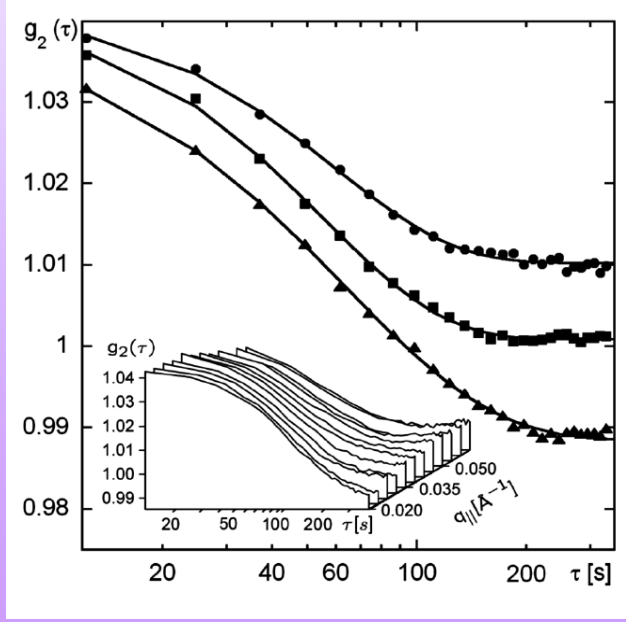
Scientific Opportunities : Grazing Incident XPCS

PRL 98, 047801 (2007) PHYSICAL REVIEW LETTERS week ending 26 JANUARY 2007

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

S. Streit,[1] C. Gutt,[1,*] V. Chamard,[2] A. Robert,[3] M. Sprung,[4] H. Sternemann,[1] and M. Tolan[1]



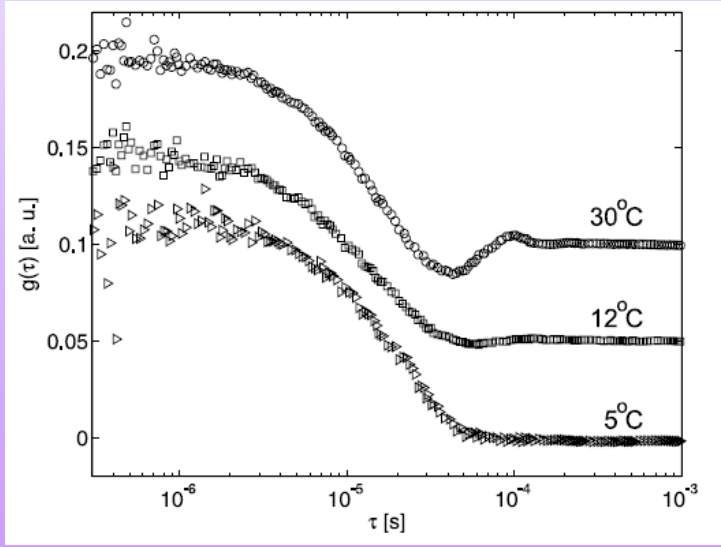


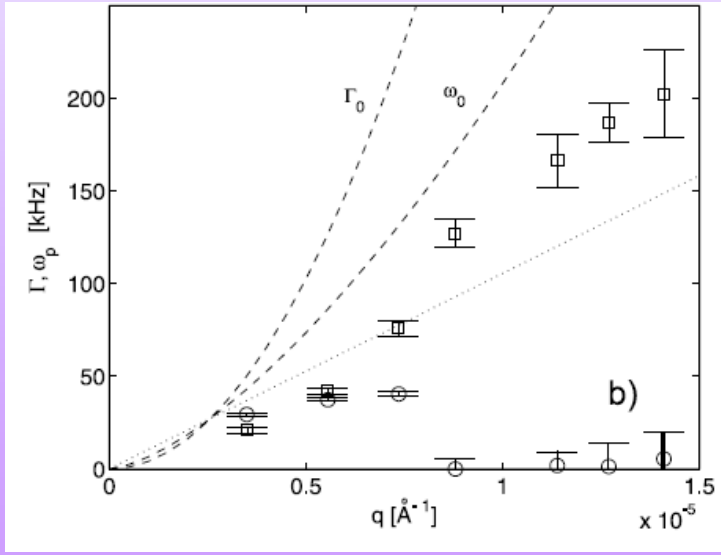
Scientific Opportunities : Grazing Incident XPCS

VOLUME 92, NUMBER 9 PHYSICAL REVIEW LETTERS week ending 5 MARCH 2004

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. Grübel[1]





Scientific Opportunities : Near Field Speckles

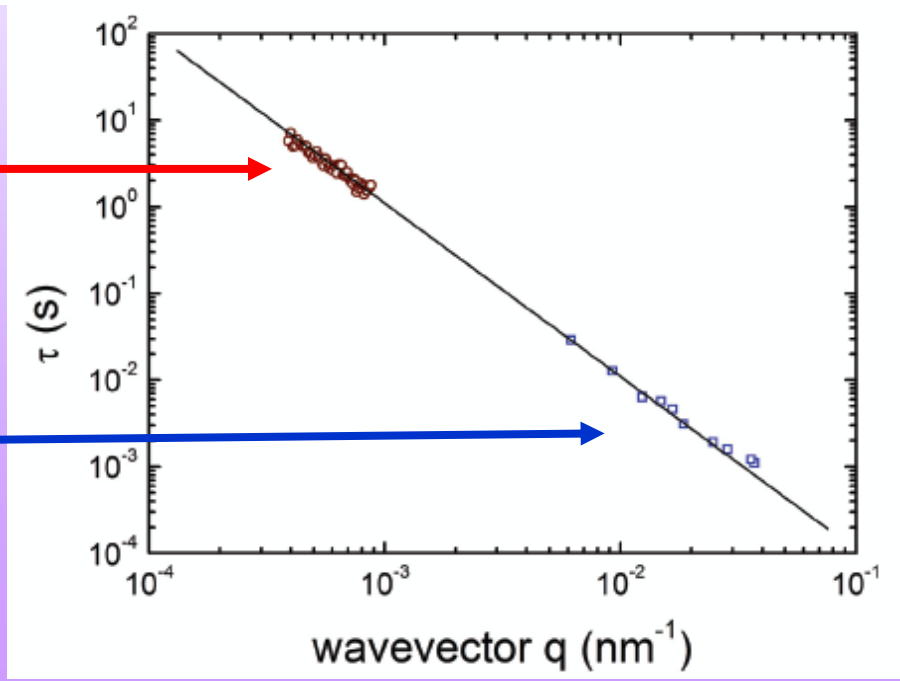
X-ray near field speckles: a new approach to small angle static and dynamic scattering

To be published in Nature Physics

R. Cerbino[1*], L. Peverini[2], M.A.C. Potenza[1], A. Robert[3], P. Bösecke[2], M. Giglio[1]

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

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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 ?

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