Today's Outline - November 30, 2016

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- Presentation schedule

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Final Exam information

Wednesday, December 7, 2016, room 213 SB

Final Exam – Session 1, 09:00-11:20

- 09:00 Johan Nilsson – High-energy surface x-ray diffraction for fast surface structure determination
- 09:20 Kathy Ho – In situ synchrotron x-ray imaging on morphological evolution of dendrites in Sn-Bi hypoeutectic alloy under electric currents
- 09:40 Jason Lerch – X-ray PIV measurement of deep vein blood flow in a rat
- 10:00 Shokoufeh Asalzadeh – Structural evolution of platinum thin films grown by atomic layer deposition
- 10:20 Stoichko Antonov – Visualization of a lost painting by Vincent van Gogh using synchrotron radiation based x-ray fluorescence elemental mapping
- 10:40 Henry Gong – Three-dimensional imaging of crystalline inclusions embedded in intact maize stalks
- 11:00 Runzi Cui – Spherical quartz crystals investigated with synchrotron radiation

Final Exam – Session 2, 13:00-15:40

- 13:00 Nicholas Goldring – Reactivity of $LiBH_4$: In situ synchrotron radiation powder x-ray diffraction study
- 13:20 Anthony Llodra – Imaging instantaneous electron flow with ultrafast resonant x-ray scattering
- 13:40 Gongxiaohui Chen – Rotation of x-ray polarization in the glitches of a silicon monochromator
- 14:00 Sarah Aldakheel – Synchrotron radiation diffraction enchanced imaging of chronic glomerulonephritis mode
- 14:20 Bo Liu – Chain stiffness of stilbene containing alternating copolymers by SAXS and SEC
- 14:40 Krishna Joshi – Transition elements and nucleation in glasses using x-ray absorption spectroscopy
- 15:00 Yang Liu – Visualization and quantification of electrochemical and mechanical degradation in Li ion batteries
- 15:20 Yiqing Zhang – TBD

X-ray holography

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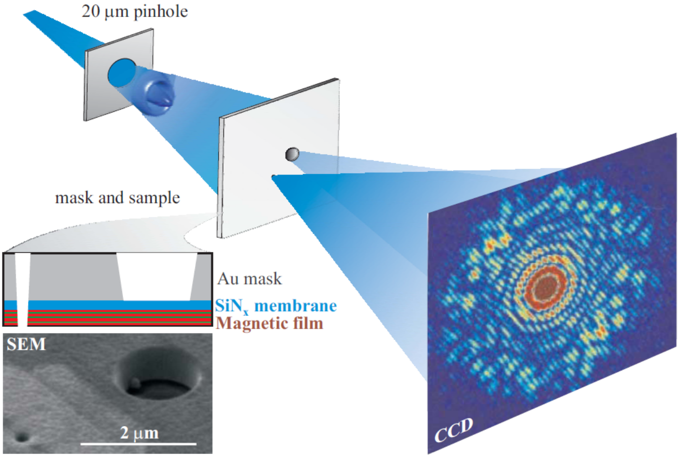
We'll cover three cases, Fourier transform holography, x-ray fluorescence holography, and femtosecond time-delay holography

Fourier transform holography

The sample (a Co/Pt magnetic multilayer) and mask which produces the reference beam are fabricated on a single substrate



"Lensless imaging of magnetic nanostructures by x-ray spectro-holography," S. Eisenbitt, et al., *Nature* **432**, 885 (2013).

Fourier transform holography

The total scattering amplitude of the Fraunhofer pattern, $A(\vec{Q})_T$, is the sum of the scattering amplitudes from the reference, $A(\vec{Q})_R$, and the object, $A(\vec{Q})_O$.

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the Fourier transform of the Fraunhofer pattern has a central portion which consists of the object and reference beam self-correlations.

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the cross-correlations appear in the corners and are the ultimate goal of the investigation

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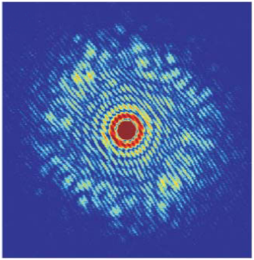
Fourier transform holography



Left circular

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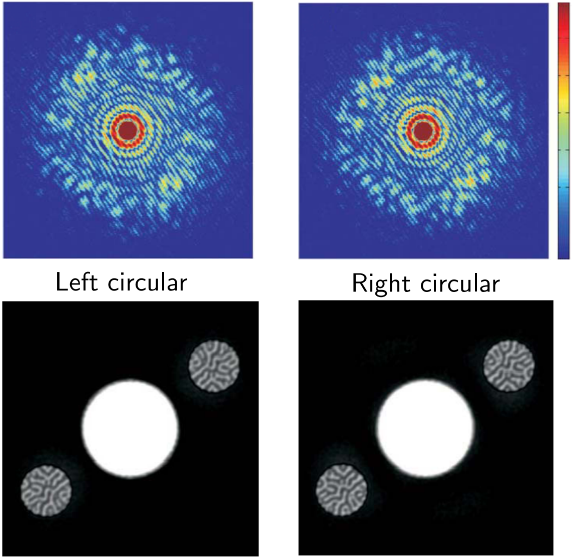
Fourier transform holography



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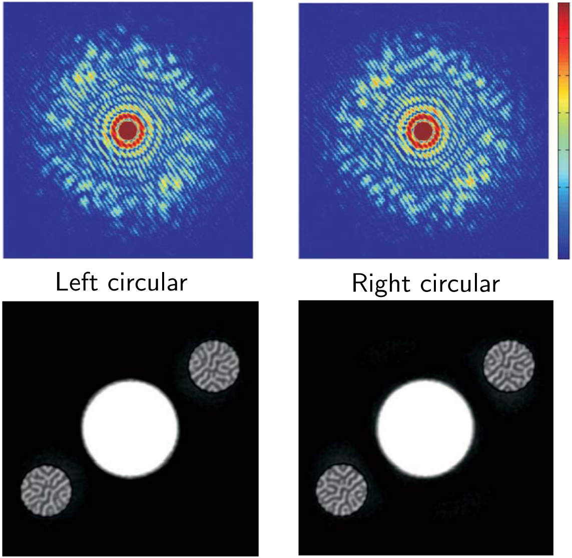
Fourier transform holography



The right circular image is the inverse of the left circular image

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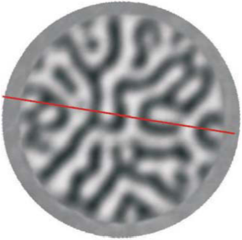
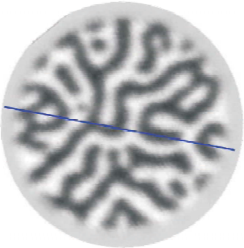
Fourier transform holography





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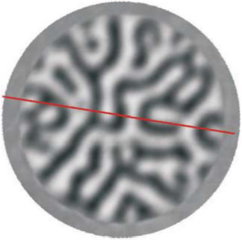

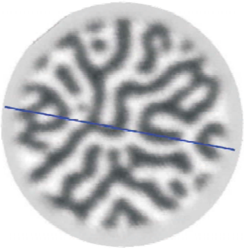

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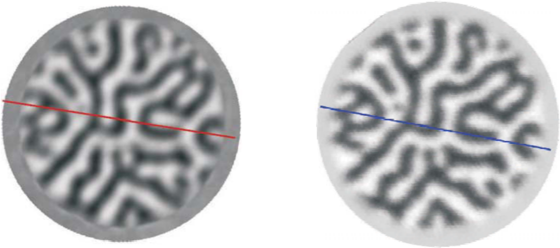

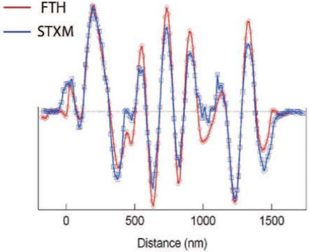

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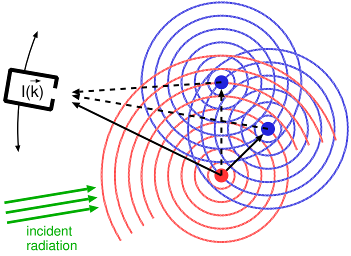
X-ray fluorescence holography



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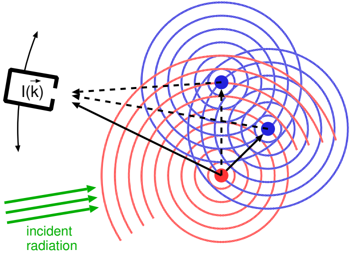

In X-ray fluorescence holography (XFH), a monochromatic source stimulates fluorescence from atom A which partially travels directly to the detector, forming the reference beam. The scattered fluorescence from nearby atoms provides the object beam

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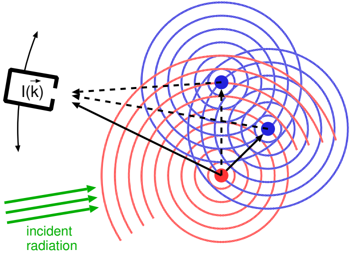

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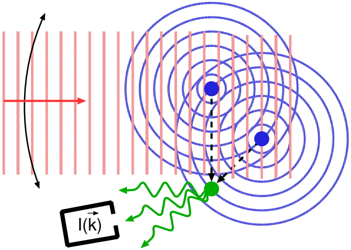

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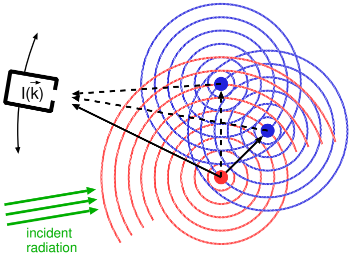

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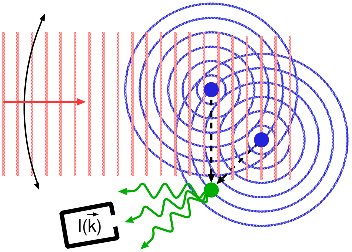

In multiple energy x-ray holography (MEXH), atom A is the detector whose flourescence is measured as a function of energy and angle. The incident radiation is the reference beam and the scattered radiation from nearby atoms is the object beam.

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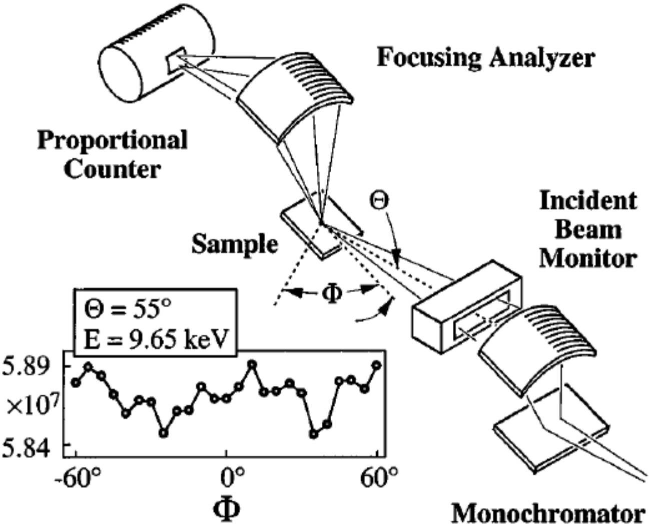

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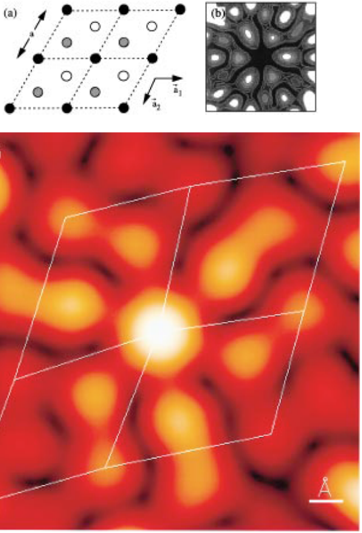

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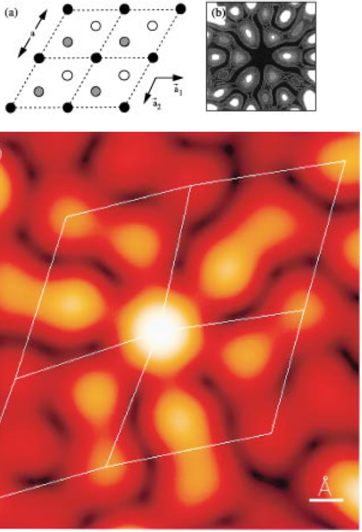

The symmetry and crystallographic axes are clearly visible

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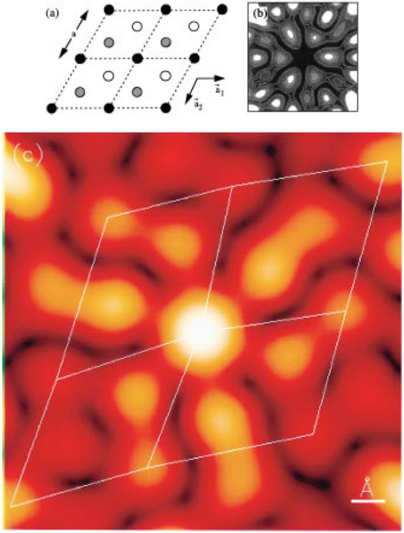

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Oxygens are too light to be readily visible in this image

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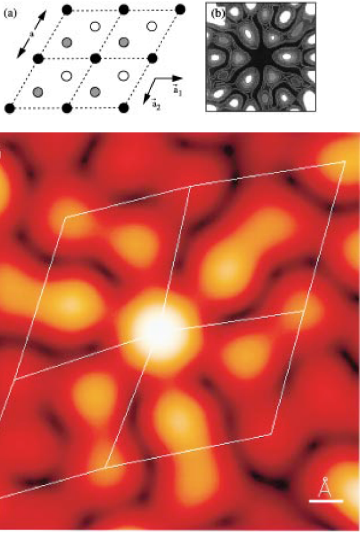

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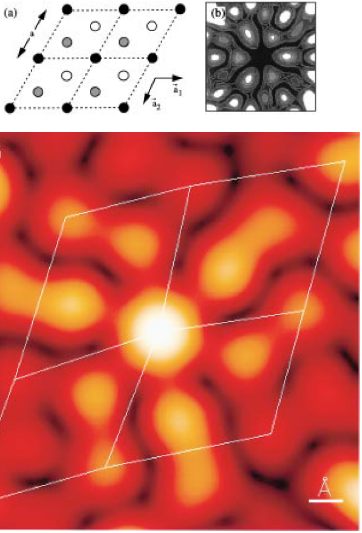

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The image is a projection of the structure to the basal plane instead of being a slice through the 3D structure. Atoms from all planes are visible.

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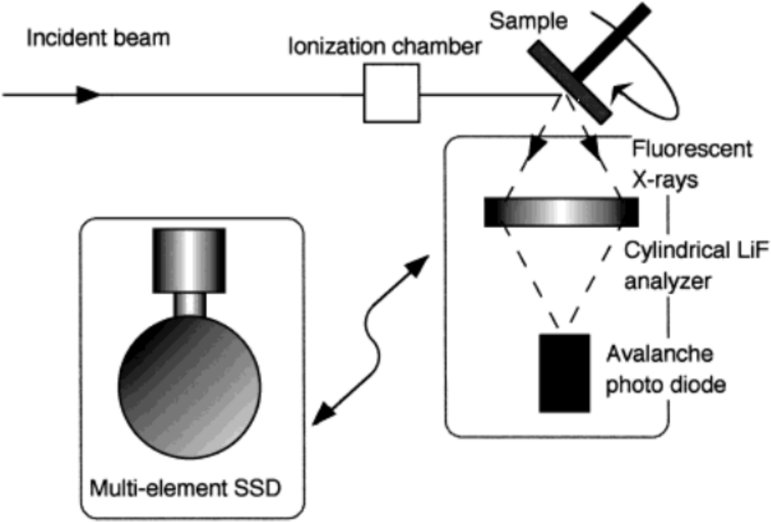
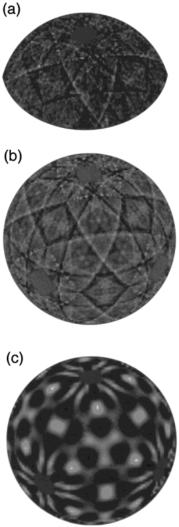
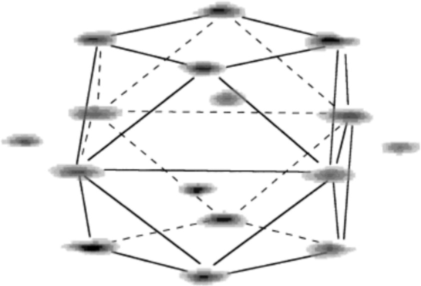


"Refinement of x-ray fluorescence holography for determination of local atomic environment," K. Hayashi, Y. Takahashi, and E. Matsubara, *Mater. Trans.* **43**, 1464-1468 (2002).

MEXH of Au





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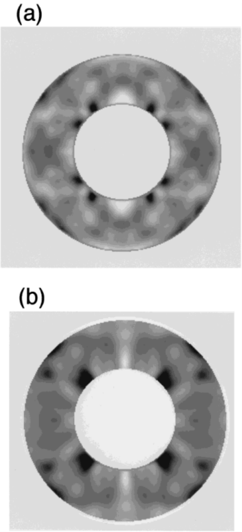

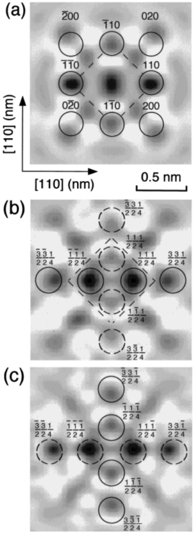

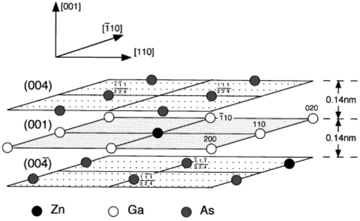

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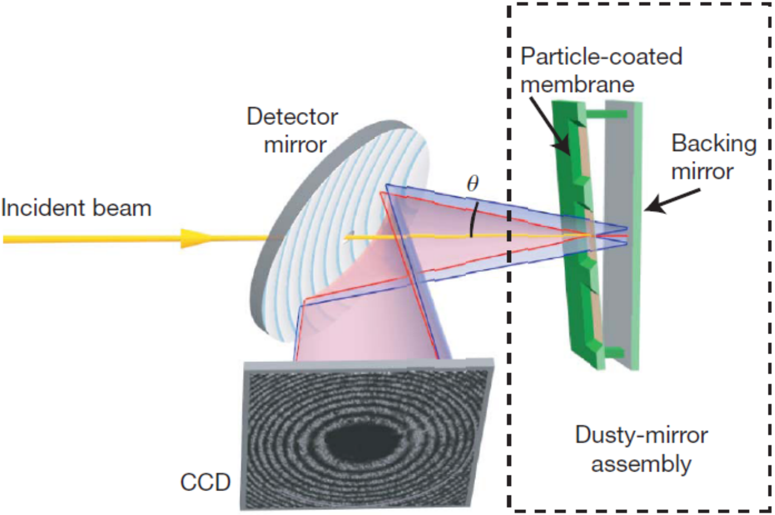
Femtosecond time delay holography



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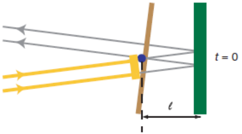

incident beam strikes sphere at distance l from mirror

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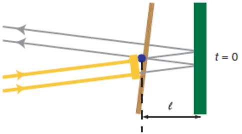

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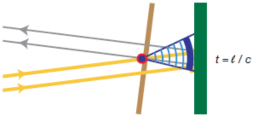

sphere scatters x-rays to mirror and explodes

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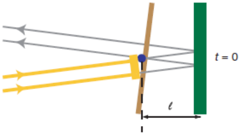
Femtosecond time delay holography



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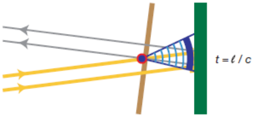

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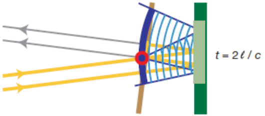

reference beam is reflected back toward exploding sphere

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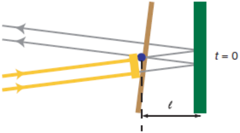

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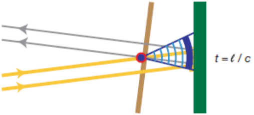

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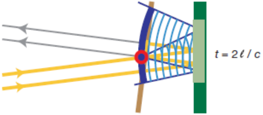

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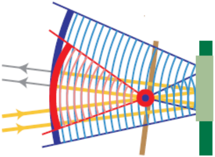

exploding sphere scatters x-rays (object beam) with time delay $t = 2l/c$

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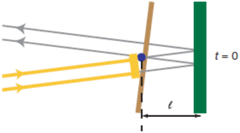
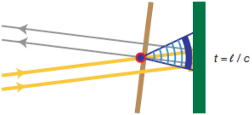
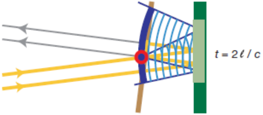
Femtosecond time delay holography



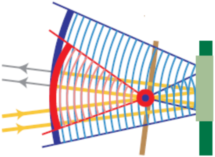
incident beam strikes sphere at distance l from mirror



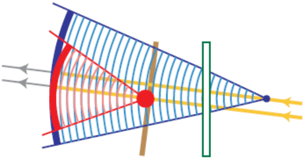
sphere scatters x-rays to mirror and explodes



reference beam is reflected back toward exploding sphere



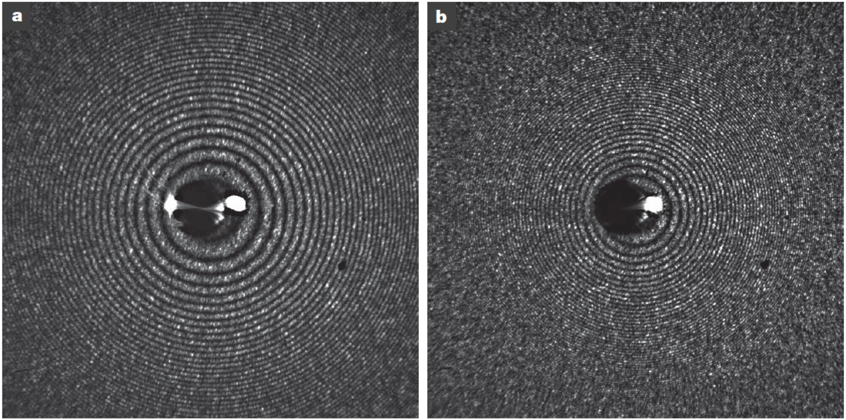
exploding sphere scatters x-rays (object beam) with time delay $t = 2l/c$



linearized layout of holographic event, varying time delay provided by angled sample holder

"Femtosecond time-delay x-ray holography," H.N. Chapman, et al., *Nature* **448**, 676-680 (2007).

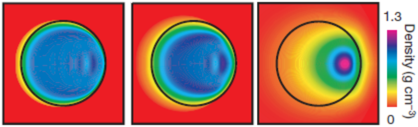
Femtosecond time delay holography



Measured holograms at two different delay times (348 fs left and 733 fs right) for at least 1000 polystyrene spheres which cause the speckle. Note the change in fringe spacing and envelope diameter

"Femtosecond time-delay x-ray holography," H.N. Chapman, et al., *Nature* **448**, 676-680 (2007).

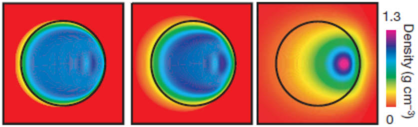
Femtosecond time delay holography



Simulated density profile of the exploding polystyrene sphere at 0.5 ps, 0.9 ps and 3.2 ps. Envelope clearly grows with time.

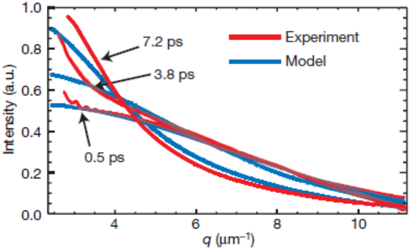
"Femtosecond time-delay x-ray holography," H.N. Chapman, et al., *Nature* **448**, 676-680 (2007).

Femtosecond time delay holography



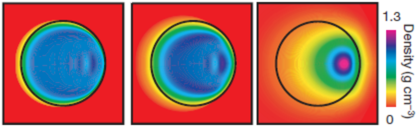
Simulated density profile of the exploding polystyrene sphere at 0.5 ps, 0.9 ps and 3.2 ps. Envelope clearly grows with time.

Envelope of the hologram intensity for simulated and measured events. The narrowing of the envelope in q-space indicates a growing particle diameter with time



"Femtosecond time-delay x-ray holography," H.N. Chapman, et al., *Nature* **448**, 676-680 (2007).

Femtosecond time delay holography



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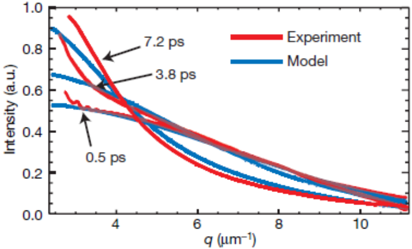

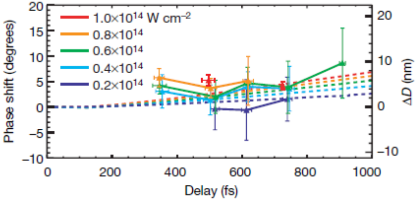

Measured (points) and calculated (dashed lines) phase shifts, and therefore changes in particle diameter.

"Femtosecond time-delay x-ray holography," H.N. Chapman, et al., *Nature* **448**, 676-680 (2007).