

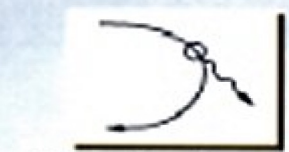
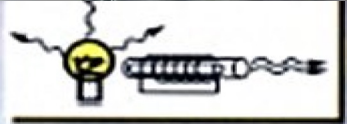
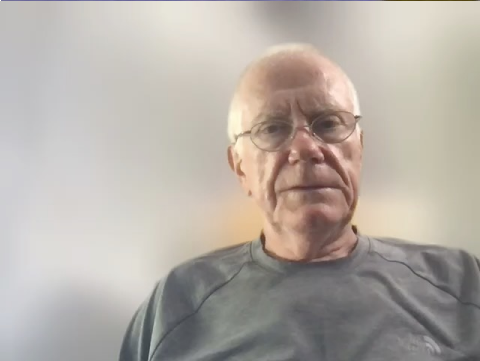
Length & Time Scales Measured using Neutron and X-Ray Scattering

by

Roger Pynn

Indiana University and Oak Ridge National Lab

Radiation Sources



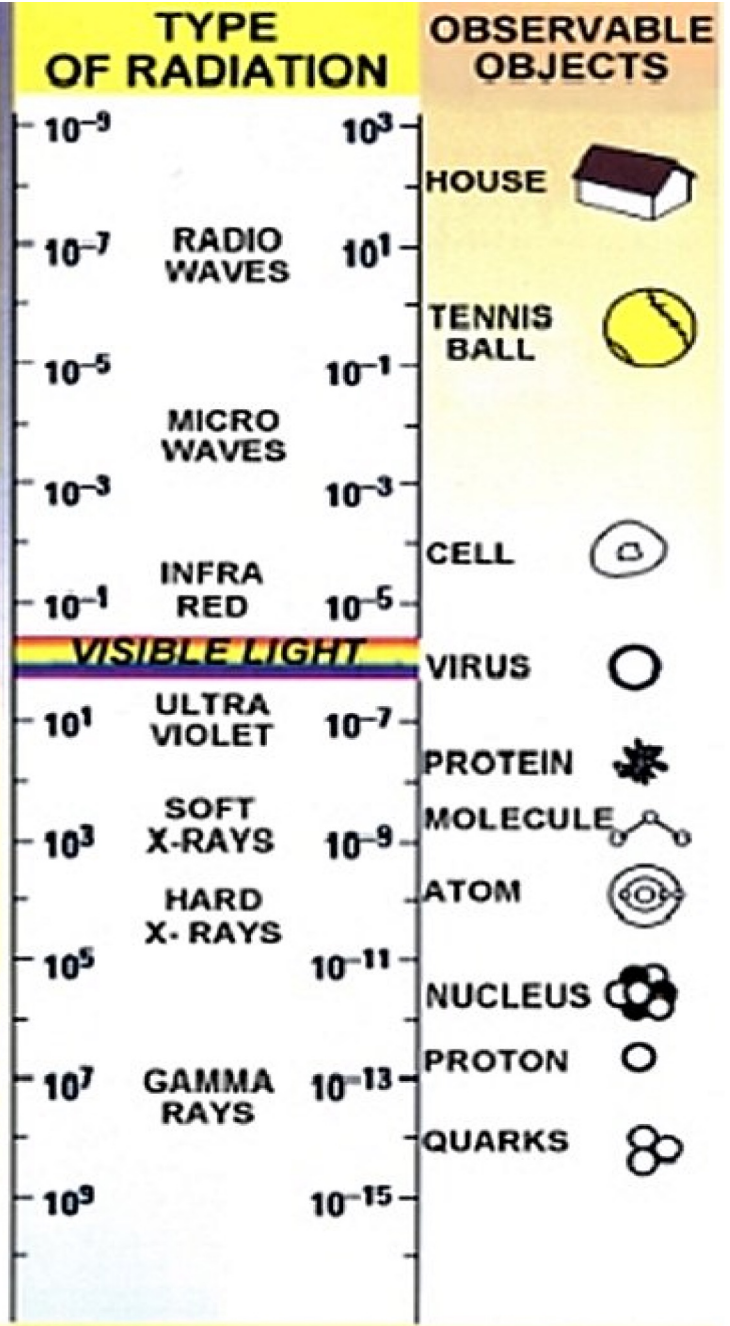
Synchrotron Radiation Sources



Radioactive Sources



Particle Accelerators



Photon Energy (eV)

Wave length (m)

Wavelength

≈

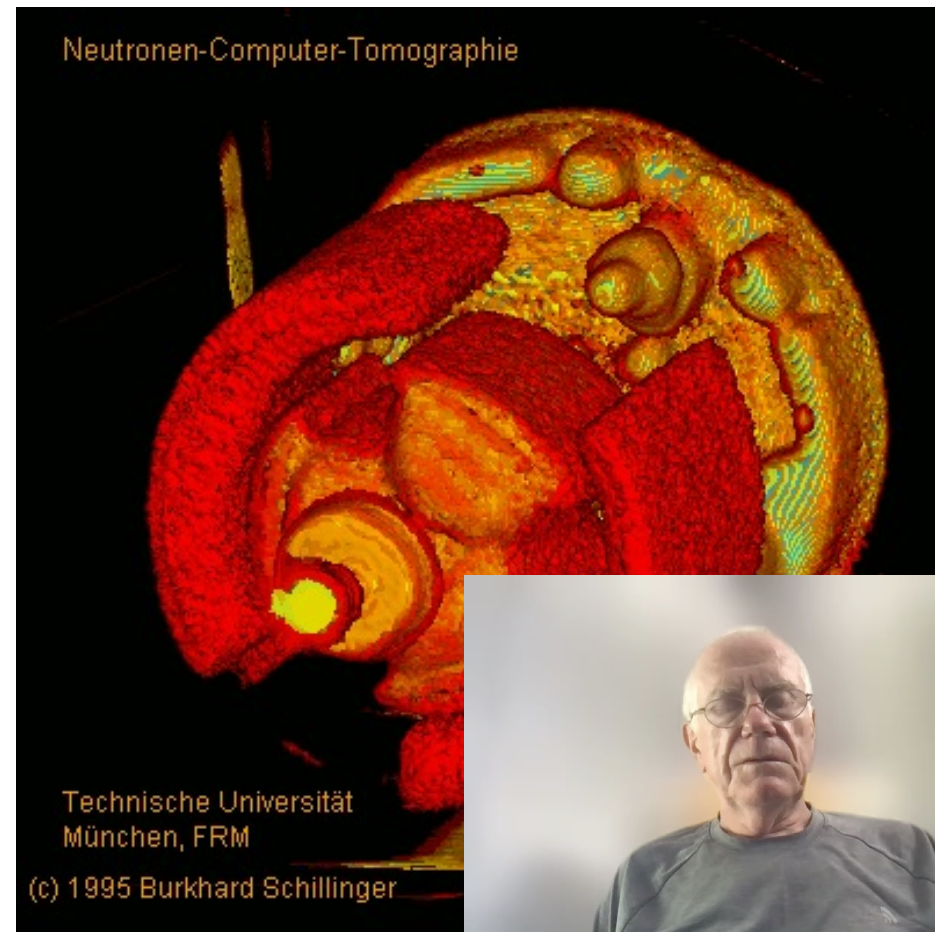
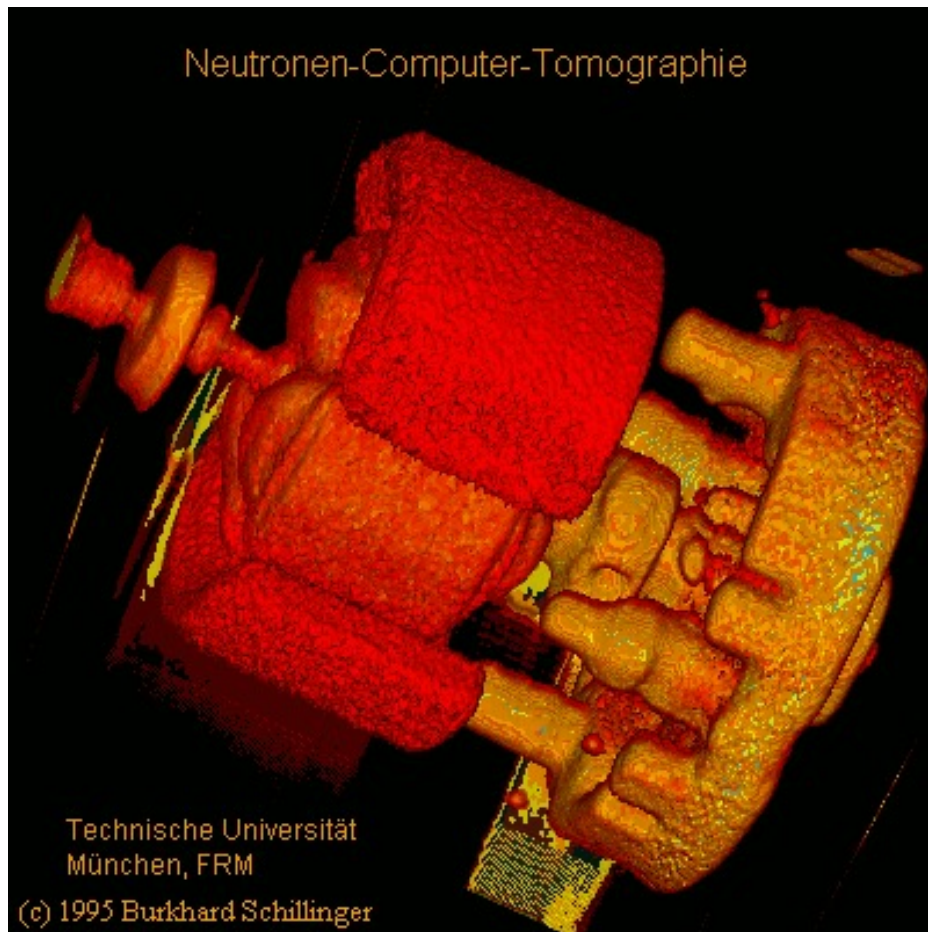
Object Size

≈

Angstroms
for Condensed
Matter Research

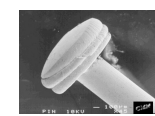
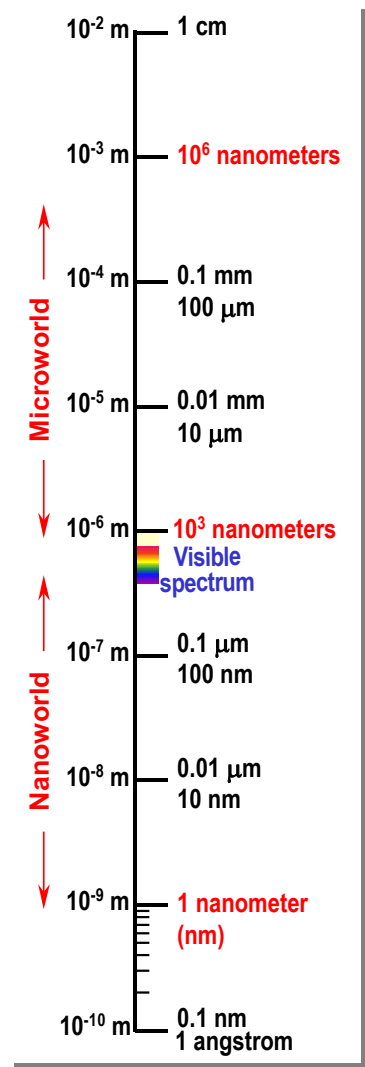
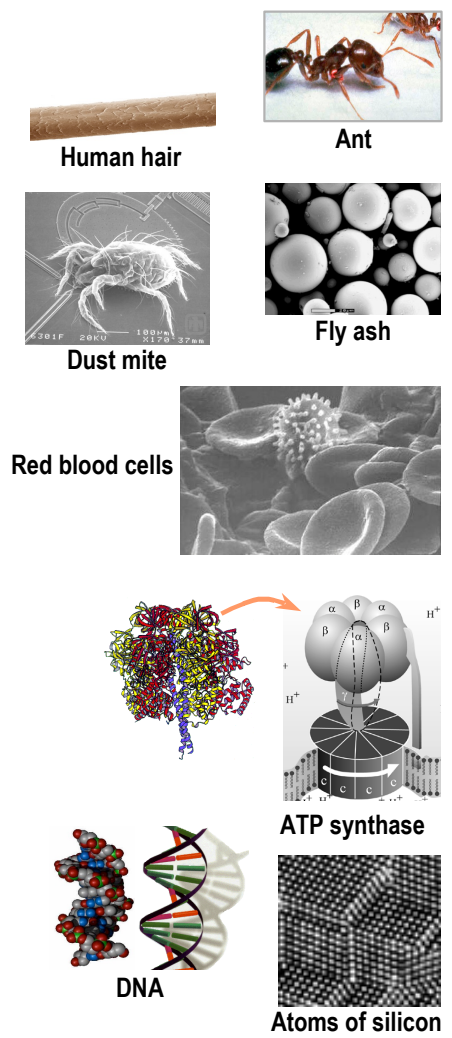
$$\lambda [\text{\AA}] = \frac{12.398}{E_{ph} [\text{keV}]}$$

The Spatial Resolution Obtainable by Direct Imaging with Neutrons cannot achieve atomic resolution



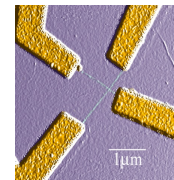
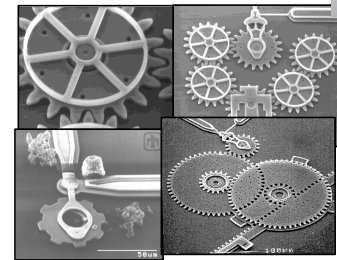
Cold Neutron Tomography — University of Munich
Small Electric motor with outer casing filtered out

Neutrons and X-Rays Measure Structures from Angstroms to Centimeters

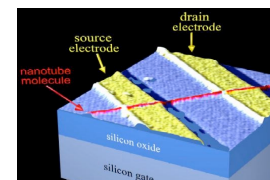


Head of a pin

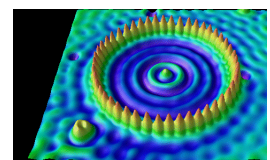
Microelectromechanical Device



Nanotube electrode



Nanotube transistor



Quantum corral of 48 iron atoms



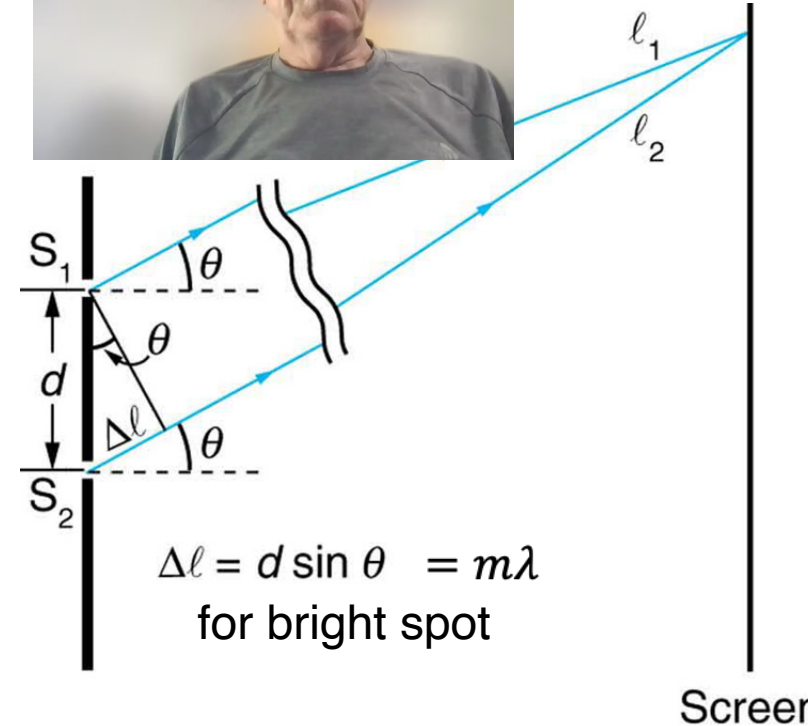
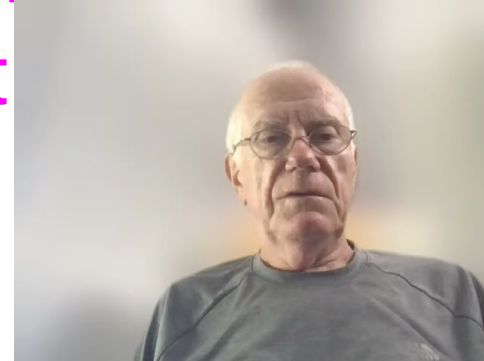
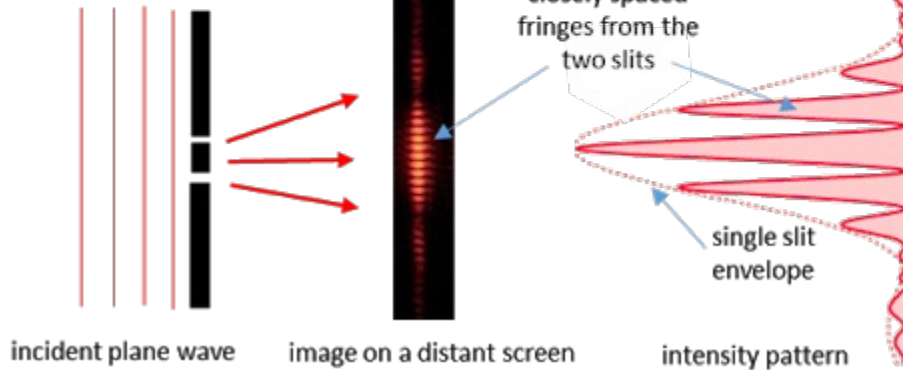
For length scales less than ~10 microns for neutrons and sub-micron for x-rays, radiography is replaced by diffraction as a structural tool

Young's Slits illustrate diffraction with visible light



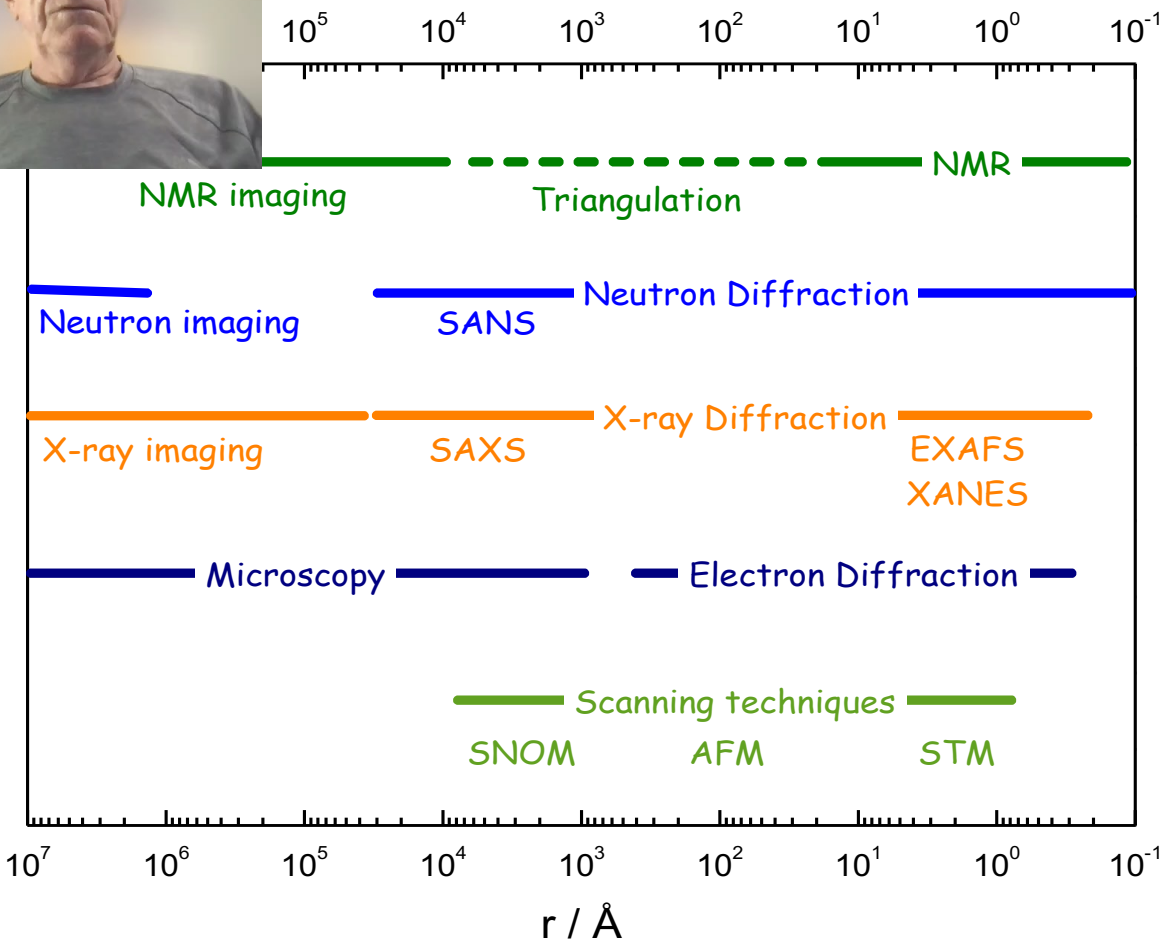
widely spaced fringes due to interference of light from the two single slits

closely spaced fringes due to interference of light from the two slits



- Bright spots appear at scattering angles, θ , related to the slit separation, d , and radiation wavelength, λ
- The envelope function is determined by the size of the slits
- X-ray and neutron diffraction follow the same interference principles as visible light

Neutron & X-ray Scattering Complement Other Techniques in Length Scale....



- considerable overlap of length scales
- complementary because of different element specificity
- very different samples sizes needed
- some techniques gives pictures, others provide averaged information

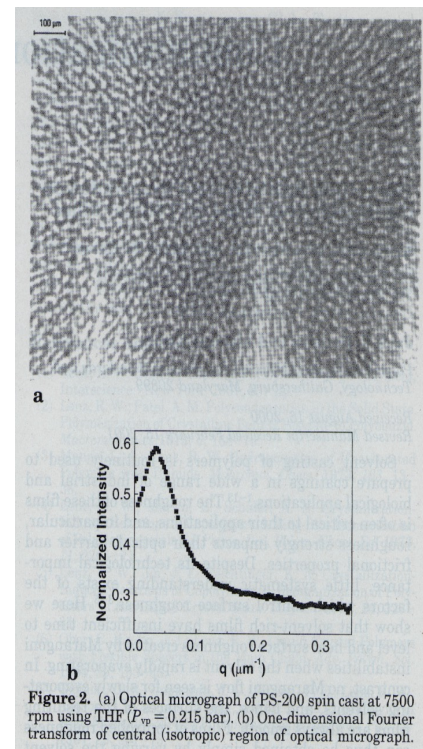


Figure 2. (a) Optical micrograph of PS-200 spin cast at 7500 rpm using THF ($P_p = 0.215$ bar). (b) One-dimensional Fourier transform of central (isotropic) region of optical micrograph.

.....and Time Scale

