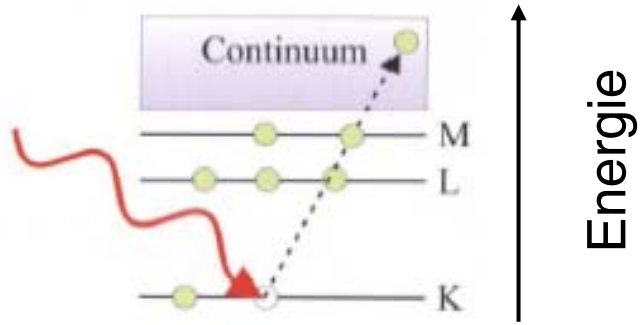
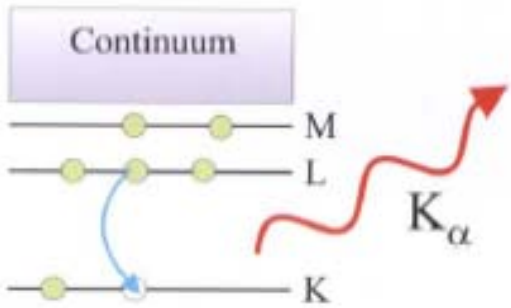
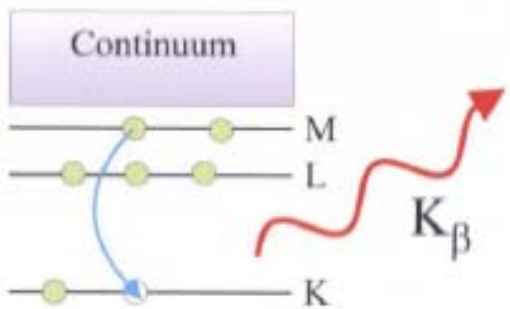
# Absorption von Röntgenstrahlung

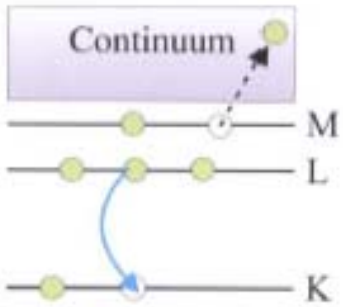
photoelektrische Absorption




Fluoreszenz-Emission

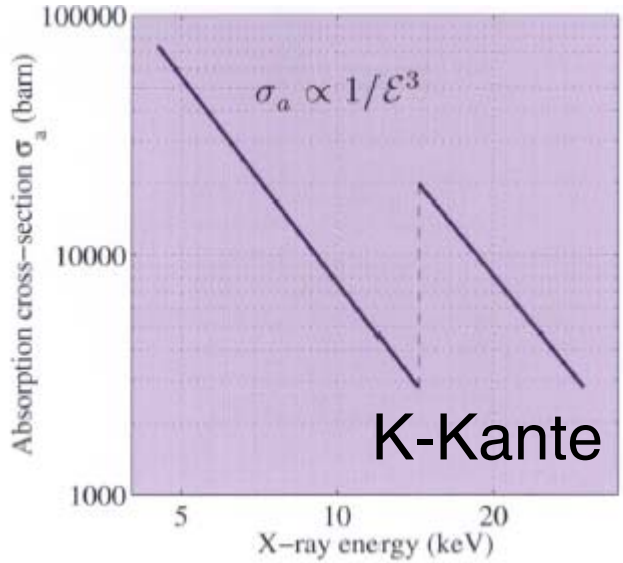



Emission eines Auger-Elektrons

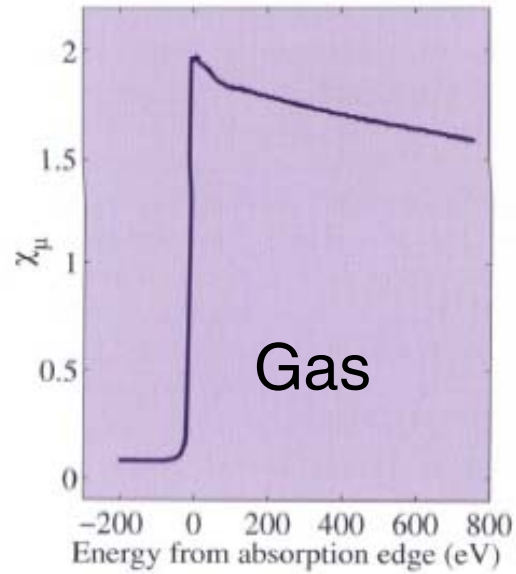
Als-Nielsen 2001, Abb. 1.9

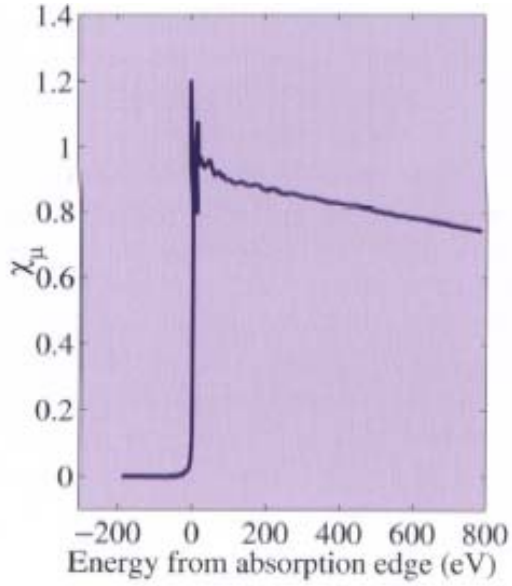
# Röntgen-Absorptionsquerschnitt

Absorptionsquerschnitt
von Krypton




Feinstruktur (EXAFS)
an der Kr K-Kante

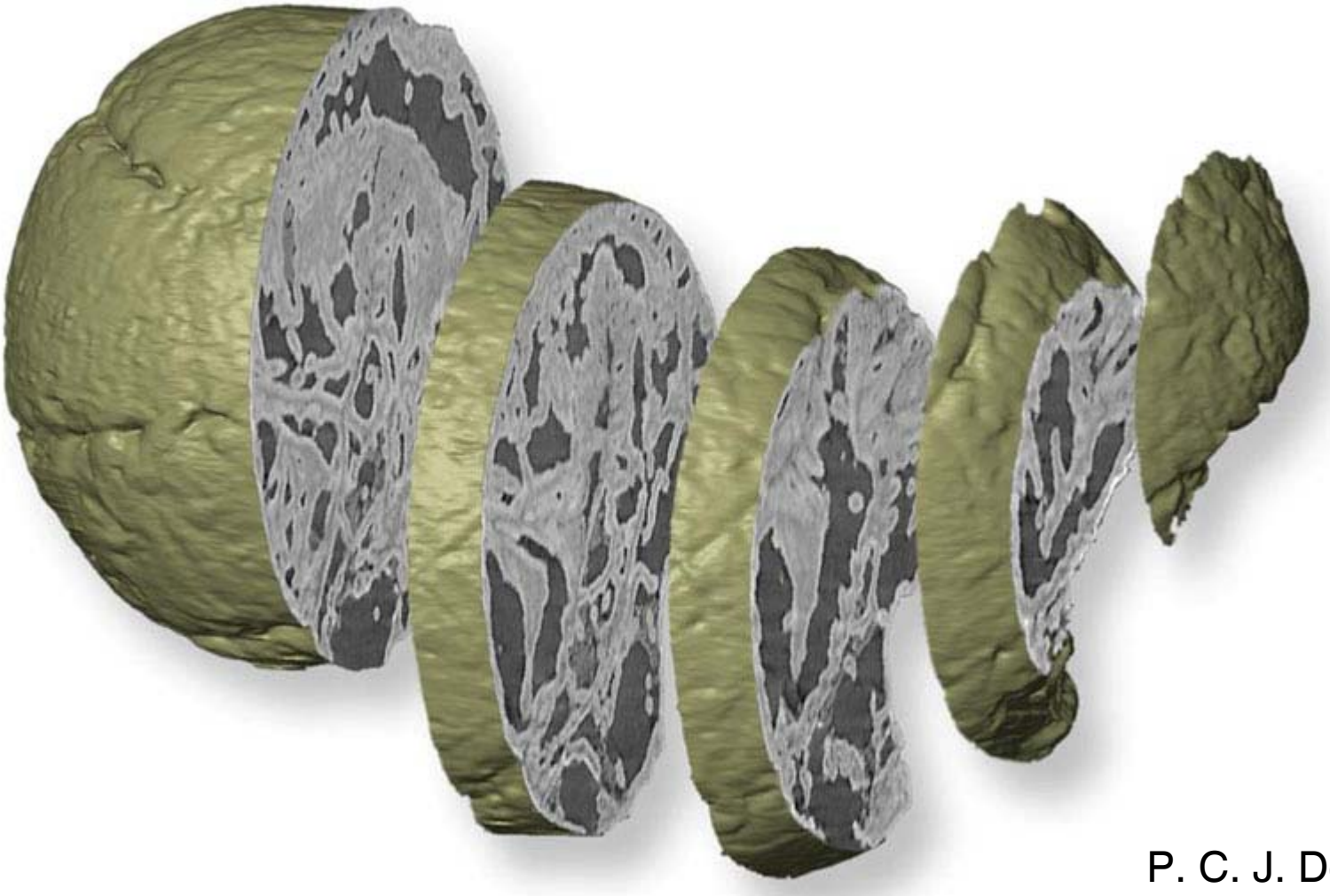



2D-Kristall
(adsorbiert
auf Graphit)

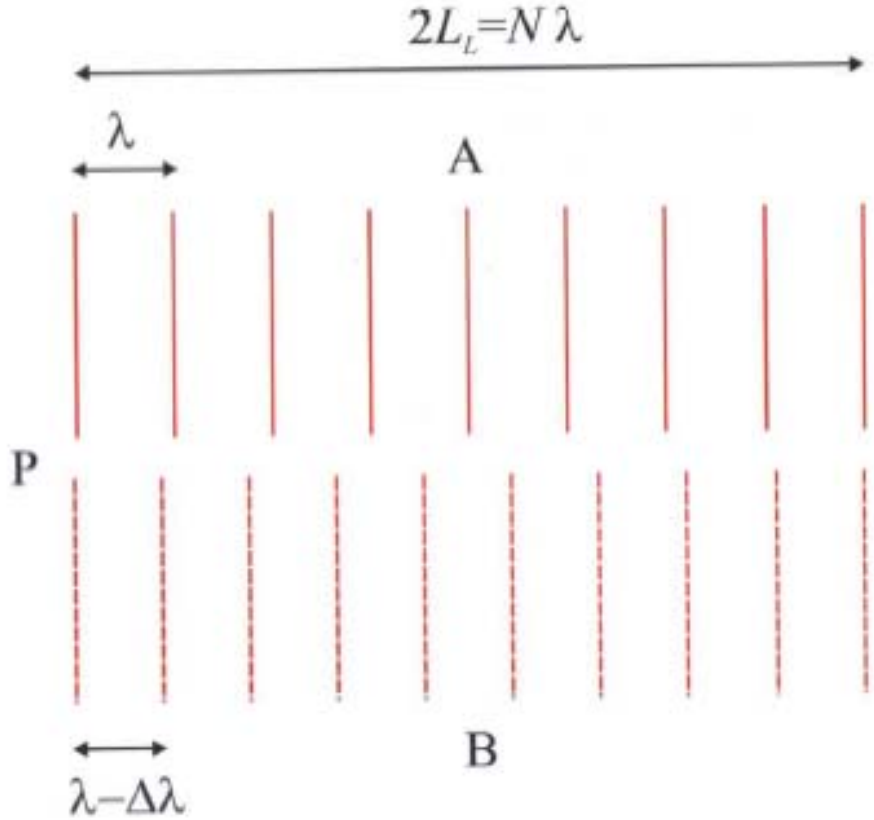
Als-Nielsen 2001, Abb. 1.11

# Synchrotron X-ray tomographic microscopy of fossil embryos

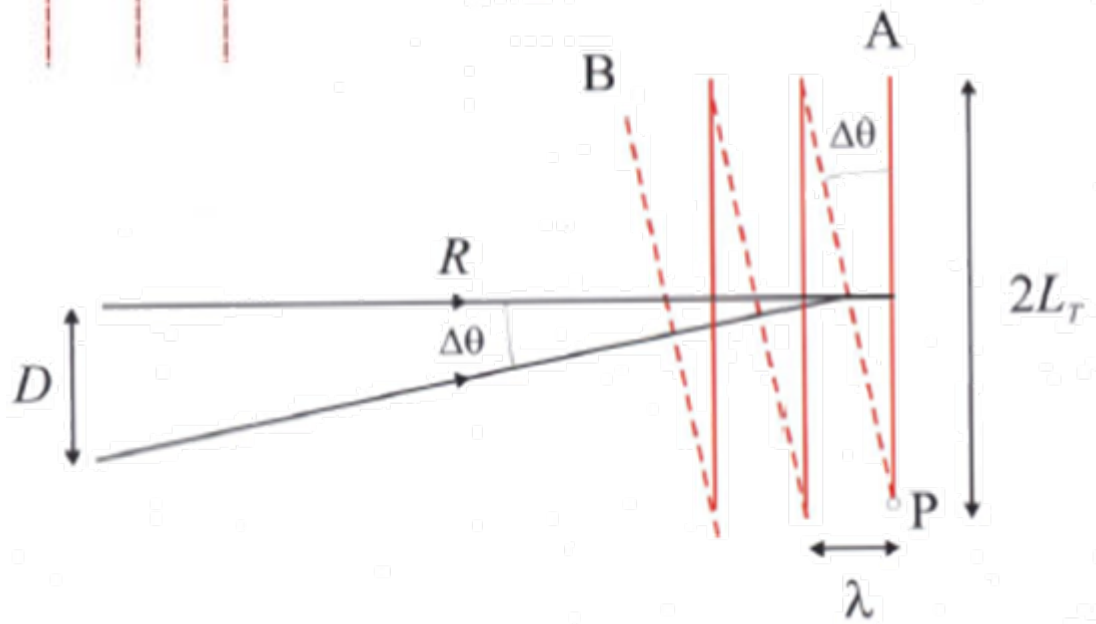


P. C. J. Donoghue *et al.*,
*Nature* **442**, 680 (2006)

# Kohärenz



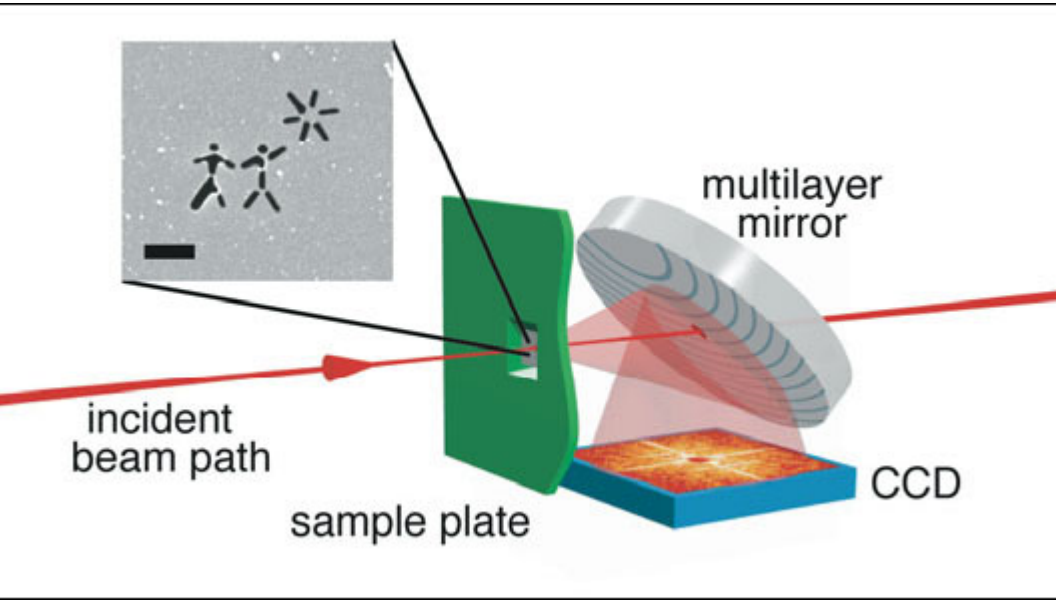

longitudinale
Kohärenzlänge

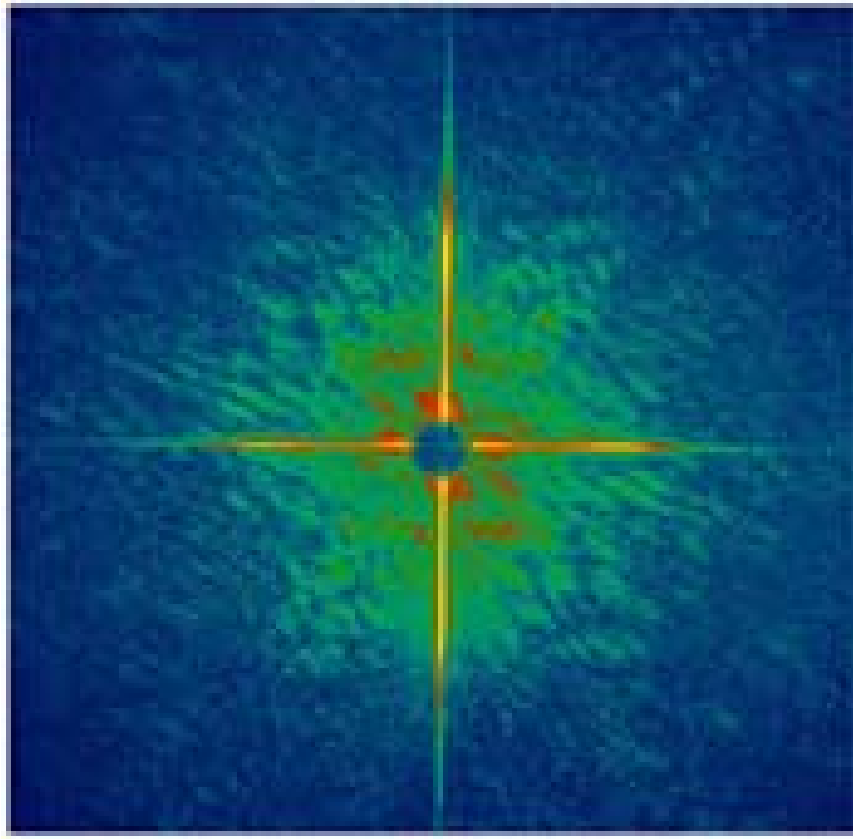



Transversale
Kohärenzlänge

Als-Nielsen 2001, Abb. 1.14

# Kohärentes Imaging

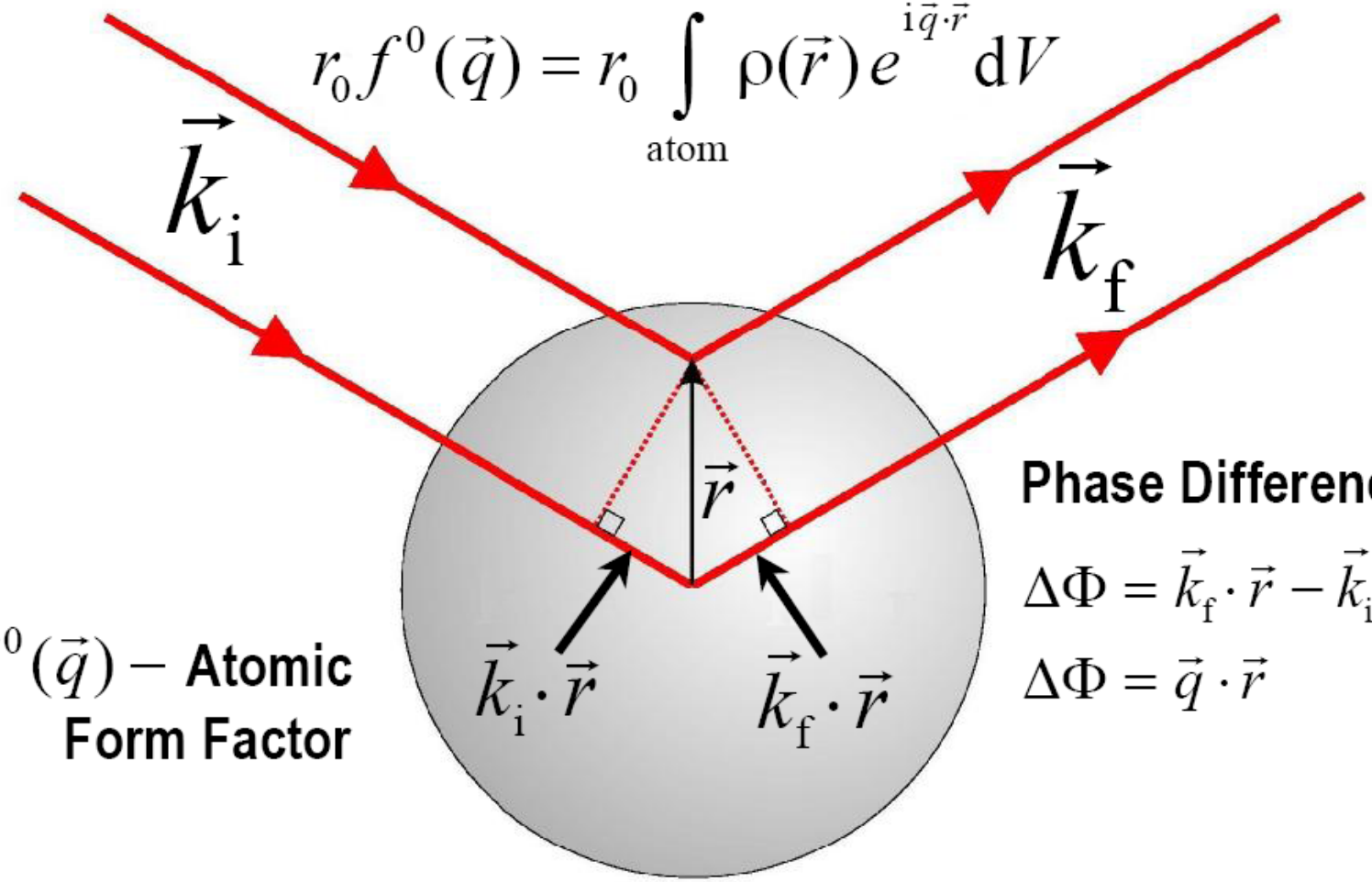


H.N. Chapman *et al.*,
Nature Physics **2**, 839 (2006)

# Scattering Length of an Atom

$$r_0 f^0(\vec{q}) = r_0 \int_{\text{atom}} \rho(\vec{r})\, e^{i\vec{q}\cdot\vec{r}}\, dV$$




$f^0(\vec{q})$ – Atomic Form Factor

**Phase Difference:**

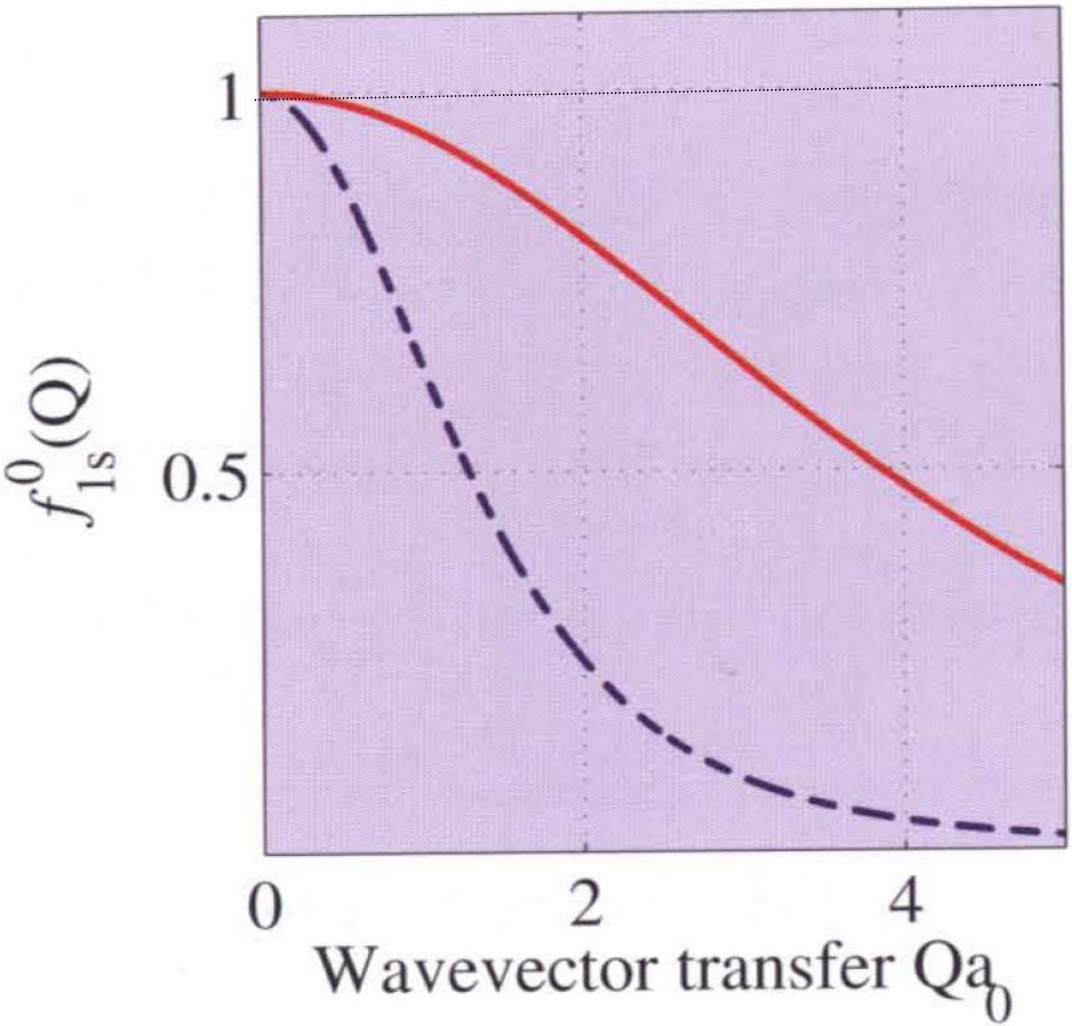
$$\Delta\Phi = \vec{k}_f \cdot \vec{r} - \vec{k}_i \cdot \vec{r}$$

$$\Delta\Phi = \vec{q} \cdot \vec{r}$$

Als-Nielsen 2001, Abb. 1.6

# Form Factor

$$f^{0}(\vec{q}) = \int \rho(\vec{r}) e^{i\vec{q}\cdot\vec{r}}\, dV$$




**“point” atom**

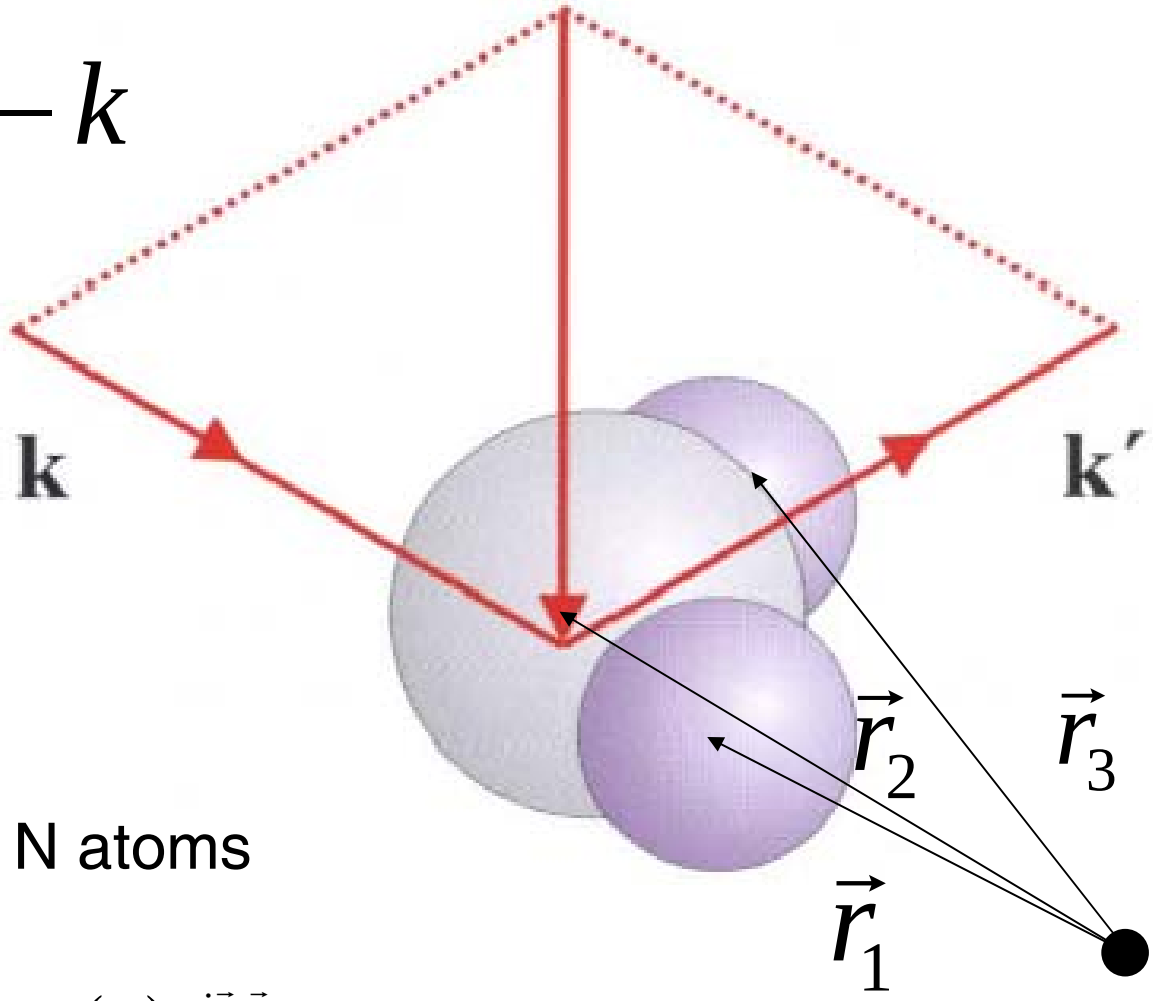
**Z = 3**

**Z = 1**

Als-Nielsen 2001, Abb. 4.3

# Scattering from a molecule

$$\vec{q} = k' - k$$

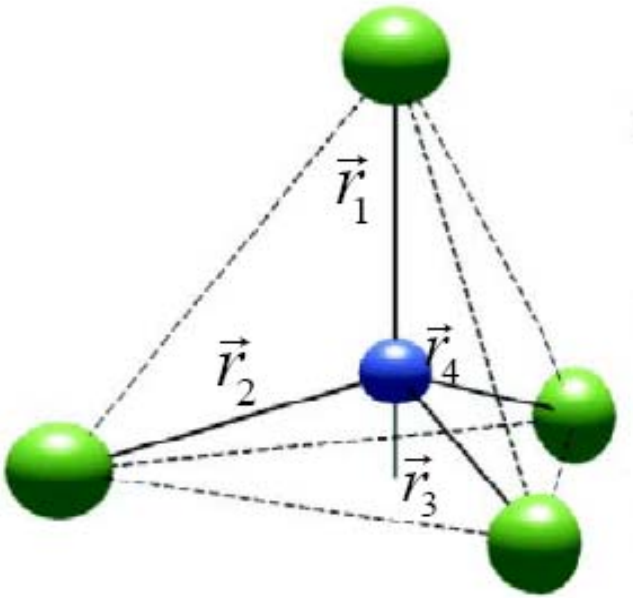


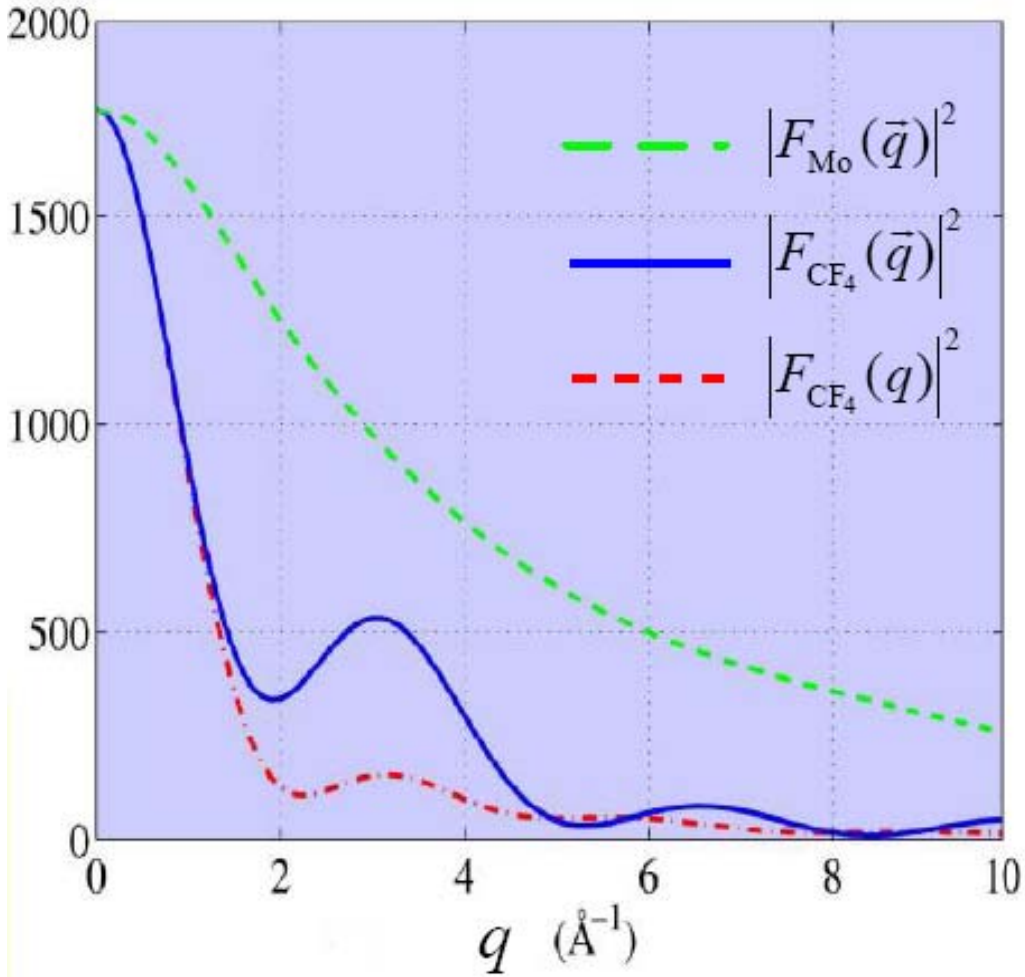

Molecule with N atoms

$$F_{mol.}(\vec{q}) = \sum_{j=1}^{N} f_j(\vec{q}) e^{i\vec{q}\cdot\vec{r}_j}$$

Als-Nielsen 2001, Abb. 1.6

# Example CF4



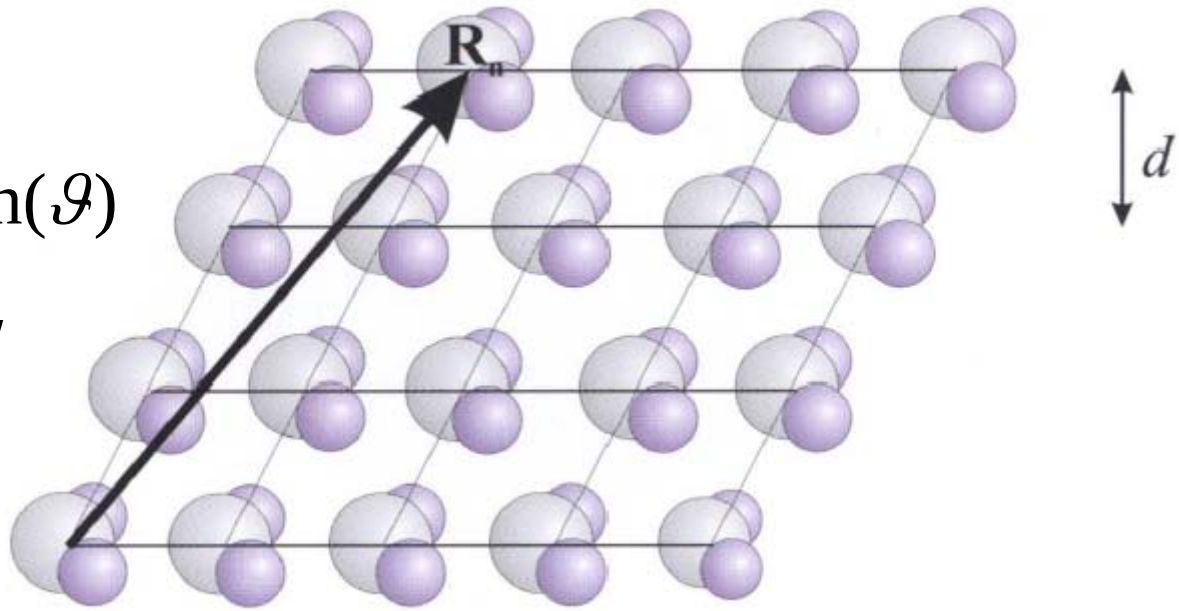

$$F_{CF_4}(\vec{q}) = f_c(\vec{q}) + f_F(\vec{q})\left(e^{i\vec{q}\cdot\vec{r}_1} + e^{i\vec{q}\cdot\vec{r}_2} + e^{i\vec{q}\cdot\vec{r}_3} + e^{i\vec{q}\cdot\vec{r}_4}\right)$$

Als-Nielsen 2001, Abb. 4.,4, 4.5

# Scattering from a crystal

$$M\lambda = 2d\sin(\vartheta)$$

Braggs law




$$F_{crystal}(\vec{q}) = \left(\sum_{j=1}^{N} f_j(\vec{q}) e^{i\vec{q}\cdot\vec{r}_j}\right) \cdot \left(\sum_{n=1}^{M} e^{i\vec{q}\cdot rR_n}\right)$$

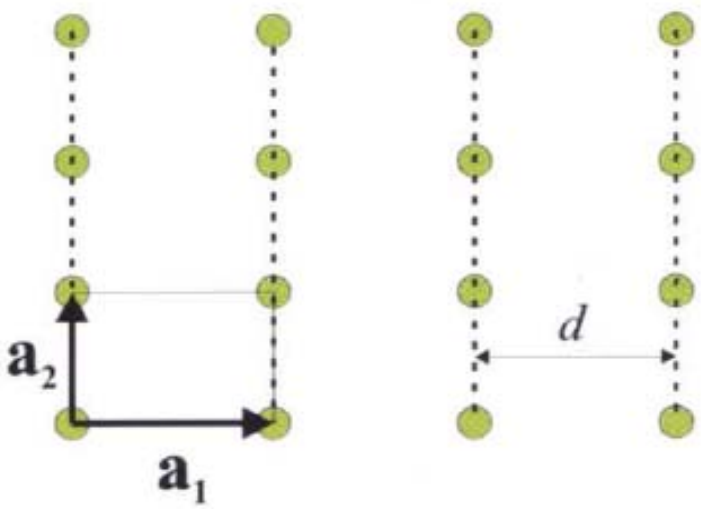
Unit cell Structure Factor

Sum over lattice

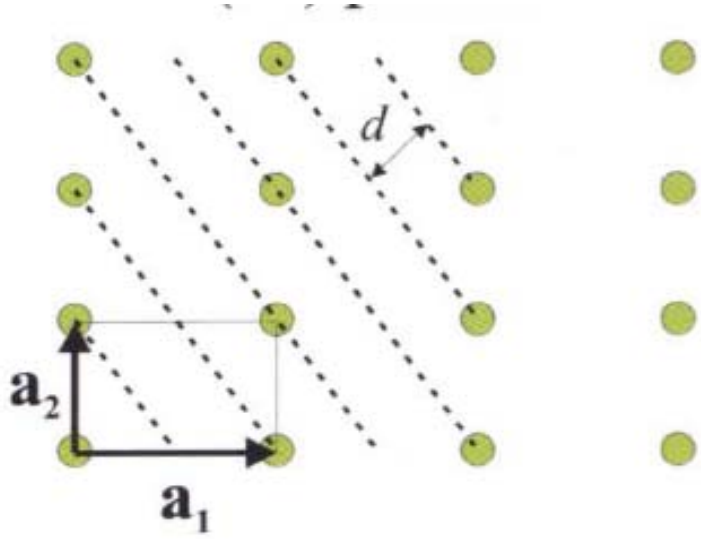
Als-Nielsen 2001, Abb. 1.6

# Miller Indices

**(10) planes**




**(21) planes**

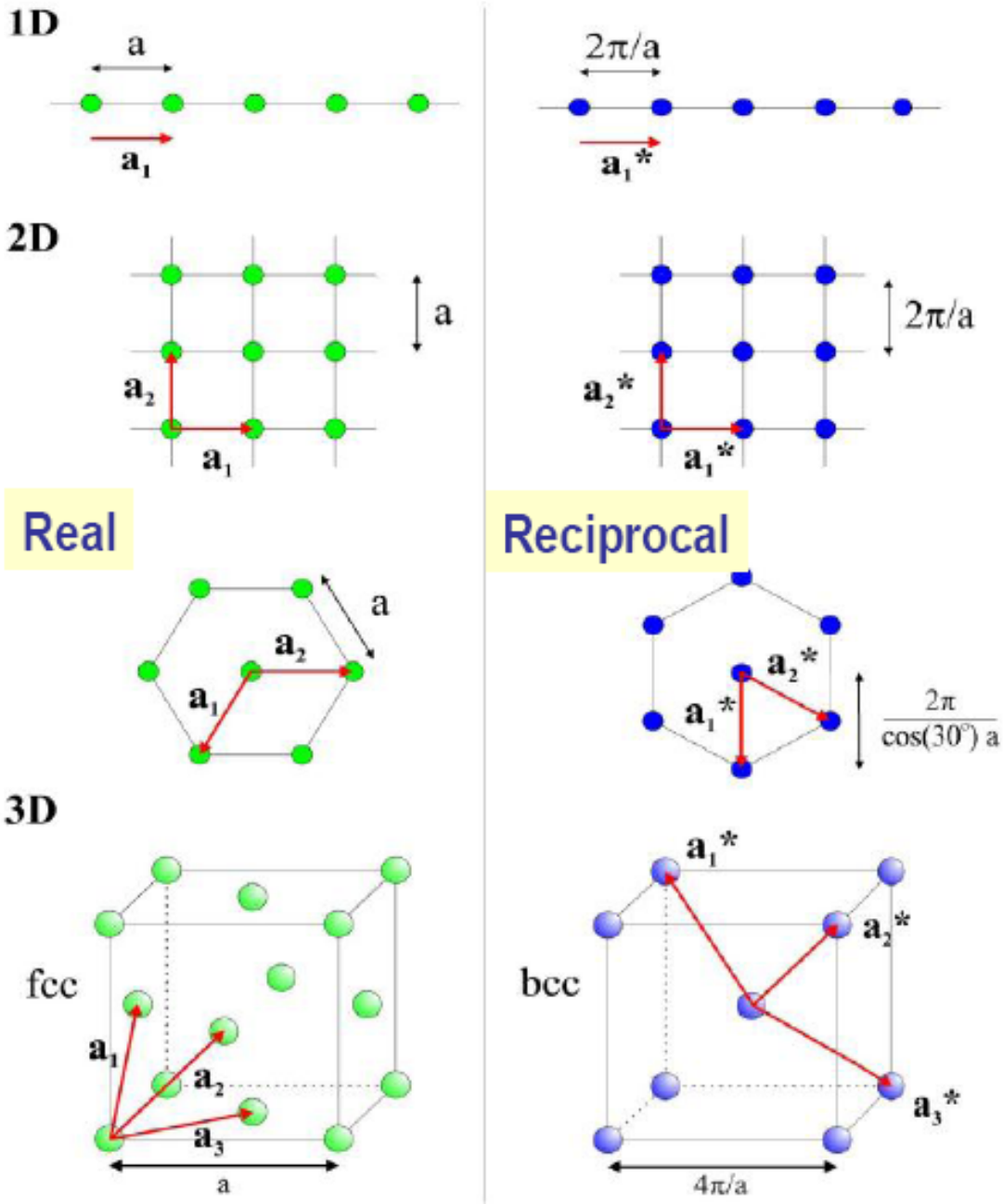



$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

a is the lattice constant

B.E. Warren, X-ray díffraction

Als-Nielsen 2001, Abb. 4.7



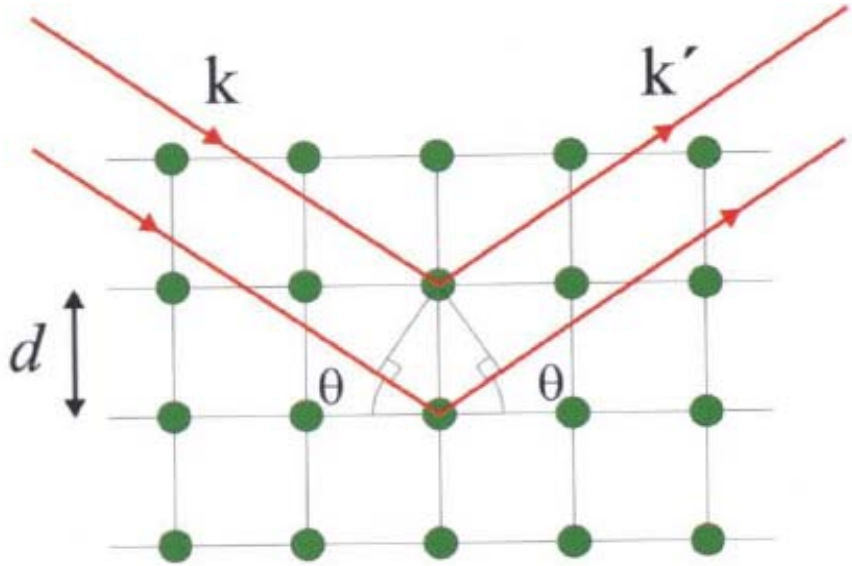

$$\vec{G} = ha_1^* + ka_2^* + la_3^*$$

$$Q = \vec{q} = \vec{G}_{hkl}$$

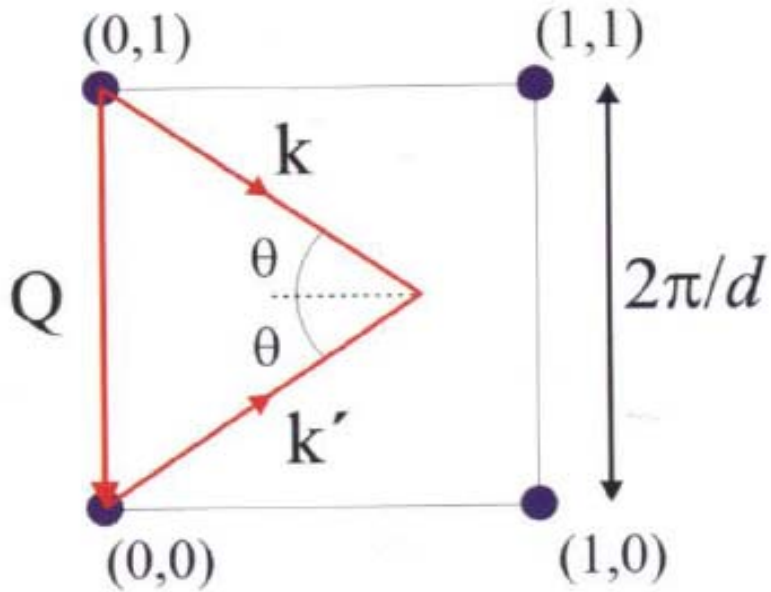
Laue

# Bragg and Laue are equivalent

Real space




Reciprocal space



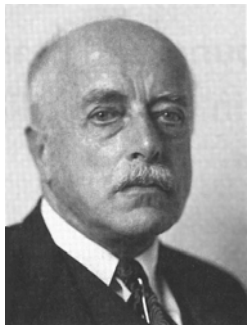

Als-Nielsen 2001, Abb. 4.9

# Quasicrystalline Cd5,7Yb alloy

5-fold axes

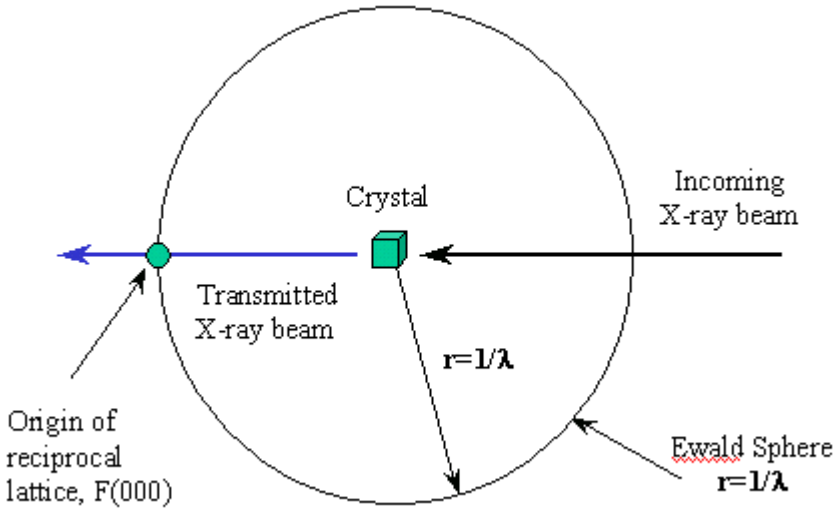
3-fold

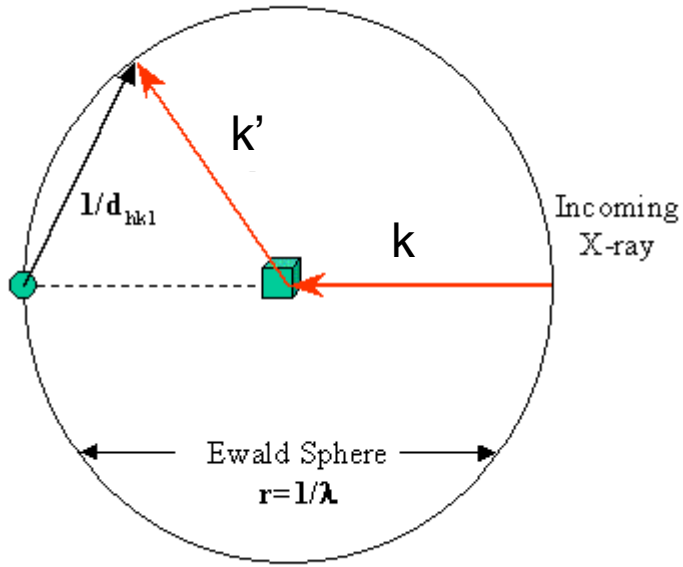
2-fold



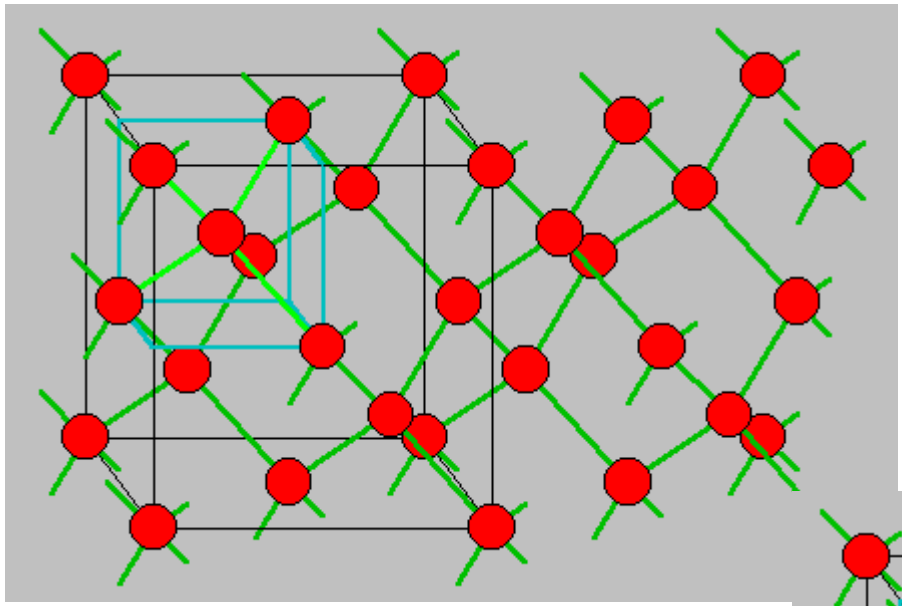
A. P. Tsai, *et al.*,
Nature **408**, 537, 2000

# Ewald Sphere



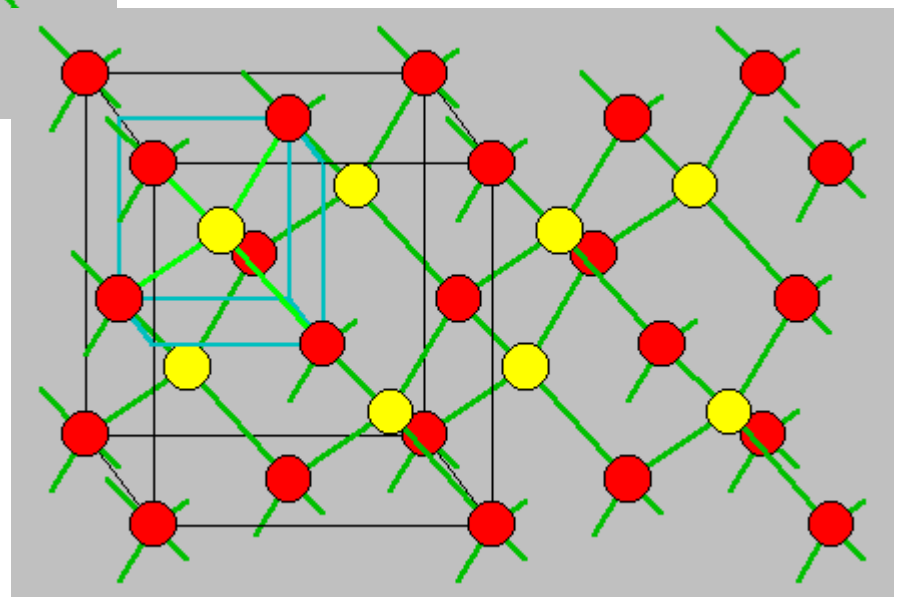



# Unit Cell Structure Factor



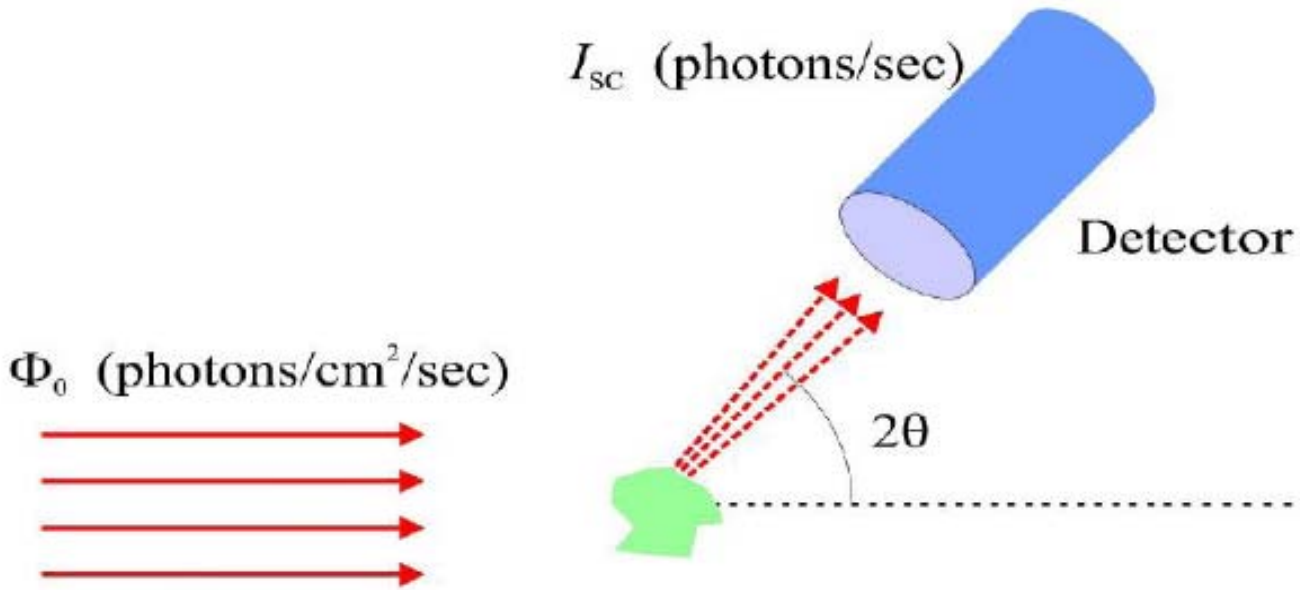
Diamond fcc

Zinc blende



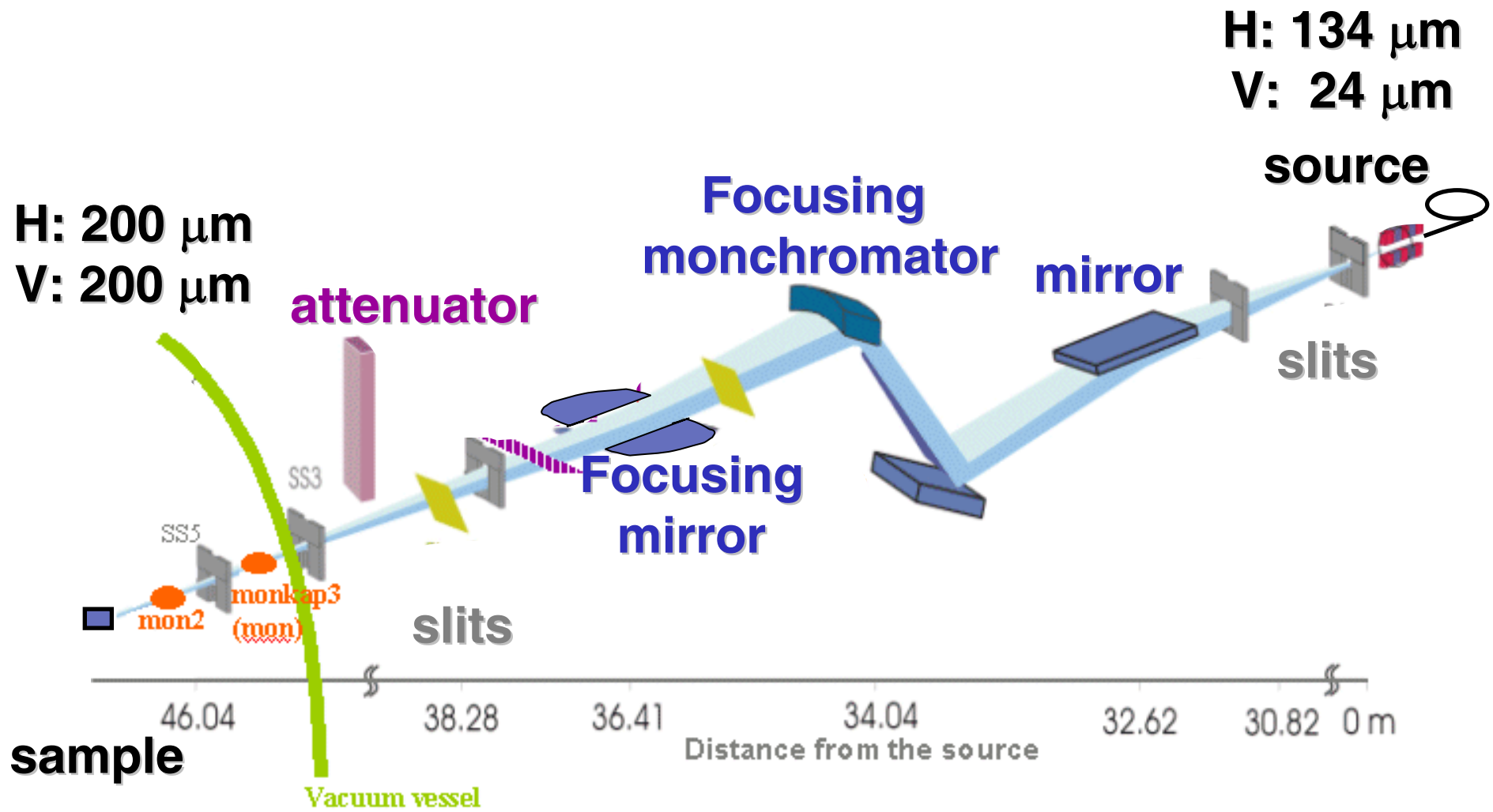
ece-www.colorado.edu/~bart/book/bravais.htm

# Measured Intensity



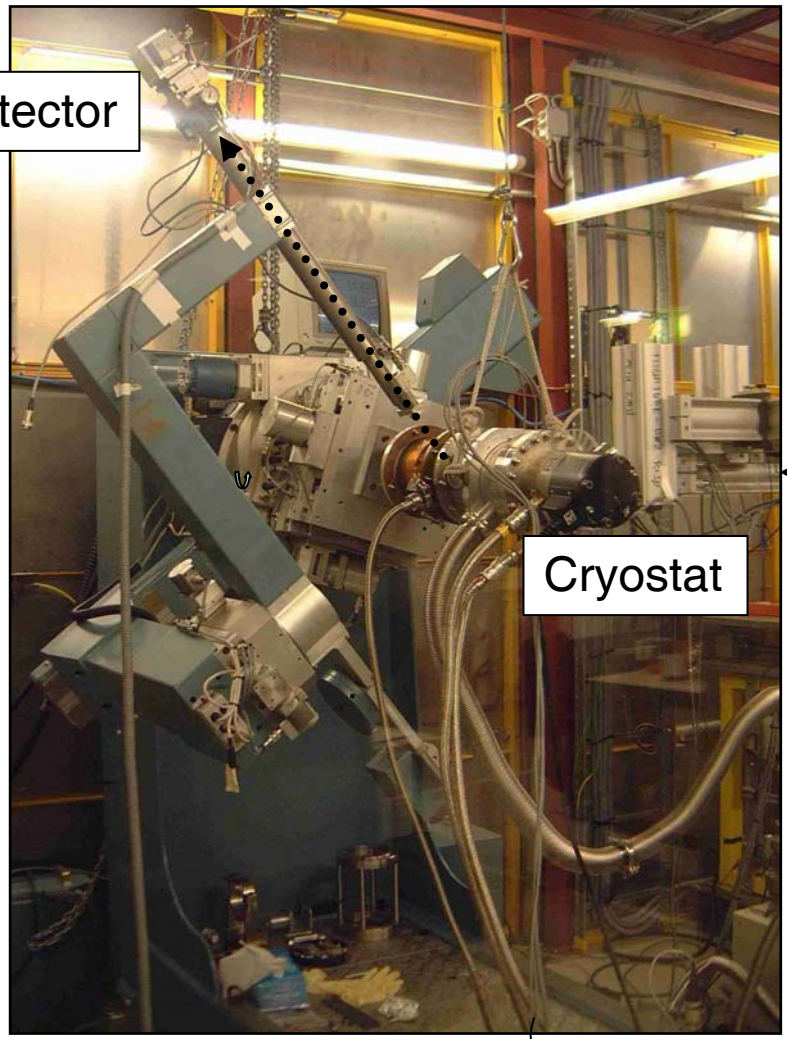

$$\left(\frac{d\sigma}{d\Omega}\right) = \frac{\text{Number of Photons Scattered per Second into } d\Omega}{(\text{Incident Flux})\ (d\Omega)}$$

# ID1 ESRF


H: 134 μm
V: 24 μm
source
H: 200 μm
V: 200 μm
attenuator
Focusing monchromator
mirror
slits
Focusing mirror
SS3
SS5
mon2
monkap3 (mon)
slits
46.04
38.28
36.41
34.04
32.62
30.82
0 m
Distance from the source
sample
Vacuum vessel

# Experimental set up at BW2

## 6 circle diffractometer




E = 9.5 keV

Beam size

0.5 mm

1 mm

Temperature controller

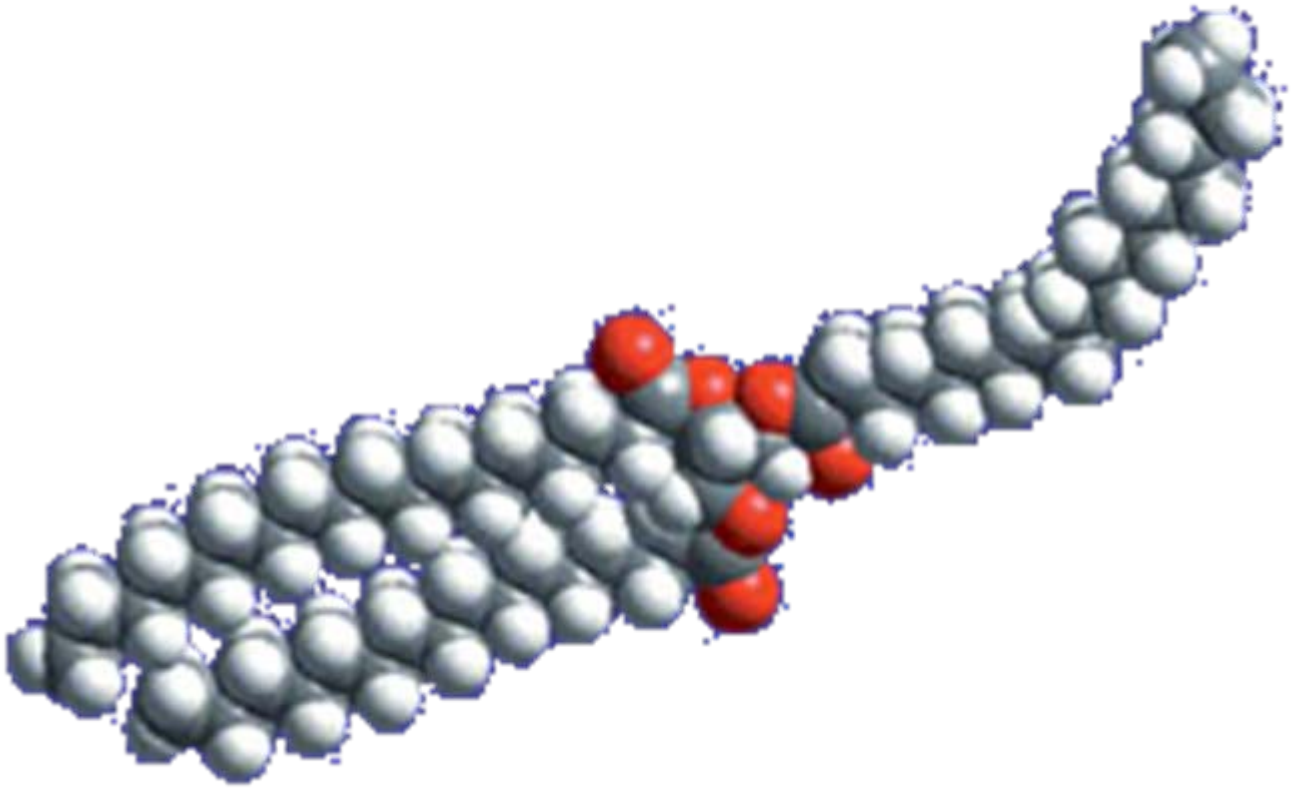
PSD output

# Chocolate


Milka
ALPINE MILK CHOCOLATE
AL LATTE DELLE ALPI
CON LECHE DE LOS ALPES
CIOCCOLATO AL LATTE
CHOCOLATE DE LEITE
ΣΟΚΟΛΑΤΑ ΓΑΛΑΚΤΟΣ
ALPENMILK CHOCOLATE
ΣΟΚΟΛΑΤΑ ΓΑΛΑΚΤΟΣ
Ritter
SPORT
VOLLMILCH


Milka

# Coco butter fat molocule

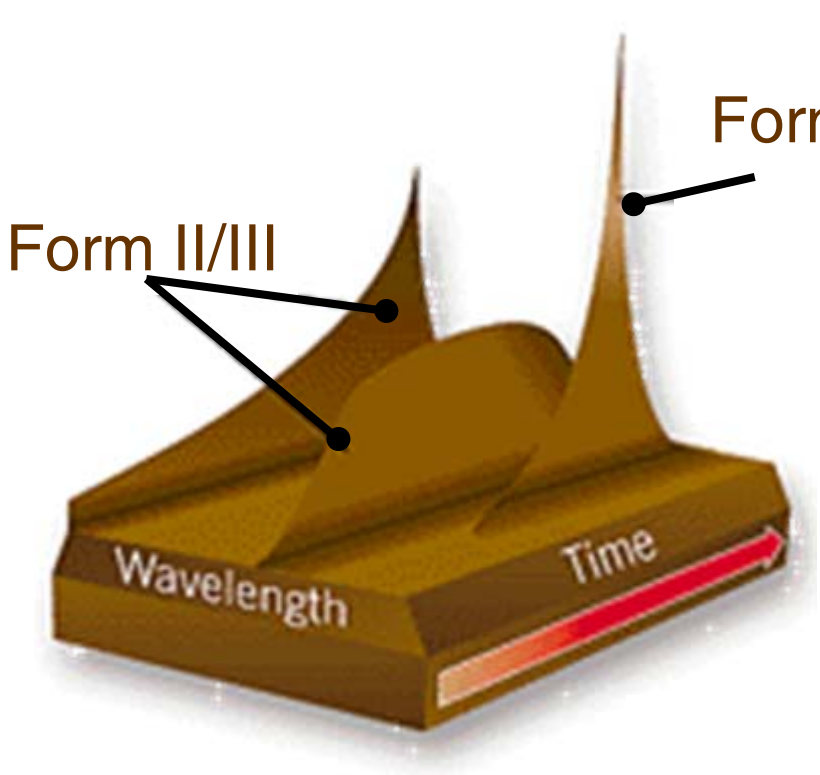


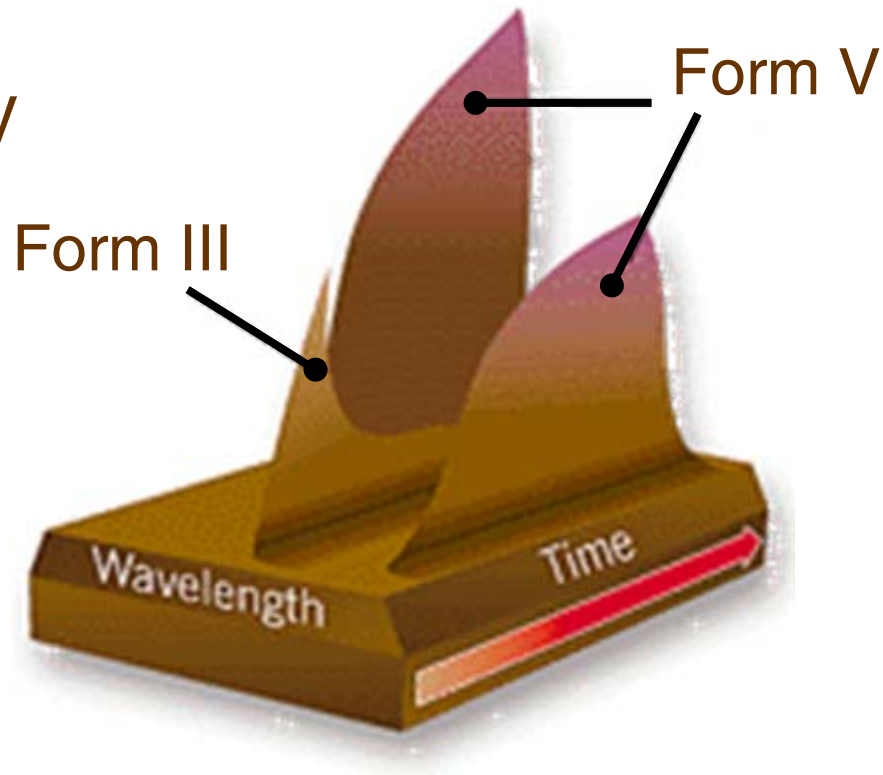
**Crystals and particles ranging from 10 μm to 120 μm**

**Taste depends on flavour**
**Texture on crystal size**

Cooled without stirring

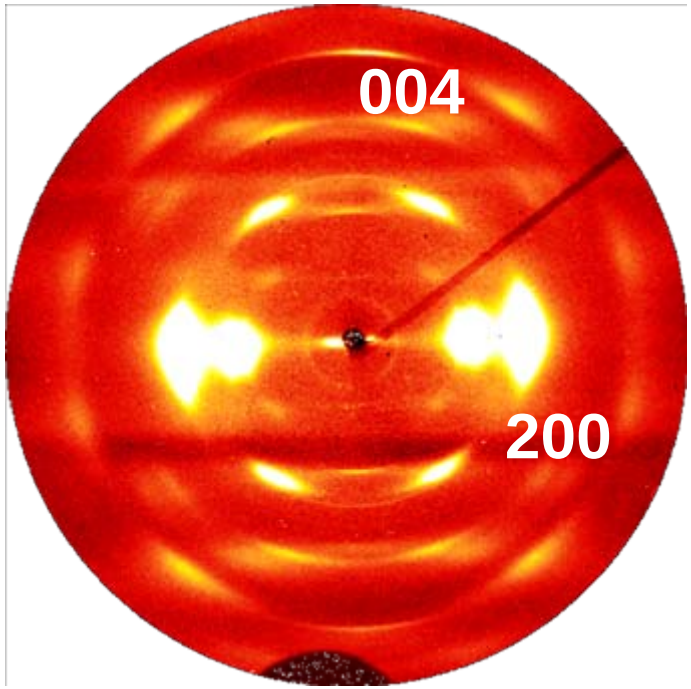
Stirred during cooling

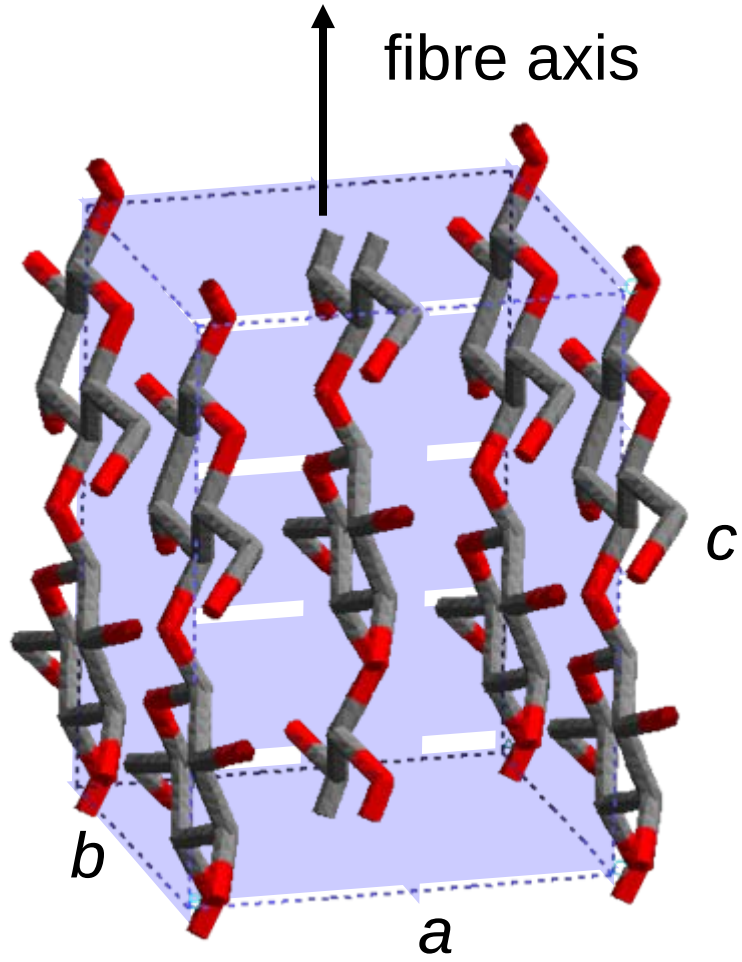



RB Hammond, *et al.,* J. Phys. Chem. B, 1997

# X-ray fibre diffraction of flax cellulose fibres

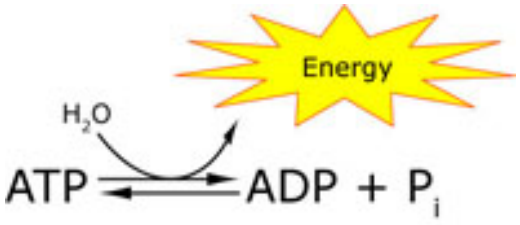


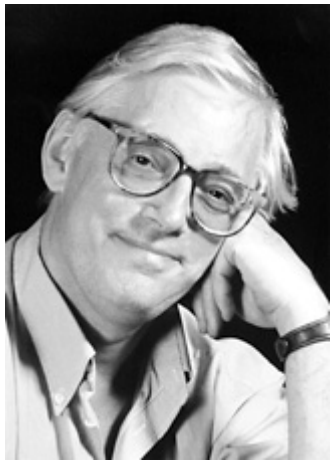

cellulose Iβ (monoclinic)

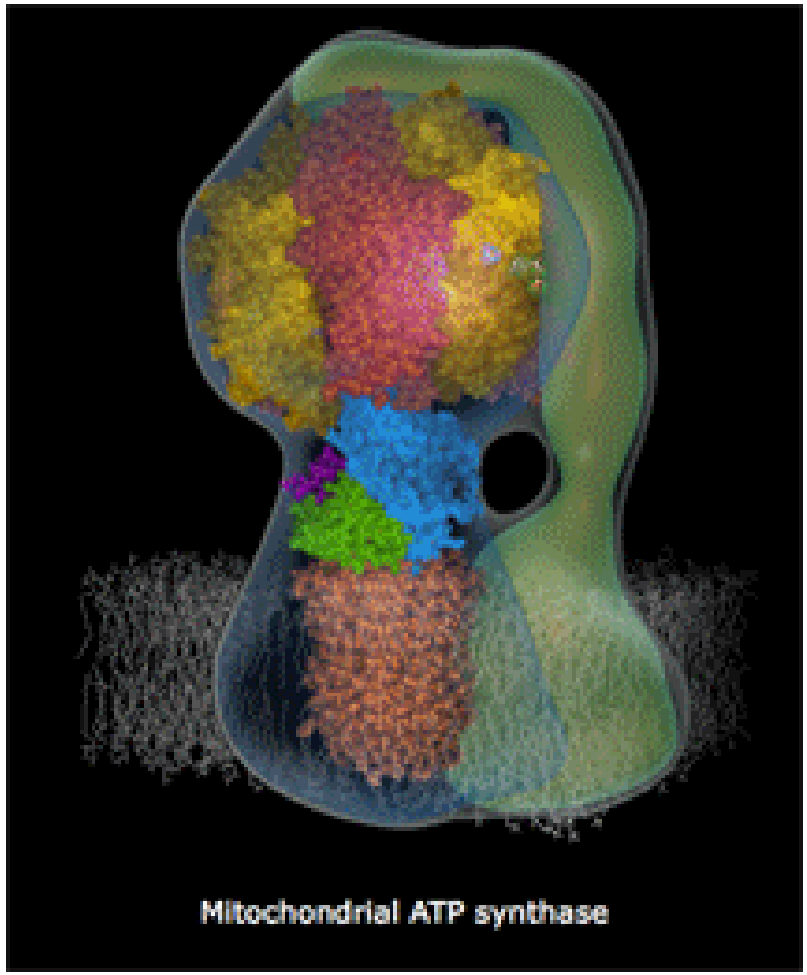
AG. Müller, Kiel

# Molecular engine




John E. Walker






The Nobel Prize in Chemistry 1997