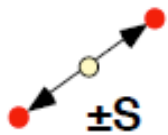
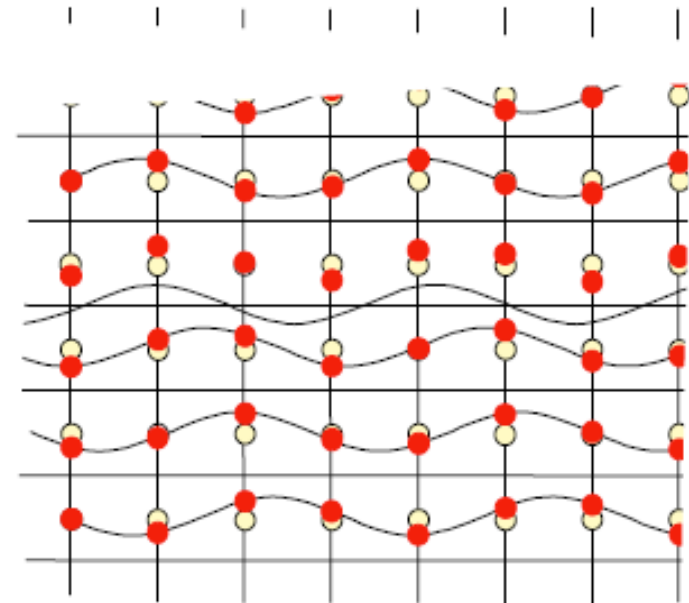
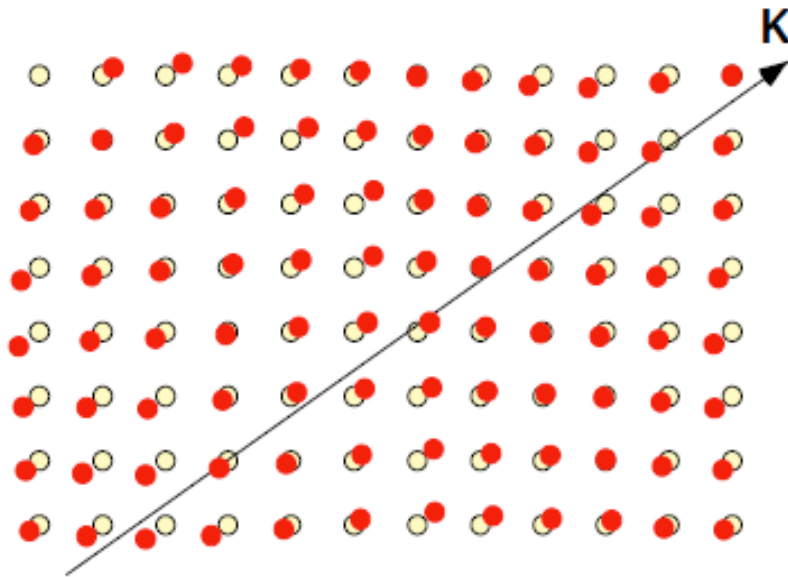
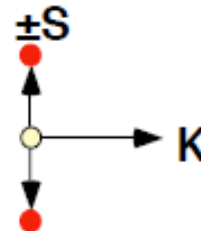


Gitterschwingungen = Phononen



Longitudinale Phononen

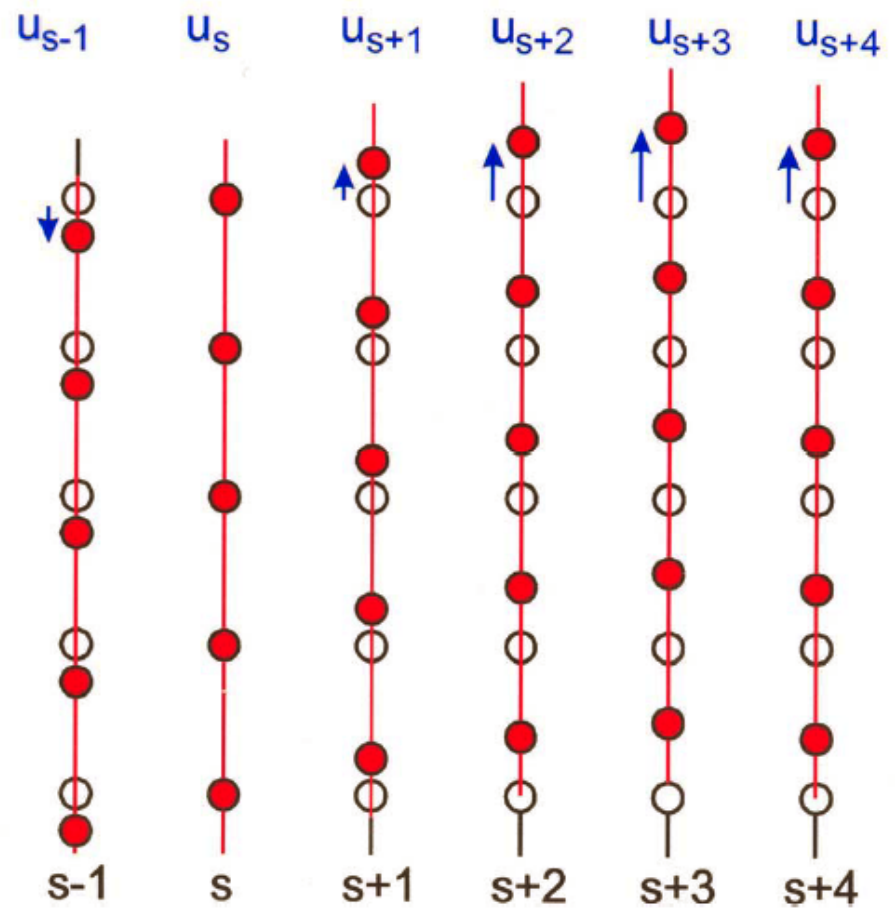
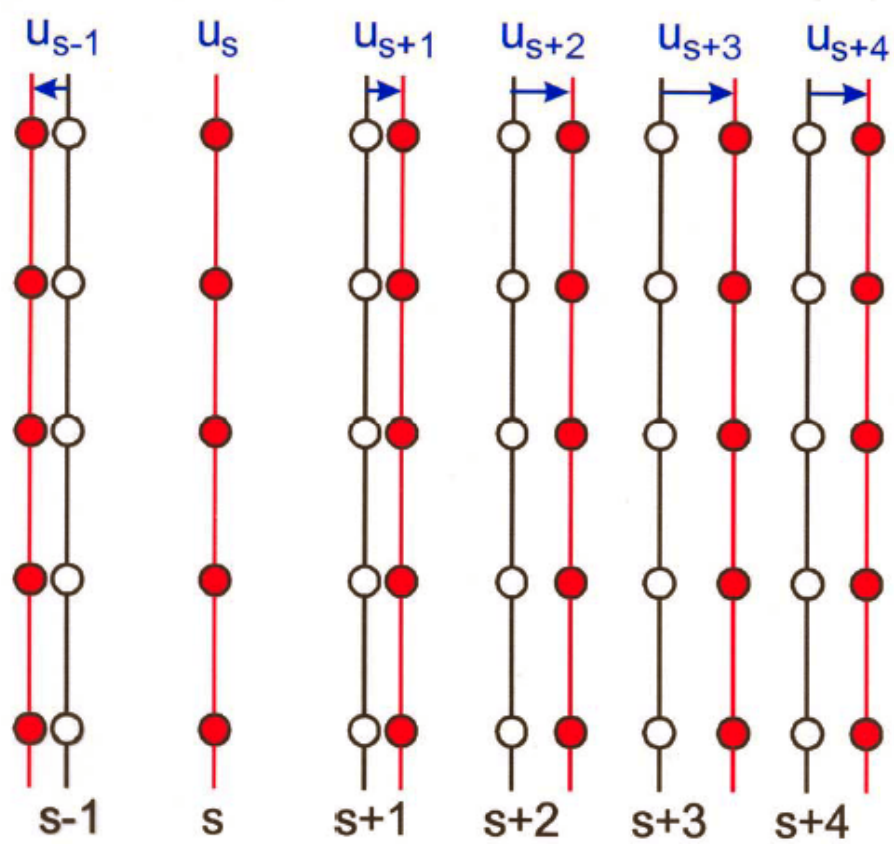


Transversale Phononen

Gitterschwingungen

longitudinal

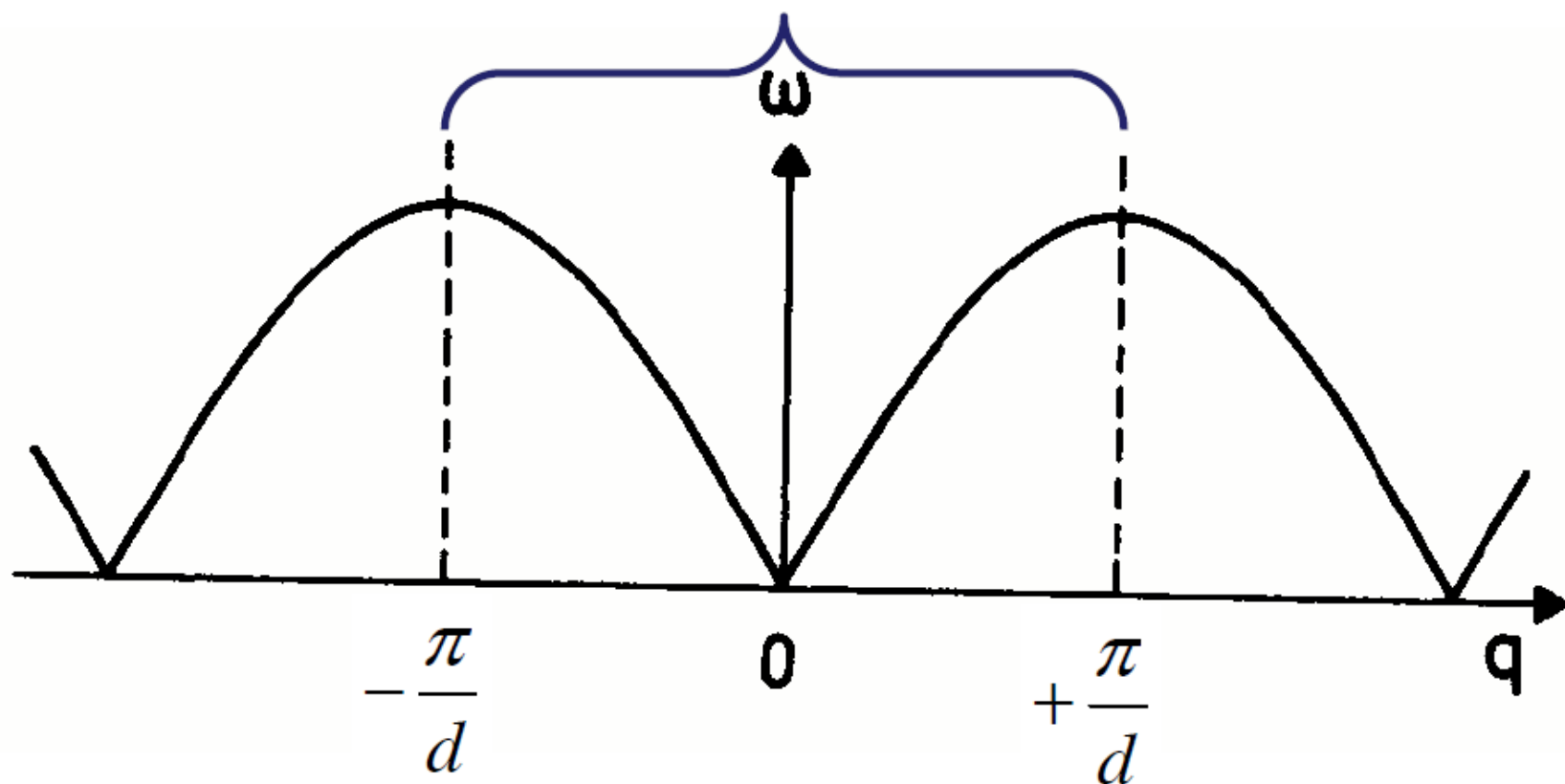
transversal



Dispersionsrelation: Gitter mit einatomiger Basis

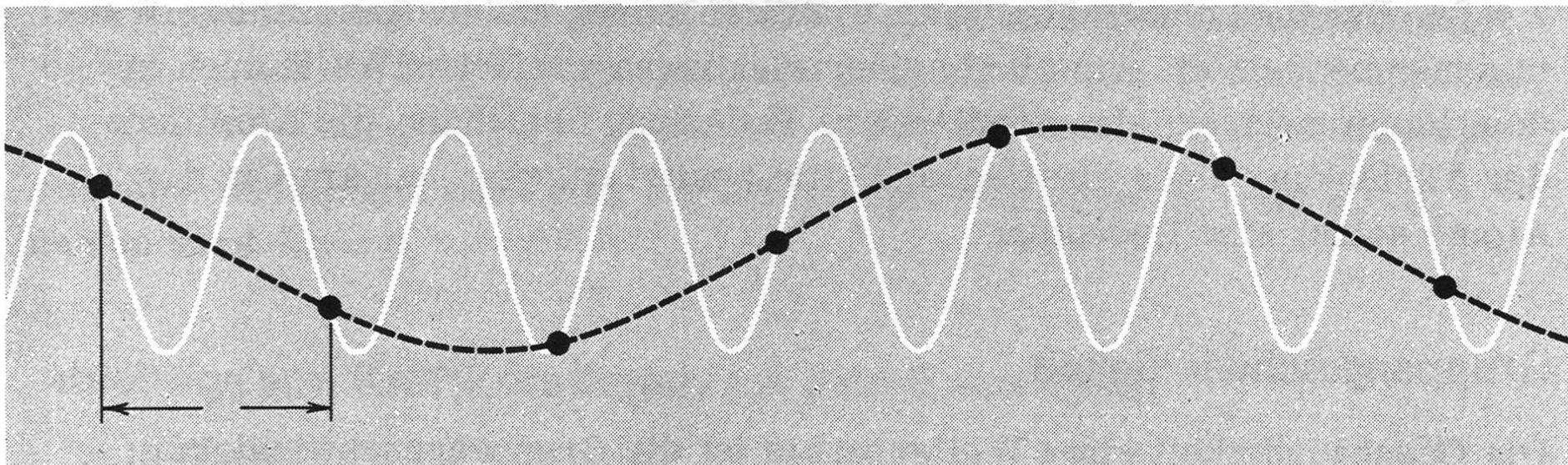
$$\omega = \sqrt{\frac{4c_1}{M}} \left| \sin \frac{qd}{2} \right|$$

1. Brillouinzone

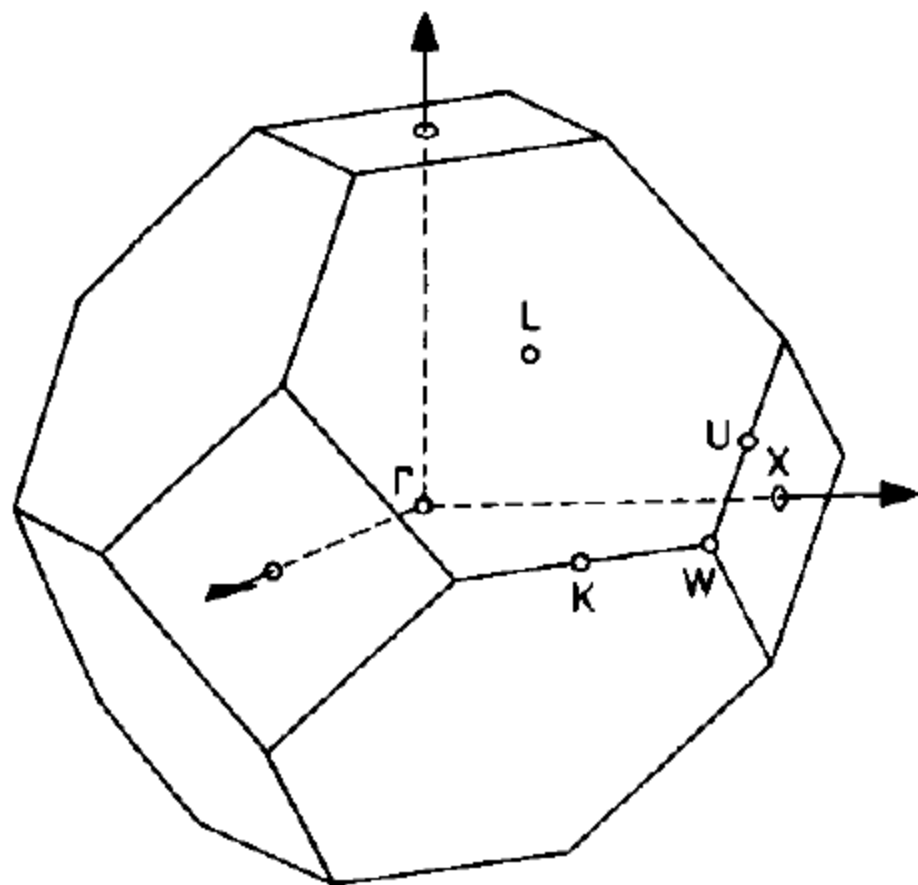


Äquivalenz einer Gitterschwingung

Beide hier skizzierten Wellen führen zu den gleichen Auslenkungen der Atome aus der Ruhelage. Sie sind physikalisch identisch.

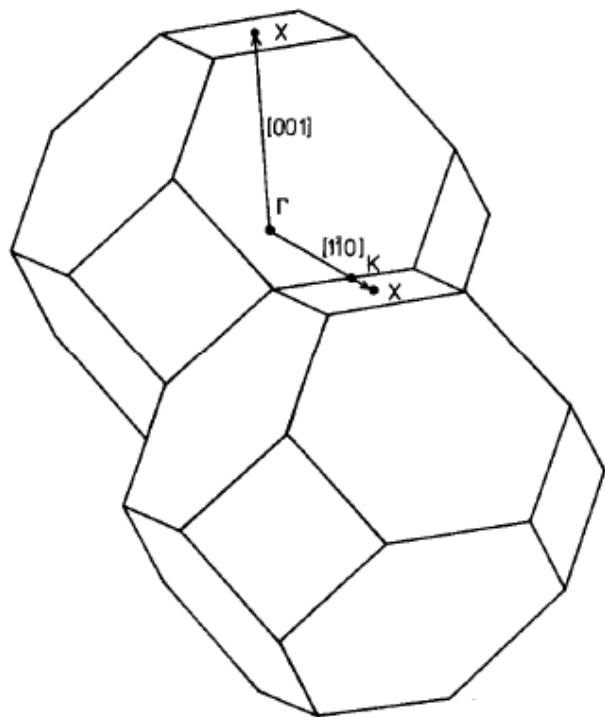


Wigner-Seitz-Zelle im reziproken Raum (hier fcc)



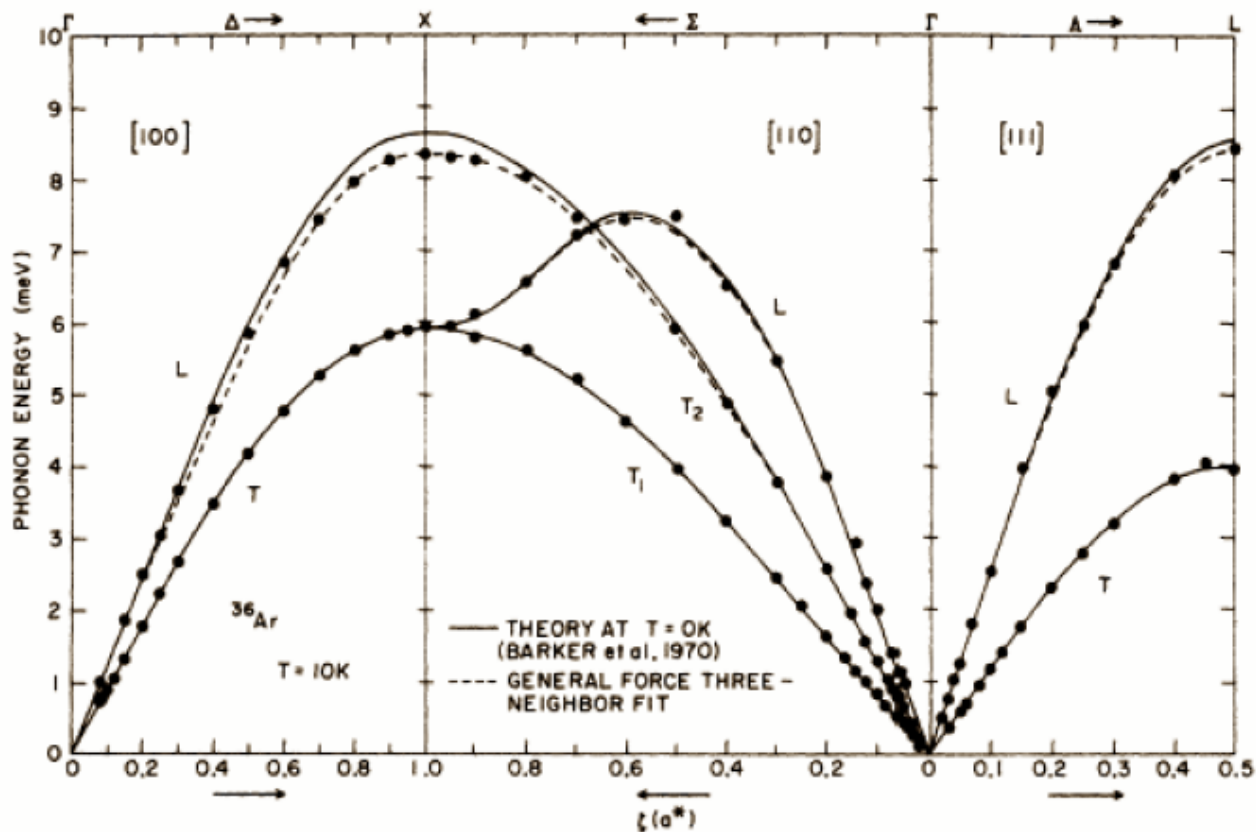
alle Wellen mit Wellenvektor vom Zonenzentrum zum Rand erfüllen die Beugungsbedingung = werden Bragg-reflektiert!

Dispersionsrelation für 3D-Bravaisgitter ohne Basis



festes ^{36}Ar , fcc, Neutronenstreuung

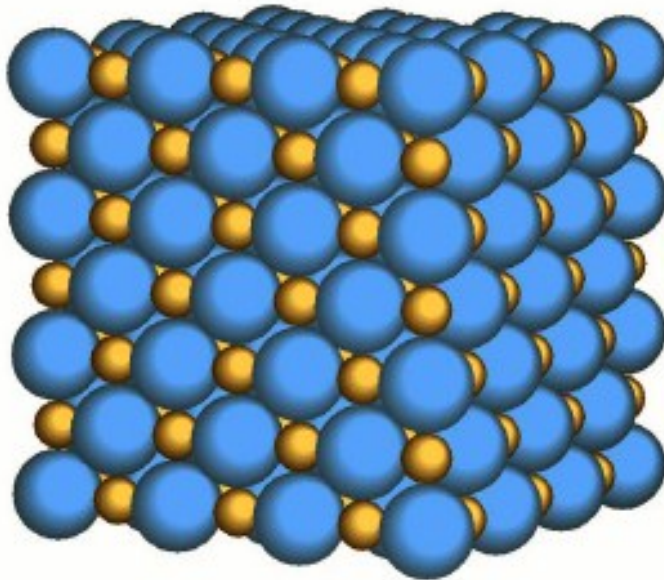
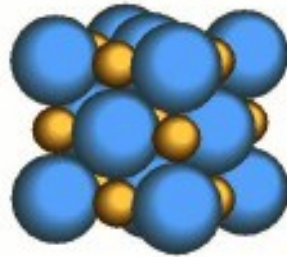
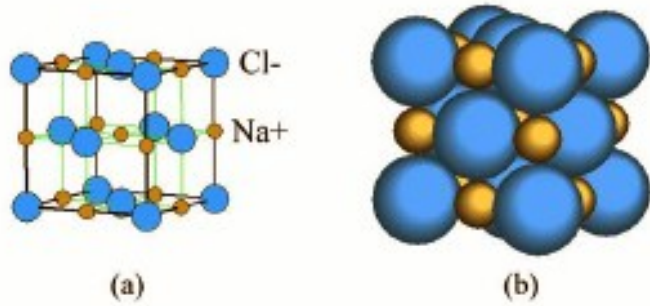
Hauptsymmetrie-
richtungen



Y. Fujii *et al.*,

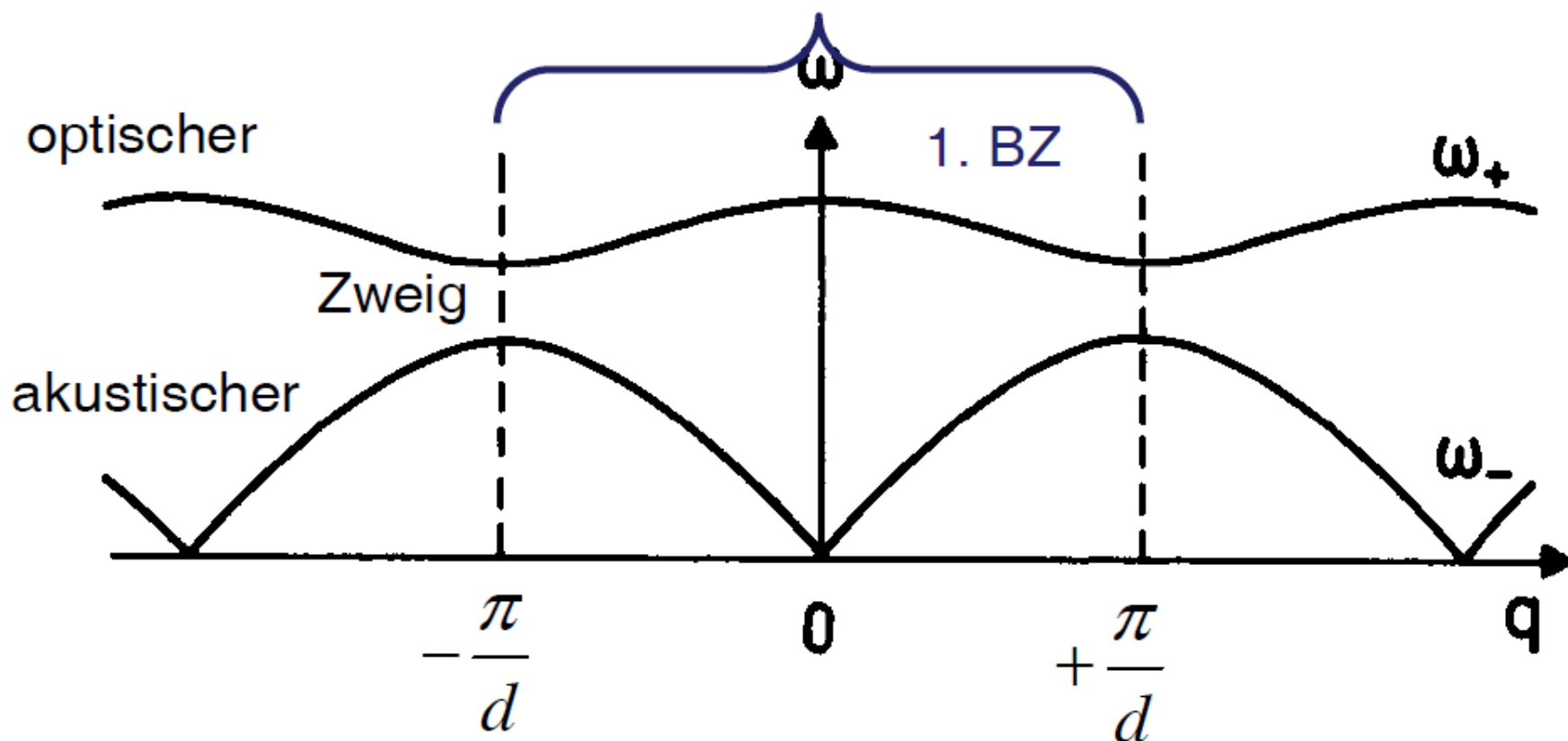
Phys. Rev. B **10**, 3647 (1974)

Packung in der NaCl-Struktur

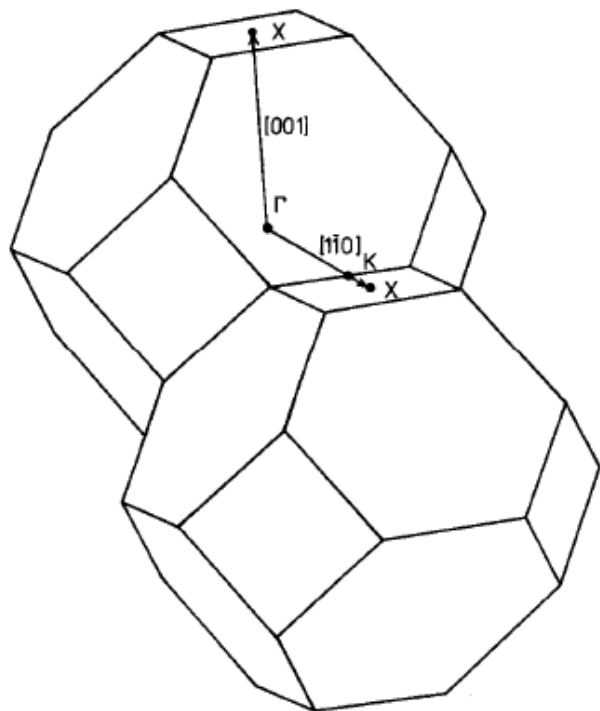


Dispersionrelation: Gitter mit zweiatomiger Basis

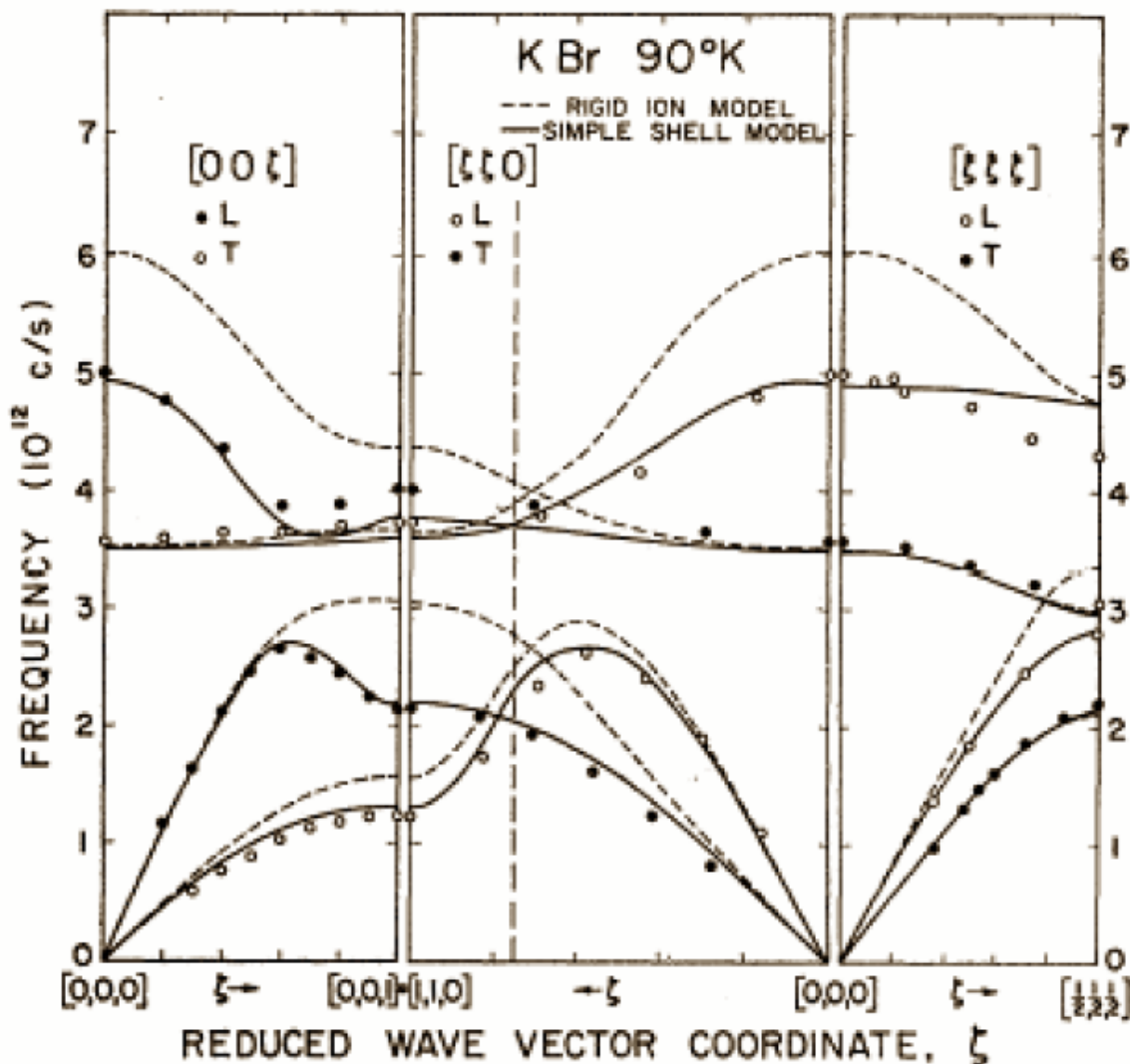
$$\omega^2 = c \left(\frac{1}{M_1} + \frac{1}{M_2} \right) \pm c \sqrt{\left(\frac{1}{M_1} + \frac{1}{M_2} \right)^2 - \frac{4}{M_1 M_2} \sin^2 \frac{qd}{2}}$$



Dispersionsrelation für 3D-Bravaisgitter *mit* Basis

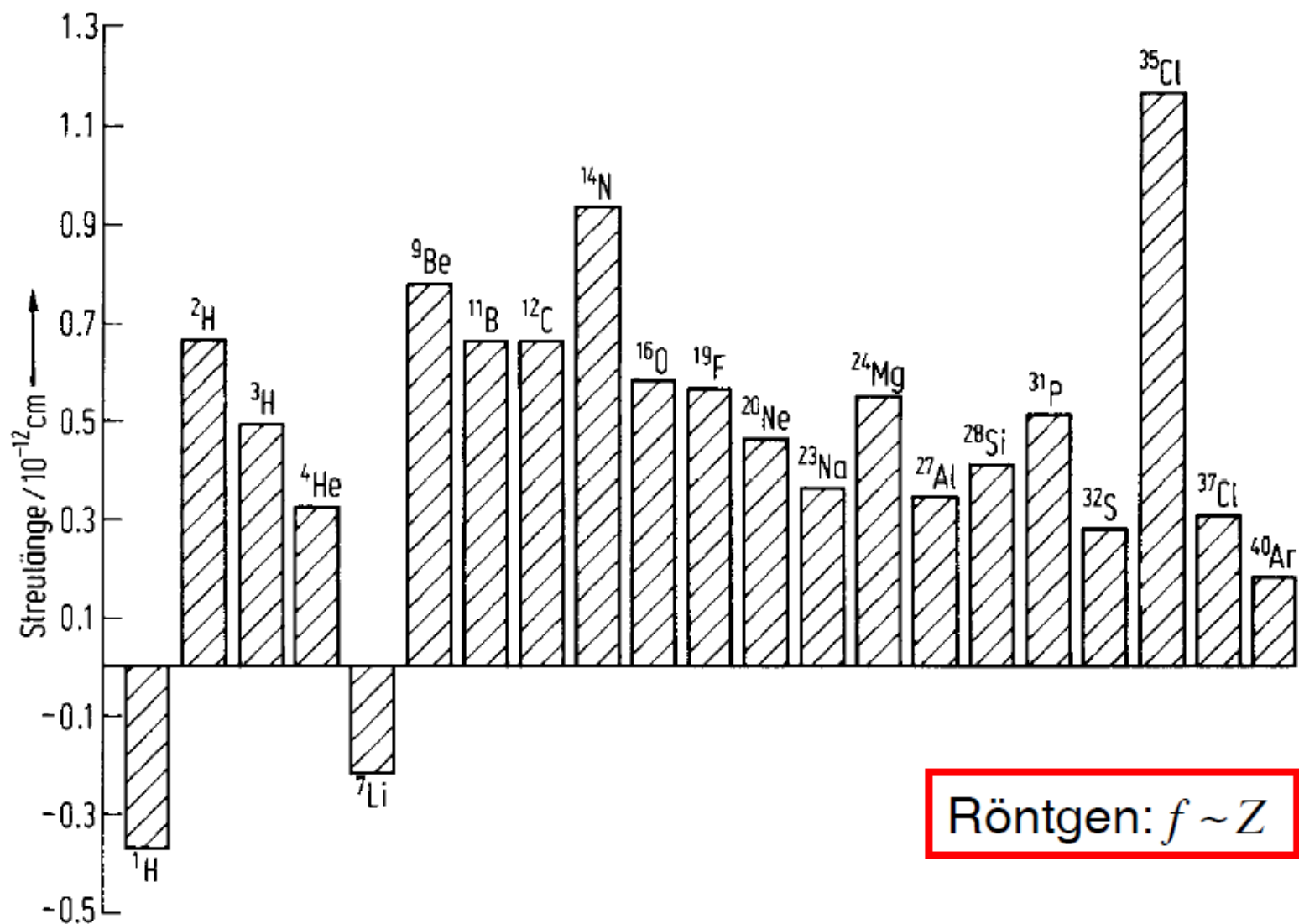


KBr, NaCl-Struktur, Neutronenstreuung



Hauptsymmetrie-
richtungen

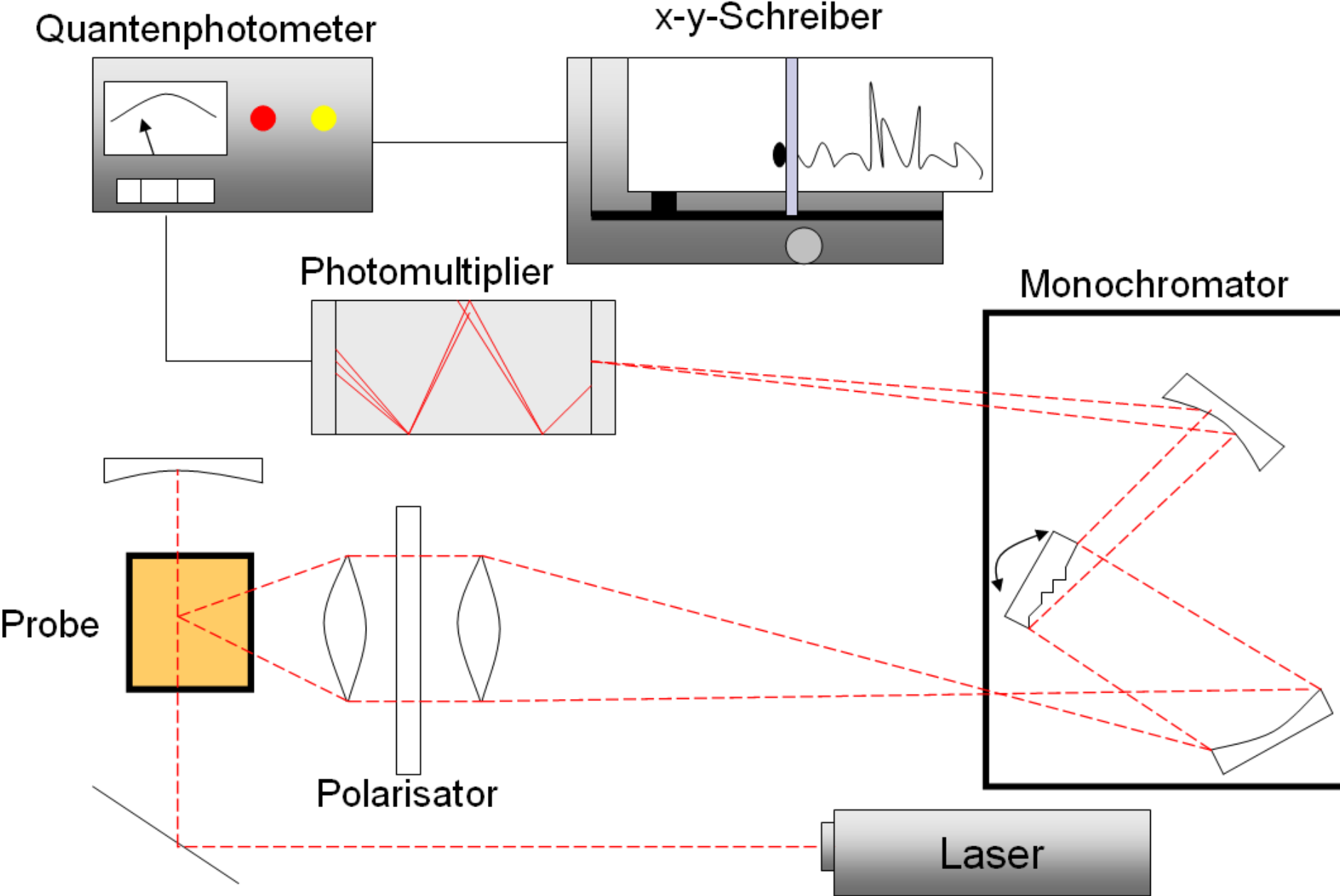
Vergleich Beugung mit Neutronen und Röntgenstrahlung



Raman-Spektrometer



Raman Spektroskopie

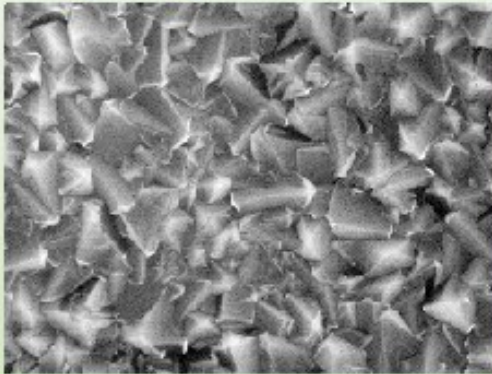


Raman Spektroskopie

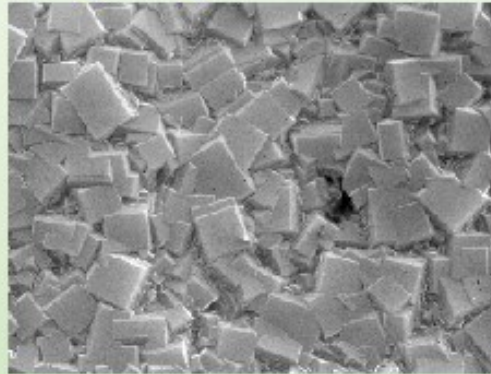


CVD-Diamant Morphologien

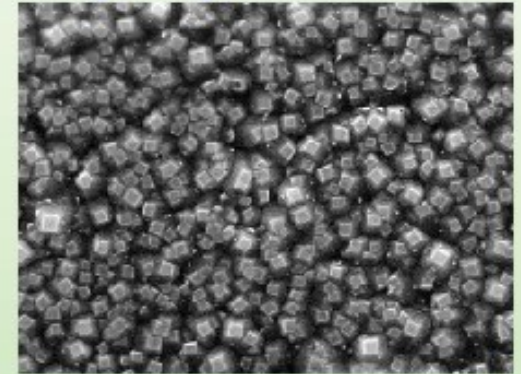
(111) Flächen



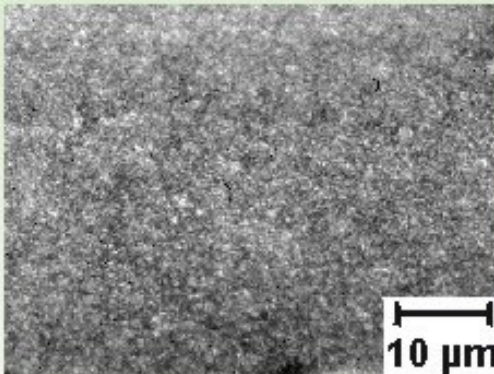
(100) Flächen



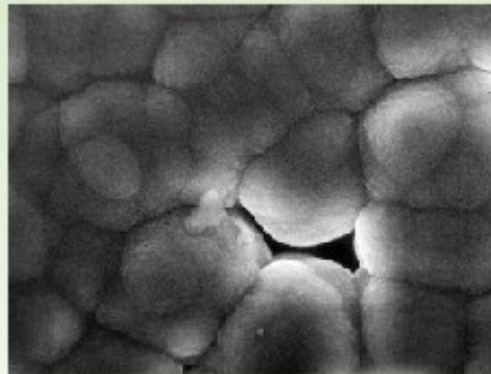
(100) + Ballas



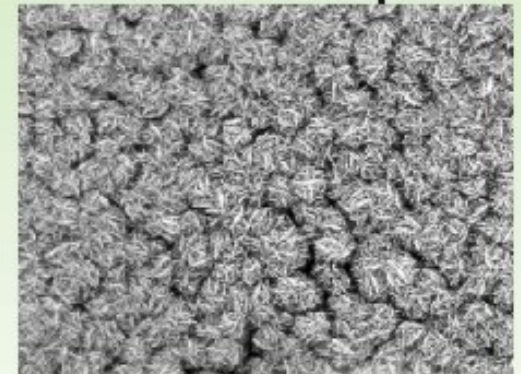
Ballas



Ballas



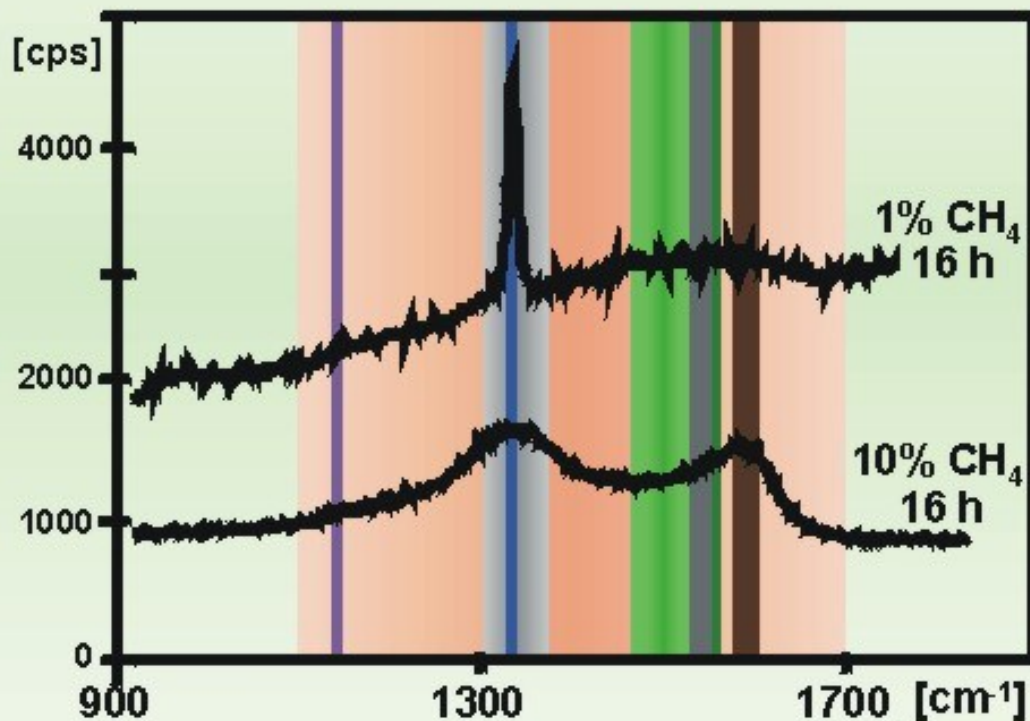
Ballas + Graphit



Raman Spektroskopie



Raman-Charakterisierung der Diamanten: Die Linien und Bänder im Spektrum



$1332,3 \pm 0,3 \text{ cm}^{-1}$ kristalliner Diamant

1140 cm^{-1} mikro- oder nano-
kristalliner Diamant

$1580 \pm 5 \text{ cm}^{-1}$ kristalliner Graphit

$1355 \pm 10 \text{ cm}^{-1}$ mikrokristalliner
Graphit (D-Band)

$1500\text{-}1550 \text{ cm}^{-1}$ mikrokrist. Graphit,
(G-Band)

$1100\text{-}1700 \text{ cm}^{-1}$ a-C oder a-C:H

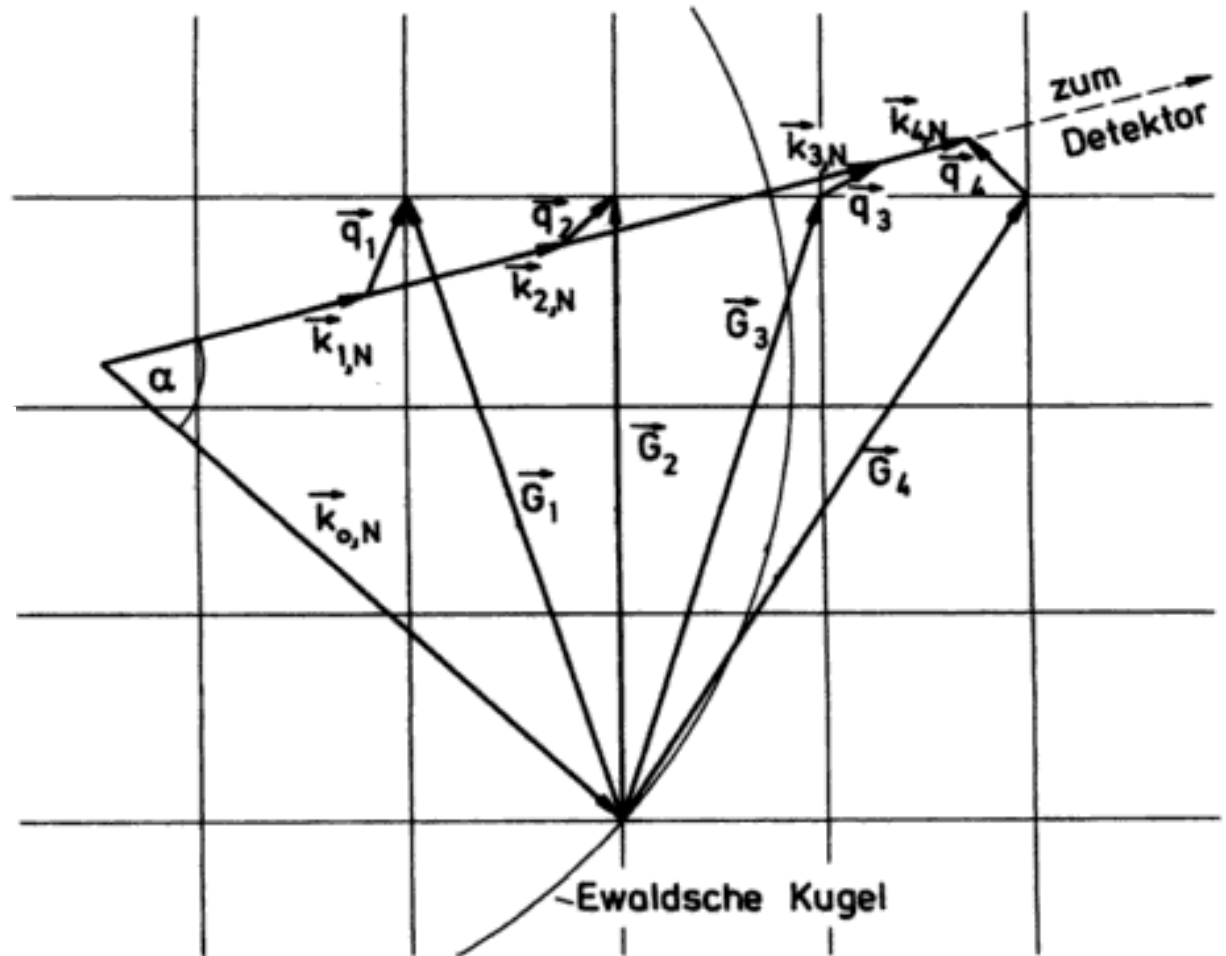
1480 cm^{-1} (breit) amorphe
 sp^2 -Strukturen

$1530\text{-}1550 \text{ cm}^{-1}$ diverse sp^2 -C Cluster

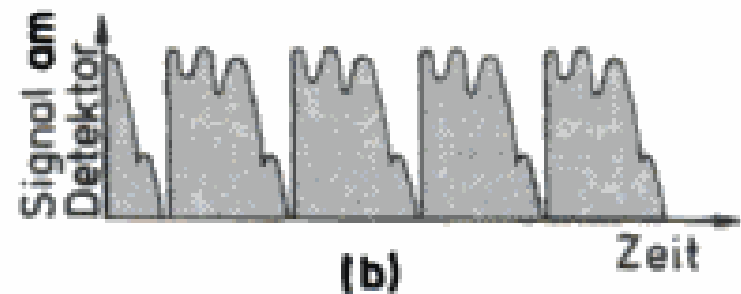
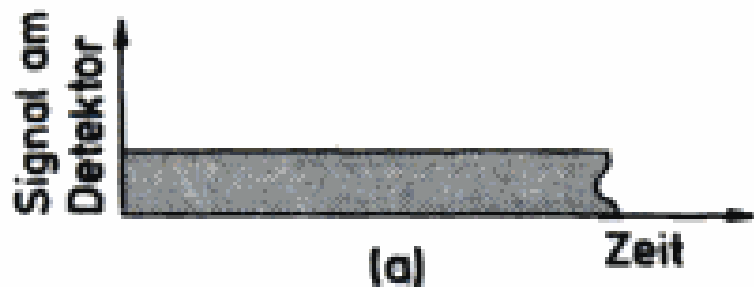
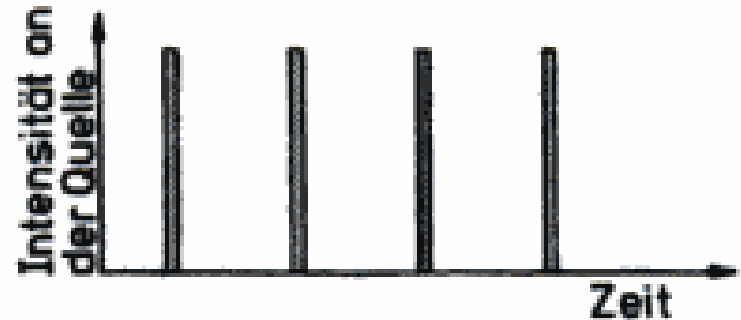
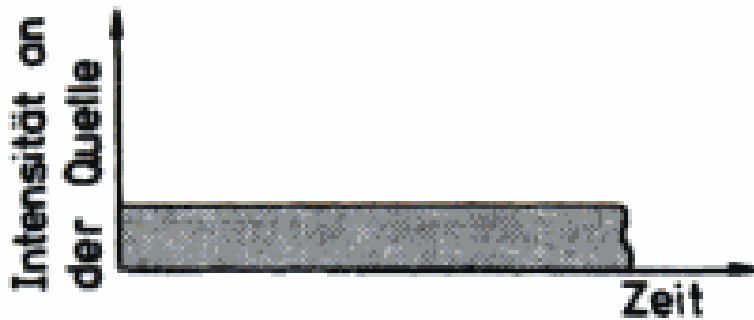
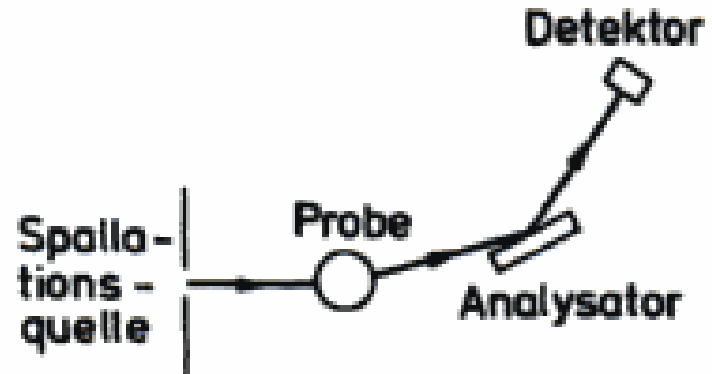
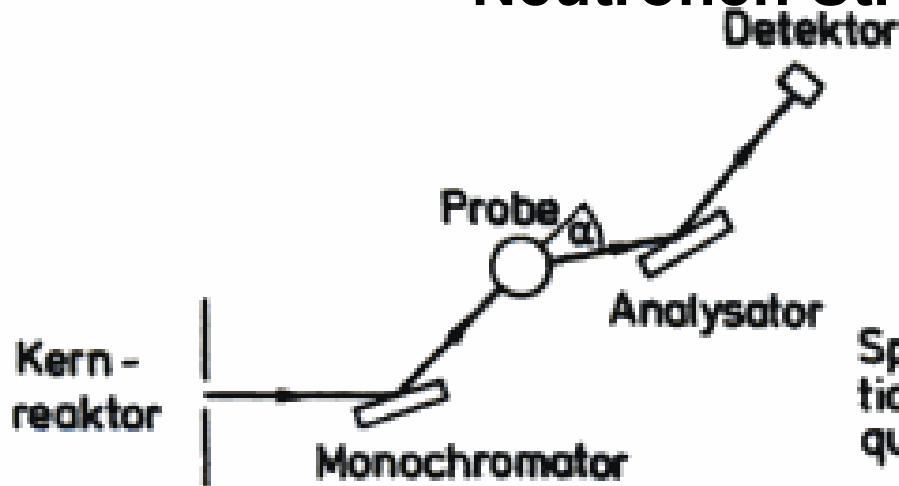
Neutronen Streuung

$$\frac{(\hbar k_{0,N})^2}{2M_N} = \frac{(\hbar k_N)^2}{2M_N} \pm \hbar\omega$$

$$\vec{k}_{0,N} + \vec{G} = \vec{k}_N \pm \vec{q}$$



Neutronen Streuung



Neutronen Streuung

VOLUME 17, NUMBER 25

PHYSICAL REVIEW LETTERS

19 DECEMBER 1966

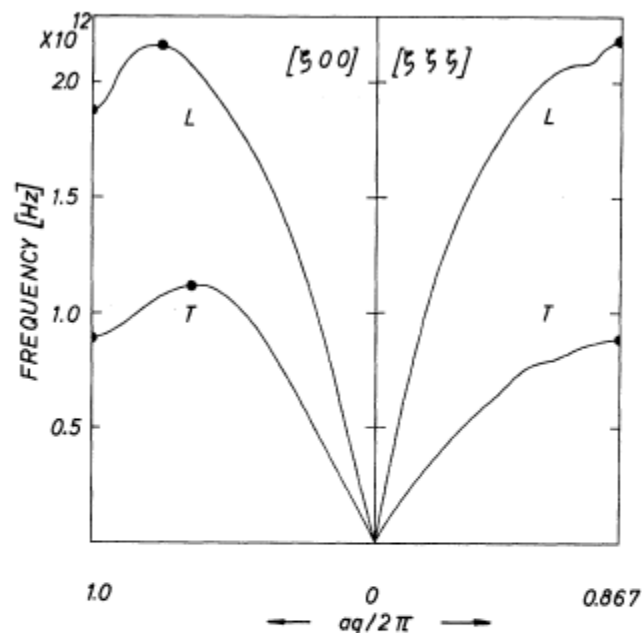


FIG. 1. Dispersion relations in the directions $[\xi 0 0]$ and $[\xi \xi \xi]$ of lead according to Brockhouse *et al.*⁴ The circles indicate the positions of the six phonons measured in the present work.

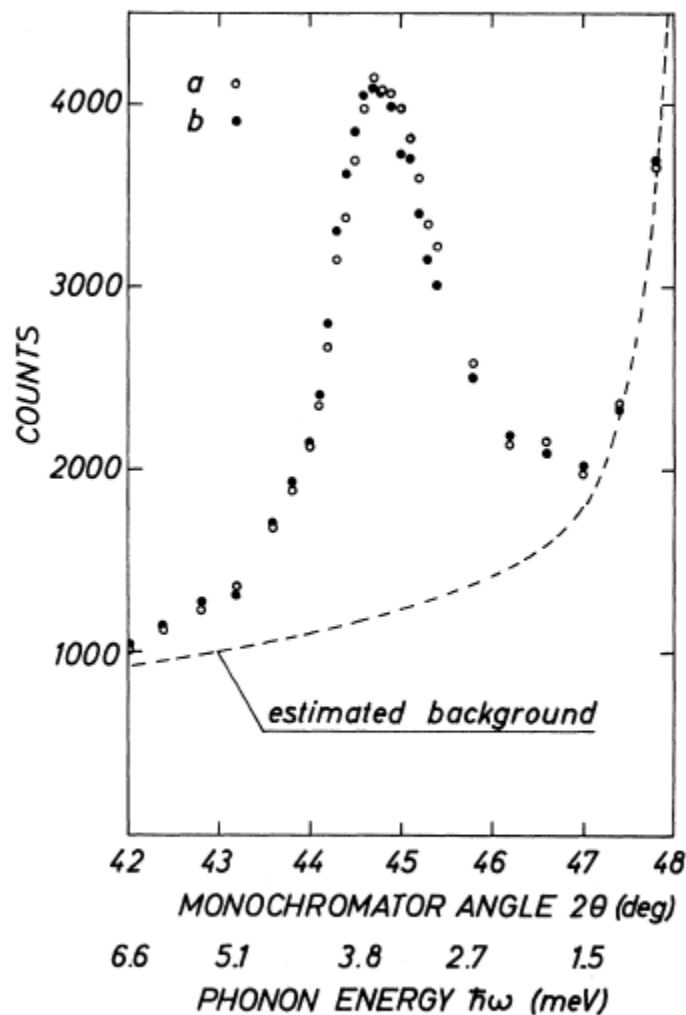
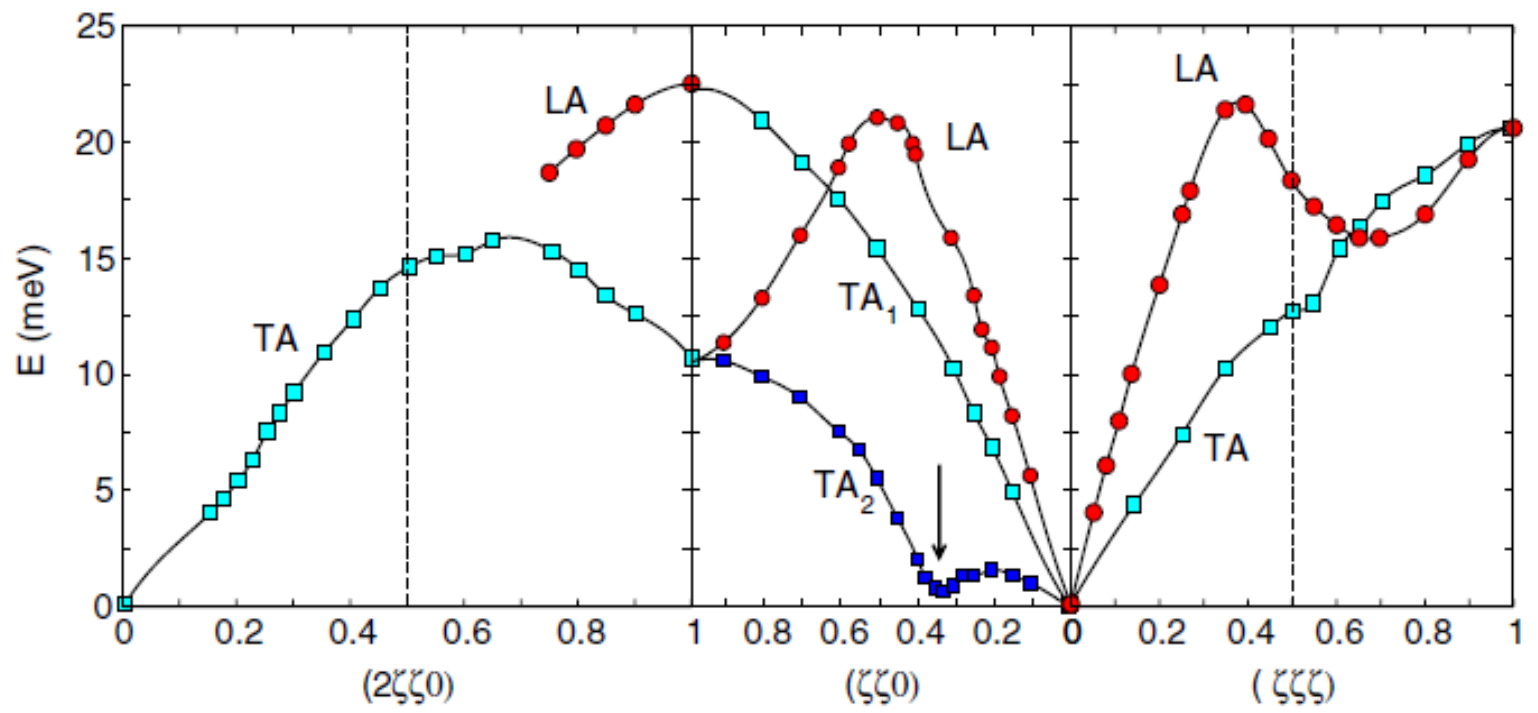
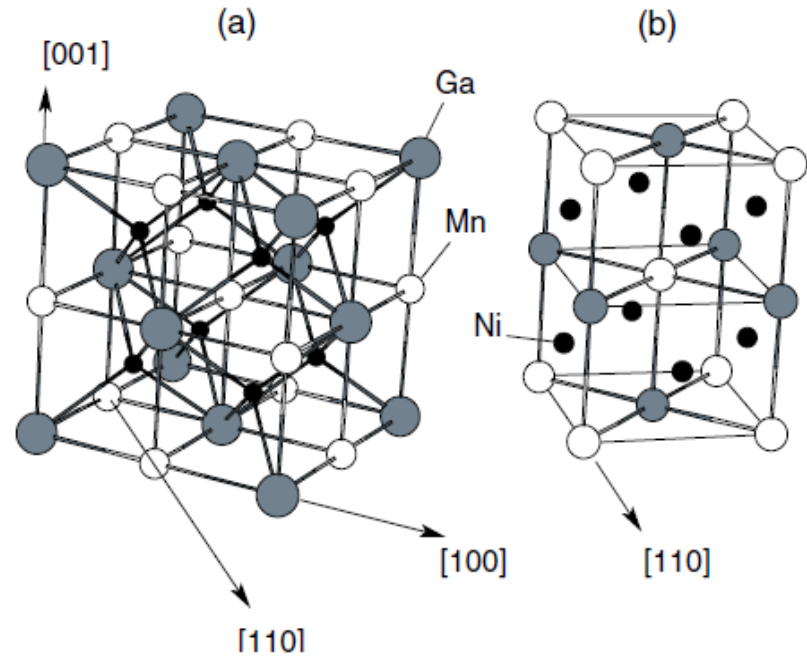
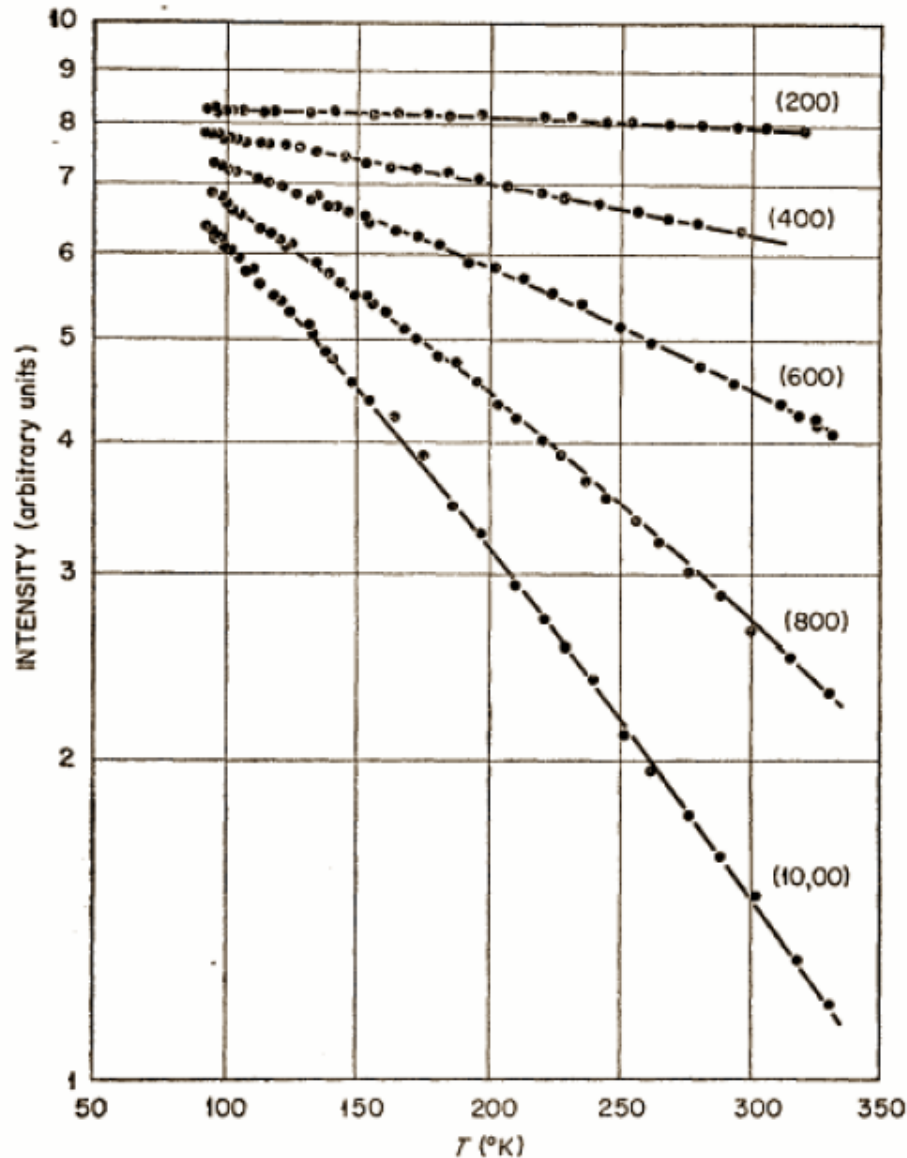


FIG. 2. Typical measurement of a phonon frequency shift: (a) peak at zero pressure; (b) peak at 3000 atm.

Ni₂MnGa



Debye-Waller-Faktor



Temperaturabhängigkeit
der Röntgen-Reflexe für
Aluminium

$$I = I_0 e^{-\langle u^2 \rangle Q^2 / 3}$$

R. M. Nicklow, R. A. Young,
Phys. Rev. **152**, 591 (1966)