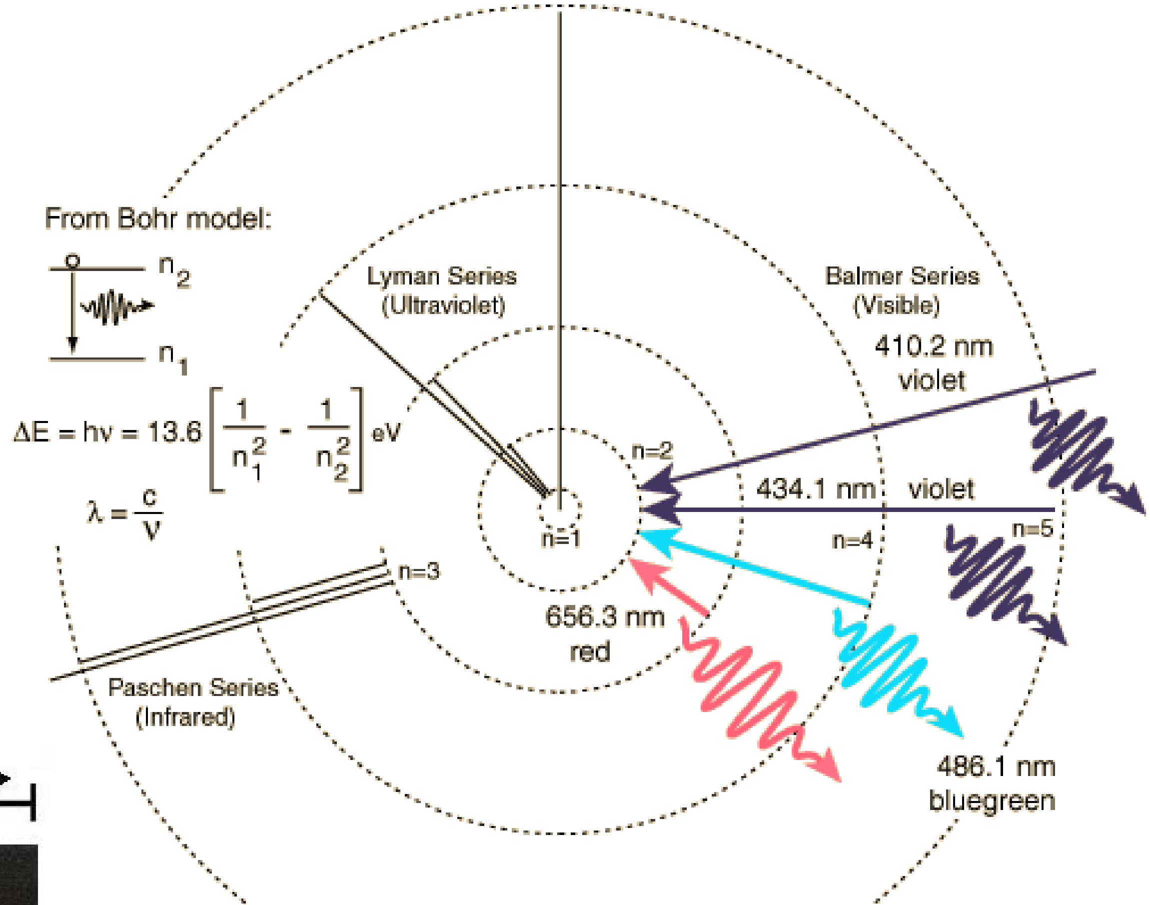
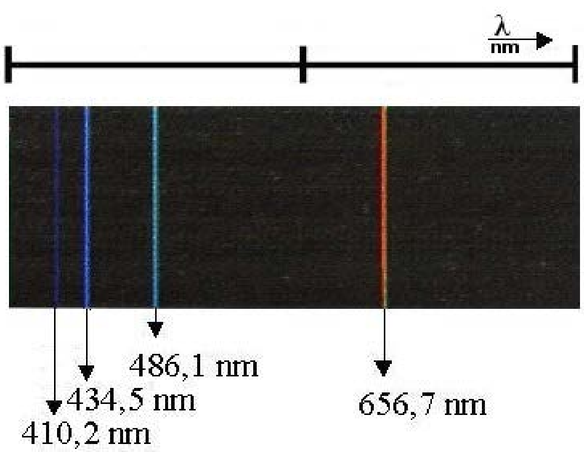
Ch. 11 Einblick in die Moderne Physik

- **Wärmestrahlung, Linienspektren**
- **Photoeffekt**
- **Teilchen-Welle Dualismus, Materiewellen (de Broglie)**
- **Unschärferelation (Heisenberg)**
- **Wellentheorie; Quantenmechanik = Wellenmechanik**
- **Atombau, Quantenzahlen, Pauliprinzip**
- **Moleküle, Festkörper**
- **Kern (Hadronen, Leptonen), Teilchenzoo**
- **Radioaktivität**

Hydrogen spectrum





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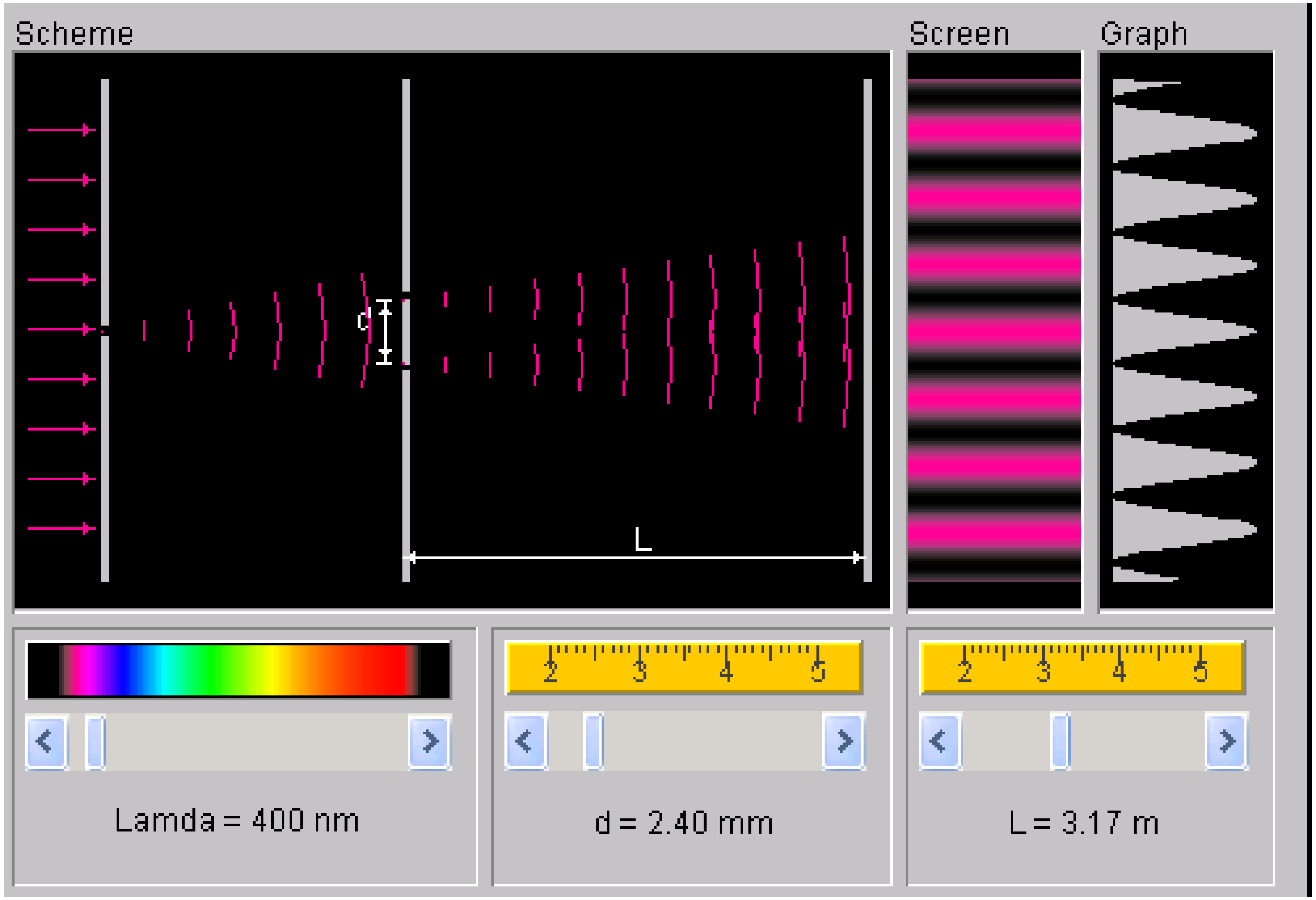
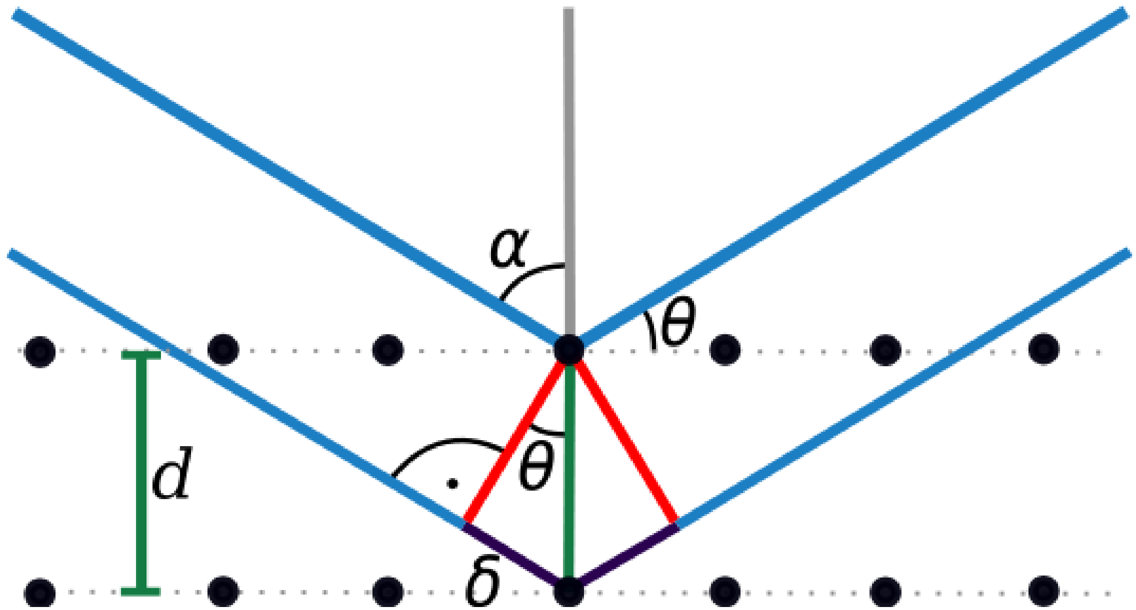
Licht als Welle: Young's double slit experiment

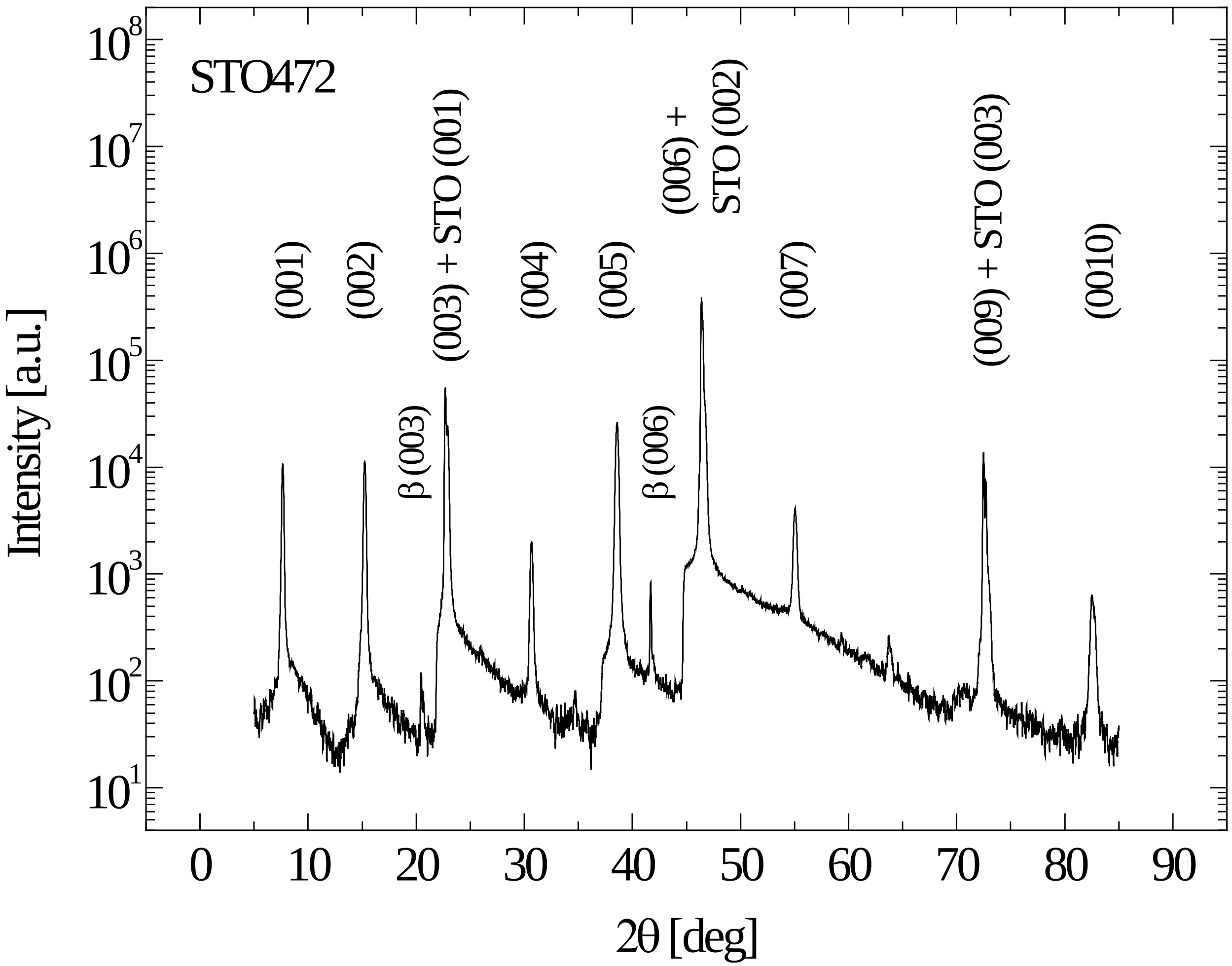


Interferenz, Beugung, etc...

Licht as Welle: Röntgenbeugung an Kristall



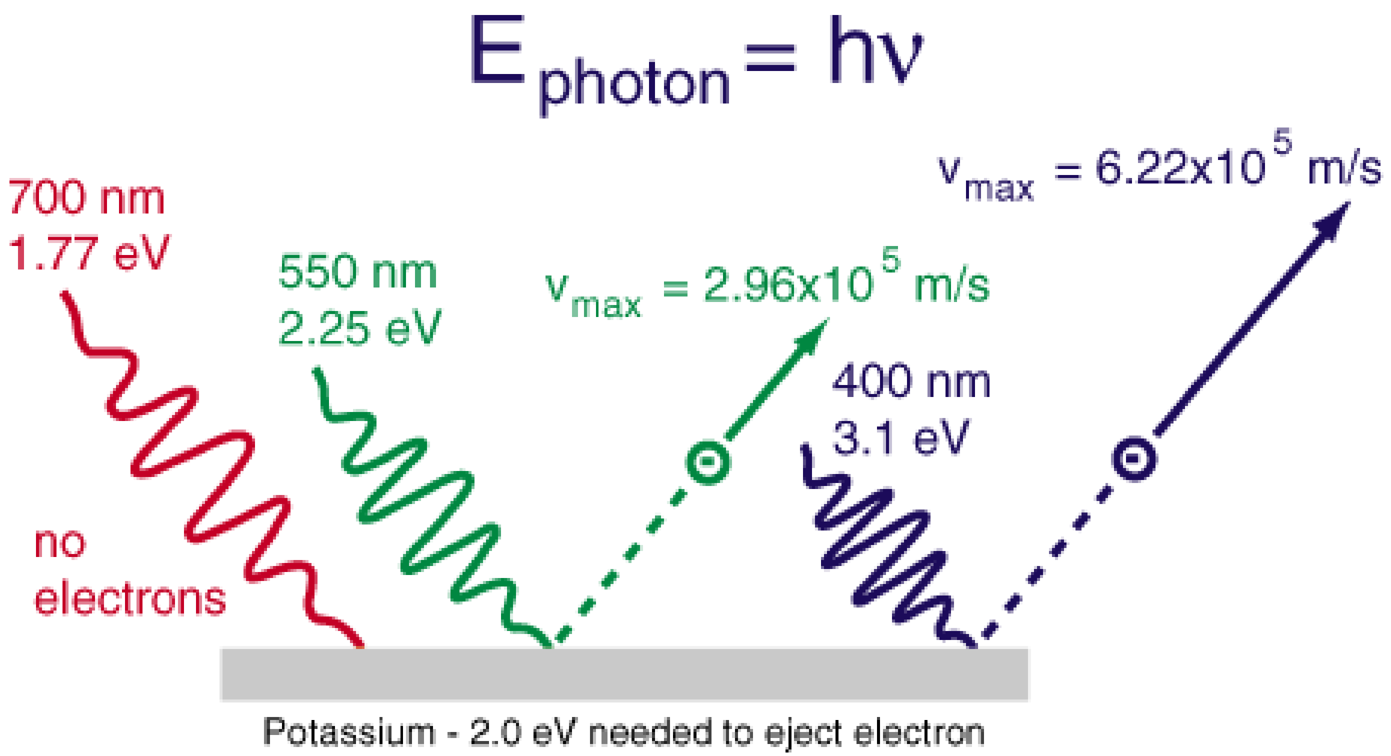
Licht as Welle: Röntgenbeugung an Kristall



Wellenlänge bekannt, Winkel varieren um d - Krystall Struktur - zu bestimmen

YBCO on STO, mc

Licht als Teilchen: Photoeffekt



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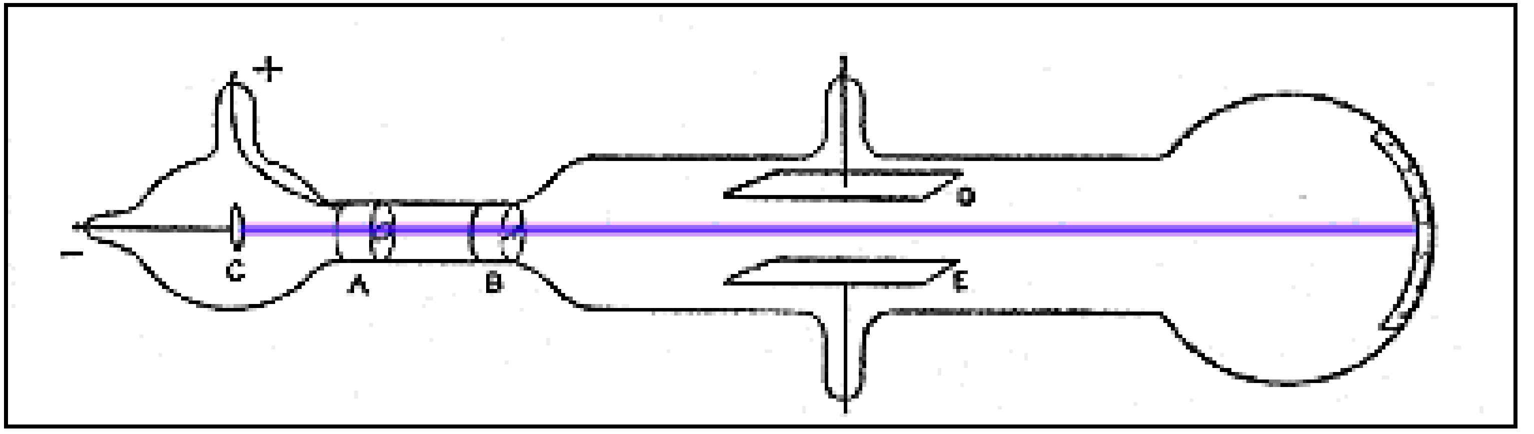
Teilchen-Welle Dualismus: Licht

Phenomenon	***Can be explained in terms of waves***	***Can be explained in terms of particles***
Reflection		
Refraction		
Interference		
Diffraction		
Polarization		
Photoelectric effect		

Elektron als Teilchen: J.J.Thomson



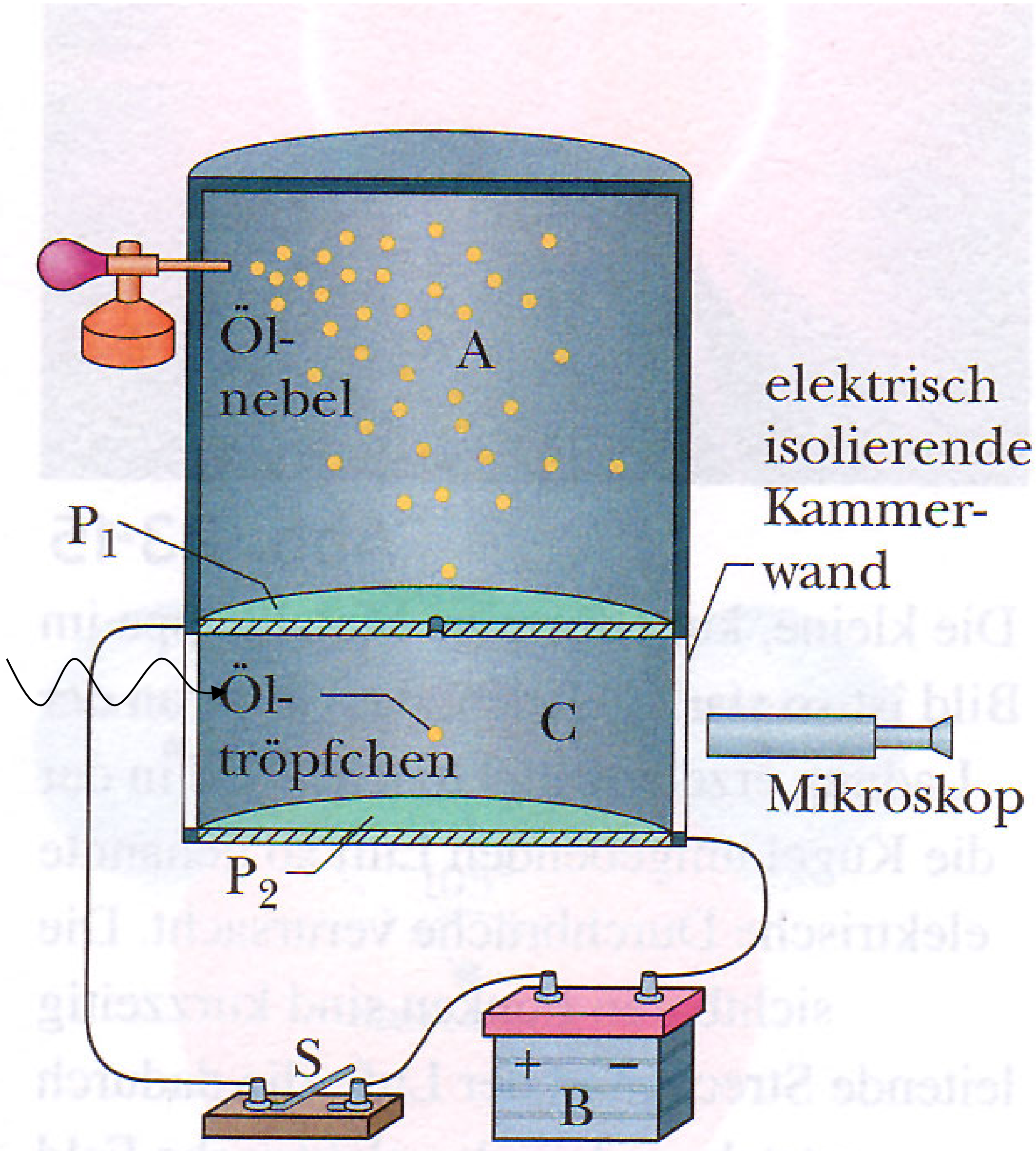
"I can see no escape from the conclusion that [cathode rays] are charges of negative electricity carried by particles of matter." ... "What are these particles? are they atoms, or molecules, or matter in a still finer state of subdivision?"

- ⇨ ***Existenz von subatomaren Teilchen (Elektronen)***
- ⇨ ***Bestimmung von m/e***

J.J. Thomson, "Cathode Rays," The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, Fifth Series, October 1897. p. 296

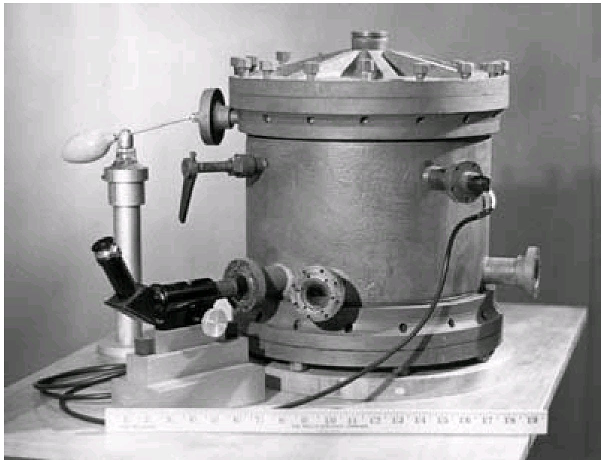
http://www.aip.org/history/electron/jj1897.htm

Elektron als Teilchen: Millikan



Robert Millikan
USA, 1868-1953
Nobel: 1923

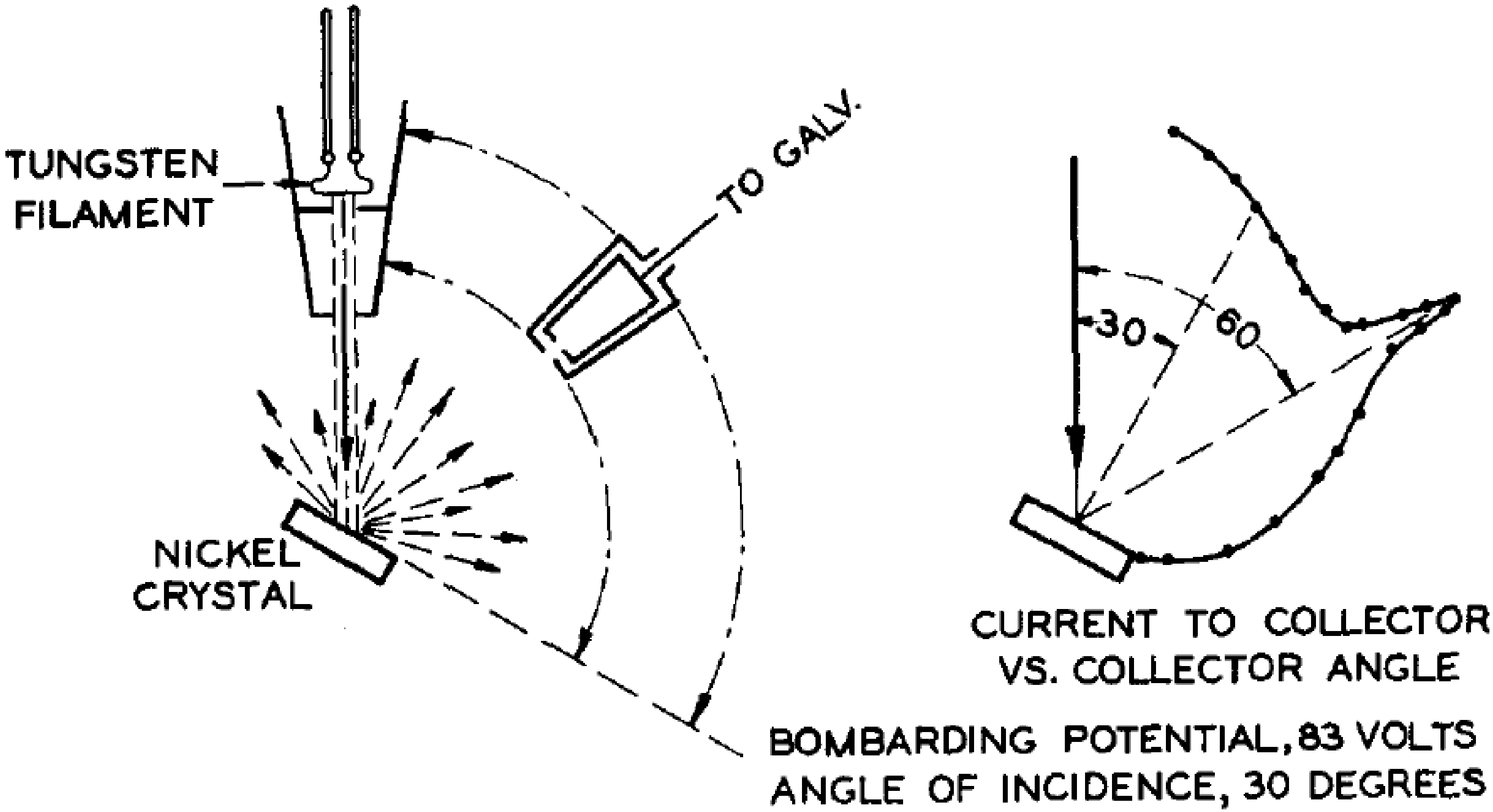
⇨ ***Ladung der Eletron***



Elektronen.... Beugung an Kristall

Davisson & Germer, 1927

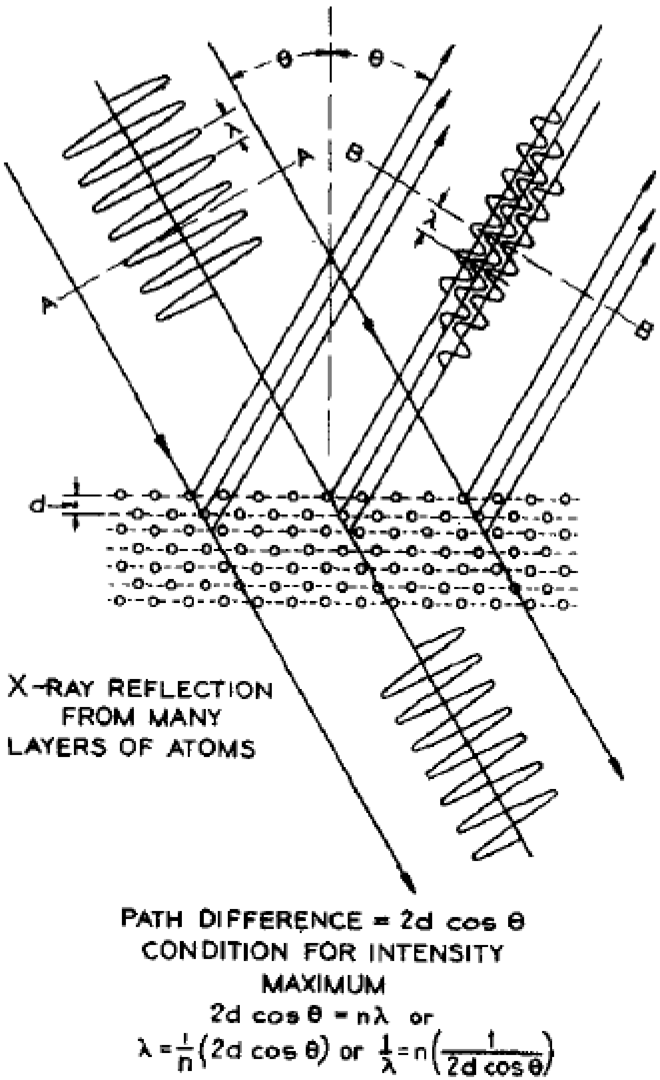
FIG. 1.

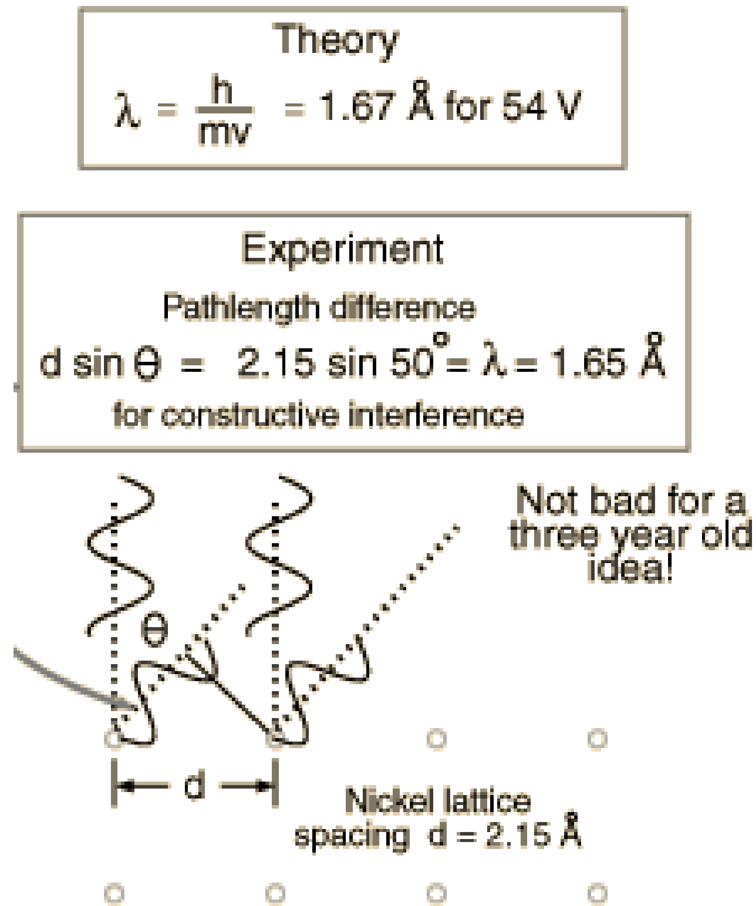


Experimental arrangement for investigating the scattering of electrons by a crystal, and a typical curve showing beam of regularly reflected electrons.

C.J. Davisson, Are electrons waves?, J. Franklin Instititute 205, 597-623 (1928)

Elektronen.... Beugung an Kristall



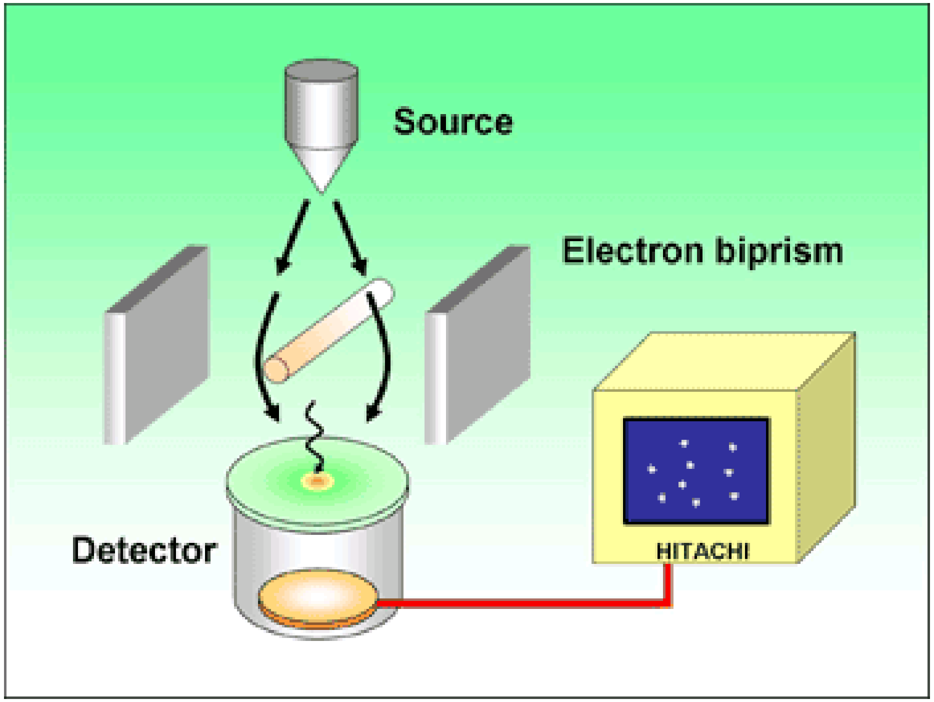


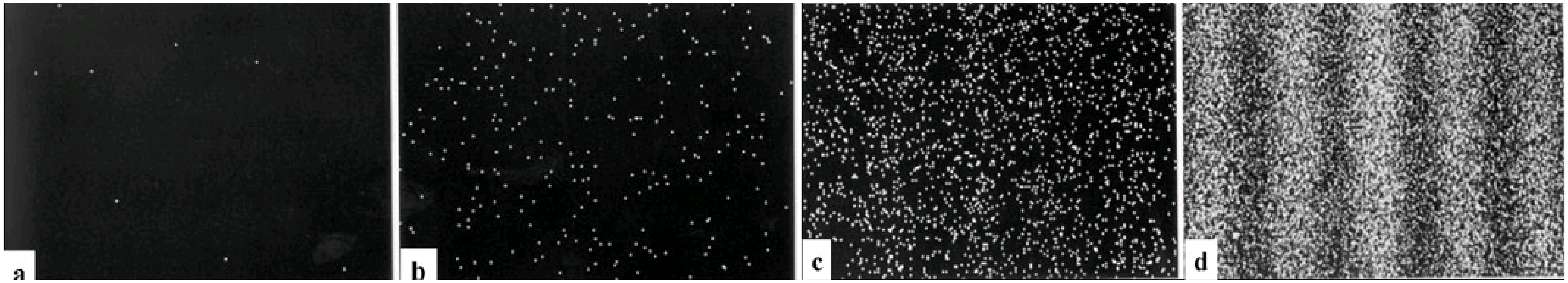
"As you see, it is really all very simple."

C.J. Davisson, "Are electrons waves?" J. Franklin Insititute 205, 597-623 (1928) & Hyperphysics

Elektronen Interferenz

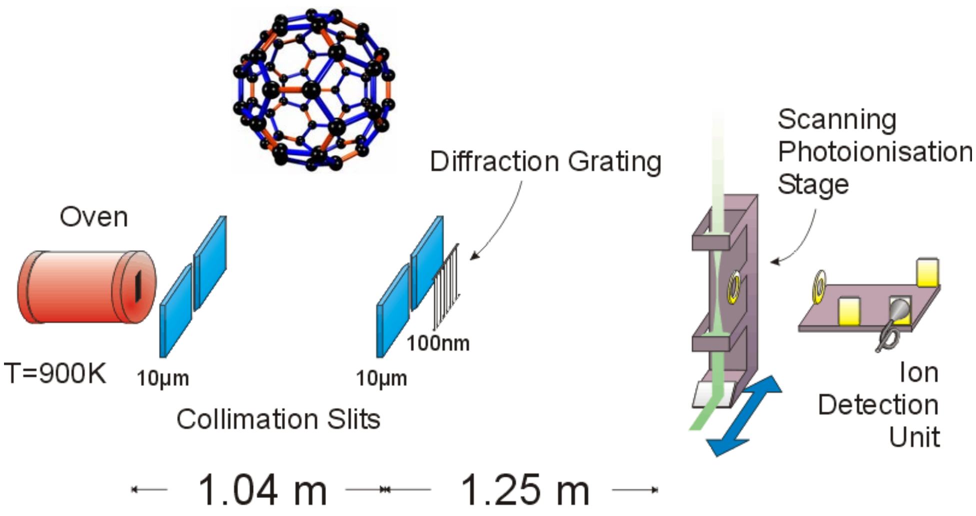
doubleslite-n.wmv



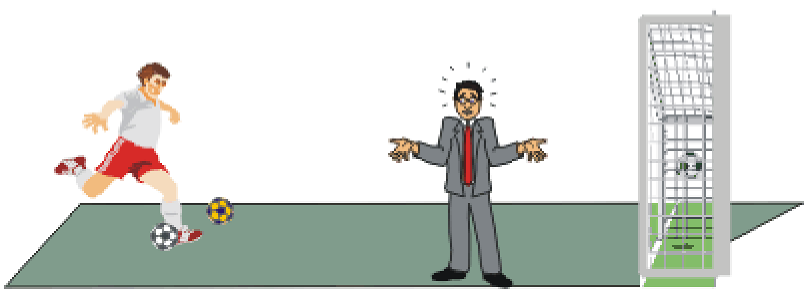


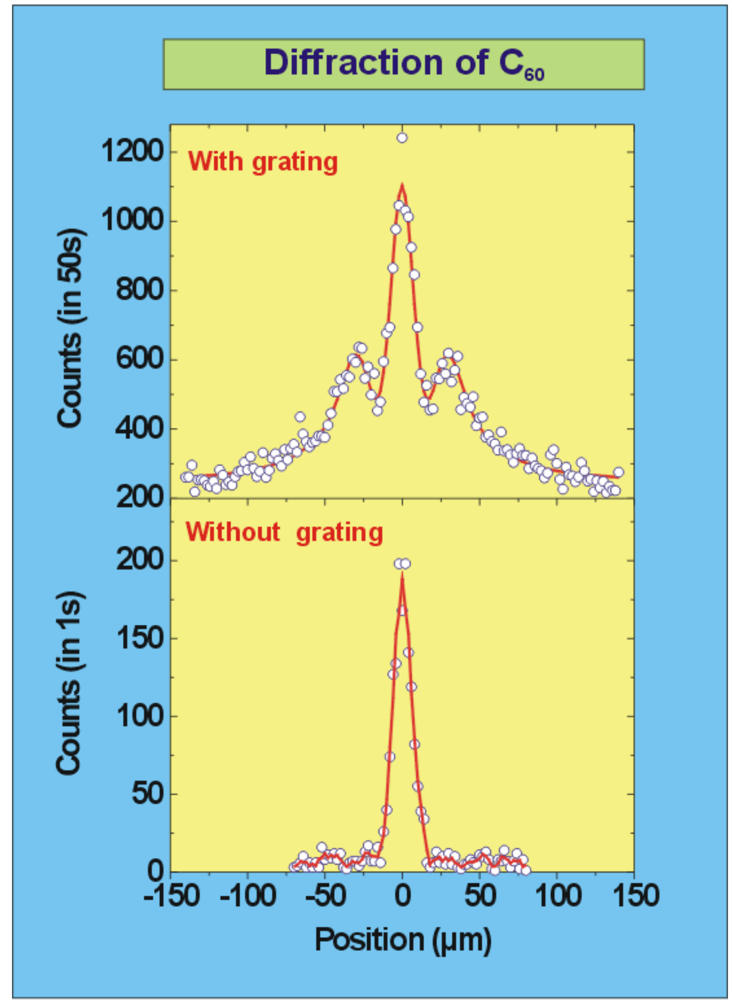
http://www.hitachi.com/rd/research/em/doubleslit.html

Interferenz mit Moleküle: C60



Pressure ~5·10^{-7} mbar



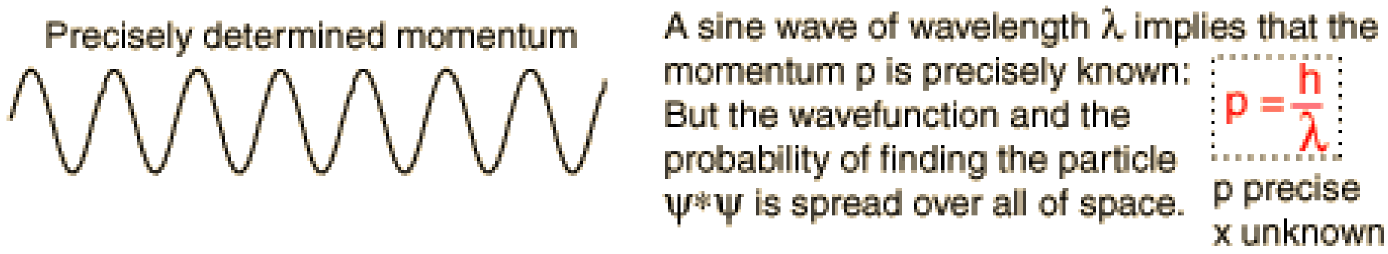


Zeilinger et al., Nature 401 680-682, (1999)

http://www.univie.ac.at/qfp/research/matterwave/c60/index.html

Unschärferelation (Heisenberg)

Ebene Welle



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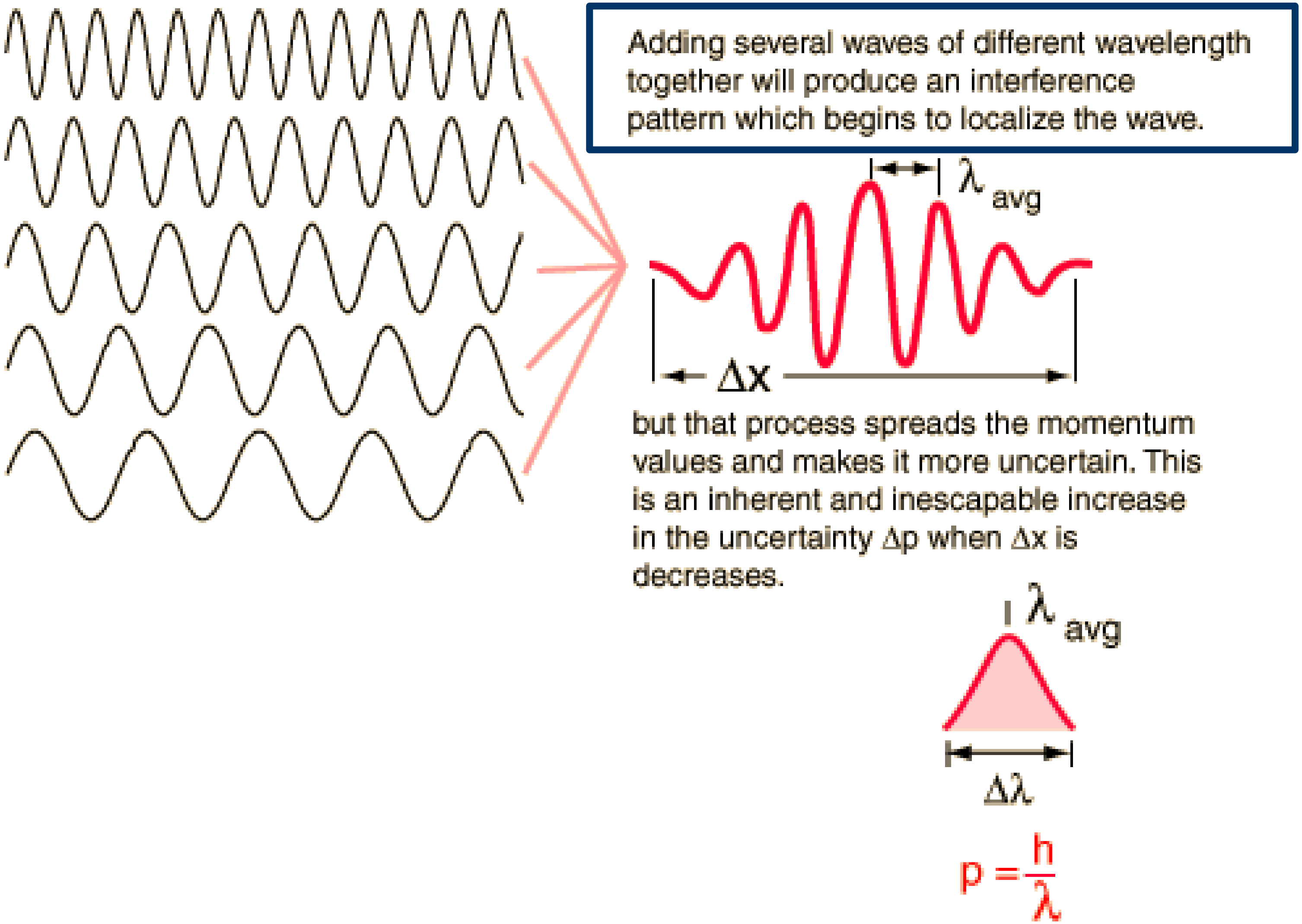
Unschärferelation (Heisenberg)

Wellen Paket

(Wellen gruppe)



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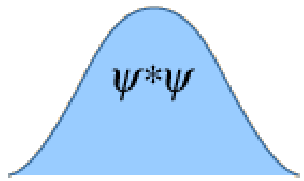
Unschärferelation (Heisenberg)

- **energy**

  required to confine a particle in a given volume (rough approx.)

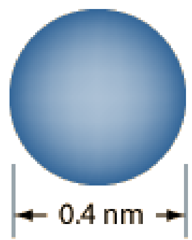
  (the smaller the volume, the larger the energy

  NB: confinement in 1D here; more precise: do it in 3D)



$\psi^*\psi$ is the probability of finding the particle.

ψ = wavefunction



Assume $\Delta p = p$

$$E = \frac{p^2}{2m}$$

Assume atomic size = $0.4nm$ $= \Delta x$

Nuclear size = $\frac{1}{20{,}000} x\ 0.4nm$

Using the atomic size as the uncertainty in position:

$$\Delta p = \frac{h}{\Delta x} = 1.66x10^{-24}\,kg \cdot m / s$$

This shows that Planck's constant determines the relationship between Δx and Δp and therefore the energy of confinement.

Energy to:

Confine electron in atom: $9.4eV$

Confine proton in nucleus: $2.05MeV$

Confine electron in nucleus: $3.77GeV$

These are in the range of observed atomic and nuclear processes.

This is about a factor of a thousand above the observed energies of nuclear processes, indicating that the electron cannot be confined in the nucleus!

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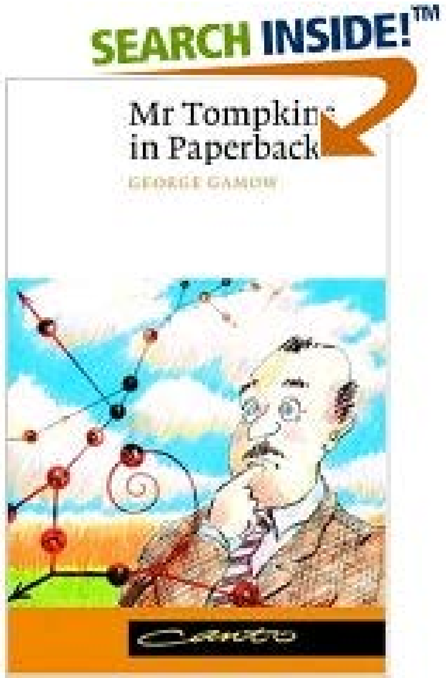
.... and a summer reading

The adventures of C.G.H. Tompkins

light speed — gravitational const. — Planck const.

or how the world would look like if these constants would be much smaller/larger…



(by George Gamow)