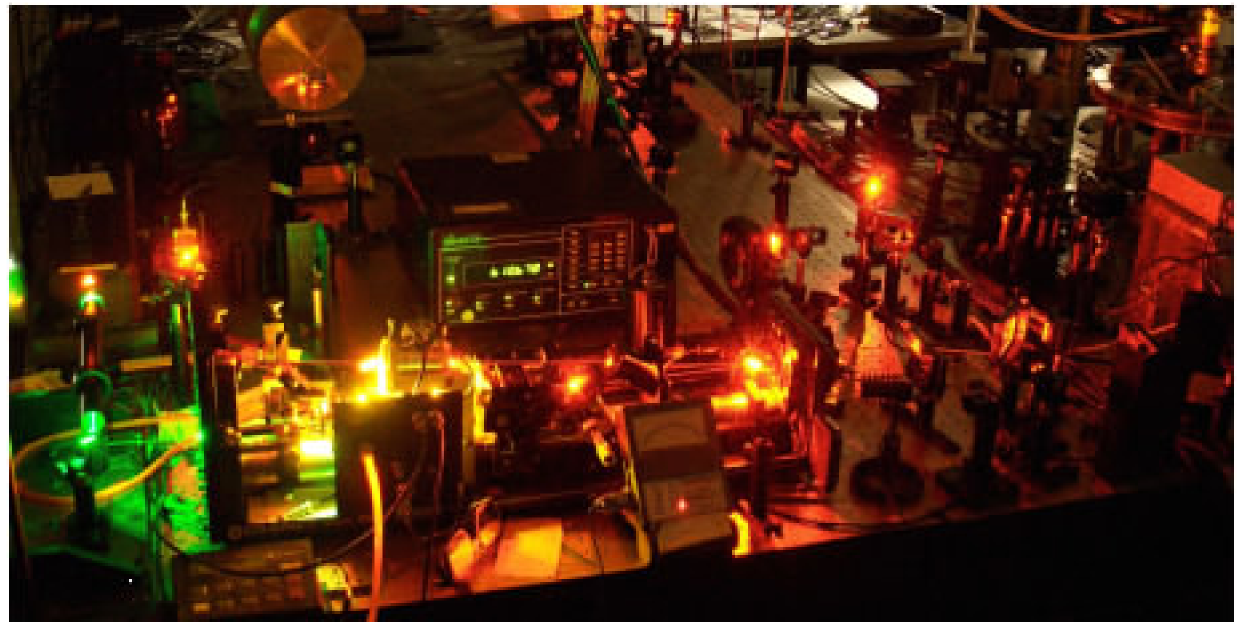
Laserspektroskopie

Was: Optische Spektroskopie mit Lasern:
Grundlagen und Anwendungen



Wann: Mi 13^{15} - 14^{00}
Fr 10^{15} - 12^{00}

Wo: P1 - O1 - 306

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Literatur

W. Demtröder : Laserspektroskopie
Springer-Verlag, 4.Auflage (2000).

F.K. Kneubühl, M.W. Sigrist : Laser
Teubner Studienbücher Physik (1999).

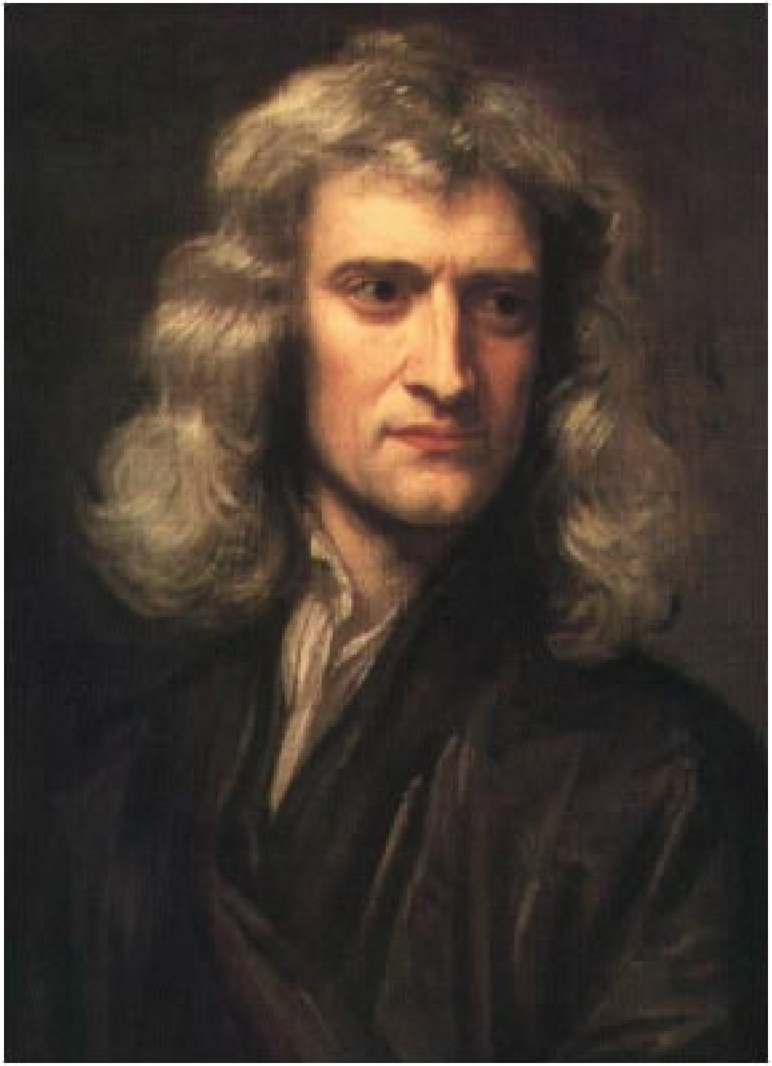
D. Meschede : Optik, Licht und Laser
Teubner Studienbücher Physik (1999).

A. E. Siegmann : Lasers
University Science Books, 1986.

J.H. Eberly : Optical resonance and two-level atoms
Dover Publications, 1975.

D. Suter : The physics of laser-atom interaction
Cambridge University Press, 2005.

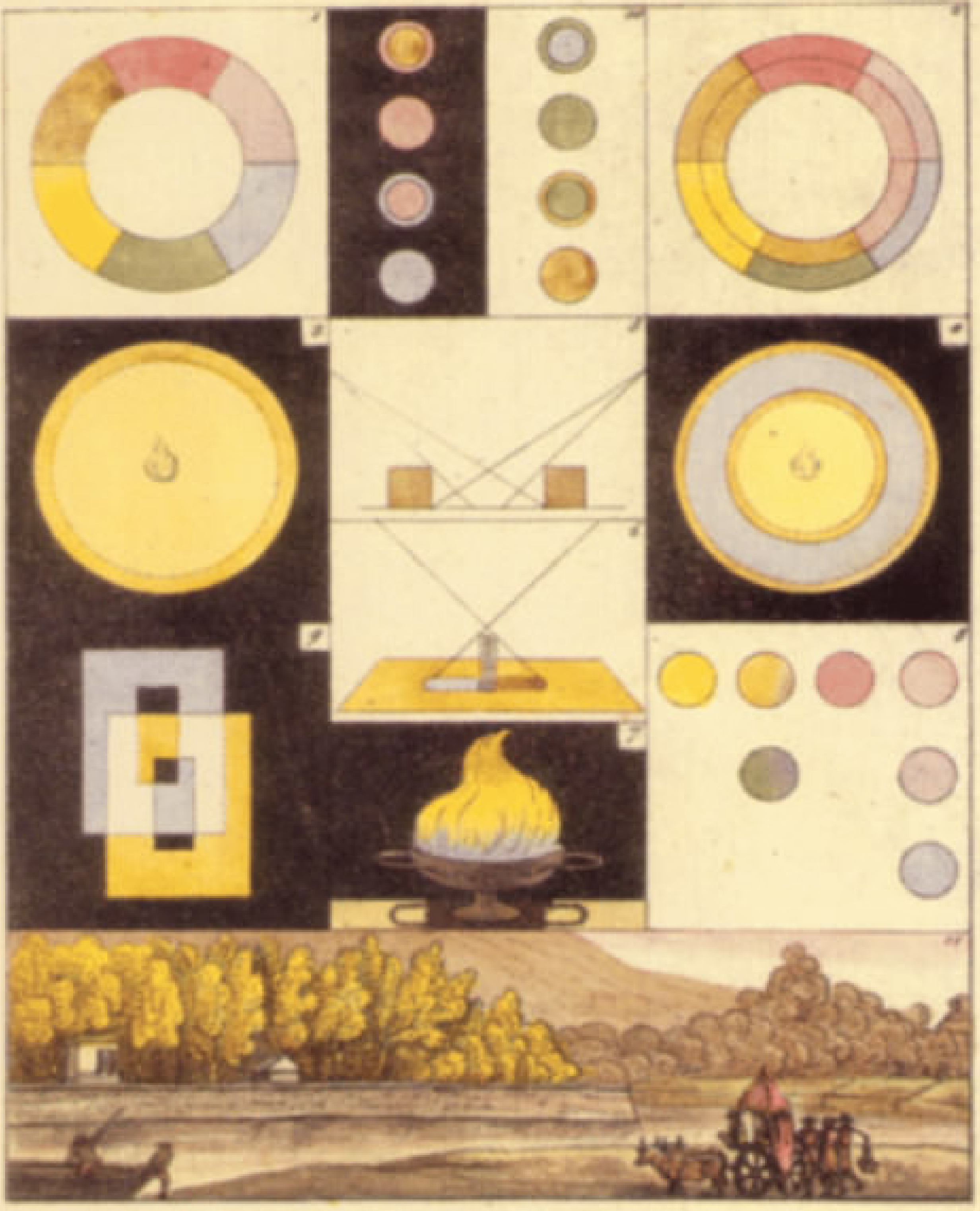
Licht und Materie



Newton (1643 – 1727)

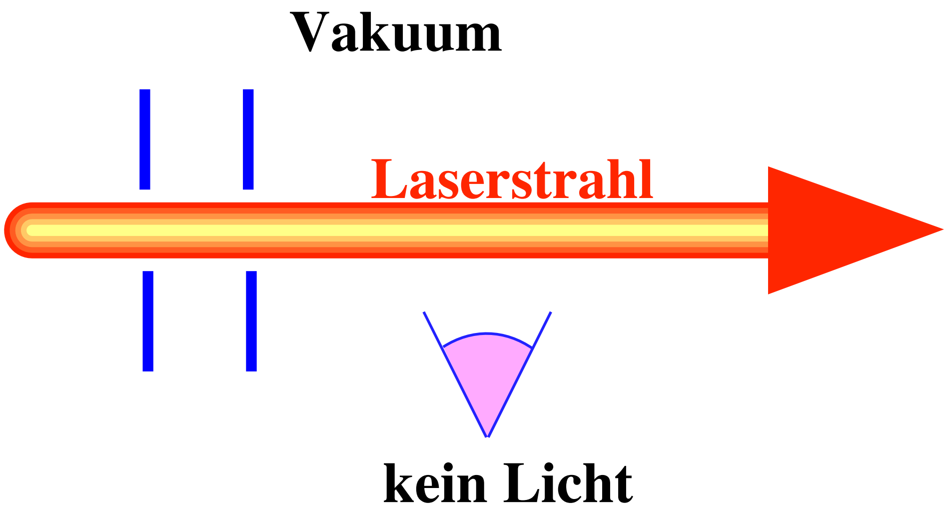
Goethe (1749-1832)

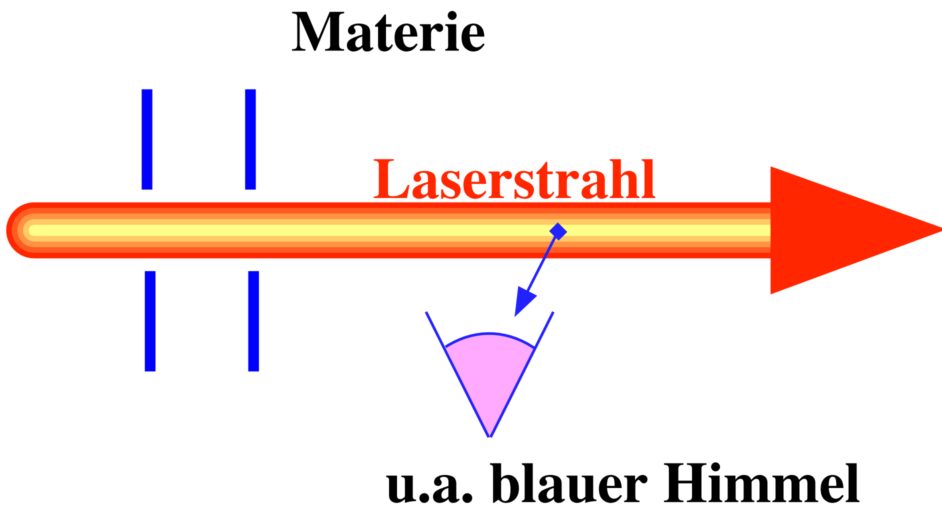
I.



Streuung

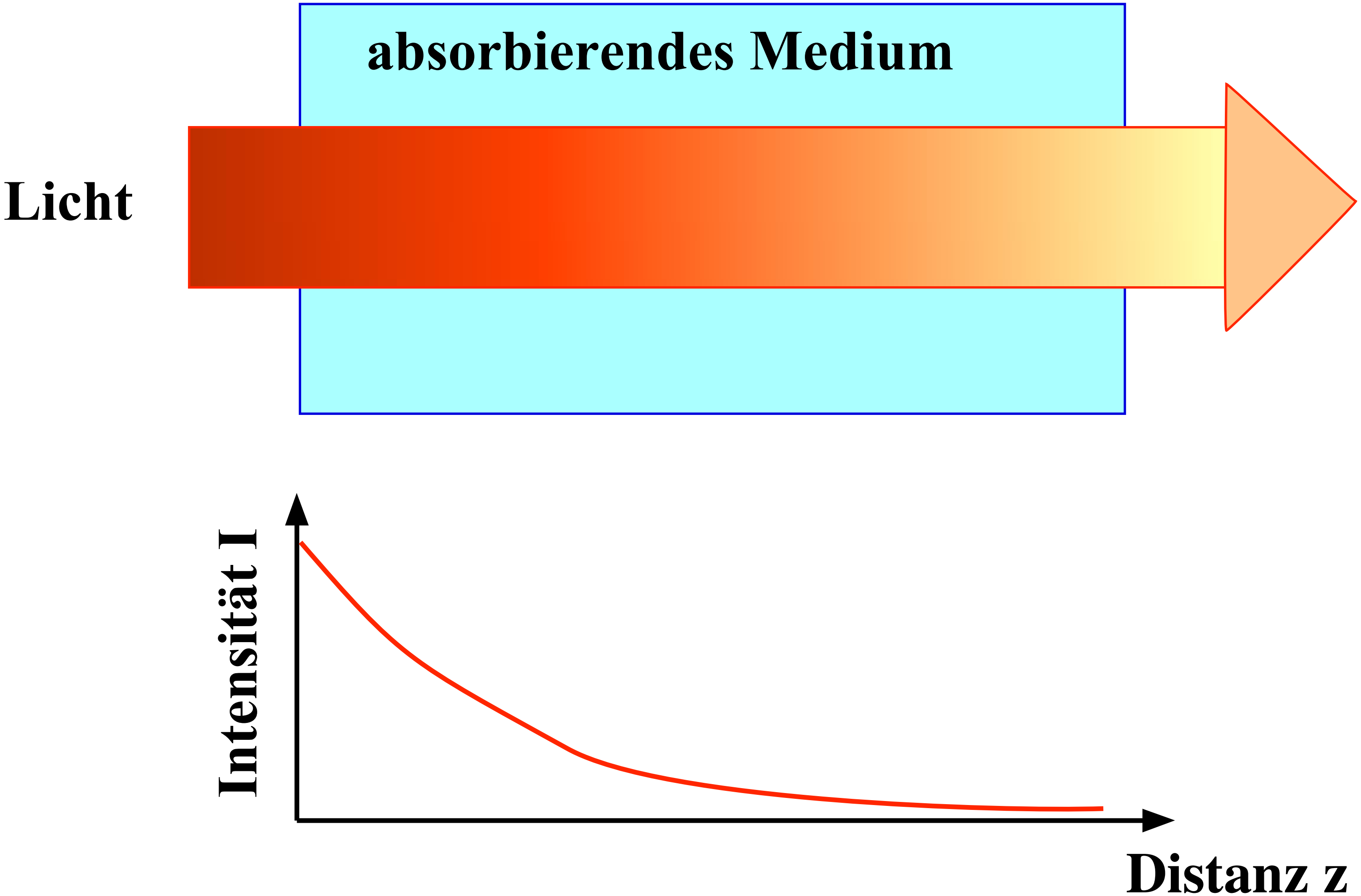
Streuung



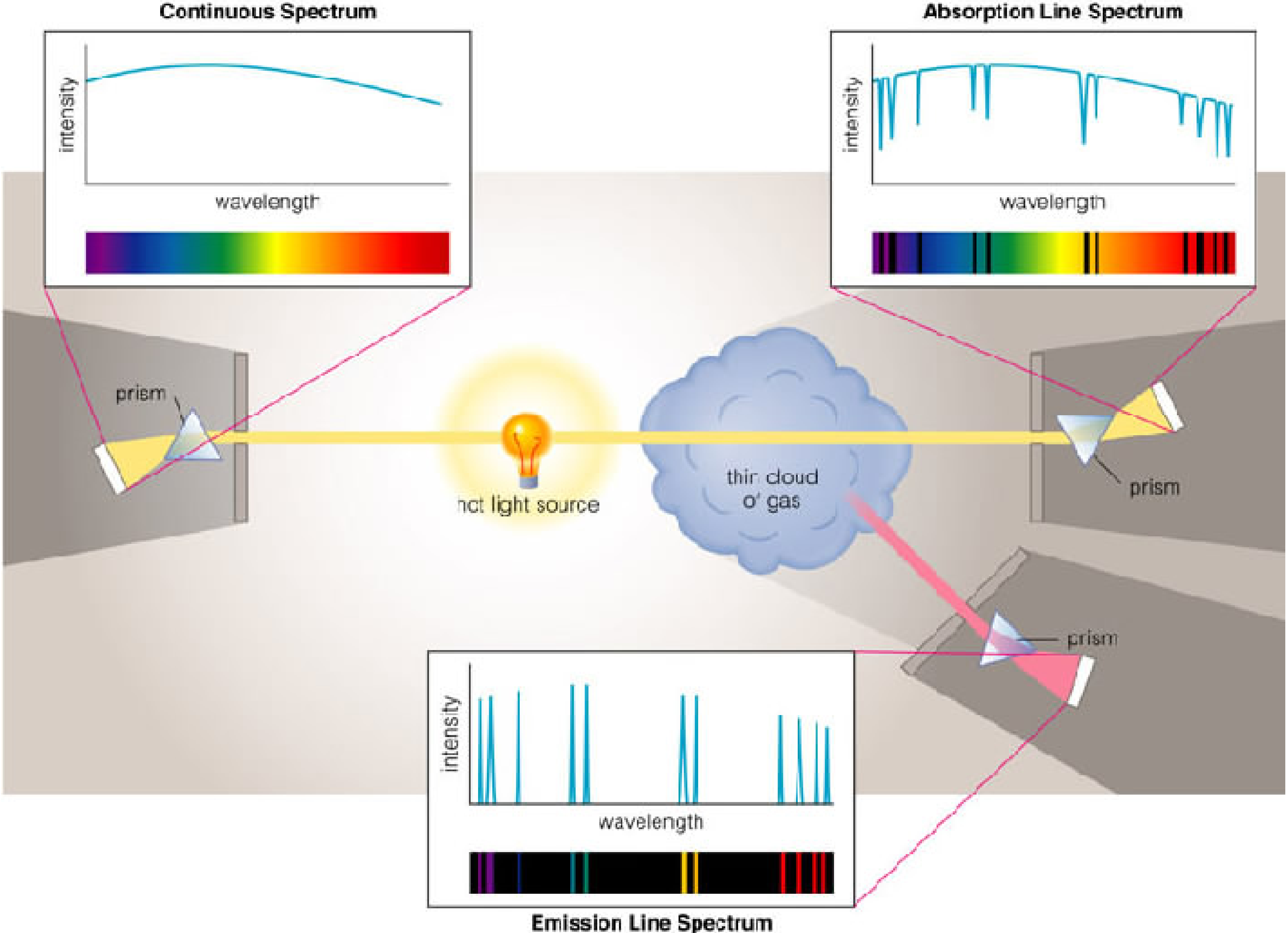


- Homogene Materie
- Inhomogene Materie

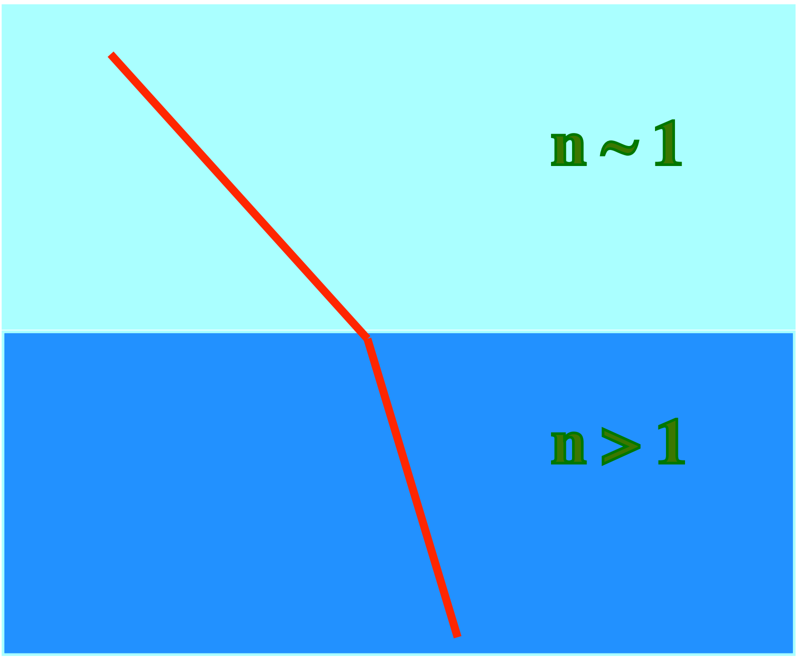
Absorption

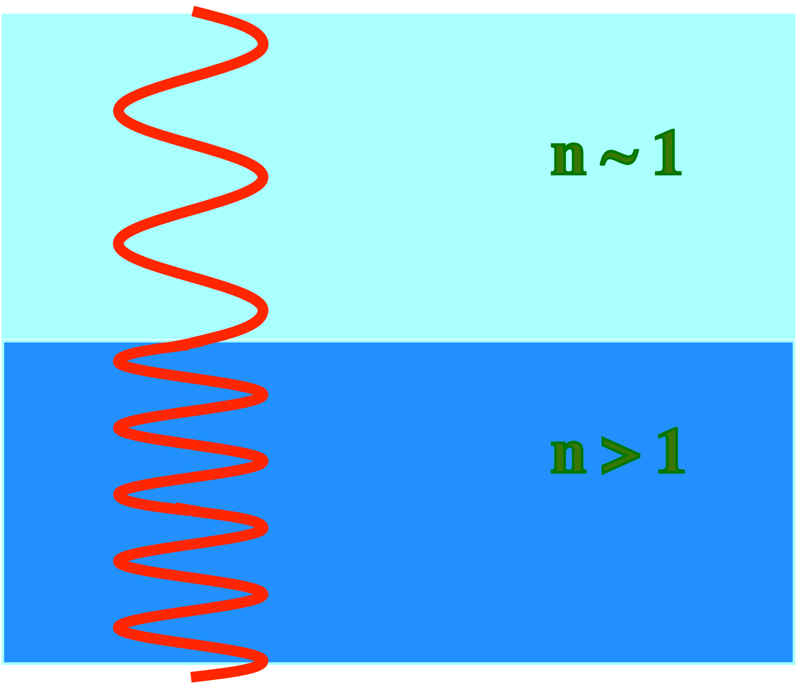


Absorption und Emission

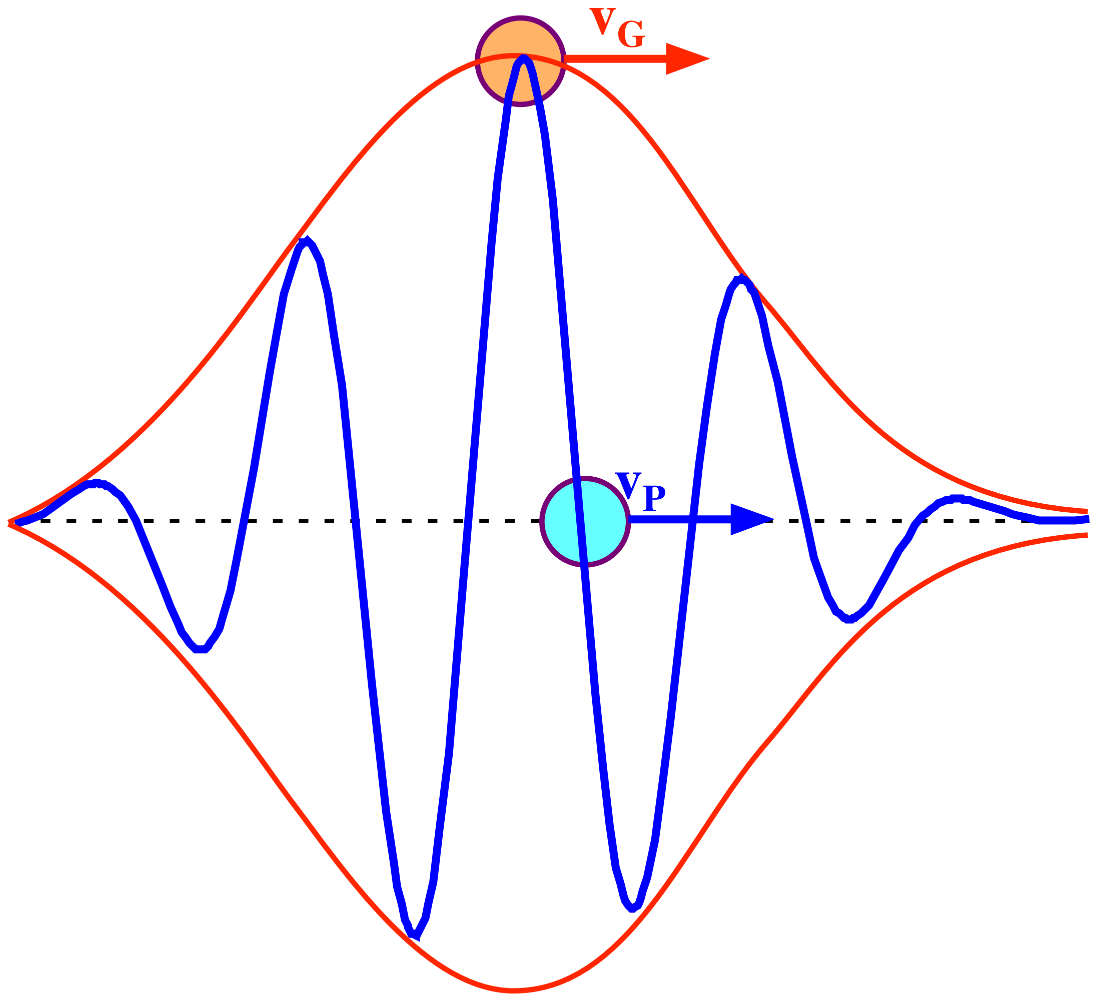


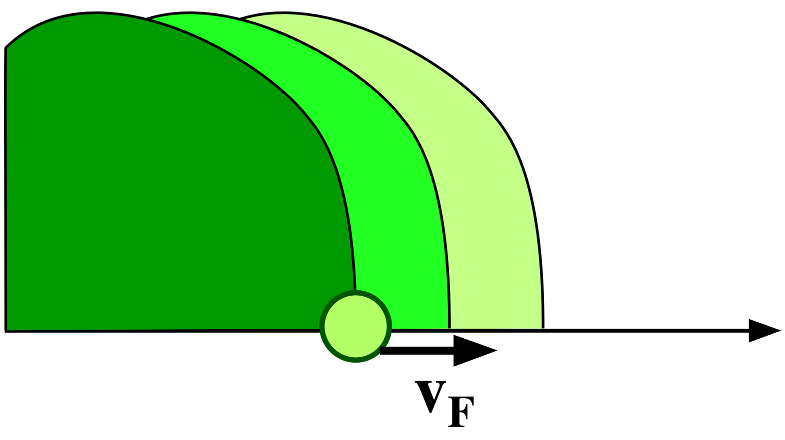
Brechung



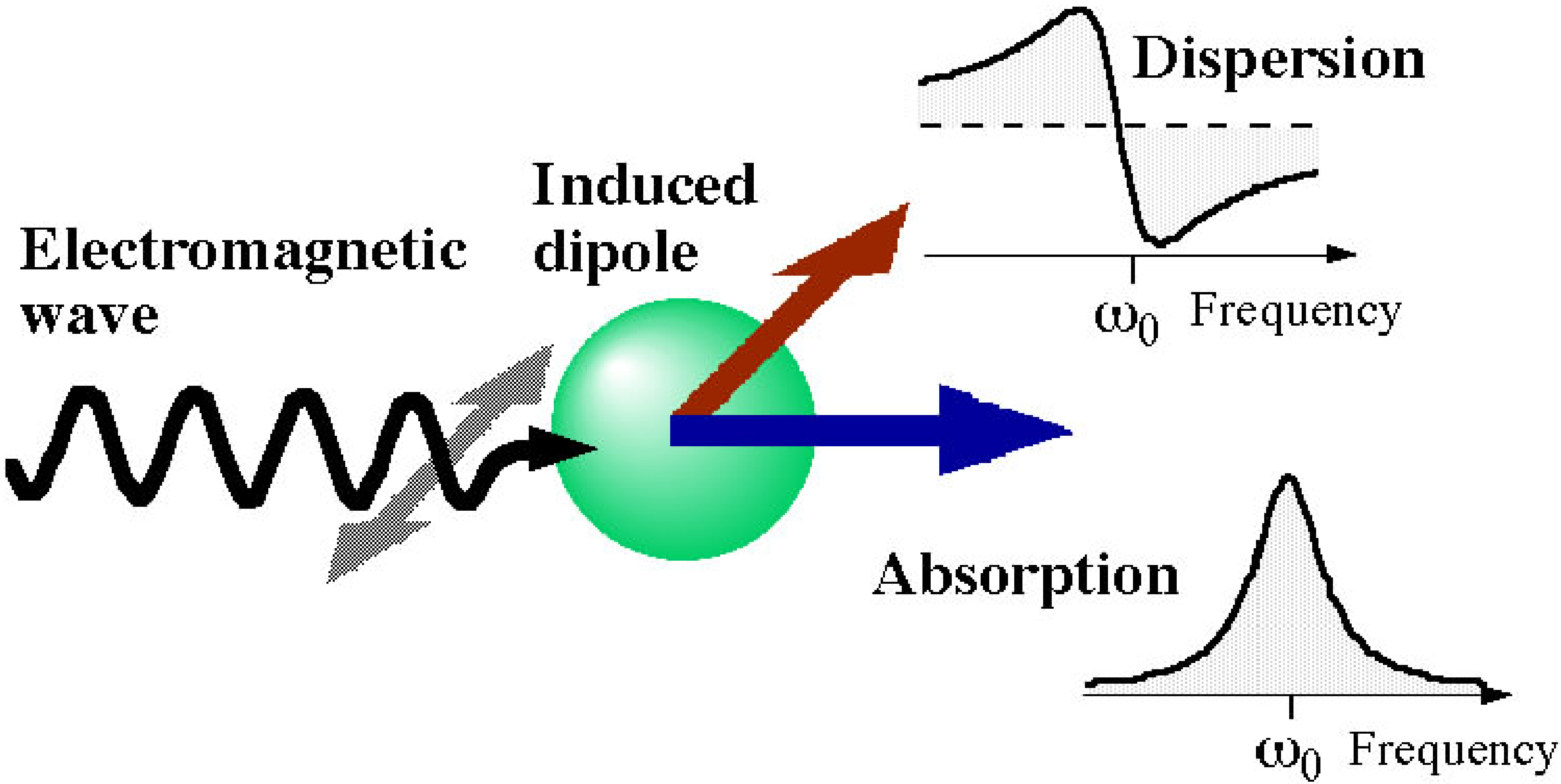


Ausbreitungsgeschwindigkeit

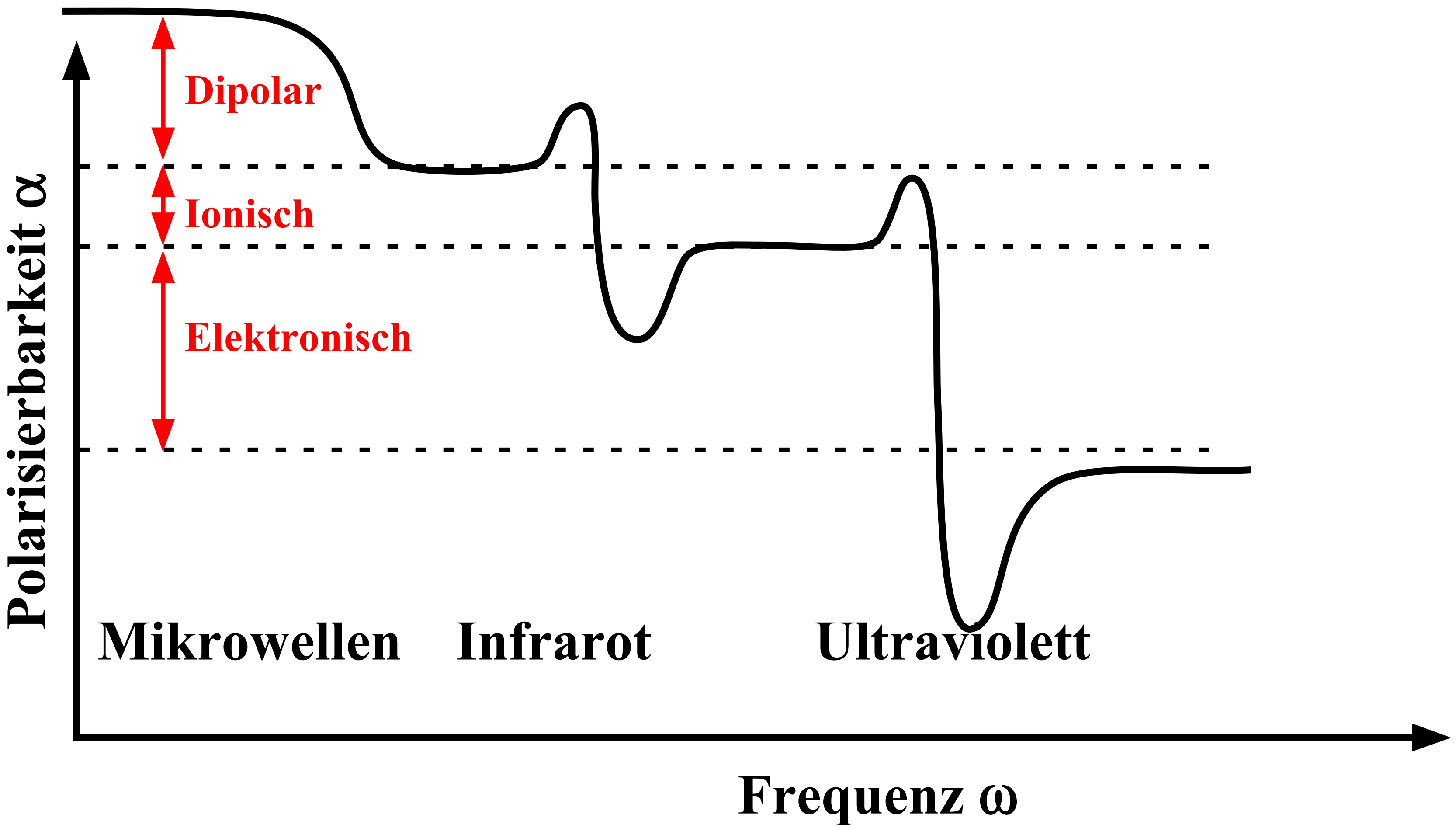




Mikroskopisches Modell



Wellenlängenabhängigkeit



1.4 Formen der Spektroskopie

Das allgemeine Umfeld:

- Wellen oder Teilchen

- elektrische oder magnetische Wechselwirkung

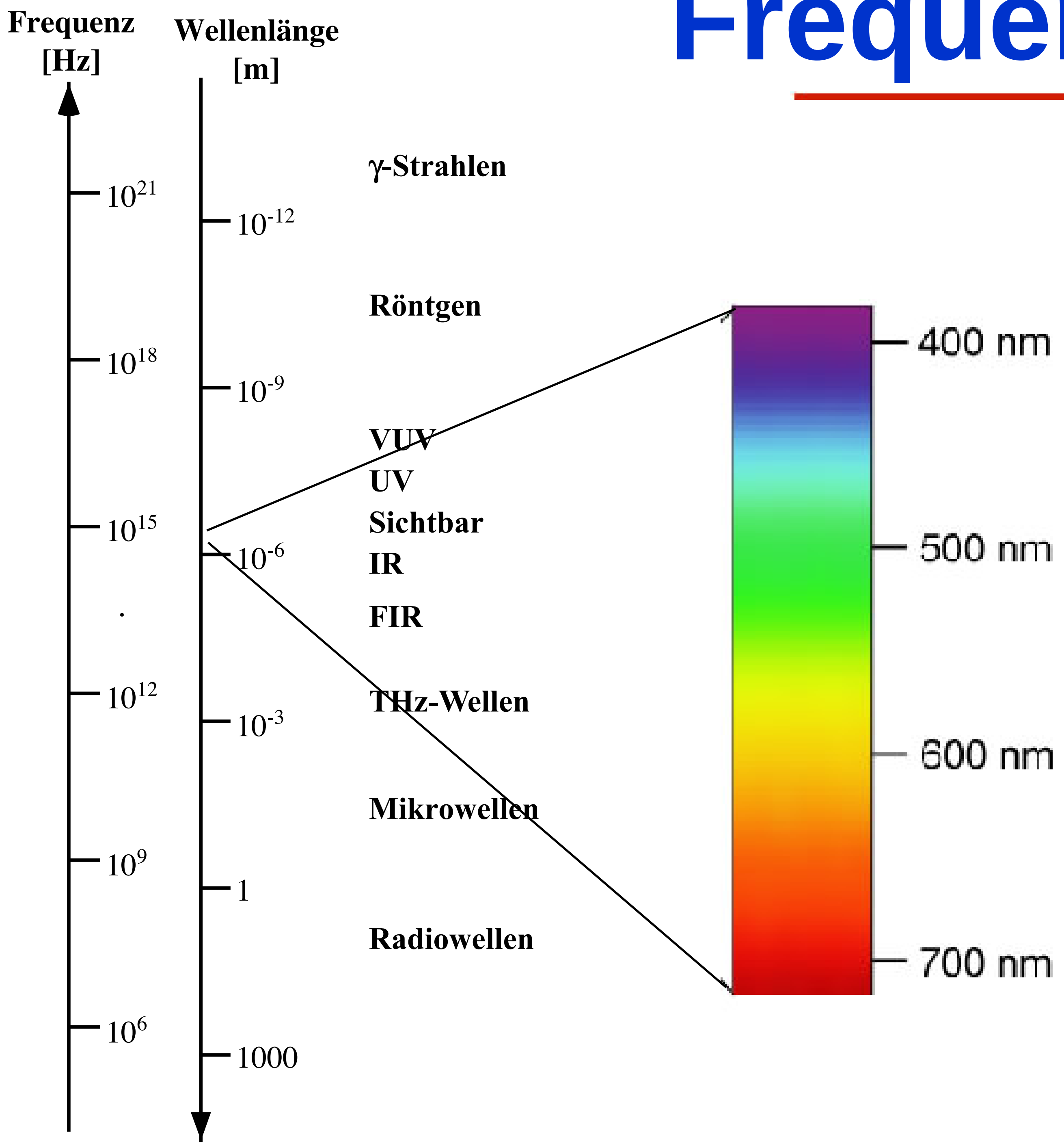
- Frequenzbereich

- lineare / nichtlineare Spektroskopie

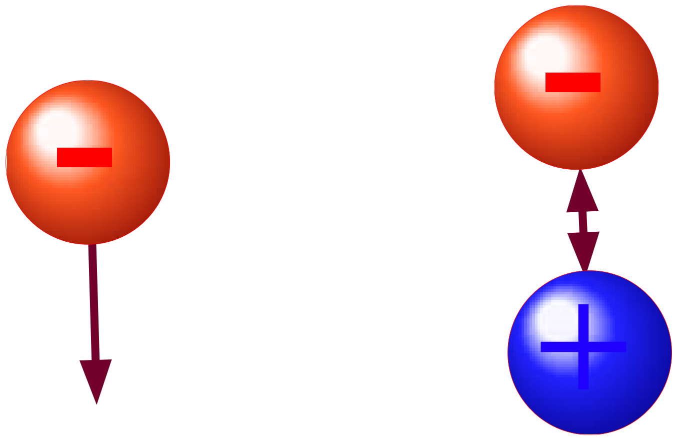
- Zeit- oder Frequenzbereich

- Absorption / Dispersion / Emission

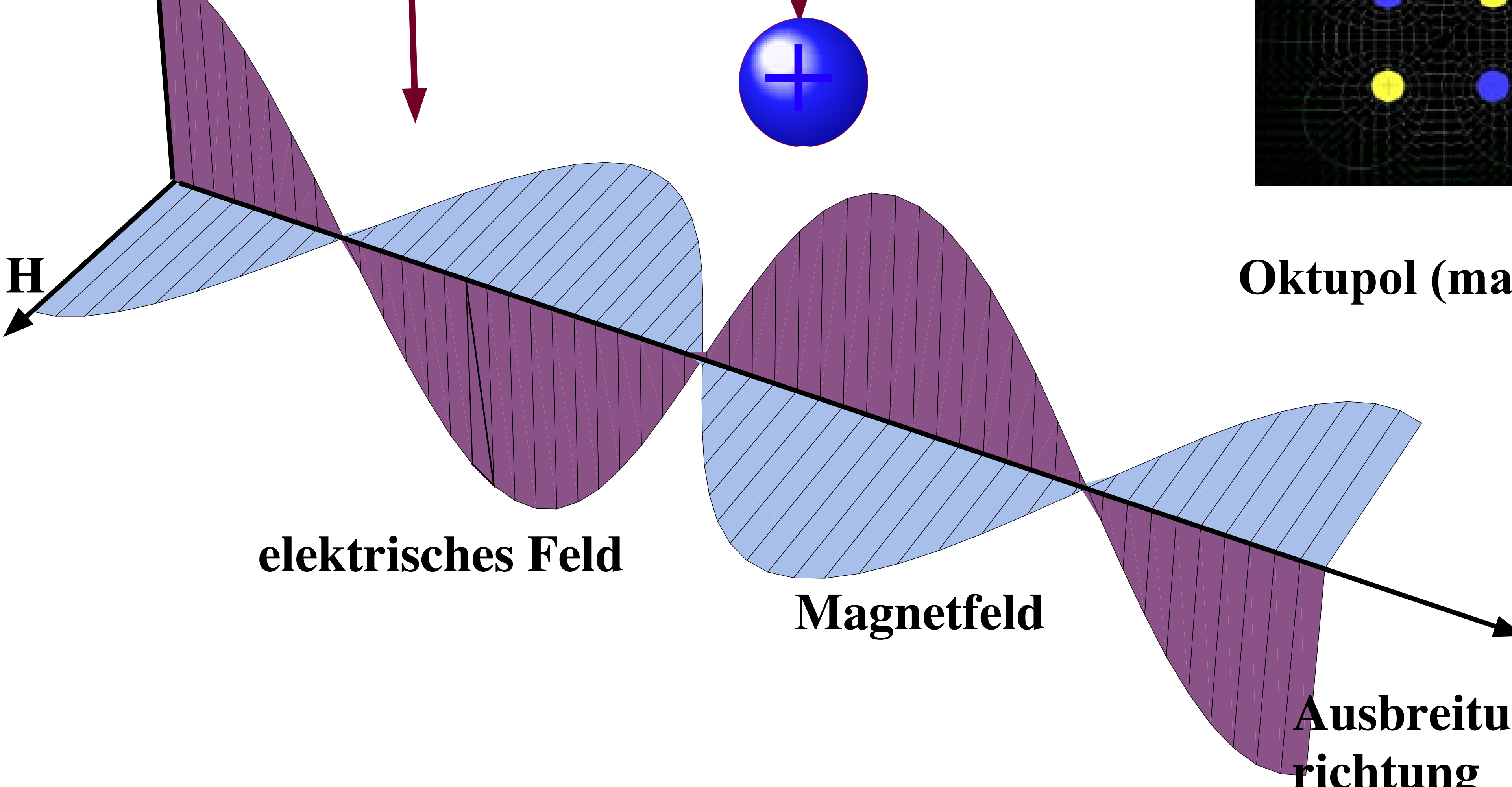
Frequenzbereiche



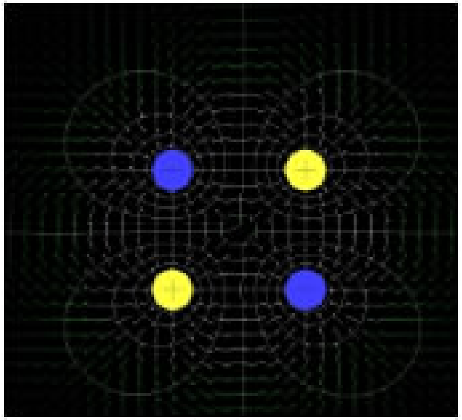
Wechselwirkungen



Dipol:
- statisch
- induziert

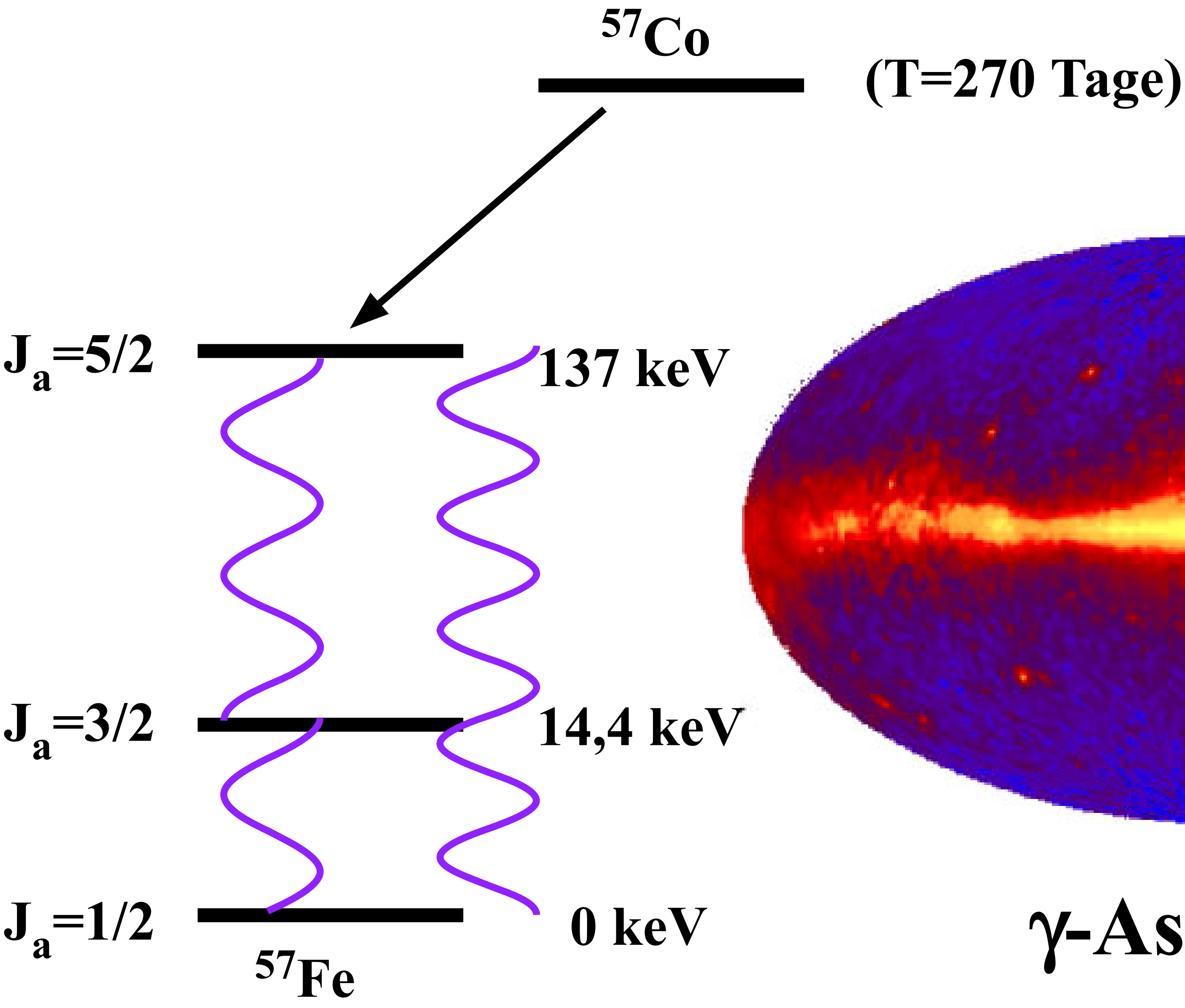


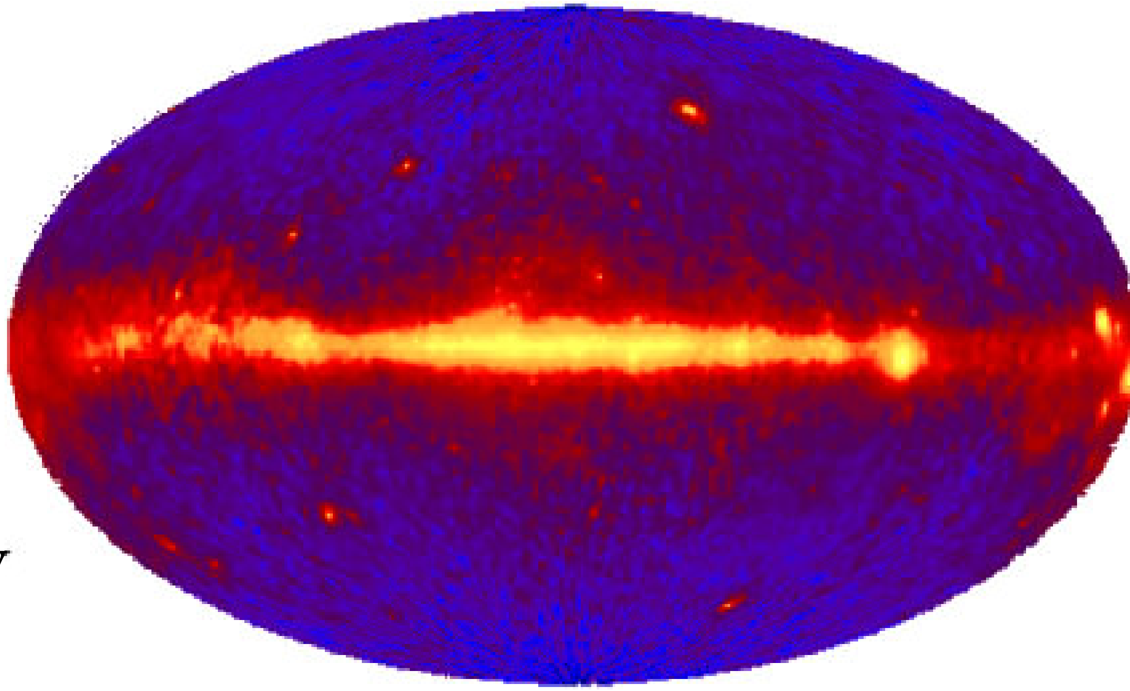
Quadrupol (elektr.)



Oktupol (magn.)

γ-Strahlen





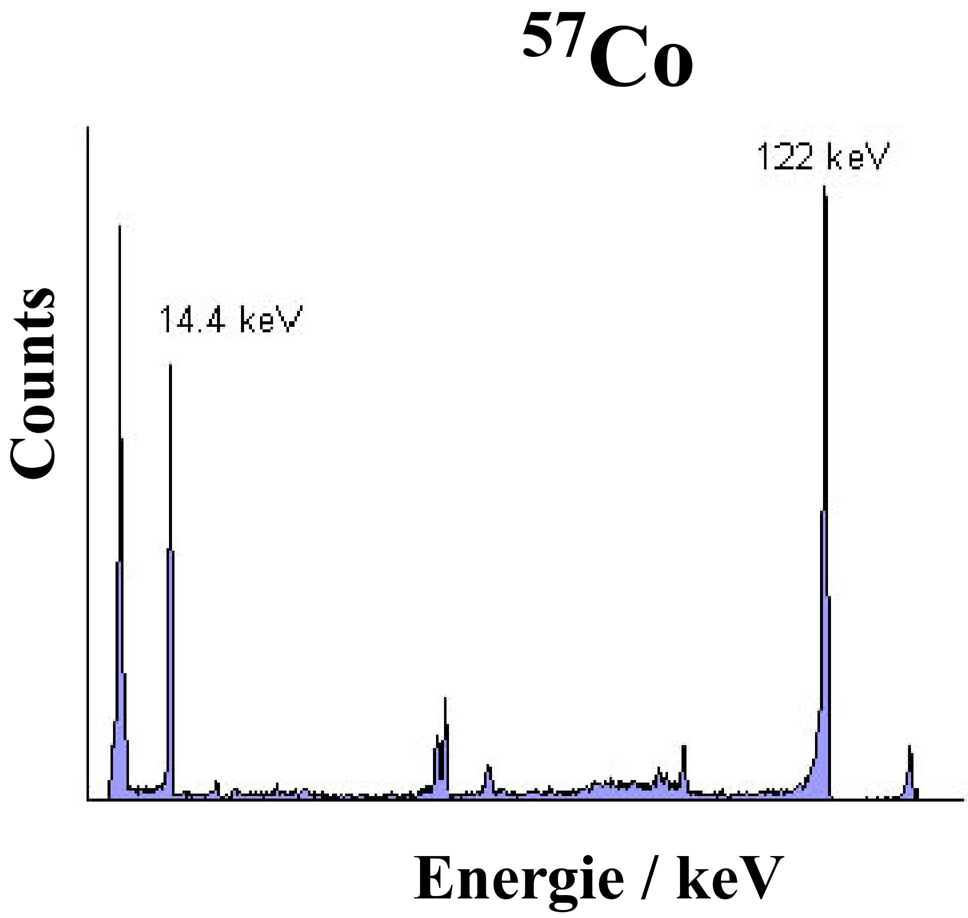
γ-Astronomie

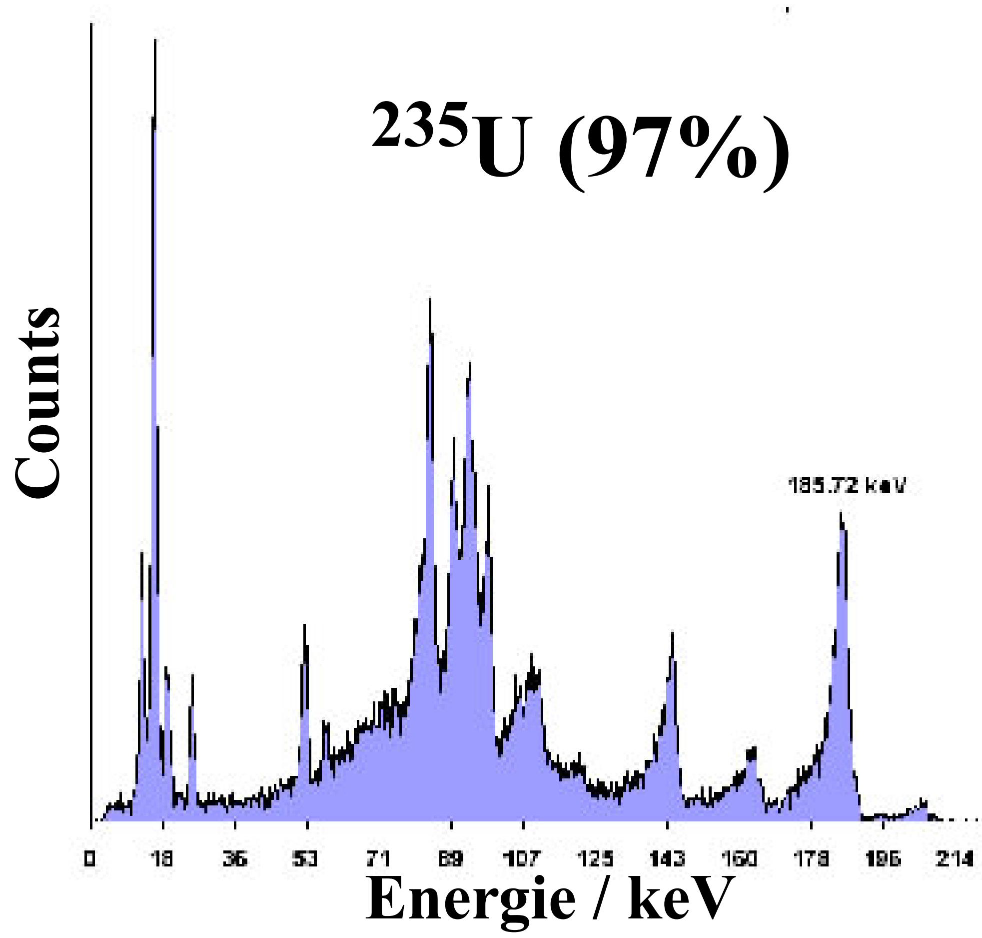
γ-Spektroskopie

Energie [keV]		relative Stärke
	$_{31}Ga^{68}$	
Ann. Rad.		
578.3		0.04 %
805.8		0.09 %
1077.1 ± 1		3.2 %
1261.3		0.1 %
1764.5		0.01 %
1884.5 ± 1		0.13 %
2338		0.001 %
	$_{31}Ga^{70}$	
173		0.15 %
1042		0.5 %
1215		

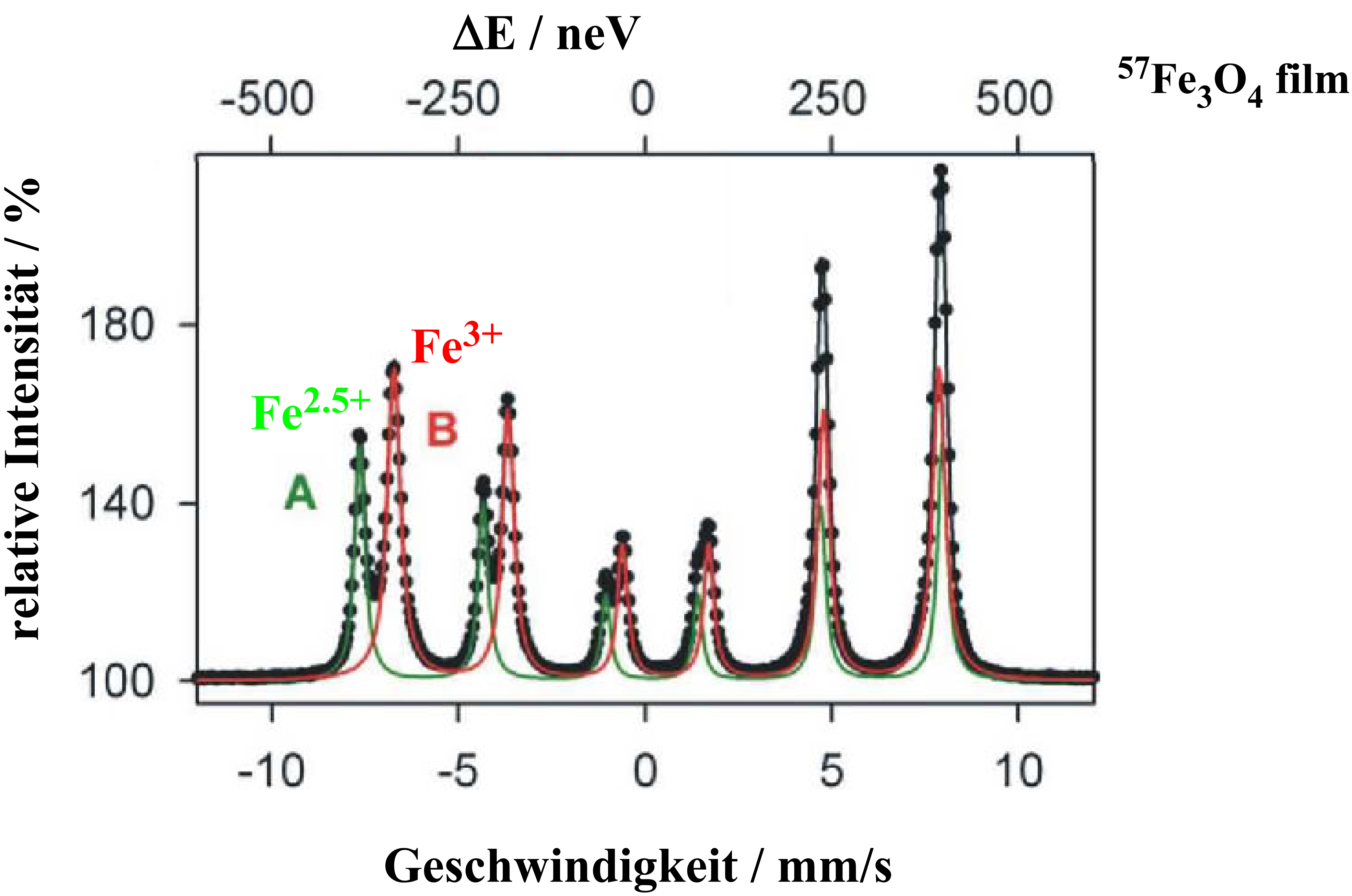
Energie [keV]		relative Stärke
	$_{31}Ga^{74}$	
53.92 ± 0.4		
380		2†
500		11
595.6 ± 0.2		87
600		13
720		2
870		5
980		4
1110		5
1200		6
1330		5
1460		6
1560		2
1700		3
1760		3
1930		6
2350		45

γ-Spektroskopie

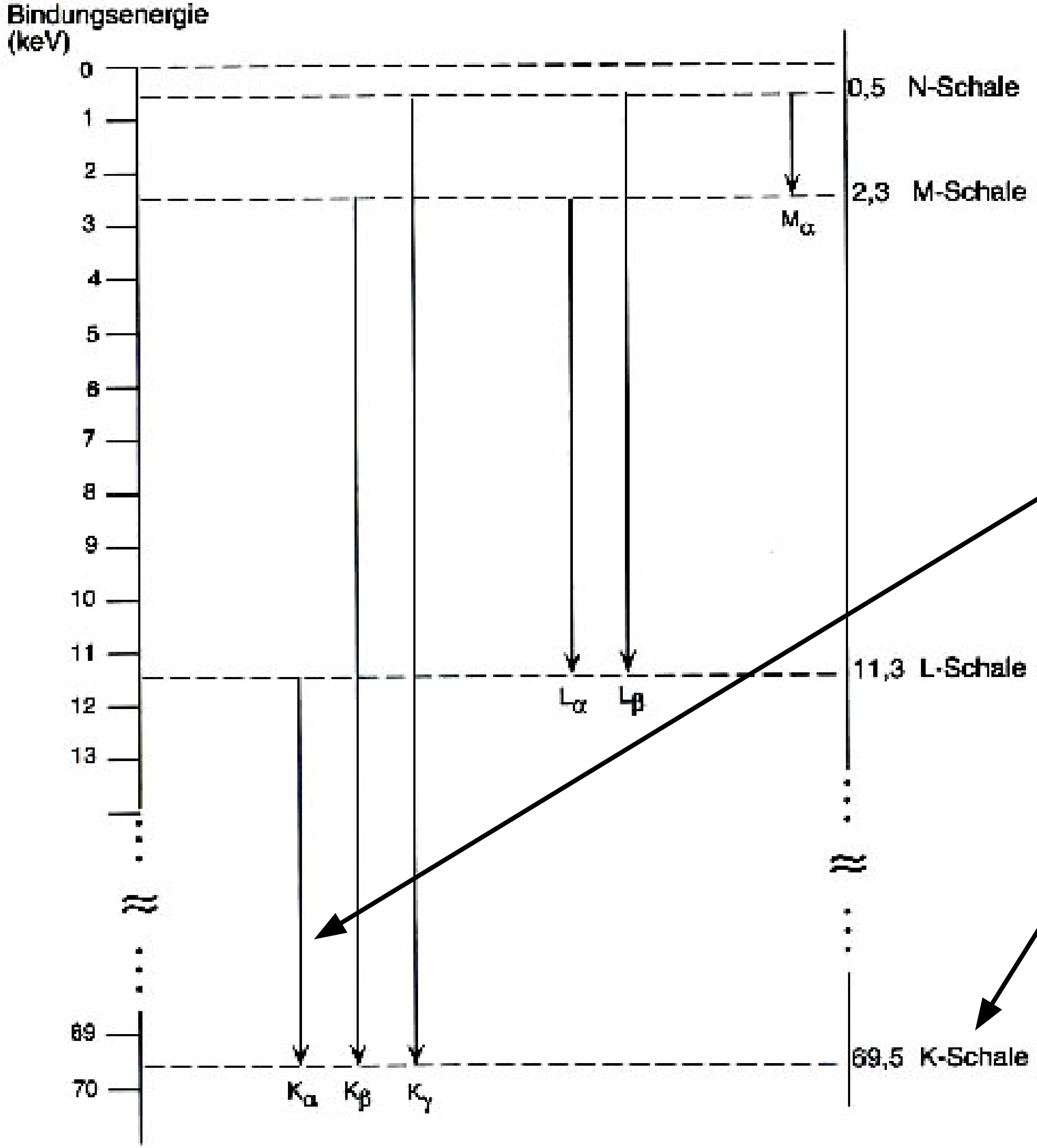




Mössbauer-Spektroskopie



Röntgenfluoreszenz



Bsp.: Wolfram

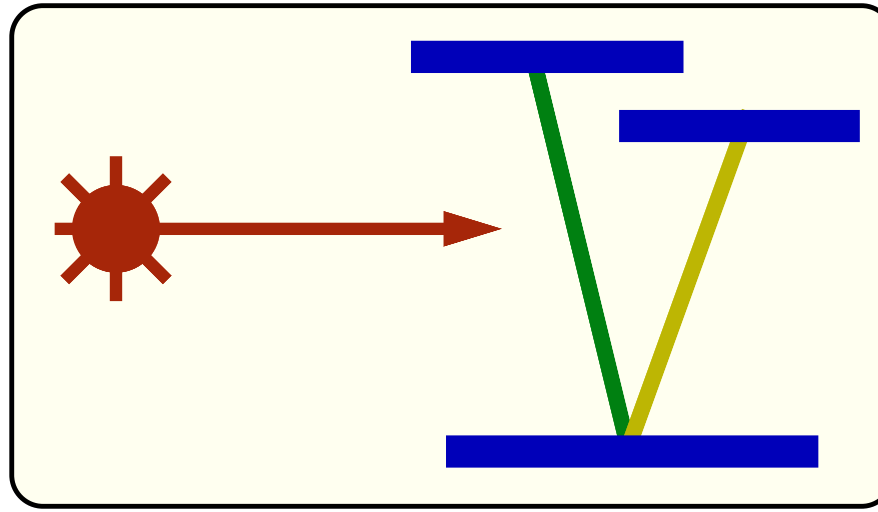
K_α-Strahlung ≈ 58 keV

Minimale Anregungsenergie

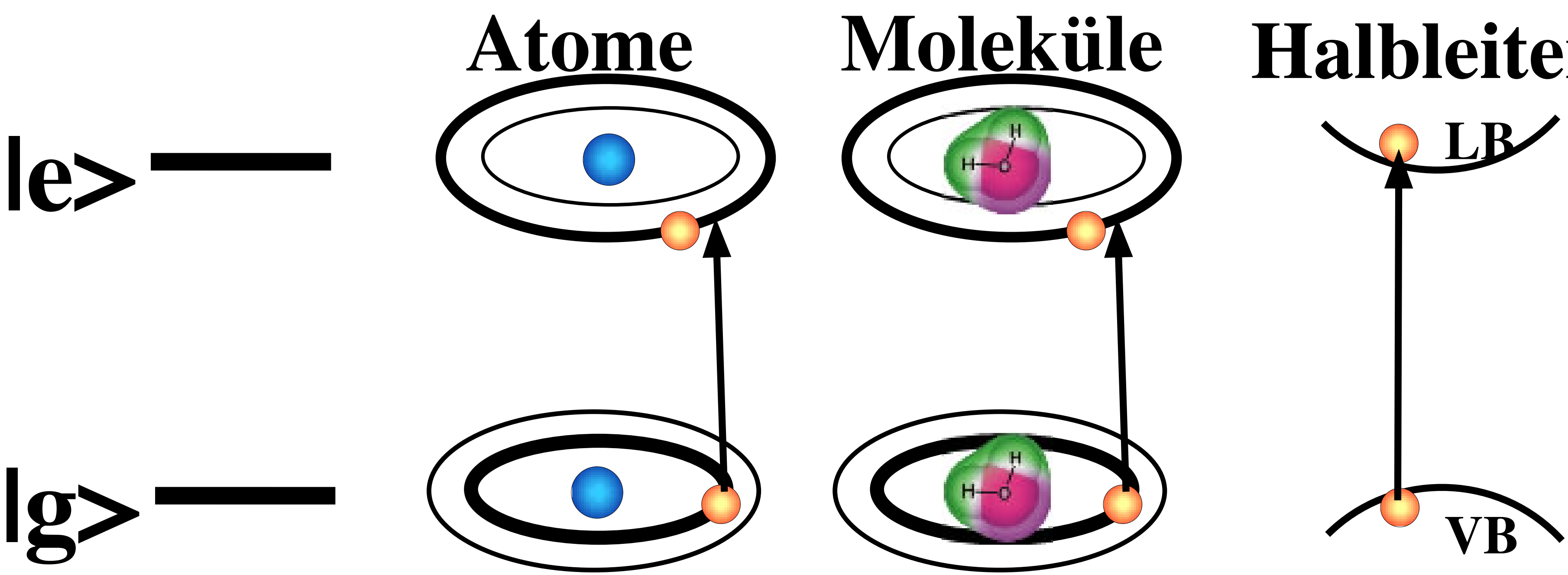
E ≈ 70 keV

Laserspektroskopie

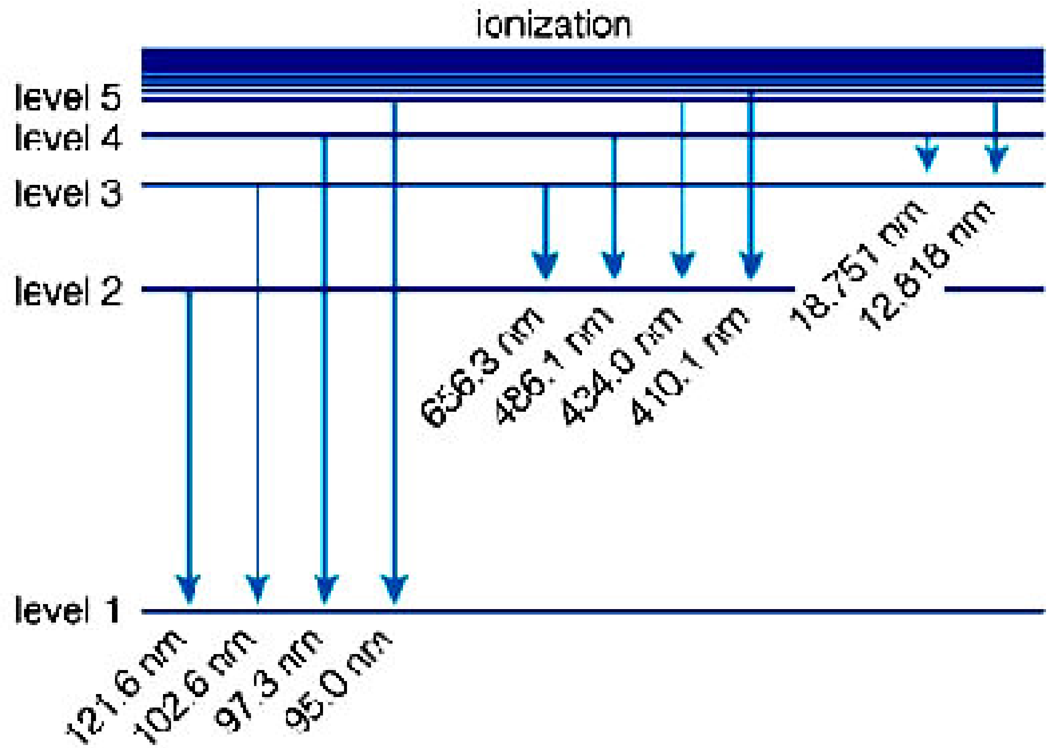
Anregung von Valenzelektronen durch optische Photonen



<u>Zustände und Systeme</u>

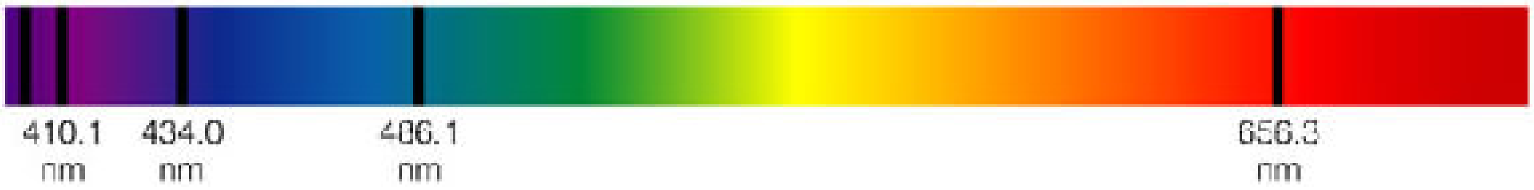


Beispiel : Wasserstoff

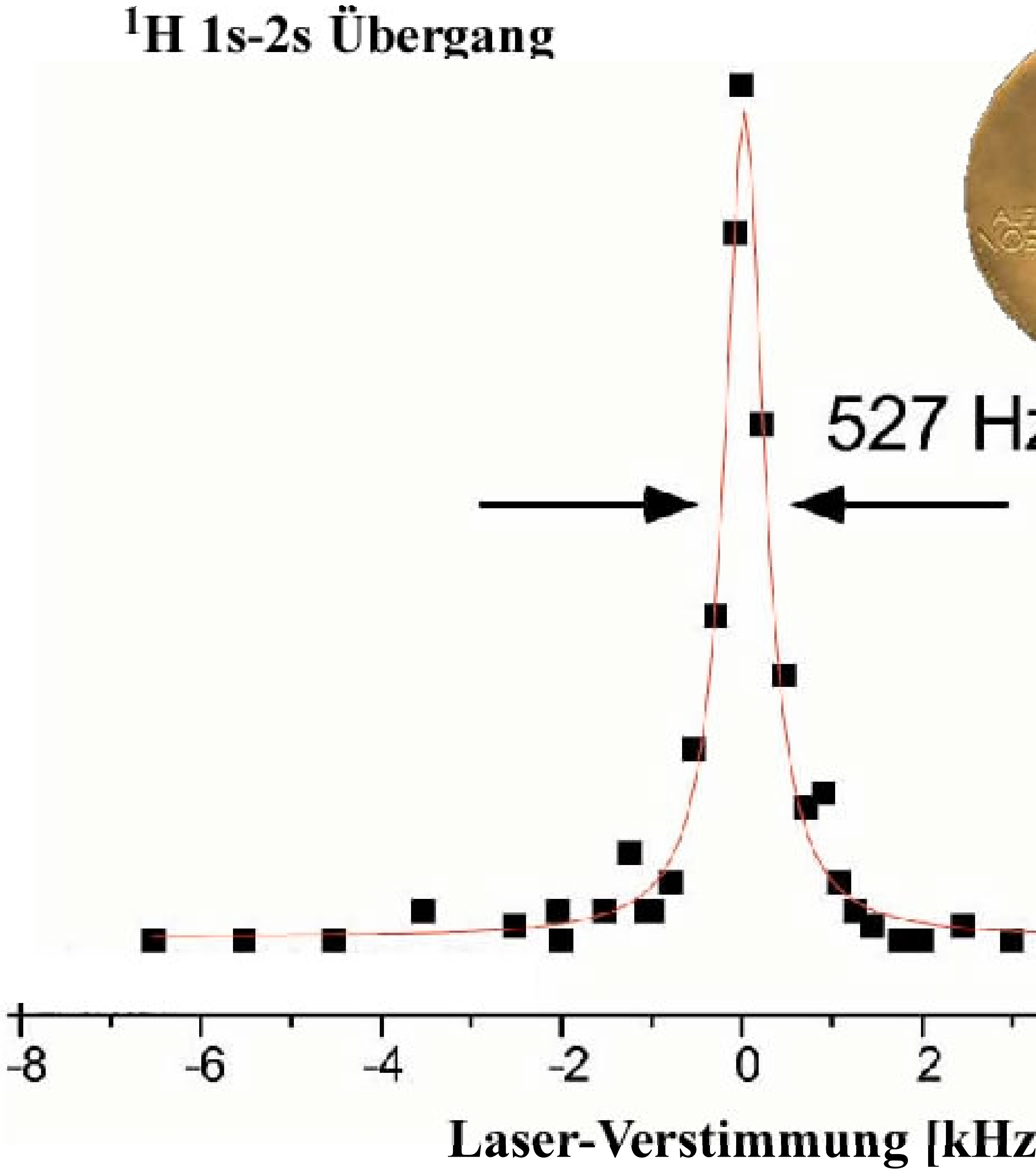


Emission

Absorption



Linienbreiten

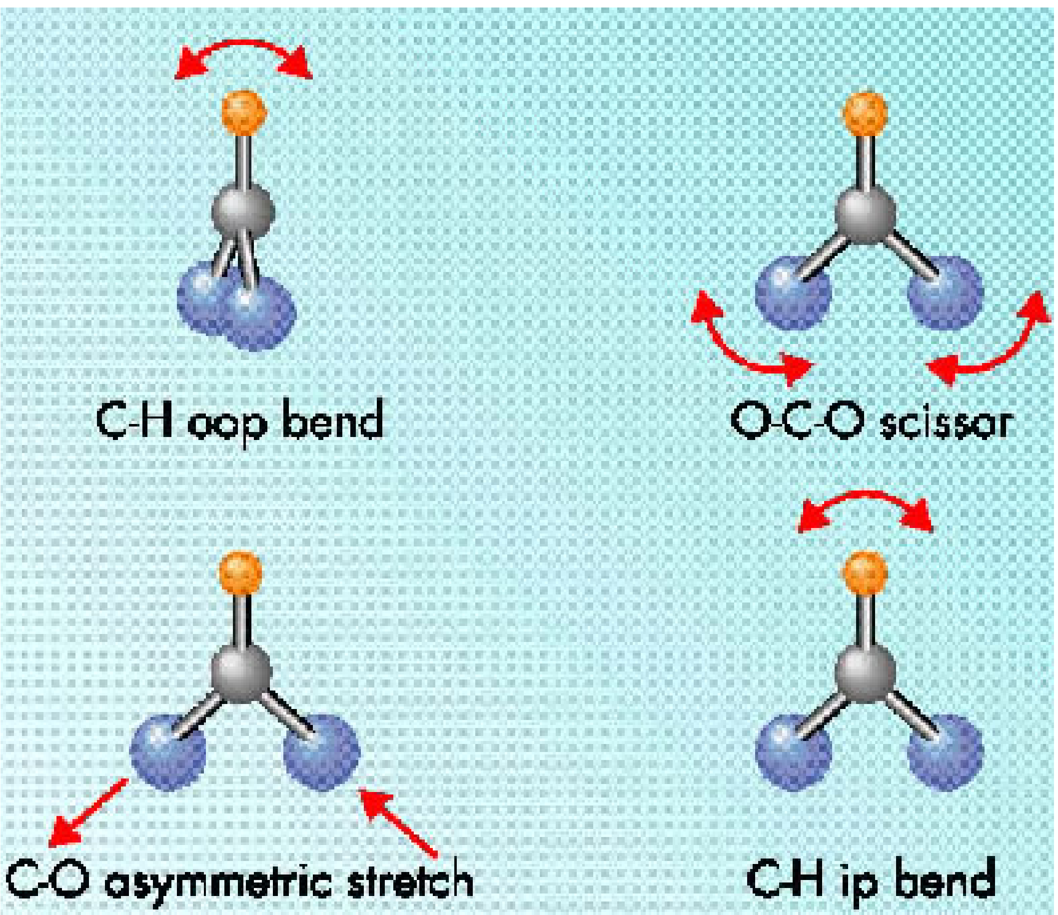


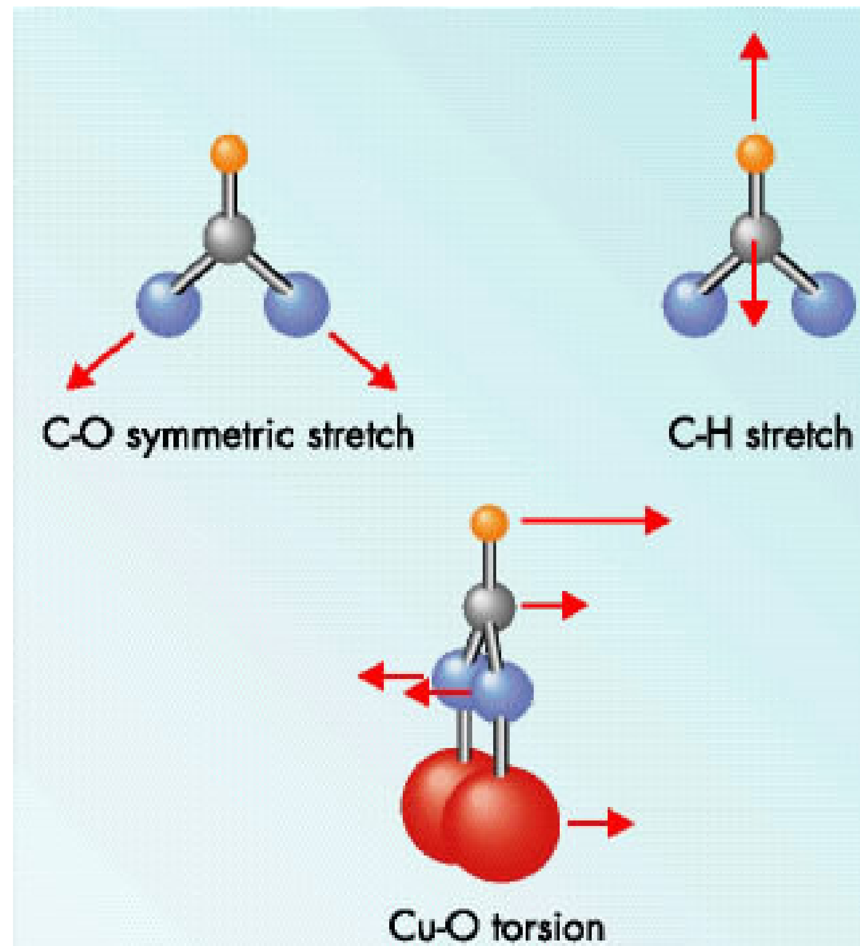
Vibrationsübergänge

Klassischer harmonischer Oszillator:

$$\omega = \sqrt{\frac{f}{m}}$$

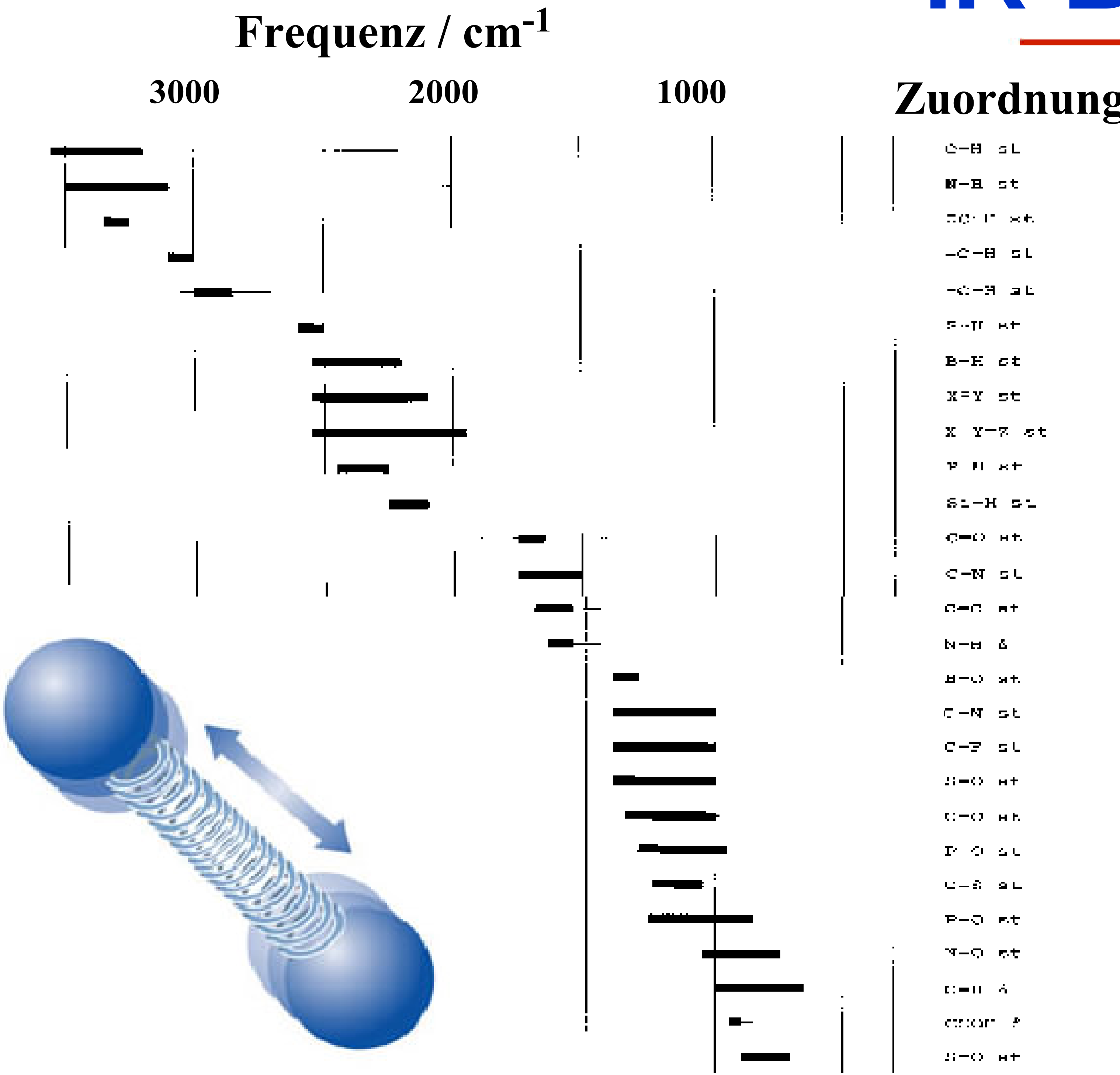
$$\frac{m_e}{m_p} \approx 1836$$





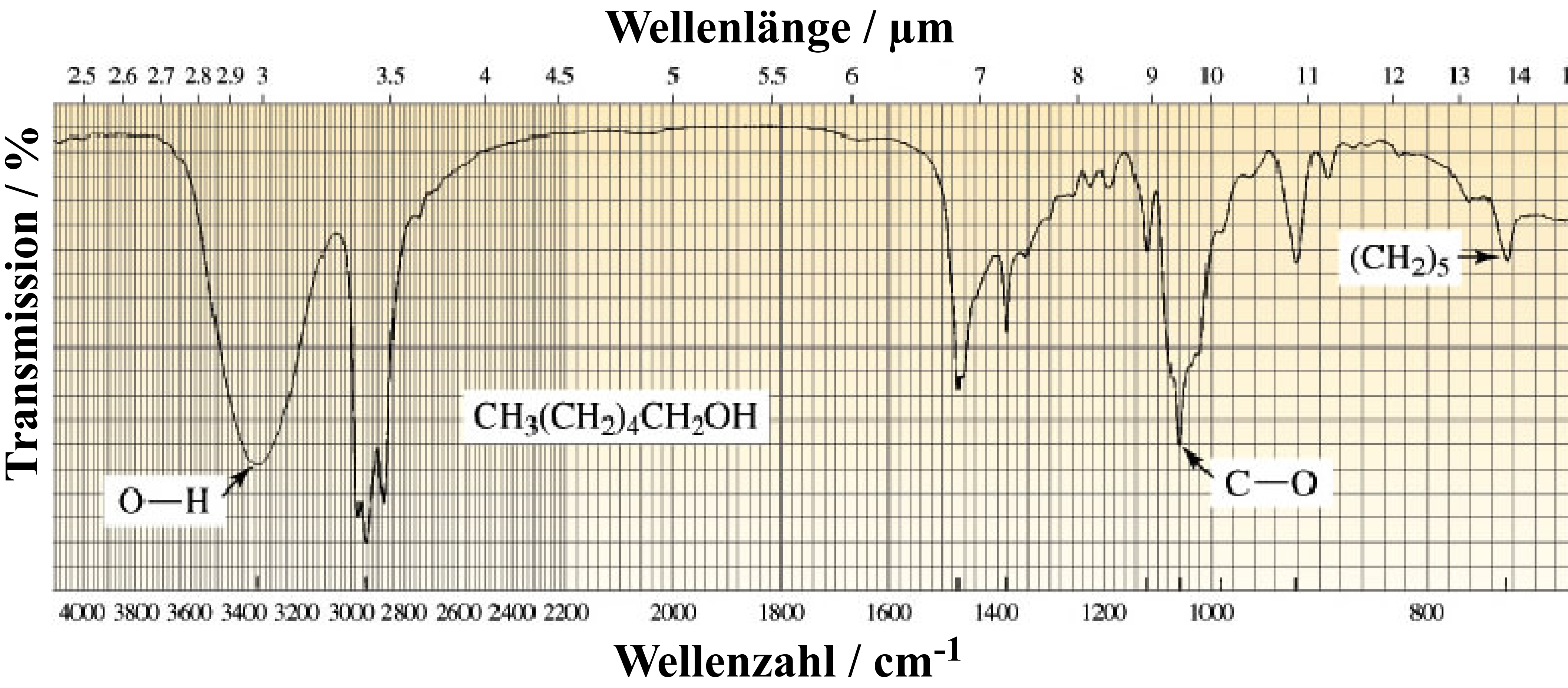
IR-Banden

E. Pretsch, T. Clerc, J. Seibl, and W. Simon, 'Tabellen zur Strukturaufklärung organischer Verbindungen', Springer, Berlin (1976).



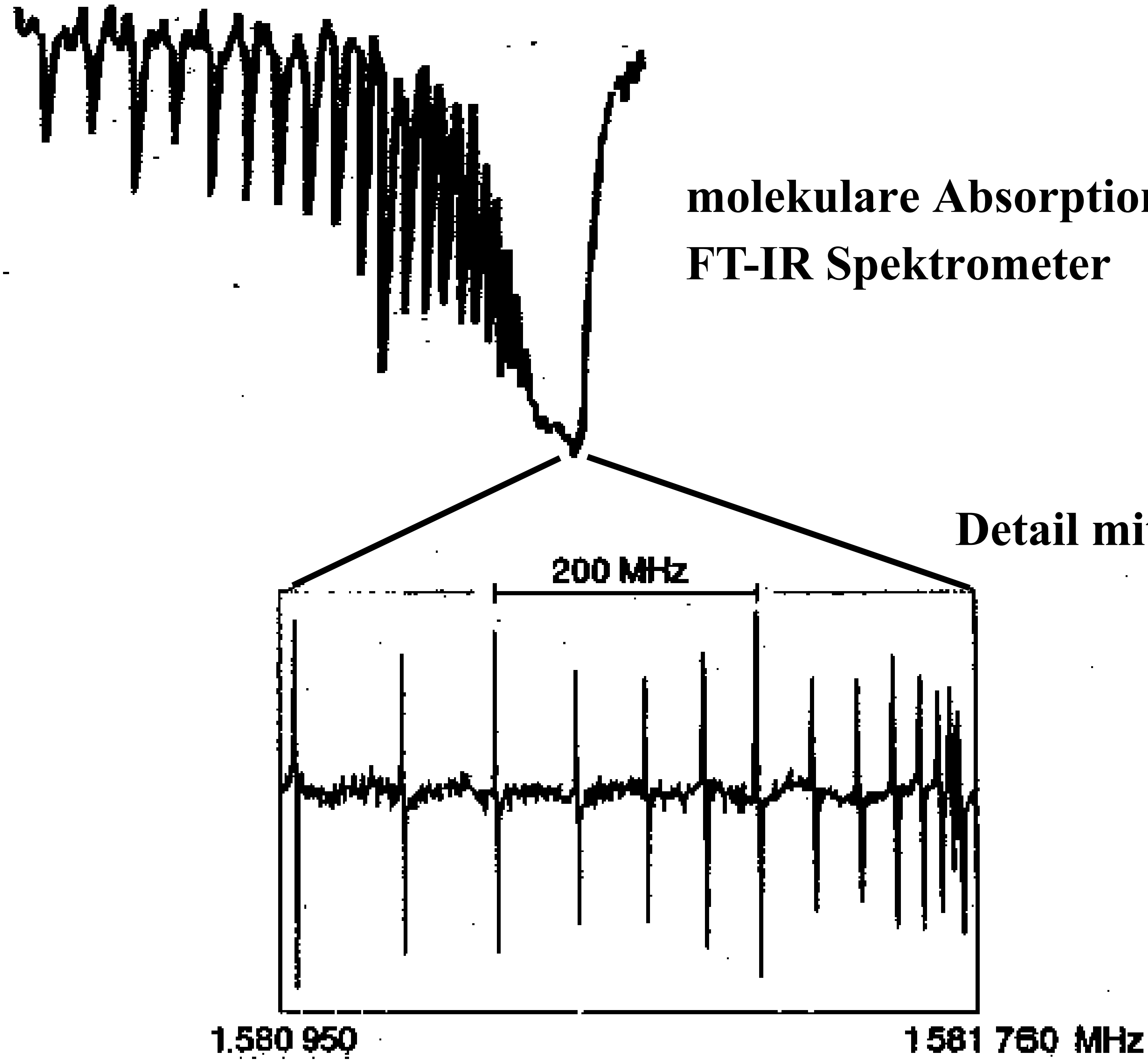
-H Streck-schwingungen

IR-Spektrum



Wellenlänge / µm
2.5
2.6
2.7
2.8
2.9
3
3.5
4
4.5
5
5.5
6
7
8
9
10
11
12
13
14
Transmission / %
CH3(CH2)4CH2OH
O—H
C—O
(CH2)5
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
Wellenzahl / cm-1

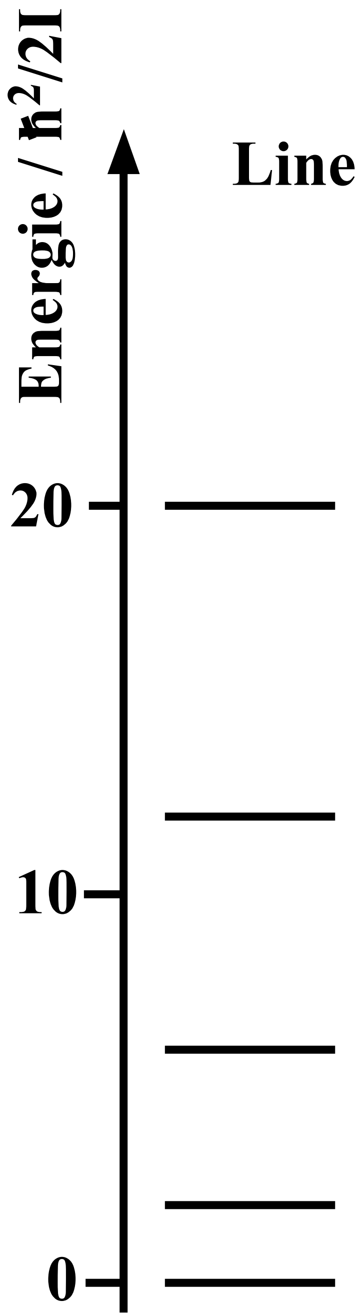
Hochauflösende IR Spektroskopie



molekulare Absorptionsbande von O_3
FT-IR Spektrometer

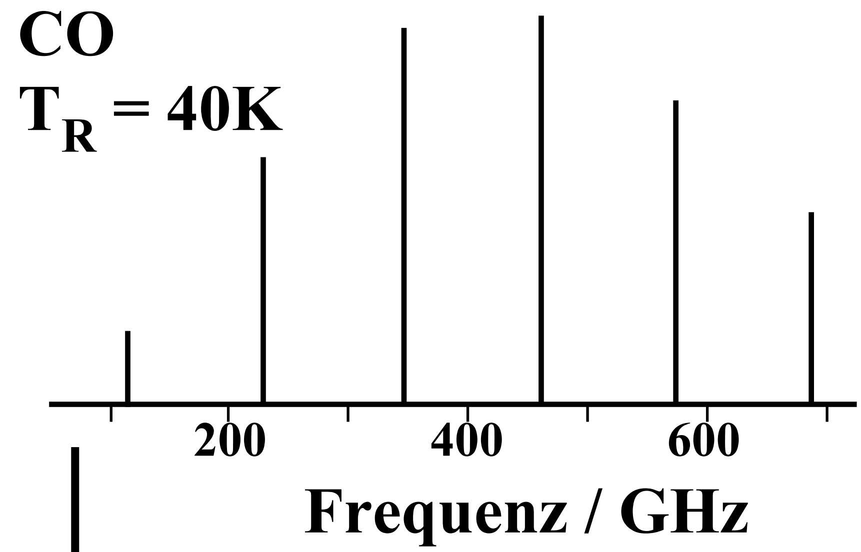
Detail mit hoher Auflösung (FIR-Laser)

Rotationsübergänge

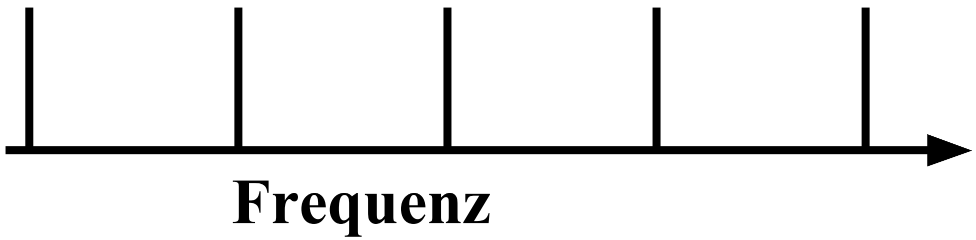


Lineares Molekül:

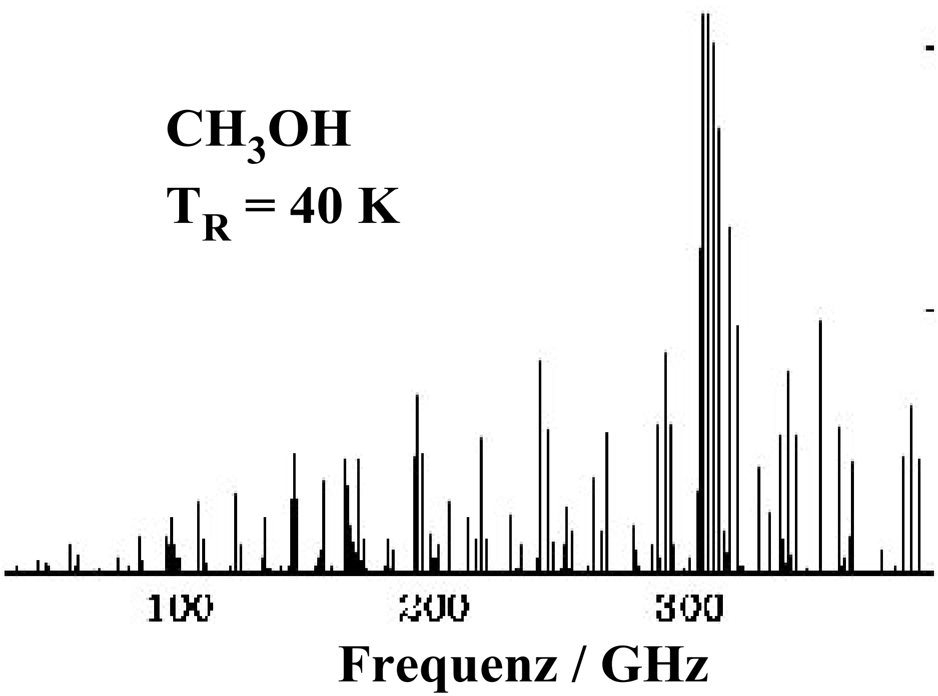
$$\mathcal{H} = \frac{\hbar^2 L^2}{2I}$$



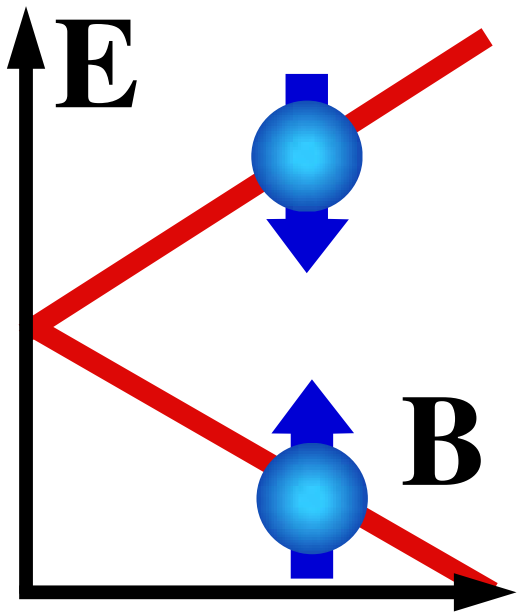
Spektrum

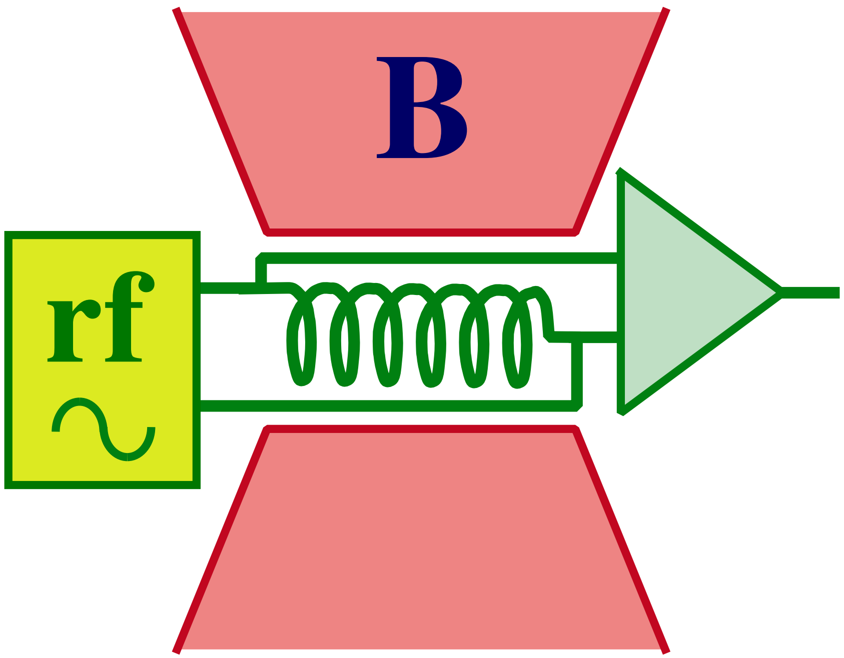


Asymmetrisches Molekül:



Magnetische Resonanz





Prinzip

Die magnetische Resonanz erzeugt und misst Übergänge zwischen unterschiedlichen Spinzuständen, die durch eine exernes Magnetfeld aufgespalten werden.

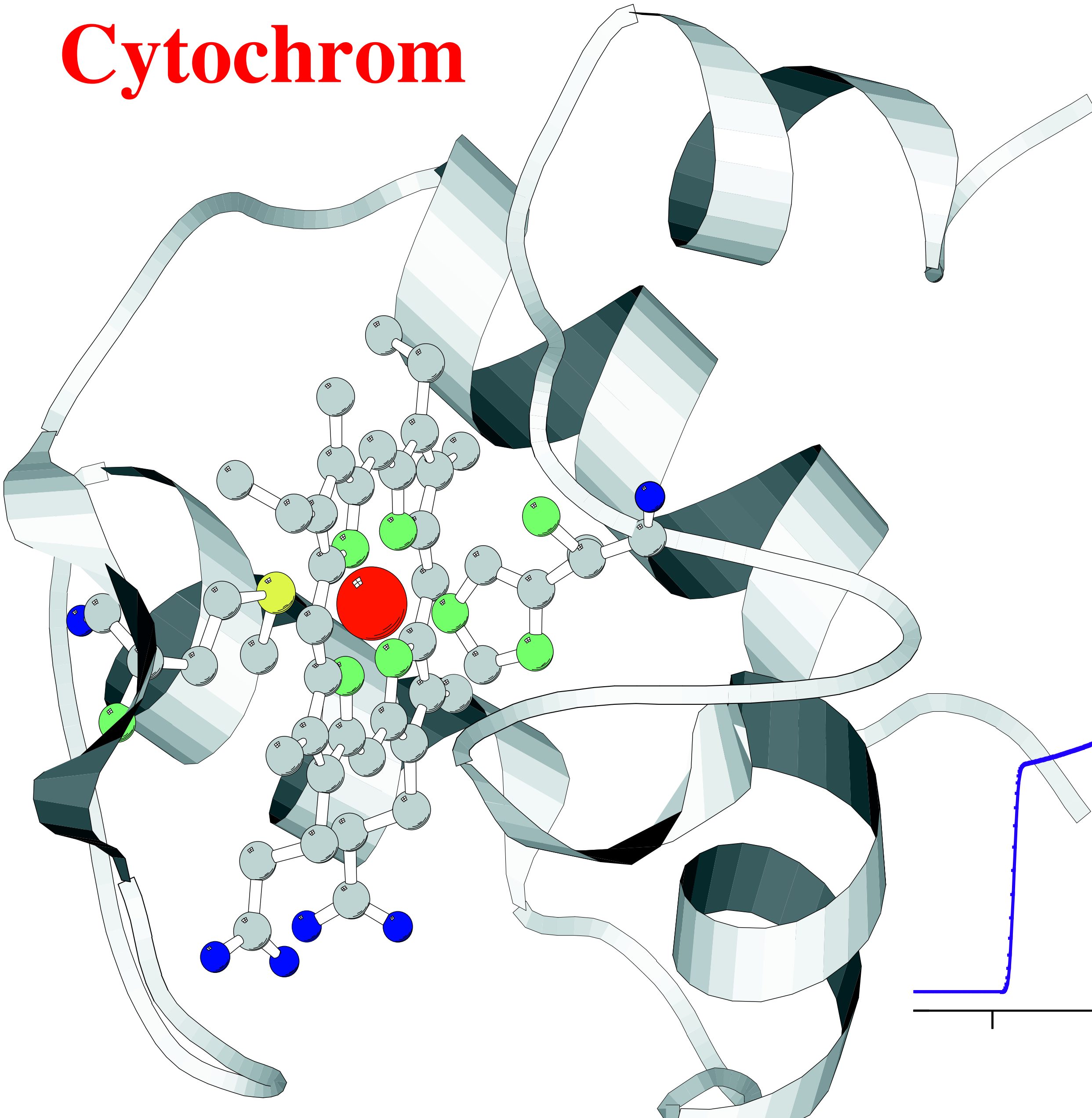
Ausführung

Statisches Magnetfeld

rf-Feld
~10 MHz - 100 GHz

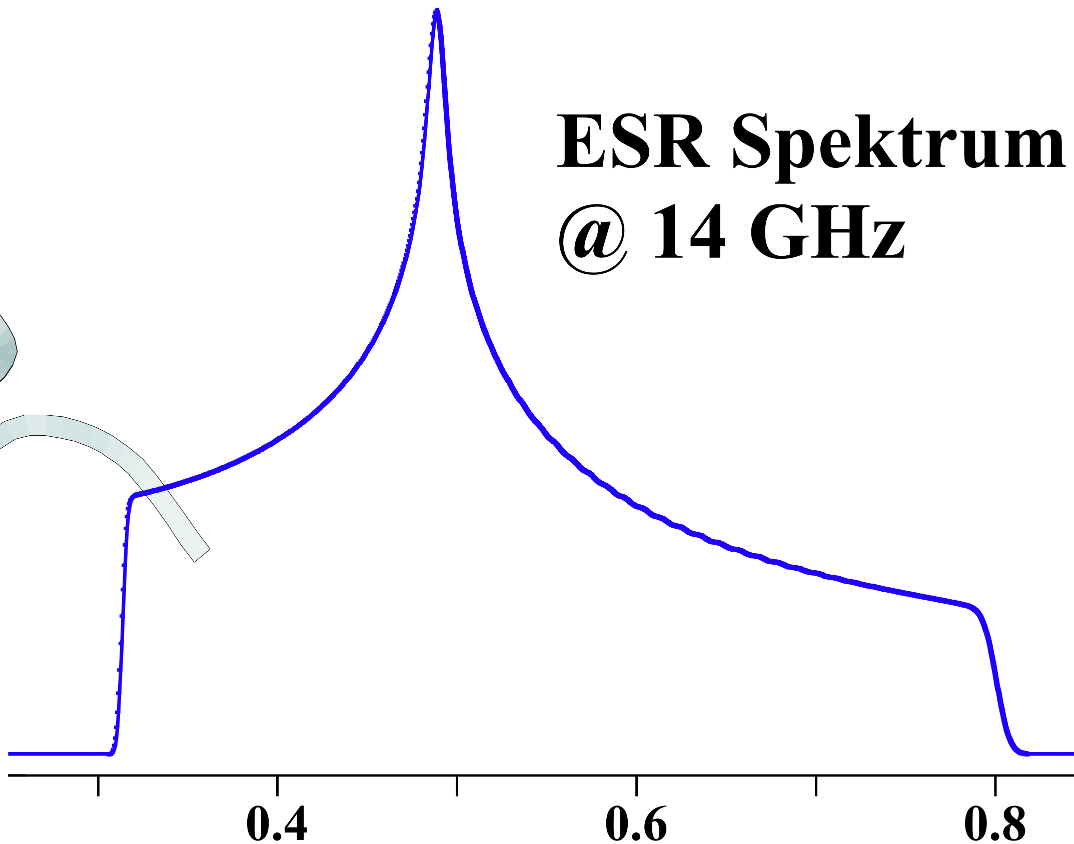
Elektronenspinresonanz

Cytochrom

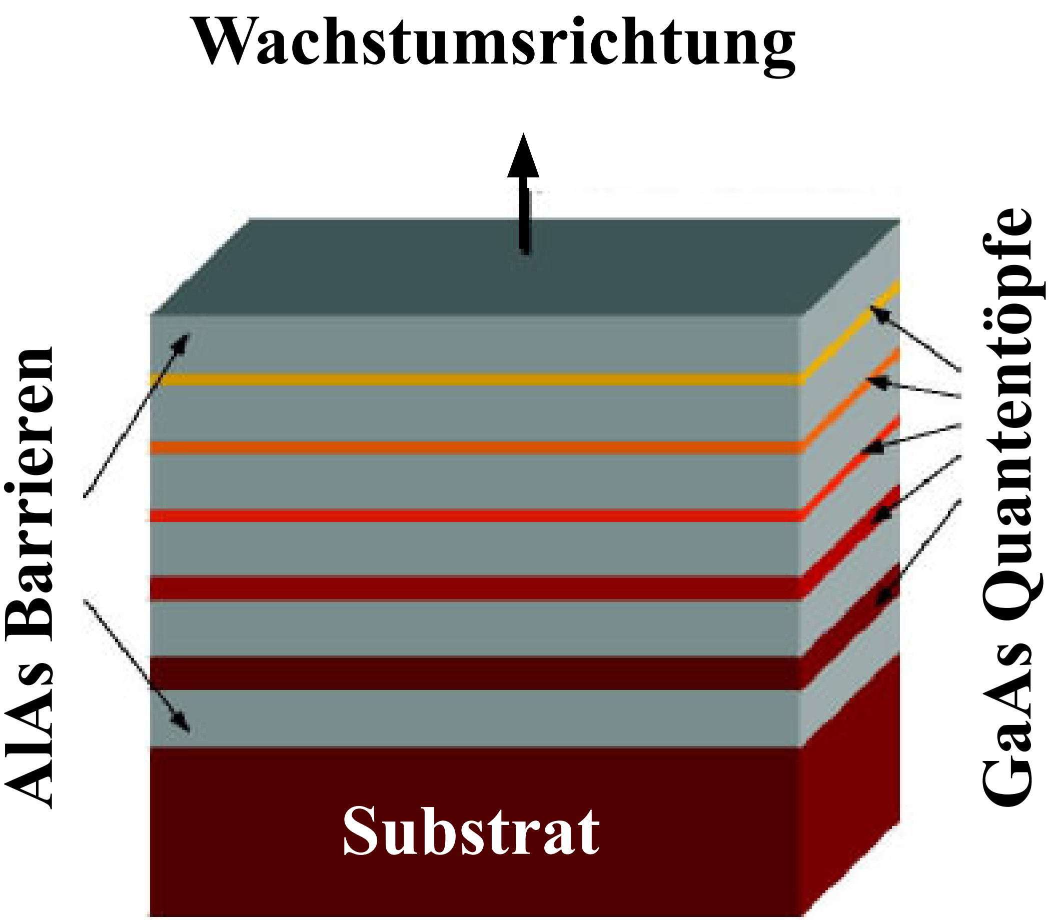


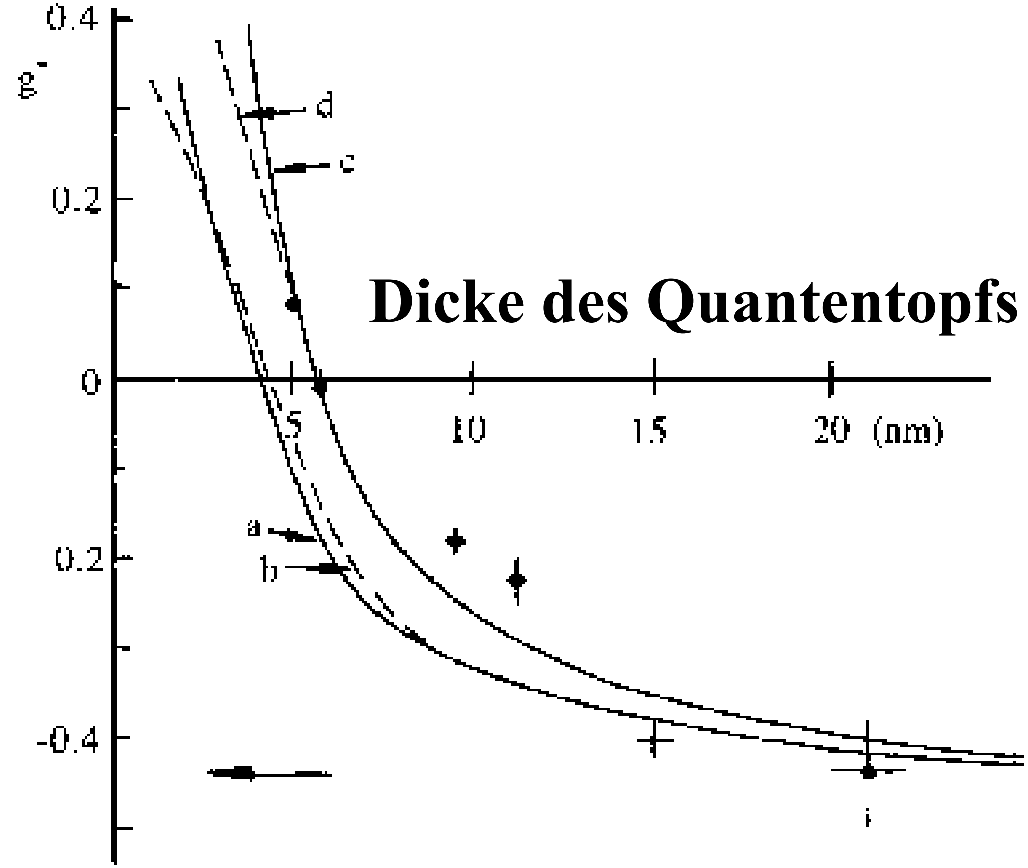
ungeordnetes System:
Orientierungsmittel

ESR Spektrum
@ 14 GHz



GaAs Quantenfilme



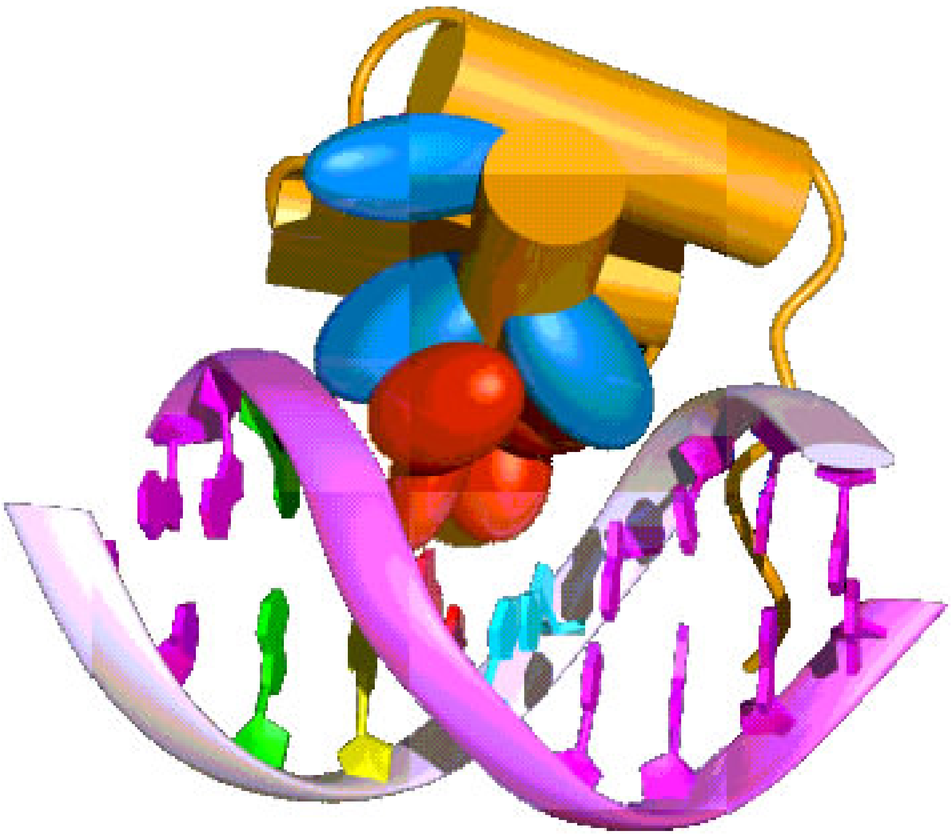


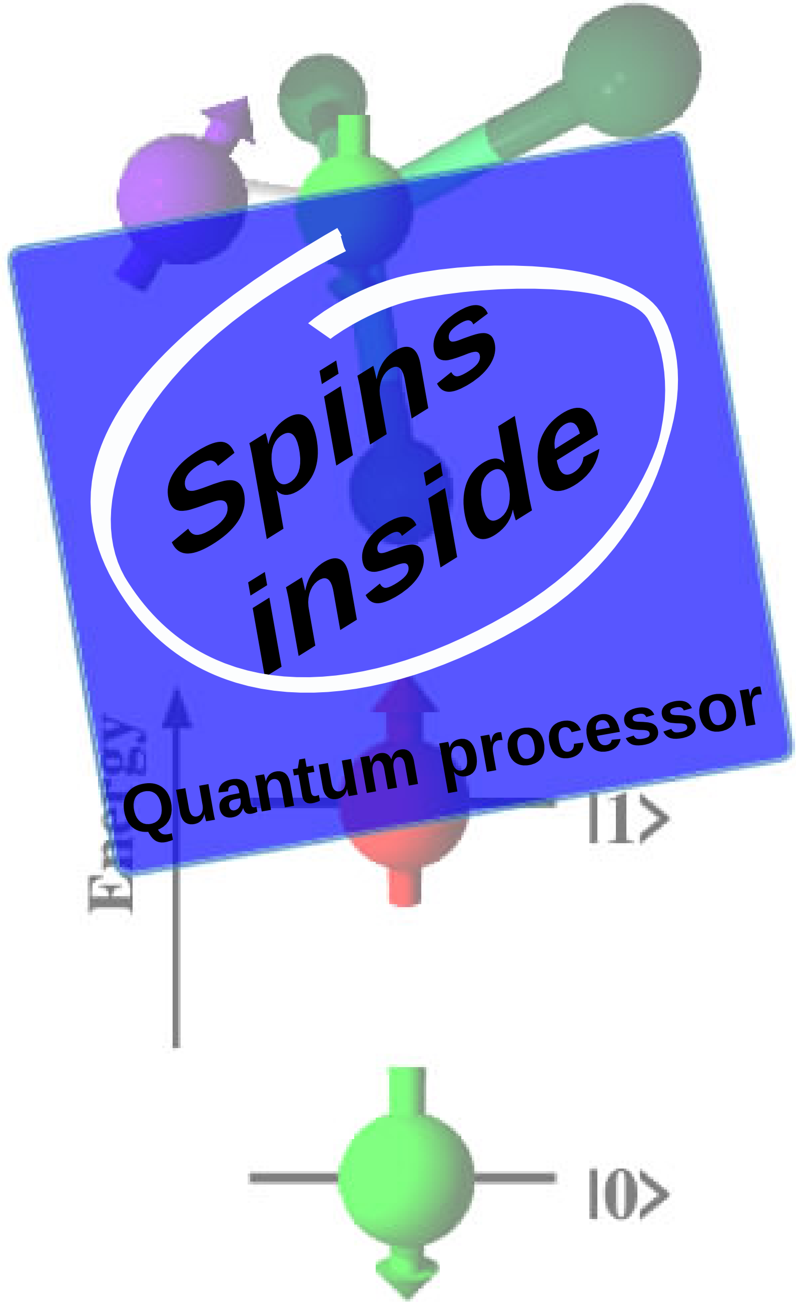
Snelling et al., PRB 44, 11345 (1991).

Kernspinrsonanz (NMR)

Anwendungen der NMR

Struktur und Dynamik von Molekülen

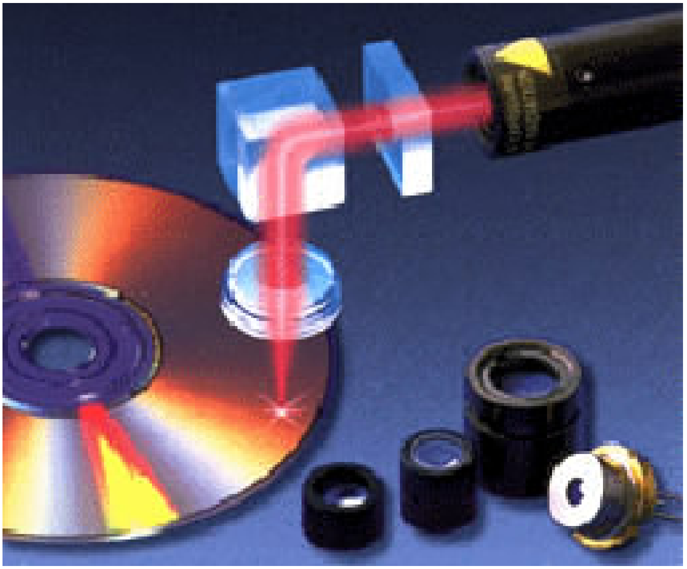


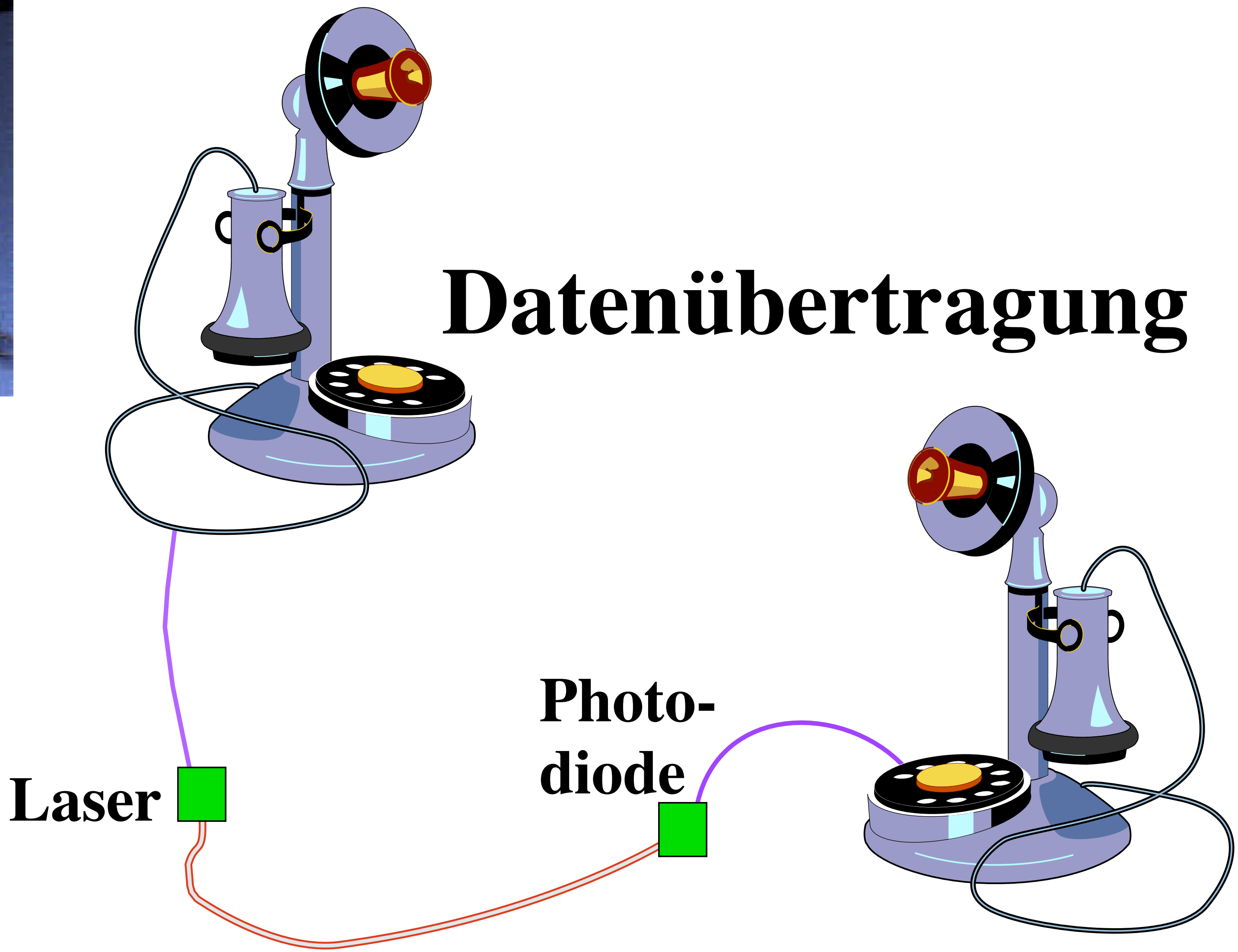


Kernspintomographie (MRI)

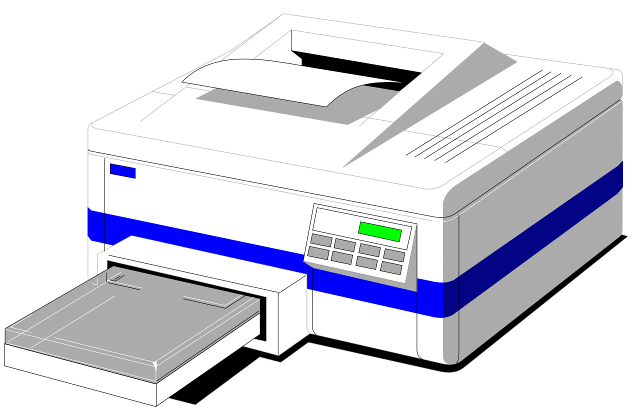
Laser Anwendungen

CD, DVD





Laserdrucker

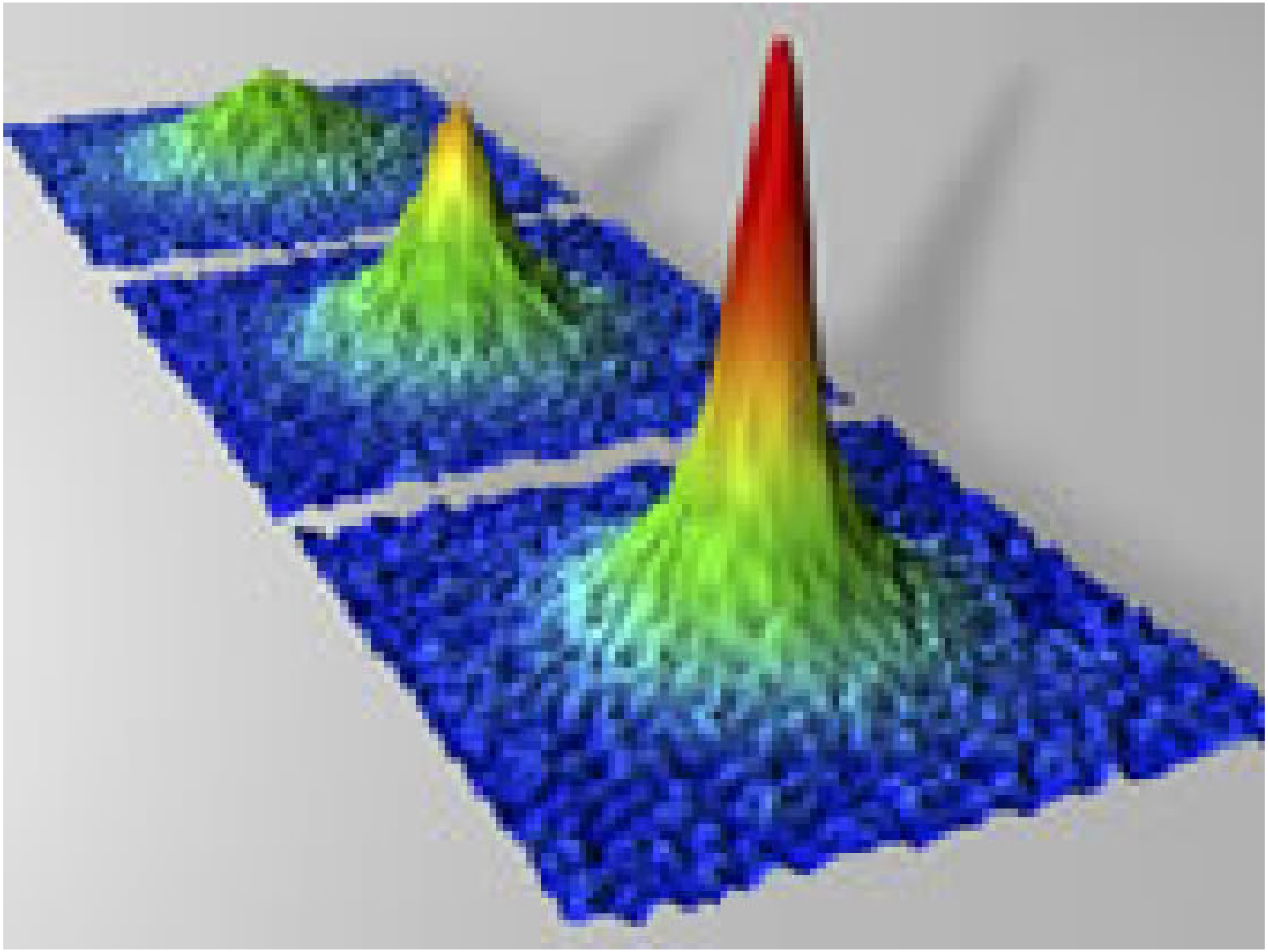


Materialverarbeitung
Unterhaltung

Medizin
Messtechnik

Weitere Anwendungen von Lasern

Kalte Atome, BEC



Gravitationswellen