Atomfysik

Rydberg

$$\tilde{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right) Z^2$$

$$E_n = -hcR\frac{Z^2}{n^2}$$

$$hcR_\infty = \frac{m_e(e^2/4\pi\epsilon_0)^2}{2\hbar^2} = 13.606 \text{ eV}$$

$$R = R_\infty \cdot \frac{M_N}{m_e + M_N}$$

Alkalilika system

$$n^* = n - \delta_l$$

$$E = -hcR_\infty\frac{Z_0^2}{n^{*2}}$$

$$\Delta E_{FS} = -\frac{Z_i^2 Z_0^2}{n^{*3}l(l+1)}\alpha^2 hcR_\infty$$

Vätelika atomer

$$V(r) = -\frac{Ze^2}{4\pi\epsilon_0 r} = -\frac{Ze_0^2}{r}$$

$$a_0 = \frac{\hbar^2 4\pi\epsilon_0}{m_e e^2}$$

I bohrs atommodell: $r_n = a_0 n^2/Z$

Radialfunktioner för vätelika system

$$R_{1,0} = \left(\frac{Z}{a_0}\right)^{3/2} 2e^{-Zr/a_0}$$

$$R_{2,0} = \left(\frac{Z}{2a_0}\right)^{3/2} 2\left(1 - \frac{Zr}{2a_0}\right) e^{-Zr/2a_0}$$

$$R_{2,0} = \left(\frac{Z}{2a_0}\right)^{3/2} \frac{2}{\sqrt{3}}\frac{Zr}{2a_0}e^{-Zr/2a_0}$$

Klotytefunktioner

l	m	$\Upsilon_l^m(\theta,\varphi)$
0	0	$\Upsilon_0^0 = \frac{1}{\sqrt{4\pi}}$
1	0	$\Upsilon_1^0 = \sqrt{\frac{3}{4\pi}}\cos\theta$
1	±1	$\Upsilon_1^{\pm1} = \pm\sqrt{\frac{3}{8\pi}}\sin\theta e^{\pm i\varphi}$
2	0	$\Upsilon_2^0 = \sqrt{\frac{5}{16\pi}}\left(3\cos^2\theta - 1\right)$
2	±1	$\Upsilon_2^{\pm1} = \pm\sqrt{\frac{15}{8\pi}}\sin\theta\cos\theta e^{\pm i\varphi}$
2	±2	$\Upsilon_2^{\pm2} = \sqrt{\frac{15}{32\pi}}\sin^2\theta e^{\pm 2i\varphi}$

Hamiltonoperator för flerelektronsystem

$$\boldsymbol{H} = \sum_{i=1}^{N}\left(-\frac{\hbar^2}{2m}\nabla_i^2 - \frac{Ze^2/4\pi\epsilon_0}{r_i} + \sum_{j>i}^{N}\frac{e^2/4\pi\epsilon_0}{r_{ij}}\right)$$

$$\langle LM_L|l_1|LM_L\rangle = \frac{\langle l_1\cdot\boldsymbol{L}\rangle}{L(L+1)}\langle LM_L|\boldsymbol{L}|LM_L\rangle$$

LS-koppling

$$\text{Termer:}\quad \begin{cases} L = |l_1 - l_2|, ..., l_1 + l_2 \\ S = |s_1 - s_2|, ..., s_1 + s_2 \end{cases}$$

$$\text{Nivåer:}\quad J = |L - S|, ..., L + S$$

Zeemaneffekt

$$E_{ZE} = \begin{cases} g_J\mu_B BM_J & \text{(end. finstrktur)} \\ g_F\mu_B BM_F & \text{(svagt fält, hfs)} \\ g_J\mu_B BM_J + AM_IM_J & \text{(starkt fält, } \mu_B B > A\text{)} \end{cases}$$

Koppling mellan magnetiskt moment och rörelsemängdsmoment

$$g_S = 2$$

$$g_J = \frac{3}{2} + \frac{S(S+1) - L(L+1)}{2J(J+1)}$$

$$g_F = g_J \frac{F(F+1) + J(J+1) - I(I+1)}{2F(F+1)}$$

$$\boldsymbol{\mu}_I = g_I \mu_N \boldsymbol{I}$$

Dopplerbredd

$$\frac{\Delta\omega_D}{\omega_0} = 2\sqrt{\ln 2}\frac{u}{c} \approx 1.7\frac{u}{c}$$

Mest sannolik hastighet

$$u = 2230\sqrt{\frac{T}{300M}} \quad \text{m/s}$$

Dopplerskift

$$\delta = kv = \frac{\omega v}{c}$$

Naturlig bredd

$$\Delta\omega_N = \Gamma = A_{21} = 1\frac{1}{\tau}$$

$$\Delta f_N = \frac{\Delta\omega_N}{2\pi}$$

¡ Missing Translation ¿

$$H = -\boldsymbol{\mu}_I \cdot \boldsymbol{B}_e = A\boldsymbol{I} \cdot \boldsymbol{J}$$

För s-elektroner i vätelika system gäller

$$A = \frac{2}{3}\mu_0 g_S \mu_B g_I \mu_N \frac{Z^3}{\pi a_0^3 n^3}$$

Boltzmanfördelningen

$$\frac{N_2}{N_1} = \frac{g_2}{g_1} e^{-\Delta E/(kT)}$$

Integraler

$$\int_0^\infty x^n e^{-\alpha x}\, dx = \frac{n!}{\alpha^{n+1}}$$

$$\int_0 \infty x^{2n+1} e^{-\alpha x^2}\, dx = \frac{n!}{2\alpha^{n+1}}$$

$$\int_0^\infty e^{-\alpha x^2}\, dx = \frac{1}{2}\sqrt{\frac{\pi}{\alpha}}$$

$$\int_0^\infty x^{2n} e^{-\alpha x^2}\, dx = \frac{(2n-1)!!}{2(2\alpha)^n}\sqrt{\frac{\pi}{\alpha}}$$

Operatorer

$$\boldsymbol{p} = -i\hbar\nabla$$

$$\boldsymbol{L} = -i\hbar\boldsymbol{r} \times \nabla$$

$$\boldsymbol{H} = -\frac{\hbar^2}{2m}\nabla^2 + V \qquad \text{(standard)}$$

$$\nabla^2 = \frac{1}{r}\frac{\partial^2}{\partial r^2} r + \frac{1}{r^2}\left(\frac{\partial^2}{\partial\theta^2} + \frac{1}{\tan\theta}\frac{\partial}{\partial\theta} + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\varphi^2}\right)$$

Dirac notation

$$< \boldsymbol{H} > = < \psi|\boldsymbol{H}|\psi > = \int_{\mathbb{R}} \psi^* \boldsymbol{H}\psi\, dv$$

Kommutatorer

$$[A, B] = AB - BA$$
$$[A, B] = -[B, A]$$
$$[A, B + C] = [A, B] + [A, C]$$
$$[AB, C] = A[B, C] + [A, C]B$$

Shrödingerekvationen

$$\boldsymbol{H}\psi = E\psi \qquad \text{(tidsoberoende)}$$

$$\boldsymbol{H}\psi = i\hbar\frac{\partial}{\partial t}\psi \qquad \text{(tidsberoende)}$$

Konfiguration	$\prod n_i l_i^{\omega_i}$
Termer	L och $S(^{2S+1}L)$
Nivåer	J
Tillstånd(ZE-subnivåer)	M_J
¡ Missing Translation ¿	F

1	$\Delta J = 0, \pm 1$	$(J = 0 \nleftrightarrow J' = 0)$	nivå
2	$\Delta M_J = 0, \pm 1$	$(M_J = 0 \nleftrightarrow M_{j'} = 0$ om $\Delta J = 0)$	tillstånd
3	bryt paritet		configuration
4	$\Delta l = \pm 1$		
5	$\Delta L = 0, \pm 1$	$(L = 0 \nleftrightarrow L' = 0)$	term
6	$\Delta S = 0$		term

$1, 2$ ersätts med liknande formler för F och M_F om F är ett gott kvanttal. $5, 6$ gäller bara om L och S är goda kvanttal.

	finstruktur - LS	hyperfinstruktur - IJ
växelverkan	$\beta \boldsymbol{L} \cdot \boldsymbol{S}$	$A \boldsymbol{I} \cdot \boldsymbol{J}$
moment	$\boldsymbol{J} = \boldsymbol{L} + \boldsymbol{S}$	$\boldsymbol{F} = \boldsymbol{I} + \boldsymbol{J}$
egentillstånd	$\lvert LSJM_J \rangle$	$\lvert IJFM_F \rangle$
energi	$\beta/2(J(J+1) - L(L+1) - S(S+1))$	$A/2(F(F+1) - I(I+1) - J(J+1))$
intervall	$E_J - E_{J-1} = \beta J$	$E_F - E_{F-1} = AF$
	(om $E_{S-O} \ll E_{re}$)	(om $A \gg \Delta E_{kvadrupol}$)