(4.11)

$$-\frac{hcR_\infty}{N^2} = -\frac{\alpha_f \hbar c}{2r}$$

$$\longrightarrow \quad -\frac{\cancel{hc}\, m_e c^2 \alpha_f^{\cancel{2}}}{\cancel{hc}\,\cancel{2}\, N^2} = -\frac{\cancel{\alpha_f}\,\hbar c}{\cancel{2}r}$$

$$\longrightarrow \quad r = \frac{\hbar \cancel{c} N^2}{m_e c^{\cancel{2}} \alpha_f} \quad \checkmark$$

(4.11)

$$\frac{hcR_\infty}{N^2} = \frac{m_e v^2}{2}$$

$$\frac{\cancel{hc}\, \cancel{m_e} c^2 \alpha_f^2}{\cancel{hc}\,\cancel{2}\, N^2} = \frac{\cancel{m_e} v^2}{\cancel{2}}$$

$$\longrightarrow \quad v = \frac{c\,\alpha_f}{N} \quad \checkmark$$

$$E_N = -\frac{hcR_\infty}{N^2} = -\frac{\cancel{hc}\, m_e c^2 \alpha_f^2}{\cancel{hc}\, 2 N^2} = -\frac{m_e}{2}\frac{c^2 \alpha_f^2}{N^2}$$

(4.11)

S 121 (5.105)

$$\frac{1}{r}\partial_r^2 \frac{r(\varepsilon_f - V(r))}{\alpha_f \hbar c} = 4\pi \rho = 4\cancel{\pi} \frac{1}{3\pi^{\cancel{2}}} \underbrace{\left(\frac{2\mu(\varepsilon_f - V)}{\hbar^2}\right)^{\frac{3}{2}}}_{\left(\frac{2\mu c\alpha_f}{\hbar}\right)^{\frac{3}{2}} \underbrace{\left(\frac{\varepsilon_f - V}{\hbar c\alpha_f}\right)^{\frac{3}{2}}}_{\frac{\chi z}{r}}}$$

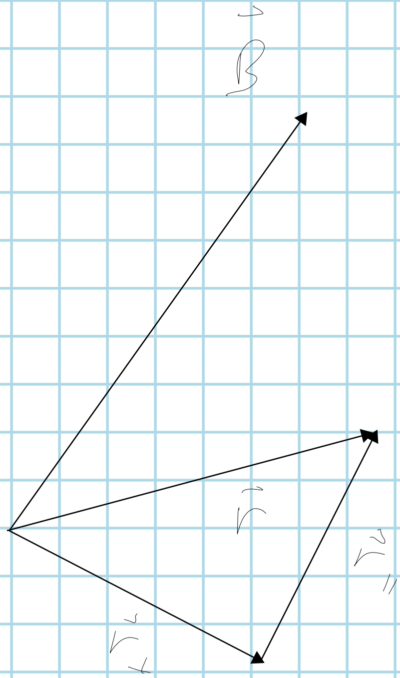
S140

$$\langle H_e \rangle = E_0 - A \mp S\langle H_e \rangle \pm SE_0 \mp B$$

$$\langle H_e \rangle \pm S\langle H_e \rangle = E_0(1 \pm S) - A \mp B$$

$$\langle H_e \rangle (1 \pm S) = E_0 (-\text{"}-) - A \mp B$$

$$\rightarrow \quad \langle H_e \rangle = E_0 - \frac{A \pm B}{1 \pm S} \quad \checkmark$$



S154 $\quad \vec{r}_{\parallel}: \quad \vec{r}_{\parallel} \times \vec{B} = \emptyset$

$\quad r_{\perp}: \quad r_{\perp} \cdot \vec{B} = \emptyset$

$$B^2 \left(r_{\perp}^2 + \underbrace{2 r_{\perp} r_{\parallel}}_{\cancel{\emptyset}} + r_{\parallel}^2\right)$$

$$B^2 \left(r_{\perp}^2 + r_{\parallel}^2\right)$$

$$\vec{B} \cdot \vec{r} = \vec{B}\left(\vec{r}_{\perp} + \vec{r}_{\parallel}\right) = \vec{B}\,\vec{r}_{\parallel}$$

$$\rightarrow \quad B^2 r^2 - (Br)^2 = B^2 \left(r_{\perp}^2 + r_{\parallel}^2\right) - B^2 r_{\parallel}^2$$

$$= B^2 r_{\perp}^2 \quad \checkmark$$

S16 O

$$m_e \ddot{x} = -m_e \omega_0^2 x - e_0 B \dot{y}$$

$x = r\cos\omega t \qquad y = r\sin\omega t$

$\dot{x} = -\omega r \sin\omega t \qquad \dot{y} = \omega r \cos\omega t$

$\ddot{x} = -\omega^2 r \cos\omega t$

$$-m_e \omega^2 r \cancel{\cos\omega t} = -m_e r \omega_0^2 \cancel{\cos\omega t} - e_0 B \omega r \cancel{\cos\omega t}$$

$$-m_e \omega^2 r = -m_e \omega_0^2 r - e_0 B \omega r \qquad | : m_e r$$

$$-\omega^2 = -\omega_0^2 - \frac{e_0 B \omega}{m_e}$$

$$\omega_L = \frac{e_0 B}{2 m_e}$$ warum da 2 ea ?

$$\omega^2 - \omega_0^2 - 2\omega_L \omega = \cancel{0}$$

S3 O

$[L^i, H]$: $c\,\varepsilon_{ijk}\,\alpha_m (x_j p_k p_m - p_m x_j p_k)$

$$= c\,\varepsilon_{ijk}\,\alpha_m (i\hbar)^2 (x_j \partial_k \partial_m - \partial_m x_j \partial_k)$$

$$= -c\,\varepsilon_{ijk}\,\alpha_m (i\hbar)^2 \partial_k \underbrace{\partial_m x_j}_{\delta_{mj}}$$

$$= \text{—"—}\ \alpha_j \partial_k$$

$$\underline{= c\,i\hbar\,\varepsilon_{ijk}\,\alpha_j p_k}$$

$$E_N = -\frac{hcR_\infty}{N^2} = -\frac{\alpha_f \hbar c}{2r} = -\frac{m_e v^2}{2}$$

$$\frac{hcR_\infty}{N^2} = \frac{m_e v^2}{2}$$

$$v = \frac{c\,\alpha_f}{N} \longrightarrow \frac{h\cancel{c}R_\infty}{\cancel{N^2}} = \frac{m_e c^{\cancel{2}}\alpha_f^2}{2\cancel{N^2}}$$

$$\longrightarrow R_\infty = \frac{1}{hc}\frac{m_e c^2 \alpha_f^2}{2}$$

S 42 / (4.28) ff.

$$\left(-\frac{\hbar^2}{2\mu}\left(\frac{d^2}{dr^2} + \frac{2}{r}\frac{d}{dr} - \frac{l(l+1)}{r^2}\right) - \frac{2\alpha_f \hbar c}{r}\right) R_l = E R_l$$

$$/ : E$$

$$\left(-\frac{\hbar^2}{2\mu E}\left(- \text{"} - \right) - \frac{2\alpha_f \hbar c}{rE}\right) R_l = R_l$$

$$\rho = \frac{r}{b} \qquad \frac{\hbar^2 l(l+1)}{2\mu E r^2} = -\frac{l(l+1)}{\rho^2}\frac{\hbar^2}{b^2\, 2\mu E}$$

$$\longrightarrow b^2 = -\frac{\hbar^2}{2\mu E} \longrightarrow b = \sqrt{-\frac{\hbar^2}{2\mu E}} \cdot \underbrace{\frac{1}{2}}_{?}$$

$$\Rightarrow -\frac{2\alpha_f \hbar c}{\rho b E} = -\frac{2\alpha_f \hbar c}{\rho \frac{1}{2}\sqrt{-\frac{\hbar^2}{2\mu E}}\; E}$$

$$= -\frac{Z \alpha \rho \hbar c}{\rho \sqrt{-\frac{\hbar^2}{8\mu} E}} = \frac{Z \alpha \rho \cancel{\hbar} c \sqrt{8\mu}}{\rho \sqrt{-\cancel{\hbar^2} E}}$$

$$= Z \alpha \rho \sqrt{-\frac{8\mu c^2}{E}}$$

$$\rho = \frac{r}{b}$$

$$\frac{d\rho}{dr} = \frac{1}{b}$$

$$\frac{d}{dr} R(\rho) = \frac{d}{d\rho} R(\rho) \cdot \frac{d\rho}{dr} = \frac{1}{b} \frac{d}{d\rho} R(\rho)$$

$$\frac{d^2}{dr^2} R(\rho) = \frac{d}{dr} \left(\frac{1}{b} \frac{d}{d\rho} R(\rho) \right)$$

$$= \frac{1}{b} \frac{d}{d\rho} \underbrace{\frac{d}{dr} R(\rho)}_{\frac{1}{b} \frac{d}{d\rho} R(\rho)}$$

$$= \frac{1}{b^2} \frac{d^2}{d\rho^2} R(\rho)$$

$$\longrightarrow \quad -\frac{\hbar^2}{2\mu E} \frac{d}{dr^2} R(r) = -\frac{\hbar^2}{2\mu E} \frac{1}{b^2} \frac{d^2}{d\rho^2} R(\rho)$$

$$= +\frac{\cancel{\hbar^2}}{\cancel{2\mu E}} \frac{4 \cancel{2\mu E}}{\cancel{\hbar^2}} \frac{d^2}{d\rho^2} R(\rho)$$

$$-\frac{\hbar^2}{2\mu} \frac{2}{r} \frac{d}{dr} R(r) = -\frac{\hbar^2}{2\mu} \frac{2}{\rho b} \frac{1}{b} \frac{d}{d\rho} R(\rho)$$

$$= +\frac{\cancel{\hbar^2}}{\cancel{2\mu E}} \frac{2}{\rho} \frac{4 \cdot \cancel{2\mu E}}{\cancel{\hbar^2}} \frac{d}{d\rho} R(\rho) =$$

$$\frac{4 \cdot 2}{\rho} \frac{d}{d\rho} R(\rho)$$

$$-\frac{2\alpha_f \hbar c}{rE} R(r) = -\frac{2\alpha_f \hbar c}{\rho b E} R(\rho)$$

$$= \frac{-2\alpha_f \cancel{\hbar c}\; 2\sqrt{-2\mu E}}{\sqrt{\cancel{\hbar^2}}\;\sqrt{E^2}}$$

$$= -2\alpha_f \; 2 \sqrt{-\frac{4\mu}{2E}}$$

$$= -2\alpha_f \; 4 \sqrt{-\frac{\mu}{2E}}$$

S 58

$$\Delta E_{nk} = -\frac{1}{2\mu c^2}\left[E_N^2 + 2E_N \frac{2\alpha_f \hbar c}{r_N} + \frac{2^2\alpha_f^2\hbar^2 c^2}{r_N^2 \left(l+\frac{1}{2}\right)} N\right]$$

$$r_N = \frac{\hbar}{\mu c}\frac{N^2}{2\alpha_f}$$

Du bringst meine Moleküle zum Vibrieren :)!

$$E_N = -\frac{1}{2}\frac{2\alpha_f \hbar c}{r_N}$$

$$E_N^2 = +\frac{1}{4}\frac{2^2\alpha_f^2\hbar^2 c^2}{r_N^2}$$

$$\Delta E_{nk} = -\frac{1}{2\mu c^2}\left[E_N^2 - 4E_N^2 + 4E_N^2\frac{N}{l+\frac{1}{2}}\right]$$

Hallo Manuel,

bist mein

(Atom) Physiker des Herzens!

$$= -\frac{1}{2\mu c^2}\left[-3E_N^2 + 4E_N^2\frac{N}{l+\frac{1}{2}}\right]$$

$$= \frac{2E_N^2}{\mu c^2}\left[\frac{3}{4} - \frac{N}{l+\frac{1}{2}}\right]$$

$$E_N = -\frac{1}{2}\frac{Z\alpha_f\hbar c}{r_N} = -\frac{1}{2}\frac{Z^2\alpha_f^2\cancel{\hbar}c^2\mu}{\cancel{\hbar}N^2}$$

$$\longrightarrow \quad \Delta E_{kin} = -E_N\cancel{2}\frac{1}{\cancel{2}}\frac{Z^2\alpha_f^2\cancel{c^2}\cancel{\mu}}{\cancel{c^2}\cancel{\mu}N^2}\left[\frac{3}{4}-\frac{N}{l+\frac{1}{2}}\right]$$

$$= -\frac{E_N Z^2\alpha_f^2}{N^2}\left[-\ \text{''}-\right] \checkmark$$

S 60 / vor 4.114

$$E_N = -\frac{\mu c^2}{2}\frac{Z^2\alpha_f^2}{N^2}$$

$$b = \frac{1}{2}\sqrt{+\frac{\hbar^2\cancel{Z}N^2}{\cancel{\hbar}\mu^2c^2Z^2\alpha_f^2}} \qquad (4.30)$$

$$= \frac{1}{2}\frac{\hbar N}{\mu c Z\alpha_f} \qquad \text{Faktor } \frac{1}{2} \text{ passt nicht!}$$

<u>S 79/80</u> $\quad E_N' = \frac{m_e c^2}{2}\frac{(Z-\sigma)^2\alpha_f^2}{(N')^2}$

$$\frac{E_N'}{hc} = \frac{mc}{h2}\frac{(Z-\sigma)^2\alpha^2}{(N')^2} \qquad \text{// Diff von 2 Schalen}$$

$h = \pi\hbar$ ✓ $\qquad K_\alpha: \quad \frac{mc\alpha^2}{\hbar\pi}\frac{\bar{Z}^2}{2}\left(\frac{1}{1^2}-\frac{1}{2^2}\right)$

mittl. Ladungszahl

$$= \frac{m_e c^2}{h \pi} \frac{Z^2}{2} \underbrace{\left(1 - \frac{1}{4}\right)}_{\frac{3}{4}}$$

Vorf. passt bis auf $\frac{1}{2}$

$$L_\alpha: \quad \frac{1}{2^2} - \frac{1}{3^2} = \frac{1}{4} - \frac{1}{9} = \frac{9}{36} - \frac{4}{36} = \frac{5}{36} \checkmark$$

$$K_\beta: \quad \left(1 - \frac{1}{9}\right) = \frac{8}{9}$$

Nenner $\cdot 4$: $\frac{2}{9}$ ✓

<u>S121)</u>

$$\frac{1}{r} \partial_r^2 \frac{r\,[\varepsilon_f - V]}{\alpha \hbar c}$$

$$= \frac{4}{3\pi} \left(\frac{2 \mu c \alpha}{\hbar}\right)^{3/2} \left[\frac{\varepsilon - V}{\alpha \hbar c}\right]^{3/2}$$

$$\chi = \frac{r\,(\varepsilon_f - V)}{2 \alpha \hbar c}$$

$$\frac{2}{r} \partial_r^2 \chi = \frac{4}{3\pi} \left(\frac{2 \mu c \alpha}{\hbar}\right)^{\frac{3}{2}} \left[\frac{2}{r} \chi\right]^{3/2}$$

$$\partial_r^2 \chi = \frac{4}{3\pi} \left(\quad 4 \quad\right)^{\frac{3}{2}} \left(\frac{2^{\cancel{3}}\,\cancel{r^2}}{r^{\cancel{3}}\,2^{\cancel{2}}}\right)^{\frac{1}{2}} \chi^{3/2}$$

$$= \left(\frac{16 \cdot 8 \cdot 2}{9 \pi^2 \, r}\right)^{\frac{1}{2}} \chi^{\frac{3}{2}} \left(\frac{\mu c \alpha}{\hbar}\right)^{\frac{3}{2}}$$

$$= \left(\frac{128 \cdot 2}{9 \pi^2 \, r}\right)^{\frac{1}{2}} \chi^{3/2} \Big(\underbrace{\frac{\mu c \alpha}{\hbar}}_{a}\Big)^{\frac{3}{2}}$$

$$x = \frac{r}{b} \qquad b = a \left(\frac{9 \pi^2}{128 \cdot 2}\right)^{1/3}$$

$$\frac{1}{b^2}\partial_x^2 \chi = \left(\frac{128 Z}{9\pi^2 b x}\right)^{1/2} \chi^{\frac{3}{2}} a^{\frac{3}{2}}$$

$$\partial_x^2 \chi = \underbrace{\left(\frac{128 Z}{9\pi^2 b^3 x}\right)^{\frac{1}{2}}} \chi^{\frac{3}{2}} a^{\frac{3}{2}}$$

$$\left(\frac{128 Z \quad (9\pi^2)^{3/3}}{9\pi^2 x a^3 (128 Z)^{3/3} x}\right)^{\frac{1}{2}} \chi^{\frac{3}{2}} a^{\frac{3}{2}} \quad \checkmark$$

$$\frac{d\chi(x)}{dr} = \frac{d\chi}{dx}\underbrace{\frac{\partial x}{\partial r}}_{\frac{1}{b}}$$

$$\frac{d}{dr}\left(\frac{d\chi}{dx}\frac{1}{b}\right) = \frac{d\chi}{dx\,dr}\frac{1}{b} = \frac{1}{b^2}\frac{d^2\chi}{dx^2}$$

$$\longrightarrow \quad \partial_x^2 \chi = \frac{\chi^{\frac{3}{2}}}{\sqrt{x}}$$

S122 (5.111)

$$N = 2\int_0^{x_0} x\,\partial_x^2 \chi \, dx$$

$$\int x\,\partial_x^2\chi = \int_0^{x_0} \partial_x(x\,\partial_x\chi) - \partial_x\chi$$

$$= x\,\partial_x\chi\Big|_0^{x_0} - \chi\Big|_0^{x_0}$$

$$\frac{N}{2} = x_0\,\partial_x\chi(x_0) - \underbrace{\chi(x_0)}_{\emptyset} + \underbrace{\chi(\emptyset)}_{1}$$

$$= x_0\,\partial_x\chi(x_0) + 1$$

$$\frac{N-2}{2} = x_0\,\chi'(x_0) \quad \checkmark \qquad \chi' \leq 0$$

$$\rightarrow \quad N \leq 2$$

$$\sum \varepsilon_k - \frac{1}{2}\sum_{j,k}^{N} W - W$$

S 130 / (5.140)

$$\varepsilon_k = \langle | \frac{P^2}{2m} + V^2 | \rangle + \sum_{j}^{N} W - W$$

$$\frac{1}{2}\varepsilon_k = \frac{1}{2}\left(\frac{P^2}{2m} + V^2\right) + \frac{1}{2}\sum W - W$$

$$\frac{1}{2}\varepsilon_k + \frac{1}{2}\left(\frac{P^2}{2m} + V^2\right) = \left(\frac{P^2}{2m} + V^2\right) + \frac{1}{2}\sum W - W$$ ✓

S 153 / (7.8)

$$(\sigma a)(\sigma b) = ab + i\sigma a \times b$$

$$\left[\vec{\sigma}(\vec{p} - q\vec{A})\right]^2 = \left[\vec{\sigma}\vec{p} - \vec{\sigma} q \vec{A}\right]^2 =$$

$$\left[(\sigma p)^2 - q\,\vec{\sigma}\vec{p}\,\vec{\sigma}\vec{A} - q\,\vec{\sigma}\vec{A}\,\vec{\sigma}\vec{p} + q^2(\sigma A)^2\right]$$

$$= p^2 + q^2 A^2 - q\left(\vec{p}\vec{A} + \vec{A}\vec{p} + i\sigma(\vec{p}\times\vec{A} + \vec{A}\times\vec{p})\right)$$ ✓

$$\partial_i \varepsilon_{ijk} B_j r_k = \varepsilon_{ijk} r_k \partial_i B_j + \underbrace{\varepsilon_{ijk} B_j \underbrace{\partial_i r_k}_{\delta_{ik}}}_{\varnothing}$$

$\partial_i B_i = 0$ gefordert??

Dirac gl:

$$p_x \,\&\, p_y = \varnothing \qquad p_z = p$$

$$\sigma_z p_z \psi_B = \frac{1}{c}(E - mc^2)\psi_A$$

$$\begin{pmatrix} p & \\ & -p \end{pmatrix}\psi_B = \frac{1}{c}(E - mc^2)\psi_A$$

$$p\,\psi_{A1} = \frac{1}{c}(E + mc^2)\,\psi_{B1}$$

$$-p\,\psi_{A2} = \text{—}\,''\,\text{—}\;\psi_{B2}$$

1. Fall

$$p \, 1 = \frac{1}{c}(E + mc^2)\, X \qquad 1. \text{ Fall}$$

$$-p \, 1 = \frac{1}{c}(E + mc^2)\, X \qquad 2. \text{ Fall}$$

$$\psi = N_+ \, e^{i(\vec{k}\vec{x} - \omega t)} \qquad \frac{pc}{E_+ + mc^2} = X$$

$$\vec{p} = \hbar \vec{k} \rightarrow \frac{\vec{p}}{\hbar} = \vec{k}$$

$$E = \hbar \omega \rightarrow \omega = \frac{E}{\hbar} \qquad \checkmark$$

siehe Skriptum