PØ1

$S_a : Z \to Z$ $\qquad \phi : M \to Z$ $\qquad S_a\phi := S_a \circ \phi$

$$
\begin{tikzcd}
M \arrow[r, "\phi"] \arrow[d, "(u)"'] & Z \arrow[r, "S_a"] \arrow[d, "(\text{bàsis})"] & Z \arrow[d, "(\text{bàsis})"] \\
T \times S \arrow[ur, "\hat{\phi}"'] \arrow[d, "(\text{bàsis})"'] & \mathbb{C}^2 \arrow[r, "\tilde{S}_a"] & \mathbb{C}^2 \\
\mathbb{R} \times \mathbb{R}^3 \arrow[r, "\tilde{\phi}"'] & \cdots \arrow[r] & \mathbb{C}^2
\end{tikzcd}
$$

$a \in \frac{S}{\mathbb{1}}$

$\sigma : \frac{S}{\mathbb{1}} \to Z$

$\sigma(c)\sigma(d) + \sigma(d)\sigma(c) = 2\, c \cdot d\, \mathbb{1}$

$\sigma(Rc)\sigma(Rd) + \sigma(Rd)\sigma(Rc) = 2\, \underbrace{Rc \cdot Rd}_{c \cdot d}\, \mathbb{1}$

$\exists\, A_R : Z \to Z$ $\qquad \sigma(Rc) = A_R\, \sigma(c)\, A_R^{-1}$

p02

$$U_{\dot L}\phi := A_{\dot L}\left(\phi \circ \dot L^{-1}\right)$$

$$\frac{d}{d\alpha}\left(\dot L(\alpha) \quad L(\alpha) \quad L(\alpha)^{-1} \right)\Bigg|_{\alpha=0}$$

$$\frac{1}{2}G(c)$$

$$\parallel$$

$$J_c := L_c + S_c$$

(1)

(2) $\Delta x \sim \frac{\hbar}{\Delta p} \sim \frac{\hbar}{m_0 c}$

(3) $\Delta x > \frac{\hbar}{m_0 c}$

$\Delta t \sim \frac{\Delta x}{c} > \frac{\hbar}{m_0 c^2}$

es ets | ps

t $L^2(t)$

es ps

u,t

$L^2(u,t)$

absolut imp. → D u-rel. imp. → P_u

P03

$L^2(Di(M))$

$L^2(S_u^*, Z_u)$ $m\beta + \alpha \cdot P$

m.r $L^2(S^*, Z)$ $Q \sim -i\nabla$

$L^2(S, Z)$ Q mnożenie.

$$\Sigma := \begin{pmatrix} \sigma & 0 \\ 0 & \sigma \end{pmatrix}$$

$$\tilde{Q} = Q - \frac{iP}{2P_0^2} - \frac{iP(\alpha \cdot P)}{2mP_0(P_0+m)} + \frac{i\alpha}{2m} + \frac{\Sigma \times P}{2m(P_0+m)}$$

$$P_0 := \sqrt{|P|^2 + m^2}$$

P04

n. r. $\dot{M} \times V(1) \times S(s)$

$k \in V(m)$

$S_k(s) := \{ \cancel{k \cdot q} : q \in M \mid k \cdot q = 0 \quad |q| = s \}$

r $\quad \dot{M} \times V(1)$

$\dot{M} \times \{ \underbrace{u \in V(1),\ q \in M}_{} \mid u \cdot q = 0,\ |q| = s \}$

$\Gamma(R_c) \ldots \quad A_R$

$\phi : \dot{M} \to X$

$\gamma(L_c) \ldots \quad A_L$

$U_L \phi := A_L(\phi \circ \dot{C}^{-1})$

P05

$$L_{a\wedge b} + S_{a\wedge b}$$

$u = V(1)$ $\quad a \cdot u = b \cdot u = 0$

$c \cdot u = 0$ $\quad \overbrace{L_c + S_c}^{\exists}$ $\quad \overbrace{(L_c + C_c) + (S_c + C_c)}^{\exists}$

$(\Pi_u (x \to) \times (i \nabla_u))_c$

RELAT. QM: Ø SPIN
(KV.)

SZABAD KG: $\overbrace{(\partial_0^2 - \underbrace{\nabla_u^2}_{\Delta_u})}^{\square} \hat{\phi} = -m^2 \hat{\phi}$, $(i\partial_0)^2 \hat{\phi} = [(-i\nabla_u)^2 + m^2] \hat{\phi}$

„MINIMÁLISAN CSATOLT KG": $(\overbrace{i\partial_0 - V_u}^{i\partial_0 + A_0})^2 \hat{\phi} = [(-i\nabla_u - A_u)^2 + m^2] \hat{\phi}$ (x.1)

P06

$$i\partial_0 \hat{\phi} = H_n \hat{\phi} = \left(\frac{(-i\nabla - A_n)^2}{2m} + V_n \right) \hat{\phi} \leftarrow \text{GAL.-REL.}$$

SZABAD:
PRÓBA: $i\partial_0 \hat{\phi} = \sqrt{(-i\nabla_n)^2 + m^2}\, \hat{\phi}$: JAJ

HÁTHA: $i\partial_0 \hat{\phi} = \left[\alpha \cdot (-i\nabla_n) + \beta m \right] \hat{\phi}$

$$(i\partial_0)^2 \hat{\phi} = (i\partial_0)[\quad]\hat{\phi} = [\quad](i\partial_0)\hat{\phi} =$$

$$= [\quad][\quad]\hat{\phi} = \left[\alpha^2 (-i\nabla_n)^2 + 2\alpha\beta m(-i\nabla_n) + \beta^2 m^2 \right] \hat{\phi}$$

$\alpha^2 = 1$ $\qquad \beta^2 = 1$

$\alpha \cdot \beta + \beta\alpha = 0$ $\qquad \exists\, 4$ DIM.

$\alpha\beta + \beta\alpha$

MIN. CSAT.: K $\quad V_n, A_n$

P07) 0 SPIN:

$$J = \frac{1}{2m}\left[\phi^{*}(-iD)\phi - \phi(-iD)\phi^{*}\right]$$

DIV.-MENTES

$$J_0 = \frac{i}{2m}\left[\hat{\phi}^{*}\,\partial_0\hat{\phi} - \partial_0\hat{\phi}^{*}\,\hat{\phi}^{*}\right]$$

2. RENDŰ „IDŐBEN":

$$\hat{\phi}(0,q) := \varphi_0(q) \qquad \hat{\phi}(0,q) = \varphi_0(q)$$

$$\partial_0\hat{\phi}(0,q) := \varphi_1(q) \qquad \partial_0\hat{\phi}(0,q) = -\varphi_1(q)$$

NEM POZ. DEF.

= NINCS H-TÉR, VALÓSZ. ELM.

FESHBACH-VILLARS:

$$\begin{pmatrix} \hat{\phi} + \frac{i}{m}(\partial_0 + iV_m)\hat{\phi} \\ \hat{\phi} - \frac{i}{m}(\partial_0 + V_m)\hat{\phi} \end{pmatrix}$$

– VLE

1.-RENDŰ

p09

L^2 - IGÉNY ESETÉN

$\partial_0 \hat{\phi}(0,\cdot)$, $\hat{\phi}_0(0,\cdot)$ NEM ELEMEK, HA t - ELEM L^2 - T AKAROK

$\partial_0^2 \hat{\phi} = -H_u^2 \hat{\phi}$, AHOL $H_u = \sqrt{-\Delta_u + m^2}$

$$i \partial_0 \hat{\phi} = \sqrt{(-i\nabla_u)^2 + m^2}\, \hat{\phi}$$

L^2 OK (JOST)

NEM-SZABAD:

$$(i \partial_0 - V_u)\, \hat{\phi} = \sqrt{(-i\nabla_u - A_u)^2 + m^2}\, \hat{\phi} \quad \not\Leftrightarrow (X.1)$$

(X.1) STAC. MO.-AI: $i \partial_0 \hat{\phi} = E \hat{\phi}$

COULOMB-POT.

$E_{n,l} = \sqrt{1 + \frac{\cdots}{\cdots}}$, $r^{1/2 + m} P_{n,l}(r)\, e^{-\cdots r}\, Y^{l,m}(\vartheta, \varphi)$

P10) 0-SPINŰ, SPINORTENZOROSAN MEGFOG. REL. KV. MECH.

$\frac{1}{2}: X \to 1: X \vee X$, DIRAC-EGY.

$\frac{3}{2}: X \vee X \vee X$, D.-E.

$\vdots$

$0: X \wedge X$, D.-E. $\leftarrow$ VAR.: SZABAD ESET, P-NYELVE

$\boxed{\text{VARADARAJAN}}$

„X-NYELVEN"?

NEM-SZABAD? (MIN. CSAT.)

ALKALMAZÁSAI – PL. COULOMB, ...

p11)

$$\gamma(-iD)\Phi = m\Phi$$

$$J(x) := \langle \Phi(x), \gamma(\cdot)\Phi(x)\rangle,$$

$\frac{1}{2}$

$$F^{m,0,0},$$

$$\langle X_1 \otimes Y_1, X_2 \otimes Y_2\rangle :=$$

$$\langle \Phi, \Phi\rangle_u \quad \int -HATÓ,$$

$$= \langle X_1, X_2\rangle \cdot \langle Y_1, Y_2\rangle$$

$$\underbrace{2\text{-DIM.} \wedge 2\text{-DIM.}}^{1\text{ DIM.}}$$

u, t — FLEN

$$\gamma(k)\Phi(k) = m\,\Phi(k) \Rightarrow \in Z_{k+} \wedge Z_{k+}$$

POZ. DEF.

$k \quad p \quad p_0 = \sqrt{\vec{p}^2 + \ldots}$

$$\langle \Phi | \Phi\rangle := \frac{1}{2}\int \langle \Phi, \Phi\rangle \, d\lambda_{V(m)}$$

M.

pr)

$$\partial_0 \hat{\phi} = -i\left[m\beta + \alpha(-i\nabla_n)\right]\Phi$$

$$\mathcal{F}^{m,p,0} \underset{z.l.a}{\subset} \mathcal{L}^2\left((u,t), X \wedge X\right)$$

FR. M.-EK , HELYZET ITT SEM SZORZÓ-OP.

PERDÜLET : $L_{a\wedge b} + S_{a\wedge b}$

$J = L$

$J^2 = L^2$

NEM-SZABAD ESET:

J , MIN. ~~...~~ CSATOLT

D.-E. $\rightarrow L^2$

COULOMB-PR.:

J SE-E IBE)

SFV-E IBE

NEM SZÓL BELE S

P13)

$$i\partial_0 \hat{\Phi} = \left(m\beta + \alpha \cdot (-i\nabla_m) + \frac{e^2}{|id_{S_m}|} \right) \hat{\Phi}$$

STAC. :

A KG-NÁL LÁTOTT $E_{n,l}$-EK

A SFV-EK NEM ELÉGÍTIK KI A KG-T