XXII

NOTE BOOK

Manufactured with best ruled foolscap
Brings easier & cleaner writing

July, 1966 ~ Feb. 1967
[illegible] Dec. 1966
([illegible]) Feb. 1967
[illegible]の検討([illegible])

VOL. XXII

H. Y.

Nissho Note

原論文: Transformation
基研コロキウム
July 14, 1966

(1)

Properties of Rigid Sphere Wave Functions and its Relation to Dirac spinor

spin ½ の case

$$\Psi(X, \varphi, \theta, \psi, \tau) = \sum_n \psi_n(X, \tau) U_n(\varphi, \theta, \psi)$$

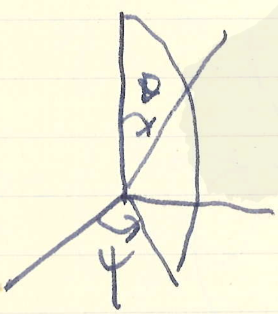
$S^2 = J(J+1)$

$S_z = K$

$S^{z'} = L$

K	L → spin	ψ
½	½	$\cos\frac{\theta}{2}\, e^{i(\varphi+\psi)/2}$
½	−½	$\sin\frac{\theta}{2}\, e^{i(\varphi-\psi)/2}$
−½	½	$\sin\frac{\theta}{2}\, e^{i(-\varphi+\psi)/2}$
−½	−½	$\cos\frac{\theta}{2}\, e^{i(-\varphi-\psi)/2}$

$$\psi_n = \int \Psi \cdot U_n^* \, d\omega$$



$$\xi = \begin{pmatrix} \sin\frac{\theta}{2}\, e^{i(\varphi-\psi)/2} \\ -\cos\frac{\theta}{2}\, e^{i(\varphi+\psi)/2} \end{pmatrix}$$

$$\eta = \begin{pmatrix} \cos\frac{\theta}{2}\, e^{-i(\varphi+\psi)/2} \\ \sin\frac{\theta}{2}\, e^{-i(\varphi-\psi)/2} \end{pmatrix}$$

ψ_n : ψ の成分

a) 空間回転

$$\left(1 + \tfrac{1}{2}\sigma_i \overset{d\omega_i}{\omega_i}\right)\xi$$

$$\left(\qquad \right)\eta$$

$$\left.\begin{aligned}
d\omega_1 &= -\sin\psi\, d\theta + \sin\theta\cos\psi\, d\varphi \\
d\omega_2 &= \cos\psi\, d\theta + \sin\theta\sin\psi\, d\varphi \\
d\omega_3 &=
\end{aligned}\right\}$$

b) inversion

$$\left.\begin{aligned}
\theta' &= \pi - \theta \\
\psi' &= \pi + \psi \\
\varphi' &= \varphi
\end{aligned}\right\}$$

$$\frac{1}{\sin\theta'}\frac{\partial}{\partial\theta'}\left(\sin\theta'\frac{\partial}{\partial\theta'}\right) + \frac{1}{\sin^2\theta'}\frac{\partial^2}{\partial\varphi'^2} + \frac{1}{\sin^2\theta'}\frac{\partial^2}{\partial\psi'^2}$$

$$+\, 2\frac{\cos\theta'}{\sin^2\theta'}\frac{\partial^2}{\partial\varphi'\partial\psi'}\Big)\Phi' = -\frac{2IE}{\hbar^2}\Psi'$$

$$\xi' = \begin{pmatrix} \cos\frac{\theta}{2}\, e^{i(\varphi'-\psi')/2} \\ \sin\frac{\theta}{2}\, e^{i(\varphi'+\psi')/2} \end{pmatrix}$$

$$\eta' = \begin{pmatrix} \sin\frac{\theta'}{2}\, e^{-i(\varphi'+\psi')/2} \\ -\cos\frac{\theta}{2}\, e^{-i(\varphi'-\psi')/2} \end{pmatrix}$$

$$\left.\begin{aligned}
\xi' &= i\,\xi \\
\eta' &= -i\,\eta
\end{aligned}\right\}$$

c) Lorentz 変換

$\xi \to \xi' = (1 + \frac{1}{2}\sigma_i v_i)\xi$

$\eta \to \eta' = \quad \cdots$

θ, φ, ψ の imaginary part を考える。

inversion に対しては

$\theta + i d\theta, \quad \cdots$

or $\theta - i d\theta, \quad \cdots$

となる。

$\xi_a \quad \eta_a \qquad \xi^{\dot\alpha} = (i\sigma_2 \xi^*)^\alpha$

$\eta^{\dot\alpha} =$

$\xi'^{\dot\alpha} = -i\Big(\qquad \Big)$

$\xi'_\alpha = i\eta^{\dot\alpha} \qquad \xi'^{\dot\alpha} = i\eta_\alpha$

$\eta'_\alpha = i\xi^{\dot\alpha} \qquad \eta'^{\dot\alpha} = i\xi_\alpha$

$\varphi = \begin{pmatrix} \xi_\alpha \\ \eta^{\dot\alpha} \end{pmatrix} \quad \chi = \begin{pmatrix} \eta_\alpha \\ \xi^{\dot\alpha} \end{pmatrix}$

$\partial^{\dot r k}\psi_k = i\kappa \chi^{\dot r}$

$\partial_{\dot r k}\chi^{\dot r} = i\kappa\psi_k$

$$\left.\begin{aligned} \xi_\alpha &= \eta^{\dot\alpha} \\ \eta_a &= -\xi^{\dot\alpha} \end{aligned}\right\}$$ c.M.S. → c.V. Euler angle unreal

$\varphi = \rho_2 \sigma_2 \psi^*$ charge conjugation

$\partial_{\dot\nu 5} = i\kappa(1+\sigma_i v_i)$

○ two component theory との関係

$\frac{1}{2}(1 \pm \gamma_5) \to \left\{\begin{matrix} \xi_\alpha \\ \eta_a \end{matrix}\right\}$ に対応

weak int. $\xi_A^* \sigma_\mu \xi_B$, $\xi_C^* \sigma_\mu \xi_D$

梅林84: Elementary Particle Spectrum

H. C. Corben P. R. <u>145</u> No. 4 1251 (1966)

基研コロキウム

(H. C. Corben Quantum Numbers of Rel. Rotational states PRL <u>15</u> (1965), (9 Aug.) 268.

$n \equiv J - I + \frac{1}{2}S \longrightarrow$ integer

$Q = \frac{1}{2}B + \frac{1}{2}S + I_3 \longrightarrow$ integer

S, P　　J　　I　　M

　　　↓　　↓　　ΔM

S, P,　J+1　I+1　ΔM

⋮

$J - I = \text{const.}$

第二日 Sept. 4　~~[illegible]~~ "新しい相互作用" 研究会
Sept. 3 ~ Sept. 4, 1966

[illegible]: C-violation

$$\left.\begin{array}{l} a b^{*\prime} - e^{i\theta} b^{*\prime} a = 0 \\ a b' - e^{-i\theta} b' a = 0 \end{array}\right\}$$

[illegible]: Quarks

$$B = 3M_q - \mathcal{M} > 2M$$

$$B = 2M_q - m \gtrsim 2M$$

high energy scattering

$\langle \pi^+ p | \pi^+ p \rangle$　Impulse 近似

$P = (p\,p\,n)$　　$\pi^+ = (p\,\bar{n})$

$$\langle \pi^+ p | \pi^+ p \rangle = 2\langle pp|pp\rangle + \langle pn|pn\rangle + 2\langle p\bar{n}|p\bar{n}\rangle + \langle n\bar{n}|\bar{n}n\rangle$$

$$\langle PP|PP\rangle - \langle NP|NP\rangle = \langle K^+P\rangle - \langle K^+N\rangle$$

baryon の磁気能率

$$\mu_i = e_i \mu_0 \qquad \rightarrow \mu_p/\mu_n = -3/2$$

$$\mu_i = \frac{e_i}{2M} \varkappa$$

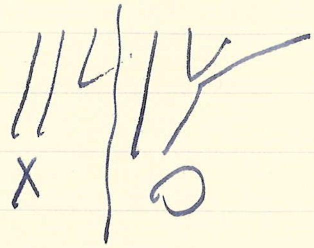
baryon の励起状態

$$J = S + L$$

L 励起は確認していない (これは何からでるか)

meson の励起状態

pair suppression



[illegible]：1) CP-violation（井上・中沢）
2) QED の ~~精密~~ Test

1) $\bar{N}\gamma N \Phi \longrightarrow$ C を変へ.

Φ　S, ps, A　　$C=+1$　$\boxed{C=-1}$

V, T　　$C=-1$　$\boxed{C=+1}$ → abnormal boson

2) photon propagator

$$\frac{1}{k^2} - \frac{1}{k^2+\Lambda^2}$$

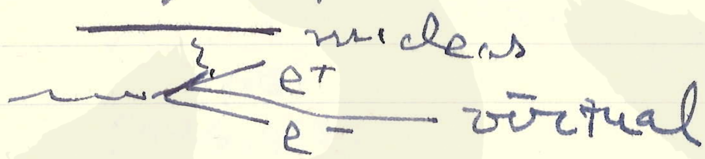
magnetic moment

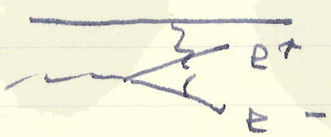
$$\frac{\delta\mu}{\mu} = \frac{\alpha}{2\pi} \delta F$$

$$\delta F \sim \frac{2}{3}\cdot\frac{m^2}{\Lambda^2}$$

$$\rightarrow \Lambda > 1\ \mathrm{GeV}/c$$

wide angle pair creation





$E_\gamma = 1 \sim 6$ GeV　　Carbon target

$E_+ = E_-$　　$\theta_+ = \theta_- = 4.75^\circ \cdots 11.74^\circ$

・英語講演会

J. Schwinger, Remarks on High-energy Particle Physics

Sept. 14, 1966

基研コロキウム
Sept. 14, 1966
湯川: Atomistics and the Divisibility of Space and Time
(Aug. 31, 1966)

Sept. 21, 1966
河辺: Berkeley High Energy Conference における素粒子の総合報告 (紹介)
255名参加
mass $N^*(3245)$ くらいまで

$0^-(CP=-1)$　$0^+(CP=+1)$　$1^-(CP=+1)$　$1^+, 2^+(CP=+1)$

$\eta\ (I=0)\ (Y=0)$ (548)　$K\bar{K}\ (I=0)$ (1068)　$\omega(I=0)$ (782)　D　f

η' (958) or X^0　$\phi(1019)$　E　f'

$\pi\ (I=1)\ (Y=0)$　$K\bar{K}\ (I=1)$ (1003)　$\rho(756)$　A1　A2

$K\ (I=\frac{1}{2})\ (Y=\pm 1)$ (494, 498)　$K^*(892)$　$K\pi\pi$　K^*

missing mass spectrum method
S (1930)
T (2200)
U (2390)

12, BeV/c　$\pi^- p \to p X^-$

$I \backslash J^P$	0^-	0^+	1^-	1^+	2^+
0	η, η'	$K\bar{K}_0$	ω, ϕ	D, E	f, f'
1	π	$K\bar{K}_1$	ρ	A_1 (B?)	A_2
$1/2$	K	κ(?)	$K^*(892)$	$K_A(1320)$ (K_C?)	$K^*(1400$

quark model

$q\bar{q}$, $l=0$
- $^3S_1$ $\rho\,\omega\,K^*\,\phi$ 1^- $C=-1$
- $^1S_0$ $\pi\,\eta\,K\,\eta'$ 0^- $C=+1$

$q\bar{q}$, $l=1$
- $^3P_2$ $A_2\,f^0\,K^*(1400), f'$ 2^+ $C=+1$
- $^1P_1$ 1^+ $C=-1$
- $^3P_1$ 1^+ $+1$
- $^3P_0$ 0^+ $+1$

$qq\bar{q}\bar{q}$?

素研談話会　Sept. 27, 1966

L. Michel, Theory of Weak Interaction

$\left\{ \begin{array}{l} \Delta I = 1/2 \\ CP \text{ violation} \end{array} \right.$

Cabibbo angle

Triplet weak boson W_2 W_1 W_3

素研コロキウム　Sept 28.

河邉：[illegible]

baryon resonances

TD $Y=2$　$I=0$: $M=1880$　$\Gamma=150$　$1/2^+$?

[illegible]　$I=1$:　1910 ± 20　180　($\sigma_K \sim 4mb$)

亀淵氏
粒子化の一般化
素粒論研究会　　Oct. 4, 1966

$$i\frac{\partial\psi(x)}{\partial x} = [P_\mu, \psi(x)]$$

$$H = \sum_k E_k N_k$$

non-local
non-bilinear

1) $N_k = \frac{1}{2}(a_k^\dagger a_k - a_k a_k^\dagger)$　para-fermi

$$\begin{cases} [a_k, N_l] = \delta_{kl} a_l \\ [a_k^\dagger, N_l] = -\delta_{kl} a_l \end{cases}$$

2) $N_k = \frac{1}{2}(a_k^\dagger a_k + a_k a_k^\dagger)$　para-boson

3) $N_k = a_k^\dagger a_k$ → okayama

$$a_k^{\nu+1} = 0$$

$$[a_k, N_k] = a_k$$

$$H = g\left[\int \psi^*(x)\psi(x)\, d^3x\right]^n$$

$$\Lambda_+ \equiv \sum_{k=1}^{f}(a_k^\dagger a_k + a_k a_k^\dagger)$$　$O(2f)$

2f次元の回転群

generators

$$N_{kl} = N_{lk}^\dagger$$

$$L_{kl} = M_{lk}^\dagger$$

$$L_{kl} + L_{lk} = M_{kl} + M_{lk} = 0$$

$$N_{kk} = N_{kk}^\dagger = N_k$$

para-fermi

$$\begin{cases} N_{kl} = \frac{1}{2}(a_k^\dagger a_l - a_l a_k^\dagger) \\ L_{kl} = \frac{1}{2}(a_k^\dagger a_l^\dagger - a_l^\dagger a_k^\dagger) \\ M_{kl} = \frac{1}{2}(a_k a_l - a_l a_k) \end{cases}$$

→ $O(2f+1)$ $\quad \Lambda = 1 + \frac{1}{2}\delta\omega_{\mu\nu} S_{\mu\nu}$

$S_{\mu\nu} = \beta_\mu\beta_\nu - \beta_\nu\beta_\mu$

O. Klein (1936)

M. Rao (1942)

H. Bhabha (1945), R.M.P. 21

$(\beta_\mu \partial_\mu + m)\psi = 0$

D-F.P. theory

$S_{\mu\nu} = \beta_\mu\beta_\nu - \beta_\nu\beta_\mu$ $\quad$ spin ≤ 1

$S_{\mu\nu} = \beta_\mu\beta_\nu - \beta_\nu\beta_\mu$ $\quad$ spin $\geq 3/2$

$+ \bigcirc\, \beta_\mu \triangle\, \beta_\nu \bigcirc$

$- \bigcirc\, \beta_\nu \triangle\, \beta_\mu \bigcirc$

K.K. Gupta

$$N = \begin{pmatrix} -3/2 & & & \\ & -1/2 & & \\ & & 1/2 & \\ & & & 3/2 \end{pmatrix} + 3/2$$

$$= \begin{pmatrix} 0 & & & \\ & 1 & & \\ & & 2 & \\ & & & 3 \end{pmatrix}$$

$$N_{kl} = \sum_\alpha \left(A^{(\alpha)}_{..}\, a_k^\dagger\, B^{(\alpha)}_{..}\, a_l\, C^{(\alpha)}_{..} - A^{(\alpha)}_{..}\, a_l\, B^{(\alpha)}_{..}\, a_k^\dagger\, C^{(\alpha)}_{..} \right)$$

$L_{kl} = \qquad a_k^\dagger \qquad a_l^\dagger$

$M_{kl} = \qquad a_k \qquad a_l$

$\frac{a^\dagger a + a a^\dagger}{2}$
$\parallel$

example 1,　　　$f=1$

$N_{KR} = N = \frac{1}{2}[a^\dagger, a]_- + \frac{\lambda}{2}[a^\dagger, \Lambda_F, a]$

$[A, B, C]_- \equiv ABC - CBA$

s - 次元表現

$s=1$:　$a = a^\dagger = 0$　　　$p=0$

$s=2$:　fermi　　　$p=1$

$s=3$:　para-fermi (order $p=2$)

$s=4$:

ex. 2.　　$N = \frac{1}{2}[a^\dagger, \Lambda_+, a]_- - \frac{1}{4}\{\Lambda_+[a^\dagger, a]_- + [a^\dagger, a]\Lambda_+\}$

$s=3$ ($p=2$) : Okayama

$N = a^\dagger a - 1$　　　$n = N+1$

$a = \begin{pmatrix} 0 & \sqrt{1} & \\ 0 & 0 & \sqrt{2} \\ 0 & 0 & 0 \end{pmatrix}$

Ohnuki

p.p. - 複合粒子の統計 $\Rightarrow$ f, b / pf　pb / その他

片山：基研談話会

Oct. 5, 1966

Y. Nambu, Rel. Wave Eq. for Particles with Int. Structure and Mass Spectrum

Form factor がはじめから入る。

$\phi(x)$, ϕ_μ, $\phi_{\mu\nu}$, ...

$\partial_\mu \phi_\mu$, $\partial_\mu \partial_\nu \phi_{\mu\nu}$ . . . . .

$$\psi(x) = \sum_n c_n \phi^{(n)}(x)$$

$\psi(p) \rightarrow$

$$\psi(0) = \sum_n c_n \phi^{(n)}_{00\ldots}$$

$$\psi(p) = \sum c_n \gamma^n \phi^{(n)}_{00\ldots}$$

Non-unitary representation

Unitary representation

$O(4,2)$ $\quad x_1^2 + x_2^2 + x_3^2 + x_4^2 - x_5^2 - x_6^2$

E. Majorana, N.C. 9 (1932) 335

$$(W/c + \alpha p - \beta Mc)\psi = 0$$

$$x'_\mu = (\delta_{\mu\nu} + \xi_{\mu\nu}) x_\nu = (1 - \tfrac{1}{2} i \xi_{\alpha\beta} I_{\alpha\beta}) x_\nu$$

$\xi_{\mu\nu}$: antisymmetric infinitesimal

$I_{\alpha\beta}$: six independent group generators

$$(I_{\alpha\beta})_{\mu\nu} = i(\delta_{\alpha\mu}\delta_{\beta\nu} - \delta_{\alpha\nu}\delta_{\beta\mu})$$

~~space~~ generators
space

$$a_i = -\tfrac{1}{2} \epsilon_{ijk} I_{jk}$$

space-time generators $\quad i, j, k = 1, 2, 3$

$$b_i = i I_{i4}$$

$$\left.\begin{aligned} [a_i, a_j] &= i\epsilon_{ijk} a_k \\ [b_i, b_j] &= -i\epsilon_{ijk} a_k \\ [a_i, b_j] &= i\epsilon_{ijk} b_k \end{aligned}\right\}$$

infinite dimensional representation

$$(j, m | a_1 - i\epsilon a_2 | j, m+\epsilon) = [(j+\epsilon m+1)(j-\epsilon m)]^{1/2}$$

$$(j, m | a_3 | j, m) = m$$

$$(j, m | b_1 - i\epsilon b_2 | j+\epsilon\lambda, m+\epsilon) = -\frac{1}{2}\lambda\{[j+\lambda(m+\epsilon)][j+1+\lambda(m+\epsilon)]\}^{1/2}$$

$$(j, m | b_3 | j+\lambda, m) = \frac{1}{2}\{[j+m+\tfrac{1}{2}(\lambda+1)][j-m+\tfrac{1}{2}(\lambda+1)]\}^{1/2}$$

$\epsilon, \lambda = \pm 1$ $\qquad m : (j, -j)$

$\left.\begin{array}{l} j = 0, 1, 2, \cdots \infty \\ \text{or } j = \frac{1}{2}, \frac{3}{2}, \cdots \infty \end{array}\right\}$

(D. M. Fradkin, ~~J. A~~ Am. J. Phys 34 (1966), 314)

$$(\gamma_\mu p'_\mu - Mc)\phi'(x') = 0$$

$$\phi'(x') = \{\exp[-\tfrac{1}{2}i\xi_{\alpha\beta}I_{\alpha\beta}]\}\phi(x)$$

$$p'_\mu = (\delta_{\mu\nu} + \xi_{\mu\nu})p_\nu$$

$$[I_{\alpha\beta}, \gamma_\pi] = i(\delta_{\beta\pi}\gamma_\alpha - \delta_{\alpha\pi}\gamma_\beta)$$

$$(j, m | \gamma_4 | j, m) = -i(j+\tfrac{1}{2})$$

$$(j, m | \gamma_1 - i\epsilon\gamma_2 | j+\epsilon\lambda, m+\epsilon) = -\frac{1}{2}i\epsilon\{[j+\lambda(m+\epsilon)][j+1+\lambda(m+\epsilon)]\}^{1/2}$$

$$(j, m | \gamma_3 | j+\lambda, m) = \frac{1}{2}i\lambda\{[j+m+\tfrac{1}{2}(\lambda+1)][j-m+\tfrac{1}{2}(\lambda+1)]\}^{1/2}$$

$$\phi = T\psi$$

$$(j, m | T | j, m) = (j + \tfrac{1}{2})^{-\frac{1}{2}}$$

→ positive energy values only

mass eigenvalues

$$M (j + \tfrac{1}{2})^{-1}$$

於：[illegible]

Oct. 19, 1968

Partially Conserved Axial vector Current

pion field:

$$\pi(\cancel{X}; f) \equiv \int d^4\xi \; f_\pi^{\rho\sigma}(\xi) T(\bar{t}_\rho(x+\tfrac{\xi}{2}) t_\sigma(x-\tfrac{\xi}{2}))$$

$$\partial_\lambda A_\lambda = c\,\pi$$

$$A_\lambda = i\bar{t}\gamma_5\gamma_\lambda t$$

$\pi \to \mu\nu$　G-T-relation

[illegible]条件　$\langle N' | \partial_\lambda A_\lambda | N \rangle = F(q)$

DR₀

片山：基礎[illegible]
非局所的理論の一般化　　　Oct. 26, 1966

Domainで定義された場
$\psi(D)$

bilocal: $\rho(x) = \frac{1}{2}\left[\delta^3(x-a) + \delta^3(x-b)\right]$

$$\psi_D = \frac{1}{V}\int d^3x\ \psi(x)\,\rho(x) = \psi(a) + \psi(b)$$

$$= \Phi(a, b) \quad \text{or} \quad \Phi(X, r^2)$$

$$X = \frac{a+b}{2} \qquad r = a - b$$

multi-local

domain's surface $f(x) = 0$

$$f(x) = c + \sum b_i x_i - \sum a_{ij} x_i x_j$$

$$1 + 3 \quad + \quad 6 \quad = 10$$

$\psi(c, b_i, a_{ij})$ 変数: 9

$$V = \int_D d^3x$$

$$X_i = \frac{1}{V}\int_D d^3x\, x_i$$

$$I_{ij} = \frac{1}{V}\int_D d^3x\,(x_i - X_i)(x_j - X_j)$$

$$= \frac{1}{5}\sum_{a=1}^{3} e^i_a e^j_a \xi_a^2$$

$$a_{ij} = \frac{c}{1 - \sum_{ij}\sum_{a} \frac{e^i_a e^j_a X_i X_j}{\xi_a^2}} \sum \frac{e^i_b e^j_b}{\xi_b^2}$$

$$b_i = 2\sum_j \sum_a \frac{e^i_a e^j_a}{\xi_a^2} X_j \frac{c}{1 - \sum\sum \cdots}$$

$$f(x) = 1 - \sum \frac{e^i_a e^j_a}{\xi_a^2}(x_i - X_i)(x_j - X_j)$$

$$\psi(D) = \psi(X_i, \xi_a, e^i_a)$$

$$\mathfrak{e}_1 = \frac{1}{2r^2}(q^T \sigma_2 \sigma q + q^* \sigma \sigma_2 q^{*T})$$

$$\mathfrak{e}_2 = \frac{-1}{2r^2}(q^T \sigma_2 \sigma q - q^* \sigma \sigma_2 q^{*T})$$

$$\mathfrak{e}_3 = \frac{1}{r^2}(q^* \sigma q)$$

$$q = \begin{pmatrix} q_1 \\ q_2 \end{pmatrix} \qquad q^* = (q_1^*, q_2^*)$$

$$r^2 = \xi^2 = q^* q$$

$$q_1 = r e^{-i\left(\frac{\chi+\phi}{2} - \frac{\pi}{4}\right)} \cos\frac{\theta}{2}$$

$$q_2 = r e^{-i\left(\frac{\chi-\phi}{2} + \frac{\pi}{4}\right)} \sin\frac{\theta}{2}$$

$$r_i = \xi_a e^i_a \qquad \xi^2 = \xi_1^2 + \xi_2^2 + \xi_3^2 = \xi_a^2 + \xi_b^2 + \xi_c^2$$

$(r, \theta, \varphi, \chi)$

$\left\{\begin{array}{l} q_i \\ q_i^* \end{array}\right. \to \left\{\begin{array}{l} p_i \\ p_i^* \end{array}\right. \to \left\{\begin{array}{l} a_i, \ a_i^* \\ b_i \ \ b_i^* \end{array}\right.$

$p_1 = -ie^{i\left(\frac{\chi+\varphi}{2} - \frac{\pi}{4}\right)}$

$\times \left[\frac{1}{2}\cos\frac{\theta}{2}\frac{\partial}{\partial r} - \frac{1}{r}\left(\sin\frac{\theta}{2}\frac{\partial}{\partial\theta} - \frac{i}{\cos\frac{\theta}{2}}\frac{\partial}{\partial(\chi+\varphi)}\right)\right]$

$L = M, \ L_3, \ M_3$

$K_1 = -\frac{1}{4}\left(\xi\frac{\partial}{\partial\xi} + \frac{\partial}{\partial\xi}\xi\right)$

$K_2 = -\frac{i}{2}\left(\xi^2 + \frac{1}{4}\frac{\partial^2}{\partial\xi^2} + \frac{3}{4\xi}\frac{\partial}{\partial\xi} - \frac{\lambda}{\xi^2}\right)$

$K_3 = \frac{1}{2}\left(\xi^2 - \frac{1}{4}\frac{\partial^2}{\partial\xi^2} - \frac{3}{4\xi}\frac{\partial}{\partial\xi} + \frac{\lambda}{\xi^2}\right)$

$K^2 = \lambda$

$N_\alpha = \left(\xi_\beta\frac{\partial}{\partial\xi_\gamma} - \xi_\gamma\frac{\partial}{\partial\xi_\beta}\right) \qquad \alpha = 1, 2, 3$

$N, \ N_3$

$K^2 = \lambda = \alpha M^2 + \cancel{\beta} N^2$

$t = \begin{pmatrix} a_i \\ b_i^* \end{pmatrix} \qquad [t_\alpha, t_\beta^\dagger]_- = \delta_{\alpha\beta}$

$t^\dagger = t^* \rho_3$

$L = \frac{1}{2} t^\dagger \sigma t$

$M_3 = \frac{1}{4}(t^\dagger t + t^T t^{\dagger T})$

$K = \frac{1}{2} t^\dagger \rho t$

N 特别 !!!

2) $f(A, B, C)$

$A = \sum a_{ij} x_i x_j$

$B = \sum b$

$C = \sum c$

3) 相対論

$c + b_\mu x^\mu + a_{\mu\nu} x^\mu x^\nu$

徳岡氏:

maki-school　　Nov. 12, 1966

c-number では

$$\underbrace{(\gamma_\mu \partial_\mu + \kappa)}_{= \Gamma} \psi = 0$$

これを出す Lagrangian は

$$L = -\bar{\psi} \Gamma \psi$$

しかない。

q-number では

Schwinger variation

$$\{\delta \Psi, \Psi\} = \{\delta \Psi, \bar{\Psi}\} = 0$$

$$\Psi = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \Psi^c$$

$$\Psi = \begin{pmatrix} \psi \\ \psi^c \end{pmatrix} \qquad \bar{\Psi} = (\bar{\psi}, \bar{\psi}^c)$$

$$\to \Gamma \Psi = 0 \to \Gamma \psi = \Gamma \psi^c = 0$$

majorana case もふくまれる。

宮嶋氏　Maki School, Nov. 15, 1966

Extended particle model と
大角散乱

$$\sigma(\theta) = \left| \int e^{ip'x} f\rho(x,t)\psi_p(x)\,dx \right|^2$$

Lab

CM　$(p, h\nu)$　$(-p, E)$　before collision

$(p', h\nu')$　$(-p', E')$　after collision

$$\sigma(\theta) = \frac{A}{[illegible]} e^{\gamma t}$$

大角　$e^{-\beta E}$

short range correlation

long range correlation

$$\sigma(\theta) = A e^{-ap_\perp}$$

斥力・芯・[illegible]

~~[illegible]~~ 強いポテンシャル

超高エネルギー レビュー

矢島氏　　Maki school　　Nov. 29 1966

10^{10}eV ~ 10^{11}eV

i) 組成比　$n^{\pm} = n_s$　n_0^{α}　n^{π^0}

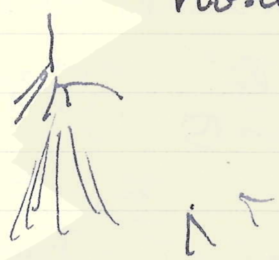
$10^{10}\text{eV} \lesssim E_0 \lesssim 10^{13}\text{eV}$

$$\frac{n_x}{n_s + n_0} = 20\% \sim 30\%$$

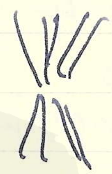
$(n^{\pi^0}/n^{\pm} = 1/2 \quad E_0 \sim 10^{12}\text{eV})$

Koshiba <ICEF>

Kim



L



CM

forward backward cone

$n_K \sim n_\pi$

ii) P_T:　$2.5\times10^{10} \lesssim E_0 \lesssim 10^{15}$eV

π, K;　$n(p_T)dP_T \propto e^{-P_T/P_0} P_T dP_T$

$P_0 = \frac{1}{2}\overline{P_T} \approx 150 \sim 200$ MeV/c

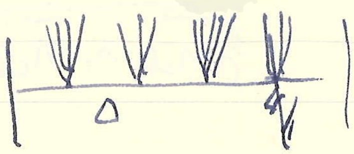
larger P_T event　ECC

$\sum P_{T\pi^0} \geq 2$ GeV/c　　$P_T \sim 600$ MeV/c

5 454 (+1 184)

iii) Δ : Hasegawa-Yokoji

$\Delta \approx M_N c$　　4-momentum transfer



$(1 \sim 10$ GeV/c$)$

$\Delta_{\parallel} \sim M$

$\Delta_T \sim ?$

iV) Δ_N Kim

約 100 MeV/c

(小さい方へbias) Δ_N

Δ_N Hasegawa・Yajima

1 GeV ~ 2 GeV

(大きい方へbias)

V) 角分布　　[illegible]　　H quanta

CMS　　log tan θ

Vi) 非弾性度　E_0　E_0'　　$\frac{E_0 - E_0'}{E_0} = K_1$

$\frac{E_0 - E_0''}{E_0} = K_2$

K_1, K_2 の違っているのが 非弾性度

	$K_1 > 0.35$	< 0.35
$K_2 > 0.35$	15±6%	20±7%
< 0.35	20±7%	45±10%

Dobrotin　10^{11} eV

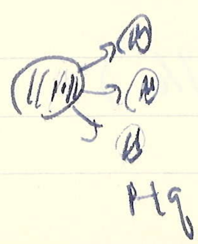
Koshiba　10^{12} eV

Vii) 非弾性度　$\langle K \rangle \sim 0.5$

$0.1 \lesssim K \lesssim 0.9$

viii) $\bar{n}_{ch} \sim E_{0L}^{1/4}$　　$\overline{\delta n_{ch}} \sim \bar{n}_{ch}$

SHQ:

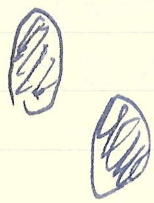


加速器 30GeV p

非弾性 ~20% ~ 30%

↓ 火の玉一種(1個)

bubble chamber (写真の話)



Wu-Yang

$$d\sigma(\vec{p}_1 \cdots \vec{p}_n) \propto \prod_{i=1}^{N} e^{-p_{i\perp}/p_0} \frac{d\vec{p}_i}{\omega_i}\, \delta(E - \sum_i \omega_i)$$

Dake-Takagi-Yokoi

p_T = const. + phase volume

$\langle n_\pi \rangle \sim \log E_0$

$n_\pi \sim \log E_0$

Hagger: 両方共は火の玉

$\phi \sim \sqrt{n}\, e^{i\theta}$　　WKB

Landau

non-linear effect

solitary wave solution

南4: Resonances

素研討論会. Nov. 29, 1966

1) $M(\delta^{\pm}) \simeq 964$ MeV $\qquad p+p \to d + (MM)^{+}$

$M(X^0) = 959$ MeV

2) $K^*(1320)$

$\downarrow$

$K^*(890)+\pi$

$I=1/2 \quad \underline{\underline{1^+}}$ or 2^-

$K^*(1430) \quad 2^+$

L or $K^*(1800)$

$B(1220) \qquad I=1$

$H(1000) \qquad I=0$

$\kappa(725)$ 消えかかってる.

$\varepsilon^0(720)$ 消えかかってる.

Arnold $\qquad$ Exchange Degeneracy

$M^2 \propto J \ (= \mathrm{Re}\,\alpha)$

模型と構造研究会

Nov. 30, Dec. 1, Dec. 2
基研 研究会

第1日 午前
益川敏英: Meson Resonances
Berkeley Conf. ~~までに出た結果にもとづく~~
のための Exp. Data

meson → $8 \oplus 1 = 9$　　$1, 8, 10, \overline{10}, 27 \cdots$

a) $SU_L(3) \times SU_R(3)$
$\sim (3, 3^*) \oplus (3^*, 3)$
$(8, 1) \oplus (1, 8)$

b) $SU_L(3) \otimes SU_R(3) \oplus$ Regge

c) $SU(6) \otimes O(3)$
$SU_6,\ L \neq 0$

$$SU(6) \longrightarrow \text{“}1\text{”} + \overset{L \neq 0}{\text{“}35\text{”}}$$
$$\uparrow$$
$$U_t(6) \otimes U_t(6) \longrightarrow U_t(3) \times U_t(3)$$

chilarity
symmetry breaking (interaction)
spurion
LS　SS　T

午後 近藤(教大): Baryon Resonances

小林(宇大): γ, e による N^*
$\sqrt{\langle r^2 \rangle_N} \leq 1.5\ \mathrm{GeV}^{-1}$

第2日

豊田(九大): cluster model

LS

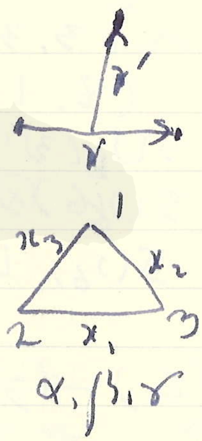
$|\mathrm{baryon}\rangle = C^{(0)}|ttt\rangle + C^{(1)}|ttt\rangle|t\bar{t}\rangle + \cdots$

$|\mathrm{meson}\rangle = C^{(0)}|t\bar{t}\rangle + C^{(1)}_{m}|t\bar{t}\rangle|t\bar{t}\rangle + C^{(1)}_{n}|ttt\rangle|\bar{t}\bar{t}\bar{t}\rangle + \cdots$

山崎(金沢)

$\Psi = \psi_{space}\,\psi_{s}\,\psi_{us}\,\psi'_{us}$

4, 10, 2, 2, 8, 8, 1



$\Psi_{space} = \psi_D\,\psi_R$

deform. rot.

$H = 3M + K + V(x_1) + V(x_2) + V(x_3)$

調和: $A\left(L(L+1) - \frac{1}{2}\mu^2\right)$

$J = L + S$ だけで説明されるか?

[illegible]: non-rel / relat } bound state

$t \sim 10M$

$30M \to M$ $\quad \frac{29}{30} = \frac{\text{binding}}{\text{mass}}$

$H_1^{Dirac} + H_2^{Dirac} + V_{12}(1-2)$

$V_0 \to \infty$, $E \to 0$　$^1S_0$

$V - A$

$\frac{S+P}{2} - T$

negative energy

fix center → どうしてよいか

山内・小出・福田:

i) SU(6) → V

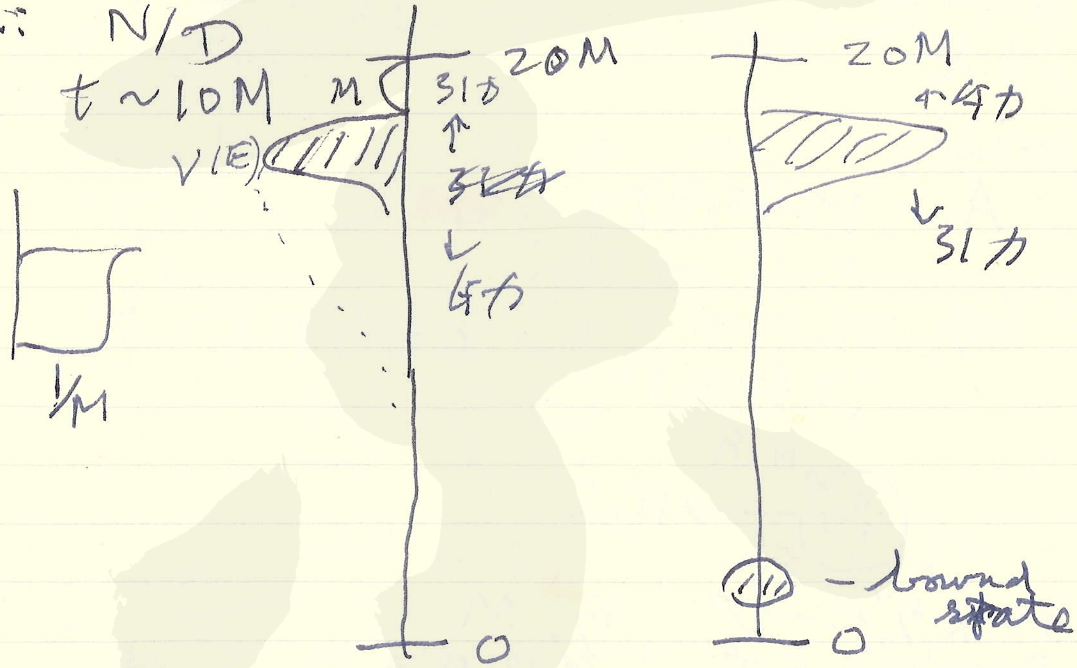
ii) Regge

iii) Current Algebra

iv) Ψ wave function をきめる

木下　N/D

$t \sim 10M$



① long range force では解につながらない

② 引力−斥力 の 逆 ~~符号~~ 強さ

松本:

木村:

田中正: Pole theory?

基本粒子国際会議 I.

モデル　~~方法論~~ | 方法論

物質の階層　無限階層説　　静力学

素粒子 — 基本粒子　　运动学

基本粒子 — 層子　　动力学

⋮

革命弁証法 (毛沢東)

(矛盾論
実践論

現 → 実 → 本
モデル
?

ansatz

A. 运动图像による記述
N.R. → Rel.

B. 七10岁 子の运动方程式 ?
运动图像的

? → N.R
→ Rel.

北京グループ　B.M
南京グループ　[illegible]強[illegible]
山東グループ　SU6による分類.

これ: II.
1964年9月頃から始めた
武谷三男, 1957の序言: 坂田の1930年代.

"予稿"
1960

1966: ~~[illegible]~~ Doctor course 学生の年齢
(Master course から
日本の文献は引用しない?
日本人に対する rival 意識?
古い学会誌号は何どう考えてるか?

第三日
午前
午後: Hadron の Form Factor
小川講演
i) quark (effective) mass M_{eff}

$$|t\rangle = Z_2^{1/2}|t\rangle + p^{1/2}|t\pi\rangle + \cdots$$

$\| K^e_\nu$ $\quad H_{eff} = i g_V \text{"}\bar{p}\text{"}\left(1 + \frac{g_A}{g_V}\gamma_5\right)\text{"}n\text{"}$

$$\frac{G_A}{G_V} = \frac{5}{3}\frac{g_A}{g_V} = 1.18$$

mag. moment $\quad \frac{g_A}{g_V} < 1 \qquad Z_2 \sim 0.69$

$\mu_p(Z_2, m_{eff}) \qquad M_{eff} \simeq \frac{m_p}{1.32}$

ii) $\delta m_{\text{"}m_V\text{"}} = 8.09$ MeV
$\delta m_{\text{"}m\text{"}} = 1.7$ MeV

[illegible]氏:

松原氏: 強い相互作用の普遍性・統一性
universality

~~Hadron I~~ g m

~~Urbaryon II~~

~~Lepton~~

午後
林(広大)

General Discussions

大要：

Strong Int. — Regge / Dis. Rel. / higher resonances — N.R.?

Weak Int. — θ_A θ_V / $\Delta I = 1/2$ rule / $\partial_\mu J_\mu^A \propto \pi$ (S 説) — Iizuka-Ra

E.M. — form factor / μ

試案：

$M_{N^*} = M_N + M_B$

d α

boson mass　　H-quanta

non-local

湯川：中間子論
meson or 素粒

Current Algebra と Sum Rule

Maki-school

河原林研　　　Dec. 6, 1966

A) とりあつかう問題

I) electromagnetic Int.

A_μ $\qquad \partial_\alpha j_\alpha(x) = 0$

II) Weak Int.

$W_\mu^\pm$ $\qquad J_\alpha = j_\alpha^h + j_\alpha^l$

$j_\alpha^l \sim v_\alpha^l + a_\alpha^l$

$j_\alpha^h \sim v_\alpha^h + a_\alpha^h$

$H_W = J_\alpha J_\alpha^+$

i) $\partial_\alpha v_\alpha^h = 0$ $\qquad$ CVC

ii) $\partial_\alpha a_\alpha^h = 0$? $\qquad$ 0 なら $\pi \to \mu + \nu$ が起らなくなる.

PCAC

iii) universality

III) strong Int.

SU(2)

Y

SU(3) 近似的

B) Current

I') $Q(t) \equiv -i \int j_4(\underset{\sim}{x}, t)\, d^3x$

$\dot{Q}(t) = 0. \qquad [Q(t), H] = 0$

II') $\partial_\alpha v_\alpha^i = 0$

$Q^i(t) \equiv -i \int v_4^i(\underset{\sim}{x}, t)\, d^3x$

$[Q^i(t), H] = 0 \qquad i = 1, 2, 3$ (isospin component)

$[Q^i(t), Q^j(t)] = i\, \varepsilon_{ijk} Q^k(t)$

(SU(2) algebra)

Gell-Mann postulate

$[Q^i(t), Q^j(t)] = i\varepsilon_{ijk} Q^k(t)$

$[Q^i(t), Q_5^j(t)] = i\varepsilon_{ijk} Q_5^k(t)$

① $[Q_5^i(t), Q_5^j(t)] = i\varepsilon_{ijk} Q^k(t)$

chiral $SU(2)\times SU(2)$ の[illegible]

$Q^{\pm} = \frac{1}{2}(Q \pm Q_5)$

② PCAC $\partial_\alpha a_\alpha^i = c\pi^i$ $\pi \to \mu\nu \to c$

Model: Gell-Mann-Levy (N.C. '60)

i) gradient coupling model (ps-pv)

ii) σ-model π と scalar σ-meson とを対称的に扱う.

iii) non-linear model

$\sigma \to \pi\pi \cdots$

Adler, Weisberger: 1965

$$\left(-\frac{G_A}{G_V}\right)^{-2} = 1 + \frac{2}{\pi}\left(\frac{M}{g_r}\right)^2 \int \frac{q\, d\nu}{\nu^2}\left(\sigma_{\pi^- p}(\nu) - \sigma_{\pi^+ p}(\nu)\right)$$

$$a_1 - a_3 = \frac{3 g_r^2}{8\pi M^2}\mu\left(-\frac{G_A}{G_V}\right)^2$$

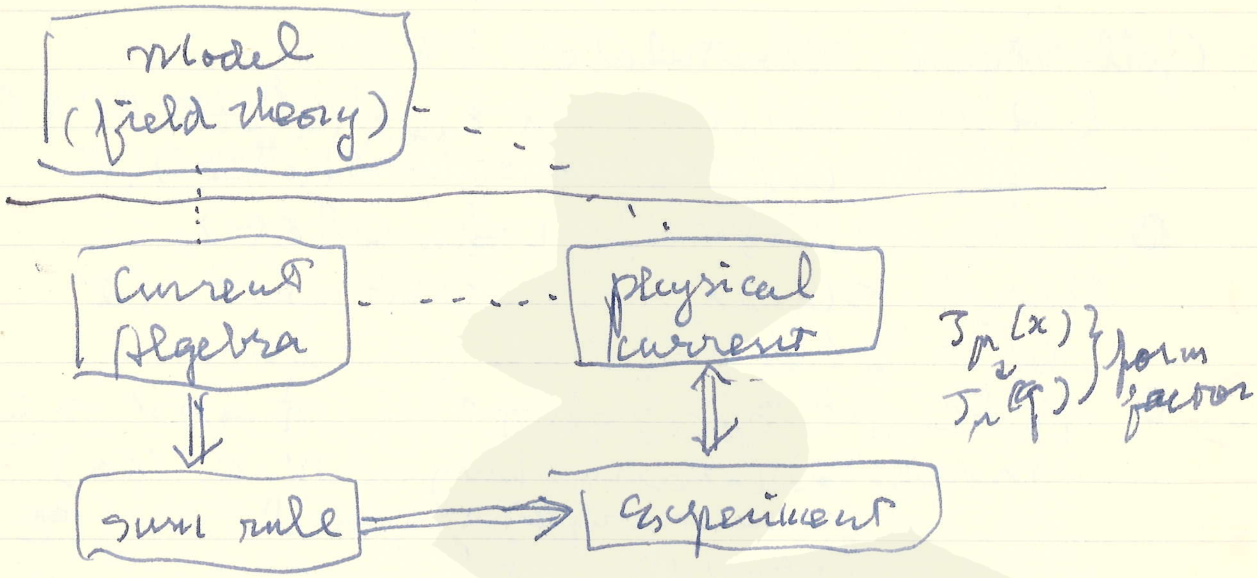
a_1: $T = \frac{1}{2}$ S-wave π-N scattering length

a_3: $T = \frac{3}{2}$

実験とよくあう

($a_1 + 2a_3 \doteqdot 0$ 実験)

perturbationでは ずっと大きすぎる.



D) local commutation relations ?

$$[v_0^i(\underline{x},t),\ v_0^j(\underline{x}',t)] = i\varepsilon_{ijk} v_0^k(\underline{x},t)$$
$$\times\, \delta(x-x')$$

sum rules

i) Cabbibo-Radicati relation

ii) $\left(\dfrac{M_a^V}{2M}\right)^2 = \dfrac{1}{2\pi^2\alpha}\displaystyle\int_0^\infty \dfrac{\sigma_P^V-\sigma_A^V}{\nu}\,d\nu$

Drell-Hearn

E) 近似的な対称性 と C.A.

(a) SU(2) x SU(2) algebra

(b) SU(2) symmetry

SU(3) SU(6) symmetry

$[F^i, F^j] = i f_{ijk} F^k$

SU(3)⇒SU(6) の張系は破綻してる。

Adler PR 140 B736 (1965)

荻田直史：電子計算機は
どう使えるか
学術談話会.　　Dec. 6, 1966

35.}
36　KDC-I　HITAC 102　±500μs
50 wds　core
2.00 wds　drum
4000 wds　mag. drum
36.11：理研へかわる
37.5：

39. 1月〜3月：　OKITAC-5090　H-M システム
月 400万円.
stack job　~~7090~~ 7090
satelite computer

read-write cycle (cycle time)

symbolic language
W/A → 100 / 1000
A/B　200 / 2000
T/C　150 / 3002

~~Assembler~~

Translator	language
Assembler (M) (SAP)	symbolic language
FORTRAN-II (ART-M)	FORTRAN's language
Assembler (H) (MASH-II)	symbolic language
ALGOL-H III	ALGOL '60 language

FORTRAN-II

IBM/360

world IBM 75 { in Japan 3
100

Others 25 { Made in Japan 3
(6社)

日本 software 開発会社.

IBM/360 モデル44　scientific use only

IBM/360モデル40　日電、工場で組立て.
モデル 20 ‥ 65 ‥ 90

Software
Operating system { Control Program
Processing Program

Language Translator
PL/I

素粒子の研究会

Dec. 12~14, 1966
附属 ホ 基研. 18名ぐらい.

	10.30am	2pm		ヨル
12日		湯川	片山 高木	谷川 ハイド 相沢
13日	井上・田中	若林	原・塚原 谷川	大貫・中野
14日	三須 田地	討論		

(12日)
湯川: Introduction
I、今までやってきたこと
i) bilocal → quadrilocal → ?
SU3 うかい
ii) 何を代表してるか
剛体 → 変形体、~~弾~~ → 連続体？
iii) half-integer spin の取扱
特に Dirac ~~f~~ particle の取扱
iv) 内部

II、まだ進んでいない点

i) divergence
causality　macro-causality

ii) anti-particle

iii) 他の approach との関係
Regge , Current Algebra
S-matrix
non-linear
Indefinite metric

iv) 相互作用の多様

v) 相関関係 → 現象解説の一般化

III、新しい試み

i) Tamm — 的空間 — Reciprocal space

ii) elementary domain の概念「*†」

iii) Hellmann

† 天地は万物の逆旅
光陰は百代の過客

* 物質と physical
(有と無　empty seat

†† ~~素~~ 座にすきまがあるか？
時空は何枚の sheet からできてるか
(Hellmann 4枚, 16枚)

片山氏：

空間(連續無限) → [illegible] {空領域 / 格子}

→ 自由度を限定する

exciton の取扱いとして、

A. Bohr の unified model

回転 → spin

$\Psi_0 \to \Psi(D_1 \cdots\cdots D_N)$

$f(x) \gtrless 1$ 外 / 内

$f(x) = c + \sum b_i x_i - \sum a_{ij} x_i x_j = 0$ が境界.

自由度(1) 3 6

重心 $X_i = \int x_i$ ③

力

$I_{ij} = \int (x_i - X_i)(x_j - X_j)$ ⑥

$$\left.\begin{array}{ll} X^i & 3 \\ \xi_1\ \xi_2\ \xi_3 & 3 \\ e_a^i & 3 \end{array}\right\} \psi(D) = \psi(\xi_a, e_a^i, X^i)$$

exciton

$$e_1 = \frac{1}{2\xi^2}\left(q^T \sigma_2 \xi + q^* \sigma_2 q^{*T}\right)$$

$$q_1 = \xi e^{-i\left(\frac{\chi + \psi}{2} - \frac{\pi}{4}\right)}$$

$$q_2 =$$

spinor

$$\xi^2 = \left(\xi_1^2 + \xi_2^2 + \xi_3^2\right)$$

$$a_s = \frac{1}{\sqrt{2}}\left(q_s + i p_s^*\right)$$

domain of (dynamics) / (kinematics)

$$t = \begin{pmatrix} a_1 \\ a_2 \\ b_1^* \\ b_2^* \end{pmatrix} \qquad t^+ =$$

空間
Finsler 空間.
$g_{\mu\nu}(x, \dot{x})$

島野氏: Hellman, N.P. 52 (1964), 609.

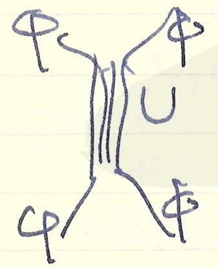
$\beta \doteqdot mcl_0/\hbar$

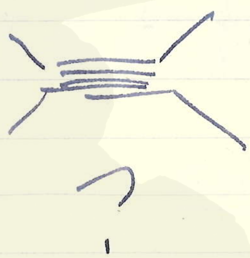
$\boxed{13日}$

四時半, 井上: 非局所場 と Regge Trajectory

spinがきまっている, spinが変わっていく

$$\left.\begin{aligned} r_\mu \frac{\partial}{\partial x_\mu} U(x, r) &= 0 \\ (r_\mu^2 - \lambda^2)\, U(x, r) &= 0 \end{aligned}\right\} \quad U(x, r) = 0 \text{ for } r^2 \neq \lambda^2$$





Fierz:

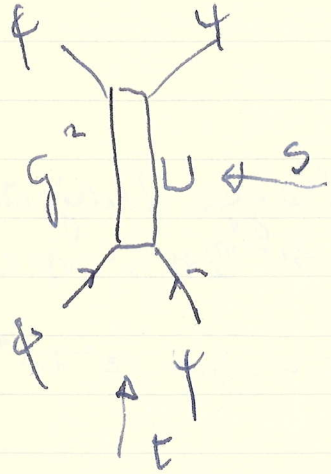
$$U(x; r) = \frac{1}{2\pi} \sum_{l=0}^{\infty} \int d\alpha\, A^{(l)}_{\mu_1 \cdots \mu_l}(x + \alpha r)\, \delta(r_\mu^2 - \lambda^2) \times P_{\mu_1 \cdots \mu_l}(r)$$

$$\mathcal{L}'(x) = g \int d^4 r\, \varphi^*\left(x + \frac{r}{2}\right) U(x, r)\, \varphi\left(x - \frac{r}{2}\right)$$

$$= 2\pi g \sum_{l=0}^{\infty} \int d^4 r \left\{ e^{\frac{i}{2} r_\mu \frac{\partial}{\partial x_\mu}} \varphi^*(x) \right\} \delta\left(r_\mu \frac{\partial}{\partial x_\mu}\right) A^{(l)}(x) \Big\} \times \Big\{ \qquad \varphi(x) \Big\}$$

$$P_{\mu_1 \cdots \mu}(r)\, \delta(r_\mu^2 - \lambda^2)$$

$$S = \frac{1}{2}\int dx\, dx'\, P^*(\mathcal{L}'(x), \mathcal{L}(x'))$$

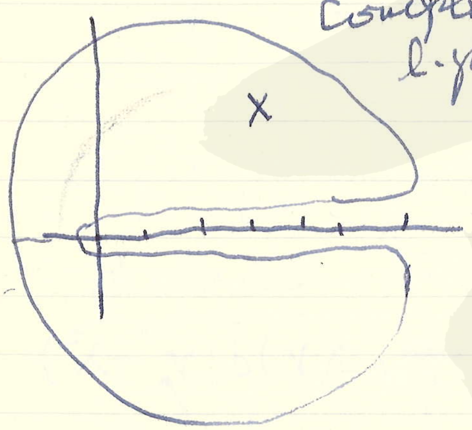


$$f(t, \cos\theta) = g^2 \sum_{l=0}^{\infty} (2l+1)\, \Delta_c^{l}(t)$$

$$\times\, j_l(\lambda\nu)\, P_l(\cos\theta)$$

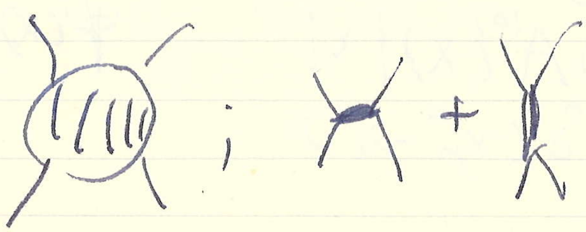
ν: CMS での momentum

$$\frac{1}{t - m_l^2}$$



= Regge pole
+ background contribution

横とび と 縦とび で behavior が
ちがってくる
~~横~~ 縦とびでは high spin の particles
の ~~cov~~ superposition
横とびでは ?



Licht, N.C.

高川氏: Tamm の論文 (Proceedings)

Curved Momentum Space

$$ds^2 = g^{\alpha\beta} dp_\alpha dp_\beta$$

$$\sqrt{|\det g^{\alpha\beta}|} \cdot dp^4$$

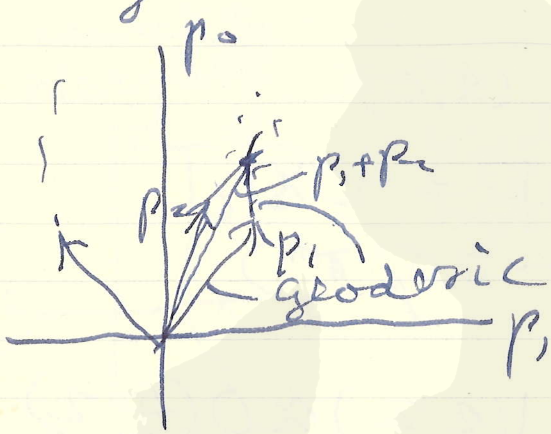
$$x^\alpha = i\hbar \frac{\partial}{\partial p_\alpha} \rightarrow x^\alpha = i\hbar F^{\alpha\beta}(p) \frac{\partial}{\partial p_\beta}$$

$$x^\alpha F(p) = \lim_{\Delta p \to 0} \frac{F(p+\Delta p) - F(p)}{\Delta p_\alpha}$$

~~Schneider~~ ~~[illegible]~~

Snyder

angular divergence



$$g^{\alpha\beta}(p^2)$$

$$p^2 = g^{\alpha\beta} p_\alpha p_\beta = m^2 \text{ (invariant?)}$$

$$g^{\alpha\beta} = \mathring{g}^{\alpha\beta} f(p^2) + p^\alpha p^\beta h(p^2)$$

$(p_1+p_2)+p_3 \neq p_1+(p_2+p_3)$

$$\sqrt{|\det g^{\alpha\beta}|} = \frac{1}{f^{3/2}(1+p^2 k)^{1/2}}$$

高林氏:

$\Psi(X_\mu, \xi_\alpha)$: scalar

ξ_α : two component spinor

response

(Nambu:

Hom. Lorentz group の無限次元の unitary repres.

$\xi' = \lambda \xi$ $\quad SL(2,C)$

$p^{ext} \times L^{int} \supset P = L \otimes T$

$v_\mu = \frac{1}{2}(\xi^* \sigma_\mu \xi - \pi \sigma_\mu \pi^*)$

$\zeta = \begin{pmatrix} \xi_\alpha \\ \pi^*_\alpha \end{pmatrix}$ $\quad U(2,2) \simeq O(4,2)$
$\supset O(3,2)$

$(v_\mu p_\mu + m)\Psi = 0$

$m = m_0 + c S_{\mu\nu}^2$

mass spectrum $x = \frac{m}{\nu_0} = m_1, \frac{2}{3} m_1, \frac{1}{2} m_1,$

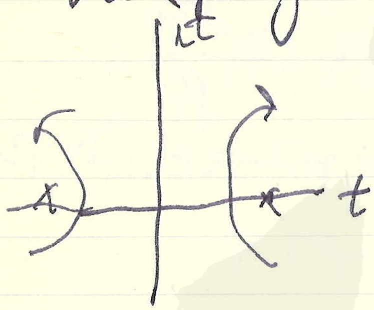
$\ldots$

particle-antiparticle conjugation
$a \rightleftarrows b$

Majorana $a = b$

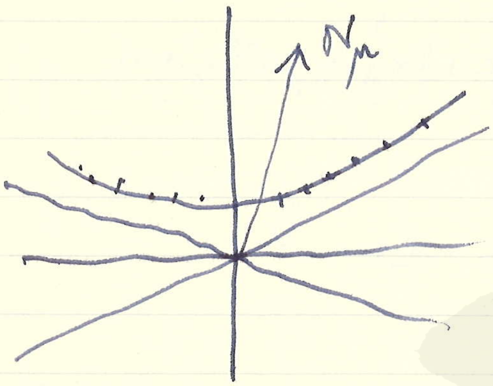
保君: 固有値論
relativistic

第3日
江沢君: P.T.P. 30, 236
4次元 量子e
proper time formulation
Synge
cosmic time
causality
Herglotz 1904



Wiechert
light cone 以外.

田地君: Possible Cosmological Consequences of the Theory of Elementary Particles with Finite Degrees of Freedom
運動的空間



$p_0 = \sqrt{p^2 + m^2}$

$p,\ p + dp$

$dn(p) = Q \frac{d_3 p}{p_0} I(p, Np)$

$e^{-\lambda^2 (Np)^2}$

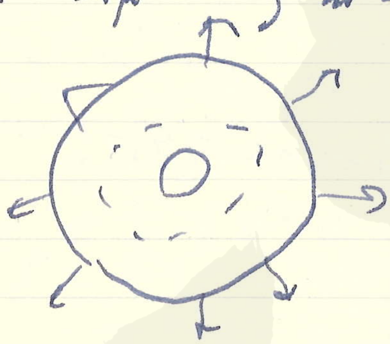
非典的な記述
時空のゆらぎ

宇宙のmodel

Milne の model に近い、一種の膨張宇宙

1. 宇宙のはじめ maximum temperature, excitation

2. N_μ が宇宙の全体系



$dn(p) = Q \frac{d^3 p}{p_0}$

$\times e^{-\lambda(N,p) - k(\Theta_0)[N \cdot p)}$

3. Red shift

McCrea, Ap. J (1466), 516
quasi-stellar object
1. Milne model
2.
3. 相対論的 model

湯川に 質問

Dirac 方程式は difference eq. の形にかけるか？

$$\gamma^{(i)} \quad (e^{(i)}_\nu \gamma_\nu)\{\psi[x_\mu + e^{(i)}_\mu l_0] - \psi(x_\mu)\}$$

$$+ m\,\psi(x_\mu) = 0$$

$$x'_\mu = a_{\mu\nu} x_\nu \quad \rightarrow \quad \psi' = \Lambda\psi$$

$$\underline{\Lambda\gamma^{(i)}\Lambda^{-1}}\{\psi'(x'_\mu + e'^{(i)}_\mu l_0) - \psi'(x'_\mu)\}$$

$$+ \frac{imc}{\hbar}\psi'(x'_\mu) = 0$$

$$\Lambda\gamma^{(i)}\Lambda^{-1} = a^{ij}\gamma^{(i)}$$

$$\Lambda\psi(x'_\mu + e'^{(i)}_\mu l_0) \neq$$

$$\gamma_\mu \frac{\partial\psi}{\partial x_\mu} + m\psi$$

$$\Lambda\gamma_\mu\Lambda^{-1}\Lambda\frac{\partial\psi}{\partial x_\mu} + m\Lambda\psi$$

$$\psi(x_\mu + e^{(i)}_\mu l_0) \neq$$

$$(e^{(i)}_\nu \gamma_\nu)\left\{\psi_\beta\left(X_\mu + l_0\frac{e^{(i)}_\mu}{2}\right) - \psi\left(X_\mu - l_0\frac{e^{(i)}_\mu}{2}\right)\right\}$$

$$+ \frac{mc}{\hbar} l_0\,\psi_\alpha(X_\mu) = 0$$

Maki school　　Dec. 20

湯川

$$\psi\left(x+\frac{l_0}{2}\right)-\psi\left(x-\frac{l_0}{2}\right)=\beta\psi(x)$$

$$\psi\left(x+\frac{l_0}{2}\right)+\psi\left(x-\frac{l_0}{2}\right)=\alpha\psi(x)$$

$$\psi(x)=\sum_n a_n \exp(n\pi i/l_0)$$

n: even

n: odd

Dirac　　Fermion

K. G.　　boson

1階 方程式

2階 方程式

space and/or time reversal
invariance or non-invariance

河原林：Algebra of Currents　　Dec. 20
& Low Frequency Limit Theorems
（談話会）

鈴木　　和田

Schwinger term　S

Cabibbo - Radicati

Drell - Hearn

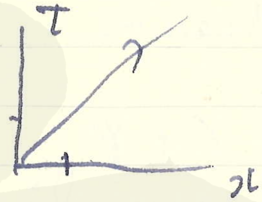
$\gamma + p \to \gamma + p$
Thomson limit $+ S$ $(-S)$

差分方程式　高島氏,
maki School　　　　Jan. 10, 1967

差分方程式　　　　微分方程式

楕円型

双曲型



放物型

linear 定係数
non-linear

常微分方程式

$$\frac{df}{dx} = i\beta f \qquad \frac{df'}{dx} = \gamma f'$$

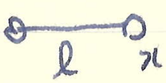
i) 前進差分

[illegible]の差

$$g_+(x+l) - g_+(x) = i\beta l\, g_+(x)$$

$$D_+ g_+ = i\beta l\, g_+$$

ii) 後退差分



$$g_-(x) - g_-(x-l) = i\beta l\, g_-(x)$$

$$D_- g_- = i\beta l\, g_-$$

iii) [illegible]

$$g(x+\tfrac{l}{2}) - g(x-\tfrac{l}{2}) = i\beta l\, g(x)$$

$$Dg = i\beta l g$$

(Euler)

$$D_- g_+^*(-x) = i\beta l\, g_+^*(-x)$$

$$D_+ g_-^*(-x) = i\beta l\, g_-^*(-x)$$

$$g_+(x+l) = (1+i\beta l)\, g_+(x)$$

$$g_+(nl) = (1+i\beta l)^n f(0)$$

$$f(nl) = e^{i\beta n l} f(0)$$

$$g_-(nl) = (1-i\beta l)^{-n} f(0)$$

$$g(nl) = \tau^n$$

$$\tau - i\beta l \tau^{\frac{1}{2}} - 1 = 0$$

$$\tau = \tfrac{1}{2} i\beta l \pm \sqrt{1-(\tfrac{1}{2}\beta l)^2}$$

$\frac{1}{2}\beta l \leq 1$: $\quad \tau = e^{\pm 2i\theta}$ $\quad \sin\theta = \frac{1}{2}\beta l$

$\frac{1}{2}\beta l > 1$: $\quad \tau = -e^{\pm 2\xi}$ $\quad \cosh\xi = \frac{1}{2}\beta l$

$$|g_+(nl)| = (1+\beta^2 l^2)^{\frac{n}{2}}\, |f(0)|$$

iii') $g'(x+l) - g'(x) = i\frac{\beta l}{2}\left(g'(x+l) + g'(x)\right)$

$$\cancel{g(x+\tfrac{l}{2}) - g(x-\tfrac{l}{2}) =}$$

$$g'(x+l) = \left(\frac{1+\frac{i}{2}\beta l}{1-\frac{i}{2}\beta l}\right) g'(x)$$

$$g'(nl) = \left(\frac{1+\frac{i}{2}\beta l}{1-\frac{i}{2}\beta l}\right)^n f(0)$$

$$g'(nl) = e^{in\varphi} f(0)$$

$$\tan\varphi = \frac{\beta l}{1-\frac{1}{4}\beta^2 l^2}$$

Accuracy

$$|f(x+l) - g(x+l)|^2 = O(l^{m+1})$$

i), ii) : $m = 1$

iii), iii)' : $m = 2$

Convergence condition

$$|f(nl) - g(nl)| \xrightarrow[\substack{n\to 0 \\ nl = L}]{} 0$$

periodic boundary

$X = L$ $\quad$ $g = f(0)$

i) $n = L/l \geq m$ $\quad$ $(1+i\beta l)^{L/l} = \cancel{k}\, e^{2\pi m i}$

iii) $\frac{1}{2}\beta l \leq 1$ $\quad$ $2\frac{L}{l}\theta = 2m\pi$

iii)' $\quad$ $\frac{L}{l}\varphi = 2m\pi$

i) $\beta = \beta_R + i\beta_I$ $\quad$ $\begin{cases} \beta_I l = 1 - \cos\left(\frac{2\pi l m}{L}\right) \\ \beta_R l = \sin\left(\frac{2\pi l m}{L}\right) \end{cases}$

iii) $\beta l = 2\sin\left(\frac{\pi l m}{L}\right)$

iii)' $\beta l = 2\tan\left(\frac{\pi l}{L} m\right)$

~~偏微分方程式~~

$\cancel{\frac{\partial f}{\partial t}}$ ~~Kler~~

$$\frac{d^2 f}{dx^2} = -\beta^2 f$$

$$g(x+l) + g(x-l) = 2\left(1 - \frac{\beta^2 l^2}{2}\right) g(x)$$

$$g(nl) = \tau^n$$

$$\tau = \left(1 - \frac{\beta^2 l^2}{2}\right) \pm \sqrt{\left(1 - \frac{\beta^2 l^2}{2}\right)^2 - 1}$$

$$= \begin{cases} e^{\pm i\theta} & \beta^2 l^2 < 4 \quad \cos\theta = 1 - \frac{\beta^2 l^2}{2} \\ -e^{\pm \xi} & \beta^2 l^2 > 4 \quad \cosh\xi = \frac{\beta^2 l^2}{2} - 1 \end{cases}$$

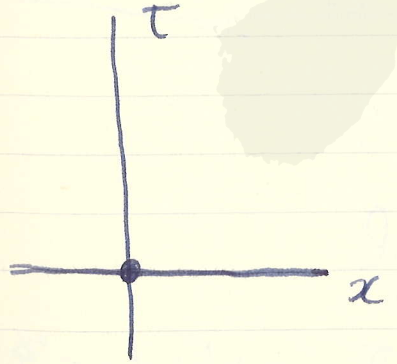
eigenvalue

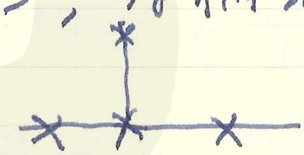
$$\beta l = 2 \sin\left(\frac{\pi l}{L} m\right)$$

偏微分方程式　　$t=0 \quad f(x,t) = f(x,0)$

$$\frac{\partial f}{\partial t} + a \frac{\partial f}{\partial x} = i\beta a f$$

i) 前進差分 (t), 対称差分 (x)

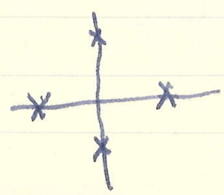




~~Friedrichs~~

$$g_+(t+\tau, x) - g_+(t, x) + a\frac{\tau}{l}\left\{g_+\left(t, x+\frac{l}{2}\right) - g_+\left(t, x-\frac{l}{2}\right) - i\beta l\, g_+(t, x)\right\} = 0$$

ii) 対称差分 (x, t)



Accuracy

$$\| f(x+\tau) - g(t+\tau) \| = O(\tau^{m+1})$$

Convergence

$$\| f(n\tau) - g(n\tau) \| \underset{\substack{n\tau = T \\ n \to 0}}{\longrightarrow} 0$$

$$\| g(n\tau) \| \leq C \, \| f(0) \|$$

$$g(x,t) = \sum_m e^{2\pi i m x / h} \tilde{g}_m(t)$$

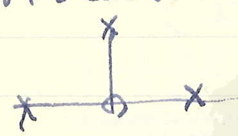
$$\tilde{g}_{+,n}(t+\tau) = \left[1 - 2ia\frac{\tau}{\ell}\left(\sin \frac{\pi n \ell}{h} - \frac{\beta \ell}{2}\right)\right] \tilde{g}_{+,n}(t)$$

$$\tilde{g}_{+,n}(j\tau) = A_+^{\,j} \hat{f}(0)$$

$$\tilde{g}_n(j\tau) = A_n e^{2ij\theta_n} + B_n e^{-2ij\theta_n}$$

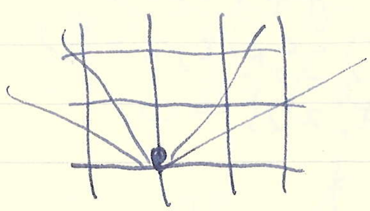
$$\sin \theta_n = a\frac{\tau}{\ell}\left(-\sin\frac{\pi n}{h}\ell + \frac{\beta \ell}{2}\right)$$

Friedrichs (Viscosity method)



$$\frac{\partial f}{\partial t} \to \frac{f(t+\tau, x) - [f(t, x+\ell) + f(t, x - \ldots}{\tau}$$

$$\frac{\partial f}{\partial x} \to \text{対称差分}$$



$$\tau < \frac{1}{|v_{max}|}\ell$$

Courant-Friedrichs の条件

$$\frac{\partial U}{\partial t} + A\frac{\partial U}{\partial x} = B(U)$$

$$\det|A - \lambda| = 0$$

<u>real</u>

λの大きなもの → v.

<u>とりに</u>

[illegible]
有馬朗人　談話会　Jan. 17 1967

liquid の vibration

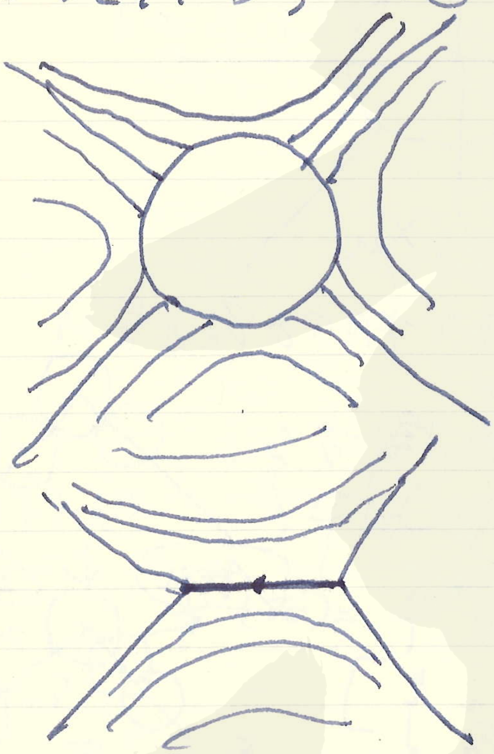
$\sigma_{\lambda} = 1500 \cdot \pi \cdot R^2$

resonance

Lord Kelvin : Transaction Royal Society

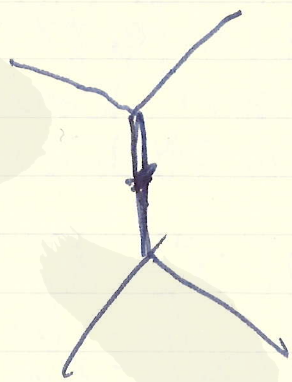
素領域と素粒子
Jan. 17, 1967
基研談話会

Jan. 18, 1967



$x^2 - c^2t^2$

$x^2 + c^2t^2$



$(x - \frac{l_0}{2})^2 - c^2t^2$

$(x + \frac{l_2}{2})^2 - c^2t^2$

1) $x' = \varepsilon(x^2+x_0^2)\{\cancel{\cos\theta}\cdot x + \sin\theta\cdot x_0\}$

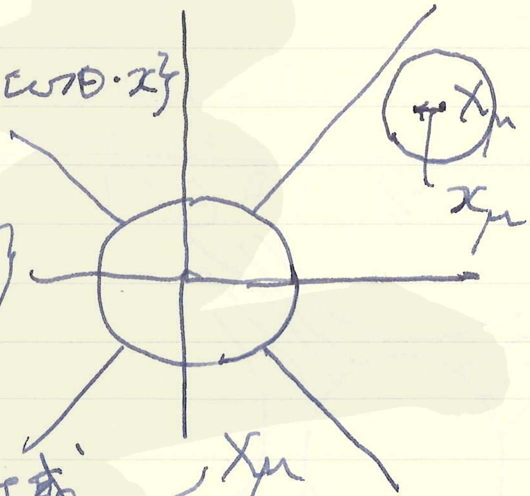
$+\eta(x^2+x_0^2)\left\{\frac{x}{\sqrt{1-\beta^2}} - \frac{\beta}{\sqrt{1-\beta^2}}x_0\right\}$

$y' = \varepsilon(x^2+x_0^2)$

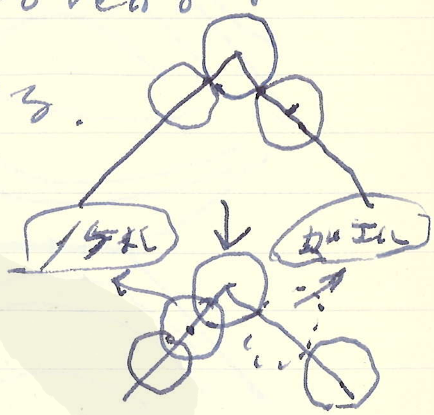
$\times\{-\sin\theta\, x_0 + \cos\theta\cdot x\}$

$+\eta(x^2+x_0^2)$

$\times\left\{\frac{x}{\sqrt{1-\beta^2}} - \frac{\beta}{\sqrt{1-\beta^2}}x_0\right\}$



4次元 球領域
の中の点は，中心に対する相対的座標は
Euclid 変換をする
X_μ は外は Lorentz 変換する．
両者は独立．



2) $\eta(x^{(1)}_\mu - x^{(2)}_\mu) \propto$

$\frac{v}{c}\exp\left\{-\sum_\mu (x^{(1)}_\mu - x^{(2)}_\mu)^2 / l_0^2\right\}\Big]$

$\{1-$

中野董夫氏
Maki school　　　Jan. 23, 1967

問題提起

$\varphi(x)$　量子化された波動函数

$\langle \varphi(x_1) \cdots \varphi(x_n) \rangle$。

Lorentz invariance

positive energy state (が存

$t \to x_4 = ict$

$P_0 > |\vec{P}|$

期待値　$\int \varphi \, \varphi(x)\, dV_3$

$\varphi^\dagger(x) = \varphi^*(\vec{x}, -x_4)$

$\xi'_\mu = \xi_\mu + \omega_{\mu\nu}\xi_\nu + \varepsilon_\mu \leftrightarrow x' = \cdots x$

$x' = x \quad \longleftrightarrow \quad \gamma_\mu$

$$\varphi' = \left(1 + \frac{i\omega_{\mu\nu}}{2} S_{\mu\nu} + i\varepsilon_\mu \frac{\partial}{\partial x_\mu}\right)\varphi$$

$$\xi_\mu = \int \varphi^\dagger(x)\, x_\mu\, \varphi(x)\, d^4x$$

The Irreducible Volume Character of Events

I. A Theory of Elementary Particles and Fundamental Length

B. T. Darling P. R. <u>80</u>, 460(1950)

Theory of Finite Displacement Operators and Finite Length

B. T. Darling and P. R. Zilsel, P. R. 91, 1252 (1953)

material process → irreducible volume

complex - 4 - ~~volume~~ dimensional space

finite displacement　中央階差

1. (creation, annihilation
   (continued existence

個別の material process の ~~[illegible]~~ mode

2. 有限の volume で process がおこる space vs continuum

self-adjointness:

$$(\gamma_\lambda \Delta_\lambda \nabla_\lambda + \varkappa \nabla)\psi = 0$$

$$\Delta_\lambda \psi = \{\psi(x_\lambda + \Delta x_\lambda) - \psi(x_\lambda - \Delta x_\lambda)\}/2\Delta x_\lambda$$

$${}_\lambda\nabla \psi = [\psi(x_\lambda + \Delta x_\lambda) + \psi(x_\lambda - \Delta x_\lambda)]/2$$

$$\nabla\psi = \prod_\lambda^4 \nabla = {}_1\nabla\,{}_2\nabla\,{}_3\nabla\,{}_4\nabla$$

$$\nabla_\lambda = \nabla / {}_\lambda\nabla$$

$$\omega x_\sigma = \gamma_{\lambda\sigma} \Delta x'_\lambda$$

$\downarrow$

rotation group G

$$\gamma'_\lambda = \gamma_{\lambda\sigma}\gamma_\sigma$$

$$\Delta x'_1 = (\omega_1, 0, 0, 0)$$

$$\Delta x'_2 = (0, \omega_2, 0, 0)$$

$$\omega_1 = \omega_2 = \omega_3 = \omega_4 = \omega$$

$$\left(e^{\omega\gamma_{\lambda\sigma}\frac{\partial}{\partial x_\sigma}} - e^{-\omega\gamma_{\lambda\sigma}\frac{\partial}{\partial x_\sigma}}\right)/2\omega\,\psi$$

$$\frac{\int (\gamma'_\lambda \Delta'_\lambda \nabla'_\lambda \psi + \kappa D'\psi)\, dG'}{\int dG'} = 0$$

$\Downarrow$

$$\left\{\frac{8J_2(z)}{z^2}\sum_\sigma \gamma_\sigma \frac{\partial}{\partial x_\sigma} + \kappa\frac{2J_1(z)}{z}\right\}\psi = 0$$

$$\frac{\partial}{\partial x_\sigma} = u_\sigma \qquad u^2 = \sum u_\rho^2$$

$$z = 2\omega i u$$

$$\Omega_\lambda = \cancel{\lambda}\, i\,\omega\,\gamma_{\lambda\rho}u_\rho$$

$$g(u) = \frac{1}{16}\prod\left(e^{\Omega_\rho} + e^{-\Omega_\rho}\right)$$

$$\frac{\int g(u)\,dG}{\int dG} \equiv f(u) \qquad \left\{-\frac{1}{\omega^2}\sum \gamma_\sigma \frac{\partial f}{\partial u_\sigma} + \kappa f(u)\right\} \times \psi = 0$$

λの決定:

$$\sum (\Delta x_\sigma)^2 + 4\omega^2 = 0$$

rel. invariant

$$\left[\frac{d^2}{du^2} - \omega^2\right] D(u) = 0$$

$$D(u) = \begin{cases} \cosh \omega u \\ \frac{1}{\omega} \sinh \omega u \end{cases} \qquad u = \frac{d}{dx}$$

$$\left[\sum \frac{\partial^2}{\partial u_\sigma^2} + 4\omega^2\right] D(u) = 0$$

$$f''(u) + \frac{3}{u} f' + 4\omega^2 f = 0$$

$$\left.\begin{array}{l} f = \dfrac{J_1(z)}{z} \\ z = 2\omega u \end{array}\right\} \qquad J_1'' + \frac{1}{z} J_1' + \left(1 - \frac{1}{z^2}\right) J_1 = 0$$

$$-\frac{1}{\omega^2} \frac{\partial f}{\partial u_\sigma} = \frac{8 J_2(z)}{z^2} u_\sigma$$

先輩 Q

Feb. 15 1967

Solution and Quantization of A Nonlinear Two-Dimensional Model for A Born-Infeld Type Field

B. M. Barbashov ; N. Chernikov
(Dubna)

JETP 1965.

~~23, 861~~

50, 1296

$$\frac{\partial U}{\partial t} + A\frac{\partial U}{\partial x} = 0$$

$$U = \begin{pmatrix} u_1 \\ \vdots \\ u_n \end{pmatrix} \qquad A(u_1, u_2, \cdots u_n)$$

real ~~root~~ eigenvalue

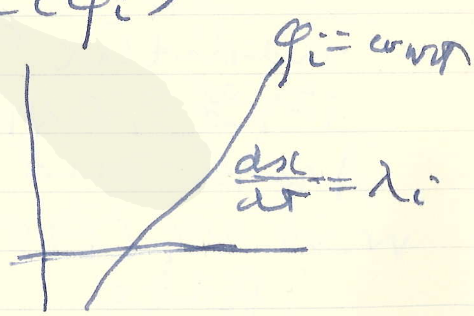
$$\begin{pmatrix} a_{11} & \cdots & \\ & \ddots & \\ & & a_{nn} \end{pmatrix}$$

distinct
↓
hyperbolic

$$l^{(i)} A = \lambda_i l^{(i)}$$

$$l^{(i)}\left(\frac{\partial U}{\partial t} + \lambda_i \frac{\partial U}{\partial x}\right)_i = 0$$

$$\int l^{(i)} dU = \text{const} = C(\varphi_i)$$

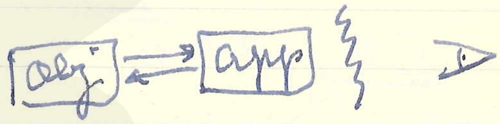


supplement : 分散

観測問題[illegible]氏
観測の理論（続）
基研談話会　Feb. 15, 1967

von Neumann

N. Bohr



E. P. Wigner : ⊗ を物理的 entity と考える.

hidden realism　素朴実在論

E. P. Wigner, Z. Phys. 133 (1952), 101.

$$U(X_\nu \otimes \xi) = X_\nu \otimes \xi^\nu + \eta$$

$$U(X_\mu \otimes \xi) = X_\mu \otimes \xi^\mu + \eta'$$

余計な state が 混合

·additive な保存量と非可換な量の測定, app を大きくすれば η は小さくできる.
Araki and Yanase
W. W. W. (1952)　superselection Rule (eigenstate の relative phase がきめられない)
~~絶対保存量の~~
skew Information
Wigner, M. M. Yanase, Proc. Nat. Acad. Sci. 49 (1963), 910

D. Bohm：量子力学の枠を越えて
hidden parameter を考える (R.M.P.)

L. Rosenfeld, suppl. extra Nr.
superposition principle を否認して
いる…

量子力学の中では観測理論は構成できない。

事実と法則

Ludwig,

Wigner, Scientists Speculates
(Good, editor 1962)
mind-Body Problem
mixture と pure state を同じ
level の問題とする。
consciousness ?
仮説 (Bohm)

大貫氏：束縛状態の統一理論

基研シンポジウム　Feb. 20, 1967

前の理論 1958

西島・Zimmermann

Asymptotic な場　in　out

$$B^{in}_{ab}(X,\xi) = T(\varphi_a(X-\tfrac{\xi}{2})\varphi_b(X+\tfrac{\xi}{2}))$$

$$+\int dX'\Delta_R(X-X')(\Box_{X'}-m_B^2)T(\varphi_a(X'-\tfrac{\xi}{2})\varphi_b(X'+\tfrac{\xi}{2}))$$

Redmond & Uretsky, ~~P.R.~~ Annals of Phys. 9('60)

non-relat.

$$\int f(\vec{\xi})\varphi_a(\vec{X}-\tfrac{\vec{\xi}}{2},t)\varphi_b(\vec{X}+\tfrac{\vec{\xi}}{2},t)d\vec{\xi}$$

Para-particle

O.W. Greenberg 1964 quark order 3

totally symmetric

→ fermion

order 3

order 3

2個の論文 (parafermion, boson)

para-particle

non-para → non-linear Hamiltonian (deri. free)

S-para fermi

$$\frac{1}{2}[[\varphi(x),\varphi^\dagger(y)]\varphi(z)] = \delta^3(y-z)\varphi(x)$$

$$\frac{1}{2}[[\varphi(x,\varphi(y)],\varphi(z)] = 0$$

$$\frac{1}{2}[[\varphi^\dagger(x),\varphi^\dagger(y)],\varphi(z)] = \delta^3(y-z)\varphi^\dagger(x) - \delta^3(x-z)\varphi^\dagger(y)$$

Jordan Ring

Para particle の場合には

(i) free Hamiltonian からの 2次形式

super-para はこうでない.

$$i\frac{\partial\varphi}{\partial t} = [\varphi, H] = \partial_i^2 \varphi$$

↓

non-linear (bi)

Ohnuki, Supp. 1966 湯川記念号.