NOTE BOOK

Manufactured with best ruled foolscap
Brings easier & cleaner writing

March 1965 ~
[illegible]研究会 ~

小[illegible]研究会 June, 1965

VOL. XX

H. Yukawa

Nissho Note

日費S △50

N90'

INDEX

I. 非局所場理論研究会

豊橋
March 18, 1965

18 VI 午前
湯川： 力の問題
constructive force 構成力
interactive force 相互力

18日午後：
宮沢：素粒子の local field
micro　電磁系

spin space		charge space
$SO(3) = SU(2)$		$SO(3) = SU(2)$
$\downarrow$		$\downarrow$
$SU(3)$		$SU(3)$
S	$\longleftrightarrow$	I
N_π	$\longleftrightarrow$	Y
$\begin{pmatrix}\uparrow\\ \downarrow\end{pmatrix}$		$\begin{pmatrix}p\\ n\end{pmatrix}$
0　S	I	Λ
0	0	η
1/2	1/2	K
1/2	−1/2	$\bar{K}$
1	1	π

Lorentz invariant

3　$O^*(4)$　　　$SU(3)$　8
　　$\downarrow$　　　　　$\downarrow$
6　$SL(2,C)$　　$SL(3,C)$　16

$L_{\mu\nu}$
P_λ　　　P_λ　$\lambda = 1, 2, \ldots 9$
$SL(2) \times T_4$　　K. G. eq.
inhomog. Lor. Group　　$\lambda = 1 \ldots 18$
$SL(3) \times T_{18}$
9 : spacelike
9 : timelike

$\binom{\psi}{\varphi} = \Psi_\alpha \quad \alpha = 1 \sim 6$　　　$q^2 - \kappa^2 = i\omega$

$$\left.\begin{aligned} -i(q-\kappa)\lambda\varphi &= m\psi \\ -i(q+\kappa)\lambda\psi &= m\varphi \end{aligned}\right\}$$

$(i\Gamma_\mu \gamma_\mu + m)\Psi = 0$

Ψ_α^β macelons　　35 次元

Lorentz 群 では　spin $\begin{pmatrix} 0^- \\ 1^- \\ 1/2 \\ \overline{1/2} \end{pmatrix}$

spin と statistics?
　近似的には max. が degenerate しうるか?

1. weak int.　$m \doteqdot m_0$
2. low density
3. spin-spin interaction >> (SL) coupling
4. Feynman graph で一寸おかしい
　$(\bar{\Psi}\Psi)^2$

5. $\Psi_\beta^\alpha = \bar{\Psi}^\alpha \Psi_\beta$　　Ψ: paraparticle
6. N.L. で(Q)Kind Quantization?

1964 Lipkin barbaryon

$SU(9)$

$\downarrow$

$SL(9) \times T_{162}$

323次元表現.

$$\begin{bmatrix} (1, 8) & 8 \\ (35, 1) & 35 \\ (35, 8) & 280 \end{bmatrix}$$

$SL(3) \times SU(3)$

35 ; (X, ω, Y_0^*)

280 ; (P_8, V_8, B_8)

$T_3^3(SU(3)_s)$, $T_3^3(SU(3)_c)$

$$M_\Xi - M_\Sigma = M_{K^*} - M_\rho$$

$$1318 - 1190 = 891 - 763$$

$$128 = 128$$

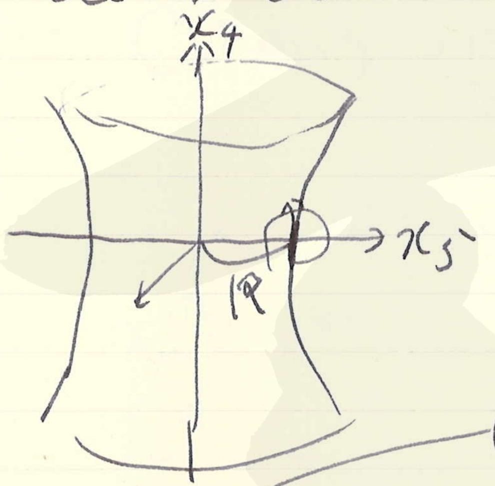
中理研 → 素研 1963.

結論：従って 4次元

spin model　　U-G
SU_2　　Pauli
$SU_2 \oplus SU_2$　　Dirac

isospin model　Heisenberg
SU_3　　G. N.

de Sitter 空間 (4次元)



$x_\alpha x_\alpha = R^2$
$\alpha = 1, \dots 5$

$$\left.\begin{aligned} \dot{p}_\alpha &= x_\alpha \\ \dot{x}_\alpha &= -p_\alpha \end{aligned}\right\}$$

$$\left(\begin{aligned} x_\alpha x_\alpha &= R^2 \\ p_\alpha p_\alpha &= -M^2 \\ x_\alpha p_\alpha &= 0 \end{aligned}\right\}$$

<u>reciprocity</u>

$p_\alpha p_\alpha + x_\alpha x_\alpha = \text{const.}$
$x_\alpha p_\alpha = 0$

$$\left.\begin{aligned} a_\alpha &= p_\alpha - i x_\alpha \\ a_\alpha^* &= p_\alpha + i x_\alpha \end{aligned}\right\} \quad a_\alpha^* a_\alpha = \text{inv.}$$

$U(5)$　　$SU(5)$
$25 \to 24$
λaux 牛

Barut,

田地i Blockintsev, P.L. 1964,
inhomogeneity of space-time
universal vector N
scattering ampl. $A(p, aN)$

$$p' = Lp, \quad N' = LN$$

$\longrightarrow x \longleftarrow$ N

$\longrightarrow x$ N

a (i) $10^{-13} \sim 10^{-14}$ cm
(ii) 10^{-20} cm
(iii) 10^{-33} cm

Tati, P.T.P. 29

x: lattice space

(Remark
universal (constant) tensor

5月19日 第2回 会議
高林：模型の内容
oscillator model
exciton　quantum of internal motion

$$x_\mu^\xi = C^{\xi\alpha} y_\mu^\alpha \qquad p_\mu^\xi = C^{\xi\alpha} q_\mu^\alpha$$

$$X_\mu = \frac{1}{2} x_\mu^0$$

$$C^{0\alpha} = \frac{1}{2}, \qquad \left.\begin{array}{l} C^{r\alpha} C^{s\alpha} = \delta_{rs} \\ \sum_\alpha C^{r\alpha} = 0 \end{array}\right\} r = 1, 2, 3$$

$$P_\mu = 4 p_\mu^0$$

$$x_\mu'^r = R^{rs} x_\mu^s \qquad R R^T = 1$$

$$L^r = \varepsilon_{rst}\, x_\mu^s p_\mu^t$$

figure space
R: bodily 回転 → O_3
O_3: rotation, transposition を含む
(S_4 が subgroup として含まれる)
constructive force of potential
~~Do~~ $V_{\mu\nu} = \sum_{\alpha,\beta} (y_\mu^\alpha - y_\mu^\beta)(y_\nu^\alpha - y_\nu^\beta)$

Relativistic Hooke potential
$V_{\mu\mu}$

4点は4つの event

$$A_s^r = a^{\dagger s}_\mu a^r_\mu + \delta_{rs}$$

self-reciprocal は要求せず が observable.

internal reciprocity

$$x^r \to l_0^2 p^r$$

$$p^r \to -x^r/l_0^2$$

3点の equivalence　$U(3)$
2点だけの equivalence　$U(2)$

subsidiary condition

$$P_\mu a^{r\dagger}_\mu \psi = 0$$

$$P_\mu (x^r_\mu - i l_0^2 p^r_\mu)\psi = 0$$

3つの条件

($l_0 = 0$: $x^r_0 \psi = 0$ (全の点系で)
$y^\alpha_0 = X_0$)

$$K_{\mu\nu} = a^{r\dagger}_\mu a^r_\nu$$

$$K_{[\mu\nu]} = x^r_{[\mu} p^r_{\nu]} = u^\alpha_{[\mu} q^\alpha_{\nu]} - X_{[\mu} P_{\nu]}$$

$$[A^r_s, K_{\mu\nu}] = 0$$

spin

$$W_\mu = \tilde{K}_{[\mu\nu]} P_\nu / P \qquad P = -P_\mu^2$$

$$W_\mu^2 : \; w(w+1) \qquad w = 0, 1, 2, \cdots$$

$$W_\mu^r, \; W_{-3} \qquad \Theta = W^{r*} W^r$$

$$W^r = a_\mu^r W_\mu$$

oscillation & rotation of
couple ($l_2 \neq 0$)

$$O_{\mu\nu} = \delta_{\mu\nu} + P_\mu P_\nu / P$$

$$K'_{\mu\nu} = O_{\mu\rho} O_{\nu\sigma} K_{\rho\sigma}$$

is subsidiary conditions compatible

$$U(3)' : \; K_{\mu\nu}$$

$$U(3) \times U(3)' \subset U(9)$$

$$\left(i\gamma_\mu \frac{\sum_\alpha q_\mu^\alpha}{P_\mu} + M\right)\psi(y^1, y^2, y^3, y^4) = 0$$

$$O_{\mu\nu} a_\nu^r \psi_0 = 0 \quad \text{(ground state)}$$

or $(x_\mu^r + i l_0^2 R_{\mu\nu} p_\nu^r)\psi_0 = 0$

$$R_{\mu\nu} = \delta_{\mu\nu} + 2 P_\mu P_\nu / P$$

$$\psi_0 = \frac{1}{(\pi l_0)^3}\, u(P'_\mu)\, \chi$$

$$\times \exp\left(i P'_\mu X_\mu - \frac{1}{2 l_0^2} R'_{\mu\nu} x^r_\mu x^r_\nu\right)$$

$$\left.\begin{aligned} A^r_s \psi_0 &= 0 \\ W_\mu \psi_0 &= 0 \end{aligned}\right\}$$

モ改

$U_t \psi = \psi$ triality

$a^{r+}_\mu a^r_\mu \psi = 0$

$a^+ a^+ a^+ \psi_0$: baryon state

spin:

$J_\mu = W_\mu \pm \Sigma_\mu$

$J = W \pm \frac{1}{2}$

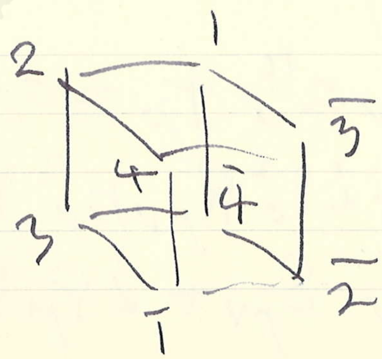
$M = \mu_0 (a^{r+}_\mu a^r_\mu + 6)^{1/2}$

<u>165</u>-multiplet

symmetry breakdown

$165 = (1,1) + (8,8) + (10,10)$

meson



8元：　4元の自由と~~他の~~ 4元の自由が一致する。

$$\alpha_\mu^r = \frac{1}{\sqrt{2}}(x_\mu^r + i\tilde{x}_\mu^r)$$

$$\pi_\mu^r = \frac{1}{\sqrt{2}}(p_\mu^r - i\tilde{p}_\mu^r)$$

素研　unitary rotator
1959 or 1960

山田：　Quadrilocal field のいろいろ
16 − 4 = 12
U′(12) → U(9) 高林
U(9)：　□　　□□　　□□□
9　　45　　165
U(3)×U(3)：　□ □　　□□×□□　　□□□×□□□
日×日　　田×田
日×日

~~序論: Nonlocal field の~~
本論: Nonlocal field と高次元空間
結論: A_μ^i について → linearity の条件で
single component に限る。これは
通常場と同等。

~~8~~ 20日(土) 午前
序論: nonlocal field の記述の可能性

$$\langle x' | \phi | x'' \rangle \longrightarrow \phi(X_\mu, r_\mu) \longrightarrow \text{[illegible]}$$

$$X_\mu = \frac{1}{n+1} \sum_{i=1}^{n+1} x_\mu^i$$

$$r_\mu^i = \frac{1}{n+1} \sum_{j=1}^{n} \lambda_j^i x_\mu^j$$

$$\sum_j \lambda_j^i = 0, \quad \sum_j \lambda_j^i \lambda_j^k = (n+1)\delta^{ik}$$

$$a_\mu^{(i)} = \frac{1}{\sqrt{2}}(r_\mu^{(i)} + i p_\mu^{(i)})$$

$$a_\mu^{(i)\dagger} = \frac{1}{\sqrt{2}}(r_\mu^{(i)} + i p_\mu^{(i)})$$

$$a_\mu^{(i)\dagger} = \frac{1}{\sqrt{2}}(\quad - \quad)$$

$$[a_\mu^{(i)}, a_\nu^{(j)\dagger}] = \delta^{ij} g_{\mu\nu}$$

$a_\mu^{(i)} \to e^{-i\theta} a_\mu^{(i)}$ に対して不変,

$L_{\mu\nu}^{ij} = a_\mu^{(i)\dagger} a_\nu^{(j)}$

$L(4) \times U(n)$

$[L_{\mu\nu}^{ij}, L_{\rho\sigma}^{kl}] = g_{\nu\rho}\delta^{jk} L_{\mu\sigma}^{il}$

$\qquad - g_{\mu\sigma}\delta^{il} L_{\rho\nu}^{kj}$

$K^{ij} = L_{\mu\nu}^{ij} g^{\mu\nu}$

$M_{\{\mu\nu\}} = \sum_i L_{\{\mu\nu\}}^{ii}$

boson → fermion

$[a_\mu^{(i)}, a_\nu^{(j)\dagger}]_+ = \delta^{ij} g_{\mu\nu}$

から出発しても代 L の代数の構造は変らぬ

spin: $S_{\alpha\beta}^{ij} = a_\alpha^{(i)\dagger} a_\beta^{(j)}$

$[S_{\alpha\beta}^{ij}, S_{\gamma\delta}^{kl}]_- = \delta\delta S - \delta\delta S$

↓

fermion → boson

$S_{\alpha\beta}^{ij} = \frac{1}{2}(\sigma^\mu \bar{\sigma}^\nu)_{\alpha\beta}\, a_\mu^{(i)\dagger} a_\nu^{(j)}$

$[a_\mu^{(i)}, a_\nu^{\dagger(j)}]_- = \delta^{ij} g_{\mu\nu}$

$\sigma^\mu (\sigma, 1)$
$\bar{\sigma}^\mu (\sigma, -1)$ }

$$(\sigma)^{\mu}_{\alpha\beta}(\bar{\sigma}^{\mu})_{\gamma\delta} = 2\delta_{\alpha\delta}\delta_{\beta\gamma}$$

$$A^{(i)} = \sigma_k a_k^{(i)} - a_0^{(i)}$$

$$A^{(i)\dagger} = \sigma_k a_k^{(i)\dagger} + a_0^{(i)\dagger}$$

capacity 3 paraboson　　capacity 1 boson

---

para-statistics

paraboson:

$$[[b_k, b_l^\dagger]_+, b_n]_- = -b_k\delta^{ln}$$

parafermion

$$[[b_k, b_l^\dagger]_-, b_n]_- = +b_k\delta^{ln}$$

Green:

parafermion $b_k = \sum_{\lambda=1}^{n} b_k^\lambda$　　capacity n

$$[b_k^\lambda, b_l^{\lambda\dagger}]_+ = \delta_{kl}$$

$$[b_k^\lambda, b_l^{\mu\dagger}]_- = 0 \qquad \lambda \neq \mu$$

paraboson

$$[b_k^\lambda, b_l^{\lambda\dagger}]_- = \delta_{kl}$$

$$\{b_k^\lambda, b_l^{\mu\dagger}\}_+ = 0 \qquad \lambda \neq \mu$$

$$b_k = \sum_{\lambda=1}^{n} \omega^\lambda b_{\lambda k}$$

$$\omega^\lambda\omega^\mu + \omega^\mu\omega^\lambda = 2\delta^{\mu\lambda}$$

$$[b_{\lambda k}, b^\dagger_{\mu l}]_\pm = \delta_{\lambda\mu}\delta_{kl}$$

$n=3$

parafermion

$$[[b^\dagger_k b^\dagger_l]_+ b^\dagger_n]_+ = \sum \psi^{\dagger\lambda}_k \psi^{\dagger\mu}_l \psi^{\dagger\nu}_n$$

$$= i \sum_{\lambda \neq \mu \neq \nu} b^\dagger_{\lambda k} b^\dagger_{\mu l} b^\dagger_{\nu n}$$

$$\rightarrow \langle \underset{?}{x' \cdots} | \phi | \underset{?}{x'' \cdots} \rangle$$

II, 模型I研究会.
基研. March 22~24, 1965

第一日. 朝：現状の整理

午後：中川：$K \to 2\pi$

$K^0_{long} \to \pi^+ + \pi^-$

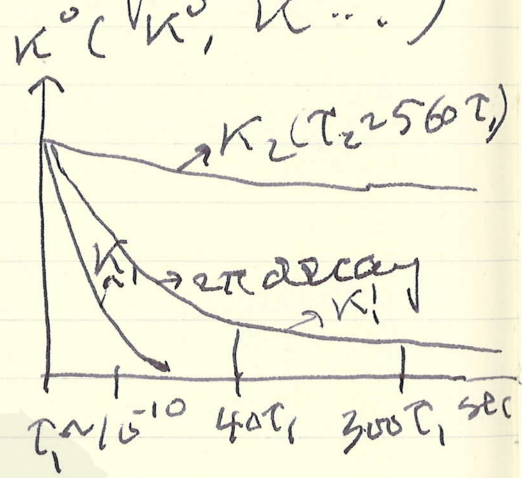
① CP non-invariance

② long range force $\pm V$ → fifth force for $K^0 (\bar{K}^0)$

③ 新しい粒子の関与

④ non-linear Schrödinger eq.

などなど



~~Brookhaven~~ (Princeton)
Christensen　$300\tau_1$

$$\frac{\Gamma(K^0_2 \to \pi^+\pi^-)}{\Gamma(K^0_2 \to \text{all modes charge})} \sim 0.002$$

Leipner et al
$40\tau_1$　$\sim$ ~~4.0~~ 0.06
(Brookhaven)　→ 0.025

fifth force　$R \propto E^2$ はだめらしい.
Harwell　1.5 BeV ~ 5 BeV

CERN

$\tau_{K_1'} \sim 2 \times 10^{-9}$ sec.

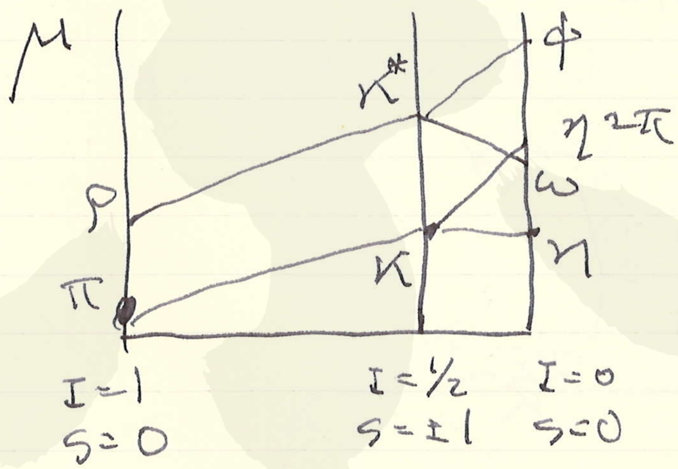
$$\frac{N(K_1')}{N(K_2)} \times \frac{\Gamma(K_1' \to 2\pi)}{\Sigma(K_1' \to \text{all})} \approx 0.014$$

	K_1^0	$K_1'^0$	2π
CP	+1	+1	+1
A	+1	−1	+1

2π leptonic 2π

$K \leftrightarrow (\text{lept}) \leftrightarrow K'$

梅田 : Mass Relations



史料: <u>Journal</u> (Feb. 1965 ~~[illegible]~~)

Baryon

$$M^2 = M_0^2 + \alpha^2 L(L+1)$$

$$L = J - \tfrac{1}{2}$$

$$\alpha^2 = 32.5 \times 10^4 \ \mathrm{MeV}^2$$

$$M_0^2 = 88 \times 10^4 \ \mathrm{MeV}^2$$

$5/2^+$ 1690 2

$3/2^-$ 1510 1

$3/2^+$ 1240 1

J^- …… L

$1/2^+$ 940 0

$1/2^-$

J L

meson 1710 $\rho\pi$

2

250 ρ

1

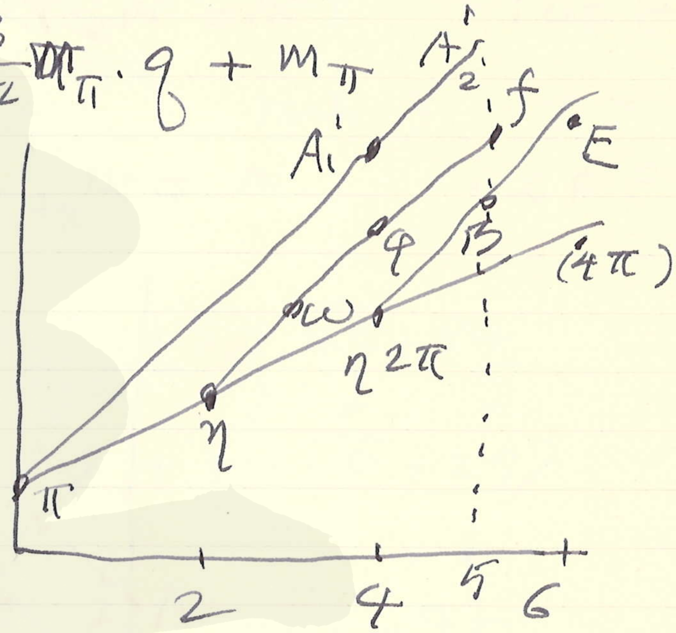
140 π

$= \left(\begin{array}{l} K^* \\ \\ K \end{array} \right.$

[illegible]・伊藤: Takeda-Ohnuki Rule の拡張.
Sternheimer Rule

Boson
$S=0$

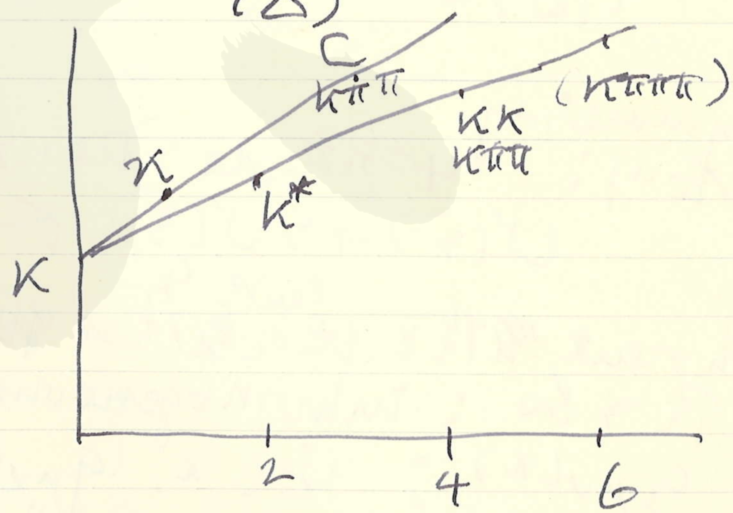
$$m = \frac{3}{2} m_\pi \cdot q + m_\pi$$



$$m = \underbrace{\frac{1}{4} m_N}_{\kappa}\, q + m_{ps}$$

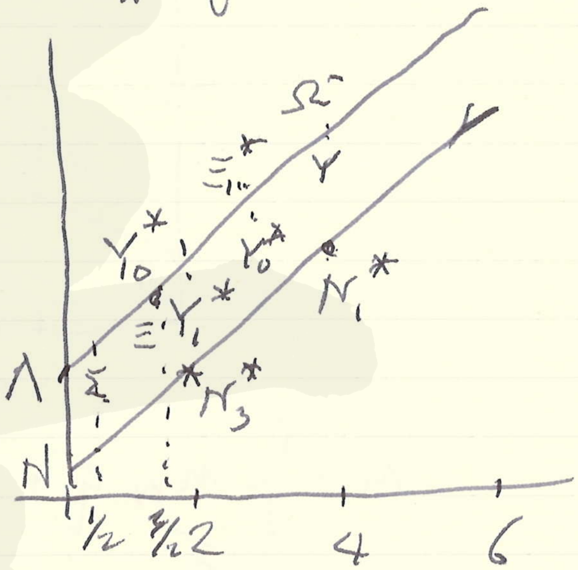
$S \neq 0$

$$m = \left\{ \frac{3}{2} m_\pi - \underbrace{(-1)^q}_{(\Delta)} \right\} q + m_K$$



$s=0$: $m = m_{\pi^\pm} q + m_N$

$s\neq0$: $m = m_{\pi^\pm} q + m_\Lambda$



2次元 8 model
偏極
回転

Symmetry
法則: 4次元 de Sitter space
$U'(5) \to SU'(5)$ ← $H = p_\alpha p_\alpha + x_\alpha x_\alpha$
rank 4
Lorentz 群と他の群とは独立でない…
$R\to\infty$: inhomogeneous Lorentz group
$g_{\mu\nu}(x)$; $\psi(x, g_{\mu\nu}(x))$
$= \sum_k a_k \psi_k$

[illegible] : Higher Rank の Symmetry Group.

SU(4)　　$15^{\text{次元}}$　　rank 3　　I, Y, Z
Sp(3)
SO(7)

SU(4)

$$15 \times 15 = 1 + 15 + 15 + 45 + \overline{45} + 84$$

$$(8 \times 8 = 1 + 8 + 8 + 10 + \overline{10} + 27)$$

Sp(3)

$$14 \times 14 = 1 + 14 + 21 + 70 + 90$$

ps　　v

$$14 \to 3 + \bar{3} + 8$$　　q.-w. missing

$$21 \to 6 + \bar{6} + 8 + 1$$

(14)

			Y	Z
3	doublet	A	1	1
	singlet	X	2	1
8				0
$\bar{3}$	doublet	B	-1	-1
	singlet	Ω	-2	-1

mass formula

(21)

		I	Y	Z
6	α	1	2	1
	L*	1/2	1	1
	β	0	0	1
8				
1				
$\bar{6}$				

田也： G parity

菅野：SU_4

	$S = U_3/2$	U	T	R (additive)	Z	K (non-additive)
X_1	0	0	$1/2$	$1/2$	0	
X_2	0	0		$1/2$	0	
X_3	$1/2$	$1/2$	0	$-1/2$	1	
X_4	$-1/2$			$-1/2$	0	

(15) meson

8	T	U_3	U	R
$L^{(K)}$	$1/2$	$1/2$		$+1$
$\bar{L}^{(\bar{K})}$		$-1/2$		-1
X	0	0	1	0
D	0	1		
$\bar{D}$	0	-1		

$$Q = T_3 + U_3 + \frac{N_B}{2}$$

$\phi \to K + \bar{K}$

$K + N \to K + N$ resonance ah.

$B\bar{B} \to 0^-$
$BBB \to p$-state　　$B - \bar{B} - B$

$Q = I_3 + \frac{Y}{2}$ $\qquad \gamma$

$Z = U_3 + \frac{N-Y}{2}$ $\qquad \gamma'$

23日：午後
山田：non-local 研究会まとめ

並木：宇宙線領域と加速器領域研究会
報告

	resonance	rearrangement ionization	production
γ-A	res. scatt.		e^+e^-
A-A, nucleus	〃	transmutation	π- production
N-N		$\pi^+ p$, $K^+ p$ 分布変わるし?	?
M-N			

S行列
核力

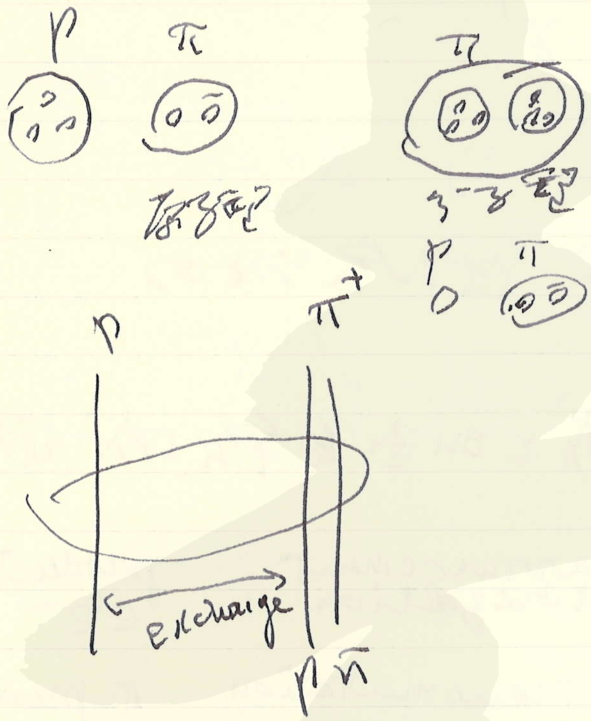
1 BeV　hard core　10 BeV　core　かくれる?　100 BeV 超高エネルギー

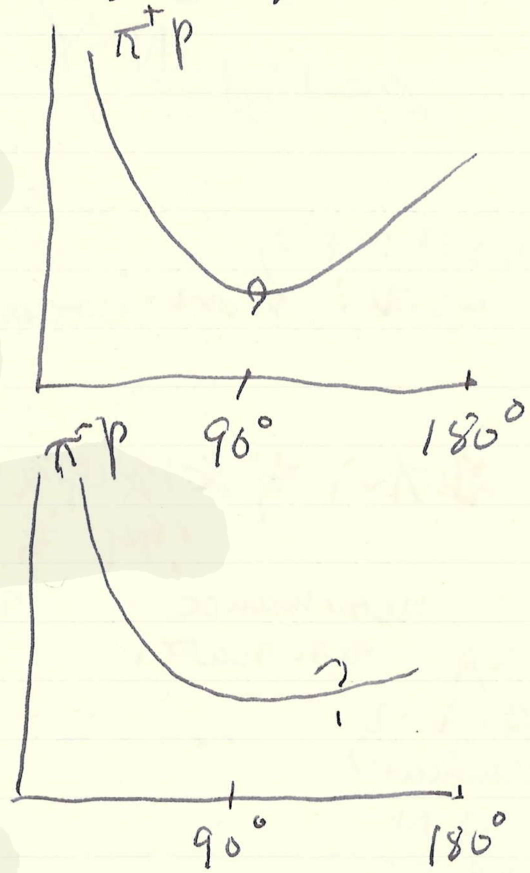
$$\left(\frac{d\sigma}{d\Omega}\right)_{\sim 90^\circ} \simeq W_c\, e^{-a\bar{N}}$$

$$\bar{N} = f(E) \propto E$$
$$\propto \sqrt{E}$$
$$\propto \ln E$$

町田：[illegible]、
藤本・並木・町田：Rearrangementの辺

4〜8 GEV πp large angle scatt.





	前	後
$\pi^+ p \to \pi^+ p$	○	△
$\pi^- p \to \pi^- p$	×	△
$\to \pi^0 n$	○	△
$K^+ p \to K^+ p$	○	△
$K^- p \to K^- p$	×	×
$\to \pi^0 \Lambda$	○	△
$\to \pi^- \Sigma^+$	△	△

山田, [illegible]

結論：field theoryでも同じ方向になるのではないか？

23日、午後

中村：　$K^0 \to 2\pi$,

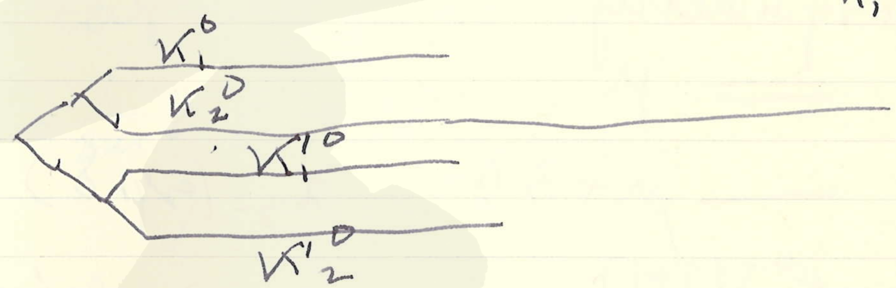
$K^{0\prime}$　　$m_{K^{0\prime}} = m_{K^0}$

$$H = i g/\kappa\, \bar{\Psi}_2 \gamma_\mu \gamma_5 \Psi_1 \partial_\mu \phi + h.c \quad (1)$$

$$H' = i g' \bar{\Psi}_2 \gamma_5 \Psi_1 \phi + h.c \quad (2)$$

$g = g'$

$$\left.\frac{\sigma(K_1^{0\prime} \to 2\pi)}{\sigma(K_2^0 \to 2\pi)}\right|_{t = 300\tau_{K_1^0}} = \frac{1}{500}$$



$$\alpha = \frac{M_1 + M_2}{\kappa} = 15.6 \qquad M_1 = M_\Lambda,\ M_2 = M_N,\ \kappa = M_\pi$$

$$\left.\frac{1}{\alpha^2}\frac{1}{x}\frac{1}{y}\frac{e^{-t/y\tau_{K_2^0}}}{e^{-t/\tau_{K_2^0}}}\right|_{t = 300\tau_{K_1^0}} = \frac{1}{500}$$

$x = 2,\ y = 1$:　$\tau_{K_\phi^{0\prime}} = \tau_{K_2^0}$

$x = 1$　$y = 6.4$;　　$\tau_{K_\phi^{0}} = 8.4 \times 10^{-9}\,\mathrm{sec}$

$\quad = 0.36$　　　$= 1.5 \times 10^{-7}\,\mathrm{sec}$

N $\Sigma(\Lambda)$ K $K^{0\prime}$

Ξ $\Sigma(\Lambda)$ $K^{0\prime}$ K

strong (dec) meso-strong (non-dec)

原説: deformable sphere

分析法: $9 = 3 + 3 + 3$
回転 重錘 音振

triosymmetry

μ

$\mu + 3\lambda$ $\quad x_3 = (\exp \delta)$

$$E = \frac{\hbar^2 J(J+1)}{2I} + h\nu(n_1+n_2) + h\nu' n_3$$

$$T_3 = \frac{1}{2}(n_1 - n_2)$$

$$T = \frac{1}{2}(n_1 + n_2)$$

i) $S = -n_3$ $\quad Q = T_3 + \frac{S}{2} + \frac{\sum n_i}{2}$

$T = 0$ $\quad S = 0$?

ii) $Y = -n_3 + \frac{1}{3}\sum n_i$ quark

gemisch:
pure state を排除. (Born-Green)

廿日会: Baryon Resonance
Greenberg 理論
SU6 56次元 　 10

u.s. 　 spin 　 L=0

$(8, J=(\frac{1}{2})^+)$

$(10, J=(\frac{3}{2})^+)$

$\frac{3}{2}$ 　 $L=1$ $(\ell=0)$

$\frac{5}{2}$, $\frac{1}{2}$

parafermion
capacity $n=3$

$$H = \frac{1}{2m}\sum p_i^2 + V$$

$$V = \frac{k}{2}(\underline{r}_1^2 + \underline{r}_2^2)$$

$$H = \frac{1}{2}(p_1^2 + p_2^2 + \underline{r}_1^2 + \underline{r}_2^2) + \frac{1}{2}\underline{P}^2$$

$$P^2 \Psi = 0$$

(or $V = \frac{1}{2}\sum x_i^2$ 　 $(P^2 + R^2)\hat{\Psi} = 0$)

Kycia–Riley 1963 ?

$J - \ell = I - 1$

spin-orbit coupling で説明.

坂田: magnetic moment

核子: B-L corr. と W. I.

			Q	I_S
ν, e, μ	$\xrightarrow{B^0}$	χ_1	0	−2
		χ_2	−1	−2
		χ_3	−1	−3
ν_0	$\xrightarrow{B^-}$	χ_0	−1	−3

baryon $\chi\chi\chi\bar{\chi}_0\bar{\chi}_0$

SU_6-symmetry

W. I. → $j_\lambda = \cdots + (B^- B^0)$

24日 午後.

大貫 : symmetry のまとめ

inhomogeneous ~~Group~~ Lorentz group

SU(6) → weak int. non-lep. 磁. 双極

→ constr. force 大貫. 宮沢

Rank 3

isospin → unitary spin → SU(4)

SU(2)　I.O.O. U(3)　SU(3)　Sp(3)

R=1　R=2　SO(7)

I_3　I_3, Y　I_3, Y, Z

de Sitter 空間

5次元 (宮沢)

→ 多次元空間

宮沢 (SL(6)　(6,C)

SL(2,C)×SU(3)⊂SL

宮沢. 菅原 : SL(9,C)

中西(1961)

宮沢 (7次元)　⊃SL(2,C)×SU(3)

→ broken → 現実世界

SL(2,C)×SU(3)

etc.

U(5) ⊂ SU(2), SU(3).

武谷 ; ν 模型.　(ν, ν)　e, e', b

1960年 :

四元子 → quark

$(\nu, \underset{e}{\nu}, \underset{e'}{\nu})\ b^+ b^-$　e　b

ばらけ

ν　ν　ν'

ϵ　ϵ'

2振動子 模型

string では annihilation がない。

π；　$\nu\ \nu\ \nu$ ばらけ

$\bar{\nu}\ \bar{\nu}\ \bar{\nu}$　$\bar{\nu}\ \bar{\nu}'$

湯川：たとえば世界：核力と斥力：{ dichotomy / trichotomy

24節気

三段階；

三態：　気体の液体
(固)液化
液体固体

→ t

素をする

(個の進み過)

Copenhagen 物理学
Neumann の 2つの Phase) 多数
① meson と baryon は同じに理解か？
② antibaryon はどんなものか？
quasi-particle？

③ 非局所 model の観点で V.V.I. は理解できるか？
urbaryon の段階では 反粒子の物理的[illegible]？

④ 力の階層性
constructive, interactive などの階層で考えるか？

模型 II 研究会

4月15日~17日, 1965, 基研

15日午後:

打合せ

紹介

午後: 谷川: weakの歴史

16日午前:

中川: strongにおける symmetry と weak int との関係.

non-leptonic int.

$$H_W = \frac{G_0}{\sqrt{2}} J_\alpha^\dagger J_\alpha$$

$$J_\alpha = (\bar{e}\nu_e) + (\bar{\mu}\nu_\mu) + \cos\theta(\bar{n}p) + \sin\theta(\bar{\Lambda}p)$$

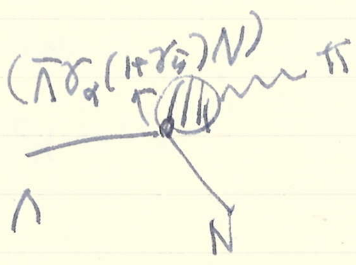
$$\cos\theta(\bar{d}u) + \sin\theta(\bar{s}u)$$

$$l_\alpha^\dagger l_\alpha + l_\alpha^\dagger g_\alpha + g_\alpha^\dagger g_\alpha$$

$\Delta I = \frac{1}{2}, \frac{3}{2}$?

1: O-M-S,

$$\frac{G'}{\sqrt{2}}(\bar{\Lambda}\gamma_\alpha p)(\bar{p}\gamma_\alpha n)$$



例 $\frac{\Gamma(\Lambda\to p\pi^-)}{\Gamma(\Lambda\to n\pi^0)} = \frac{2}{1}$

(弱)　$\alpha_\Lambda > 0$　~~実験~~ 理論

$\alpha_\Lambda < 0$　~~理論~~ 実験

$$G' \approx 1.6\, G_0 \leftarrow \underbrace{\sin\theta\cos\theta}_{\frac{1}{\sqrt{15}}} \cdot G_0 \qquad \theta = 15^\circ$$

(~~大数~~・粒; Σ, Ξ . .)

SU_3:

$$f_V = 1 \qquad \left(\frac{f}{d}\right)_A = \frac{1}{3}$$

$$d_A = 0$$

$$-\frac{10}{4} < \frac{F}{D} < -\frac{5}{4}$$

(strong では $\frac{F}{D} \sim \frac{1}{3}$)

(I) $g_\alpha^\dagger g_\alpha$ だけでは不充分

new int. $(\Delta I = 1/2)$ が必要!!!

$K \to 2\pi$ の問題

$$M = \alpha K\pi\pi + \beta\,(K \overleftrightarrow{\partial_\alpha} \underbrace{\pi)\partial_\alpha \pi}_{\to\ (m_K^2 - m_\pi^2) K\pi\pi}$$

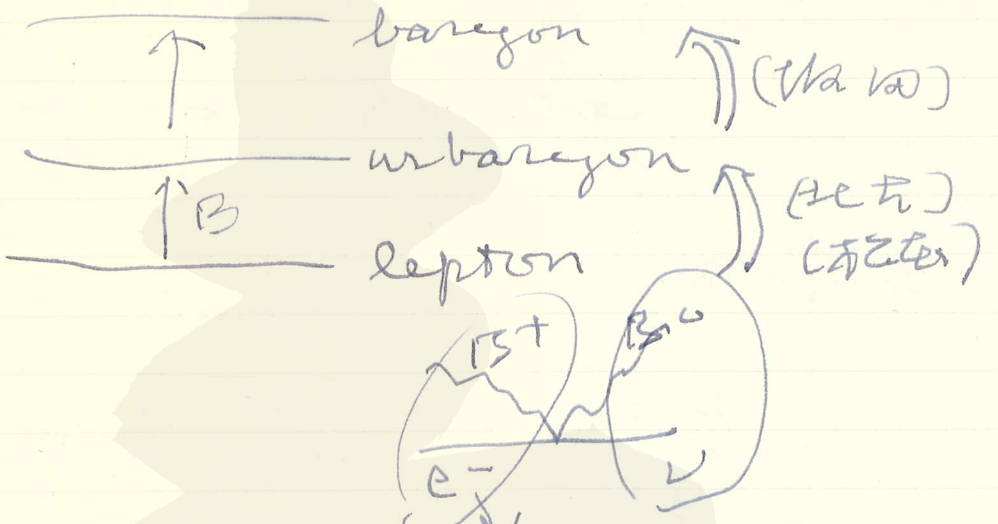
$$\alpha = G_0\,[g_{S.B} + g_{SB}^2 + \cdots]$$

$$\beta = G_0\,(1 + g_{SB} + \cdots)$$

$$\Gamma(K^+ \to \pi^+\pi^0)_{cal} \sim \cos^2\theta\sin^2\theta \times 5.8\times 10^9\ \mathrm{sec}^{-1}$$

実 $\sim 1.8 \times 10^7\ \mathrm{sec}^{-1}$

(II) $q_\alpha^\dagger q_\alpha$ はどうして存在しては困る?



$(u_0\ \chi_0)$

$(\bar{\Lambda}\nu)(\bar{\nu}e)$ $\}(-1,1,1)$

$\downarrow$

$(\bar{\Lambda}\langle\nu\bar{\nu}\rangle_{B}\, n)$

[illegible]: Parastatistics

[illegible]:

quarks　SU_3　　SU_6
fractional charge　　para-fermion

1) O-R-M
Sakata　$SU_3 \to U_3$

2) Nambu　3 Triplets ([illegible]は違う)

Q　(1 0 0)　(1 0 0)　(0, −1, −1)

3) Han

$Q \quad I_3 \quad Y$

I　Iso (doublet, singlet)

U　Uso ('' , '')

V　Vso ('' , '')

Pauli-reflection でうつる.

皆れ・稀有.

$q \begin{pmatrix} u \\ d \\ s \end{pmatrix}$　I_3 の eigenstate
Q, Y の eigenstate では..

$$q^\lambda = \sum_{\alpha=1}^{3} t_\alpha^\lambda$$

$$t_\alpha^\lambda = \begin{array}{ccc} \left(\begin{matrix} 1 \\ 0 \\ 0 \end{matrix} \right. & \begin{matrix} 1 \\ 0 \\ 0 \end{matrix} & \left. \begin{matrix} 0 \\ -1 \\ -1 \end{matrix} \right) \\ t_1 & t_1' & t_2 \end{array}$$

$\frac{1}{3}(Q_{11} + Q_{22} + Q_{33})$

$\frac{1}{3}(\quad\quad)$

$$u = \frac{1}{\sqrt{3}}(t_u^1 + t_u^2 + t_u^3)$$

para-fermion

$$q^\lambda = \sum_\alpha t_\alpha^\lambda$$

$$[t_\alpha \; t_\alpha]_+ =$$

$$[t_\alpha \; t_\beta]_- =$$

fermion:

$$[[q^\lambda, q^\mu]_+, q^\nu]_+ = 0 \sum_{\alpha \neq \beta \neq \gamma} t_\alpha^\lambda t_\beta^\mu t_\gamma^\nu$$

t が fermion であれば、

$$t_\alpha^\lambda = \omega_\alpha F_\alpha^\lambda \qquad \underline{F_\alpha^\lambda : \text{fermion}}$$

$$\sum F_\alpha^\lambda F_\beta^\mu F_\gamma^\nu$$

i) exciton

ii) $\langle l \, l \, l \, b^+ b^+ \rangle$ = baryon

~~[illegible]~~ parafermion

団Z : Dynamical Model of Symmetry Violation

① $\begin{cases} \text{baryon} & qqq \\ \text{meson} & q\bar{q} \end{cases}$

② q : parafermion
equal mass

③ (q q q) — θ (ud)   B $2/3$ C $1/3$

$$H = H_0 + H'$$ → spinless

$$H' = G_-[\psi_\mu(x)\psi_\nu(x)]_- \bar{\theta}(x)$$
$T^{3\bar{3}}$

$$+ G_+[\psi_\mu(x)\psi_\nu(x)]_+ \bar{\theta}(x) + h.c.$$
T^{3}

q_1
q_2
q_3

$\delta m_N = 6\,\xi$
$\delta m_\Lambda = 4\,\xi$ } → G.O.

$\Xi^*(1810)$
$Y_1^*(1660)$ $\Lambda(1660)$
$N^*(1520)$

$(\frac{3}{2}^-)$ octet で equal spacing

中x) : $K^{0}_{\text{lL}} \to \pi^+ + \pi^-$
Brookhaven p_K (BeV/c) 1.1   τ proper ~40τ,

$$R = \frac{(K_{2,L} \to \pi^+ + \pi^-)}{(K_2^0 \to \text{charged all})} = (2.5 \pm 0.9)\,10^{-2}$$

CERN
p_K 10.7 (7.0 ~ 15.0)
t_{proper} $\sim 80\,\tau_1$
R $(3.5 \pm 1.4) \cdot 10^{-3}$

England
3.0 (1.5 ~ 5.0)
$\sim 250\,\tau_1$
$(2.08 \pm 0.35) \cdot 10^{-3}$

~~Brookhaven~~
Princeton
1.1
$\sim 300\,\tau_1$
$(2.0 \pm 0.4)\,10^{-3}$

CP-violation の方がよいだろう。
(K' による説明は考えにくい)

横尾: CP violation と ΔS, $|\Delta I| \neq 1/2$

$CP(H_{1,5})(CP)^{-1} = H_{1,5}$

$CP(H_3)(CP)^{-1} = -H_3$

$\lvert\Delta I\rvert = 1/2$	H_1
$3/2$	H_3
$5/2$	H_5

$K^+ \to \pi^+ + \pi^0$: $\frac{H_5}{H_1} = 6.8 \times 10^{-2}$

$\frac{H_3}{H_1} = 3.1 \times 10^{-3}$

$$\frac{K_2^0 \to \pi^+ + \pi^-}{K_2^0 \to 2\pi \text{ all}} = \frac{K_1^0 \to \pi^0 + \pi^0}{K_1^0 \to 2\pi \text{ all}}$$

$$\left.\begin{array}{l} \Lambda \to N + \pi \\ \Xi \to \Lambda + \pi \end{array}\right\} \quad |\Delta I| = 1/2 \quad \text{O.K.}$$

$\Sigma \to N + \pi$

$K \to \pi + l + \nu$　　H_1, H_3

$\Delta I = 1/2$, ~~ΔK~~, O.K.

$K^0 \to \pi^+ + l^- + \bar{\nu}$　　$\frac{\Delta Q}{\Delta S} = -1$　　$\sim 10^{-5}$

$\Sigma^+ \to n + l^+ + \nu$　　$\sim 10^{-6}$

$K \to 2\pi + l + \nu$　　H_5

石井：$K^0_{l.l.} \to \pi^+ + \pi^-$

$K^{0\prime}$　　$K_1^{0\prime}$　　$K_2^{0\prime}$

$CP = 1$　　$CP = -1$

鵜飼：$(e\nu)(e\nu)$ をりさくする
中村理論.

藤田：β-decay
Langer effect など

明光?:
陳:　μ capture by hydrogen
大1下 / G_μ
$p + \mu^- \to n + \nu$
$p\mu p$　　zerolcale

山口:　宮?
S, R, + W.G.I,
(CPT) theorem

$$\frac{1}{m_g} \gtrsim 5\ \text{hr} \times c$$

$$\gtrsim 75\text{万光年}$$

n　　$980 \pm 10\%$　$\text{cm}\cdot\text{sec}^{-2}$
Schiff:　e^+ 931力,
$K^0\ \bar{K}^0$:　$\pm 3\text{eV}$. (地球の31力)
光の曲り:　spin 0 はだめ
spin even なら、いつでも引力.

equivalence principle
$\langle | T_{\alpha\beta} | \rangle \to F_1(0) = \text{const} \Leftarrow EP$

$$\left|\frac{M_I}{M_G}\right| < 10^{-16}\quad \sim 10^{-20}$$

17日金曜：

中野：穴のたくさんある新 diagram
1958年[illegible])から粒子がたくさん
あるといっていた.

[illegible] が independent で[illegible]の数学
[illegible]

$$Q = I_3 + \frac{Y}{2} \qquad \times$$

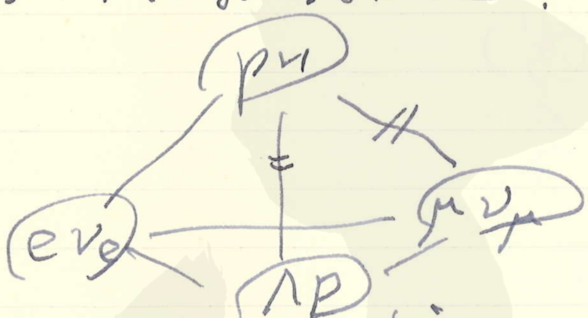
$$Q = T_3 + \xi_3$$

$$|\vec{U}| = 1, 0$$

$$Y = U_3$$

K, K_2^0 の mass は等しい!!!,
(違いは数 MeV)

小川：弱の理論.　先日の話のつづき,
Kite diagram



(1) coupling の大きさ
(2) type ~ $\gamma_\mu(1+\gamma_5)$

$$\frac{K_1^0 \to \pi^+ + \pi^-}{K^+ \to \pi^+ + \pi^0} = 500 \qquad \Delta I = 1/2$$

α_Λ, α_Σ, α_Ξ の問題

内山：重力

Einstein 方程式　　　　運動方程式

Wigner

$g_{\mu\nu}$: c-number

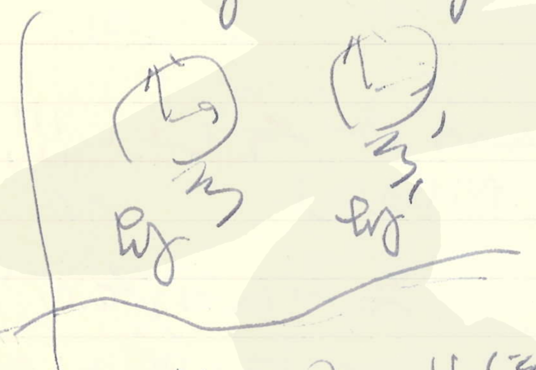
equivalence principle

elevator

local frame

Hilbert space

$\mathfrak{H}(\xi)$, $\mathfrak{H}(\xi')$



$\psi(\xi)$　$\psi(\xi')$

||el displacement の

integrability

$\psi(Q, C, \text{history})$

Dirac: $\operatorname{div} \vec{B} = \mu$ の

との analogy

torsion

$\Box A_\mu = j_\mu \qquad \partial_\mu j_\mu = 0$

$\Box \varphi_{\mu\nu} = T_{\mu\nu} \qquad \partial_\mu T_{\mu\nu} = 0$

$\Box A_{\mu[k,l]} = R_{\mu[k,l]} \qquad \frac{\partial R_{\mu[k,l]}}{\partial x^\mu} = 0$

[illegible]: principle of equivalence
or いいかえれば...
C, P, T non-invariance

武谷: $\nu \rightarrow$ . . . .
subquantal

内山: 弱い相互作用で $\nu \to q$

湯川: 素粒子の考え方
W, I, のgravitationへの寄与.

[illegible]：GeV領域における核子核子散乱の分析
April 21, 1965, 基研談話会

3.020 MeV
970 MeV   p-p
660 MeV
2 GeV   cross-section のdata }
1.7 GeV   polarization のdata }
6 GeV

Simple groups (RMP 34 (1962), No.1, 1)
Behrends, Dreitlein, Fronsdal, Lee

M 2 seminar 第1回
平山 実 君. (April 21, 1965)
第2回
福井 郁男 君, (April 28, 1965)
沢田 齋藤 憲昭.

誰 complex → compact

第 回 (June 2, 1965)
林 憲二 君 : Mass Formula

Okubo 1964

$M^2 = P_\mu P_\mu$

$P_\mu = P_\mu^{(0)} + \lambda P_\mu^{(1)}$

$M \simeq M_0 + \frac{\lambda}{2M_0} V,$ for baryon

$$\frac{1}{2}(N^2 + \Xi^2) = \frac{3}{4}\Lambda^2 + \Sigma^2$$

物理教室談話会
Cologuium
April 1965 春休

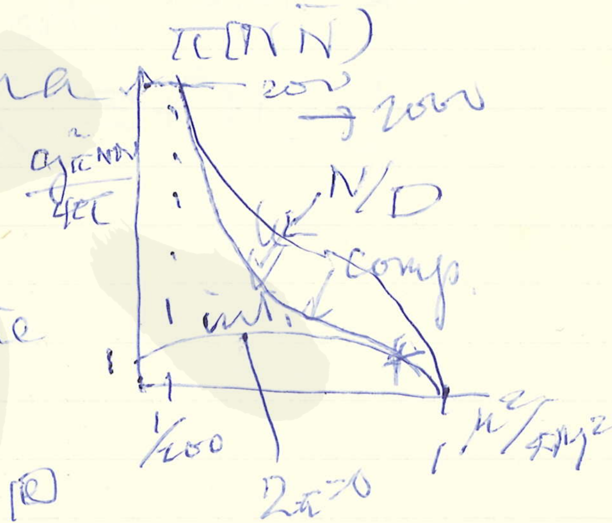
林憲二: Dynamical Model of Pion (Ida, Uehara, Saegusa, Shirafuji, Hayashi)

equivalence Proof (Ida)
$Z_3=0$ → composite particle
1957: Jouvet
1961: Vaughn et al
(N/D a residue eq.
Lee model
Zachariasen model

$D(m^2)=0 \leftarrow Z_2=0$?

$g^2 = -\frac{N(m^2)}{D'(m^2)} \leftarrow Z_3=0$

inequivalent?
1964: Uehara
equivalent
1964: Ida



$Z_3=0$ { composite / intermediate

compositeの場合
propagatorに1回
引き算
intermediateの場合
必要なし.

Green's functions

(1) pseudo-resonance
$\delta l(\infty) \neq 0$

$Z_3 \neq 0$ super-elementary $n(\infty) > 0$

$Z_3 = 0$ $n(\infty) < 0$

$\delta Z_3 = 0$ composite

(2) $n(\infty) = 0$

$Z_3 \neq 0$ Elementary

$Z_3 = 0$ $Z_3(s) \sim \frac{\ln(s)}{s}$ Intermediate

$\pi(N\bar{N})$

$\pi\rho$-model

$3\pi \sim \rho\pi$

comp. $g_{\rho\pi\pi}^2 \simeq 40$

interm. $g_{\rho\pi\pi}^2 \simeq a C_\omega + C_A.$

$\downarrow$ 1.3 $\downarrow$ 0.7

exp

$(g_{\rho\pi\pi}^2)_{exp} \simeq 2.$

~~intermed.~~ interm comp

$N(N\pi)$ $g_{\pi NN}^2 \lesssim 20$ ~~X~~

$\pi(\rho\pi)$ $g_{\pi\rho\rho}^2$ ~ 1.3 x

$\pi(N\bar{N})$ x x

BS (NN^*) ρ K^* ω

物理教室 [illegible] 午后8時

Colloquium

物理教室. May 4, 1965

武田氏 : 加速器領域と一超高エネルギー領域とのつながり

大学院 講演 (以上)

核子と核力研究会

5.21; 5.22, 1965 基研

I. 小川修三氏

level I. meson, baryon,
II. urbaryon　　II' baryon
III. lepton
IV. neutrino
⋮

① II → I への移行 (大貫)
[SU(6) symmetry と Yukawa int.,
[mass formula

② III → II を構成する時の問題 (鈴・片山)
II の reality の検討
[illegible]

③ I での階段 (原子型, 分子型 etc)
(町田, 並木, 藤本)
e.g. high energy 散乱
④ non-leptonic decay (散乱の仕方)
(中川・松本・吉田・小川)

⑤ constructive force
interactive force

⑥ 階梯的でない型 又は
階梯的取扱いをつくせない..
各段階の問題の整理.
empirical mass formula
(e.g. 大貫・宮本 rel., 大貫公式
中野公式 ...)

[7] weak int. の space-time property
と level Ⅳの問題

Yukawa int. によるcloud と
耐泡的 approach
bosonism の発展ゲ

$U_3 \longrightarrow SU_3 \longrightarrow SU_6$

$\left\{ \begin{matrix} K \\ \eta \end{matrix} \right\} = 0^-$　$m_8(1^-)$　$m_1(1^-)$

$\Xi = \frac{1}{2}^+$　$b_{10}(\Omega^-)$

$m_{35} = 8(0^-) + 8(1^-) + 1(1^-)$
$b_{56} = 8(\frac{1}{2}^+) + 10(\frac{3}{2}^+)$
mass の J-dep.

Ⅱ. g_A = 可り.

小研究会　基研

June 7, 8, 9, 1965

A.M. 10.30 ~ 12.30　　P.M. 13.30 ~ 15.20

7: Non-linear (片山)　　non-linear (高林)
8: Spontaneous breakdown (関林)　　Indefinite metric (中西) (田中)
9: Vertex function (位田)　　Bootstrap (細田)

7日午前

片山: Heisenberg の理論

1. urmaterie
2. vacuum　(spurion)
3. fundamental eq. ($\pm l^2$ の問題)
4. quantization

1. 1953年: ψ 4-component
1959年: isospin ⇒ nucleon　~~宇宙方程式~~
4-comp = 2×2
1965年: isospin　Y-charge (Y = −1)　2×2
⇒ Ξ-particle　2×4

2. 1961年: spurion with parity ~~odd~~
Λ ~ Σ の relative parity odd
1965年: spurion with parity even　多

3. 1954　4-comp　S-型
1959　4-comp　A 型 (宇宙方程式)
8-comp　V-A 型

4. 1954: S型 classical solution →
regularized propagator
1957　dipole ghost (indefinite metric)
(Lee model)　zero mass

1965 ; finite mass (Q.E.D.)

$m_e < m < m_\mu$

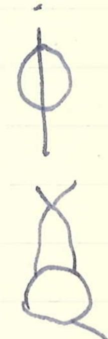
非局所場 : NTD 近似の良さ? (1st appr)

l^2, κ : 結合常数

self-consistent : κ = nucleon mass

($\kappa \equiv \kappa_N$) : $(l\cdot\kappa)^4$ が定まる

$$1+(l\kappa)^4 F\left(-\frac{\mu^2}{\kappa^2}\right)=0$$



pion-mass
η-meson-mass) 上の sign の決定
$\frac{\mu}{\kappa}$ の ~~計算~~ 計算
pion-nucleon coupling の計算

$$\frac{g^2}{4\pi}=f\left(\frac{\mu^2}{\kappa^2}\right)$$

$\left(\mu \to 0 \quad \frac{g^2}{4\pi}=4\pi A\, \exp\right)$

1965

$l\kappa = 6.39$: $\frac{\mu_\pi}{\kappa}=0.30$ (0.20) (0.15)

(= 5.78) $\frac{\mu_\eta}{\kappa_\iota}=0.90$ (0.80) (0.58)

$\frac{g^2_{\pi N}}{4\pi}=12.20 \sim 12.50$ (14.4)

$\frac{g^2_{\eta N}}{4\pi}=8.07 \sim 11.10$ (12.12)

Unsymmetrical vacuum

$|0\rangle \to |0\rangle \cdot \quad |\Sigma_\lambda\rangle \quad |a_\lambda\rangle \quad \cdots$

	I	
spurion	1/2	−1
anti- 〃	1/2	+1
Ξ	1/2	−1

$\sum_n \langle 1|n\rangle\langle n|1\rangle$

Λ, Σ … 1/2 −1, 1/2 +1, 0, 1 ; 0

… 1/2 −1, 1/2 +1, 1/2 +1

1/2 3/2 ; +1

N ?

boson: $1 - Z_{I,Y}\,\alpha\left(\frac{\mu^2}{\kappa^2}\right) = 0$

$$Z_{I,Y} = 3 - \left(I(I+1) - \frac{Y^2}{4}\right)$$

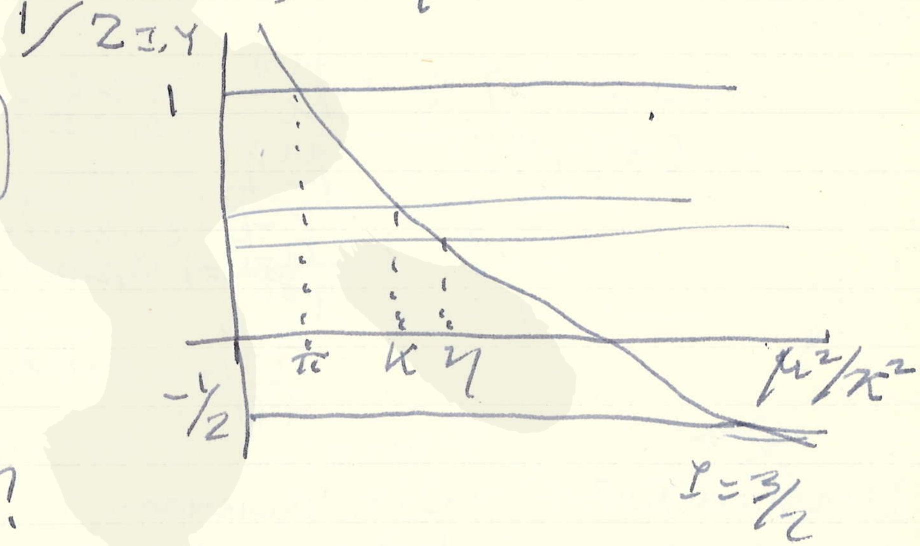
$$O(n_s, n_a) = \left(\sum_{n_s}\vec{\tau}_s - \sum_{n_a}\vec{\tau}_a\right)^2 - f(n_s + n_a)$$

$$= -\left(\sum\vec{\tau}_s + \sum\vec{\tau}_a\right)^2 + 2n_s(n_s+2) + 2n_a(n_a+2) - f(n)$$

$$= -\left(\sum \quad + \sum \quad\right)^2 + (n_s - n_a)^2 - c \quad \cancel{-f(n)}$$

$$= -4I(I+1) + Y^2$$

$\boxed{V, A \text{ 型}}$



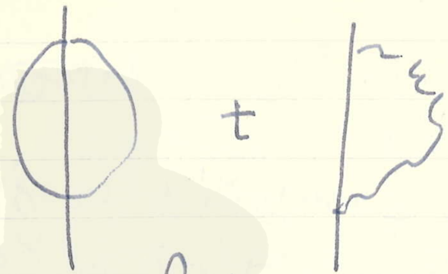
Gemisch?

Coupling Constant:

$\frac{g^2}{4\pi} \simeq 4\pi$, $\frac{g^2_{\eta BB}}{4\pi} \simeq 4\pi$ (spurion なし)

$\frac{g^2_{\pi K\Lambda}}{4\pi} \simeq 8\pi$, $\frac{g^2_{\pi K\Sigma}}{4\pi} \simeq 6.2\pi$ (spurion あり)

baryon:

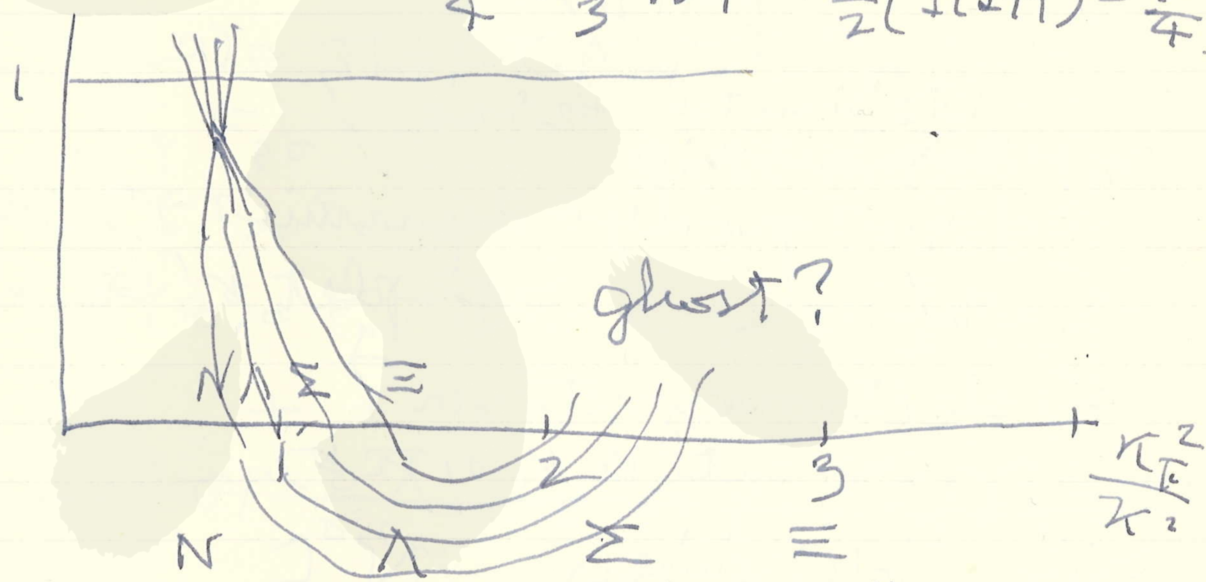


$$0 = 1 + \frac{3}{2}\left(\frac{\kappa l}{2\pi}\right)^4 L\left(-\frac{J^2}{\kappa^2}\right)$$

$$\sim \frac{3}{2}\sum_B \frac{C_{FB}}{2_B^2}\,\frac{\varphi\left(-\frac{J^2}{\mu_B^2}\right)}{\varphi'\left(\frac{\mu_B^2}{\kappa^2}\right)}$$

$C_{F,\eta} = \frac{3}{4}$, $C_{F,\eta} = \frac{1}{4}$

$$C_{F,K(\bar K)} = \frac{1}{2}\left(C_{F,K} + C_{F,\bar K}\right)$$
$$= \frac{7}{4} + \frac{5}{3}BY - \frac{1}{2}\left(I(I+1) - \frac{Y^2}{4}\right)$$



$\frac{\kappa_F}{\kappa}$: 0.74 0.81 0.88 1.04

$I = 3/2$?

問題点

1) 近似法　NTD　lowest order

2) 量子化

方程式と compatible か?

$x \to \eta x$, $\psi \to \eta^{-1/2}\psi$

$\langle|\psi\bar{\psi}|\rangle = F(x)$

$$s$$

$$\frac{\gamma x}{\lambda^2}$$

2') dipole ghost

F^+, F^-　　G^+　D^+　g^-

$\langle G|G\rangle = \langle D|D\rangle = 0$

$\langle G|D\rangle = 1$

$\langle g|g\rangle = -1$

indefinite metric?

3) 素子の分類

SU(2) group + dynamics → SU(3)

$\left|\frac{Y}{2}\right| \leq I$　　decuplet が困る.

4) electromagnetism?

zero-cut は次のため

Dirac, Heisenberg,　N.C.

Yamazaki,　N.C.

Kayama, Dahn　N.C.

D.H.Y.Y.,　N.C.

ニ12
~~素~~粒子：QED

Heisenberg, Kortel, Mitter. Naturf. 10a ('55) 425
Ascoli, Heisenberg 12a ('57) 177
Heisenberg, 1962 Int. Conf. CERN p. 675
Dürr, Heisenberg, Yamamoto, Yamazaki, N. C.

$$\gamma_\mu \frac{\partial \psi}{\partial x_\mu} + l^2 \psi (\bar{\psi}\psi) = 0$$

model theory $\tau(x/y) = e^{i J_\mu x_\mu} \tau(z)$

$$\tau(z) = \frac{1}{2(2\pi)^4} \int d^4p \{ \quad \}$$

$$\tau(0) = F_{\mu\nu}(\gamma_\mu\gamma_\nu - \gamma_\nu\gamma_\mu)$$

$$\left.\begin{array}{l} J_\rho F_{\rho\sigma} = 0 \\ J_\rho F_{\mu\nu} \varepsilon_{\sigma\rho\mu\nu} = 0 \end{array}\right\} \text{Maxwell eq.}$$

$$\tau(z) = F_{\mu\nu}(\gamma_\mu\gamma_\nu - \gamma_\nu\gamma_\mu) f(J_\mu z_\mu)$$
$$+ \cdots$$

$$-i\sigma^\mu \frac{\partial \chi}{\partial x_\mu} \pm l^2 \sigma^\mu \chi (\chi^* \sigma_\mu \chi) = 0$$

$\tau_k \Lambda_k$　Λ_k: world 二値 [illegible]
+ = operator
$\tau_3 \Lambda_3$. $\Lambda_3^2 = 1$

charge operator ~~ar~~ $\Lambda_3 + \tau_3$ は factor 1 (こ 3. ときの.

D. H. Y. Y. →

scale transf. が QED で重要.

$\chi(x) \to \sqrt{\eta}\,\chi(x\eta)$

vacuum が scale transf に対して不変でない.

$\mu = \dfrac{\kappa}{17.5} = 60\,\mathrm{MeV}$ (for $J^2 = 0$)

$\alpha = \dfrac{e^2}{\hbar c} \sim \dfrac{1}{100}$ (Dahr-Katayama)

第2日 午前

岡林氏; spontaneous Break-Down

I. i) Nambu の self-consistent method (1961)

$i\gamma p + m_0 + \Sigma(p, m, g, \Lambda) = 0$

$m - m_0 = \Sigma(\quad)\big|_{i\gamma p + m = 0}$

$\therefore\ m = -\dfrac{g_0 m i}{2\pi^4} \displaystyle\int d^4p \, \frac{1}{p^2 + m^2 - i\varepsilon} F(p, \Lambda)$

i) $m = 0$ normal

ii) $m \neq 0$ ab-normal singular

ii) Baker-Glashow (1962)

spont. breakdown

iii) 言葉の違い.

iv) formal

degenerate vacuum

zero-mass boson {Goldstone

→ $p_\mu = 0$

Goldstone theorem $\mu^2 = 0$

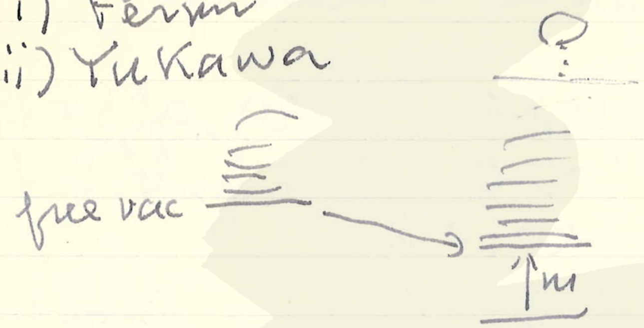
v) Spont. breakdown の古典的; φ

Nambu 理論と比較う

II. Bogoliubov Transf.

i) Fermi

ii) Yukawa



i) dangerous part $= 0$

ii) $E_p = \sqrt{p^2 + m^2}$

iii) Dirac, Klein-Gordon

Nambu 理論

i) $m \propto \langle\langle \bar{\psi}\psi \rangle\rangle$

ii) $m \propto \langle\langle \phi \rangle\rangle$

III. Breakdown of Spont. ~~…~~ Breakd."

田中正君 : Indefinite metric

Q.E.D.

multimass $\prod_i (\Box - \mu_i^2)\psi = \rho$

Lee model $g^2 > g_{cr}^2$

(ultraviolet) $\Lambda \to \infty$ $g_{cr}^2 \to 0$

Pauli-Villars

Heisenberg

i) 中途性　不動性
ii) 確率概念 → 観測の問題
iii) hidden variable – acausality

Lorentz inv.　$a|0\rangle = 0$　$[a, a^*] = 1$
$b|0\rangle = 0$　$[b, b^*] = -1$

$\langle 0|b b^*|0\rangle = -\langle 0|0\rangle$

$|A\rangle \to \langle A|$　$\langle A|B\rangle = \{\langle B|A\rangle\}^*$
$\langle A|A\rangle = 0$,　$|A\rangle \neq 0$
h.c. → adj.

$\langle A|A\rangle = \langle B|B\rangle = 0$　$\langle A|B\rangle \neq 0$

P: self-adjoint
$P|p\rangle = p|p\rangle$　$\langle p|P = \langle p|p^*$
$(p - p^*)\langle p|p\rangle = 0$
$(p_1^* - p_2)\langle p_1|p_2\rangle = 0$

eigen-vector だけで complete set をなすか？
限られない　$k > 1$
$(P - m)^k |A\rangle = 0$
$(P - m)^{k-1} |A\rangle = |B\rangle \neq 0$
$|A\rangle$ を仮定（但し、eigenvector ではない）
$\langle B|B\rangle = 0$

$\langle t|t\rangle \to$ 負も

の場合 is pseudo-unitarity

$S^\dagger S = S S^\dagger = 1$

$$\sum_m |\langle t,m|S|t,i\rangle|^2 - \sum_n \langle t,n|S|t,i\rangle^2 = 1$$

$S \to \tilde{S}$　$\tilde{S}\tilde{S}^\dagger = \Lambda_p$

a) Bogolinbov　　　予定調和

$|p\rangle, |u\rangle$

$\tilde{S} \uparrow \uparrow S$

$|p\rangle, |u\rangle = N|p\rangle$

$\tilde{S}|p\rangle = P_p S (P_p + N)|p\rangle$

1) $\tilde{S}\tilde{S}^\dagger = \tilde{S}^\dagger\tilde{S} = P_p$

2) $|u,i\rangle + |u,f\rangle = 0$　　$P_u = 1 - P_p$

$$\tilde{S} = P_p S [P_p - (P_u + P_u S P_u)^{-1} P_u S P_p]$$

S　local interaction

$\tilde{S}$　non-local interaction

causality

I　　II

$S = S_I S_{II}$

$\tilde{S} \neq \tilde{S}_I \tilde{S}_{II}$

Sudarshan P. R. 123 (1961), 2183

physical state

1) positive norm

2) scattering operator S の eigenvector

$$\tilde{S} = P_p S P_p$$

$$\tilde{S}^\dagger \tilde{S} = P_p S P_p P_p S^\dagger P = P_p$$

$$S = \exp(i\delta) \qquad \delta = \begin{pmatrix} a+b & ic+d \\ ic-d & a-b \end{pmatrix}$$

eigenvalues: $a \pm [b^2 - (c^2+d^2)]^{1/2}$

<u>Approximate unitarity</u>

確率解釈が近似的に許され[illegible]?

energy の eigenvalue が[illegible].

$$H = \cdot\, m_\nu a_\nu^\dagger a_\nu$$

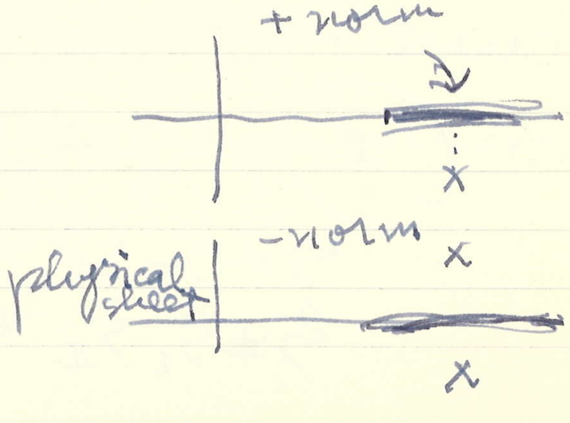
$$[a_\nu, a_\nu^\dagger]_+ = -1$$

$$a_\nu |0\rangle = 0 \qquad H a_\nu^\dagger |0\rangle = m_\nu a_\nu^\dagger |0\rangle$$

$$m_f \to \Lambda$$

[Gupta, P. R. S. 1953

instability



Heisenberg
multi-pole ghost

$$\frac{1}{p^2+\varkappa^2} - \frac{1}{p^2+\mu^2} + \frac{\varkappa^2-\mu^2}{(p^2+\mu^2)^2}$$

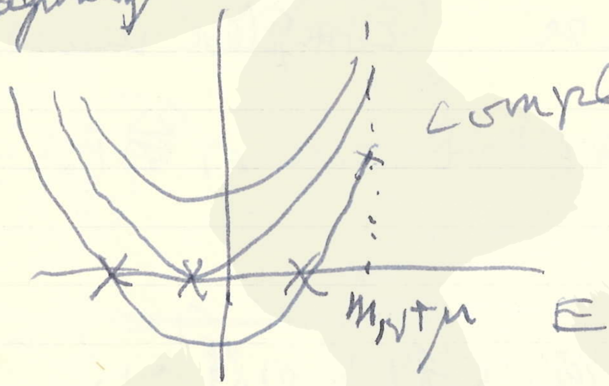
Lee model

$V \rightleftarrows (N, \theta)$　　g_0, m_V

$$S'_V = \frac{1}{h(z)}$$

$$h(z) = \frac{z-m_V}{g_0^2} + \int \frac{k^2 dk}{2\omega(\omega+m_N-z)}$$

(g_0: pure imaginary) $h(E)$



a) 二つの根 E_-, E_+
b) E_0 二重根 (0-norm, dipole)
c) 複素根 α, α^*

$$\langle \Phi_i | \Phi_i \rangle = |c|^2 h'(E_i)$$

b) $\Phi_0(t) = e^{-iE_0 t}\Phi_0(0)$
$\Phi_D(t) = e^{-iE_0 t}\Phi_D(0) - ict\,\Phi_0$

散乱波動で Ψ は束縛状態をふくむ
(Φ_b はふくまない)

$\Psi(-\infty) = \Phi_p + a\Phi_0$

↓

$\Psi(\infty) = \Phi'_p + a'\Phi'_0 + \cancel{\Phi_b}$

double scattering?

Nagy

complex pole theory

→ instability

Relativistic Case　　complex mass

$\Psi(x, \xi_\mu)$

ξ_μ: time-like vector の無限の set.

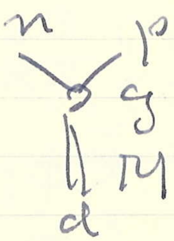
第3回

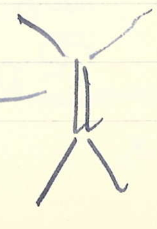
位田氏；素粒子と複合粒子の違い

1) Ψ: 素粒子. Lagrangian
書かれている場に結合

2) $F(m, g) = 0$
m, g を勝手に決められるのか条件で

3) 漸近的振舞
Levinson の定理
$\delta(\infty) = 0$　素　?
$= -\pi$　複合　?





一般にはこれだけではすまない

4) くりこみ定数

$Z_3 > 0$ 有限　$(1 \geq Z_3 \geq 0)$

$= 0$ 発散

5) Regge 太田 $\begin{cases} \text{動かない} \\ \text{動く} \end{cases}$ 一致 発散

$$\Delta'_F(s) = \frac{1}{\mu^2 - s} + \frac{1}{\pi}\int^{\infty} \frac{\sigma(s')}{s'-s}\, ds'$$

$\shortparallel$
Δ_F

$\sigma(s) \geq 0$

$$Z_3(s) \equiv \frac{\Delta_F(s)}{\Delta'_F(s)} \qquad Z_3(\infty) \equiv Z_3$$

$Z_3 > 0$ 有限 $\begin{cases} \int^{\infty} \sigma\, ds < \infty & \mu_0^2 \text{ 主発散} \\ \int^{\infty} s\sigma\, ds < \infty & \mu_0^2 \text{ 有限} \end{cases}$

~~$Z_3 = 0 \quad \int^{\infty} \sigma\, ds \ldots$~~

$$\mu_0^2 = \frac{\mu^2 + \frac{1}{\pi}\int s\sigma\, ds}{1 + \frac{1}{\pi}\int \sigma\, ds} = \langle s \rangle_{av.}$$

$$= \frac{\int s\tilde\sigma\, ds}{\int \tilde\sigma\, ds} \qquad \tilde\sigma = \delta(s-\mu^2) + \frac{\sigma}{\pi}$$

$$> \mu^2$$

$Z_3 = 0$ 発散 $\left\{ \int^{\infty} \sigma\, ds = \infty \right\} \begin{cases} \int^{\infty} \frac{\sigma}{s}\, ds < \infty \\ \int^{\infty} \frac{\sigma}{s^2}\, ds < \infty \end{cases}$

$Z_3 \neq 0$: lepton $\left\{ \begin{array}{l} \nu \quad (\gamma ?) \\ e, \mu \end{array} \right.$

$Z_3 = 0$: hadron $\left\{ \begin{array}{l} B_8, P_8 \\ B_{10} \ldots \quad \text{bootstrap} \end{array} \right.$

observable　　Thales

エンペドクレス 四元素　　磁石

アナクサゴラス [illegible]

デモクリトス

構成力 (内)　　相互力 (外)

[illegible] → 磁石

U(3)

アナクシマンドロス　Urmaterie　　粒子

一元論　　obs.

多元論

SU(3)

quarks → hadrons

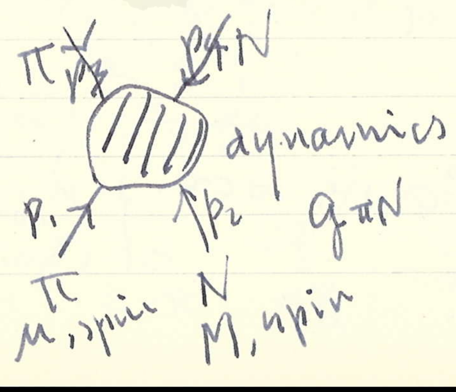
urbaryons

第3回 [illegible]

[illegible]: Bootstrap

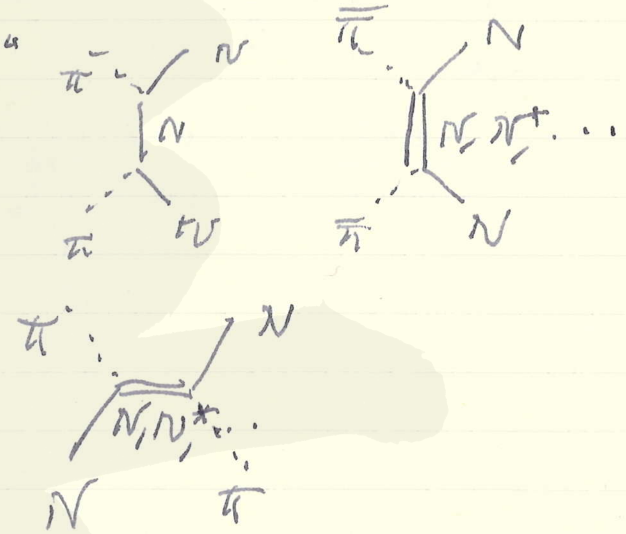
1960: Chew-Mandelstam　　π-π → vector

1961: Chew-Frautschi



input → [ ] → output
resonance
bound state M', g'

結合力
"crossing"



N/D の方法.

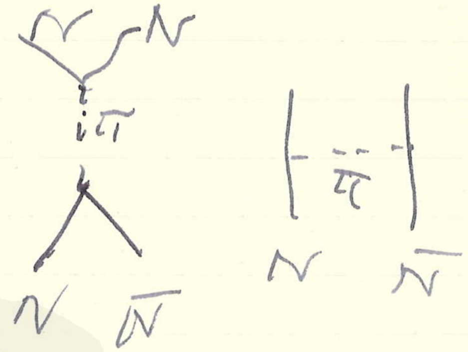
$T(s, t, u)$

$s \equiv -(p_1 + p_2)^2$

$\quad = -(p_3 + p_4)^2$

$t \equiv -(p_1 + p_3)^2 = -(p_2 + p_4)^2$

$u \equiv -(p_1 + p_4)^2 = -(p_2 + p_3)^2$



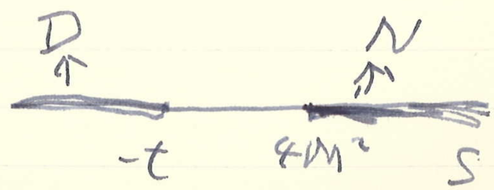
同種粒子の散乱

$s = 4(p^2 + M^2)$

$t = -2p^2(1 - \cos\theta)$

$u = -2p^2(1 + \cos\theta)$

$s + t + u = 4M^2$



one channel:

$$D(s) = 1 - \frac{s_1 - s_0}{\pi} \int_0^\infty \frac{\rho(s') N(s')}{(s'-s_0)(s'-s)} ds'$$

$$N(s) = \frac{1}{\pi} \int_{-\infty}^{0} \frac{\mathrm{Im}\, T(s', t, u) D(s')}{s'-s} ds'$$

$$T(s) = \frac{N(s)}{D(s)}$$

(1) $D_{re}(m^2) = 0$ mass eq.

(2) $g^2 = -\left.\frac{N(s)}{D'(s)}\right|_{s=m^2}$ residue eq.