R, I,

NOTE BOOK

Manufactured with best ruled foolscap
Brings easier & cleaner writing

April, 1970 ~
~ July, 1971

VOL. R. I.

H. Yukawa

Nissho Note

日章 B △ 100

INDEX

CHAPTER	DESCRIPTIONS	PAGE

G. Börner

Some Aspects of Q.F.T.
in curved space-time

April 9, 1970　　基研談話会

embedded in 5-dim. Mink. space

$\eta_{ab} = \mathrm{diag}\,(+ - - - -)$

$\xi^a \eta_{ab} \xi^b = -R^2$

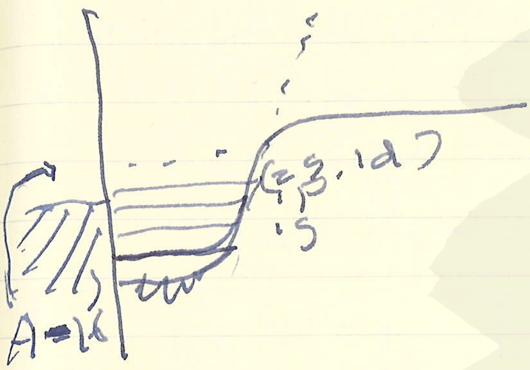
$SO(1,4)$　　$a, b = 0, 1, \ldots 4$

$T^{\mu\nu} = 0$,　　$\lambda \neq 0$

$B_\mu = \frac{1}{R} J_{4\mu}$　　$\mu = 0, \ldots 3$

Malcolm Harvey
(Chalk River Nucl. Lab.)
April 10, 1970

SU(3) Model and Hartree-Fock Model



$A = 16 \sim 40$

$H = H_0 + V$

$\left\{ \begin{array}{l} Q = (r_i^2 Y^2 + p_i^2 Y^2) \\ L \end{array} \right.$

SU(3)　Elliot

$V = \sum \left(\xi_0 + \xi_2 \frac{r_{ij}^2}{a^2} + \xi_4 \frac{r_{ij}^4}{a^4} + \cdots \right)$

$A_{ij} = \frac{1}{2}(a_i^\dagger a_j + a_j a_i^\dagger)$

$a_x^\dagger = \sqrt{\frac{1}{2}}(x + i p_x)$ . . .

SU_3

$\downarrow$ $SU_2 \times U_1$　$\searrow$ R_3

Hartree-Fock

V_c: avg potential → SU_3

comparison with experiment

^{28}Si

^{20}Ne　SU(3)

QQ + Pairing

QQ + (SL)

Arima

[illegible]氏

April 21, 1970

[illegible] ~~[illegible]~~ [illegible] の Example

と[illegible]

Poincaré 群 の generator を operator

が[illegible]

$P_l = \overset{(0)}{P}_l,$

$M_{lm} = \overset{(0)}{M}_{lm}$

$P_4 = \overset{(0)}{P}_4 + \sum_n \overset{(n)}{P}_4$

$M_{4l} = \overset{(0)}{M}_{4l} + \sum_n \overset{(n)}{M}_{4l}$

→ generator equations に[illegible]

"場" を[illegible]と、[illegible] simple で[illegible]、

$$N = \int \frac{d\mathbf{k}}{k_0} A^\dagger(\mathbf{k}) A(\mathbf{k}) \qquad k_0 = \sqrt{\mathbf{k}^2 + m^2}$$

$$[P_\mu, N] = [M_{\mu\nu}, N] = 0$$

[illegible]の[illegible] N

$$P_\mu, \quad W_\alpha = \varepsilon_{\alpha\beta\sigma\delta} M_{\beta\sigma} P_\delta$$

[illegible]

bound state

scattering state

wave packet の[illegible]

$$\langle pp' | S | qq' \rangle = \frac{1}{\sqrt{p_0 p_0' q_0 q_0'}} \langle\langle p, p' | q, q' \rangle\rangle^{(+)}_{(-)}$$

unitary

梅内氏

R. Gatto, Revista del Nuovo Cim. 1, 514 ('69)

Leading Divergences in Weak Interactions, the Algebra of Compound Fields and Broken Scale Invariance.

講演 2124号 17日　April 28, '70

$$\mathcal{L}_W = g_i \{ j_\mu^c W^\mu + j_\mu^{c\dagger} W^{\mu\dagger} \} :$$

$$S_{\alpha\beta} = \delta_{\alpha\beta} - \delta^4(P_\alpha - P_\beta) M_{\alpha\beta}$$

Chiral $SU(3) \otimes SU(3)$

$$\mathcal{L} = \mathcal{L}_0 - H'$$

$$H' = \sum_{l=0}^{\infty} \varepsilon_l u_l(x)$$

↑ ps density

$(3, 3^*), (3^*, 3)$

$u_l \to v_l$

$$[F_i, u_l] = i f_{ilk} u_k$$

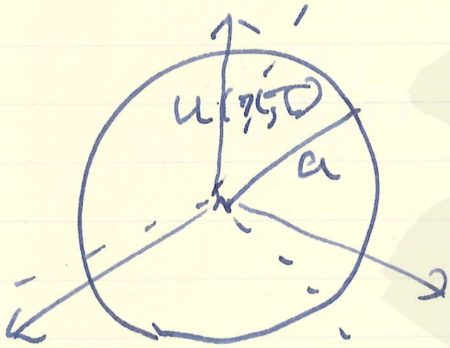
$$v_l \qquad v_k$$

$$[F_i^5, u_l] = -i d_{ilk} v_k$$

$$[F_i^5, v_l] = i d_{ilk} u_k$$

原治氏
Deformable Sphere Model of Hadrons
基研　May 18, 1970

non-relat.　　non-homog. deform.

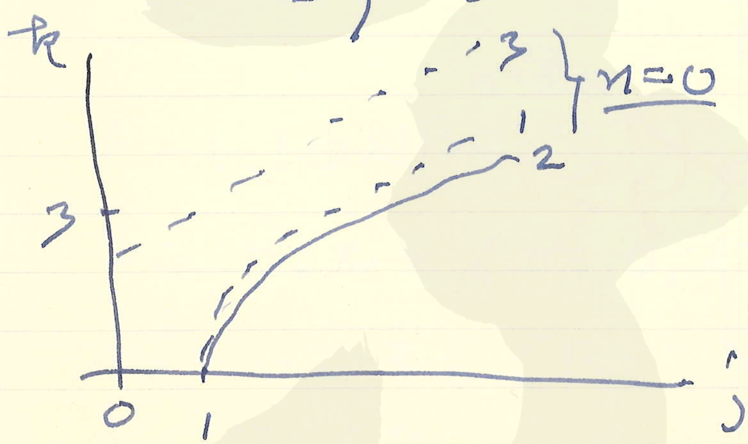


$\frac{u}{a} \ll 1$

$X_i = x_i + u_i$

(φ, θ, ψ)

$T = \frac{1}{2}\int \dot{X}_i^2\, dm$



truncated system
$S = J$ の条件を満たす level だけ考える.
$S - J = \omega$

$\frac{\hbar^2}{I\mu a^3} \ll 1$

$S - J = 0$ or $1/2$

$S = J + \sigma$ $\qquad S = \frac{\sigma}{2}$ $(\sigma \neq 0)$

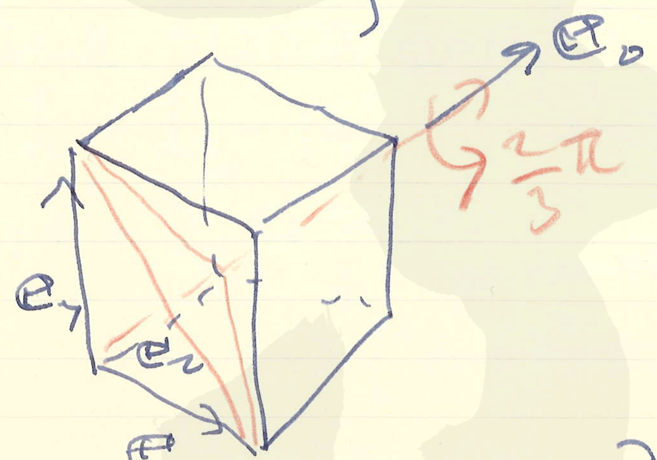
$S = J$

$$L = \frac{1}{2}\int\left\{\rho\, \dot{u}^*_\alpha u_\alpha + u^*_\alpha F u_\alpha\right\} dv$$

quark or boson

triality

$I_{rs} \to I_p$



$$U_t = e^{i\alpha(m-n)}$$

$m - n = 3N$

$$\alpha = \frac{2\pi}{3}$$

$U_t \psi = \psi$

$$H = \nu \sum (l + an + b)(n^2_{lmn\alpha} + n^2_{lmn\alpha})$$

$$+ \Delta\nu \sum (n^3_{lmn\alpha} + n^3_{lmn\alpha})$$

$$+ \frac{1}{2I} \sigma^2$$

? $m^2 =$ ' ' $+ m_0^2$

B (3.0) (4, 1) (5, 2) - -

M (1, 1) (2, 2) - -

normal exotic

$\nu = 1.10 \times (\mathrm{BeV})^2$

$c = 0.24$ (or 0.23) $(\mathrm{BeV})^2$

$m_0^2 = -0.98\ (\mathrm{BeV})^2$

$b = 0.49\ (\quad)^2$

鶴田さん (Smithsonian Institution)
Neutron Star
受領：5月20日, 1970

1930年ごろ　Oppenheimer, Volkoff
Zwicky

戦後　Wheeler, Wakano
1964：X-ray
1968：Pulsar

$\rho > 10^{12}$ gm/cm^3　　neutron matter
$5 \times 10^{13} \sim 10^{14}$　　n, p, e^-
$\rho > 10^{14}$　　μ, hyperon

general relativity
核力

超流動
超伝導

neutron star → crystal
の中の matter

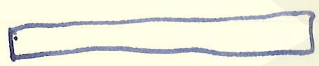
$10^{14} > \rho > 10^{11}$

Pulsar

[illegible]二郎

"Lorentz 収縮はどう見えるか"

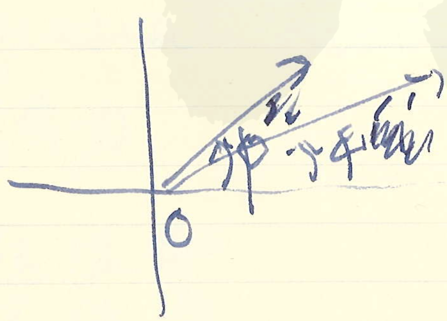
基研 May 25, 1970

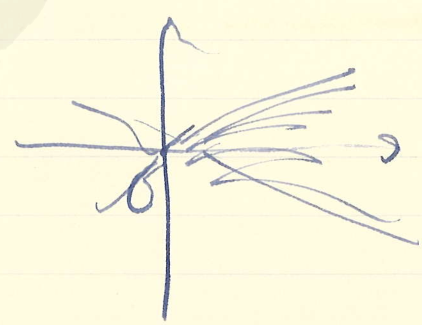


1959 Terrel, Phys. Rev.

aberration

$$\tan\phi' = \frac{\sqrt{1-v^2/c^2}\,\sin\phi}{\cos\phi + v/c}$$



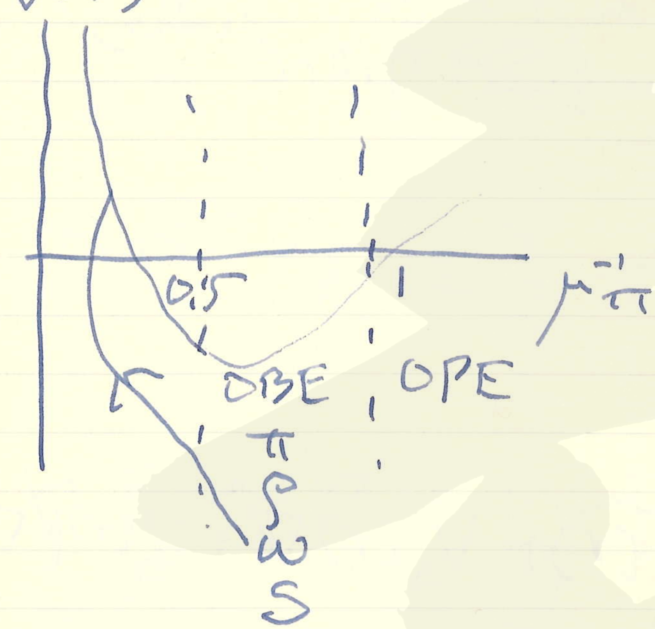


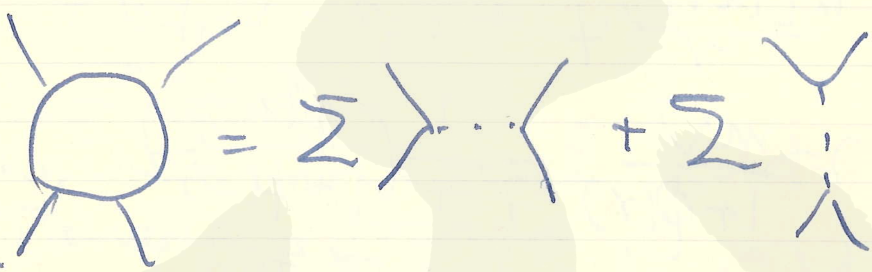
上田信男

核子・核子散乱と extended particle model

講演　June 9, 1970

$V(r)$（要約など）





OBE

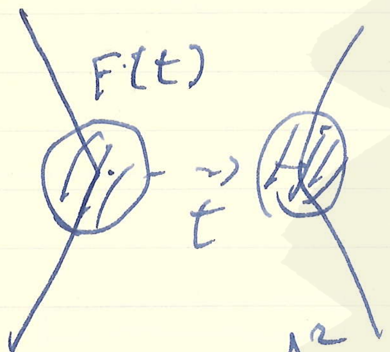
$E_{lab} < 350$ MeV　　　P波はOK

$^1S_0$ はうまくいかない…

結合 $\left(\begin{array}{l} g_\omega^2 = 6 \sim 10 \\ g_\omega^2 = 25 \sim 35 \end{array} \right.$

① 'S の form factor で確認
② 高エネルギー (> 5 GeV) での振舞
③ non-locality

①



$$S = \eta(s)\, e^{2i\delta(s)}$$

$$F(t) = \frac{\Lambda^2}{t + \Lambda^2}$$

$$V(r, \nabla) = \bar{V}(r) + V_\Delta(r)\nabla^2 + V_\Delta(r)(r\nabla)$$

$$\psi'' - \frac{m\,l(l+1)}{r}\psi + (p^2 - V_{eff}(r))\psi = 0$$

$$V_{eff}(r) = \frac{m\bar{V}}{1+\phi(r)} - \frac{1}{4}\left(\frac{\phi'(r)}{1+\phi(r)}\right)^2 + p^2\frac{\phi(r)}{1+\phi(r)} + \frac{1}{2}\frac{\nabla^2\phi(r)}{1+\phi(r)}$$

$$\phi^{NE}(r) = \frac{1}{m}\sum_{i=s,v} g_i^2 \frac{e^{-\mu_i r}}{r}$$

$$\phi^{E}(r) = \frac{1}{m}\sum_{i=s,v} g_i^2 \left(\frac{\Lambda_i^2}{\Lambda_i^2 - \mu_i^2}\right)\left[\frac{e^{-\mu_i r}}{r} - \frac{e^{-\Lambda_i r}}{r}\left(1 + \frac{\Lambda_i^2 - \mu_i^2}{2\Lambda_i} r\right)\right]$$

(2) $\dfrac{E^{2l}}{\tau-\tau_0}$

pp 5 GeV にムトーで g_ω^2 が $\tau \to \tau$
比べて考えれば

$\frac{d\sigma}{d\Omega}$, P, Re/Im : OK

Duality $\sum$ = t-ch Regge

s

H.E. pp = + diffraction

structure

[3] non-locality
original bilocal field
Tanaka - Bando
more general bilocal field

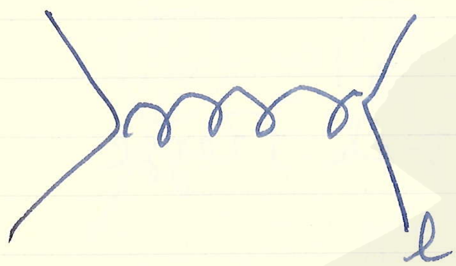
$$\begin{cases} F\left(x_\mu^2,\ x_\mu \frac{\partial}{\partial x_\mu}\ \left(\frac{\partial}{\partial x_\mu}\right)^2\right) U(X, r) = 0 \\ (\Box_X + M^2)\, U = 0 \\ x_\mu \frac{\partial}{\partial X_\mu}\, U = 0 \end{cases}$$

Fierz 展開:

$$U(P,x) = \delta(Px)\sum_{l=0}^{\infty} b_l\, x_{\mu_1}\cdots x_{\mu_l}$$

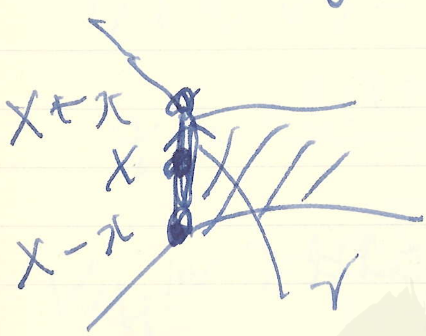
$$\times\, u_{\mu_1\cdots\mu_l}(P, x^2)$$

$$b_l = (-1)^l\sqrt{\frac{(2l+1)!}{4\pi l}}$$



$$H(X) = g\int d^4x\, \psi^*(X+x)\,\psi(X-x)$$

$$\times\, U(X,x)$$



$$\langle 0|U(P,Q)\,U^*(P',Q')|0\rangle$$

$$= \delta(P-P')\,\Delta(P^2,M^2)\,N(P^2,Z)$$

$$N(P^2,Z) = \frac{4\pi}{(P^2)}\sum_{l=0}^{\infty}(2l+1)\underbrace{(h_l(Q^2))^2}_{h_l(Q^2)\,h_l(Q'^2)}P_l(-Z)$$

$$Z = -1 - \frac{8E^2}{Q^2} = -\frac{QQ'}{Q^2}$$

$$h_\ell(Q^2) = \int_0^\infty dr\, r^{2+\ell} j_\ell(\sqrt{Q^2}r) f_\ell(r^2)$$

$\partial \ell$

$Q^2 > 0$

$$= \int_0^\infty dr\, r^{2+\ell} i_\ell(-\sqrt{-Q^2}r) f_\ell(r^2)$$

$Q^2 < 0$

$$i_\ell(z) = \sqrt{\frac{\pi}{2z}}\, I_{\ell+\frac{1}{2}}(z)$$

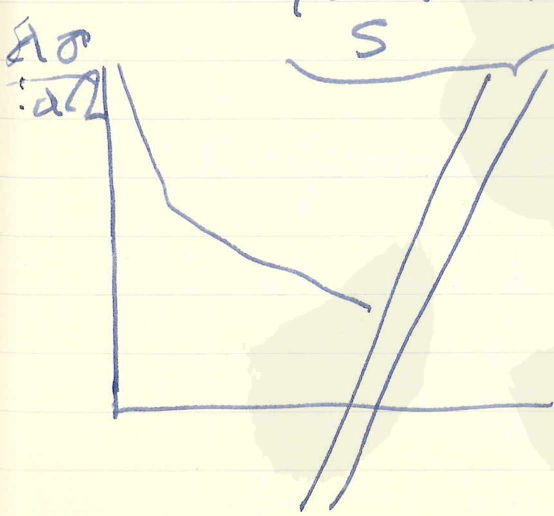
pp散乱の実験式

Orear　　5 GeV ~ 30 GeV

$$\frac{d\sigma}{d\Omega} = B p^2 \exp(-\alpha p_T^2)$$

$\to$ 多重散乱 Im. part

$$\underbrace{+\frac{A}{s}\exp\left(-\frac{p_T}{p_0}\right)}_{\text{Re. part bilocal exchange}}$$



$$A^{emp}(p^2, z) = \sum_{n=1}^{3} A_n \exp\left(-\frac{\sqrt{-Q^2}}{2p_0} \times (a_n z + b_n)\right)$$

$$F(p^2) = \left(\frac{\Lambda^2}{p^2+\Lambda^2}\right)^{1 \text{ or } 2}$$

Mr. 梅村氏

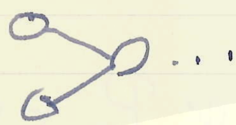
N.C. LXVI A No. 1. (1970) p. 36

Unified Treatment of hadrons

A. O. Barut, P. Cordero and G. C. Ghirardi

~~若~~研 ~~セミナー~~ ゼミ. 6月16日, 1970

$O(4,2)$

$O(6)$  $\sim SU(4)$

$$\sum_{a=1}^{6} \lambda_a X^a = \text{inv.} \equiv g_{ab} X^a X^b$$

$$(a, b = \underbrace{1, 2, 3, 4}_{\text{space}}; \underbrace{5, 6}_{\text{time}})$$

$$- \; - \; - \; - \; + \; +$$

15-generators

$$[L_{ab}, L_{cd}] = -i(g_{ac} L_{bd} + \cdots)$$

$$L_{ab} \equiv \frac{i}{2} \gamma_a \gamma_b \quad (a \neq b)$$

$$\gamma_a \equiv (\gamma_1, \gamma_2, \gamma_3, -\gamma_5, \gamma_0, -iI)$$

$$\gamma^5 \equiv \gamma^0 \gamma^1 \gamma^2 \gamma^3$$

$$\gamma^i = \begin{pmatrix} 0 & \sigma_i \\ -\sigma_i & 0 \end{pmatrix}$$

4-dim. repr.

L^{05} $\quad J^2 \quad L^{12} \equiv J^3$

$n \quad j(j+1) \quad m$

4dim $\to$ $n = \pm\frac{1}{2}$, $j = \frac{1}{2}$, $m = \pm\frac{1}{2}$

$$j_\mu = \bar{\psi}(x)(\alpha_1 \gamma_\mu - i\alpha_2 \overleftrightarrow{\partial}_\mu)\psi$$

$\downarrow$

$$\Gamma_\mu = \alpha_1 \gamma_\mu - \alpha_2 P_\mu + \alpha_6 (\gamma P) P_\mu + \alpha_8 (\gamma \cdot q) P_\mu$$

$$\left(i\alpha_1 (\gamma_\mu \partial_\mu) + \alpha_2 \partial_\mu \partial_\mu - i\beta(\gamma_\mu \partial_\mu)\partial^2 - \kappa \right)\psi(x) = 0$$

$\beta = \alpha_6 + \alpha_8$

$\kappa = \beta m_\nu m_e m_\mu$

$\beta m^3 - \alpha m^2 + \alpha_1 m - \kappa = 0$

$m_\nu = 0$, $\kappa = 0$ $\Big\} \downarrow$

$\beta m^2 - \alpha_2 m + \alpha_1 = 0$

$m_e + m_\mu = \alpha_2/\alpha_6$

$m_e m_\mu = \alpha_1/\alpha_6$

$$(i\gamma_\mu\partial_\mu - m_e)\left(i\gamma_\mu\partial_\mu - m_e + \frac{a_2}{a_1}\right) = 0$$

$$\gamma_\mu^{\sim al} = \gamma_\mu - \frac{a_6}{a_2}\gamma_\mu - \frac{a_6}{a_2}\gamma_{\mu\nu}q^\nu$$

[illegible]

因果律の破れとPomeranchuk の定理

6月30日, 1970

Pomeranchuk theorem → local field theory

↓

non-local field theory

1) $\sigma^{tot}_{AB}(\infty) = \sigma^{Tot}_{\bar{A}B}(\infty)$

$\left[\text{if } \lim_{E\to\infty} \sigma^{tot}_{AB}(E) = \sigma_{AB}(\infty) < \infty \right.$

$\left. \lim_{E\to\infty} \sigma^{tot}_{\bar{A}B}(E) = \sigma_{\bar{A}B}(\infty) < \infty \right]$

2) Serpukhov の実験
[P. L. 30B ('69) 500]

20 GeV ~ 65 GeV

i) $\pi^- - p$, $\pi^- - n$ $(= \pi^+ - p)$

$K^- - p$, $K^+ - n$

の σ^{tot} は 30 GeV 以上で一定.

$\bar{p} - p$, $\bar{p} - n$ とは減少している

$\sigma(\pi^- - p) = 25$ mb

$\sigma(\pi^- - n = \pi^+ - p) = 24$ mb

$\sigma(K^- - p) = 21$ mb

$\sigma(K^+ - p) = 20$ mb

(ii) $\sigma(\pi^- - p) - \sigma(\pi^- - n \approx \pi^+ - p) \approx 1.3 \pm 0.7$ mb

$\sigma(K^- - p) - \sigma(K^+ - p) = (3 \sim 4)$ mb

20 GeV に extrapolate

17 mb

$\sigma(K^- - p) - \sigma(K^- - n) \approx 1.0 \pm 0.6$ mb

3) Pomer. Theor. の仮定
Soviet Physics JETP 7 (158) 499
素粒子論の論理 p.289 以下 ([illegible])
河原林氏
散乱振幅 F(E, 0) analytic or dispersion relation を満たす

microcausality
charge-independence
unitarity

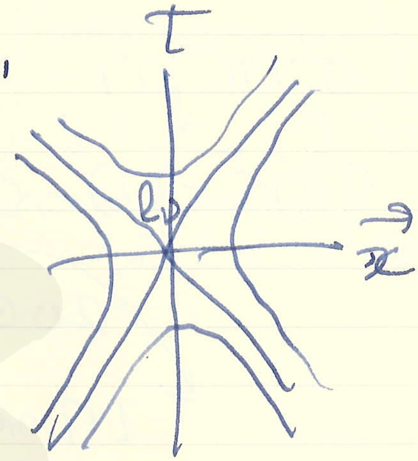
$$\lim_{E \to \infty} \frac{F(E,0)}{E} = \text{const.}$$

4) micro-causality

$[A(x_1), B(x_2)] = 0$　x_1, x_2: space-like

[illegible]

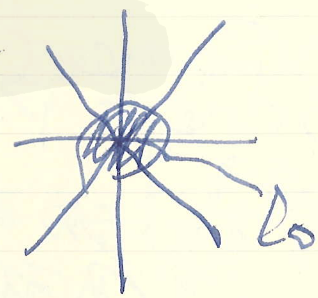
i) $|x^2| < l_0^2$ ならよい



ii) Blochintsev, 四元 time-like vector

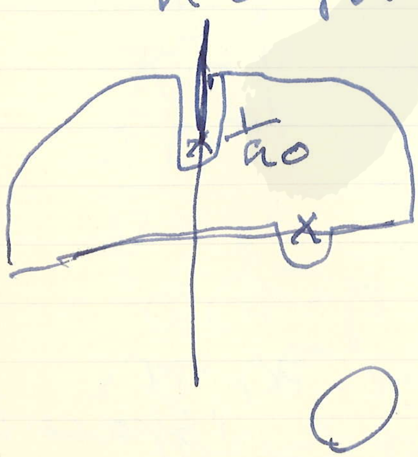
$|x^2 - 2(nx)^2| < l_0^2$

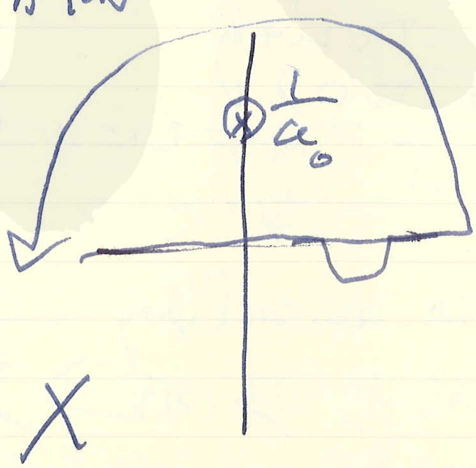
$n(1,0,0,0)$



1) 相互作用する素粒子と関係してる場合
全運動量の方向 をn.

2) 真空に関係してる場合
nが特別にない方向





D. I. Blochintsev and G. T. Kolerov

~~D. I.~~ N. C. 34 ('64), 163

spectral condition

$$p_\mu p^\mu = p_0^2 - \vec{p}^2 = m^2 > 0$$

$$p_0 \geq 0$$

$$\rho = \sqrt{\frac{\Omega^2}{\omega^2 + \Omega^2}}$$

$$\Omega = \frac{1}{a_0}$$

$\pi^\pm - p$:

$$\sigma_+(\omega) - \sigma_-(\omega) = 8\pi \left[\qquad \right]$$

$$a_0 \simeq 10^{-15}\ \mathrm{cm}$$

混沌会

July 16, 1970

片山氏:

lepton : Barut

QED : Lee-Wick

indefinite metric

$\Gamma_\mu(p, q)$ weak lepton current $\begin{cases} p = p_1 + p_2 \\ q = p_1 - p_2 \end{cases}$

$q^\mu \Gamma_\mu = 0 \longrightarrow$ 3種の粒子 ν e μ

$f(m) = 0$

lepton m_i $i \geq 3$

$f(\gamma p)\psi(p) = 0$

$f(m_i) = 0$

$$f(x) = e^{g(x^2)} \prod_{i=1}^{\infty} (x - m_i)$$

$$f(\gamma p) = (\gamma p - \nu_1)(\gamma p - \nu_2)(\gamma p - m_e) \times (\gamma p - m_\mu) \tilde{f}(\gamma p)$$

ν_1, m_e : positive metric.

ν_2 m_μ : negative metric

S: unitary

$\langle x | (-1)^{\bar{q}q} \cdots | x \rangle$ positive

〃
η

$N_\mu + N_{\nu_2}$: invariant

① muon number の保存
(e-number の保存)

electromag. current

$f(\gamma p)\psi(p) = 0$

$\gamma p \to \gamma(p - eA)$

② $\nu_1 = \nu_2$:

$(\gamma p - \nu)^2$

③ neutral current → no effect

weak current

$\Gamma_\lambda^W = g\left(\frac{p^2+q^2}{2}, pq\right)\gamma_\lambda \frac{1+\gamma_5}{2}$

$g(m_1^2 + m_2^2, m_1^2 - m_2^2)$

$g(\ ) = \sqrt{G}(pq)\,\Pi\left(\frac{p^2+q^2}{2} - m_{2i}^2 - m_{2j-1}^2\right)$

(3) universality
$\langle e\nu\rangle$, $\langle \mu\nu'\rangle$
$\sqrt{m_\nu^2 - m_{\nu'}^2}$ の order

田中正(?)、　e, μ　QED

γ

$\gamma_\mu \to z, \frac{\partial}{\partial z}, \rho, \frac{\partial}{\partial \rho}$

$\left(\Gamma_\mu \frac{\partial}{\partial x} + \varkappa\right)\psi = 0$

$[\Gamma_\mu, \Gamma_\nu] = S_{\mu\nu}$

$(S_{\mu\nu}, \Gamma_\nu) \to O(4,1)$

(spin
mag. mom $\to$ Zitterbewegung
くりこみ群

友沢幸男 (Univ. Michigan)
W-Boson
基研談話会 Aug. 11, 1970

Vector type charged W_μ, $m_W \gtrsim 3 \sim 5$ GeV

1958 V−A theory
G. F. G. M.

$$H_W = \frac{G_F}{\sqrt{2}} J_\mu^{\dagger} J_\mu$$

$$J_\mu = J_\mu^{\Delta S=0} \cos\theta + J_\mu^{\Delta S=1} \sin\theta$$

lepton current
$$+ \, l_\mu$$

leptonic
semi-leptonic

$$\left(\begin{array}{l} J_\mu = V_\mu + A_\mu \\ l_\mu = \overline{\binom{e}{\mu}} \gamma_\mu (1+\gamma_5) \nu \end{array} \right.$$

$$H = g J_\mu W_\mu$$

$$\frac{g^2}{m_W^2} = \frac{G_F}{\sqrt{2}} \qquad G_F = 10^{-5} m_N^{-2}$$

non-leptonic
$$H^{NL} = \frac{G_F}{\sqrt{2}} J_\mu^{\Delta S=0\dagger} J_\mu^{\Delta S=1} \sin\theta\cos\theta$$

G.L.C. angle $\sim \frac{1}{4}$

c033-865挟込

問題：あるいは説明すべきこと.

1) Amplitude real?

2) SU_3

$8 \times 8 = 1 + \underline{8} \cdots + \underline{27}$

$\Delta I = 3/2$ 小さい

3) CP violation（小さいがある）

$K_L \to 2\pi$

SU_3から出発する限り → CPは保たれざるを得ない…

W-bosonの種類

$\cancel{1}$, $\underbrace{8 \quad (9)}$, 27

$$(J_\mu)^\alpha_\beta = \bar{q}^\alpha \gamma_\mu (1+\gamma_5) q_\beta$$

$m_W = 10\,\mathrm{GeV} \sim 60\,\mathrm{GeV}$

W: octet かな…

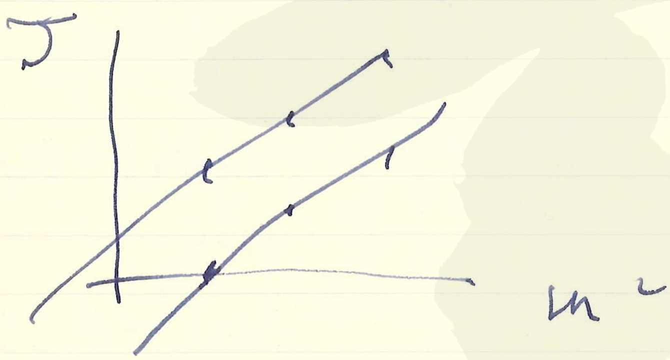
Pines, Neutron Star
Sept. 1970

Lichtenberg, quark-like model
Sept. 1970

江沢氏　第3回
Sept. 16, 1970

4a: quark-like - -

[illegible]: duality
V. Alessandrini et. al.
C. Lovelace



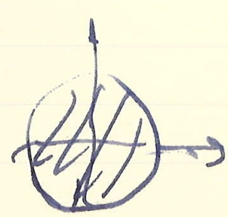
Reggeon

$V_N(\underbrace{p_1, \{a_i^\mu\}}; \ldots \quad p_N \{a_N^\mu\})$

$p = a^0$

a_μ

Dirichlet product



たるをしれ

めてし

Landau '70

荒木不二洋

spin · statistics

superselection rule

Sept. 24, 1970

{ Doplicher-Haag-Roberts '69
Drühl-Haag-Roberts '70

comm. or anticom.

Wightman field

1. 仮定 {covariant field of finite comp}

2. 反例 infinite field component free

3. para statistic (Green field)

Local Algebra

$(B) \to O(B)$

$B_1 \supset B_2 \to O(B_1) \supset O(B_2)$

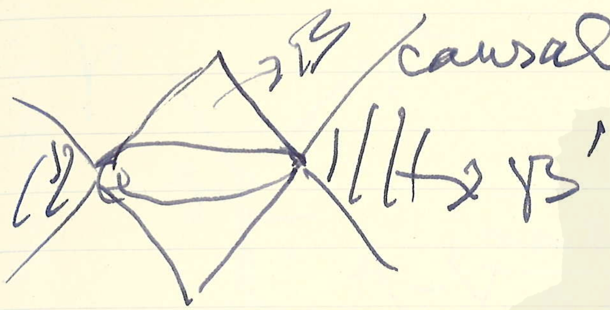
スペクトル条件 $P_0 \geq 0$

$P_0 = 0$ Ω

space-like $B_1 \sim B_2$: $O(B_1)$ と $O(B_2)$ は commute

Observable algebra

Field Algebra $\mathfrak{F}(B)$



causal adjoint

duality

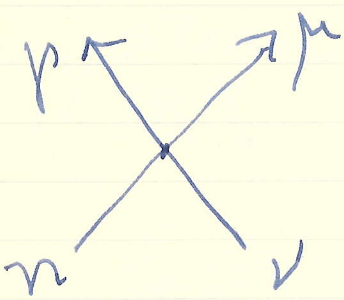
Weak Interaction

谷川安孝氏：T-boson

第4回，混沌会
Oct. 15, 1970

Simple structure

1) Fermi Interaction   V−A



$G\,\bar p\,\gamma_\mu(1+\gamma_5)n\;\bar\mu\gamma_\mu\nu$

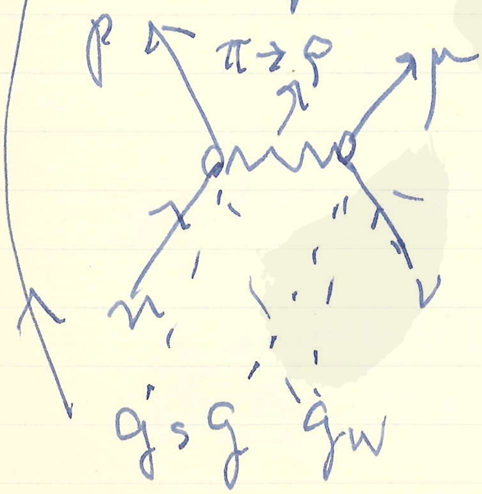
ν helicity —
two component

2) Yukawa-Ogawa- F-G.
vector boson theory

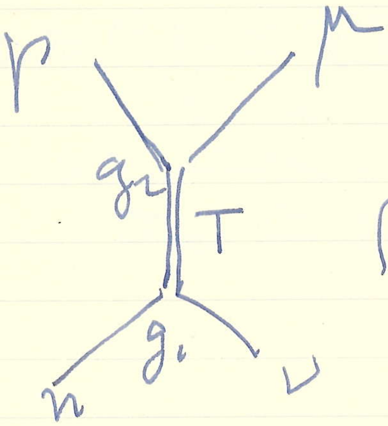
$g_w^2\,\bar p(x)\gamma_\mu(1+\gamma_5)n(x)\,D_{\mu\nu}(x-x')$
$\bar\mu(x')\gamma_\nu\nu(x')$

revival

V−A   ↑ weak boson



3) Tanikawa - Watanabe



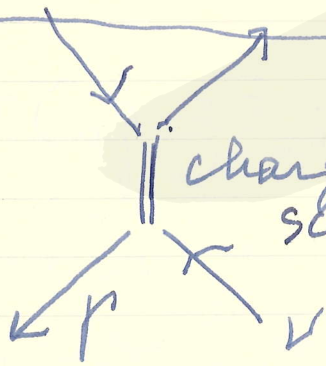
$\boxed{\text{neutral scalar}}$

$$g_1 g_2 \bar{p}(x)\gamma(1-\gamma_5)\mu^c(x)$$
$$\times D(x-x')\bar{\nu}^c(x')n(x')$$

V − A

(Fierz・Pauli 変換)

$\nu + n \to p + \mu$ resonance



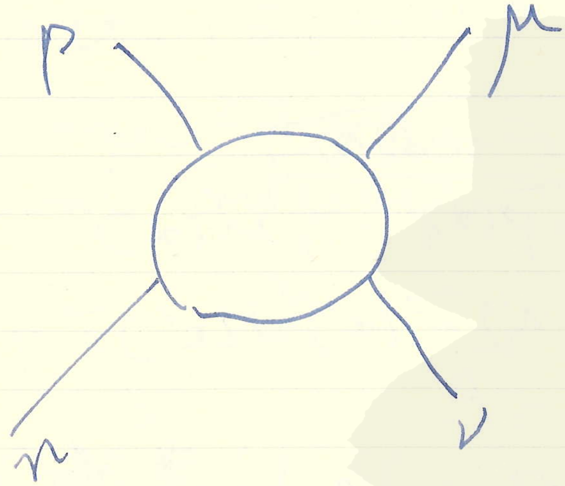
$$f_1 f_2 \bar{p}(x)\nu(x) D(x-x')$$
$$\bar{\mu}(x')(1-\gamma_5)n(x')$$
$$\downarrow$$

V + A

$\nu + \bar{p} \to \bar{n} + \mu$ resonance

neutral spin 1　　V + A

$\boxed{\text{charged spin 1}}$ vector　　V − A general structure



$$\sqrt{\mu_0 p_0}\,\langle \mu p | T | \nu n\rangle \sqrt{\nu_0 n_0}$$

$$= \bar p \left(F_V \gamma_\mu - \frac{F_V'}{M}\sigma_{\mu\nu} q_\nu - i\frac{F_S}{m_\mu} q_\mu\right) n \cdot$$

proton spinor

$$\times\ \bar\mu \gamma_\mu \nu$$

$$+ \bar p \left(F_A \gamma_\mu \gamma_5 - \frac{i F_P}{m_\mu}\gamma_5 q_\mu\right) n \cdot \bar\mu \gamma_\mu \nu$$

$$+ (\bar p F_T \sigma_{\mu\nu} n)\,\bar\mu\, \sigma_{\mu\nu}\, \nu + \cdots$$

CP invariance

$$F_V(t),\ F_A(t) = \left(\frac{1}{1+\frac{t}{M^2}}\right)^2 \qquad \to t$$

resonance ←

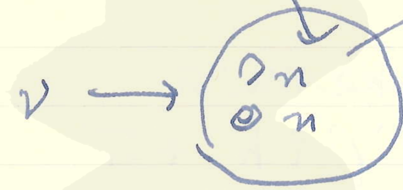
Kinoshita あり

CERNの実験 $\quad 10^{-38}\,\mathrm{cm}^2$

$\nu_0 \sim 2\,\mathrm{GeV}$ で resonance

Kinoshita

$\sigma_{res} \simeq 10^{-28}\,\mathrm{cm}^2 \quad \rightarrow 10^{-32}\,\mathrm{cm}^2$

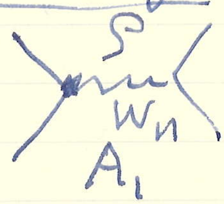
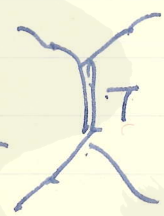


$$|g_1|^2 \ll |g_2|^2 \; ; \quad \frac{g_1 g_2}{M^2} = \frac{G}{\sqrt{2}}$$

$$\frac{g_2^2}{\hbar c} < 10^{-13}$$

$$\rightarrow \frac{g_1^2}{\hbar c} > 10^{-9} \quad \rightarrow 10^{-35}\,\mathrm{cm}^2$$

duality

$\sum_n$  $=$ $\sum_n$  spin 1 spin 0

$$\sum_n \frac{b_n(s)}{t-t_n} \qquad \sum_n \frac{C_n(t)}{s-s_n}$$

Saito model

$$F_V(t,s) = \sum_n \frac{b_n^V(s)}{t-t_n}$$

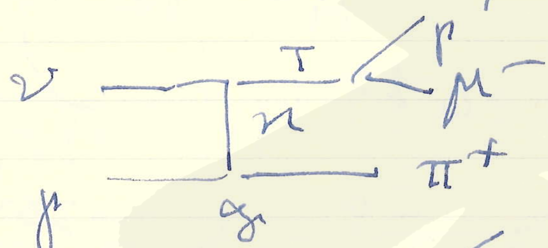
$$F_V(0,M^2) = \sum_n \frac{b_n^V(M^2)}{0-t_n} = G \quad \text{(Fermi constant)}$$

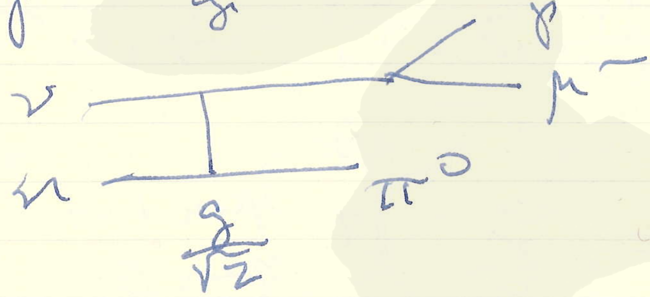
$$= \sum_n \frac{C_n^V(0)}{M^2 - S_n}$$

Tanikawa-Nakamura 。

$\nu + n \to p + \mu^- + \pi^0$ ①

$\to n + \mu^- + \pi^+$ ②





斎藤 : Saito model

$$F_V(s,t) = \frac{G}{\sqrt{2}}\left[V_1 \frac{\Gamma(1-\alpha_T(s))\Gamma(1-\alpha_\rho(t))}{\Gamma(2-\alpha_T(s)-\alpha_\rho(t))} - V_2 \frac{\Gamma(1-\alpha_T(s))\Gamma(1-\alpha_{\rho'}(t))}{\Gamma(2-\alpha_T(s)-\alpha_{\rho'}(t))}\right]$$

$$\alpha_T(s) = \frac{1}{3}\sigma(s - M_T^2) + 1$$

$$\alpha_P(t) = t + \tfrac{1}{2}$$

$$+0.5$$

$$\alpha_{P'}(t) = t + 0.4$$

岩崎君

「量子論における4次の重力ポテンシャルと2体系の近日点移動」

基研ゼミ　Nov. 10, 1970

Dicke-Goldenberg　⊙　5×10^{-5}

近日点移動　8%ズレル

harmonic coordinate → 等方座標

1体問題　flat

$$H=\frac{p^2}{2m}-\frac{p^4}{8c^2m^3}-\frac{\kappa mM}{r}-\frac{3GM}{2m}\frac{p^2}{r}+\frac{G^2}{2c^2}\frac{mM^2}{r^2}$$

2体問題　(Einstein-Infeld-Hoffmann-Fock)

$$H=\frac{1}{2}\left(\frac{p_1^2}{m_1}+\frac{p_2^2}{m_2}\right)-\frac{1}{8c^2}\left(\frac{p_1^4}{m_1^3}+\frac{p_2^4}{m_2^3}\right)-\frac{Gm_1m_2}{2c^2r}\left[\qquad\right]+\frac{G^2m_1m_2(m_1+m_2)}{2c^2r^2}$$

$$-\frac{Gm_1m_2}{r}$$

$) \sim f \kappa \sim \sqrt{G}$

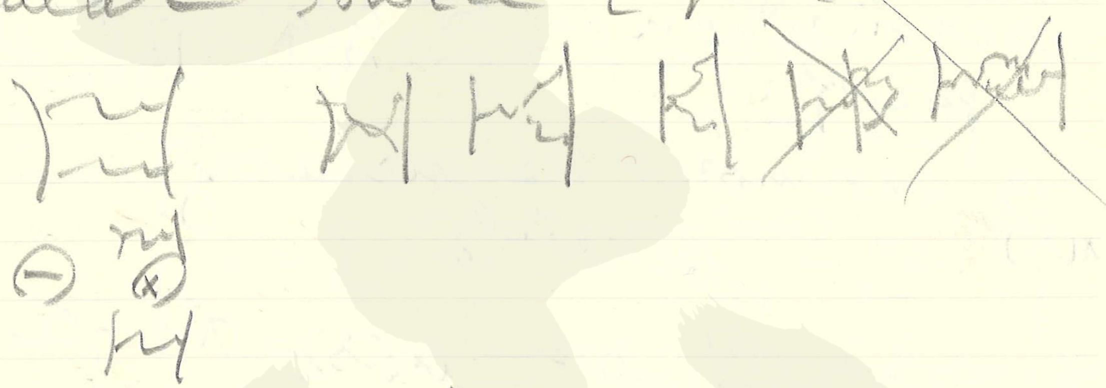
massless spin 2

gauge invariance

→ conserved energy-momentum
とcoupleする

→ self-interactionがある.

scalar sourceとすると



Einsteinとの食違いは出てこない

spinor ($\frac{1}{2}$) particle sourceとしたら
G^2 程度で食い違う,

Bergmann-Wignerによれば
Tapo　$\frac{N}{6} \times$ Einstein

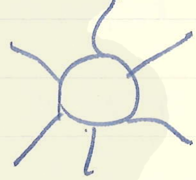
general ~~De~~ level structure of dual Resonance Model

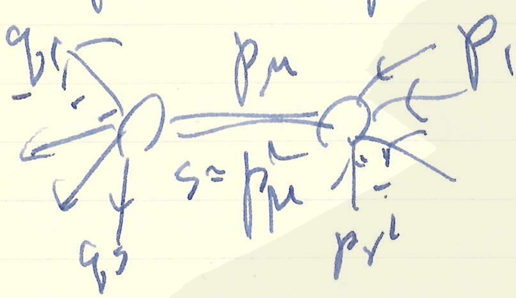
with J. Soffer (CERN)

位田正邦氏

~~東~~基研. Nov. 10, 1970

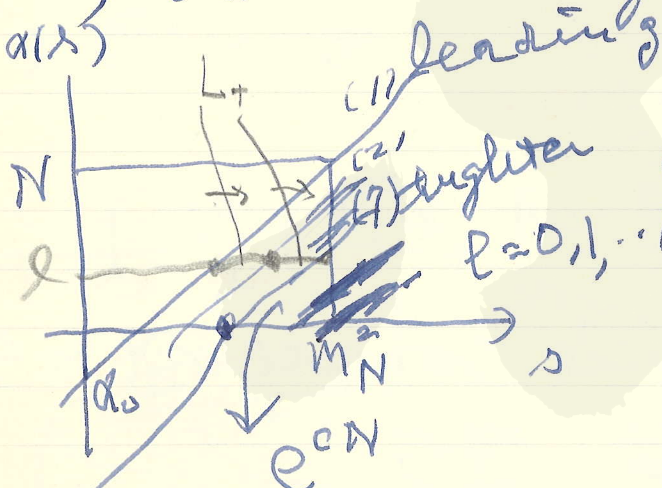
4 pt → N pt





factorization prop. $\sum_i g_i(q_j) f_i(p_i)$

→ enormous degeneracy

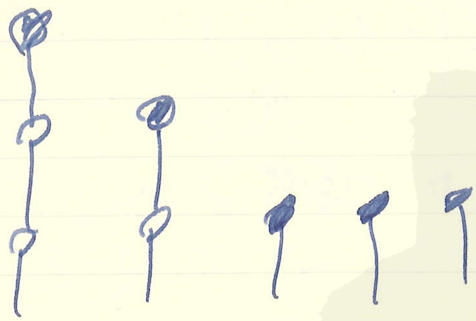


$\alpha(s) = \alpha' s + \alpha_0$

$l = 0, 1, \ldots N$

gauge conditions → removal of spurious states

ghost (gauge cond. では除けない…)



$$[a_\mu^{(n)}, a_\nu^{\dagger(n')}] = g_{\mu\nu}\,\delta_{nn'} \qquad g_{00} = -g_{ii} = 1$$

$$a_\mu^{(n)}|0\rangle = 0$$

occupation number space

$$\langle \Phi | \eta \Psi \rangle \qquad R \qquad \eta = (-1)^{\sum_{n=1} a^{(n)\dagger} a^{(n)}}$$

$$h_0(p) = \sum n\, a^{\dagger(n)} a^{(n)} \simeq \alpha' p^2$$

$$h_+(p) = \sum \sqrt{n(n+1)}\, a^{\dagger(n+1)} a^{(n)} + p\, a^{\dagger(1)}$$

$$h_-(p) = \sum \sqrt{\cdots}\; a^{\dagger(n)} a^{(n+1)} - p\, a^{(1)}$$

$$\left\{ \begin{array}{l} [h_0, h_\pm] = \pm h_\pm \\ [h_+, h_-] = -2h_0 \end{array} \right\} \quad SO(2,1) \text{ or } SU(1,1)$$

Twisting operator $\Omega(p)$

$$\left. \begin{array}{l} \Omega(p) = e^{h_+}(-1)^{R} = (-1)^{R} e^{-h_+} \\ \Omega^\dagger(p) = (-1)^{R} e^{h_-} \\ \Omega^2 = \Omega^{\dagger 2} = 1 \end{array} \right\}$$

$A(p) \equiv h_0(p) - h_-(p)$

resonance states at rest

$p_\mu = (m_N, \vec{0})$

混沌会

Nov. 26, 1970

牧二郎：学説史

1952 卒業（文理大）

1932 ～ 1952　Heis., Yuk., Fermi –24年　Field Theory

~1950　(1) 奇妙な粒子 — Strangeness

→ 坂田モデル → quark

(2) parity非保存 — V-A

(3) "Regge"物語

(1) stu-physics

(3) IBY-physics

時空記述研究会

1970年12月17日～19日

基研．小講義室

17日 9.00　挨拶 湯川

片山氏：歴史的概観．

1. 内部変数をどのように記述できるか！

reciprocity

η_μ : space-like vector としての導入．

2. 内部自由度(非局所性)は時空記述からどれくらい可能か！

スピンの問題，

内部回転．　$S_{\mu\nu} = \eta_\mu q_\nu - \eta_\nu q_\mu$

bilocal: $\frac{1}{4}\epsilon_{\mu\nu\rho\sigma} S^{\mu\nu} S^{\rho\sigma} = 0 \to$ integer spin

3. スピンの記述形式

中野氏：

[illegible]群．

parameter group

谷川氏：

bose 束縛状態 → fermi . .

田中氏：

Zitterbewegung　ξ　charge の広がり

Vierbein　b_μ

spinor 表わして置く

→ $\xi^{+}\bigcirc\xi$

$b_\mu^{+} \propto P_\mu$ （原氏）　$b_\nu^{+}\xi$

谷川氏

proper time とは．

原氏．

色々は考えにくい．

佐藤氏：

Dirac 方程式

1710 午後，堀氏．四·P·五

近藤氏：無限成分？

duality

string

詳細は 新 方程式

にて 演算子 と相互作用する．

indefinite metric

$-1 \leq u \leq 1$

$x_\mu(u)$

$[x_\mu(u), \pi_\nu(u')] = i g_{\mu\nu}\delta(u-u')$

$[x_\mu(u), x_\nu(u')] = [\pi_\mu(u), \pi_\nu(u')] = 0$

$\Psi[x_\mu(u)]$

$$P_\mu = \int_{-1}^{1} \pi_\mu(u)\,du$$

$$[x_\mu(u), P_\nu] = i g_{\mu\nu}$$

$$M_{\mu\nu} = \int_{-1}^{1} x_{[\mu}(u)\,\pi_{\nu]}(u)\,du$$

$x_0(u)$: 各微細の時間

$$X_\mu = \int_{-1}^{+1} f(u)\,x_\mu(u)\,du$$

$$\int_{-1}^{1} f(u)\,du = 1$$

局所的な運動方程式（各微細の方程式）

$$H(u)\Psi = 0$$

$$H(u) = \quad \pi(u)^2 + \left(\frac{dx}{du}\right)^2 + \Phi(u)$$

global な運動方程式

積分可能条件

$$[H(u_1), H(u_2)] = \int_{-1}^{+1} K(u_1, u_2, u')\,H(u')\,du'$$

$$H(u) = \frac{\pi(1-u^2)}{2}\left[\frac{\pi(u)^2}{\kappa} + \kappa\left(\frac{dx(u)}{du}\right)^2\right]$$

$$-\frac{i}{2}\int_{-1}^{+1}(1-u'^2)\left\{\frac{dx(u')}{du'}, \pi(u')\right\}\frac{du'}{u-u'} + w_0$$

principal value

$$[H(u_1), H(u_2)] = \frac{2(1-u_1 u_2)}{(u_1-u_2)^2}(H(u_1)-H(u_2))$$

$$-\frac{1}{u_1-u_2}\left[(1-u_1^2)\frac{dH(u_1)}{du_1}+(1-u_2^2)\frac{dH(u_2)}{du_2}\right]$$

$$\pi(u) \rightleftarrows x\frac{dx(u)}{du}$$ symmetry

$w(u)$
$x(w)$ $$\pi(w) = \left|\frac{du}{dw}\right|\pi(u)$$

$u = \cos\sigma$; $0 \leq \sigma \leq \pi$

$$x_\mu(\sigma) = \sum_{r=0}^{\infty} \xi^r \cos r\sigma$$

$$p_\mu(\sigma) = \frac{1}{\pi l_0}\left(\frac{1}{2}\pi^0 + \sum_{r=1}^{\infty}\pi^r\cos r\sigma\right)$$

$$[\xi_\mu^r, \pi_\nu^s] = i\delta_{rs}g_{\mu\nu}$$

Veneziano: mass spectrum
oscillator model
plus ∞ number of subsidiary conditions

external scalar field

$\Phi(x)$

$\sigma=0$

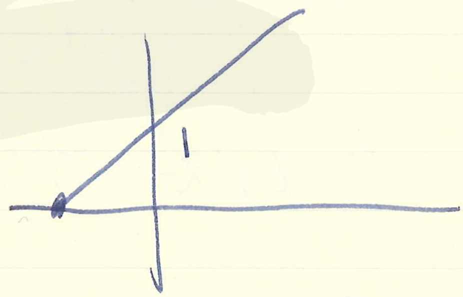
$\hat{H}(\sigma)\Psi = 0$

$\hat{H}(\sigma) = H(\sigma) + g\delta(\sigma)H'$

$\Phi(x_\mu(\sigma))$ 0

imaginary mass

log N にする
ことも.



例:

1. Rigid Body

$H = \frac{1}{2I} S^2$,

half-integer spin

$J=\frac{1}{2}$ の波動函数は z-component

spinor の變換性をもつ.

Lorentz 變換に対しても spinor である

ためには Euler angle を complex

にしなければならない → inversion をやる

故 Dirac spinor

$K = \pm\frac{1}{2}$: particle-antiparticle

2. deformable body
non-uniform deformation
(spin integer
(spin half-integer
SU_3

3. Interaction
i) Propagator $\quad H = \sum_n n\, a^{*n} a^n$
ii) vertex

$$e^{ik\left[\sqrt{\frac{2}{n}}(a^n + a^{n*}) + X\right]}$$

$$\int A(X+u)\, dq \to Q\, A(X+\bar{u})$$

$x_\mu(\sigma)$ Lagrange 決定 [illegible])

σ の [illegible] 変換に 対する covariance,
Klein の 5次元の

$$\sigma \to \sigma' = \sigma + \varepsilon \sum_{p=-\infty} \xi_p e^{ip\sigma}$$

3次元 Lorentz 変換

後藤 : 開 [illegible]

第2回. 18日
午前. 沢田 大要
講師: leptonの問題点
1. 構造
2. 相互作用
3. 対称性

I. Q.E.D. の test
確かに
photon propagator $\frac{1}{q^2} - \frac{1}{q^2+\Lambda_1^2}$
lepton 〃 $S_F \frac{\Lambda_2^2 q^2}{(p^2+m^2)+\Lambda_2^2}$
vertex $\gamma_\mu \frac{\Lambda^2}{q^2+\Lambda_3^2}$

μ の a.m.m.:
$$a = \frac{g-2}{2}$$
$$\Delta a = a_{exp} - a_{th} = (29 \pm 34) \times 10^{-8}$$
$$\Lambda_1 \gtrsim 3.6 \text{ GeV}$$
$$\Lambda_2 \gtrsim 10 \text{ GeV}$$
$$\Lambda_3 \gtrsim 5 \text{ GeV}$$

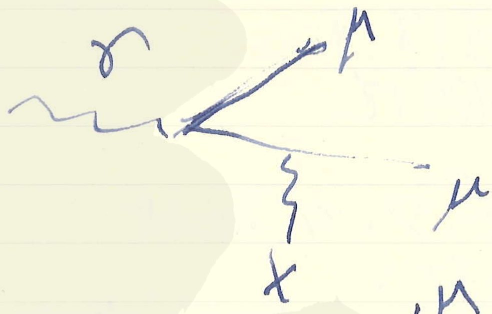
e-e
e-μ } scattering → { $\Gamma_\mu^{(e)}$, $\Gamma_\mu^{(\mu)}$, D_F
μ-μ

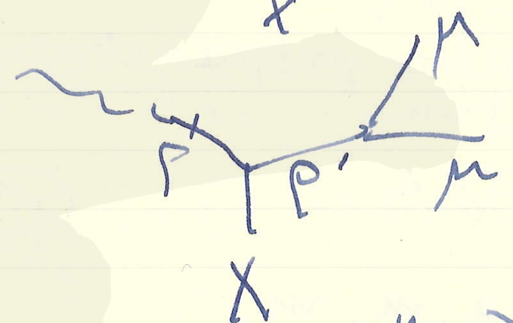
$$\left(\frac{\Lambda_1^2}{q^2(q^2+\Lambda_1^2)}\right)^2 \left(\frac{\Lambda_2^2}{q^2+\Lambda_2^2}\right)^4$$

$\gamma + C \rightarrow C' + \mu^- + \mu^+$
Carbon

$\underbrace{\mu^- + \mu^+}$ invariant mass
2 GeV までは 実験と一致している、

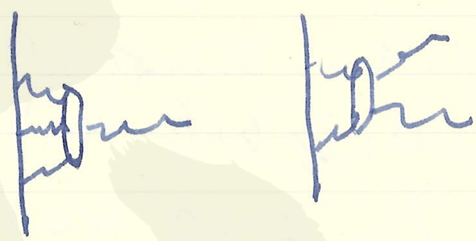
Q.E.D. の破れ
$D < 9 \times 10^{-15}$ cm





$m_{\rho'} > 2$ GeV

Lepton の構造:
photon には無修正



electric polarizability
$H \sim \frac{1}{2}\alpha E^2$

magnetic 〃
$\frac{1}{2}\beta H^2$

$\frac{1}{2}\gamma E H$

II. Weak Interaction
weak boson mass $\gtrsim$ 5 GeV

CERN

$\nu + n \to \mu^- + p$

$M_T \sim 2\,\mathrm{GeV}$ (Tanikawa boson)

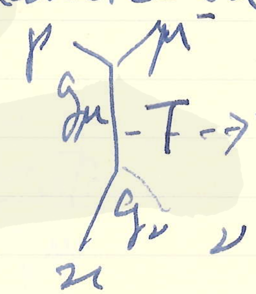
P a resolution 100 MeV

$\sigma_{obs} \sim \frac{2}{3} \times 10^{-38}\,\mathrm{cm}^2$

Nakawaki – Saito – Tanikawa

$\frac{G'}{\sqrt{2}} \equiv \frac{g_\mu g_\nu}{M_T^2} < 10^{-8} M_N^{-2}$

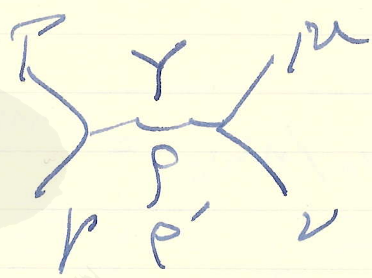
$\sim G \cdot 10^{-3}$



$\left\{ \begin{array}{l} B = 1 \\ L = 1 \end{array} \right.$

V+A : superweak

$\Gamma \sim 10^{-3}\,\mathrm{eV}$



duality

T–Y duality

V−A theory

$\bar{\psi}_A O \psi_B \bar{\psi}_C O \psi_D$

neutral current $(e\nu)(e\nu)$?

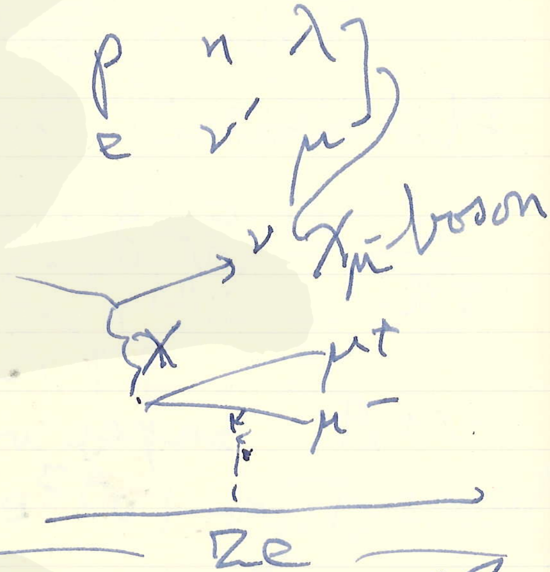
(III) μ-e difference
mass

$(\nu_\mu\ \mu)$ $(\nu_e\ e)$

$m_{\nu_\mu} < 5\ \mathrm{MeV}$

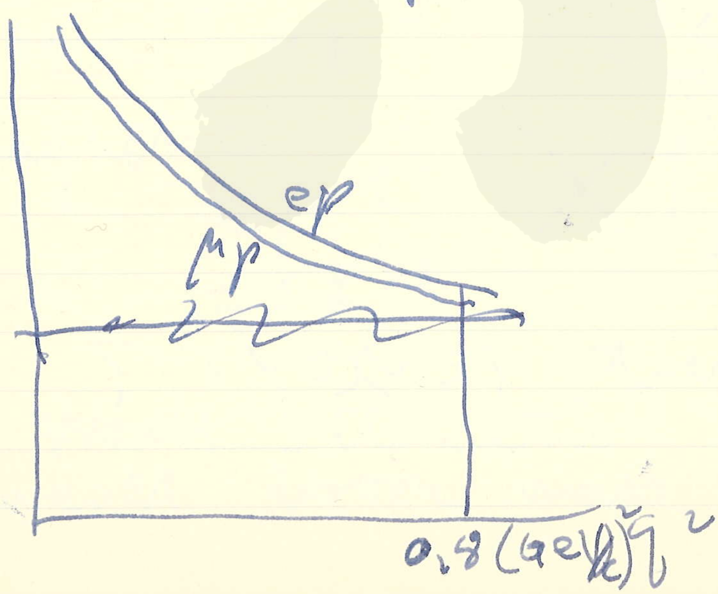
$m_{\nu_e} < 60\ \mathrm{eV}.$

$$\frac{f_\chi^2}{m_\chi^2}$$



$m_{\nu_\mu}/m_{\nu_e} = m_\mu/m_e$ としているだろうか?

加速器　pe, pμ scatt



Lepton symmetry

e^* > 500 MeV

μ^* ?

① $\nu_1 = \cos\theta\, \nu_e + \sin\theta\, \nu_\mu$

× $\nu_2 = -\sin\theta\, \nu_e + \cos\theta\, \nu_\mu$

e^- ν_1 ν_2 μ^-

p n λ λ'

SU(3)×U(1) Maki

SU(2)×SU(2)

~~西~~川氏:

hadron 現象の[illegible]

chiral symmetry に従う current 概念に

strong
weak
electromag.
} に共通する.

chirality の → $\partial A = C\pi$

C. A. + PCAC Treatment ⇒ low energy theorem (1965~67)

Weinberg effective Lagrangian

SU(2)⊗SU(2) ($m_\pi \to 0$)

i) chiral symmetry + π (N.G. Boson)

$$\langle 0|A_\mu|\pi\rangle = i P_\mu f_\pi$$

$$\left.\begin{array}{l} m_\pi^2 = 0 \\ f_\pi \neq 0 \end{array}\right\}.$$

ii) C.S. 破れ

$$\partial A^a = \varepsilon\, \phi^a$$

$$m_\pi^2 = \epsilon M(\epsilon)$$

$$M(0) \neq 0$$

$$\epsilon \ll M$$

$$m_\pi \gg \epsilon$$

Okubo

ϵ ~ unbaryons bare mass

u, d : 9 MeV

s : 150 MeV

i) phase transition

$$\langle 0|A_\mu(0)|\pi^+\rangle \neq 0$$

iii) A, V →

current 9 locality

4/10 [illegible] 教

/物理学会：

小川 [illegible] 教

[illegible] → 現状 [illegible]

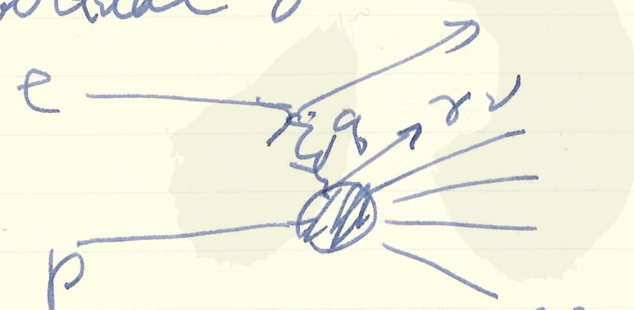
Nucleon Compton Scatt.

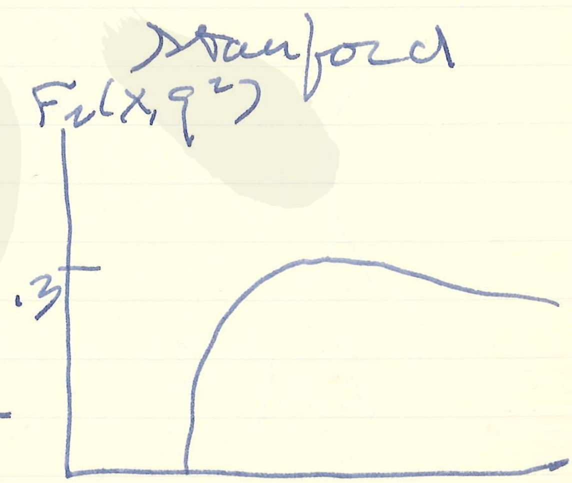
$$\sigma_T(\gamma p) = 94 + \frac{29 \pm 1}{\sqrt{\nu}} \ \mu b \quad 1$$

$$\sigma_T(\gamma n) = 95 + \frac{24.6}{\sqrt{\nu}} \quad \frac{2}{3}$$

$$\sigma_T(\gamma p) - \sigma_T(\gamma n) = \frac{24.6}{\sqrt{\nu}} \quad \frac{1}{3}$$

virtual γ



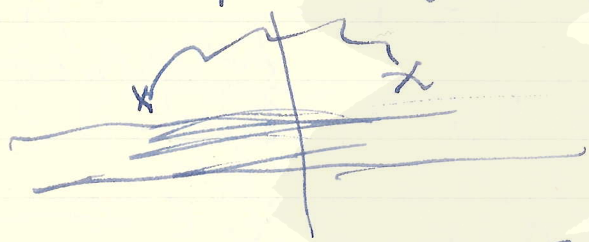


$q^2 > 0$ $\quad \nu = \frac{p \cdot q}{M}$

scaling law ← $\frac{2M\nu}{q^2} = x$

scaling law の origin
light cone 上の singularity
係数の問題.

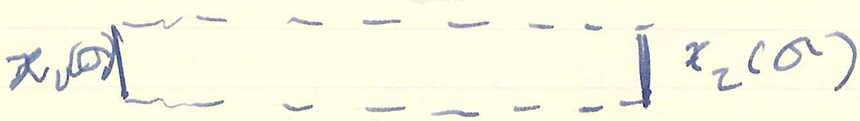
$\delta m_p \to$ quadratic 発散



$q^2 \lesssim 15 (GeV/c)^2$

南部氏の duality と World sheet

$$\sum_A \frac{f(t)}{s-s_R} = \sum \frac{f(s)}{t-t_R}$$



田中正氏：

河辺氏：対応原理的

実験・理論に基づく

複合体の組織を認識とする

近似的模型の方法

ごまかす

lepton の世界

quarks 以外の自由度

Chiral dynamics

1925～1928

$(\gamma_\mu \partial_\mu + \kappa)\psi = 0$

$O(4) = O(3)_L \times O(3)_R$

$\dfrac{\vec{J} \pm i\vec{K}}{2} = \vec{J}_{L,R}$

$\eta = (\varphi, \theta, \psi, \varphi)$

$\xi(\eta_L)$ $\xi(\eta_R)$

$\Psi(x,\eta) = \bigcirc_L \bigcirc_R + \bigcirc_L \bigcirc_R$

$= \varphi_i^*(x)\,\xi_i(\eta_L) + \chi_i^*(x)\,\xi_i(\eta_R)$

$\psi = \begin{pmatrix} \varphi \\ \chi \end{pmatrix}$

$[\Gamma_\mu \partial_\mu + D]\,\Psi(x,\eta) = 0$

$K\psi =$ collision operator

Prop $[\Gamma_\mu, \Xi^\alpha] = \gamma_\mu^{\alpha\beta}\,\Xi_\beta$

$$\Xi \equiv \begin{pmatrix} \xi_i\,(\eta_L) \\ \xi_i\,(\eta_R) \end{pmatrix}$$

1) $\vec{v} \parallel \vec{p}$ の $\vec{\sigma}$ をもってしまえばいい
縦に表わして 回転を許す.

(1) (2)

L — L

R — R

L — R

1) R — L } interaction

2') 回転してる面をとれば[illegible]
ε_γ …

→ V−A (Fierz invariant)

結論： ψ_μ ψ_μ

$\vec{n}$

$a \approx \frac{e}{m} a_0$

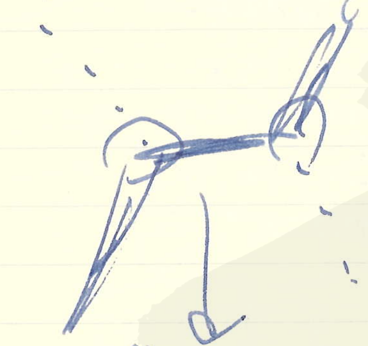
$\psi^* \vec{n}\,(\vec{v}_1 - \vec{v}_2)\,\psi = 0$

→ V−A 型

$$g = \frac{a}{m} \Big)$$

中間子: higher spin

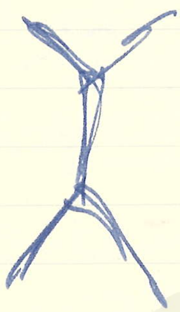
重粒子: 振動をもった粒子を散乱するとRegge behavior が出るか?
多重成分



$O(p)\psi = 0$

Majorana

$$S(p) = \frac{1}{O(p)}$$



相互作用を non-local にする可能性あり。

$$(e^{\partial_1 \Gamma})(e^{\partial_2 \Gamma})(e^{\partial_3 \Gamma})\psi_a(x_1)\psi_b(x_2)\psi_c(x_3)$$

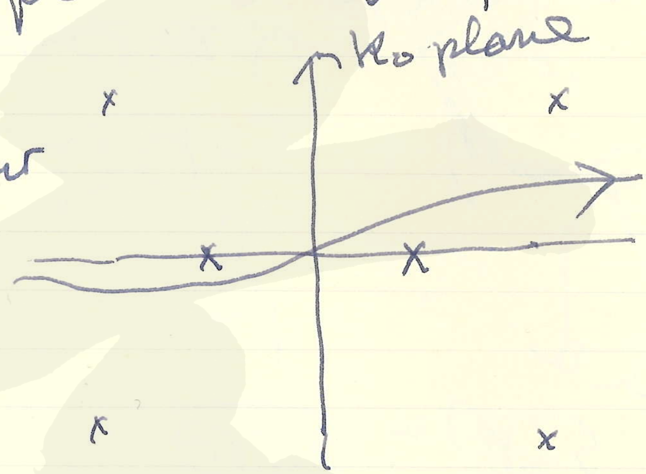
aa′ bb′ cc′　aa′　bb′

$$\delta(x_1 - x_2)\,\delta(\cdots)$$

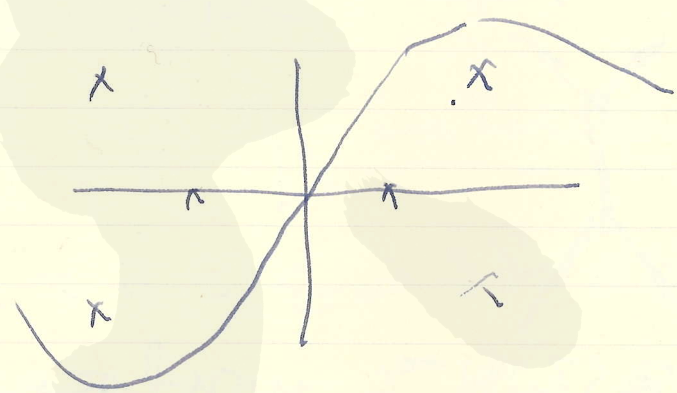
$$(e^{\partial_t \xi}+1)u=0$$

第3回　12月19日
[illegible]　[illegible]　[illegible]氏
山本氏：complex massをもつ場の量子化.

S の unitarity
$H_{int}^* = H_{int}$



Lee-Wick
$t\to\pm\infty$ で
[illegible],



[illegible]氏：四次元量子化
hyperquantization　[illegible]

c033-875～876挟込

その2
存在：時間
横[illegible]G： Nonpolynomial Lagrangian theory
Fradkin, Efimov, Volkov
[illegible] ≡ [illegible]　[illegible]

[illegible] 1954

'63 ~ '68

$$\mathcal{L}_{int} = g\,U(\varphi)$$

$$= g\sum_n \frac{v_n}{n!}(-\varphi)^n$$

$$\frac{G}{1+f\varphi} \rightarrow v_n = f^2 n!$$

Delbourgo - Salam - Strathdee
[illegible]
x-space method

Salam - Strath.
p-space method

chiral $SU(2)\times SU(2)$

$$L = \frac{(\partial_\mu \varphi)^2}{1+f\varphi^2}$$

Weak Interac. boson

$$\mathcal{L}_{int} = g\,\bar{Q}\gamma_\mu(1+\gamma_5)Q A_\mu + m\bar{Q}(e^{i\gamma_5 [illegible]}-1)Q$$

Gravitation

これまでの問題点。

1) 発散

くりこみ

2) 結合の種類

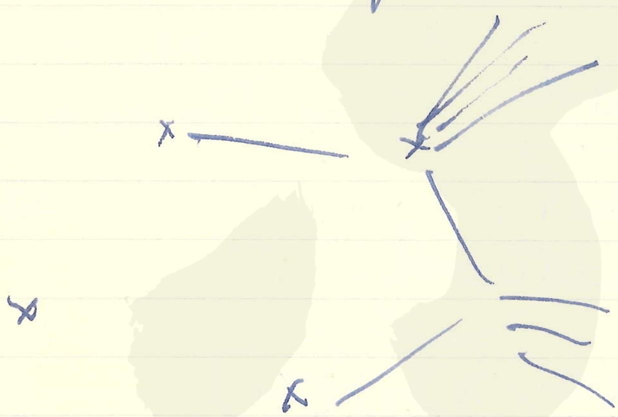
3) high energy behavior
(external momenta)^n
$U(\phi) \to \phi^n$

$D > 4$ $\qquad$ $D \leq 4$

$D \leq 3$

$D < 2$

4) unitarity, causality の再吟味



Borel sum

$$n! = \int_0^\infty e^{-\xi} \xi^n d\xi$$

S行列の完全性,

Lehmann展開?

斎藤氏

Removal of Level Degeneracy in D.R.M. (Dual Resonance Model)

Feb. 12, 1971. 基研

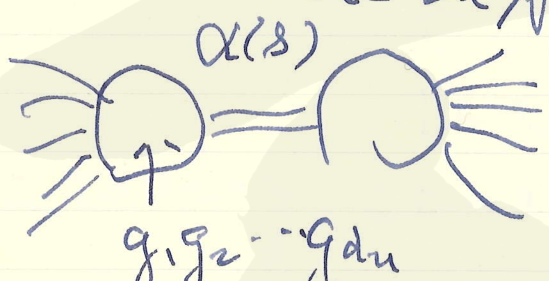
N-point Veneziano amp.

$n = \alpha(s_n)$ $\quad s_n = M_n^2$

M_n : mass of resonant state

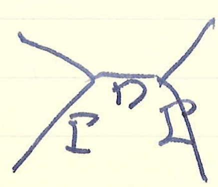
of 級 $\quad d_n \sim e^{a\sqrt{n}}$

$a = 2\pi/\sqrt{6}$

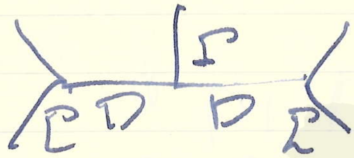
$T =$ 

unitarity を考慮すると縮退は remove される.

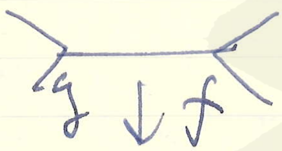
Born 近似 term を考える $\longrightarrow$ higher order を考えて unitarity を回復できる

$T_4 =$  $= B(-\alpha(s), -\alpha(t))$

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

$T_5 =$  $= \langle 0 | \Gamma D \Gamma D \Gamma | 0 \rangle$

2 → 2 unitarity → factorization

$s \to$ 

$$\frac{g f}{s - M^2} \qquad \cancel{\sum_{n=1}^{\infty} \frac{g_n f_n}{s - M_n^2}}$$

$$\frac{\gamma(s)\,\delta(s)}{J - \alpha(s)}$$

中野董夫：重力理論
談話会
1971年 2月17日

1963年：素粒子の研究
Dirac particle

phase transformation
charge conservation

$$\psi \to e^{i\lambda}\psi$$

$$\psi(x) \to e^{i\lambda(x)}\psi(x)$$

i) $D_k\psi = \{\partial_k - i a_k(x)\}\psi(x)$

$$\delta a_k(x) = \partial_k \Lambda(x)$$

$$\bar{\psi}\sigma_{kl}\psi f_{kl}(x)$$

(ii) $a_k \equiv \dfrac{\bar{\psi}\partial_k\psi - \partial_k\bar{\psi}\psi}{2\bar{\psi}\psi}$)

{ 与好定

$$j_k^f = f j_k + 4\alpha(\partial_l f) f_{kl}$$

$$\partial_k j_k^f = 0 \qquad \alpha = \frac{1}{4e^2}$$

$$Q^f = \int j_0^f dV$$

f : arbitrary fn

$$f_{k,l} = \partial_k a_l - \partial_l a_k \qquad a_k = e A_k$$

Infinite Lie group

推進変換．

$$\delta x^\mu = \varepsilon^\mu(x)$$

$$\delta\psi = 0,\quad \delta\bar\psi = 0$$

不変微分：

$$D_k\psi = \{\partial_k + \varphi_k^\mu(x)\,\partial_\mu\}\psi$$

$$= b_k^\mu(x)\,\partial_\mu\psi$$

$$b_k^\mu = \delta_k^\mu + \varphi_k^\mu$$

$$\delta b_k^\mu = \partial_\nu\varepsilon^\mu \cdot b_k^\nu$$

$$b_k^\mu \cdot b_{k\nu} = \delta^\mu_\nu,\quad b^\mu_k\, b_{l\mu} = \delta_{kl}$$

$$L = \frac{1}{2} b_k^\mu\left(\bar\psi\gamma_k\partial_\mu\psi - \partial_\mu\bar\psi\gamma_k\psi\right)$$

$$+ m\bar\psi\psi$$

不変な場の強さ

$$C_{klm} = b_{k\nu}\left(b_l^\mu\, b_m{}^\nu{}_{,\mu} - b_m^\mu\, b_l{}^\nu{}_{,\mu}\right)$$

$$b_{k\mu,\nu} \equiv \partial_\nu b_{k\mu}$$

C_{klm} の[illegible]

c033-877挟込

評議会

March 25, 1971

(片山) 小林俊君:
Spinor 場一元理論に帰着
重力の理論.
未完成.

益川君: Finite Theory はあるか?
Cut-off などの込みとるか?
π: Nambu-Goldstone boson
(近似的に)

$$\left\{\begin{array}{l} \langle 0 | A_\mu | \pi \rangle = i p_\mu f_\pi \\ \partial A_\mu = 0 \\ f_\pi \neq 0 \end{array}\right\}$$ 極限で成り立つ

$$A_\mu(x) = \sum \psi^\dagger_{n'}(x) C_{n'n} \psi_n(x)$$

subbaryon の段階での vertex なし.

$\Lambda^{-1} < 10^{-14}$ cm

lepton　　weak int.　10^{-17} cm
(unitarity がこわれる)

$$m_E \sim \frac{\Lambda}{2}$$

第四段階：
$\pi^{+}-\pi^{0}$；

Q.E.D.：　$\delta m_e < \infty$？

Q.G.D.：unrenormalizable.

Salam
non-polynomial Lagrangian
Efimov
Fradkin
Volkov
) 1963：$L = \frac{g\phi^n}{1+f\phi^n}$

Okubo　1954
exponential　　$L = g\exp(f\phi)$
$= g\sum \frac{1}{n!}(f\phi)^n$

Jaffe　micro-causality を満たすようにできる．

$$\frac{\delta m}{m_e} = \frac{3}{4\pi}\sum_n \alpha \log(\kappa^2 m^2)^n$$

"素粒子と励起子"
研究会

基研. March 29〜31, 1971

	11〜13	14〜15:30	16〜
29日	京 あいさつ かわり (議論)	丸森 素粒子と励起子 (大槻)	(並木)
30日	鈴木 Veneziano と黄道	石田 みたいなもの	(武田) (議論)
31日	野森 (武田) 全体討論	(湯川) (中野)	

29日 午前

原治: 励起子をどうして考えるか?

spin 1/2 Fermion ←? Quark

i) baryon 56 次元

orbital: symmetric

~~unitary~~ unitary spin: symmetric

total symmetric

ii) dual amplitude がつくれない

∞の自由度が必要

→ continuum

→ 内部自由度を記述する exciton

→ boson 的.

iii) weak $\Delta I = 1/2$ が exciton から出ることになる.

Zu の見方

$$H_W \cong (\bar{t}^{\alpha} O_i t_{\kappa})(\bar{t}^{\beta} O_i t_{\lambda})$$

$$O_i = \gamma_\mu (1 + \gamma_5)$$

t^{α}: boson 的 $\Delta I = 1/2$

iv) exciton → background

v) binding の問題が新しい問題になる.
potential

exciton の場:

$a_{\alpha\lambda}$ $a^{*}_{\alpha\lambda}$

deformable body の回転の自由度が
α. (spinor)

振動に固有の自由度が λ.

三次元振動 → SU_3

素粒子のいれもので回転が
起る. 従って振動もいれかわった描象
も考える必要がある.

弦理論
SU₃ の violation は 横波と
縦波のちがい,

Triality 0 の意味
A. Kohn　　対称軸の取り方に
　　　　　対する arbitrariness

mass operator

$m^2 = f(N, n)$
quark 数　　antiquark 数

fermion, boson に共通の式,
統一的に見ればこれは.

弦理論 → 粒子エーテル
→ 素領域　　的空領域に
　　エネルギーが注入される

相対論化.
i) ghost
ii) Lagrangian のきめ手.

縦横座標　$x^\mu(\sigma)$　　$\sigma = [0, 2\pi]$
$p^\mu(\sigma)$

$$D = \frac{\partial}{i\,\partial\sigma^\mu}$$

$$\left[\int_0^\pi \{P^{\mu 2} + (Dx^\mu)^2\} d\sigma\right]\psi = 0$$

$$\{P^2 + (\quad)\}\psi = 0$$

$$H = \frac{1}{2}\int C^\mu(\sigma)^\dagger C^\mu(\sigma)\,d\sigma$$

$$C^\mu(\sigma) = -iDA^\mu$$

$$A^\mu(\sigma) = \frac{1}{\sqrt{2}}(x^\mu - D^{-1}p^\mu)$$

$$\sigma = f(\sigma')$$

$$\sigma = \sigma' + \varepsilon f(\sigma') \qquad \sigma' = [0, 2\pi)$$

$$f(\sigma') = \sum_{n=-\infty}^{\infty} \xi_n e^{in\sigma}$$

一番簡単な場合:

$$f(\sigma') = \xi_0 + \xi_1 e^{i\sigma'} + \xi_{-1} e^{-i\sigma'}$$

Virasoroの条件と一致する.

ghostが排除されているか?

L-相対性原理

$x^\mu(\sigma, \tau)$

$$g_{00} = \frac{\partial x_\mu}{\partial \tau}\frac{\partial x^\mu}{\partial \tau}$$

$$g_{01} = \frac{\partial x_\mu}{\partial \tau}\frac{\partial x^\mu}{\partial \sigma}$$

$$g^{11} = \frac{\partial x_\mu}{\partial \sigma}\frac{\partial x^\mu}{\partial \sigma}$$

$$\det g = g_{00}g_{11} - g_{12}^2$$

$$L = \mu \iint d\sigma\, d\tau \sqrt{-\det g}$$

$$\left.\begin{aligned} &p_\mu p^\mu + \mu (Dx^\mu)^2 = 0 \\ &p_\mu \frac{\partial x^\mu}{\partial \sigma} = 0 \end{aligned}\right\}$$

Takabayasi　[illegible]

$$L = \mu \int \sqrt{-g_{00}}\, d\tau \sqrt{(d_\perp x^\mu)^2}$$

$$v_\mu = \frac{1}{\sqrt{g_{00}}}\frac{\partial x_\mu}{\partial \tau} \qquad v_\mu d_\perp x^\mu = 0$$

[illegible]

[illegible]
Vertex の形 or [illegible] → local limit
[illegible] の [illegible]
duality

午後：有馬：原子核と励起子

1932 n, p
π

one-particle motion × liquid
model drop

1960 microscopic theory
(1949 : Mayer · Jensen shell model)
nuclear matter
excitation mode
exciton ≈ nucleon
ではなく..

J^π exciton

0^+

§1. Nuclear Shell-Model

$$H = \sum T c^\dagger c + \sum V c^\dagger c^\dagger c c$$

$$\Downarrow$$

$$H' = \sum_n \hbar\omega X_n^\dagger X_n + \sum V_{eff}$$

$X, X^\dagger$: boson
or fermion

$$\{\psi^\dagger(x), \psi(x')\} = \delta(x, x')$$

$$\psi^\dagger(x) = \sum c_\alpha^\dagger \varphi_\alpha^*(x)$$

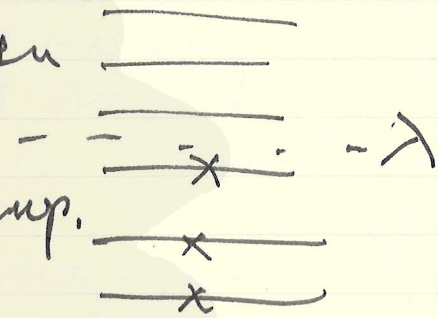
φ_α: shell model wave function

$\alpha \equiv (n, l, j m, \tau)$

$a \equiv (n, l, j)$

$$H \to H_0 = \sum_{\alpha} \epsilon_a^{(0)} :c_\alpha^\dagger c_\alpha:$$

$\epsilon_a \equiv \epsilon_a^{(0)} - \lambda > 0$ open



$\epsilon_a \equiv \epsilon_a^{(0)} - \lambda < 0$ occup.

"free vacuum"
$|0\rangle$

$$c_\alpha^\dagger = \begin{cases} a_\alpha^\dagger & \epsilon_a > 0 \\ (-)^{j_a - m_a}(-)^{\frac{1}{2}-\tau_a}\, b_{-a} & \epsilon_a < 0 \end{cases}$$

$$-\alpha = (n, l, j, -m, -\tau)$$

$$a_\alpha|0\rangle = b_\alpha|0\rangle = 0$$

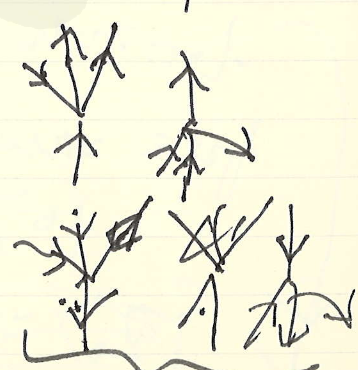
$$H = H_0 + H_{int}$$

$$H_{int} = \sum_{\alpha\beta\gamma\delta} \langle \alpha\beta | V_{eff} | \gamma\delta \rangle :c_\alpha^\dagger c_\beta^\dagger c_\gamma c_\delta:$$

$: \ :$ ≡ normal product

$(\hat{n}_{part} - \hat{n}_{hole})$: 一定

H_{pp} H_{hh} H_{ph} H_V



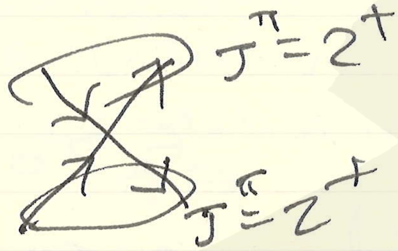
$$H_{int} = H_{pp} + \underbrace{\cdots\cdots}_{?!}$$

constructive force

interactive part

Tamm-Dancoff App.

pairing interaction



§ 2. Collective motion

R.P.A

(random phase approximation)

chain approximation

boson $(X_n, X_n^\dagger)$

free vacuum → true vacuum

$|0\rangle$ $\qquad X|\Phi_0\rangle = 0$

$|\Phi_0\rangle = C_0|0\rangle + C_1 a^\dagger a^\dagger b^\dagger b^\dagger |0\rangle + \cdots$

quadrupole interaction

free vacuum の instability
Haag の定理

2^+
0^+

plasmon spectrum → rotational spectrum
(vibrational)

one-particle mode
が残こる.
or broken symmetry

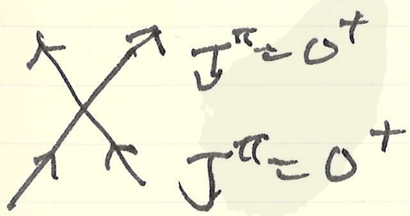
$a'|0'\rangle = 0$

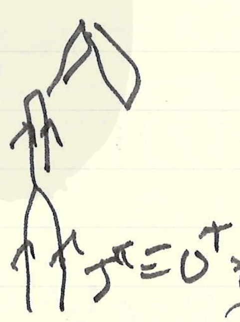
$b'|0'\rangle = 0$

angular momentum conservation を破る
deformation

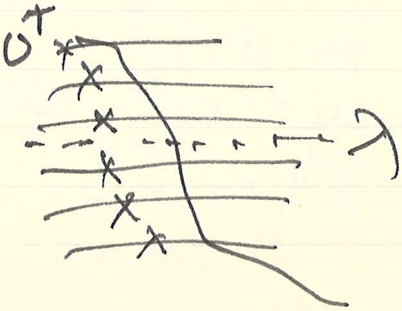
§3. Pairing Vibration

B.C.S.の transformation





H_{pp}
free vacuum → |BCS⟩ →



one particle mode を記しいたら
number conservation を破るわけがない、

$a_\alpha|BCS\rangle = 0$

$a^\dagger_\alpha = u_\alpha c^\dagger_\alpha - (-)^{j_\alpha - m_\alpha} C_{-\alpha}$

が1つの筆。

quasi-particle は nucleon じゃない。

$\underline{s=2}$ $a^\dagger a^\dagger|BCS\rangle$ ~~s=5~~ $\underline{s=3}$ $a^\dagger a^\dagger a^\dagger|BCS\rangle$

$\underline{s=0}$ $|BCS\rangle$ $\underline{s=1}$ $a^\dagger|BCS\rangle$

even odd

seniority

change はそれなってない。

3個の composite : fermion
anomalous coupling

spin もうそうってない。

丸義・山本
current algebra 的考え。
群の構造?
non-local $c^\dagger_\alpha c_\beta$ $c_\alpha c_\beta$ $c^\dagger_\alpha c^\dagger_\beta$

vacuumからつくってゆくのではない。

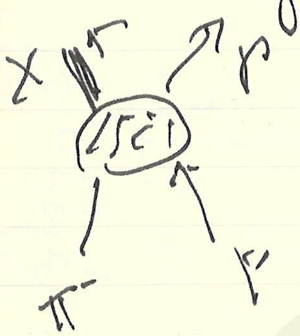
並木氏:

複合模型 → quark模型

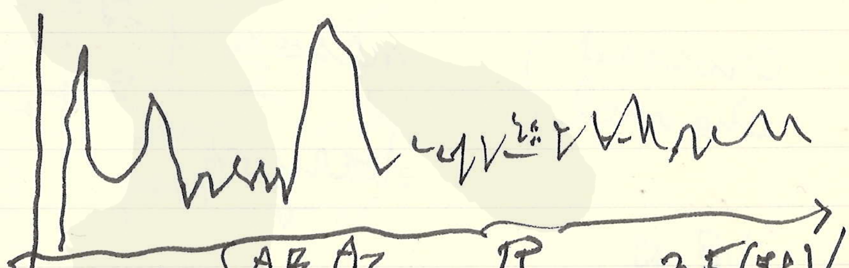
charge
strangeness } → 加法性 } SU(6)
spin　　　　　　　　　　　56

中心力 + LS力 議論

missing mass spectrum

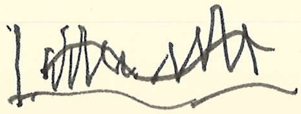


Xのspectrumは3GeV以上に存在する?

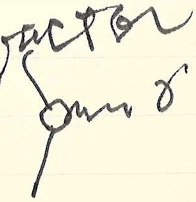


① 静的性質 (m, J^P, μ …
対称性

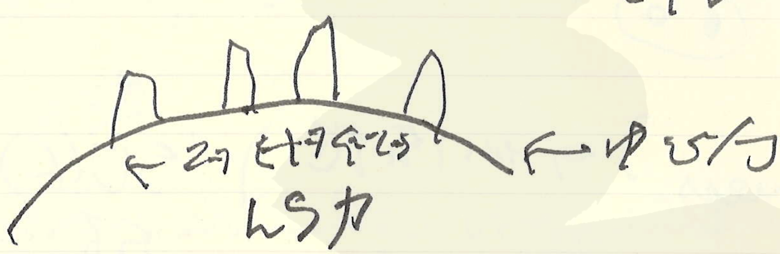
② 動的　analyticity
optical model
n → 回折



form factor



one-particle mode
(殻模型) → giant resonance
(compound nucleus → liquid drop
one-particle mode → optical model
(平均 potential)



乙結合 → 多結合

quasi
準静的

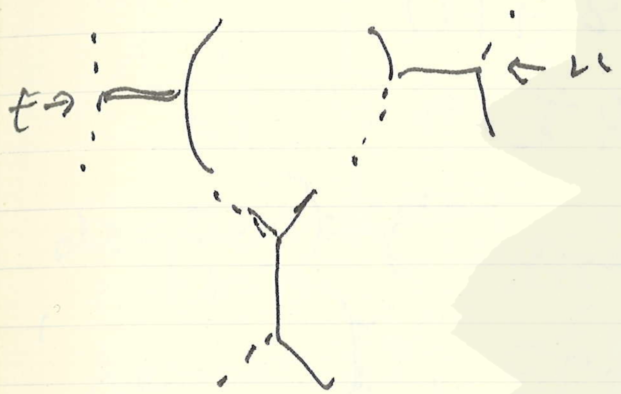
$\sigma(E) \propto E^{-2}$　　Morrison rule (23)

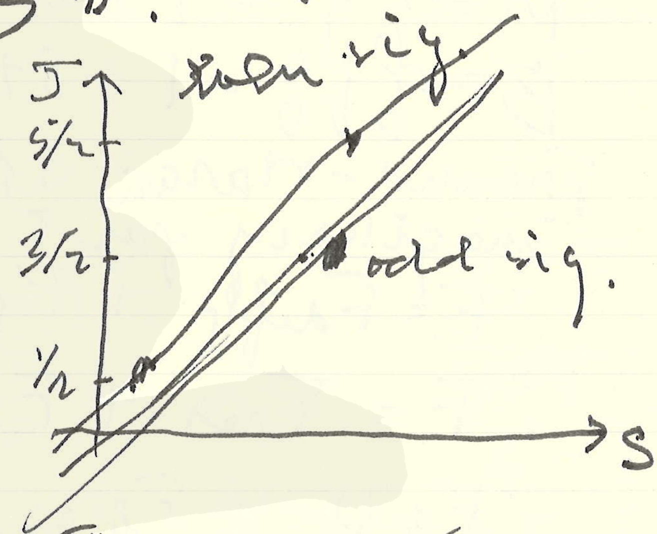
			parity	
	vacuum		+	0
crossed channel)	meson	S=0	−	−1
				−2
		S≠0		−3
	baryon			−4

混沌

multiple production
次の理
H尾方

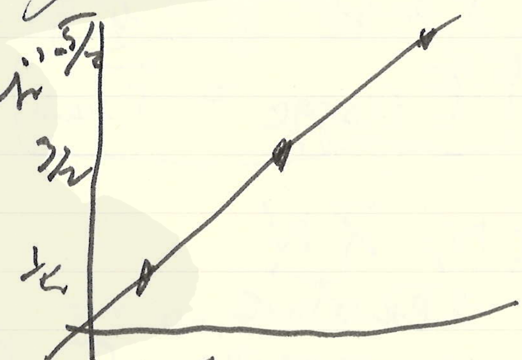
3.0 10: 午前
猫見君: Veneziano ampl. などの
らいい実験とあうか.





t-channel only

π is が

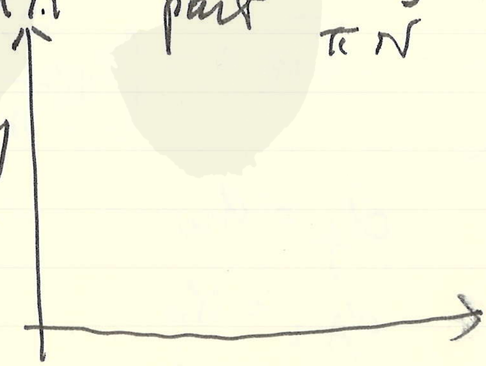


S = Σ ← t = Σ

Im $A^{(-)}$ imag. part

s
πN

Igi:
experimentally
には
4GeV いかまで
近似的に
成立 し.



no exotic ~~state~~ one-particle state

$$M = q\bar{q} = 1 + 8$$

$$B = qqq = 1 + 8 + 8' + 10$$

Freund-Harari の仮定

imaginary part

$$F_i = F_{\text{diffr}} + F_{\text{Regge}}$$

$$F = F_{\text{res}} + F_{\text{b.g}}$$

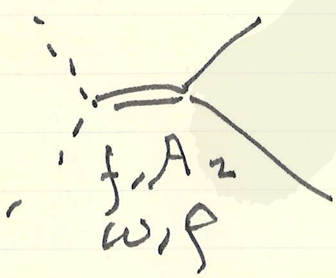
$$\cdot\ F_{\text{diffr}} = F_{\text{b.g.}}$$

$$\boxed{F_{\text{Regge}} = F_{\text{res}}} \rightarrow \text{Veneziano}$$

KN, $\bar{K}N$

KN は exotic

$$\text{Im}\,[F(KN) - F_P(KN)] = \text{Im}\,F_{\text{res}}(KN) = 0$$

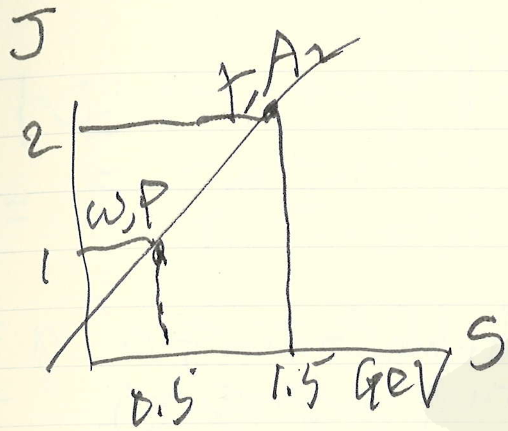


$$F_R \simeq \beta_R \frac{e^{-i\pi\alpha_R} \pm 1}{\sin \pi\alpha_R(t)} \nu^{\alpha_R(t)}$$

$$\alpha_f = \alpha_\omega \qquad \beta_f = \beta_\omega$$

$$\alpha_{A_2} = \alpha_\rho \qquad \beta_{A_2} = \beta_\rho$$

exchange degeneracy



~~degenerecy~~ ... $V\,/\,-T$

meson $8^{(-)} \leftrightarrow 9^{(+)}$

baryon I, $8^{(+)} \leftrightarrow 1^{(-)} + 8^{(-)}$ ... ~~V~~

$\frac{1}{2}^{+} - \frac{3}{2}^{-}$

II, $10^{(-)} + 8^{(-)} \leftrightarrow 8^{(+)}$ ... $\frac{3}{2}^{+} - \frac{5}{2}^{-}$

困難

η meson

$I=0$ と $I=1$ が degenerate?

(η) (π)

$m_\eta^2 - m_\pi^2 = 0.3$

石田君
Ur-citon 模型

I.

i) Quark 模型の方法

i) non-rel. rel momentum ≠ 0 strong binding

ii) 統計 スピン $\frac{1}{2}$ Bose
56 次元 symm.

nonleptonic interaction $\Delta I = 1/2$

補例

iii) 複合模型 → Quark 模型

II. 一般問題

$\psi_\alpha(\xi, p)$

$4 \times 3 = 12$

$$-i P_\mu \gamma_\mu \psi^{\pm}(\xi, p) = \pm\sqrt{p^2}\, \psi^{\pm}(\xi, p)$$

$$\{\psi_\alpha^{(\pm)}(p, \xi), \bar\psi^{(\pm)\beta}(p', \xi')\} = \Lambda_\alpha^{(\pm)\beta}(p)\, \delta_{pp'}\, \delta(\xi - \xi')$$

$$\psi(p, \xi) = \psi^{(+)}(p, \xi) + \psi^{(-)}(p, \xi)$$

$$\{\psi_\alpha(p, \xi), \bar\psi^\beta(p' \xi')\} = \delta_\alpha{}^\beta\, \delta_{pp'}\, \delta(\xi - \xi')$$

$$\psi^{(+)}|0\rangle = \psi^{(-)}|0\rangle = 0$$

$$|\Psi(p, \psi(p,\xi))\rangle$$
$$= \sum \bar{\Psi}^{(+)} \bar{\Psi}^{(+)} \cdots \psi^{(-)} \psi^{(-)} \Phi(\cdots) |0\rangle$$

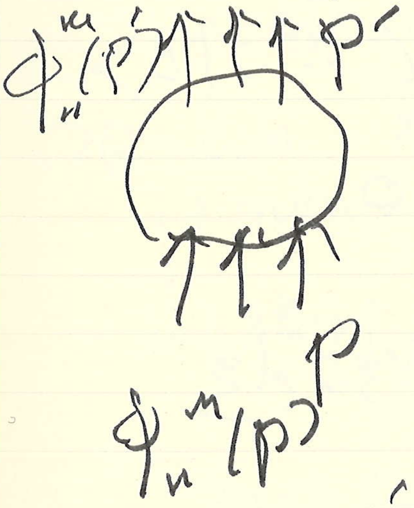
$$(p^2 - s_0 + S)|\Psi\rangle = 0$$
$$S = S^{(+)} + S^{(-)}$$
$$S^{(\pm)} = \pm \int \bar{\Psi}^{\pm}(\xi)\, m^2(\xi)\, \psi^{\pm}(\xi)\, d\xi$$

Postulate: 要素2重子系
(hadron内部)
spinの和　奇数個　fermi統計
　　　　　偶数個　bose

mass level
B: $M^2 = \omega\left(\sum_{i=1}^{3} a^{(i)+} a^{(i)} + 3\right) + s_0$
M: $M^2 = \omega\left(\sum_{i=1} a^{(i)} a^{(i)} + 2\right) + s_0$

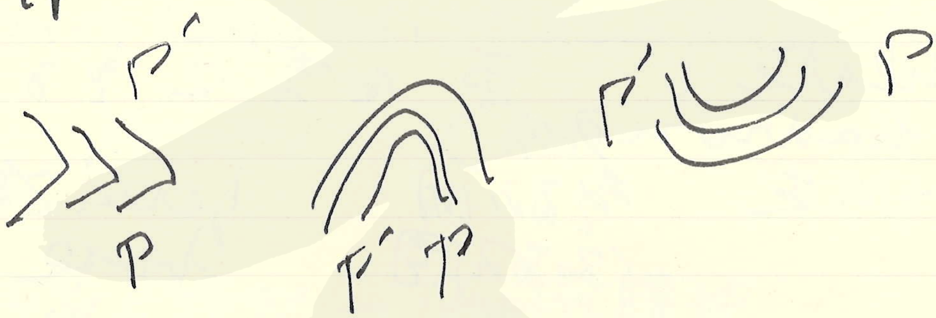
B　　M

III. 相互作用　i) connector

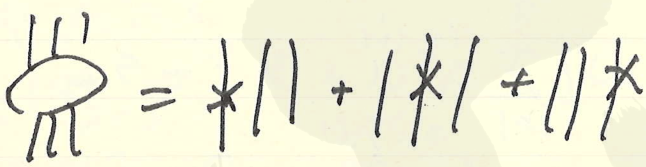


$$\Sigma^{(+)}(p',p) = :\exp[\bar\psi^{+}(p')\psi(p)]:$$

$$\Sigma(p,p') \equiv \sum_{p_1 p_2} \exp \bar\psi(p_1)\psi(p_2)$$



ii) bilinear

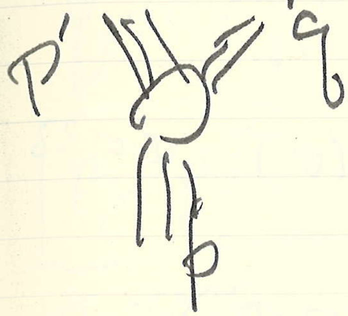


$$\tilde{O} \equiv g \sum_{p_1 p_2} \int d\xi\, \psi(p_1 \xi)\, O(\xi)\, \psi(p_2 \xi)$$

$$:\Sigma\, \tilde{O}:$$

iii) multi.

non-leptonic decay

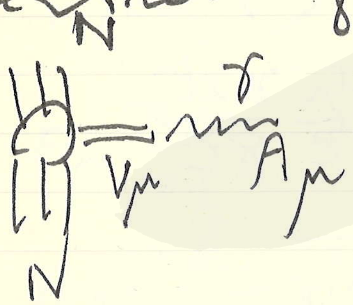


$\Sigma \tilde{W}$

$\tilde{W} = \sum \bar{\psi} Q \psi \, O_\mu \psi \; \bar{\psi} O_\mu \psi$

$O_\mu = \gamma_\mu (1 \pm \gamma_5)$

electromagnetic form factor



$(\Psi \,|\, \Sigma \tilde{O}_\mu \,|\, \Psi) \cdot V_\mu$

uniton
の函数

baryon $\dfrac{1}{\left[1 + \dfrac{q^2}{2m^2}\right]^3}$

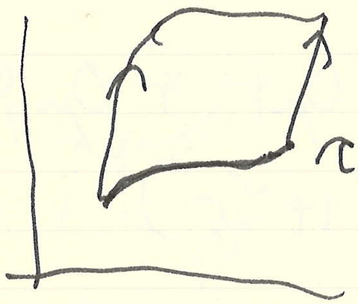
$\exp\left\{-\dfrac{1}{4\pi}\,\dfrac{q^2}{1+\dfrac{q^2}{2m^2}}\right\} \cdot \dfrac{\left(1+\dfrac{q^2}{4m^2}\right)^2}{\left(1+\dfrac{q^2}{\mu^2}\right)}$

vector meson

π-meson

$4\pi = 5$ GeV.

後藤氏:
(湯川中q)　Copen,



$\tau = \mathrm{const}$

σ, τ

$x_\mu = x_\mu(\sigma)$ $\quad \tau = \tau_0$

$\downarrow$

$x_\mu = x_\mu(\sigma, \tau)$

$$\frac{1}{\sqrt{g_{\tau\tau}}}\frac{\partial x^\mu}{\partial \tau} = v_\mu$$

$$g_{\tau\tau} = \frac{\partial x_\mu}{\partial \tau}\frac{\partial x^\mu}{\partial \tau}$$

$$v_\mu \delta_\perp x^\mu = 0$$

$$\delta_\perp x^\mu = \delta\sigma \sqrt{\frac{g_{\sigma\tau}^2 - g_{\tau\tau} g_{\sigma\sigma}}{g_{\tau\tau}}}$$

$$-dl^2 = (\delta_\perp x^\mu)^2$$

$\kappa\, dl$

$$L = \kappa \int dt\, ds(l) = \kappa \int d\sigma\, d\tau \sqrt{-\det g}$$

$$\sqrt{\frac{-\det g}{g_{\tau\tau}}}\, d\sigma \qquad \sqrt{g_{\tau\tau}}\, d\tau$$

$$p_\mu(\sigma) = \frac{\partial L}{\partial\left(\frac{\partial x^\mu}{\partial \tau}\right)} = \frac{\kappa}{\sqrt{-\det g}}\left[-g_{11}\frac{\partial x_\mu}{\partial \tau} + g_{01}\frac{\partial x_\mu}{\partial \sigma}\right]$$

$$\boxed{p^\mu \frac{\partial x_\mu}{\partial \sigma} = 0 \quad (1)} \qquad p_\mu \frac{\partial x^\mu}{\partial \tau} = \kappa\sqrt{-\det g} = L$$

$\downarrow$ $H \approx 0$

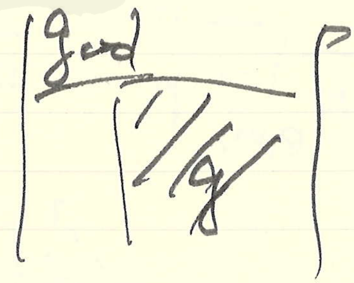
$$p_\mu(\sigma) \cdot p^\mu(\sigma) + \kappa^2 g_{11} = 0$$

$$\boxed{p_\mu p^\mu + \kappa^2 \left(\frac{\partial x^\mu}{\partial \sigma}\right)^2 = 0 \quad (2)}$$

新拘束

$$\frac{1}{\sqrt{g_{00}}} \frac{\partial x^\mu}{\partial \xi^0} \qquad \xi^\alpha = (\xi^0, \xi^a)$$

$$p_\mu \frac{\partial x^\mu}{\partial \xi^a} = 0$$



$$p_\mu p^\mu + \kappa^2 \det \bar{g} = 0$$

$$L = \kappa \int d^4\xi \sqrt{-\det g}$$

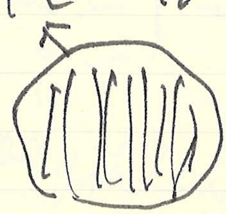
$\downarrow$

$$L = \int d^4\xi \sqrt{-\det g}\, \kappa(\psi^A(\xi))$$

$\downarrow$

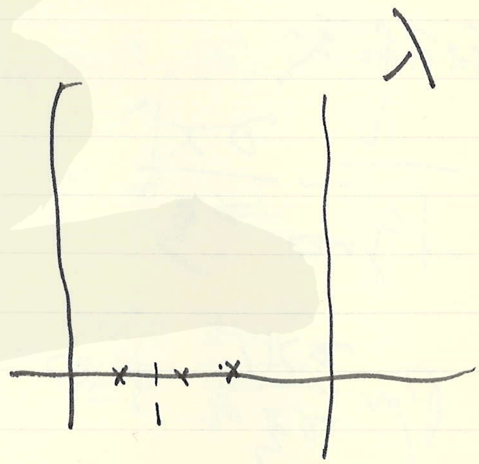
R 曲率 scalar

$$p_\mu \frac{\partial x^\mu}{\partial \xi^a} + \pi_A \frac{\partial \psi^A}{\partial \xi^a} = 0$$



3月31日
無限的 (九大)

A. $\varphi(x) \to \varphi'(x') = x^{\lambda-1}\varphi(x)$
$x' = \rho x$
$\Box^{1+\lambda}\varphi(x) = 0$
$\dim \varphi(x) = \lambda - 1$



B. 質量成分

$N \begin{cases} n \\ p \end{cases}$ e.m.

$\pi \begin{cases} \pi^{\pm} \\ \pi^{0} \end{cases}$ e.m.

$8 \begin{cases} \eta \\ K \\ \pi \end{cases}$

semistrong

SU(6)
35

super multiplet

$9 \begin{cases} \varphi \\ K^* \\ \omega \\ \rho \end{cases}$

"infinite multiplet"

Hadrons: composite internally structured (extended)

excitation

fully relativistic treatment

zero width approximation

non-compact groups

i) relativistic covariance

ii) 物理量 ⇄ generator

iii) observables (Born 以後)

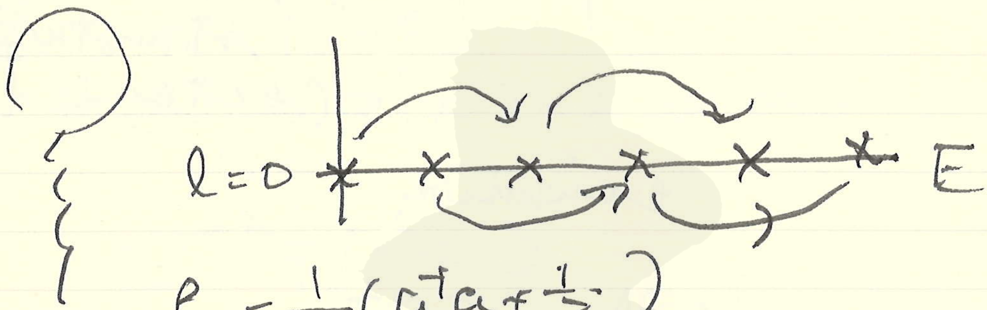
Yukawa ('56)

infinite multiplet exciton

Sakata ('55)

→ t

$a, a^{\dagger}$

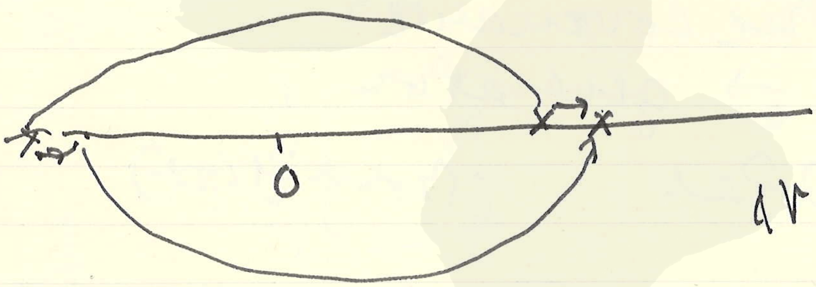


$h_0 = \frac{1}{2}(a^{\dagger}a + \frac{1}{2})$

$h_1 = \frac{1}{4}(a^{\dagger}a^{\dagger} + aa)$

$h_2 = \frac{i}{4}(a^{\dagger}a^{\dagger} - aa)$

"SO(2, 1)" dynamical group



4v 5次元散乱

Source

I. Nonlocal F.T.

II. Majorana - Gel'fand - Yaglom - Nambu Theory

('32) ('48)

Fradkin

('66 : [illegible]

Takabayasi ('65)

expansion

III. Relativistic generalization of SU(6) symmetry

index invariant theory

$G^{m} \otimes$ p or b

mass degenerate

U(6, 6)

SL(6, C)

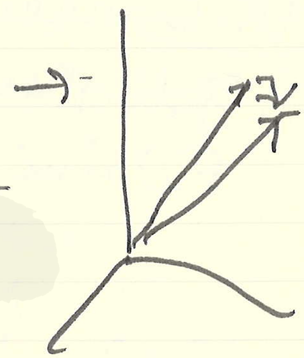
unitarity →

→ 無限縮退 (Feldman -Mathews)

→ spin 統計の関係 がおかしくなる (locality)

PCT

crossing symmetry

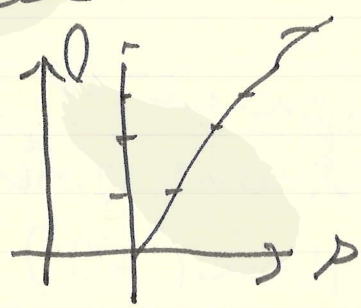


→ '68 : "no-go theorem"

無限縮退を除く

Miyazaki

"Tachyon"



locality

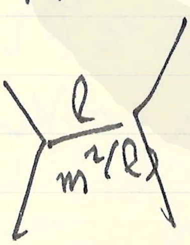
IV. Generalized Regge th.

Toller ('67)

parent trajectory
daughter trajectories

Friedman - Wang ('67)
Domokos - Tindle ('67) $SL(2, C)$

V. Current Algebra at $|P| \to \infty$
Gell-Mann ('62)
Fubini - Furlan ('65)
∞-mom. method
fixed q^2 sum rule
Adler - Weisberg ('65)
g_A-sum rule
Cabibbo - Radicati ('66) sum rule
Adler ('67) sum rule

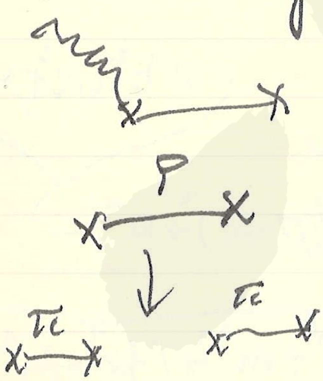
VI. Generalized Born App.
in strong Interaction
Van Hove ('67) Σ 

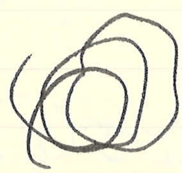
Halpern (unitarity)
Tanaka (convergence) $\downarrow$ s^α
Tanaka et al ('64)

Fronsdal, Hayasi, Ota Kozawa
-Obara, Matsumoto

VIII Non-compact groups from dynamics
H-atom $SO(4,2)$
harmonic oscillator $SU(3,1)$ $(O(3,3))$
strong coupling model $SL(4,R)$
$(I, J) = (\frac{1}{2}, \frac{1}{2}), (\frac{3}{2}, \frac{3}{2}) \cdots$
second quantization をやるのは
やられていない。

IX. S-matrix
Susskind, Nambu
Takabayashi ('70)
string model
それ程正しいとはいえない



花瓣 

午後

中野氏 : Compact group

Dirac 方程式

compact　non-unitary

indefinite metric

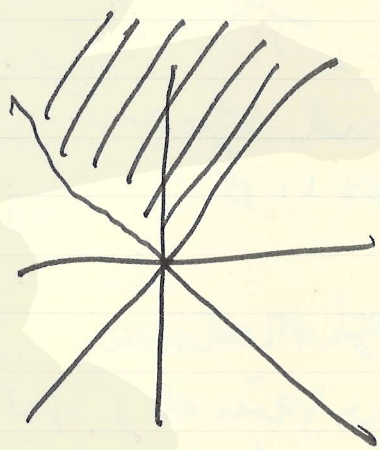
$\bar{\psi} = \psi^* \gamma_4$

$\bar{\Psi} = \psi^* \eta_4$

Wick

Wightman function

$\langle 0 | \phi \cdots \phi | 0 \rangle$



$\bar{\Psi} = \psi^*(x^+)$

ϕ, ρ　$e^{a^2(\Box - m^2)}$

$\bar{\Psi} f(\Box) \varphi \psi$

$$S(p) = \int_{-\infty}^{+\infty} d^4k \frac{e^{-2a^2\{(p-k)^2+m^2\} - 2b^2(k^2+\mu^2)}}{\{(p-k)^2+m^2\}(k^2+\mu^2)}$$

$$= \int_{(m+\mu)^2}^{\infty} \frac{d\kappa^2}{p^2+\kappa^2} \sigma(p^2, \kappa^2)$$

$$\sigma(p^2, \kappa^2) = \pi^2 \left\{ \int_{\frac{b^2}{a^2+b^2}}^{1} d\xi \, \theta\left(\kappa^2 - \frac{m^2}{\xi} - \frac{\mu^2}{1-\xi}\right) e^{-2a^2\xi(p^2+\kappa^2)} + (a \leftrightarrow b, \xi \to 1-\xi) \right\}$$

斎藤にまかせるかし.

unitarity ?

$$S = \frac{1+iK}{1-iK}$$

学士会館にての

4月1日, 1971)

講演.

紘田之話 Pu

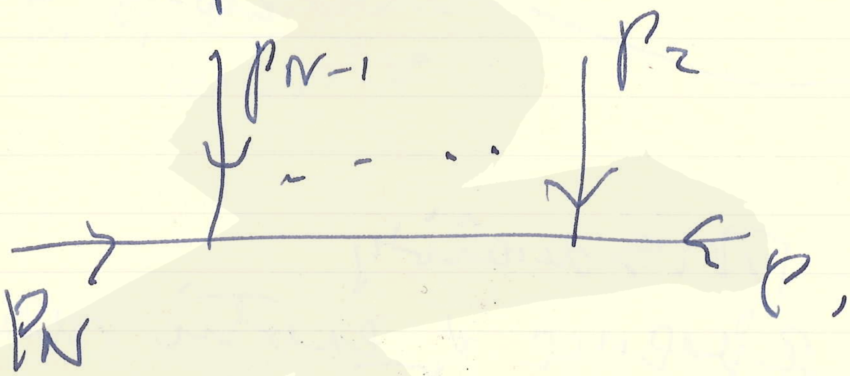
I. DRM での zeroth mode (宮内・紘田)

II. duality の破れ (?)

混沌会

April 22, 1971

I,



$$R = \sum_{n=1}^{\infty} n\, a^{(n)\dagger} a^{(n)}$$

$$R^{(0)} = \frac{\varepsilon}{\varepsilon}\, a^{(0)\dagger} a^{(0)}$$

$$V^{(0)}(p) = e^{a^{(0)\dagger} p/\sqrt{\varepsilon}}\, e^{-a^{(0)} p/\sqrt{\varepsilon}}\, e^{-\frac{p^2}{2\varepsilon}}$$

$$\varepsilon \to 0^{+}$$

Möbius 変換

$$w = \frac{az+b}{cz+d}$$

$$ad - bc = 1$$

$SL(2,C)$

$\to T = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$

$\frac{1}{\sqrt{\alpha}} = 1$ (Lovelace)

魔法の絨毯

II. DHS duality

absence of exotic resonances

$10, \overline{10}, 27$ mesons

→ exchange degeneracy

of V, T_{π}, nonet

ps(P)-meson と nonet

これらの関係.

実験的には

V, T : nonet

P, A : octet

$\pi\ K\ \eta$

$A, K^*\ D$.

F_0^5 の非保存 → duality の破れ.

trace 型　dual　$U(3)\times U(3)$

determinant 型　non-dual

broken dilatation invariant
(scale)

$D_\mu = x_\nu \Theta_{\mu\nu}$ DC

$\partial_\mu D_\mu = \Theta_{\mu\mu} = (l_\delta + 4)\delta$

δ, δ_{ξ} dilaton
massive

)

表向き → 新 class
第2種の相互作用
湯川, April 27, 1971

弱い相互作用
VA

$$H_{int} = J_\alpha^V \left[\bar{\psi}_e \frac{\gamma_\alpha(1+\gamma_5)}{\sqrt{2}} \psi_\nu\right]$$
$$+ J_\alpha^A \left[\bar{\psi}_e i\gamma_\alpha \frac{\gamma_5(1+\gamma_5)}{\sqrt{2}} \psi_\nu\right]$$
$$+ h.c.$$

$$J_\alpha^V = C_V \bar{\psi}_p \gamma_\alpha \psi_n$$
$$J_\alpha^A = C_A \bar{\psi}_p i\gamma_\alpha\gamma_5 \psi_n$$

$$J_\alpha^V = \bar{\psi}_p [f_V \gamma_\alpha - i g_V \sigma_{\alpha\beta} p_\beta + i h_V p_\alpha] \psi_n$$
$$J_\alpha^A = \bar{\psi}_p [i f_A \gamma_\alpha \gamma_5 - g_A p_\alpha \gamma_5 - h_A \sigma_{\alpha\beta} \gamma_5 p_\beta] \psi_n$$

G-parity:

$$\left.\begin{aligned} G J_\alpha^V G^{-1} &= J_\alpha^V \\ G J_\alpha^A G^{-1} &= -J_\alpha^A \end{aligned}\right\}$$ と仮定すると → 第一種 current

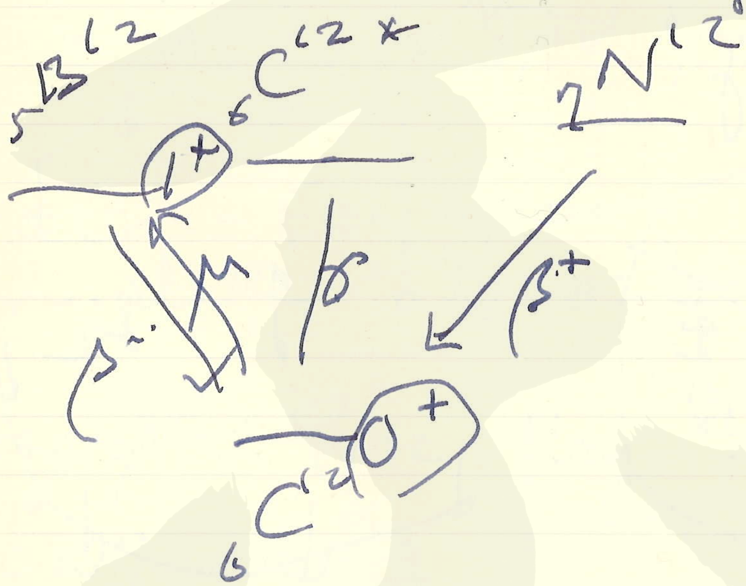
$$h_V = h_A = 0$$

$$\partial_\alpha V_\alpha^\nu = 0 \to h_\nu = 0$$
(CVC)

Tensor型 h_A はあるか？

β-decay
μ-capture

mirror nuclei of $\beta^\mp$ decay



Wilkinson

混沌会

茶館. 5月27日　1971年

細川氏：Mach原理

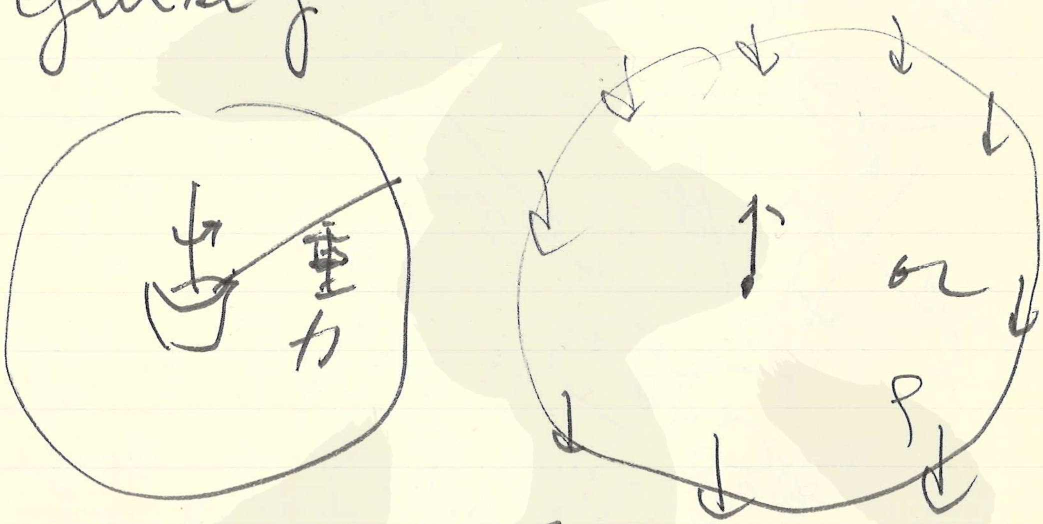
等価原理の考え方

慣性誘導

重力誘導

Sciama, Camb. Phil. Soc.

F. Gürsey



加速系内の重力の

見方

vector field　　　zero mass

　　　　　　　　　　$\frac{1}{r}$

遠心力　E

Coriolis　H

慣性質量

$$m_i = m_g f(\varphi)$$

$$g_{\mu\nu} = \varphi^2 \gamma_{\mu\nu} \qquad (\det \gamma_{\mu\nu}) = 1$$

$$L = m_g \dot{x}_\mu \dot{x}_\nu g_{\mu\nu}$$

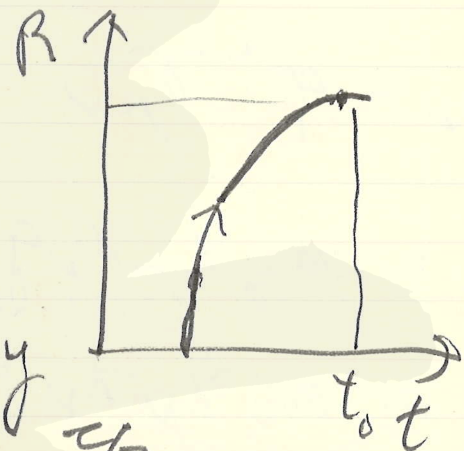
$$= m_i \dot{x}_\mu \dot{x}_\nu \eta_{\mu\nu} \gamma_{\mu\nu}$$

Wheeler-Feynmann
complete absorber

Hogarth: Proc. Roy. Soc.
expanding universe
Hoyle and Narlikar

佐藤氏：あつい宇宙
超高エネルギー宇宙線)
銀河形成 [illegible]

膨張宇宙



$$\frac{R(t)}{R_0} = 1 - 10^{-3}$$

$10^9 y$

$$R(t) \propto \cancel{\text{[illegible]}}\ t^{2/3}$$

$$\frac{\dot{R}}{R} \propto \frac{1}{t}$$

$$\frac{R(t)}{R_0} = \frac{1}{3}$$

QSO

3°K 輻射
↓
2.7°K

$$= \frac{1}{10^9}$$

He

$$= \frac{1}{10^4} \sim \frac{1}{10^3}$$ 偏向

~~百年~~違いがでてきたから

$n_\gamma \sim 400/cc$

$\bar{E}_\gamma \sim 6 \cdot 10^{-4}\, eV$

$(n_N \simeq 10^{-5} \sim 10^{-8}/cc)$

$\gamma + N \to N + \pi$

$\overrightarrow{Mc^2\gamma}$ $\gamma_{th} = \dfrac{m_\pi c^2}{E_\gamma} \doteqdot 10^{11}$

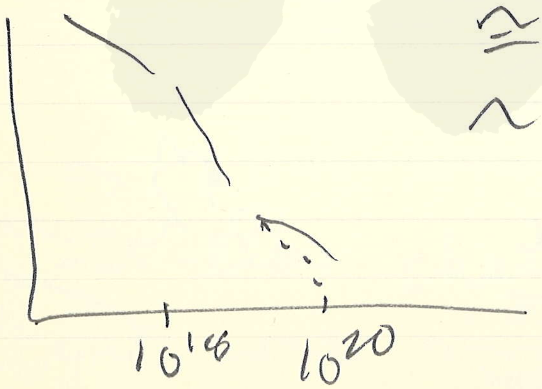
proton $E_p \gtrsim 10^{20}\, eV$

$\sigma \sim 0.3\, mb$

$$l \simeq \frac{1}{400 \cdot 0.3 \cdot 10^{-27}}$$

$\simeq 10^{25}\, cm$

$\sim 10^7$ 光年



$5 \cdot 10^{20}$

[illegible]
近く. (Andromeda 10^6光年)
pulsar

Lorentz 変換を越え

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = 10^{11} \; ?$$

絶対慣性系

$$E = \frac{Mc^2}{\sqrt{1-\left(\frac{v}{c_0}\right)^2}} = Mc^2\gamma$$

$$\hat{E} = \frac{E_\gamma}{\sqrt{1-\left(v/c(\gamma)\right)^2}} = E_\gamma \Omega$$

$$c(\gamma) > c_0$$

$$\left\{\begin{array}{l} v \to c_0 \\ \Omega \to \Omega_{max} \end{array}\right.$$

$$10^{4} < \Omega_{max} < 10^{11}$$

$$\frac{c_0}{c(\gamma)} = 1 - \frac{1}{2\Omega_{max}^2}$$

/[illegible]

Deep Inelastic Collision

1977年6月22日(水)

[illegible]談話会,

素粒子物理. small distance

high energy Phenomena

$SU(3) \otimes SU(3)$ - chiral sym.

SLAC-experiment

$m \simeq 0 \rightarrow$ scale invariance

$q^2 \rightarrow$ large

$\nu = -\frac{p \cdot q}{m}$

light cone singularity

Inclusive reactions

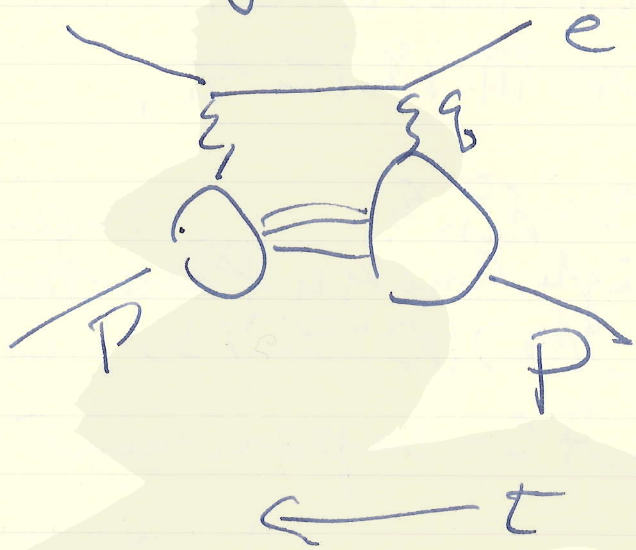
γ, electron $\rightarrow$ lepton

hadrons

Light-like charge etc

Light cone singularity

Bjorken's scaling law



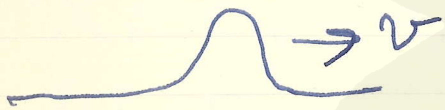
localized quarks

versus

uniform charge distri

Solitonについて
谷内俊弥
談話会　6月25日, 1971
要旨

solitary wave
nonlinear waveのパルス型の解



安定 (disturbanceに対して)
追いこし
粒子性の保存

[illegible] thresholdを越えることによる安定

歴史

linear wave ; 分散性
$\omega = \omega(k)$ をとる
wave packet の拡散
速度 or amplitudeにdependする
両者のつりあい　$\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + \cdots\right)$ (一次元的)

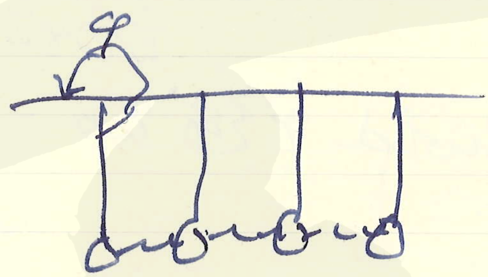
$\Box\varphi + \lambda\varphi^3 = 0$
振動を引かす potential が引きとめる。
(三次元的)

$$\Box\varphi + \alpha\varphi + \beta\varphi^3 = 0$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + \delta^2\frac{\partial^3 u}{\partial x^3} = 0$$

$$u = \lambda - \frac{1}{\psi}\frac{\partial^2\psi}{\partial x^2}$$

$$\Box\varphi + \lambda\sin\varphi = 0$$



斎藤 武

Operation Formalism of Dual Resonance Model with Different Trajectories

617-29 P 1971

結論: $\alpha_\rho - \alpha_{A_1} = 1/2$

不満足 $P = 0$

unitarity ?

π-ρ phase shift

なぜ?