XXVI

NOTE BOOK

Manufactured with best ruled foolscap
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Sept. 1969
～March, 1970

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H. Yukawa

97 *Nissho Note*

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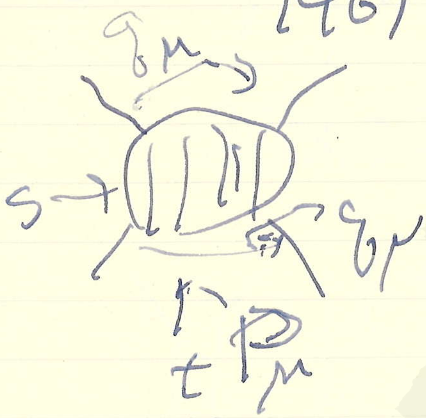
INDEX

CHAPTER	DESCRIPTIONS	PAGE

Veneziano から Nambu へ

田中 6 7行

, 9月19日(金) 長谷
1969



$O(3,1)$

n, l, m

n integer

p $(0, \infty)$ (gaussian の巾, 外…)

0 : point-like

$$f(s,t,u) = A(t,s) + \sum_{\text{cyclic}}$$

$$A(t,s) = g^2 \frac{\Gamma(1-\alpha(t))\,\Gamma(1-\alpha(s))}{\Gamma(1-\alpha(s)-\alpha(t))}$$

$$\left.\begin{aligned} t &= P_\mu^2 \\ s &= (q-q')_\mu^2 \\ u &= (q+q')_\mu^2 \end{aligned}\right\} \quad P^2,\ q^2,\ q'^2,\ qq'$$

Pq x $\quad Pq'$ x

3次元 → 4次元

$P_l(\cos\theta) \to C_n(q_\mu q'_\mu)$

gegenbauer

$A(s,t)$

$$= g^2(-\alpha(t)) \sum_{m=0}^{\infty} \frac{\Gamma(\alpha(t)+m+1)}{\gamma m!\,\Gamma(\alpha(t)+1)} \frac{1}{z_t + \frac{\delta+m}{\gamma}}$$

$$z_t = \tilde{q}_\mu \tilde{q}'_\mu$$

$$\gamma = 2a(q_\mu^2)^{1/2}(q_\mu'^2)^{1/2}$$

$$\delta = 1 - b - a(q_\mu^2 + q_\mu'^2)$$

$$\alpha(t) = at + b$$

$$A(t,s) = \varepsilon \int_c dx\, A^s(x,t)\, C_{x-1}^{1}(z_t)/\sin \pi x$$

$$z^{-\lambda} = \frac{1}{\Gamma(\lambda)} \int_0^\infty e^{-zp} p^{\lambda-1} dp$$

$$A^s(x,t) = g^2($$

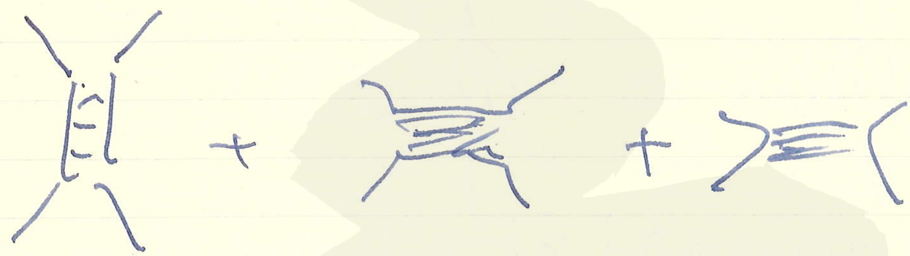
bilocal
ρ-trajectory

$$H(x) = \sqrt{2\pi}\, g \left(\sum_{x=1}^{\infty} \sum_{l=0}^{x-1} \sum_{m=-l}^{l} \right) \left(\sum_{n=0}^{\infty} \int_0^\infty dp \right)$$

$$\times \int d^4P\, e^{iP_\mu X_\mu} [$$

$$= \sqrt{2}\pi g \int d^4x_1\, d^4x_2\, \delta^4\left(X - \frac{x_1+x_2}{2}\right)$$

$$\pi(x_1)\pi(x_2)]\,\rho\,(X, x_1 - x_2)$$



$\frac{1}{2}A(t,s)$

$+\frac{1}{2}A(t,u)$

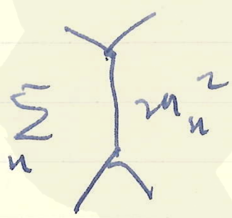
Quark Model and Factorization of Veneziano Amplitude

Y. Nambu

河原林研氏　発表　Sept. 30, 1969

factorization

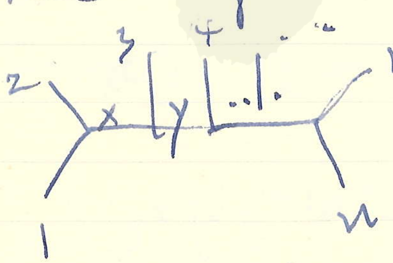
$$V_4 = \sum_n \frac{c_n(t)}{s - m_n^2}$$



$\left\{ \begin{array}{l} \text{1) mass spectrum} \\ \text{2) coupling constant} \end{array} \right.$

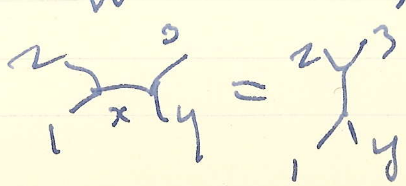
infinite component equation →

tree diagram



$$V_N = \int_0^1 x^{(12)} y^{(123)} z^{(1234)} \cdots w^{(n-1,n)}$$

$$\times \left[\frac{1-x}{1-xy}\right]^{(23)} \left[\frac{(1-y)(1-xyz)}{(1-xy)(1-yz)}\right]^{(34)}$$

duality 

$$\sim \frac{dx\,dy \cdots dw}{(1-xy)(1-yz)\cdots}$$

$$[a_\alpha^{(r)}, a_\beta^{(s)\dagger}] = -\delta_{rs} g_{\alpha\beta}$$

$$\alpha, \beta = - - - + -$$

$$r, s = 1, 2, \cdots\cdots \infty$$

$$e^A e^B = e^B e^A e^{[A,B]}$$

$$[A, B] : \text{c-number}$$

$$H = -\sum_r r\, a_\alpha^{\dagger(r)} a_\alpha^{(r)}$$

$$\langle N | \Gamma | 0 \rangle = \langle N | e^{i \sum_r \sqrt{\frac{2}{r}} a^{(r)\dagger} \pi} | 0 \rangle$$

$$N = -\sum_{r,\alpha} r\, a_\alpha^{\dagger(r)} a_\alpha^{(r)}$$

$$\langle N' | \Gamma | N \rangle = \cdots$$

$$V_N = \cancel{\ } \langle 0 | \Gamma(p_n) \frac{1}{H - \alpha_{n-1}} \Gamma(p_{n-1}) \frac{1}{H - \alpha_{n-2}}$$

$$\cdots \Gamma(p_2) \frac{1}{H - \alpha_1} \Gamma(p_1) | 0 \rangle$$

$$\phi_\alpha(\xi) = \sum_{r=1}^{\infty} \sqrt{\frac{1}{2r}} \{ a_\alpha^{(r)} + a_\alpha^{(r)\dagger} \} \cos r\xi$$

$$\pi_\alpha(\xi) = \sum \cdots$$

$$0 \leq \xi \leq 2\pi$$

$$H = -\frac{1}{\pi}\int_0^{2\pi} i\{\partial_\xi \Phi_\alpha(\xi)\partial_\alpha(\xi) + \pi[\xi]\pi[\xi]\} \times d\xi$$

$$(\Box - H)\,\Psi(X, \Phi(\xi)) = 0$$

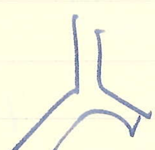
$$\Psi^\dagger\, \Gamma\, \Psi\, \varphi$$

$$\Gamma = i\exp\{2i\kappa\Phi(0)\}$$

$\| \sim\sim \Phi(X)$

$\varphi(x, \nu)$

$\downarrow$



quark との結合 (未吟味)

$$H = a^{0\dagger}a^0 + \sum_{\mu=1,4;\, n} n\, a_\mu^{(n)\dagger} a_\mu^{(n)}$$

$a^{0\dagger}$ ~~a~~: radial excitation

$n=1$: $a_\mu^{(1)\dagger}$ l-excitation

$n \geq 2$ $(q\bar{q})$ excitation ${}^3S, {}^3P_0$

iq 模型,

$a^{0\dagger}$ ~~a~~ $\quad (\bar{q}q)$ excitation $\Big|$ $(\bar{q}\gamma_5 q)$

$a_\mu^{(1)\dagger}$ ~~a~~ $\quad (\bar{q}\gamma q)$

$a_\mu^{(n)\dagger} \quad (\bar{q}\gamma_\mu q)(\bar{q}q)^n$

$n \geq 2$

砂川君

Self-Energyの話

基研　Oct. 21, 1969 ~~~23~~

~~Oct. 21, 午前~~

液体 He

Bose 場　Yukawa coupling

$$H = \int d^3x \left[(\pi^* \pi + \nabla\varphi^* \nabla\varphi + M^2 \varphi^* \varphi) + \frac{1}{2}(E^2 + (\nabla A)^2 + m^2 A^2) + g A \varphi^* \varphi \right]$$

$$= \sum_k \Omega_k (a_k^* a_k + b_k^* b_k) + \sum_k \omega_k \alpha_k^* \alpha_k$$

$$E_0 + \qquad + H_I$$

$$H_I = \frac{g}{\sqrt{V}} \sum_{p,q} \frac{1}{\sqrt{2^3 \Omega_p \Omega_q \Omega_{p-q}}} \varphi_p^* \varphi_q A_{p-q}$$

$$\varphi_k = a_k + b_{-k}^* \qquad \Omega_k = \sqrt{k^2 + M^2}$$

$$A_k = \alpha_k + \alpha_{-k}^* \qquad \omega_k = \sqrt{k^2 + m^2}$$

$$H|0\rangle = \varepsilon_0 |0\rangle$$

$$H_0 |0\rangle = E_0 |0\rangle$$

$$H \Psi_k = (\varepsilon_0 + \varepsilon_k) \Psi_k$$

$$H_0 |k\rangle = (E_0 + \Omega_k) |k\rangle$$

$$\Delta E_k = \overset{\infty}{\varepsilon_k} - \overset{\infty}{E_k^F}$$

$$E_k^F = \Omega_k / \langle 0 | \varphi_k \varphi_k^* | 0 \rangle$$

$$(H - \varepsilon_0 - E_k^F)\Psi_k = \Delta E_k \cdot \Psi_k$$

$$\Psi_k = \varphi_k^* |0\rangle + \sum_l C_{l,k-l} A_l^* \varphi_{k-l}^* |0\rangle$$

[illegible]の理論 (Heitler の damping theory)
lowest non-vanishing な matrix element だけ取る!!!

$$\mathfrak{J}_s a_k \mathfrak{J}_s^{-1} = b_{-k}^*$$

$$\mathfrak{J}_s \varphi_k \mathfrak{J}_s^{-1} = \varphi_k$$

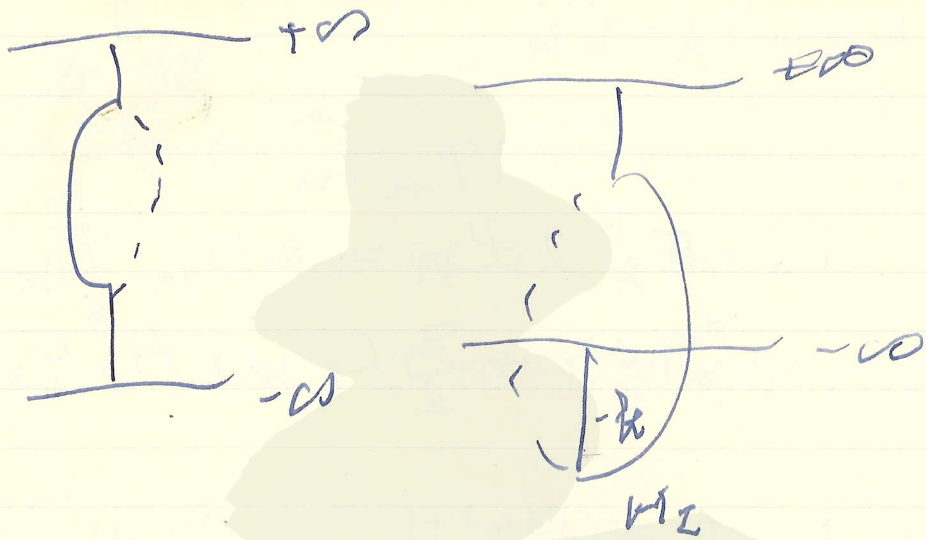
$$\Delta E_k = -\sum_l \frac{|\langle 0 | \varphi_{k-l} A_l (H - E_0 - \Omega_k) \varphi_k^* | 0 \rangle|^2}{\Omega_{k-l} + \omega_l - \Omega_k}$$

true vacuum は存在するか?

$$|0\rangle = |0) + \frac{1}{E_0 - H_0} H_I |0) + \cdots$$

$$\cancel{\Delta E_k} = \frac{g}{\sqrt{2^3 \omega_l \Omega_{k-l} \Omega_k}} \left(\frac{2\Omega_k}{\Omega_{k-l} + \omega_l + \Omega_k} \right)$$

damping factor



模型と構造研究会

基研　Oct. 23 ~25, 1969

午前

大貫氏:

SU(6) → static から離れたら...

i) Lorentz pole

Prel ℓ_0 の後で $\left|\frac{\cdots}{\Delta x}\right| \Delta t$

は Δx に対して Δt

を無視できない

ii) chiral invariance

goldstone boson

B.S. amplitude

$$\chi_{\alpha\beta}(P, q) = \gamma_5 \left(A + (q \cdot P) \not{q} B + C \not{P} + D(\not{q}\not{P} + \not{P}\not{q})\right)$$

$P^2 = -m_\pi^2$

$A, B, C, D = \mathrm{fn}\left((P q)^2, q^2\right)$

$$\chi = \begin{pmatrix} \chi_{+-} & \chi_{++} \\ \chi_{--} & \chi_{-+} \end{pmatrix}$$

$\beta \equiv \gamma_4$ diagonal rep 表示. .

(i) $|q| \ll M$

(ii) $|\chi_{++}| \gg |\chi_{\pm\mp}|, (\chi_{--})$

weak binding

rest system

$$\chi_{\pm\pm} = A \pm \mu_\pi (B q_0^2 + C)$$

$$\chi_{\pm\mp} = (\sigma q)(2\mu_\pi D \pm B q_0 \mu_\pi)$$

$\mu_\pi = 0$: $\chi_{\pm\mp} \to 0$　$\chi_{++} = \chi_{--}$

$\chi_{\alpha\beta} \to \gamma_5 A$

$$\chi^{\pi}_{++} - \chi^{\pi}_{--} = O(\mu_\pi) \quad (\simeq C\mu_\pi)$$

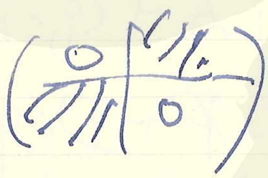
$$\chi^{K}_{++} - \chi^{K}_{--} = O(\mu_K) \quad (= C\mu_K)$$

$$\langle 0|A_\mu(0)|\pi\rangle = f_\pi \cos\theta \, \frac{P_\mu^{q}}{2}$$

$$\langle 0|A_\mu(0)|K\rangle = f_K \sin\theta \, \frac{P_\mu^{K}}{2}$$

$$f_\pi \simeq f_K$$

chiral PS　　V,　　SU(6)
　　　　　　　　　　PS, V

$V =$ 

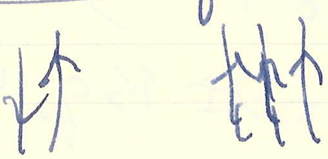
weak binding から離れなくてはい..

strong binding

Dirac の量化が弱る

line で symmetrize する

line は unitary spin の空を持つ
Dirac の spinor を持つ



$\chi_{\beta\alpha}$　　$\chi_{\alpha_1\alpha_2\alpha_3}$

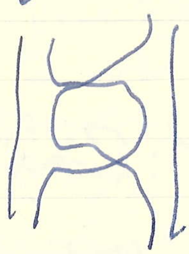
on shell (外線) の an だけ

$(\gamma_\mu^{(i)} \partial_\mu + m) \chi_{\cdots} = 0$

up-down だけですむ

Iizuka rule の正当化?

disconnected graph は考えない…



?

Hori

three triplet model

exotic resonance 発?

Smith Ann 55 521

筆録：河原林研
　北門、気賀 など

Venegiano model

i) Finite Energy Sum Rule (FESR)

Freund Harari

$T(s, t, \cdots) = T_{\text{diffr.}} + T_{\text{non-diffr.}}$

$$\int_0^N \mathrm{Im}\, T_{\text{non-diff.}}(s,t)\, ds \;\simeq\; \sum_{i \neq P} N^{\alpha_i(t)} \beta_i(t) \qquad P : \text{Pomeron}$$

$$\int_0^N \mathrm{Im}\, T_{\text{diff.}}(s,t)\, ds \simeq N^{\alpha_P(t)} \beta_P(t)$$

ii) Narrow Resonance Saturation for non-diff. part of T

iii) Non-exotic resonance

Veneziano 公式 は ii), iii) を満たす

A) Application

i) meson systems

∘ generalized exchange degeneracy

$$\left.\begin{aligned} &\alpha_\rho = \alpha_f \;;\; \beta_\rho = \beta_f \\ &= \alpha_\omega = \alpha_{A_2} \;;\; = \beta_\omega = \beta_{A_2} \end{aligned}\right] \Leftrightarrow \begin{aligned} &m_\omega^2 = m_\rho^2 \\ &m_f^2 = m_{A_2}^2 \end{aligned}$$

$1^-, 2^+$ nonet scheme

Okubo, Iizuka

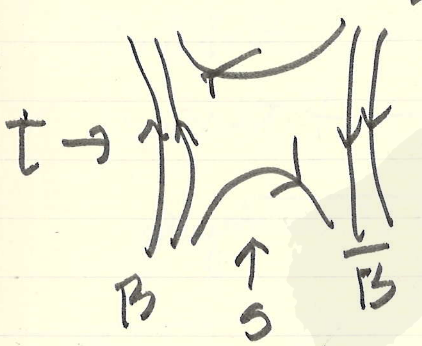
∘ chiral dynamics と consistent
∘ ρ-universality ⟷ trajectory
の derivative の universality

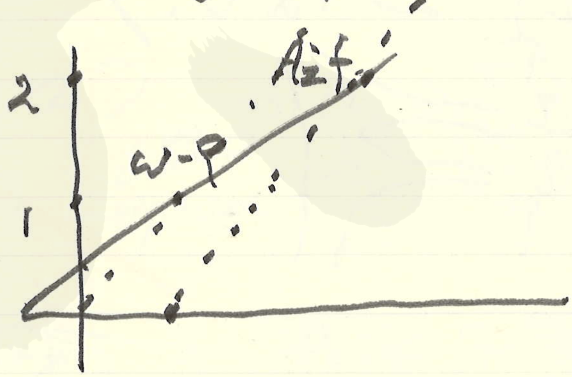
SU(6)⊗O(3)

ii) meson + baryon
Zweig
baryon spectrum SU(6)⊗O(3)
Σ-Λ f-type
duality breaking ~~((ii) と (iii) の [illegible])~~
(local)

iii) baryon-antibaryon
no solution

K. K. Y. (exotic resonance を入れるか
(あるいは duality の 放棄)か.





B) Formulations
i) N体の Veneziano formula
ii) unitarity (higher order correction)

→ level structure の degeneracy

$N_E \sim e^E$

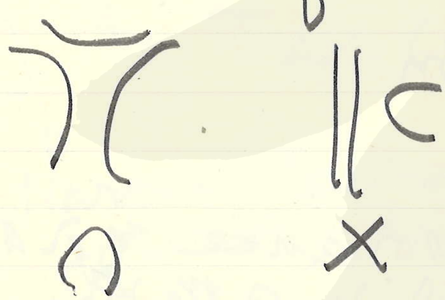
<u>ghost state をもつ</u>

(Lorentz invariance)

c) Selection rule based on duality

Freund, Rosner, Waltz

1) Y vertex の "a pair のアトとして → quark line を書かすべし



(2)

composite particle の統計

Oct. 24

午前　後藤氏　ひろがった粒子

three oscillator model

quark model →

$\Psi_{\alpha_1\alpha_2\alpha_3}(x^{(1)}, \ldots x^{(3)}; p^{(1)}, \ldots p^{(3)}) \to a\ a^*$

6種の oscillator の集団

午. 伊藤
解説　$(\theta, \psi, \phi) \to$ 2-comp. spinor

(a, a^*) 4種の oscillator

相対論的波動方程式は unique でない

(並木氏: Lorentz群の unitary 表現と nonunitary 表現の区別)

abstraction

(高林氏:

(Barut? $SO(4,2) \to (a_i, a_i^*)$ 2種の spinor (b_i, b_i^*)

physical な $SO(3,1)$ のとり方.

湯川

nonl. def. に対する無数の数階段 → 表面不變

(?) ?

ある程度 → discrete の構成

(時空点と 統計)

(素領域)

nonl. def. configuration space での 非局所性

$$[C^{(i)}_{\alpha}, C^{(j)}_{\beta}] = \varepsilon_{\alpha\beta}\delta^{ij}$$

$$\varepsilon_{\alpha\beta} = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$$

$$i, j = 1, 2, 3$$

の中にある

$$SL(2, C)$$

$$SO(3, C) \to SO(3,1) \otimes SO(3,1)$$

回転体

$$L = \frac{I}{2}\omega^2 \qquad \vec{\omega} \to \frac{d\xi}{dt} \to d\tau$$

$$\left[(P_\mu^2)^2 - \frac{1}{2I}T^2\right]u = 0$$

i) $d\tau^2 = dx_\mu dx_\mu$

ii) $d\tau = \dfrac{p_\mu dx^\mu}{p_\mu^2}$

body frame での rotation

$$[P^\mu P_\mu - \varkappa]u = 0$$

majorana

$$\underset{J\to\infty}{m} = \frac{\varkappa_0}{J+\frac{1}{2}}$$

$$[P_\mu^2 - \varkappa P_\mu \Gamma^\mu]u = 0$$

$$m = \varkappa_0 (J + \tfrac{1}{2})$$

negative energy state なし

節 III: daughter trajectory
mass spectrum
infinite comp. となるか (差分的方程 difference eq ?)

$$(\Gamma_\mu \partial_\mu - \varkappa \partial_\mu \Sigma^\mu) u = 0$$

(質点 : $m^2 = \kappa_0 (s + \frac{1}{2})$)

three spinor
$\xi^{(i)}(\vec{x})$
ゴムまりの中の3質点

infinite component
rest frame

$$\vec{S} = \frac{1}{2} a^* \vec{\sigma} a$$

$$R_3 = \frac{i}{2}(a_1 a_2 - a_1^* a_2^*) \quad \text{(Lorentz 変換)}$$

$$e^{\frac{i\omega}{2}(a_1 a_2 - a_1^* a_2^*)} |n_1, n_2; 0\rangle_{\text{rest}}$$

$$= | \qquad ; \omega \rangle$$

$$|0; \omega\rangle = \frac{1}{\mathrm{ch}\frac{\omega}{2}} e^{a_1^* a_2^* \tanh\frac{\omega}{2}} |0; 0\rangle$$

$\omega \gg$ ~~~
$\omega \ll$

$$|s, s_z; \omega\rangle = \frac{1}{(\mathrm{ch}\frac{\omega}{2})^{2s+1}} \frac{1}{\sqrt{(s+s_z)!(s-s_z)!}}$$

$$\times e^{a_1^* a_2^* \tanh\frac{\omega}{2}} (a_1^*)^{s+s_z} (a_2^*)^{s-s_z} |0; 0\rangle$$

$(P_\mu^2 - \kappa P_\mu \Gamma^\mu) u = 0$

$P_2 \neq 0$

$m \simeq m(J) \rightarrow J = J(m)$

m : time-like

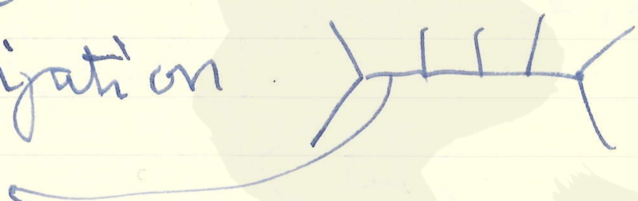
→ space-like

space-like solution

評価: Veneziano と extended model
Nambu

内部

factorization



無限個の harmonic oscillator

$H = \sum_{n=0} n\, a^{(n)*} a^{(n)}$ → Nambu 3注

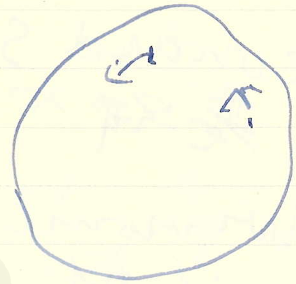
level density e^E

$H = \sum_{(i)} \sum_{n=1} n\, a^{(n),i\,*} a^{(n),i}$

→ deformable body

[illegible]構造

$H \sim \sum_{J,n} a^{*}_{Jn}(Jn)\; a_{Jn}(Jn)$



$u(x,t)$

vertex

$V \sim \phi(0)$

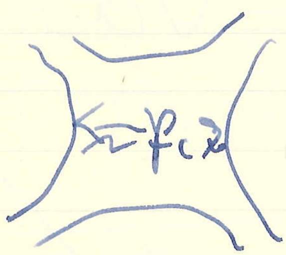
boundary condition

湯川：統計

田中正：指出　SU(3)　SU(6)×O(3)

力学　Regge

duality　　reciprocity のかわり



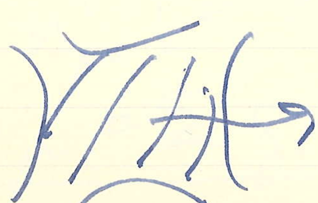
$e^{a p q_\mu^2} \to e^{-\frac{r_\mu^2}{ap}}$

$p \to 0$: pole contrib.

oscillator model との関係

Nambu　$\psi(X, r(u))$　$u:(0,1)$

Susskind



→ 膜になる

北門新作氏

Leonard Susskind の講演
基研　Nov. 4, 1969

1) Harmonic Oscill. Analogy
for V.M.,

$$(\Box_1+M^2)(\Box_2+M^2)\psi(x_1,x_2)$$
$$+U(x_1,x_2)\psi(x_1,x_2)=0$$

$M^2\to\infty$　　$X=\frac{1}{2}(x_1+x_2)$

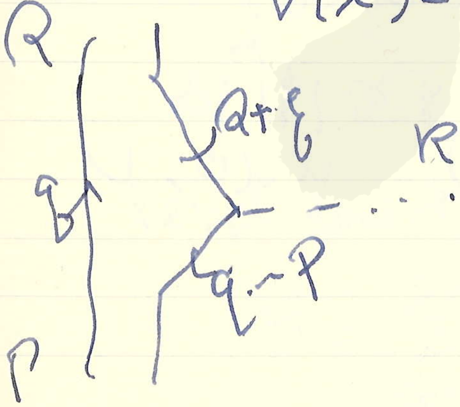
$x=x_1-x_2$

$$\left[\frac{\Box_X}{2}+2\Box_x+V(x)\right]\psi(x,X)=0$$

$$\lim_{M^2\to\infty}\frac{M^4+U}{M^2}=V(x)$$

$$\left(-\nabla+\frac{V}{2}\right)\psi=\frac{P^2}{4}\psi$$

$V(x)=x^2$



$R=-(P+Q)$

$$I = \int x^{-p^2} (e^{-x})^{-\frac{t_{12}}{2}} dx$$

$$\frac{1}{p^2 - n} = \int_0^1 x^{-p^2+n-1} dx$$

$$e^{-x} \to 1-x = e^{\ln(1-x)}$$

$$= e^{-\sum_j x^j/j}$$

2) structure of hadrons implied by duality

$m \to n$

$$\langle n | e^{a^+ k} e^{-ak} | m \rangle =$$

Nambu

$$T(k_1, k_2) = \langle 0 | T(k_1) n \rangle$$

$$\times \frac{1}{s - \sum n - c} \langle n | T(k_2) | 0 \rangle$$

$$x_i \to \sum g_i^2 x^i$$

$$a_\mu^+, a_\mu \Rightarrow a_\mu^{i+}, a_\mu^i$$

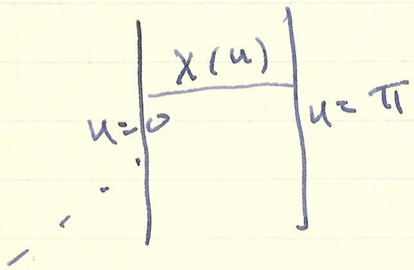
$$\langle n_\mu^i | e^{A_\mu^+ k_\mu} e^{-A_\mu k_\mu} | m_\mu^i \rangle$$

$$A_\mu = \sum g_i a_\mu^i$$

$$= \int x^{-s+c-1} [e^{-\sum g_i^2 x^i}]^{-t_{12} + 2\mu^2}$$

$$\sum g_i^2 x^i = \sum \frac{x^i}{i} = \ln(1-x)$$

3) Phys. Interpretation of Duality



M. Konuma and M. Nakagawa

Universal V-A Interaction
with CP violation

基研・談話会

Nov. 11, 1969

current-current
$V - e^{i\phi} A$

(charged current
neutral current

1969

火の玉 研究会 12月1日〜4日

第3日 12月3日

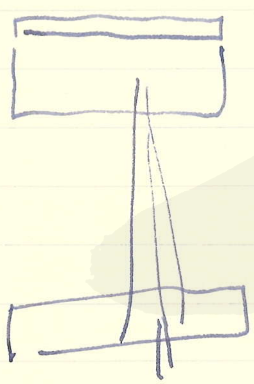
長谷川俊一 : アンドロメダの話

チャカルタヤ

ch.12 ('65) ch.13 ch.14 ch.15 (Oct.'69)

乾板

C



E.C
乾板
1 n mfp
2 cm.

30 cm
~20 cm

$\Sigma E_\gamma \gtrsim 3\times10^{12}$ eV

90个

火の玉 H. 質量 ≈ 2.6 GeV

小さい火の玉 : (5 ~ 7) m_π

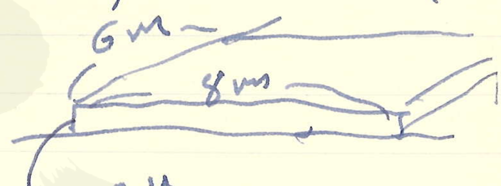
SH.

ch.14
48 m²
Clean Air
jet
ΣE_γ
20~100 TeV
SH 多数

EAS
アンドロメダ ≈ 10^{16} eV
マゼラン
カシオペア } 10^{15} eV

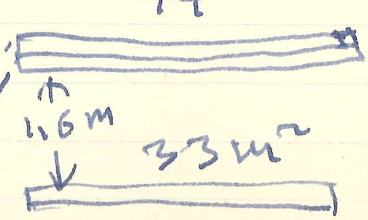
ch.15
粒流計数
薄い乾板
二段チェンバー

6m~
8m

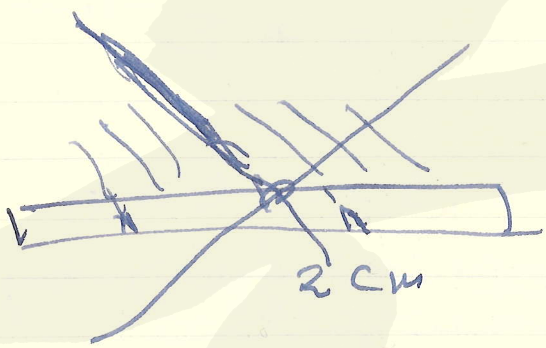


22 cm
15 cm
Pb 60 Ton

44 m²
E.C
乾板
23 cm
1.6 m
33 m²
EC



$\Sigma E_\gamma > 3$ TeV 500个
10 TeV 50个



Andromeda　一風変わる

Magalhães　10^{15} eV

$E_\gamma > 1$ TeV　~ 35 ケ

$\Sigma E_\gamma = 555$ TeV

$E_\gamma \geq 0.5$ TeV　+) 101 ケ

ΣE_γ　+) 71 TeV

$E_{p\ell} > 1$ TeV　20 ケ

ΣE_γ　+) 60 TeV

Lateral distribution

$e^{-r/\alpha}$ $\alpha = 5$ cm

エネルギーと共に変わるか…

Energy spectrum

power type

And. $N(>E) = * E^{-1.6\pm} \rightarrow \left\{ \begin{array}{l} T = 9\ \mathrm{c.u.} \\ 6.5\ \mathrm{km} \\ E_0 \geq 5 \times 10^{15}\ \mathrm{eV} \end{array} \right.$

Mag. $= * E^{-1.8\pm}$

And.

N-type X-ray film

R type

Emulsion

$\Sigma E_\gamma = 400$ TeV

生きのこり粒子

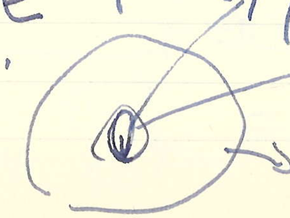
$\left\{ \begin{array}{l} T = 650\ \mathrm{m} \\ E_\gamma > 5\ \mathrm{TeV} \quad 25本 \end{array} \right\} \rightarrow \Sigma E_\gamma \simeq 8 \times 10^{15}$ eV

$\sim 1.2 \times 10^{16}$ eV

$K_\gamma \sim 0.2 \sim 0.3$

芯の拡がり方

$e^{-x/\beta}$



$\beta = 0.5$ cm

400 TeV

2.8×10^{16} eV

それぞれの粒子, 200 TeV.

真中のエネルギーは高くない
の理由

1. 核のエネルギー
$E_0 \simeq 3\times10^6$ eV

2. 粒子数の transition の max. 7 c.u.
(10^{12} eV)

3. 粒子構造なし

4. $e^{-r/\rho}$　　$\rho = 0.5$ cm

Mag.
$\rho = 0.2 \sim 0.3$ cm
high energy γ と balance
background

藤本：　10^{12} eV
$3\cdot10^4$ g
ひろがり　1.2 cm
E_γ　空気中 1m　10 cm) ×
$3\cdot10^{15}$　10m　8 cm) ×
$3\cdot10^{14}$　100m　6 cm) ○
UH 100 GeV
p_T　300 MeV

藤本君:
multiplicity versus energy

$10^{10} \sim 10^{11}$ eV　$N=10$　one fire

$10^{11} \sim 10^{14}$ eV　$N=10$　one fire / two fire / three fire / four fire

$(N_0 = N_{ch}$ として$)$

火の玉 → H quantum

1° 形 isotropic

2° mass　$\mathfrak{M}_\gamma = 1.36 \to \mathfrak{M} = 2.6$ GeV

$\mathfrak{M}$　$2 \sim 3$ ~~GeV~~ m_N

3° 温度　$f(P)$　$p \cdot e^{-P/P_0} \sim e^{-E/kT}$

$kT \sim m_\pi$

$10^{14} \sim$

S.H. quantum

$\mathfrak{M} = 5 \sim 10\, \mathfrak{M}_H$

$kT \cong 3 m_\pi$

$N_\gamma \sim 3 N_H$

SH → H → π

U.H.　$(\mathfrak{M} \sim 100\, m_N)$

---

1) Resonance と 火の玉 の関係

1° ガス体

2° cut-off　e^{-P/P_0} (Wataghin)

物質の新形態 (Lattes)

3° $N\bar{N}$

2) 核の力の dynamics

$\Delta \sim \cancel{m_N}\ (1\sim 2)\, m_N$　　虚 | 仮想

斥 $\sim 3\, m_N$　　実 | 遊

duality ?

$E_0 \to E_1 + E_2$

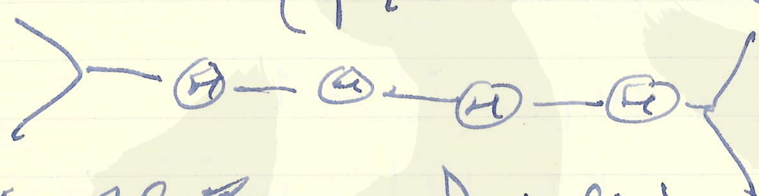
$P_0 \to P_1 + P_2$

3) 並木路

H粒子の衝突を

multiperipheral = 並木路

(P_T 小)　　しめかわ モデル



その理由 multiplicity 6 ぐらい

4) 階層

H → SH → UH ... EAS

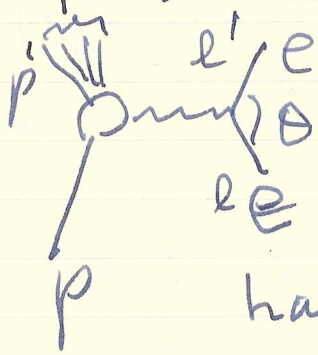
丹生さんの 2 fire

[illegible]田氏　　基研

Parton Model　　Dec. 9, 1969

Feynman

e-p inelastic scattering



Lab. 5 GeV ~ 20 GeV

Mark II　　40 GeV

kinematics

$s = (p+p')^2 \qquad t = (l-l')^2$

$w = \sqrt{p'^2}$

$s \doteq m(m+l_0)$

$t \doteq -4 l_0 l_0' \sin^2\frac{\theta}{2}$

$w = m^2 + 2m(l_0 - l_0') + t$

$$\frac{d\sigma}{d\Omega\, dl_0'} = \frac{e^2}{k^4}\frac{|l'|}{|l|}\phi^{\mu\nu} \mathrm{Abs}\, T_{\mu\nu}$$

$k = l - l' \qquad K = l + l'$

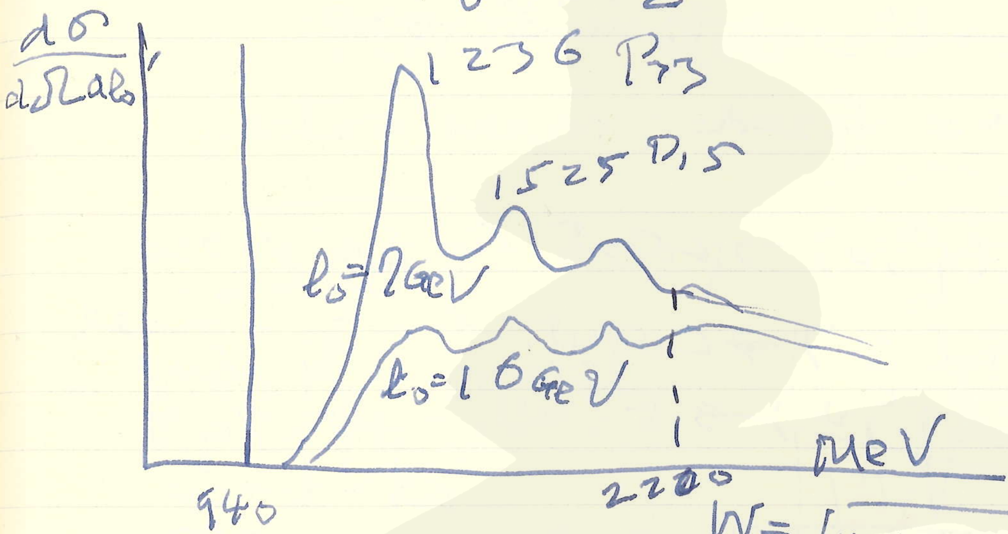
$\phi^{\mu\nu} = \frac{1}{4}(K^\mu K^\nu - k^\mu k^\nu + \kappa^2 g^{\mu\nu})$

$g^{\mu\nu} = (1, -1, -1, -1)$

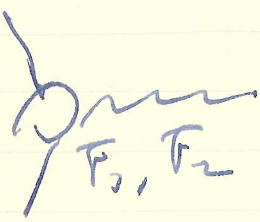
$\mathrm{Abs}\, T_{\mu\nu} = (2\pi)^3 \sum_n \delta(p_n - p - k)$

$\times \sum_s \langle N p s | j_\mu | n \rangle \langle n | j_\nu | N p s \rangle$

$$\frac{d\sigma}{d\Omega\, d\epsilon_0'} = \frac{\alpha^2 \cos^2\frac{\theta}{2}}{4\epsilon_0 \sin^4\frac{\theta}{2}}\left(2W_1 \tan^2\frac{\theta}{2} + W_2\right)$$

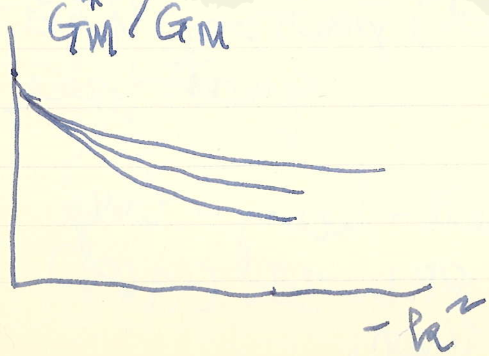


$$W = \sqrt{m(m+2\epsilon_0) - 2(m+2\epsilon_0 \sin^2\theta)\epsilon_0'}$$



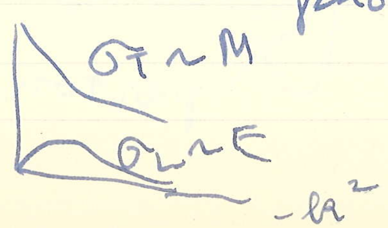
$F_1, F_2 \to G_E, G_M$

$W_1, W_2 \to G_E^*\ \ G_M^*$



$$\frac{d\sigma}{d\Omega\, d\epsilon_0'} = \Gamma(\sigma_T + \epsilon\,\sigma_L)$$

virtual photon



Deep inelastic region

$$\nu \equiv k_0 = l_0 - l_0' \to \infty$$

$$q^2 \equiv -k^2 = 4 l_0 l_0' \sin^2 \frac{\theta}{2} \to \infty$$

$$\nu / q^2 = \text{fixed}$$

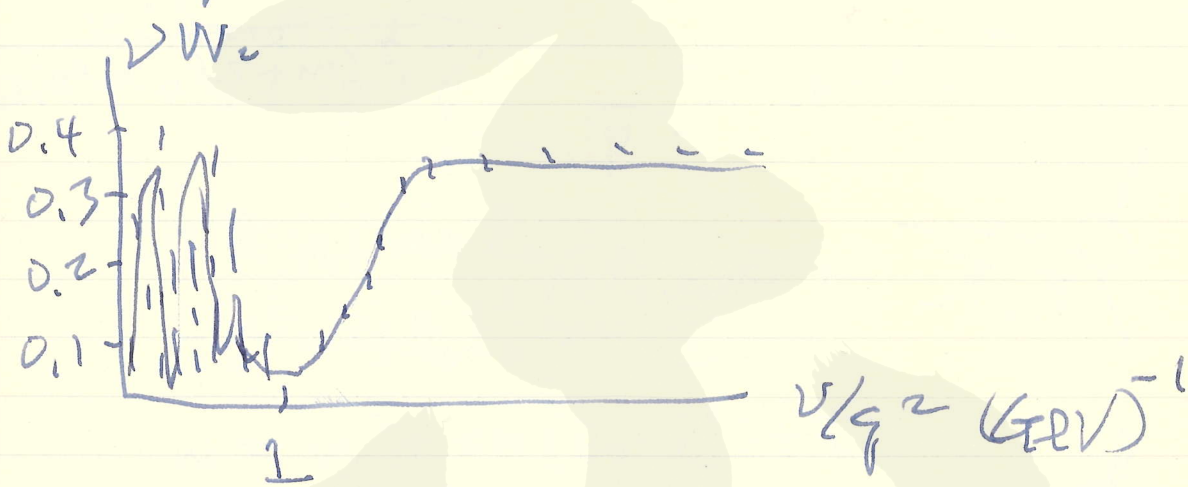
1) $\nu W_2(q^2, \nu) \to \text{const}$ } as $\nu \to \infty$

$\frac{q^2}{\nu} W_1(\;''\;) \to \text{const.}$ } q^2 : fixed

2) $\nu W_2(q^2, \nu) \to F(\omega)$ $\quad \omega = \nu / q^2$

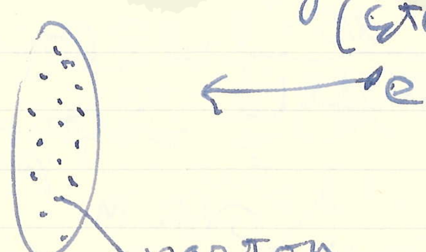
as $\nu \to \infty$

$F(\omega) \to \text{const.} \neq 0$ $\quad \omega \to \infty$



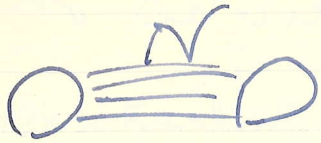
Parton model

Drell　　Bjorken - Paschos (Stanford) parton { point-like, 構造なし, quasi-free



parton

Drell - Levy - Yang
PRL 22 (1969)
Preg.



$P(N) \to \frac{1}{N^2}$

parton mass : "

$\sqrt{\langle Q^2 \rangle} = 0.4$

① quark model
qqq

N: Thiele [illegible]

$P(N) = 0$

② $qqq + n(q\bar{q})$

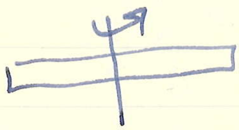
$Q(N) = \left(\frac{2}{3}\right)^2 + \left(\frac{2}{3}\right)^2 + \left(\frac{1}{3}\right)^2 + \frac{1}{3}\left(\left(\frac{2}{3}\right)^2 + \left(\frac{1}{3}\right)^2\right) \times (N-3)$

$= \frac{1}{3} + \frac{2N}{9}$

Abarbanel – Goldberger – Treiman
PRL $\underline{22}$ (1969)

G. Börner

"Gravars": Speculations on Sources of gravit. radiat. and discussions of Weber's experiments



← 1 m →

10^{-30} erg sec^{-1}

earth - moon 10^{5} erg sec^{-1}

super nova 10^{50} erg sec^{-1}

10^{2} erg cm^{-2}

Weber PRL (1969)

1660 Hz ± 0.017 Hz

transverse wave

from the galactic center

10^{4} erg cm^{-2}

	1 kpc	10 kpc	10 Mpc	1 Gpc
	pulsar	Gal. Cent.	galaxies	Quasars
E	10^{53}	10^{55}	10^{61}	10^{65}
$m_\odot$	1/20	5	$5 \cdot 10^{6}$	$5 \cdot 10^{10}$
	$10^{-6.3}$ sec	$10^{-4.5}$ sec	1 min	1 week

τ^{-1}

Kerr 1962

galaxy expanding 7 km/sec

70 $m_\odot$/year mass-loss

for 10^8 years

Schwarzschild radius R_s

$$1+z = \frac{1}{\sqrt{1 - R_s/R}}$$

cluster of black holes

"gravar"

quasar → gravar

重力場と重力子
岩崎洋一
基研 12月9日, 1969

Dicke
higher spin + lower spin

	mass	spin
γ	0	1^-
π	135 MeV	0^-
g	$\leq 3\times10^{-29}$ eV/c²	0^+ 2^+ 4^+ 6^+ …
ν	$m_{\nu_e} \leq 300$ eV	
	$m_{\nu_\mu} \leq 3$ MeV	
	$m_\gamma \leq 10^{-13}$ eV	

$\Box \varphi_{\mu\nu} = 0$
$\varphi_{\mu\nu} = \varphi_{\nu\mu}$
$\varphi_{\mu\mu} = 0$
$\partial_\mu \varphi_{\mu\nu} = 0$
$\xrightarrow{?}$
$\Box \varphi_{\mu\nu} = T_{\mu\nu}$
$T_{\mu\nu} = T_{\nu\mu}$
$T_{\mu\mu} \neq 0$
$\partial_\mu T_{\mu\nu} = 0$

$L = L_m + L_f + L_i$
$L_m = -\frac{m}{2}\int ds\, \dot{z}^i \dot{z}^m \eta_{im}$
$L_i = f m \int ds\, \dot{z}^i \dot{z}^m \varphi_{im}(s)$
$L_m + L_i = -\frac{m}{2}\int ds\, \dot{z}^i \dot{z}^m g_{im}(s)$

$g_{im} = \eta_{im} - 2f\,\Phi_{im}(s)$

Fierz
Gupta
Wyss

Thirring

素粒子の[illegible]研究会

12月22日(月) 午前中 ([illegible] 中野[illegible])

湯川：Introduction

伊藤君：

[illegible]の振動

$$\Big[P_\lambda^2 + M_0^2 + \sum_{i=1}^{n} M^2(p_i, \xi_i)\Big]\psi_n(P, \xi_1 \cdots \xi_n) = 0$$

$$n = 0, 1, 2, \ldots$$

$$M^2(\xi, p) = \frac{1}{2}(p^2 + \omega_0^2 \xi^2)$$

$$\left.\begin{array}{l} P_\lambda \xi_\lambda = 0 \\ P_\lambda p_\lambda = 0 \end{array}\right\}$$

$$a|0\rangle = 0$$

$$\Big(P^2 + M_0^2 + \sum_N \omega_N a_N^* a_N\Big)\psi(P, a^*)$$

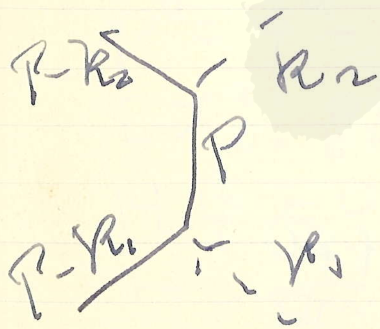
電磁場

電磁式

$$\Big[P_\lambda^2 + M_0^2 + \sum_{s,\lambda} \omega_s a_\lambda^{*s} a_\lambda^s$$

$$+ P_\lambda \sum_s \rho_s\Big(\frac{a_i^s - a_i^{s\dagger}}{i}\Big) + g M_0 A(x_\lambda)\Big]$$

$$\times \psi(P, a^*, A^*)|0\rangle = 0$$



続き　担当：[illegible]

研究会：Deformable Sphere Model

Non-uniform deformation

微小変形

$$L = S \qquad u(x) \quad \text{real field}$$

$$= S \pm \frac{1}{2} \qquad u_\alpha(x) \quad \text{complex field}, \quad \alpha = 1, 2 \quad \text{spinor field}$$

$$u_\alpha = \sum \xi^{\gamma}_{\ell m n \alpha} U^{\gamma}_{\ell m n}$$

$$\downarrow$$

$$\rightarrow \xi^{\gamma}_{\alpha}(x)$$

$$\downarrow$$

quark

$$H = \sum \nu_{pn}\left(m^{\gamma}_{\ell m n \alpha} + n^{\gamma}_{\ell m n \alpha}\right) + \Delta\nu \sum \left(m^{3}_{\ell m n} + n^{3}_{\ell m n}\right) + \frac{1}{2\nu}\sigma^2 + b$$

$$\downarrow$$

$$m^2$$

triality

i) baryon $(m, n) = (3, 0)$

$$6 \times 6 \times 6 = 56 + \underbrace{70 + 70}_{} + 20$$

$\ell = 0, 0, 0$ — 56: O, 70: X, 20: X

$$m^2 = \nu(l + \alpha n + \beta) + \frac{1}{2I}\sigma^2 + b$$

$$(m, n) = (4, 1)$$

ii) meson
$(1, 1)$

座長：[illegible]氏
[illegible]氏：
multilocal $\quad n \to \infty$
[illegible] model

$N, \; 1, \; 2, \; \ldots, \; \alpha, \; y^\alpha$

$$X_\mu = \frac{1}{N}\sum_{\alpha=1}^{N} y_\mu^\alpha$$

$$x_\mu^\alpha = y_\mu^\alpha - X_\mu$$

$$\sum x^\alpha = 0$$

$$q^\alpha = \frac{1}{i}\frac{\partial}{\partial y^\alpha} \qquad P_\mu = \sum q^\alpha$$

$$p^\alpha = q^\alpha - \frac{1}{N}P$$

$$[x_\mu^\alpha, p_\nu^\beta] = i\delta^{\alpha\beta} g_{\mu\nu} - i\frac{1}{N} g_{\mu\nu}$$

$$H\psi = 0$$

$$H = \frac{1}{2\mu}\sum_{\alpha=1}^{N} q^\alpha q^\alpha + \frac{\kappa}{2}U + C$$

$$U = \sum_{\alpha=1}^{N}(y^\alpha - y^{\alpha+1})^2 - \sum_{\alpha=1}^{N}\left(\frac{y^\alpha - y^{\alpha+2}}{2}\right)^2$$

$$+ \sum_{\alpha=1}^{N} \left(\frac{y^\alpha - y^{\alpha+3}}{3} \right)^2 - \cdots$$

or $U = \sum_{\substack{\alpha=1 \\ \nu=1,\cdots \frac{N}{2}}} \frac{(-1)^\nu}{\nu^2} (x^\alpha - x^{\alpha+\nu})^2$

saxhint 2'1/2 $(y^\alpha - y^{\alpha+1})^2$ のみ

~~N→∞~~
normal coordinates

$$x^\alpha_\mu = \frac{1}{\sqrt{N}} \sum_{l=-\frac{N}{2}}^{\frac{N}{2}} Q^l_\mu e^{i2\pi l\alpha/N}$$

$$Q^{-l} = Q^{l*} \rightarrow Q^0 = 0$$

$$H = \sum p^\alpha p^{l*}$$

$$U = \sum_l Q^l_\mu Q^{l*}_\mu \sum_{\nu=1}^{N/2} 2\left(1 - \cos\frac{2\pi l}{N}\nu\right) \frac{(-1)^{\nu-1}}{\nu^2}$$

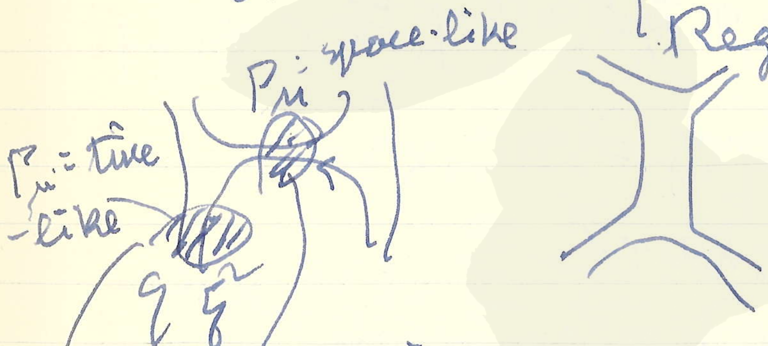
$$\xrightarrow[N\to\infty]{} 2\left(\frac{\pi l}{N}\right)^2 \qquad -\frac{N}{2} \leq l \leq \frac{N}{2}$$

$M^2 = \sum \omega_l' (a_l^+ a_l + b_l^+ b_l + 2)$ ~~ト~~...

$$\omega_l' = 2N\omega_l \rightarrow 2\sqrt{2\mu\kappa} \cdot \pi \cdot l$$
$$= l\, m_0^2$$

$$\langle 0 | x_\mu^{\alpha 2} | 0 \rangle = \left(\gamma + \log \frac{N}{2}\right) \frac{1}{m_0^2}$$

第2回．12月23日．
午前：江沢．大貫氏
田中正氏：Duality と四次元的描像
Duality の論理
time-like　space-like (momentum)
~~composite~~　~~elem~~
elementary　composite
resonance　exchange
　　　　　　Regge



composite, space-like (momentum)
(2体系, spin 0 に適用されない → 従来の議論
spin の意味？　O(2, 1) →
→ spin (0, ½, 1, . . .　1次4　O(3,1)
→ Regge pole　$\alpha(p^2)$

finite energy sum rule (FESR)
意味：resonance と high energy の Regge の結びつき
low energy での

Chew-Frautschi

$\alpha(p^2) = a p^2 + b$

$p_\mu \quad M_{\mu\nu}$

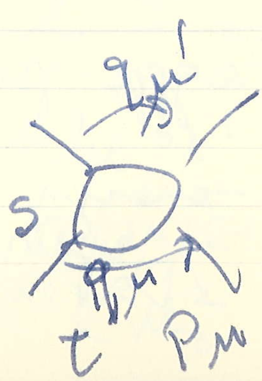
spin 1 は $p^2 = 0$ で singular を除くのに色んな spin の寄与が必要

(Friedmann-Wang)
(Sakita)
O(3,1) の対称性
Veneziano
Regge trajectories の線.

何が飛んでるか.
propagator からの構造
$$p_\mu^2 = \omega \sum_{r\mu} r\, n_\mu^r$$
相互作用の構造から

2-2 散乱について考える

$s = (q - q')^2 \qquad u = (q + q')^2$
$t = p_\mu$



$$A(t,s) = \frac{\Gamma(1-\alpha(s))\Gamma(1-\alpha(t))}{\Gamma(1-\alpha(s)-\alpha(t))}$$

$O(3,1)$ $\quad x,\ j,\ m$

$$P_\mu^2 = \frac{1}{a}(x-1+2n+\underbrace{l+m}_{?})-b \qquad m \to \sigma$$

$$A(t,s) = \qquad \uparrow\ p(0,\infty)$$

$$H(X) = \int d^4x_1 d^4x_2\, \delta^4\left(X - \frac{x_1+x_2}{2}\right)$$

$$\times\, \pi(x_1)\pi(x_2)\,\rho(X, x_1-x_2)$$

$$\rho(X,\ ) = \sum_{x=1}^{\infty}\sum_{j=0}^{x-1}\sum_{m=-j}^{j}\int dp \sum_n \rho^{m\,n}_{x;j,p}(X)$$

$$\times\, F^{m,n}_{x\,j,\,p}(x_\mu)\,dp$$

これまでの(A)では ρ-field の bilocal として書く.

Jacob の polynomial

indefinite metric

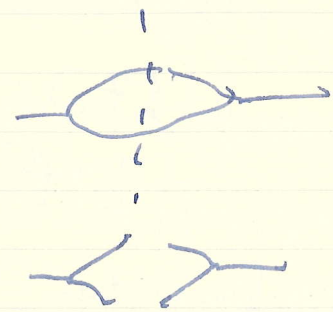
$x-1+2n+l+\sigma = L$

縮退 : L^3

ごご：社会，内山G
吉川君：Veneziano model に
あらわれる困難について
1) SU(3) 的問題
M, B
$\underline{B}\cdot B$ の困難　8，10 で閉じない．
$(q\bar{q})$ ℓ excitation
$(q\bar{q})$ excitation
2) 縮退スペクトル
$H = \sum n a_{\mu}^{(n)\dagger} a_{\mu}^{(n)}$
N体，unitarity，Born近似，

自己エネルギー —
混合論

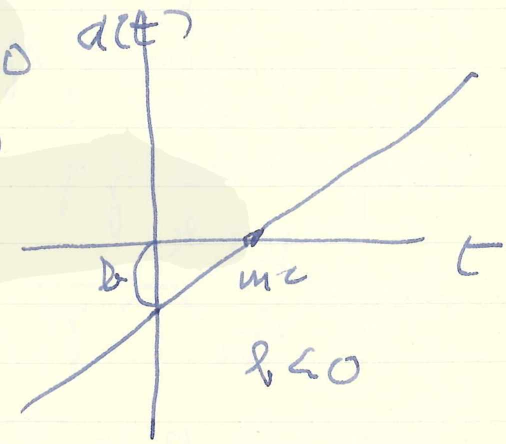
$$\mathrm{Im}\, T = T T^*$$



Operator formalism

$\alpha(t) = at + b \qquad b<0$

$\alpha(m^2) = 0 \ ; \quad am^2 + b = 0$



$a_\mu |z\rangle = z_\mu |z\rangle$

$a^\dagger a |n\rangle = n|n\rangle$

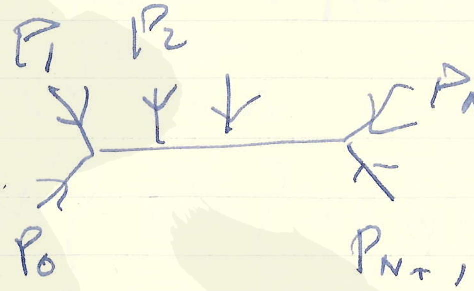
$\langle z'|z\rangle \neq 0$

$z = l + im$ complex

lattice point

(von Neumann)

$$|z\rangle = e^{-\frac{1}{2}|z|^2} \sum_{n=0}^{\infty} \frac{z^n}{\sqrt{n!}} |n\rangle$$



$\langle z|H|z\rangle = \omega z^* z = \frac{1}{2}(p^2 + \omega^2 q^2)$

$|z\rangle = U(z)|0\rangle$ driving operator

$U(z) = \exp i(z a^\dagger - z^* a)$

$$:U(z): = e^{iza^\dagger} e^{-iz^* a}$$

$$U(z) = e^{-|z|^2/2} e^{iza^\dagger} e^{-iz^* a}$$

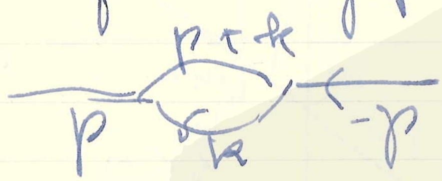
$$\prod e^{\frac{p^2}{2n}} U_n(p)|0\rangle$$

Klauder & Sudarshan

Fund. of Quantum Optics

S. T. Ma ? entire function

Self-energy



$$\Sigma(p) = \int d^4k\, M(k, p+k)$$

$$M(k,p) = Tr\left[P(\alpha(-k^2))V(p)P(\alpha(p+k)^2) \times V(-p)\right]$$

$$\Sigma(p) = \int d^4k \int_0^1 dx_1 \int_0^1 dx_2\; x_1^{-\alpha(-k^2)-1}$$

$$\times\, x_2^{-\alpha(-(p+k)^2)-1} \left[(1-x_1)(1-x_2)\right]^{-c}$$

$$\times \prod_n Tr\left(x_1^{h_n} V_n(p)\, x_2^{h_n} V_n(-p)\right)$$

$$H = \sum n\, a_n^{(n)\dagger} a_n^{(n)} = \sum h_n$$

[illegible] 3-4 : Veneziano ~~model~~ amplitude

resonance と background

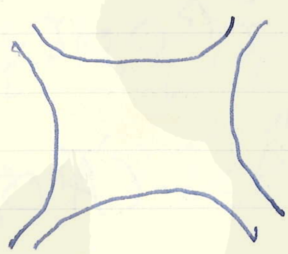
		resonance	hard core	
$I=2$	$\pi^+\pi^+$	×	○	$a>0$
$I=0$		○	×	$a<0$

low energy で効くと
[resonances ではすまない:
hard core ?

Imaginary part ?
δ-fn 的.

[illegible]：[illegible]：[illegible]

~~[illegible]~~
形式：“綜合構造”との関係
“line”



$\langle 0|q(x)\bar{q}(y)|\rangle \sim \varphi(X,\xi)$ → parameter
→ が与え[illegible]

current algebra
$\xi=0$
$SU_6 \otimes O(3)$
chiral symmetry $SU_3 \otimes SU_3$
→ $SU_2 \times SU_2$ ⟶ SU_2 ⟵ SU_3

γ_5

SU_6

$$H = \sum_{\mu} n\, a_{\mu}^{\dagger(n)} a_{\mu}^{(n)}$$

quark pair

$$\psi(x, \xi) \to \psi(X, \phi(\xi))$$

[illegible]君: Bose Quarks and Non-leptonic Weak interaction

([illegible]君・[illegible]君)

i) 統計 → 3体　56次元

ii) binding problem

exciton → base shift
→ binding の問題がおこる.

$$H = (\bar{t}^{\alpha} O_i t_{\gamma})(\bar{t}^{\beta} O_i t_{\lambda})$$

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

$$(\bar{A} O_i B)(\bar{C} O_i D) = -(\bar{A} O_i D)(\bar{C} O_i B)$$

$$9 = 1 + 8$$

A. i) $|\Delta S| = 2$ ない

ii) $|\Delta S| = 1$:　$|\Delta I| = 1/2$

iii) $|\Delta S| = 0$:　$|\Delta I| = 0, 1$

B. neutral current をなくてすませる.

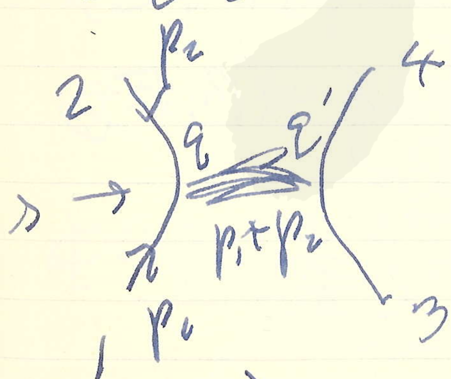
C. $\tau_3 \equiv \Lambda_0$ が関係しない process

これらが核力の long range force
$|\Delta I| = 0$
(weak の入った核力)

第3回　12月24日
[illegible]：沢氏　[illegible]
片山泰久氏：相互作用と量子化

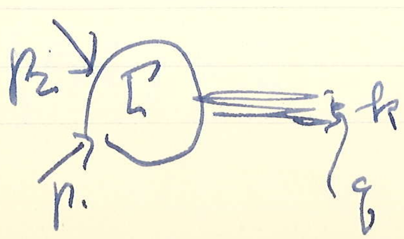
$$\delta^4(p_1+p_2+k)\int dq\, \psi(p_1)\Gamma(p_1, p_2, q)$$
$$\times\ \psi(p_2)\,\phi(k, q)$$

$$\langle 0|T(\phi(k, q)\phi(k', q')|0\rangle$$
$$= \delta^4(k+k')\,D(k; q, q')$$



$$A_s = \int dq\,dq'\,\Gamma(p_1, p_2; q)$$
$$\times D(-(p_1+p_2), q, q')$$
$$\times \Gamma(p_3, p_4; q')$$

$A_t =$



$A_u =$

$A_s = A_t = A_u$

(I) q, q' trivial な場合が (独立)

$D(k; q, q') = \delta^4(q - q') D(k; q)$

(II)

(II-A) $\delta^4(k + k') D(k; q, q') = \delta^4(k + k') \times \delta^4(q - q') \Delta(q^2)$

$\Delta_F(x - x', \gamma, \gamma') = \delta^4(x - x') \Delta(\gamma + \gamma')$

(II-B) $\Sigma(p_1, p_2; q) = V(p_1, q) V(p_2, q)$

$I(p_1, p_2; q) = \int d\lambda\, \gamma(\lambda) \left[\int d\mu\, f(\mu)\, e^{\frac{\lambda}{4} q^2 + 2\mu q p_1 + \mu p_1^2} \right] \times \left[\int d\nu\, f(\nu)\, e^{\frac{\lambda}{4} q^2 + 2\nu q p_2 + \nu p_2^2} \right]$

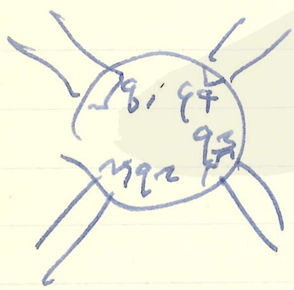
(III) $\delta^4(p_1 + p_2 + k) \int d\lambda\, \gamma(\lambda) \int dq\, \psi(p_1, \sqrt{\lambda} q) \times \psi(p_2; \sqrt{\lambda} q) \phi(k; q)$

ii) どの場合も少なくとも局所的でない
と考えた方が natural
iii) 媒介する場は 4次元的変化に従う

$$\left(\int \psi(p_1;q)\,\psi(p_2;q')\,\Phi(k;q,q')\,dq\,dq'\right)\times\delta^4(p_1+p_2+k)$$

$$\langle 0|T(\phi(k,q_1,q_2)\,\phi(k',q_3,q_4))|0\rangle$$

$$=\delta^4(k+k')\,D(q_1,q_2,q_3,q_4)$$



$$\alpha(p^2)=\alpha(0)+\alpha'(0)\,p^2$$

$$\alpha'(0)/\lambda \doteqdot 1$$

→ Veneziano

$$\langle 0|T(\phi(x)\phi(x'))|0\rangle=\delta^4(x-x')$$

$$\langle 0|T\,\phi(x,m^2)\,\phi(x',m'^2)|0\rangle$$

$$=\delta(m^2-m'^2)\,\Delta_F(x-x',m^2)$$

$$\phi(x)=\frac{1}{\sqrt{\pi}}\int_{-\infty}^{+\infty}dm^2\,f(m^2)\,\phi(x,m^2)$$

$$f(m^2)=1$$

$$\langle 0 | T(\phi(x, q_1 q_2)\phi(x', q_3 q_4)) | 0 \rangle$$

$$= \delta^4(x - x') D(q_1 q_2 q_3 q_4)$$

$$\phi(x, q_1 q_2) = \sum_\alpha \int dk\, e^{-ikx} \frac{1}{\sqrt{\Omega}}$$

$$\times C_\alpha(q_1 q_2, k) \phi_\alpha(k)$$

$$\frac{i}{\pi} \sum_\alpha \frac{C_\alpha(q_1 q_2, p_{12}) C_\alpha(q_3 q_4, -p_{12})}{m_\alpha^2 - p_{12}^2}$$

$$= D(q_1 q_2 q_3 q_4)$$

[illegible]

5次元調和振動子.

[illegible]：複素質量をもった粒子の[illegible]と同値

Causality

microcausality

macrocausality

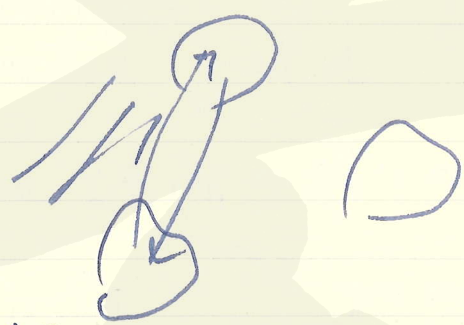
complex massをもった粒子はcausalityをやぶるか?

$A = \rho^2 - \lambda^2 \quad B = 2\rho\lambda$

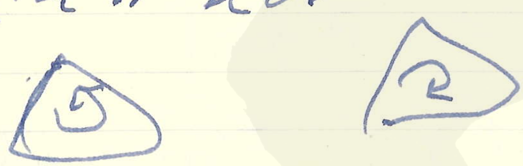
A ≧ 0 ならば 時逆行は C を起さない。

函数を導く propagator

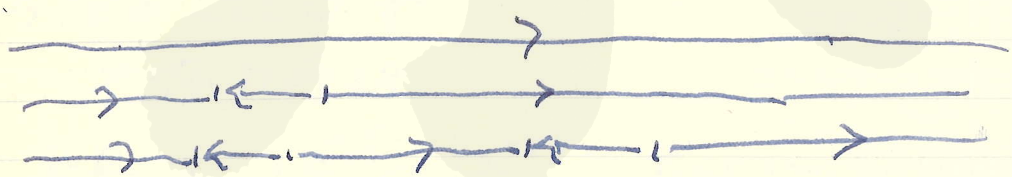
益川氏：統計
連続体
離散集合
を一括統にとこつなぐ mapping の問題.



向きをかえない



一次元



$$D(g) = \begin{bmatrix} g'(0) & g''(0) \\ 0 & (g'(0))^2 \end{bmatrix}$$

1970年 11月13日 基研

玉垣良三氏

Superfluidity due to Spin-Orbit Forces in Neutron Star
(Superstate)

Generalized Bogoliubov transformation

$^1S_0 \rightarrow {}^3P_2$

$n_\star$ = pulsar
{rotation
magnetic field ← 南條・内藤

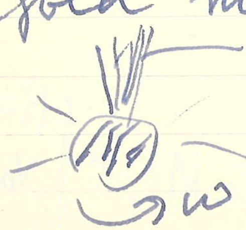
supernova 爆発の残りかす
カニ星雲
period (P) {最小 30 m sec.
最大 ~ sec.

$\frac{\Delta P}{P} \sim 10^{-9}$

→ 安定した周期
天体が時計

$\frac{\Delta P}{P} \sim 10^{-5} \sim 10^{-13}$　time に linear に大きくなる.

Gold model



磁力線 → pulse を出す

$E_{rot}(\text{rigid}) \sim 10^{49}$ erg
$(M \simeq M_\odot,\ R = 10^6 \text{cm})$

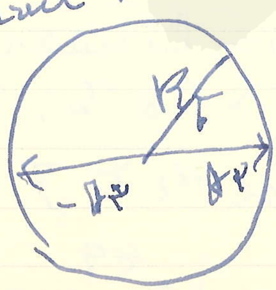
slow down energy loss
3×10^{38} erg/sec
(radio emission < 10^{31} erg/sec)
cosmic ray ?

磁場 → 「ポロイダル
$10^{12\sim13}$ Gauss at surf
10^{5} 〃 at $r=\frac{c}{\omega}$

2成分:
中性子・超流
high density では S-wave 斥力
(引力)は ${}^{3}P_{2}$ $\left.\begin{matrix} s=1 \\ l=1 \end{matrix}\right\} j=2$
強い coupling
super → S → M → H

N-N: $T=1$ $S=0$: ${}^{1}S_{0}$ ${}^{1}D_{2}$ ${}^{1}G_{4}$
$S=1$: ${}^{3}P$ ${}^{3}F$

Fermi 球



$$E_F=\frac{\hbar^2 k_F^2}{2M}$$

(hab)

$$E_{NN}=4E_F$$

$$E_F(\text{N.M.})=42\,\text{MeV}\left\{\begin{matrix} R=r_0A^{1/3} \\ r_0=1.07\,\text{fm} \\ \text{fm}=10^{-13}\,\text{cm}\end{matrix}\right.$$

$E_F \gtrsim 150$ MeV high density
$^3P_2$ pairing int.

$E_F = 75 \sim 150$ MeV $\longrightarrow n, p, e^-, \Lambda$
$\rho = 10^{14} \sim 10^{15}$ gm cm^{-3} X
$\sim 1\%$

energy gap

spin $N_☆ \times \left(\frac{\Delta(k_F)}{E_F}\right) \times \mu_N$

$\sim 10^{57} \times \frac{1}{100} \times 10^{-18}$ MeV

$\rightarrow 10^{12}$ Gauss (表 Zw)

片山泰久

非局所場の量子化 相互作用と

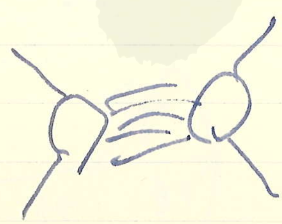
11月13日, 1970
基研談話

1930　　　　40　　　　50　　　　60　　　　70

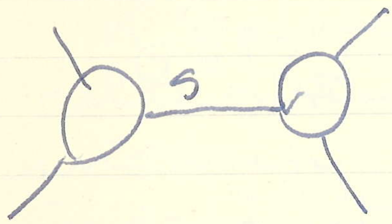
発散論 → 引算
切断
Born
最短長
Heisenberg
→ 非局所概念
Markov

非局所場 (1948)
[illegible] 概念
[illegible]
S行列
非局所相互作用
量子化
1953
内部構造
素領域
[illegible]
対称性
素粒子の可能性
統一的量子化 - - -
双子 [illegible] 一現象
Regge
Veneziano
相互作用

交叉対称性
二重性



$A = A_s(t,u) + A_t(u,s) + A_u(s,t)$



$A_s(t,u) = A_s(u,t)$

$\equiv A(s,t,u)$

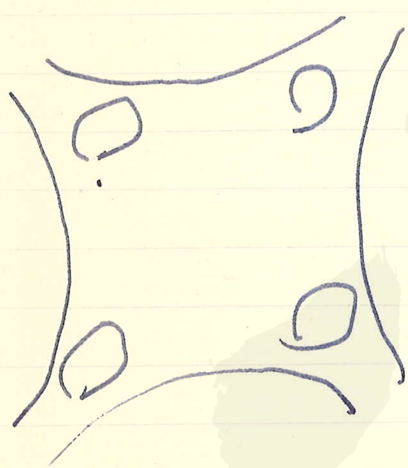
1) $A_s(t,u) = A_t(u,s) = A_u(s,t)$

2) $A_s(t,u) = v_s(t) + v_s(u)$

$v_s(t) = v_t(s)$

bilocal $\phi(x;q)$

local $\psi(p)$



$$\phi(x) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{+\infty} dm^2\, \phi(x, m^2)$$

$\phi(x)\Omega_0 = 0$ 発散[illegible]

$$(\Box + m_0^2)\,\phi(x)\,\Omega = 0$$

$$\int dm^2 (m_0^2 - m^2)\,\phi(x, m^2)\,\Omega = 0$$

i) 内部パラメーター

m^2　　$(-\infty, +\infty)$

徳岡氏 来信 LK-21 IV. 1970

Hyperquantization of Electromag. and spin 1/2 Fields

K. Dormuth and Y. Takahashi

relativistic ?
unitarity ?

indefinite metric vanish.

Non-local Field Theory of the Quark Model II

[illegible]

[illegible]　2月10日, 1970

rigid) subunits ~ quarks
separate

その composite system は
nonlocal field (bilocal) で
記述する

$\Phi_a^{\,b}(X; r)$

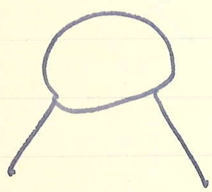
(1) local → $\tilde{U}(12)$
(2) degeneracy
(3) nonrela → potential theory
(4) Regge
(5) oscillator

~~Pome~~ Surface ~~Resonance M~~
Excitation model of hadron resonances

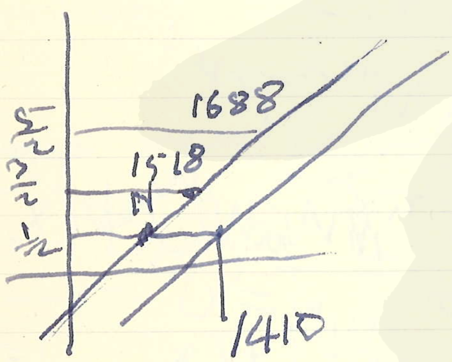
春衛　2.17, 1970

$A + B \rightarrow A^* + B$

N^* 1410 $(\frac{1}{2}^+)$
1518 $(\frac{3}{2}^-)$
1688 $(\frac{5}{2}^+)$
2190 $(\frac{7}{2}^-)$



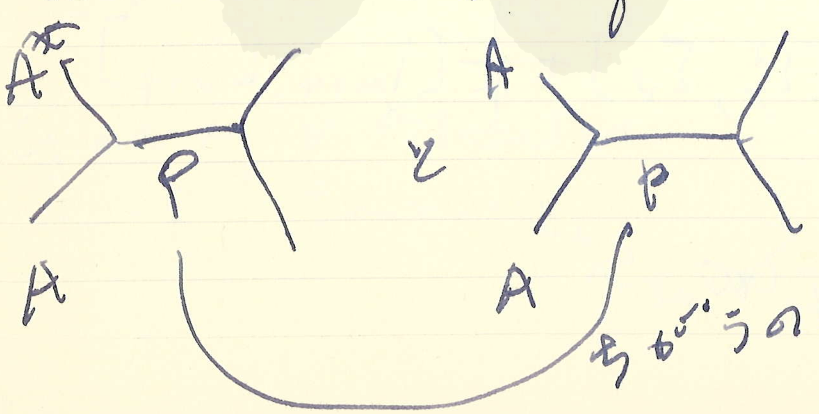
$\Delta P = (-1)^{\Delta J}$



$H = H_A + H_B + T_{AB} + V_{AB}$

$R = R_0 + \sum \xi_{LM} Y_{LM}(\theta, \varphi)$

Pomeranchuk
resonance a background



ちがうのじゃないか?

Success and Difficulty in Particle Picture by use of Inf. Comp. Wave Equations

宮嶋研 岩研 March 10, 1970

1. Lagrangian formalism

$\psi_\alpha(x)$ $\alpha = 1, 2, \cdots$

2. Compositeness $O(3,1)$

Majorana, Nambu $O(4,2)$

P_μ, $M_{\mu\nu}$ $|m, J; p\, J_z\rangle$

Wigner

$m^2 = \kappa_0^2 + \kappa_1^2 J(J+1)$

$W_\mu W^\mu = -P_\mu P^\mu \cdot J(J+1)$

$W_\mu = \tilde{M}_{\mu\nu} P^\nu = \frac{1}{2}\epsilon_{\mu\nu\kappa\lambda} M^{\kappa\lambda} P^\nu$

$\{(P_\mu P^\mu)^2 + \kappa_0^2 (P_\mu P^\mu) - \kappa_1^2 W_\mu W^\mu\}\psi(x)$

Takabayasi

$\{P_\mu P^\mu + \kappa_0 \Gamma_\mu P^\mu - \kappa_1 \Gamma_{\mu+4} W^\mu\}\psi(x) = 0$

$\{\Gamma_\mu, \Gamma_\nu\} = 2 g_{\mu\nu}$ $\mu, \nu = 0, \cdots 7$

$g_{\mu\nu} = (-+++\ -+++)$

16×16

$S_{\mu\nu} = \frac{1}{4}[\Gamma_\mu, \Gamma_\nu] + \frac{1}{4}[\Gamma_{\mu+4}, \Gamma_{\nu+4}]$

$M^{in}_{\mu\nu}$

$\Lambda = 1 + \frac{1}{2}\delta\omega_{\mu\nu} S^{\mu\nu}$

phys. Lorentz group

$O_{4}(3,1) \times S_{\mu\nu} \times M^{in}_{\mu\nu}$

$X_{[\mu} P_{\nu]} + S_{\mu\nu} + M^{in}_{\mu\nu}$

Majorana: $[a_i, a_j^\dagger] = \delta_{ij}$　　$i, j = 1, 2$

$$|jm\rangle = \frac{1}{\sqrt{(j+m)!\,(j-m)!}} a_1^{\dagger j+m} a_2^{\dagger j-m} |0\rangle$$

$$M^{(in)}_{ij} = \frac{1}{2} a^\dagger_\alpha (\sigma_k)_{\alpha\beta} a_\beta$$

$$M^{(in)}_{0j} =$$

Regge mass formula

$$m^2 = a^2 (J + 1/2)$$

$$\left\{ (\Gamma_\mu P^\mu)^2 - \frac{a}{2} \Sigma (P_\mu P^\mu) + O_{\mu\nu} P^\mu W^\nu \right\}$$

$$\times \Psi(X, \ldots) = 0$$

$$O_{\mu\nu} = \gamma_\mu \otimes \gamma_\nu$$

$$\Sigma = i\gamma_5 \otimes 1$$

$$\{\Gamma_\mu, \Gamma_\nu\} = 2 g_{\mu\nu}$$

$$\mu, \nu = 0 \sim 11$$

64×64

Gradsky & Streater

No-Go theorem

河原林研　March 19 & 20

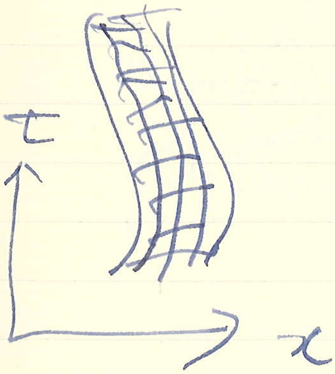
Susskind

Space-Time Approach to Duality

1. World sheet　world lineのかわり

$X_\mu(\tau) \to X_\mu(u)$

$X_\mu(\tau, \theta)$　$0 \leq \theta \leq \pi$



x_μ　　τ, θ

$\varphi(x)$　　$X_\mu(\tau, \theta)$

$\mathcal{L} = -\frac{1}{2}(\partial_\mu \varphi)^2$　　$\mathcal{L} = -\frac{1}{2}\left[\left(\frac{\partial X_\mu}{\partial \theta}\right)^2 - \left(\frac{\partial X_\mu}{\partial \tau}\right)^2\right]$

$\Box \varphi = 0$

$\left.\frac{\partial \varphi}{\partial x_\mu}\right|_{x=\infty} \to 0$　　$\left.\frac{\partial X_\mu}{\partial \theta}\right|_{\theta = 0, \pi} = 0$

$H^{\text{tot}}(\tau) = \int_0^\pi d\theta\, H(\tau, \theta)$

2. $\mathcal{L} \to T_{\mu\nu}$　　$\partial_\mu P_\mu = 0$

3. space of meson states

$X_\mu = C_\mu + \tau P_\mu + i \frac{1}{\sqrt{2}} \sum_{l=1}^{\infty} \left\{ \frac{a_\mu^\dagger(l)}{\sqrt{l}} e^{il\tau} - \frac{a(l)}{\sqrt{l}} e^{-il\tau} \right\} \cos l\theta$

$\frac{dX^{cM}}{d\tau} = \pi P_\mu$　　X_μ^{cM}, P_μ

$$H = \pi\left[\frac{1}{4}P^2 + \sum_{l=1}^{\infty} l\, a_\mu^\dagger(l)\, a_\mu(l)\right]$$

$$M^2 = \mu_0^2 + \sum l\, a_\mu^\dagger(l)\, a_\mu(l)$$

$$(H + \mu_0^2)|\ \rangle = 0$$

$$a_\mu |0\rangle = 0$$

$$P_\mu |0\rangle = 0$$

ground state ψ

$$a_\mu |\psi\rangle = 0$$

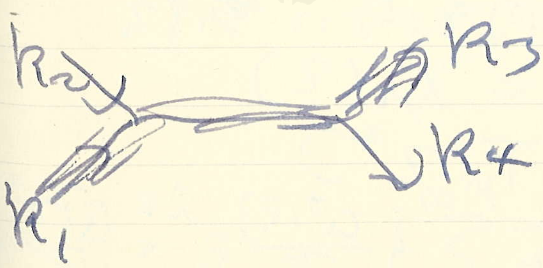
$$P_\mu |\psi\rangle = k_\mu |\psi\rangle$$

$$k_\mu^2 + \mu_0^2 = 0$$

$$|\psi\rangle = e^{ikx^{cM}} |0\rangle$$

$$\underbrace{\left\{-\Box + \mu_0^2 + \sum_{l=1}^{\infty} l\, n(l)\right] \psi(x_\mu^{cM}, n(l))}_{=0}$$

4. Meson Scattering Amplitude



$$T(k_1 k_2 k_3 k_4) = :e^{ik_2 X(0)}: \frac{1}{(k_1+k_2)^2 + M^2} :e^{ik_3 X(0)}:$$

$$\frac{\partial^2 X_\mu}{\partial\theta^2}+\frac{\partial^2 X_\mu}{\partial\lambda^2}=0 \qquad \lambda+i\theta=z$$

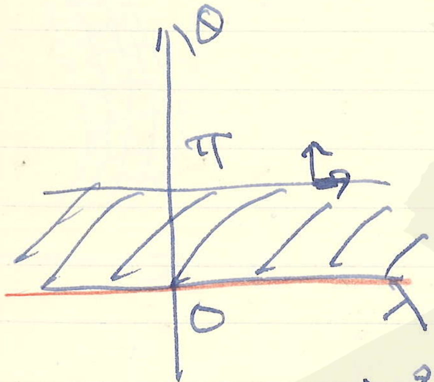
$$\left.\begin{array}{l} 0\le\theta\le\pi \\ -\infty<\lambda<+\infty \end{array}\right\} \qquad X_\mu(z)$$

$w=f(z)$

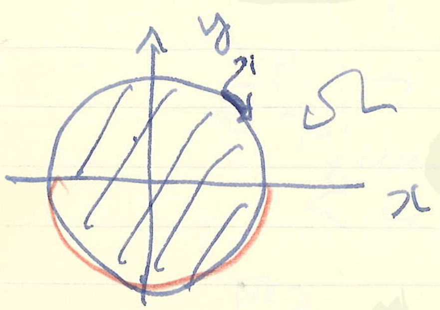
Möbius 変換

$$\left.\begin{array}{l} w=\dfrac{\alpha z+\beta}{\gamma z+\delta} \\ \alpha\delta-\beta\gamma=1 \end{array}\right\}$$

$w=x+iy$



$$\downarrow \quad w=\frac{-ie^z-1}{-ie^z+1} \quad \text{duality}$$



$$\langle 0|\prod_{i=1}^{n}e^{ik_iX(\rho_i)}|0\rangle = \tilde{T}(\Omega)$$

duality invariance < conformal invariance

5. duality 変換　　円を円に変換

$$X_\mu(\tau,\sigma)\to X_\mu(\lambda,\theta)=X_\mu(z)$$

$$=F_\mu(z)+F_\mu(z^*)$$

$$F_\mu(z)=\frac{P}{2}(z)+\frac{c}{2}+i\sqrt{2}\sum_{l=1}\left\{\frac{a^+(l)}{\sqrt{l}}e^{lz}+\frac{a^-(l)}{\sqrt{l}}e^{-lz}\right\}$$

automorphic fn　$w=\cancel{\frac{\alpha z+\beta}{\gamma z+\delta}}$; $X_\mu(z)=X_\mu(w)$

baryon