R. III

N100

NOTE BOOK

Easy Write, Easy Read, Containing best White Paper.

R. III.

July. 1972
~ Jan. 1974

100

SPARTA

Contents N100

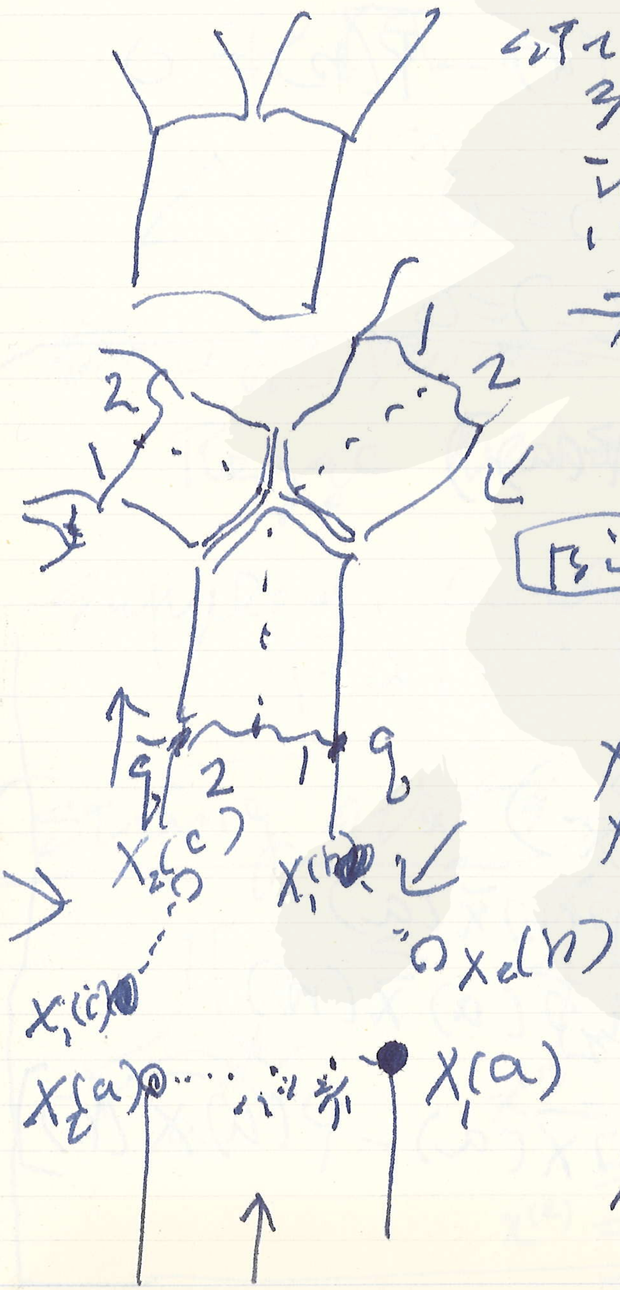
CHAPTER	*	PAGE
日大研究会	*	
1972年9月	*	

日大 研究会
"拡がった粒子の相互作用"
1972年

7月6日(木)　[鳴滝]

序論:

後藤: bilocal 的 string model の対称性と vertex



string model:
3本目を結合すると
indefinite metric における困難
→ bilocal と同じ.
(time component について indefinite metric)

Bilocal の場合
vertex
$\delta(X_1(a) - X_2(b))$
$\times\,\delta(\quad)$
$\times\,\delta(\quad)$

X_0

$\frac{1}{2}(X_1 + X_2) = X$

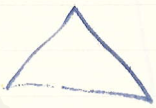
$X_1 - X_2 = \bar{X}$　　$i\bar{X}_0$

$X_1 = X + \frac{1}{2}\bar{X}$
$X_2 = X - \frac{1}{2}\bar{X}$　) complex

$$\left[X_1(a) - X_2(b)\right]|\Psi\rangle = 0$$
$$\left[P_1(a) + P_2(b)\right]|\Psi\rangle = 0$$

$$X(a) - X(b) + \frac{1}{2}\left[\bar{X}(a) + \bar{X}(b)\right] = 0$$
$$\frac{1}{2}(P(a) + P(b)) + \bar{P}(a) - \bar{P}(b) = 0$$

$$\bar{X}(a) + \bar{X}(b) + \bar{X}(c) = 0$$



$$P(a) + P(b) + P(c) = 0$$

Vertex

$$\delta^4\Big(\sum_{abc} \bar{X}(a)\Big)\,\delta^4\Big(\sum P(a)\Big)$$

$$X(a) \to i\frac{\partial}{\partial P(a)}$$
$$\bar{X} = (i x_0, x)$$
$$\bar{P} = \left(\frac{\partial}{\partial X_0}, -i\frac{\partial}{\partial X}\right)$$

$$e^{-\frac{1}{2}P_0(b)\bar{X}_0(a) - \frac{i}{2}\vec{P}(b)\vec{\bar{X}}(a)}$$
$$\times e^{+\frac{1}{2}P_0(a)\bar{X}_0(b) + \frac{i}{2}\vec{P}(a)\vec{\bar{X}}(b)}$$
$$\to \exp\left\{\frac{i}{2}\left\{P(b)\bar{X}(a) - P(a)\bar{X}(b)\right]\right.$$

$$\bar{x} = \sqrt{\frac{1}{2\omega}}\,(a + a^{\dagger})$$

$$\bar{P} = i\sqrt{\frac{\omega}{2}}\,(a - a^{\dagger})$$

$$\bar{P}\,|x\rangle = 0$$

$$|x\rangle = e^{-\frac{1}{2}a^{\dagger 2}}$$

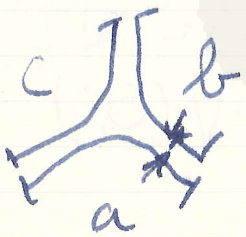
[illegible]

Regge behavior

Supplem. condition

$$P\,a\,|\psi\rangle = 0$$

string の[illegible]



$$x_a(\sigma) = x_a^{(1)}(\sigma) + x_b^{(2)}(\sigma)$$

$$x_b(\sigma)$$

$$\left.\begin{array}{lll} x^{(1)} = x & & 0 < \sigma < \frac{L}{2} \\ \phantom{x^{(1)}} = 0 & & \frac{L}{2} < \sigma < L \\ x^{(2)} = 0 & & 0 < \sigma < \frac{L}{2} \\ \phantom{x^{(2)}} = x & & \frac{L}{2} < \sigma < L \end{array}\right\}$$

$$\left.\begin{array}{l} x_a^{(1)}(\sigma) - x_b^{(2)}(L-\sigma) = 0 \\ p_a^{(1)}(\sigma) + p_b^{(2)}(L-\sigma) = 0 \end{array}\right\} \quad 0 < \sigma < \frac{L}{2}$$

$$x_a^{(1)}(n) - (-1)^n x_b^{(2)}(n) = 0 \qquad n = 0$$

$$p_a^{(1)}(n) + (-1)^n p_b^{(2)}(n) = 0 \qquad n \geq 1.$$

spin

$$[\gamma_\mu^{(1)}(a) + \gamma_\mu^{(2)}(b)]\,|\psi\rangle = 0$$

$$\sigma_{\mu\nu}^{(1)}(a) + \sigma_{\mu\nu}^{(2)}(b) \quad = 0$$

unitary spin

line physics

大阪: string model

$$H_0 = p^2 + \frac{1}{a^2} \sum n\, a_n^\dagger a_n$$

2つに[illegible]和…[illegible]に関し

$$H = \frac{\pi}{\sigma_1} H_1 + \frac{\pi}{\sigma_2} H_2 = H_0 + V(\sigma_1)$$

[大貫]

素粒子：拡がった素粒子の理論の相対論的定式化

Wigner : inhomogeneous Lorentz group の unitary representation

$[P_\mu, P_\nu] = 0$

$[M_{\mu\nu}, P_\nu] = i\delta_{\mu\rho}P_\nu - i\delta_{\nu\rho}P_\mu$

$[M_{\mu\nu}, M_{\rho\sigma}] = \cdots\cdots$

$\longrightarrow P_4, M_{\kappa\lambda}$ の Helicity

form factor

$$U(\Lambda_{\mu\nu}, \tau_\rho)|p, p'\rangle^{(\text{stand})} = e^{i\tau_\rho(p_\rho + p'_\rho)} |\Lambda p, \Lambda p'\rangle^{(\text{stand})}$$

$$|p, p'\rangle\rangle^{(I)}$$

$$\langle\langle q, q' | p, p'\rangle\rangle^{(I)}$$

$$P_\mu = e^{iJ} P_\mu^{(0)} e^{-iJ}$$

$$M_{\mu\nu} = e^{iJ} M_{\mu\nu}^{(0)} e^{-iJ}$$

$$J = \cdots\cdots$$

$$e^{iJ\theta}\underline{U(\Lambda,\tau)}e^{-iJ} = U(\Lambda,\tau)$$

reducible　　bound state
regions.　　[illegible]
　　　　[illegible]

$A^{\dagger}A^{\dagger}AA$
$A^{\dagger}A^{\dagger}A^{\dagger}A$
{ finite self-energy
{ mass [illegible]
field theory [illegible]
$A^{\dagger}A^{\dagger}A^{\dagger}A^{\dagger}$ [illegible] !!!

Dirac
crossing symmetry は form factor
[illegible]

field theory [illegible]
causality?
外場?

中嶋：Dual Field Theory
無限成分方程式

Virasoro

free $[L_r, L_s] = (r-s) L_{r+s}$

外場 $[L_r - V, L_s - V]$

$= (r-s)(L_{r+s} - V)$

$V = e^{ikx}\, e^{\sqrt{2}i\sum \frac{k a^\dagger}{\sqrt{n}}}\, e^{''}$

$L_r = L_r + L_r$

$(L_0 - 1)|\psi\rangle = 0$

$L_n|\psi\rangle = 0$

$(L_0 + n - 1) L_n |\psi\rangle = L_n (L_0 - 1)|\psi\rangle = 0$

quark model

〔田地〕

高林: hadron の bilocal model

(と string model)

multilocal $N \to \infty$ string

primitive bilocal

$$\{p^{(1)2} + p^{(2)2} + \frac{\kappa^2}{2}(x^1 - x^2)^2 + \frac{\kappa_0}{2}\}\psi = 0$$

$$\{p^{(1)2} - p^{(2)2} - i a \kappa (p^{(1)} + p^{(2)})(x^{(1)} - x^{(2)})\}\psi = 0$$

$a = +1$ or -1

$$a_\mu = \frac{1}{2}\left(\frac{p^1 - p^2}{\sqrt{\kappa}} \mp i\sqrt{\kappa}(x^1 - x^2)\right)$$

$$a^\dagger_\mu = \quad \cdots \quad \pm$$

$$[a_\mu, a^\dagger_\nu] = g_{\mu\nu}$$

$$P a \psi = 0 \qquad a = +1$$

$$P a^\dagger \psi = 0 \qquad a = -1$$

$$\psi \to \psi^*$$

$$j(X) = i\int d^4\xi \left(\frac{\partial \psi^*}{\partial X}\psi - \psi^* \frac{\partial \psi}{\partial X}\right)$$

$$x^1 \rightleftarrows x^2$$

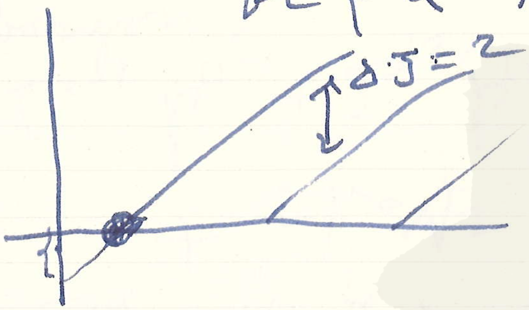
$$M^2 = 4\kappa(\bar{n} + 2) + \kappa_0$$

rest frame, space part

$(P^2 + \mu^2 a^2 + \gamma_0)\psi = 0$

$p_a \psi = 0$

or $p_a a^+ \psi = 0$



$(P - eA)^2 + \cdots$

$(\sigma P) P_\mu - \cdots$

form factor

$\frac{1}{\gamma} = \frac{m_0}{p_0} \to \frac{1}{1 + t/2m_0^2}$

$\begin{cases} \alpha_0 < 0 \\ \text{parity} = (-1)^J \end{cases}$

結論: $\frac{1}{4\kappa} = l_0^2 \to 0$ local theory

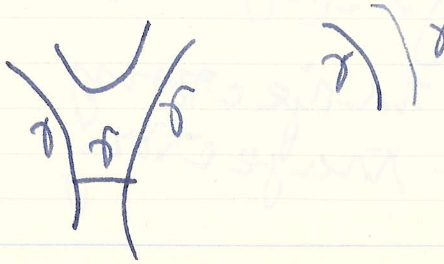
modified bilocal

1) baryon linear
meson bilinear

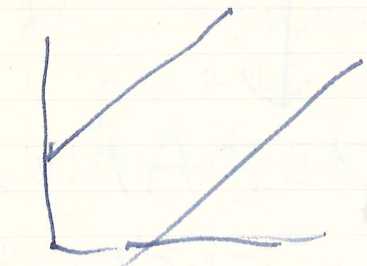
2) subsidiary cond.: linear

meson
$\gamma^{(1)}, \gamma^{(2)}$

baryon
$\gamma, \gamma', \gamma''$



$\alpha(0) \le \frac{1}{2}$



$$\left[\gamma^{(1)}_\mu p^{(2)}_\mu + \gamma^{(2)}_\mu p^{(1)}_\mu - \frac{i\kappa}{2}\varepsilon(\gamma^{(1)} - \gamma^{(2)})(x^1 - x^2)\right],$$

$\Psi = 0$

$$[\gamma^{(1)}_\mu, \gamma^{(2)}_\nu] = 0$$

$\Psi_{\rho\sigma}$

$$\left[p^{(1)2} + p^{(2)2} + \frac{\kappa^2}{2}(x^1 - x^2)^2 + \frac{\kappa}{2}\gamma^{(1)}\gamma^{(2)} + \frac{\kappa_0}{2}\right]\Psi(x^{(1)}x^{(2)}) = 0$$

(π-meson)

$$M^2 = \mu^2\left(a^\dagger a + \frac{1}{2} d^\dagger d\right) + \kappa_0$$

$\downarrow$ 0, 1, 2, 3, 4

$\downarrow$

$0, \frac{1}{2}, 1, \ldots$

$$P = (-1)^{a_k^\dagger a_k + d_0^\dagger d_0}$$

ρ-trajectory

π-trajectory

(baryon)

$$\left(\Gamma^{(1)} p^{(1)} + \Gamma^{(2)} p^{(2)} + \frac{\kappa}{\sqrt{2}}\Gamma^{(3)}(x^{(1)} - x^{(2)}) + i\mu_0\sqrt{2}\right)\psi = 0$$

$$\{\Gamma^{\alpha}_{\mu}, \Gamma^{\beta}_{\nu}\} = 2\delta_{\alpha\beta}\, g_{\mu\nu}$$

64×64

$\gamma^{(1)}, \gamma^{(2)}, \gamma^{(3)}$

$$M^2 = \mu^2(a^\dagger a, b^\dagger b)$$

SU(3), U(1)

7月17日(金)
[総括]
問：8月からこれ迄の精否の判定範囲。

Veneziano amplitude
unitarity
1) satellite の存在性
$\Gamma(-n-\alpha(s))$, $n-\alpha(t)$
2) unitary spin をどう入れるか？
realistic q.m. → quark
dual amplitude → string
3 次元の振動子モデルの例 φ, θ, ψ

$$u(x) = \sum \underbrace{\xi^A_{jmn} V^A_{jmn}}_{\sum (lmn) T_{jlm}}$$

$$H = \sum \left(\pi^*_{jmn} \pi_{jmn} + \mu \xi^*_{jmn} \xi_{jmn} \right) + \frac{1}{2I} (S - J)^2$$

S : total angular momentum
J : 振動による angular momentum

S : int. half int
J : int. int

μ が小さいと S − J のついた状態が energy の低い...

S : int　　$S = J$

S : half-int,　$S = J + \frac{1}{2}$

int :

$$L_1 = \frac{1}{2}\sum_{r=1}^{3}\int(\rho\,\dot{u}^2 + \mu\, u\,\Delta u)\,dv$$

half-int :

$\xi^r \to \xi^r_\alpha$ (spinor)

$s_3 = \pm\frac{1}{2}$

$m_3 = \pm\frac{1}{2}$

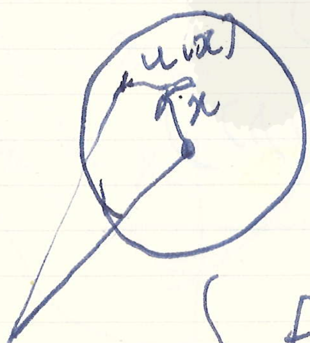
$$L_2 = \frac{1}{2}\sum_{r=1}^{3}\int(\rho\,\dot{\xi}^{r*}_\alpha\,\dot{\xi}^r_\alpha + \mu\,\xi^{r*}_\alpha\,\Delta\,\xi^r_\alpha) \times dv$$

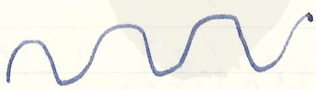
quark の

$L = L_1 + L_2$

string　　quark

SU_3





$A(x)$

$$\int A(X + x + u)\,d\Omega \cong \Omega\, A(X + \bar{x} + \bar{u})$$

$$u = (\omega^{-\frac{1}{2}}/a)\, u\Big|_{x=0}$$

$$\left[P_\mu^2 + (m_0^2 - \Pi_\mu^2)\right]\psi(X_\mu, x_\mu(\sigma), \xi_0^r) = 0$$

$$\left[\frac{1}{2}\int\{p_\mu^2 + (D x_\mu)^2\}\, d\sigma\right]\psi = 0$$

$$\left[P_\mu^2 + M_0^2 + \sum r\, a_\mu^{r\dagger} a_\mu^r\right]\psi = 0$$

scattering amplitude

$$S = \sum_N \frac{\langle f|H_{int}|N\rangle\langle N|H_{int}|f\rangle}{(p_1+p_2)^2 + M^2}$$

$$M^2 = m_0^2 + N$$

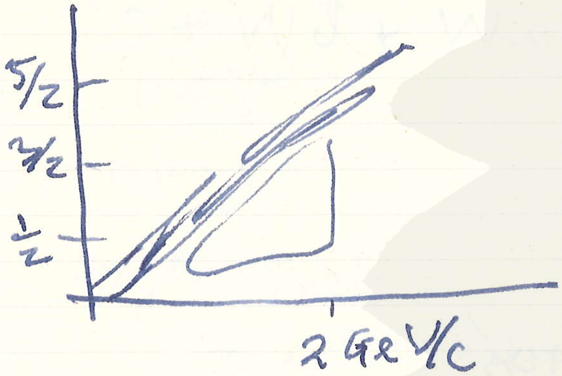
$$\times \quad 2m^2 = -\alpha_\rho(0)$$

$$A(s,t) = B(1-\alpha_\rho(s), 1-\alpha(t))$$

$\pi\pi$: $$B(1-\alpha_\rho(s), 1-\alpha(t)) + B(1-\alpha_\rho(t), 1-\alpha(s))]$$

(続き)

笹田: classification of baryons in a dual Regge SU(3) scheme



orbital excitation quark model

$SU(6) \otimes O(3)$

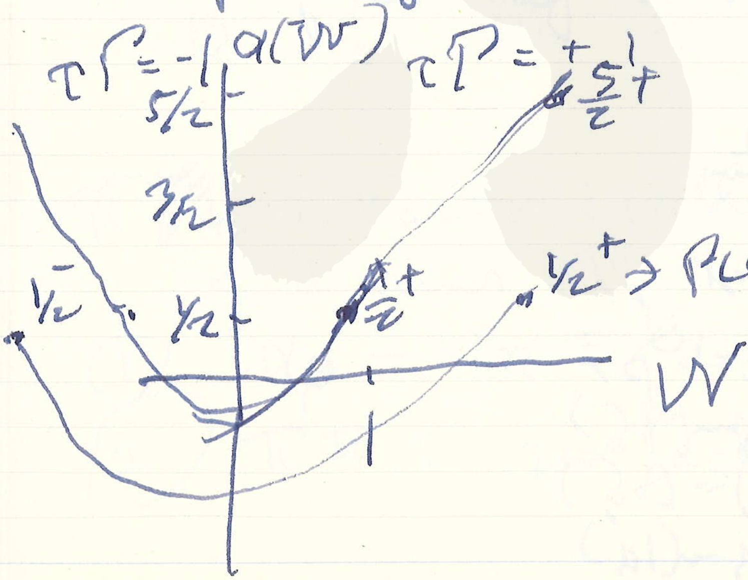
rad. exc.

イ) Regge recurrence

ロ) approx. SU(3)

baryon trajectory a linearity ?

→ parity doubler



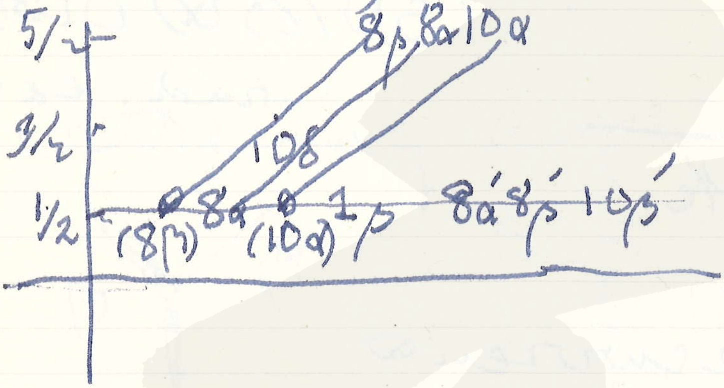
$\alpha(W) \approx aW^2 + C$

i) 10δ, 1β, 1γ ×

ii) 8α と 8β

経験法 : $\alpha(W) = aW^2 + bW + c$

Σ-Λの話



single Regge family

decaplet Δ → 10

singlet Λ → 1

octet について Σ → family が

ある!!!

10, 8, 8, 1

3⊗3⊗3

par. 1st.

10δ - 10δ', 10α - 10β'

8β - 8α', 8γ - (8δ)'

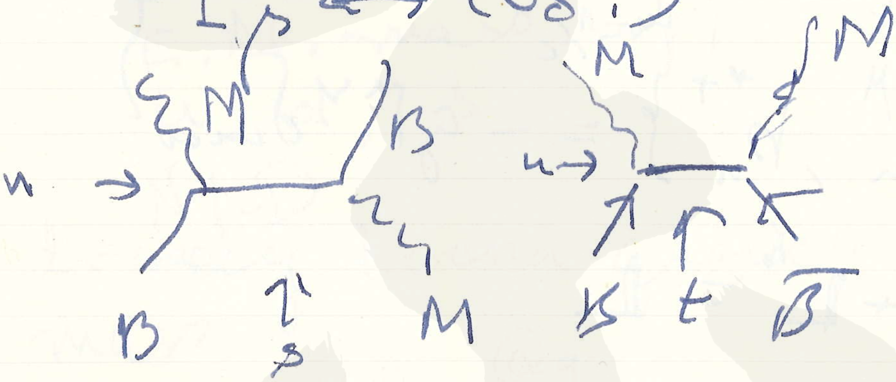
8α - 8β', (8δ) - (8δ')

1γ - (1δ'), 1β - (1α')

	$SU(6)\times O(3)$	Ours
$N_\gamma(1700)$?	yes	no
$^1\alpha$, $^1\delta$	no	yes

Roper
daughter

数学構造：
$8_\rho \longleftrightarrow 10_\delta$
$(8\oplus 10)_\alpha \longleftrightarrow (1\oplus 8)_\gamma$
$1_\rho \longleftrightarrow (8_\delta ?)$



[illegible]: Factorizable Dual Model of π and K
(1) $\alpha_\rho - \alpha_\pi = 1/2$
(2) $\pi\pi$: no Tachyon
Neveu-Schwarz

(3) $\alpha_{K^*} - \alpha_\rho = \alpha_\phi - \alpha_{K^*}$

$= \alpha_K - \alpha_\pi$

$$O(2,1)\left\{\begin{array}{l} L_0^a = R^a - p^2 \qquad R = -\sum_1^\infty n a_n^\dagger a_n \\ L_-^a \\ L_+^a \end{array}\right.$$

$$\left.\begin{array}{l} L^b = R^b = -\sum_{m=1/2}^{\infty} m b_m^\dagger b_m \\ \{b_m^\mu, b_n^{\nu\dagger}\} = -g^{\mu\nu}\delta_{mn} \end{array}\right\}$$

$\mathbb{L}^a + \mathbb{L}^b = \mathbb{L}$

Λ-quark : 1個 } よろしい
N 〃 : 縮退的 }

Λ quark : 2個以上で困る.

〔強粒子〕

実体：quarkでできた複合粒子

nuclear democracy
→ oligarchy
寡頭政治

1) quark current

2) SU(6): B(56), M(35)

$\mu_p : \mu_n = 3 : -2$

3) quark counting

$\sigma_B : \sigma_n = 3 : 2$

E.M. mass diff.

u, d, s

NLD

loosely bound quarks

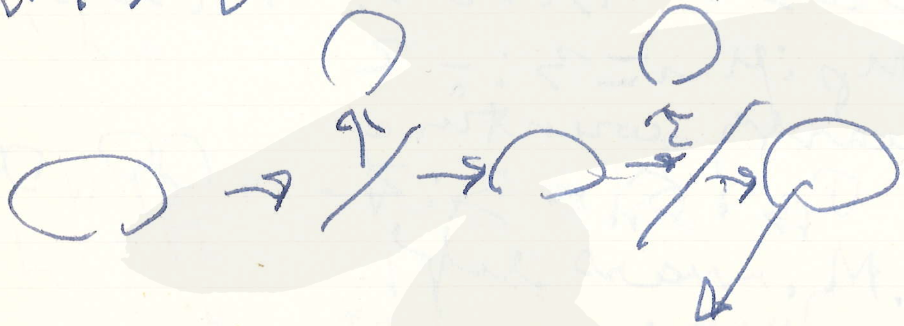
mass

mag. mo $\dfrac{Q_q}{2M_q}$

$\mu_p = \dfrac{e}{2M_q}$, $\mu_n = -\dfrac{e}{3M_q}$

$M_q = 340\ \mathrm{MeV} \to 400\ \mathrm{MeV}$

	u	d
$\langle N_B \rangle$	$\frac{1}{3}$	$\frac{1}{3}$
$\langle Q \rangle$	$\frac{2e}{3}$	$-\frac{e}{3}$
$\langle M \rangle$	400 MeV	400 MeV



$$\langle Q \rangle = -e \int \psi^* \psi \, dx$$

$$= -e/3$$

state　　　　observation

[illegible] $\psi(x)$　　[illegible]　　$Q = ne$

Q = continuous

quark　Q.F.T.　　　$Q = ne$

$Q = \frac{e}{3} n$

[illegible]の議論

1) u: $\frac{1}{3}$ Δ^{++} $(h = \pm\frac{3}{2})$

$\frac{2}{3}$ ~10

phantom quark

4) [illegible]質量は.
nucleon

$$B.E. = 80 \, MeV/q$$

$$\frac{1}{r} \sim \sqrt{2M_q|E|} \sim 250 \, MeV$$

$$r \sim 0.8f$$

$$F(t) \sim \frac{1}{t^2}$$

pion:

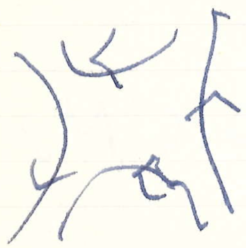
$$B.E. = 330 \, MeV/q$$

$$r \sim 0.4f$$

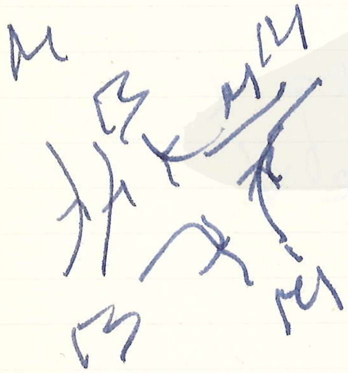
五回 : Urciton scheme での duality

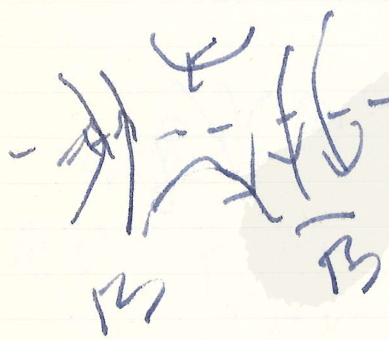
Veneziano Amplitude

i) duality diagram



Okubo-Iizuka rule





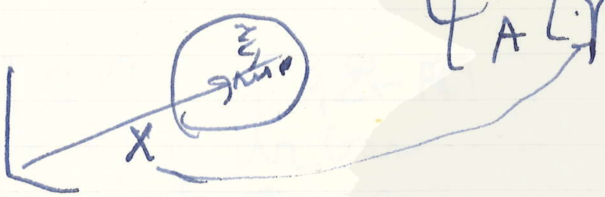
ii) spin, unitary spin

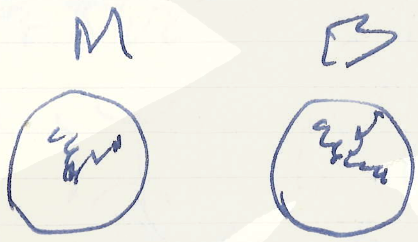
$\xi_\mu \to \phi_\mu(\sigma)$

[II] dual amplitude

[A] 素領域 ξ^μ

$\psi_A(p, \xi_\mu)$

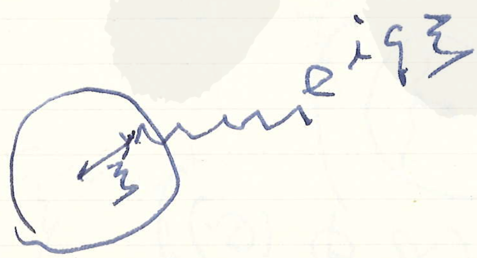


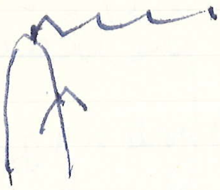


$$|\Psi_M\rangle = \int \Psi^{(+)A}(p,\xi)\,\psi^{(-)}_B(p,\eta)\,\Phi^B_A(p,\xi,\eta)|0\rangle$$

$$|\Psi_B\rangle = \Psi \quad \Psi \quad \Psi \quad \cdots$$

connector





$= 0$

line picture

$\xi_\mu \to EE$

$$\psi_A(p,\xi) \to \psi_A(p, \phi_\mu(\Omega))$$

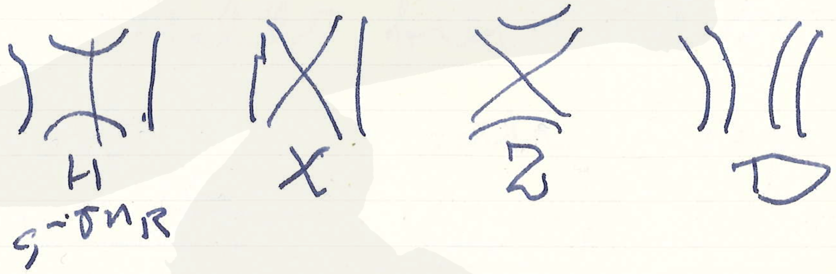
$$\phi_\mu(\Omega) = \sum_{r=1}^{(n)} \xi_\mu^{(r)} \cos r\Omega$$

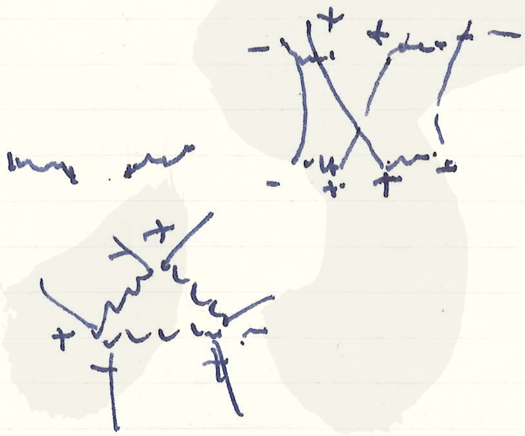
$$e^{iq\xi} \to e^{iq\phi_\mu(0)}$$

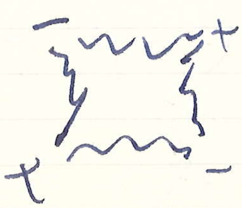
時空の局所化するように

7月8日　[徳岡]
井川: Unbaryon Rearrangement
と素粒子の2体反応.

1) MM







resonance の崩壊について

浮沈会

Weak Interaction の Renormalizable Gauge Model とその問題

荻川(?) 報告(?)

7月13日, 1972

$$\frac{\delta_{\mu\nu} + \frac{k_\mu k_\nu}{M^2}}{k^2+M^2}$$

Yang-Mills field → Boulware(?)

't Hooft path integral

$$\frac{\delta_{\mu\nu} - \frac{k_\mu k_\nu}{k^2}}{k^2+M^2} = \frac{\delta_{\mu\nu} + \frac{k_\mu k_\nu}{M^2}\left(1 - \frac{k^2+M^2}{k^2}\right)}{k^2+M^2}$$

$$= \frac{\delta_{\mu\nu} + \frac{k_\mu k_\nu}{M^2}}{k^2+M^2} - \frac{k_\mu k_\nu}{M^2 k^2}$$

Goldstone Boson : $+ \frac{k_\mu k_\nu}{k^2}$

on shell

SU(2)

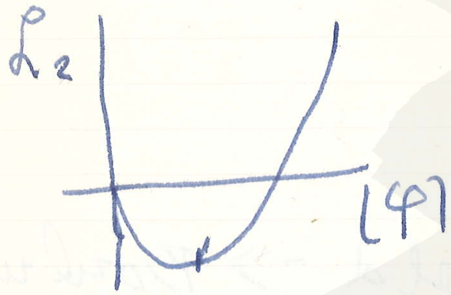
φ : doublet (scalar)

A : Gauge field

c033-951挟込

$$\mathcal{L}_1 = -\frac{1}{2}|\partial\varphi - igA\varphi|^2$$

$$\mathcal{L}_2 = -\mu^2\varphi^*\varphi - \underbrace{G}_{=\lambda}(\varphi^*\varphi)^2$$



$$\langle|\varphi|\rangle \neq 0$$

$$\varphi = \begin{pmatrix}\psi_1 + i\psi_2 \\ \underbrace{\lambda +}_{\sigma +} i\psi_3\end{pmatrix}$$

$$\langle\sigma\rangle = \langle\psi_i\rangle = 0$$

σ: massive

ψ_i: massless

Weinberg 1967

weak boson ← gauge field

$j^+ \to 0$ $\quad SU_W(2)$

φ: doublet を導入

$\varphi \to$ spontaneous breakdown

$A \to$ massive

hadron model はどうすれば
以上の考えと整合になるか？

1. weak boson → gauge boson
gauge group G ($\supset SU_W(2)$)
2. W-boson を massive にする scalar
field として何を使うか？

3. lepton, hadron (or baryon) を
$SU_W(2)$ のどの表現に assign するか？

Weinberg: $G = SU_W(2) \otimes U(1)$
$W^{\pm}$ Z γ

triplet
quartet
quintet

adler : unitarity が悪くなるので、

梅沢博臣　Wisconsin Univ.

Self-consistent Field Theory
と Symmetry Breaking
1972年 8月4日.

simple field theory から
いかにして (複雑~~な~~を 説明するか：
その mechanism.

invariant

quantum

two levels: basic eq. (ψ)

observed symmetry

ψ^{in} quasi-particle

$\psi(\psi^{in})$

$$\Lambda(\partial)\psi = F\psi \to \partial_\mu J_\mu[\psi]=0$$

$$[H, \psi] = [H^{in}, \psi]$$

self-consistent

L.S.Z., weak lim $\psi = \psi^{in}$

1) ここでは com. relation は ~~te~~ いらない

canonical commutator は [illegible]!

generator $Q_f = \int f(x) J_4(x) d^3x$

Nambu model

$\bar\psi(\gamma\partial)\psi + \frac{\lambda}{2}(\bar\psi\psi)^2 + \frac{\lambda}{2}(\bar\psi\gamma_5\psi)^2$

$$J_\mu = \left(\delta_{\mu\nu} - \frac{\partial_\mu \partial_\nu}{\Box}\right) j_\nu(\psi^{in})$$

$$+ a\,\partial_\mu B^{in}$$

gauge transf.

$$\Box B^{in} = 0$$

$$Q = \int J_4 d^3x = a\int d^3x\, B^{in}$$

$\psi^{in} \to \psi^{in}$ $\qquad B^{in} \to B^{in} + a\theta$

$\psi(\psi^{in}) \to e^{i\theta\gamma_5}\psi$

scale invariance

$\frac{1}{2}\partial_\mu\phi\partial_\mu\phi + \lambda\phi^4$

$\Theta_{\mu\nu}$ $(\Theta_{\mu\mu} = 0 \quad \partial_\mu\Theta_{\mu\nu} = 0)$

$D_\nu = x_\mu\Theta_{\mu\nu}$ $\quad D = \int d^3x\, D_4$

$[D, \phi] = ((x\partial) + 1)\phi$

dimensional transformation

$m^2 = 3\lambda\langle 0|\phi^2|0\rangle$

mass difference の問題.

山口嘉夫
場の理論

Aug. 17, 1972

spinless self-interacting field

$$\mathcal{L}(x) = \frac{1}{2} \frac{(\partial_\mu \vec{\phi})(\partial^\mu \vec{\phi})}{[1 + l^2 (\vec{\phi})^2]^2} - m_0^2 \vec{\phi}^2$$ ~~mass term~~

Schwinger's chiral Lagrangian
(nonlinear) ps-part

$l = \frac{f^0}{m_\pi}$

$\vec{v}_\mu(x) \to \partial_\mu \vec{v}^\mu = 0$

$\vec{a}_\mu(x) \to \partial_\mu \vec{a}^\mu = 0$ $(m_0 = 0)$

physical meson (stable) → periodic 性

amplitude の ある limit ?

c033-953挟込

北川敏男
「カントール集合論の基礎論への[illegible]」
1972年9月26日
基礎論講演.

$\aleph_0 < \aleph_1 <$

連続体仮説
集合の公理

$\aleph_0 < \aleph_1 < \aleph_2 <$

18..：Cantor
193..年：Gödel　無矛盾性証明
1962年：Cohen　〃 独立性

van der Waerden："Algebra"

$x(\tau) = x_0\tau^n + x_1\tau^{n-1} + \cdots + x_n$

τは[illegible]

$$\frac{x(\tau)}{y(\tau)} = \frac{x_0}{y_0}$$

$$\varepsilon > \frac{1}{\tau} > \frac{1}{\tau^2} > \cdots > 0$$

$$x(\tau) = x_{-n}\tau^{n} + x_{-n+1}\tau^{n-1} + \cdots + x_0$$

$$+ \frac{x_1}{\tau} + \frac{x_2}{\tau^2} + \cdots$$

$$y(\tau) = f(x(\tau))$$

回転群. $\vec{x} = \vec{x}_0 + \frac{\vec{x}_1}{\tau} + \frac{\vec{x}_2}{\tau^2} + \cdots$

SU(3)?

談話会 (湯川) Sept. 28, 1972
素粒子と時間

[illegible] ([illegible])

Duality or Topsy-Turvydom

~~No~~ October 26, 1972

ルイス・フロイス (1532~1597)
日欧文化比較.

Topsy-Turvydom (Chamberlain)
あべこべ

[illegible]

ゼロあり

西洋型　東洋型

R. Riemann (1826~1866) : 東洋型
K. Weierstrass (: 西洋型
Göttingen
Berlin

N. Bohr → Heisenberg 西洋型
de Broglie → Schrödinger 東洋型

函子での duality

(domain, field) →

& 量子化

(domain, field)

\+ 量子化

(Nakanishi)

Veneziano

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

2次元 Minkowski space

Snyder 1946 Quantized Space Time

岩波思想
非局所場と因果律

評議会　11月30日, 1972

quark-antiquark → bilocal field

3 quark → trilocal field

SU(6)×O(3) →

分割
離散

非局所
因果律

S-matrix

時空-物質
両者とそれぞれの相関 → 新しい秩序

(Markov
(Yukawa

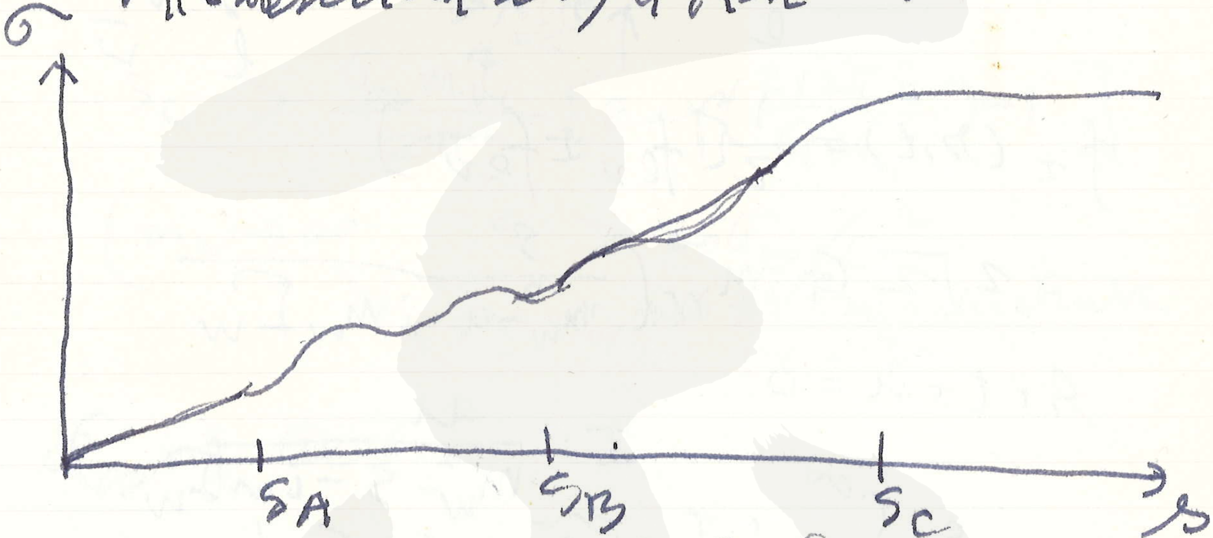
$p P \Phi = 0$

Intermediate Weak Boson
and Weak Interaction at
High Energy
湯川秀樹　(京大PL)
（基研 Dec. 19, 1972）

二宮・田中、湯川

Pure-leptonic　$\nu + l \to \nu + l$
$\nu \to ?$

Bjorken
π-meson 場の理論の状況に似ている



$\nu + l \to \nu + l$ （1〜10 GeV str. int.）（10〜100 GeV str. int.）

$\sigma \simeq G^2 s / \pi$

$G \simeq 10^{-5}\, m_p^{-2}$

$0 < s < s_A$: Perturbation region
$s_A < s < s_B$: Resonance region
$s_B < s < s_C$: Transition region
$s_C < s$: asymptotic region

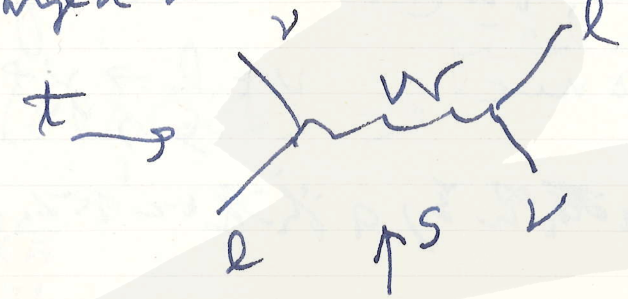
c033-957〜960挟込

Pomaranchuk, I. Ya,
Soviet Journal of Nucl. Phys.
11 (1970), 477.

$\bar{\Psi}\Psi\bar{\Psi}\Psi \leftarrow \infty$

$\uparrow m_W$

Weak boson
charged vector



$$f_\pm(s,t) = \frac{1}{2}\left[f_{e\nu} \pm f_{e\bar{\nu}}\right]$$

$$= 2\sqrt{2}\, G\, m_W^2 \left(\frac{s}{m_W^2 - u - i m_W \Gamma_W} \pm \frac{u}{m_W^2 - s - i m \Gamma_W} \right)$$

$s + t + u = 0$

$$+ \frac{s}{\pi} \int_{s_0}^{\infty} ds'\, \mathrm{Im}\left[\tilde{f}_\pm(s',t)\right] \left[\frac{1}{s'(s'-s)} \pm \frac{1}{(s'+t)(s'+s+t)} \right]$$

$m_W \gg \Gamma_W$

$$S_A = m_W^2 \left[\exp\left(\frac{2\sqrt{2\pi}\,\varepsilon}{G\, m_W^2}\right) - 1\right]$$

m_W GeV	$\sqrt{S_A}$ GeV	$\sqrt{S_c}$
50	2×10^8	2.5×10^9
100	4.6×10^3	10^5
300	3.5×10^2	2×10^4
⋮	⋮	
∞	~~10^5~~ 3×10^2	10^5

$$S_c > \frac{\sigma_\infty m_W^4}{2\pi^2}\left[\exp\left(\frac{2\sqrt{2\pi}\,\varepsilon}{G m_W^2}\right) - 1\right]$$

($m_W \to \infty$ $\quad S_c > \varepsilon^2 \sigma_\infty / G^2$)

($s \ll m_W \to \infty \to$ Pomeranchuk と一致)

$\sigma_\infty = 1\ \mathrm{GeV}^{-2}$

大将係 出

第2量子化
Super-Quantization
(仮称) 深化する symmetry
(Dec. 21, 1972)

① Lagrangian-Hamiltonian
② Yang-Feldman
③ Super-Quantization
(第3量子化)
運動方程式　unitarity?
④ Feynman Path Integral

運動方程式がない、然し
① $S^\dagger S = 1$
② limit で普通の理論と一致.

$\phi(x)$ ← bilocal field
$\phi(x, \xi)$
⋮
$\phi(x_1, x_2, \dots)$
$\phi(D)$

↓
4次元とは
限らない

Assumption ①
$[\phi(x), \phi(y)] = G(x, y)$
$= c\text{-number}$

$\phi^\dagger(x) = \phi(x)$

$G(x,y) = -G(y,x)$

$G^*(x,y) = G(y,x)$

② partial ordering

$x > y$ (time-like) $\quad x \sim y$ (space-like) $\quad x < y$ (past-like)

causality の一般化

$G_A(x,y) \qquad G_R(x,y)$

$$G_A(x,y) \equiv \begin{cases} 0 & \text{if } x > y \text{ or } x \sim y \\ G(x,y) & \text{if } x < y \end{cases}$$

$(\theta(y_0 - x_0) G(x,y))$

$x \sim y$:

③ $G(x,y) = 0 \quad x \sim y$ (causality)

$G_A(x,y) \equiv \theta(y-x) G(x,y)$

$G_R(x,y) \equiv \theta(x-y) G(x,y)$

$\equiv -G(y,x)$

$$G_A(x,y) - G_A(y,x) \equiv G(x,y)$$

$$\cancel{A}\ \Lambda(x) \equiv \phi(x) - \int dy\, G_A(x,y) \frac{\overrightarrow{\delta}}{\delta\phi(y)}$$

$$\hat{\Lambda}(x) \equiv \phi(x) + \int dy\, G_A(x,y) \frac{\overleftarrow{\delta}}{\delta\phi(y)}$$

$$[\Lambda(x), \Lambda(y)] = [\Lambda(x), \hat{\Lambda}(y)]$$

$$= [\hat{\Lambda}(x), \hat{\Lambda}(y)] \equiv 0$$

$$T(\phi(x_1) \cdots \phi(x_n))$$

$$\equiv \Lambda(x_1)\Lambda(x_2) \cdots \Lambda(x_n) \cdot 1$$

(1) $x_1, x_2 \cdots x_n$; symmetry

(2) $x_1 > x_2 > \cdots > x_n$

$$\tilde{T}(\phi(x_1) \cdots \phi(x_n)) = 1\, \hat{\Lambda}(x_1) \cdots \hat{\Lambda}(x_n)$$

interaction

$$L_1(x) \equiv L_1(x; \phi(x))$$

Quasi-local:

$$\frac{\delta}{\delta\phi(y)} L_1(x;\phi(x)) = 0$$

$$S \equiv \exp\{iK\}\cdot 1$$

$$K = \int dx\, L_1(x;\Lambda(x))$$

S a unitarity;

$$S^\dagger \equiv 1\, \exp\{-i\tilde{K}\}$$

$$\tilde{K} = \int dx\, L_1(x, \tilde{\Lambda}(x))$$

$$S^\dagger S = 1\cdot e^{-i\tilde{K}}\, e^{iK}\, 1$$

$$= 1\, e^{i(K-\tilde{K})}\, 1$$

(これは local な條件)

$$K - \tilde{K} = \int dx\, D(x)$$

$$SS^\dagger = 1$$

然し

Example (1)

$G(x, y) = 0 \quad x^2 - y^2 = \lambda^2$

markov

Example (2)

bilocal

$\phi(x, \xi)$

$G(x, \xi; y, \eta) = 0$

$(x - y - \lambda\xi + \lambda\eta)^2 = 0$

$(x, \xi) \rightarrow (y, \eta)$

$\longleftrightarrow \quad x_0 - \lambda\xi_0 = y_0 - \lambda\eta_0$

Example (3)

$[\phi(D), \phi(D')] = G(D, D')$

$D \rightarrow D'$

Example (4)

Non-flat space の理論.

$(ds)^2 = g_{\mu\nu}(x)\, dx^\mu dx^\nu$

討論：隠れたる symmetry

{ 対称
{ symmetry

① ICP

② crossing symmetry

$\pi^+ N \to \pi^+ N$ } $B \to -B$ }
$\pi^- N \to \pi^- N$ } $Q \to -Q$ }

discont. conti.,
(Lorentz

$SU(2) \to SU(3) \to SU(6)$
$\searrow$
$\to SW(2) \to SW(3)$

長谷部勝也 (京教大)

Space-Time Quantization

(寺沢氏 Jan. 18, 1973
還暦記念 [素粒子論研究の一方向]

Riemann, 1854
n重に広がったもの
連続的、　離散的な多様体、
大きさが有限 → 曲率 (確定)
測りえない程に小さい空間

Boltzmann, 1891
Ostwald, Planck との論争

1897:
物質の atom
Aether の vector atom

Heisenberg 1938
universal length の
非局所的理論を作る!!!

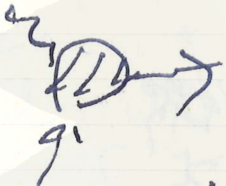
~~S~~ Snyder, 1947
Tokuoka
Tamm, 1965

1953 国際会議

Landau, 1954?

$$e^2 = e_0^2 \frac{1}{1 + [\mathrm{const}]\, e_0^2 \ln \frac{\Lambda^2}{m^2}}$$

$\frac{1}{\Lambda} = a$

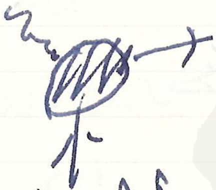


Haag　$u \varphi u^{-1} = \psi$

free　⇒　free

analytic continuation!!!

non-local interaction



Stueckelberg - Wanders

"Minkowski空間は Euclid的である"

局所的空 → 素領域

spin : up, down

粒子が[illegible]によって構造を考える

そういう理論

$\rho_n(x)$の素[illegible]的解釈

$\rho_n(x) \to \rho_{n'}(x')$

macro-causality

positive energy が macro から micro へ流れるか",

[illegible]

物理を素領域說か

光速度の不變性

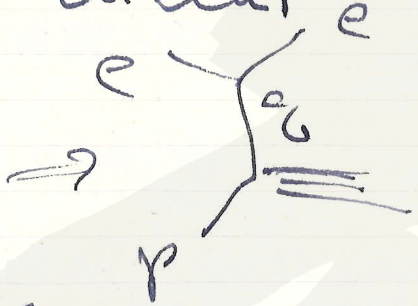
1955年 (湯川"論文)

湯川

uccc

A. Tavkhelidze
Automodel (Scaling)
Behavior in Field theory
(1973年2月23日
華頓)

e-p scattering
Bogoliubov — .. — Tavkh.
deep inela.



$\xi = q^2/\nu$
Markov

$-q^2 \to \infty$　　$\nu \to \infty$
Nakanishi

causality
Sudra

Limitations on Weight Functions

$\sum \rangle_\lambda \langle$

1) increasing fn of λ. (polynomially)

2) decreasing

田中正

Bilocal Currents and Finite Q.E.D.

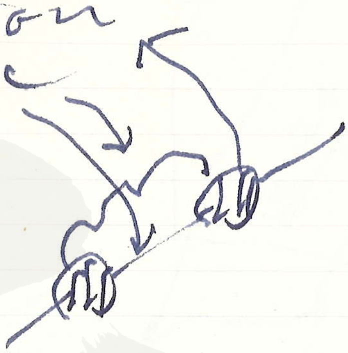
談話会, Feb. 16, 1973

[illegible]
混合論 → くりこみ Q.E.D.

素域の理論

legion の指摘

{ non-local interaction
{ indefinite metric



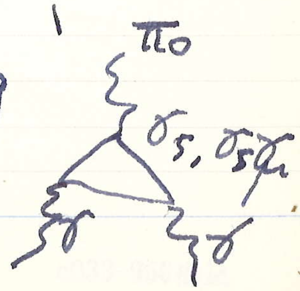
anomaly inv.

1) anomaly, gauge

$e^{iF(\sigma)}$ $F(\sigma)=e\int \Lambda(x')\bar{\psi}(x')\gamma_\mu\psi(x')d\sigma$

$[F, \bar{\psi}(x)\gamma_\mu\psi(x)]_{x\in\sigma}=0$?

Fukuda - Miyamoto 1949



Gauge Indep. QED
Valatin
Jauch - Rohrlich
Schwinger

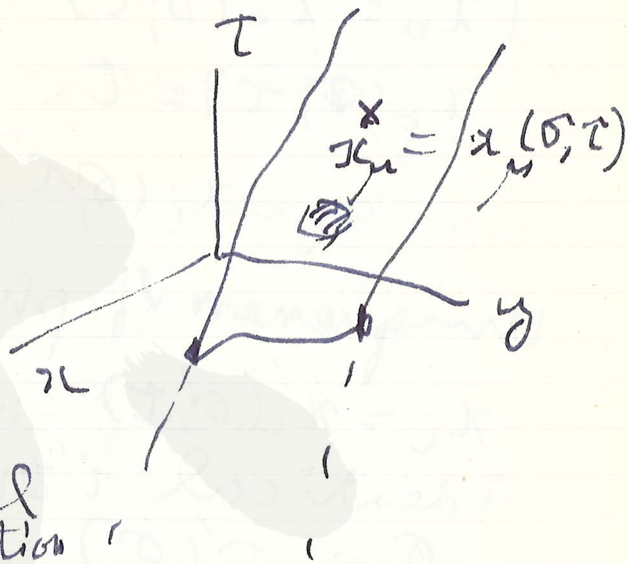
宮沢浅野氏
Theory of one-dim. Relativistic Elastic Continuum and Hadronic Wave Eq.
基研談話会
1973年3月13日(火).

$H(\sigma)\,\Psi[x(\sigma)] = 0$

Hara
Goto
Tanikawa
Konishi

Nambu

Classical theory
world strip



σ : label
$[\sigma_1, \sigma_2]$
τ : $[-\infty, +\infty]$

x_μの変換 → external transformation

$\sigma \to \sigma'(\sigma,\tau)$ の変換
$\tau \to \tau'(\sigma,\tau)$
→ internal な変換.

$x_\mu(\sigma,\tau) = x'_\mu(\sigma',\tau')$
reparametrization

$$(dx_\mu)^2 = \left(\frac{\partial x_\mu}{\partial\sigma}d\sigma + \frac{\partial x_\mu}{\partial\tau}d\tau\right)^2$$

$$= G_{11}\,d\sigma^2 + G_{00}\,d\tau^2 + 2G_{01}\,d\sigma d\tau$$

$$G_{01}^2 - G_{00}G_{11} \geq 0$$

$$\sqrt{G_{01}^2 - G_{00}G_{11}}\,d\sigma d\tau$$

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

$$\begin{cases} x_i = x_i(\sigma,\tau) \\ x_0 = x_0(\sigma,\tau) \rightarrow \text{超多時間} \end{cases}$$

$$x_0(\sigma,\tau) = t \quad \rightarrow \quad \tau = \tau(\sigma,t)$$

$$x_i = x_i(\sigma,\tau) \rightarrow x_i(\sigma,t)$$

uniqueness of phys. interpretation

$x_i = x_i'(\sigma', t)$ is $x_i(\sigma,t)$ と
identical であれば可!!

$$\left.\begin{array}{l}\sigma \rightarrow \sigma'(\sigma) \\ \tau \rightarrow \tau'(\sigma,\tau)\end{array}\right\} \rightarrow \text{physical parameter transform.}$$

$$V_i = \frac{\partial x_i(\sigma,t)}{\partial t}$$

$$= \frac{\partial x_i(\sigma,\tau)}{\partial\tau} \Big/ \frac{\partial x_0(\sigma,\tau)}{\partial\tau}$$

$$U_\mu = \frac{1}{\sqrt{-G_{00}}} \frac{\partial x_\mu}{\partial \tau}$$

$$G_{00} \leq 0$$

$W_i(\sigma, t)$

$$\frac{\partial x_i(\sigma t)}{\partial \sigma} d\sigma = \underbrace{\left(\frac{\partial x_i(\sigma t)}{\partial \sigma} - V_i \frac{\partial x_i(\sigma t)}{\partial \sigma} \right)}_{d\sigma}$$

$$\underbrace{\left(\frac{\partial x}{\partial \sigma} \right)^2}_{> 0} d\sigma^2 \rightarrow G_{11} \geq 0$$

(causality によって符号が決まる)

$G_{01} = 0$: orthogonal curvilinear coord. を選ぶ!!!

$$L = \frac{\kappa}{2} \left(\left(\frac{\partial x_\mu}{\partial \tau} \right)^2 - \left(\frac{\partial x_\mu}{\partial \sigma} \right)^2 \right)$$

$$\delta W_{12} = \delta \int_{\tau_1}^{\tau_2} \int_{\sigma_1}^{\sigma_2} d\sigma \, d\tau \, L = 0$$

$$\frac{\partial^2 x_\mu}{\partial \tau^2} = \frac{\partial^2 x_\mu}{\partial \sigma^2} \qquad \left. \frac{\partial x_\mu}{\partial \sigma} \right|_{\sigma_1, \sigma_2} = 0$$

$$\Lambda^0 = \frac{\varkappa}{2}\int_{\sigma_1}^{\sigma_2}(G_{00}+G_{11})d\sigma$$

$$= -\omega_0 \qquad \omega_0 \geqq 0$$

$$\left.\begin{array}{l}\sigma' = \alpha\sigma \\ \tau' = \alpha\tau\end{array}\right)$$ internal scale transf.

$$p_\mu(\sigma,\tau) = \varkappa\frac{\partial x}{\partial\tau}$$

$$P_\mu(\tau) = \int_{\sigma_1}^{\sigma_2} p(\sigma,\tau)d\sigma$$

$$M_{\mu\nu} =$$

spin

$$S = \frac{m^2}{2\pi\varkappa} - \frac{\varkappa\Omega}{2\pi}$$

$$(m^2 = -P_\mu^2)$$

佐藤文隆
New Series of Exact Solutions
for Gravitational Fields of
Spinning Masses
談話会
1973年3月15日

Tomimatsu-Sato Solution

black hole

1. $R_{\mu\nu}=0$ 　外部の解
2. 遠方で flat
3. 定常
4. 軸対称

$g_{\mu\nu}(\rho, z)$

Schwarzschild の解（球対称）

Weyl 　回転楕円体対称

回転物体の解析
Lense-Thirring（近似解）
Papapetrou

Spinor 表現
Kerr の Solution (1963)

Schwarzschild 解を回転させた

(m, J)

m

Schwarzs. $\longrightarrow$ Kerr

$\downarrow$ $\qquad\qquad\qquad\qquad$ $\downarrow$

Weyl $\longrightarrow$ T-S. (1972)

(m, δ) $\qquad\qquad$ (m, δ, J)

$$ds^2 = f^{-1}[e^{2\gamma}(d\rho^2 + dz^2) + \rho^2 d\phi^2] - f[dt - \omega d\phi]^2$$

1968 Ernst

$$(\xi\xi^* - 1)\nabla^2\xi = 2\xi^*\nabla\xi\cdot\nabla\xi$$

$$f = \mathrm{Re}\,\frac{\xi - 1}{\xi + 1} \qquad \varphi = \mathrm{Im}\,\frac{\xi - 1}{\xi + 1}$$

$$\rho^{-1}f^2\nabla\omega = \hat{n}\times\nabla\varphi$$

ξ : real $\qquad$ 回転のない..

$\downarrow$ $\qquad\qquad$ $(\omega = 0)$

$$\xi_0 = -\coth\Psi$$

$$\nabla^2\Psi = 0$$

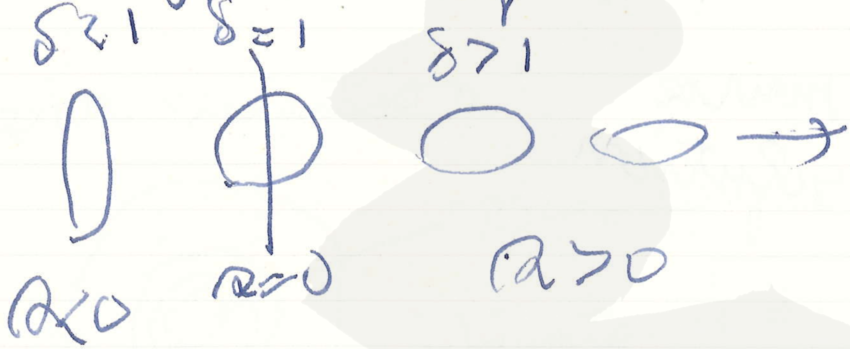
$$\Psi = \frac{\delta}{2}\ln\left(\frac{x-1}{x+1}\right)$$

$$\phi \sim -\frac{m}{r} + \frac{1}{3}\left(1 - \frac{1}{\delta^2}\right)\frac{m^2}{r^3}P_2(\theta)$$

quadrupole moment

$\delta = 1$: Schwarzschild.

$$f = 1 - \frac{2m}{r}$$



Schwarz. $\zeta = x$

Weyl $\zeta = \dfrac{(x+1)^\delta + (x-1)^\delta}{(x+1)^\delta - (x-1)^\delta}$

Kerr $\zeta = px - iqy$

$$p^2 + q^2 = 1$$

$$J = m^2 q$$

T.-S.
$\delta = 2$:

$\delta = 3$:

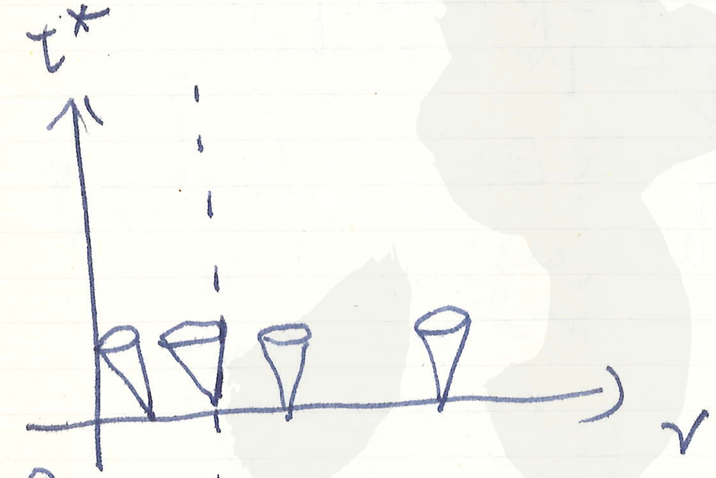
$\vdots$

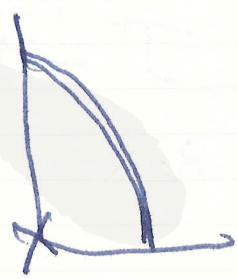
$\xi = x \to \xi = ix$ dipolarity

$\xi' = \xi e^{i\alpha}$

charged source
R-N solution

Black Hole との関係.





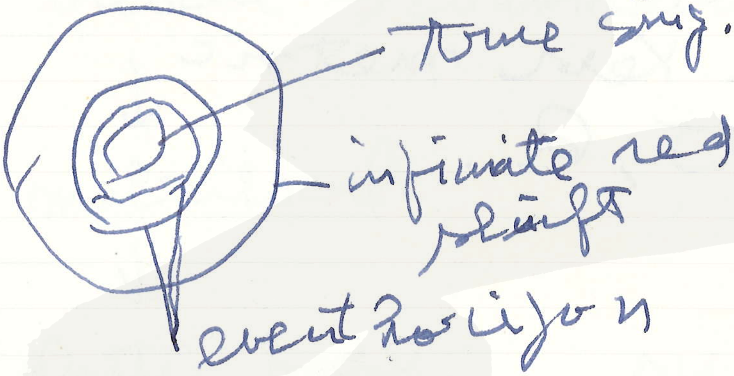
null-surface $\to r = 2m$

Schwarz. surface $\to$ event horizon

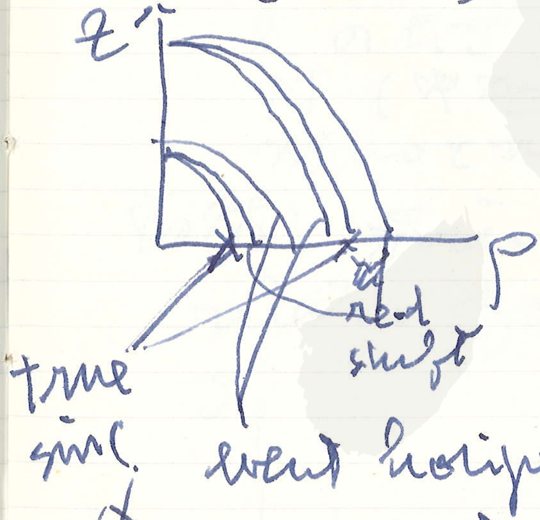
$\to$ red shift ∞

外の
出て行くのは入ってこない
入ってくるのは出てゆかない

Kerr solution:



T-S ($\delta = 2$)



↘ naked singularity
↘ weyl sol.

Wheeler; 重力崩壊の結果として
"black hole has no hair"

charged Kerr metric
M, J, Q.

素粒子の時空記述
研究会
1973年 3月22日, 23日, 24日

3月22日; 午前
湯川; introductory talk
bilocal → constraint → hyper-quantization
↓
multilocal　　(時間 / 粒子
↓
elastic body　　$\Delta V \cdot \Delta t \gtrsim l^4/c$
string
l の長さ ([illegible])
N (中間子) を長さくらべてでも言える
micro と macro の時間の違い ([illegible])
高林: string model の relat. formulation.

(三次元のひろがり)

とKa 今法：ひろがった粒子の相互作用

Γ 関数 と infinit. deformation

$$H' = e^{ik_\mu (x_\mu + \underbrace{u_\mu}_{O_{\mu\nu}})}$$

X_μ

$$[\tilde{\Lambda}^+, H'] = rH'$$

covariance

Vir ogov

粒子

$k_\mu^2 \sim 1$! space-like

$$O_{\mu\nu} = \delta_{\mu\nu} - \frac{p_\mu p_\nu}{p^2} \qquad \begin{pmatrix} 1 & & \\ & 1 & \\ & & 0 \end{pmatrix}$$

$$ik_\mu X_\mu = A$$

$$ik_\mu O_{\mu\nu} u_\nu = B$$

$$e^{A+B} = e^A e^{B - \frac{1}{2!}[A,B] + \frac{1}{3!}[A[A,B]] + \cdots + \frac{(-1)^n}{(n+1)!}[A[A,[\cdots[A,B]]\cdots]}$$

$$X_\mu = i\frac{\partial}{\partial p_\mu} \to D^n B$$

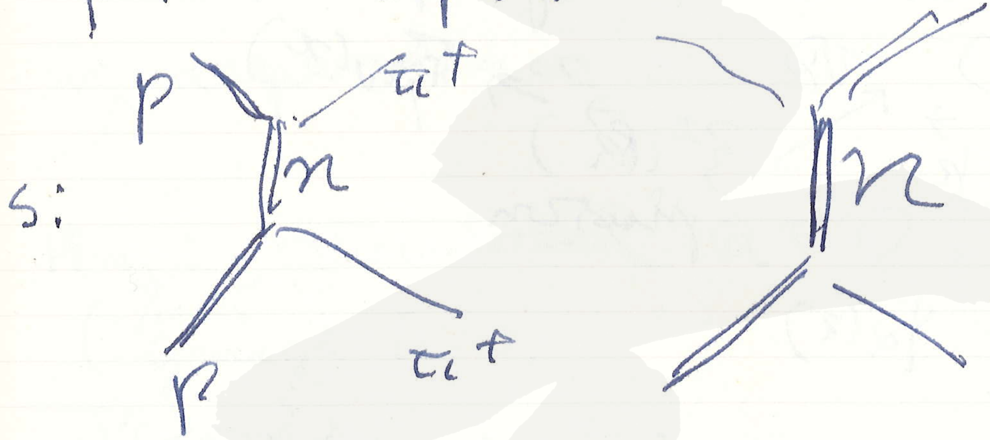
$$e^A \cdot e^{\int_0^1 B(p+\lambda k)\, d\lambda}$$

$$\Sigma = e^{i\vec{\pi}_\mu \sum \sqrt{\frac{2}{n}}\left(a_\mu^{(n)} e + a_\mu^{(n)\dagger}\right)}\sqrt{k_\mu^2}$$

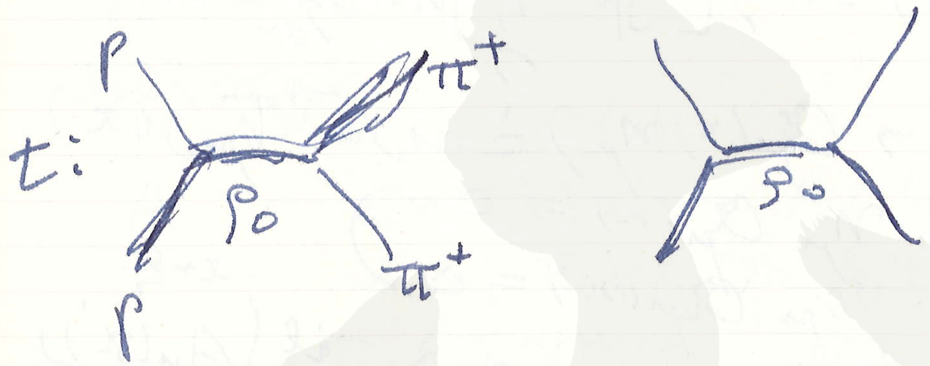
$$\bar{\pi}_\mu = \overleftarrow{O}_{\mu\nu}(P,\lambda)\,\pi_\nu$$

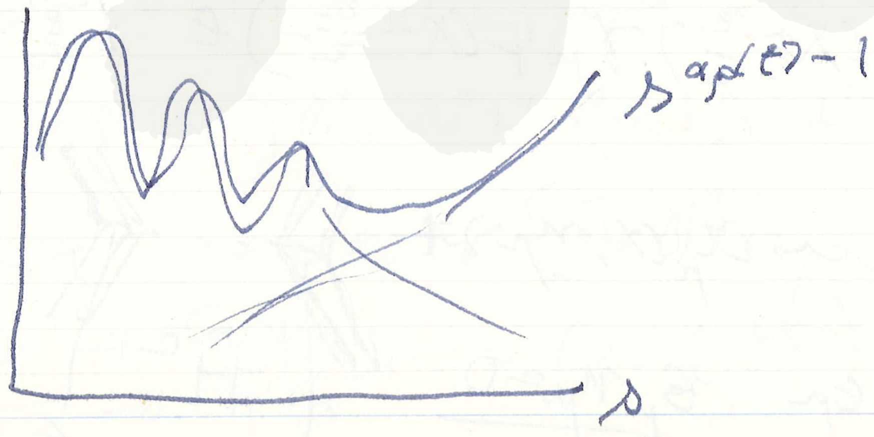
$p + \pi^+ \rightarrow p + \pi^+$

s:



t:





duality?

SU_3

四-七: QED での gauge invariance

$A_\mu(x)$ $\nabla\chi$ $\rightarrow F_{\mu\nu}(x)$

波 $\vec{k}$ $\xi^\pm(\vec{k})$

photon

粒 $\psi_\alpha(x)$

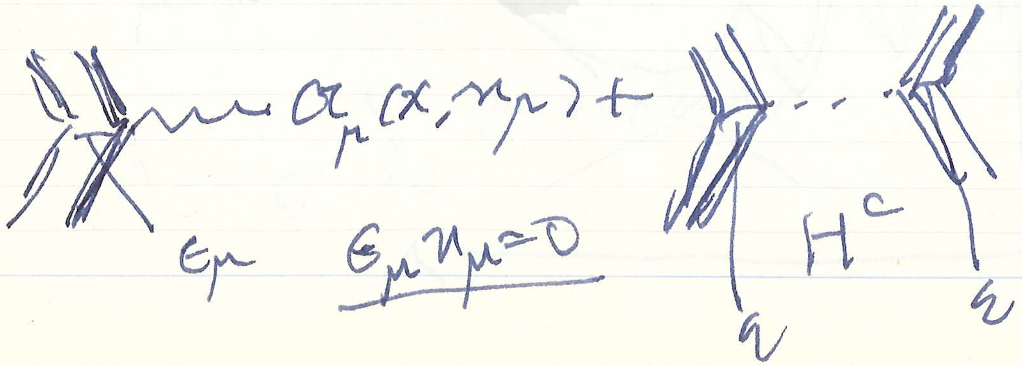
matter

$$\partial_\mu j_\mu(x) = 0, \quad [j_\mu(x), j_\nu(x')]/\sigma = 0$$

$$F_{\mu\nu}(x) \to \alpha_\mu(x, n_\mu) \overset{?}{\doteq} n_\nu \partial^{-1} F_{\mu\nu}(x)$$

$$\left.\begin{array}{l} n_\mu \alpha_\mu(x) = 0 \\ \partial_\mu \alpha_\mu(x) = 0 \end{array}\right)$$

$$\bar{\psi}(x+\tfrac{\varepsilon}{2})\gamma_\mu\psi(x-\tfrac{\varepsilon}{2})\, e^{ie\int_{x-\frac{\varepsilon}{2}}^{x+\frac{\varepsilon}{2}} A_\mu(x')\,dx'_\mu}$$



$\underline{\varepsilon_\mu n_\mu = 0}$

検討:

$$J_\mu(x, n_\mu) = \int d^4\varepsilon\, \bar{\psi}\left(x+\frac{\varepsilon}{2}\right)\gamma_\mu \psi\left(x-\frac{\varepsilon}{2}\right)$$

$$\times \sqrt{\frac{\pi^3}{\kappa^3}}\, e^{-\varepsilon_\mu^2}\delta(\varepsilon_\mu n_\mu)$$

n_μ-dependence

他に: non-local QED?
(ただし
Gauge inv.

Peierls
Bloch

bilocal
Markov　　Yukawa

A : $\langle x|A|x'\rangle = A\left(\frac{x+x'}{2}, x'-x\right)$

$\langle x|E|x'\rangle = \delta^4(x-x')$

$$L_E = \mathrm{tr}\left[\bar{\psi}\gamma^\mu[\partial_\mu, \psi] + m_0\bar{\psi}\psi\right]$$

$$\mathrm{tr}\, AB = \int d^4x\, d^4x' \langle x|A|x'\rangle\langle x'|B|x\rangle$$

$$L_I = -ie\,\mathrm{tr}\left[\bar{\psi}\gamma^\mu A_\mu \psi\right]$$

$\psi \to G\psi$　　$G = e^{ie\Lambda}$

$\bar{\psi} \to \bar{\psi}G^{-1}$

$$A_\mu \to G A_\mu G^{-1} - \frac{i}{e}[\partial_\mu, G]G^{-1}$$

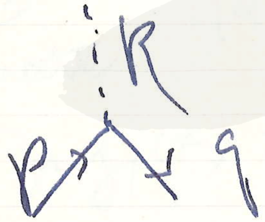
$L_F + L_I =$ gauge inv.

$$F_{\mu\nu} = [\partial_\mu, A_\nu] - [\partial_\nu, A_\mu] - ie(A_\mu A_\nu - A_\nu A_\mu)$$

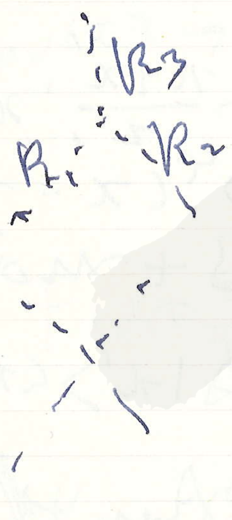
$$F_{\mu\nu} \to G F_{\mu\nu} G^{-1}$$

$$L_F = \frac{1}{4}\mathrm{tr}[F_{\mu\nu}F^{\mu\nu}]$$

Yang-Mills



$$\Sigma_g(p, q, k) = \Sigma_g\left(k; \frac{p+q}{2}\right)$$



$$\Sigma_{3g}(k_1, k_2, k_3) =$$

$i_\mu = \bar{\Psi}\gamma_\mu\Psi \qquad [\partial_\mu, i^\mu] = 0$

$j_\mu = \gamma_\mu \bar{\Psi}\Psi - (A^\nu F_{\nu\mu} - F_{\nu\mu}A^\nu)$

$[\partial_\mu, j^\mu] = 0$

$[\partial_\mu, A^\mu] = 0$

$\mathrm{tr} \to \mathrm{tr}^* = \frac{1}{\sum c_i} \iint c_i \langle x_1 | \quad |x_2 - \frac{\varepsilon}{2}\rangle$

$\times \langle x_2 + \frac{\varepsilon}{2} | \quad | x_1 \rangle \, d^4\varepsilon$

$\langle x_1 | \exists | x_2 \rangle = \delta^4(x_2 - x_1 - \epsilon)$

$\tilde{L}_E = \mathrm{tr}[\exists \bar{\Psi}(\gamma^\mu[\partial_\mu, \Psi] + m_0 \bar{\Psi}\Psi]$

$\tilde{L}_I = \mathrm{tr}[\exists \bar{\Psi}\gamma^\mu A_\mu \Psi]$

$\tilde{L}_P = \frac{1}{4}\mathrm{tr}[\exists F_{\mu\nu}F^{\mu\nu}]$

$\to \widetilde{\mathrm{tr}}(G^{-1} \exists G F_{\mu\nu}F^{\mu\nu})$

$\mathrm{tr}(G \exists G^{-1} F_{\mu\nu}F^{\mu\nu})$

摂動：

O.K.

X

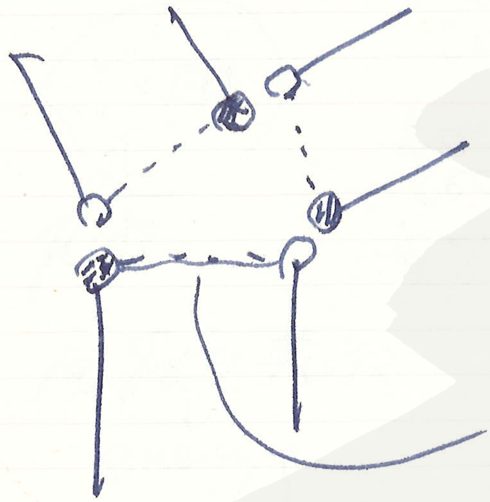
3月22日. 午前
鈴木氏: model

bilocal場と string

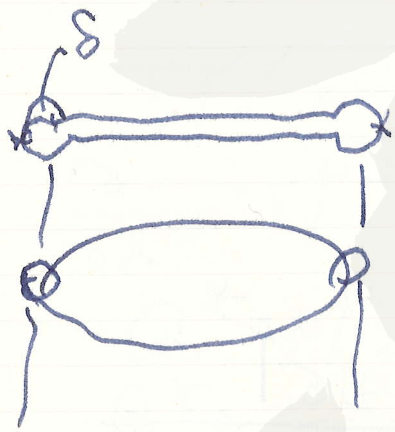
scattering angle,

$s \to \infty \quad A \to e^{\infty}$

causality ?



bilocal → string
方が優れる



$\bar{x}(0) \qquad \bar{x}(L)$

$\bar{p}(0) \qquad \bar{p}(L)$

$x_\mu(\sigma) \quad (0 \leq \sigma \leq 2L)$

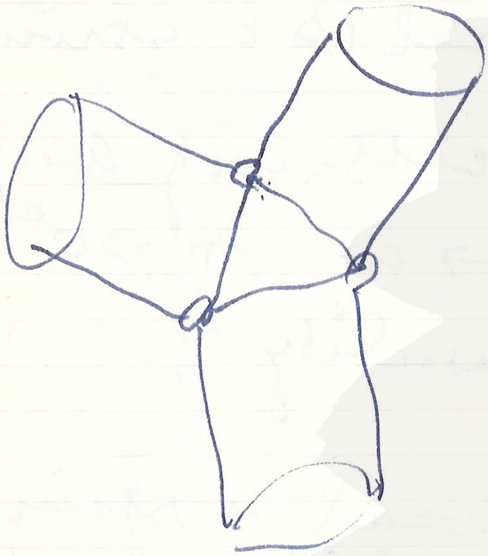
$x_\mu(\sigma) - x_\mu(2L-\sigma) = 0$

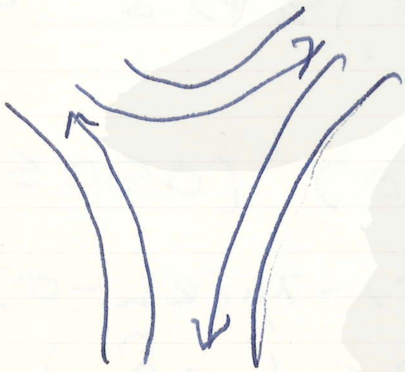
$(\delta < \sigma < L-\delta)$

$p_\mu(\sigma) + p_\mu(2L+\sigma)) = 0$

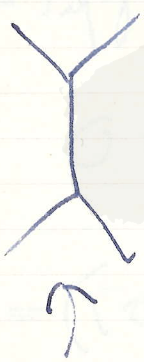
$\delta \to 0$

$$\Pi^{(\nu)}_{(\delta)} = \int_\delta^{L+\delta} (p_\mu(\sigma) + p_\mu(2L-\sigma)) = 0$$





scattering amplitude

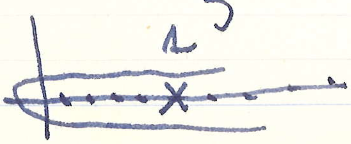


$$A \sim \frac{1}{\sin \pi\, \alpha(s)}$$

$$\times \int_C dz\, (-z)^{-\alpha(s)-1} (1-z)^{c_0 s}$$

$$\times \left(\frac{1-z}{1+z}\right)^{c_1(t-u)} \times \boxed{}$$

s



$\alpha(s) = c_2 s + c_3$

定例G: 弾性体, ~~流体~~の力学.
相対論的弾性体論的

energy-momentum tensor

応力

local rest system での local mass density ρ^* (scalar)

質量密度 $\rho = \dfrac{\rho^*}{\sqrt{1-v^2}}$

全質量密度 → energy

$$\frac{\rho}{1-v^2} = \rho^* u^0 u^0 = T^{00}$$

$$T^{\mu\nu} = \rho^* u^\mu u^\nu$$

$$\frac{\partial}{\partial x^\nu} T^{\mu\nu} = 0$$

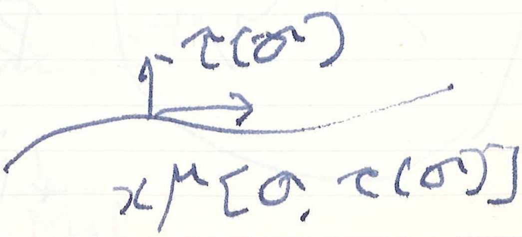
$$Q^* u^\mu + \rho^* w^\mu = 0$$

$$Q^* = \frac{\partial(\rho^* u^\nu)}{\partial x^\nu}, \quad w^\mu = \frac{\partial u^\mu}{\partial \tau}$$

$$u_\mu u^\mu = 1 \qquad w_\mu u^\mu = 0$$

$$Q^* = 0 \longrightarrow w^\mu = 0$$

string



Møller
Fock) 記号等.

pressure $P = \frac{1}{2}\left(\frac{\partial x^\mu}{\partial \sigma}\right)^2$

静止系

$$T^{\mu\nu} = \begin{pmatrix} -p & & & \\ & -p & & \\ & & -p & \\ & & & \mu^* \end{pmatrix}$$

座標変換

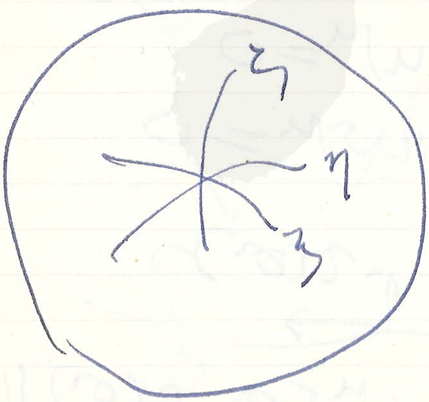
$$\rightarrow T^{\mu\nu} = (\mu^* + p)\, u^\mu u^\nu - p\, g^{\mu\nu}$$

状態方程式

$$\mu^* = f(p)$$

$$\frac{\partial T^{\mu\nu}}{\partial x^\nu} = 0$$

$$(\mu^* + p)\, w^\mu = g^{\mu\nu}\frac{\partial p}{\partial x^\nu} - \frac{\delta p}{\delta \tau} u^\nu$$



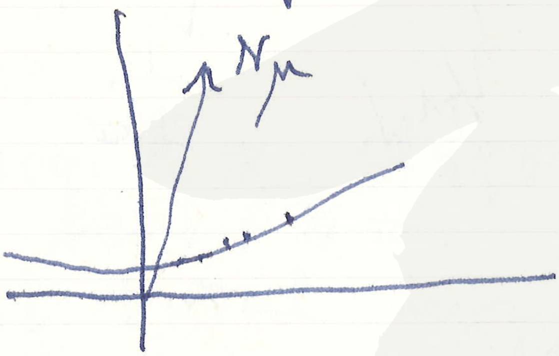
$x^\mu\{\xi, \eta, \zeta, \tau(\xi, \eta, \zeta)\}$

$$P = \frac{1}{2}\left\{\left(\frac{\partial x^\mu}{\partial \xi}\right)^2 + \left(\frac{\partial x^\mu}{\partial \eta}\right)^2 + \left(\frac{\partial x^\mu}{\partial \zeta}\right)^2\right\}$$

23日 金曜
田地氏：素粒子のひろがり

古.　模様　Y

場の理論的
新しい dynamics



(form factor

$$P_\mu = \sum p_\mu a^* a$$

$$+ l^2 N_\mu \int \psi^* \psi \psi^* \psi \, d^3x$$

$$l^2/M \sim \Lambda \approx 10^{-15}\ \mathrm{cm}$$

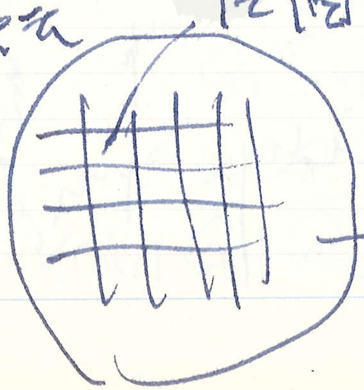
$$d\rho = \rho e \rho \frac{d^3p}{p_0} e^{-\Lambda^2 (p\cdot N)^2}$$

空間構造の変化.

hadronic matter

N.

3次元　12個



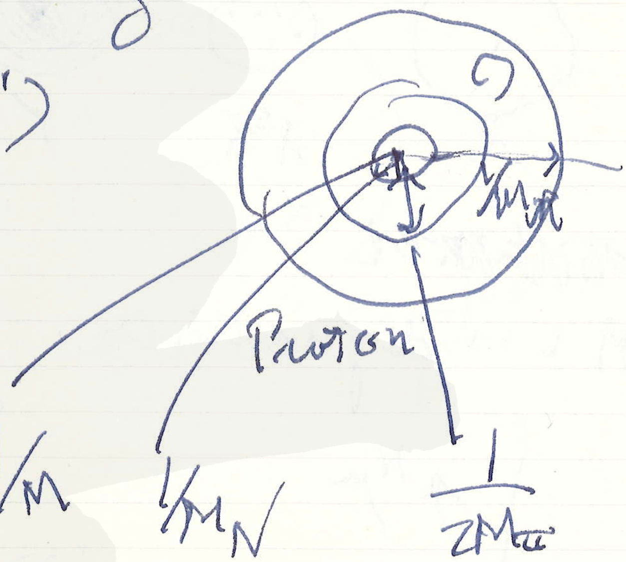
$$\langle n \rangle \approx 10^4$$

$$\rightarrow \frac{1}{M_N}$$

相互作用

g 正正正　$g \sim 10$

$G(x-x')$



$\gamma_{react} \sim 10^5$

p-p
E.M. F.F.

$\sigma \sim \pi\left(\frac{1}{M_\pi}\right)^2$

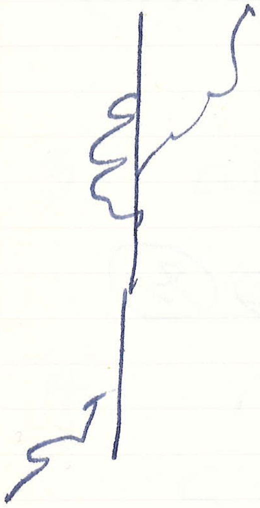
$\langle P_\perp \rangle \sim 2 \sim 3 M_\pi$

中距離：ひろがりをもった粒子の相互作用

[illegible]
形式
[illegible]

$\langle |S| \rangle$
unitarity

causality
macrocausality



山本、[illegible]：S行列のunitary性は絶対必要だ！

① total normの保存

② physical state condition

Hilbert space

① $|a\rangle \xleftrightarrow[1対1]{} \langle a|$

② $|a_1\rangle, |a_2\rangle$

$$\overline{\langle a_1|a_2\rangle} = \langle a_2|a_1\rangle$$

③ $\langle a|a\rangle > 0 \quad (|a\rangle \neq 0)$

$$\overline{\langle a_1|Q|a_2\rangle} = \langle a_2|Q^\dagger|a_1\rangle$$

$$\left.\begin{array}{l}(Q^\dagger)^\dagger = Q \\ (cQ)^\dagger = \bar{c}\,Q^\dagger \\ (Q_1 Q_2)^\dagger = Q_2^\dagger Q_1^\dagger\end{array}\right\}$$

indefinite metric

③だけ認める~~か~~のではなく
physical state だけで ① ② ③
が満されてるように~~定る~~しよう.

$$\left\{\begin{array}{l}(Q^*)^* = Q \\ (cQ)^* = \bar{c}\,Q^* \\ (Q_1 Q_2)^* = Q_2^* Q_1^*\end{array}\right.$$

$$Q|0\rangle \longleftrightarrow \langle 0|Q^*$$

1 対 1 対応
が成立

$\langle 0|Q^* Q|0\rangle$ は一般に complex number!!!

$S^*S=1$ は total norm の保存

Example

1. $H = \int d^3k \{a^*(k)a(k) + \beta^*(k)a(k) + \beta(k)a^*(k)\}$
2. $[a(k), a^*(k')] = \omega_0\,\delta(k-k')$

$[\alpha(k), \beta^*(k')] = \omega_1 \delta$ $\qquad \omega_0$: real

$[\beta(k), \alpha^*(k')] = \bar{\omega}_1 \delta$

$\mathrm{Im}\, \omega_1 < 0$

3. $a|0\rangle = \alpha|0\rangle = \alpha^*|0\rangle = 0$

$\langle 0|a^* = \langle 0|\beta = \langle 0|\beta^* = 0$

4. $H_{int}^* = H_{int}$

$S = T\exp(i\int H_{int}\, d^4x)$

$S^* S = 1$

$[S, H] = 0$

$|a\rangle = \underbrace{a^* \cdots \beta(\cdot) \cdots \beta^*(\cdot) \cdots}_{\alpha} |0\rangle$

$E = \begin{cases} \text{real} & \text{for phys. state} \\ \text{complex} & \mathrm{Im}\, E < 0 \end{cases}$

$|P\rangle = a^* \cdots a^* |0\rangle$ physical state

$|Q\rangle \neq 0 \longrightarrow \geq 0$

$0 \longleftarrow \langle Q| \neq 0$

山崎氏:

$$[p_\mu,[p_\mu,\phi]]+m^2\phi=0$$

$$[q_\mu,[q_\mu,\phi]]-\lambda\phi$$

...

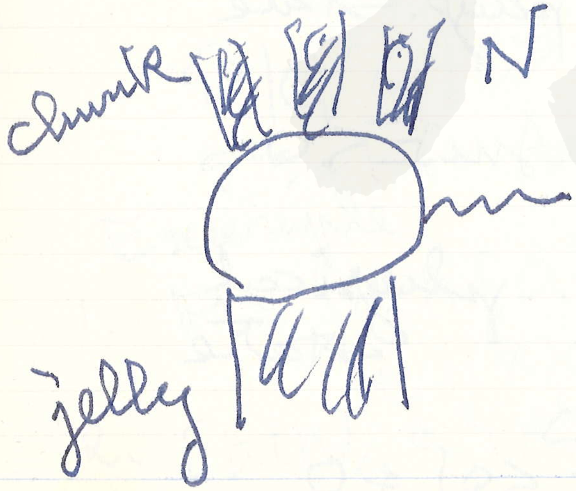
$$-i\hbar\frac{\partial}{\partial E}\varphi' = J\varphi'$$

$$J\varphi' = t\varphi'$$

$$J=J(p,q)$$

~~益~~川氏: 紫外障害 → 内部構造 の消失

H. B. Nielsen　$d=1$ string



transverse momentum

← zero point oscillation

2.4日(土)

高橋康：4次元一般化

Coester,
K. T. Y.,
Jauch, Vleh v. Physica
Heitler

$$\mathcal{H}(x) = \int d^4x' d^4x'' d^4x''' \,\bar{\psi}(x')\gamma_\mu \psi(x'')$$
$$\times A_\mu(x''') F(x-x', x-x'', x-x''')$$

$$m(v) = \frac{m(0) - v^2 S(0)}{\sqrt{1-v^2}}$$

非常に小さい

J. S. Bell, 1959~1960 Nuovo Cimento

gauge invariance

convergence

(relativistic invariance は共存できない。

Synge

$$\boxed{\begin{array}{l} i\dot{F} = [F, H] \\ \frac{\partial \Psi}{\partial t} = 0 \end{array}} \leftarrow \boxed{\begin{array}{l} h\nu = E \\ h\nu_{12} = E_1 - E_2 \end{array}}$$

$$+$$

$$\boxed{m(v) = \frac{m(0)}{\sqrt{1-v^2}}}$$

para statistics

Pauli　　spin-statistics

$\mathcal{L} \to$ symmetry $\to$ conservations

中[illegible]充足性について

$-i\partial_\mu \phi = [\phi, P_\mu]$: identity

$[\phi(x), \phi^\dagger(x')]_\pm = \delta^4(x-x')$

$P_\mu = -\frac{i}{2}\int d^4x \{\phi^\dagger(x)\partial_\mu\phi(x) - \partial_\mu\phi^\dagger(x)\cdot\phi(x)\}$

$(\Box - m^2)\phi(x)\Omega = 0$

S-matrix ? $\to$ unitarity

spin-statistics $\nearrow$

(1) T^* が定義できる.
relativistic 理論にしなければ
unitarity が成り立たなくなる

(2) higher spin
spin 3/2, e.m.f.
Sudarshan - Johnson Paradox

(3) Unitary representation
Tachyon があり得る?

(4) 重力論

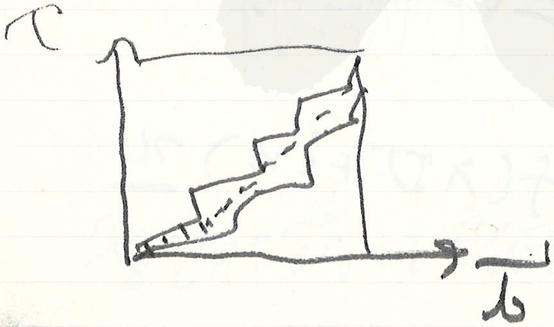
欠陥: unitarityの破綻.

	$m(v)=\frac{m(0)}{\sqrt{1-v^2/c^2}}$	$h\nu=E$	u. (unitarity)	o.c. (overall conv.)
Møller (T^*)	yes	?	no	no
Heitler (T)	no	yes	yes	yes
Tanaka	no	yes	yes	yes
Katayama	yes	?	no	no
4次元量子化	yes	yes	?	no
Q.E.D.	yes	yes	yes	no

究的方向: stochastic theory

Brown運動

impact parameter $\vec{b}$ ($\vec{p}_\perp$ に対する canonical conjugate)



$$|\psi(\vec{b},\tau)|^2 d\vec{b} = \mathrm{Prob}(\vec{b},\tau)\, d\vec{b}$$

$$d\sigma = \int \exp\{-\vec{x}^2\, \alpha[\alpha - 1 + e^{-\alpha}]\}\, d\vec{x}$$

$$\alpha = \langle \vec{u} \rangle \tau_c$$

$p_{\parallel}$

M. Bander, P. R. 6D July (1972)

毛ba

例：差分方程式

$$v(\tau) - v(\tau + \Delta\tau) = 0$$

$$L_x = \frac{m}{2} D x\, f(\Lambda D)\, D \underline{x}$$

$$f(z) = \frac{\sinh \pi z}{\pi z}, \quad D = \frac{d}{d\tau}$$

$$f(\Lambda D) D^2 \underline{x} = \Lambda \underline{x}(\tau + \pi\Lambda) - \Lambda \underline{x}(\tau - \pi\Lambda) = 0$$

$$x[0] = f(\lambda D)\, \underline{x}$$

$$x[n] = \sqrt{2}\, \mathrm{Re}\, f(\lambda D + in)\, \underline{x}$$

長谷川：量子的時空の場の量子化

(益川)

時間：古典的な連続

空間：立方格子

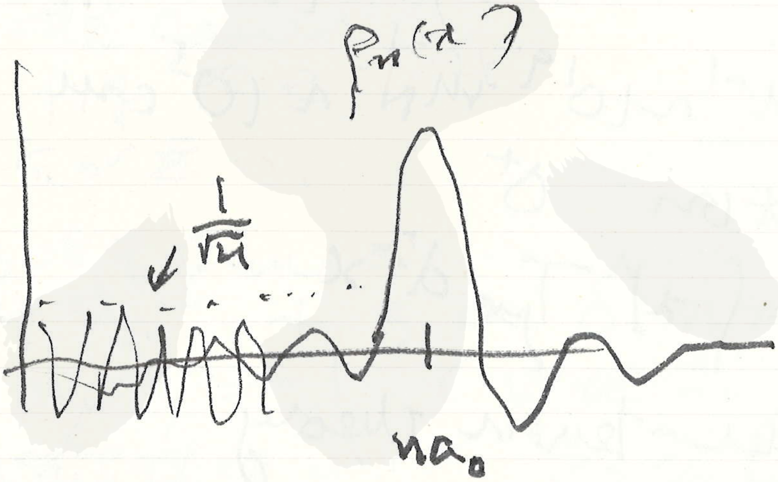
$$\varphi_n = \varphi_{n_0, n_1, n_2, n_3}$$

$$\varphi'_{n'} = L^{n}_{n'}(\Lambda, a)\,\varphi_n$$

$a_0 \to 0$; $\varphi'(x') = \varphi(x)$

$x' = \Lambda x + a$

$$\Lambda^{\mu}{}_{\nu} L^{n}_{n'}(\Lambda, a)\, n_\mu + a_\nu = n'_\nu$$



高波数の項は収束しない．

藤井保: scale invariance と定め

$$\varphi = v + \sigma$$

$$v \sim \frac{1}{\sqrt{G}}$$

$$m_N = g\, v$$

$$V \sim \frac{G}{r}\left(1 + A e^{-\mu r}\right)$$

$c = \hbar = 1$ $\quad \sqrt{G\, m_N^2} \sim 10^{-19}$

$$\mu \sim 10^{-19}\, m_N$$

$$\mu^{-1} \sim 10^{19}\, m_N^{-1} \sim 10^{5}\,\mathrm{cm}$$

dilaton σ^{+}

$$D = \int x^{\mu} T_{\mu 0}\, d^3 x$$

scalar-tensor theory

Dicke

$$\frac{GM}{R} \sim 1$$

Nonlocal QED

片山泰久氏

談話会　1973, 4, 19

素研

gauge invariance

Peierls：相互作用表示.

Yang-Mills：

問題点

1. Γ, $\Sigma_{\psi\gamma}$　形状因子 f ← ルンドモデル

A) 4次元 gauss

$f, g \propto e^{-r^2/2\lambda^2}$

発散が悪い.

B) 3次元 gauss

四中式.　$f, g \propto \delta(n\cdot r)\, e^{-\frac{r^2}{2\lambda^2}}$

$n_\mu n^\mu = -1$　(四元式)

nの選択性は…….　ただし

n-dependent

self-stress ?

$\delta(n_k \cdot r)\, e^{-r^2/2\lambda^2}$.　$n_k^\mu = \frac{k^\mu}{\sqrt{-k^2}}$

photon self-energy について

2. ここで励起状態の入れかたによって
積分を収束させうるか.

$e^{-\lambda^2(k^2)^2}$?

3. 励起状態の mass.
スピノル場 → 軌 $(M\bar{\psi}\psi)$
ボーズ → $\mu^2=0$ (電磁)
$\mu^2 \neq 0$ (励起状態)

?

4. 中性場
$tr(\phi\bar{\psi}\psi)$

5. S行列

準星と宇宙(四)

May 17, 1973

佐藤文隆

七宇活会

Redshift of OH 471

Carswell, Strittmatter (アリゾナ)

Nature 242 April 6

Ohio State Univ 電波望遠鏡

Radio-telescope Survey

Palomar Survey (光学)

$m_B = 18 \sim 18.5^m$

3200 ~ 5800 Å

2本の emission line

$\begin{cases} 4548 \text{Å} \\ 5351 \text{Å} \end{cases}$ 1:1.177 OVI 1033.8 Å

Lyα

1:1.176

$$z = \frac{\Delta\lambda}{\lambda_0} = \frac{\lambda - \lambda_0}{\lambda_0} = 3.40$$

$$\cancel{z = \frac{v}{c}}$$

1970年 $z = 2.877$ 4C05,34

QSO '63 0.158 3C273
'65 2.2 0.367 3C48
'67 2.36
2.38
'70 2.877
'73

zのわかっている QSO: 250
〃 galaxy: 100

Slipher '14 $v = 10^3$ km/sec ($z = 0.003$)
Hubble '29 $0.003 < z < 0.02$
$v = HR$ ↓
0.2
Palomar

Minkowski '54 ↓ Radiogalaxy
- Baade Cyg A $z = 0.056$
(電波と光学の対応) ↓ 3C295 $z = 0.4614$
(1960)

Doppler shift

$$z + 1 = \sqrt{\frac{1 + v/c}{1 - v/c}} \qquad \left(z \simeq \frac{v}{c} \text{ for } \frac{v}{c} \ll 1 \right)$$

$\frac{v}{c} = 0.8 \rightarrow z = 2$
$= 0.9 \rightarrow z = 3.4$

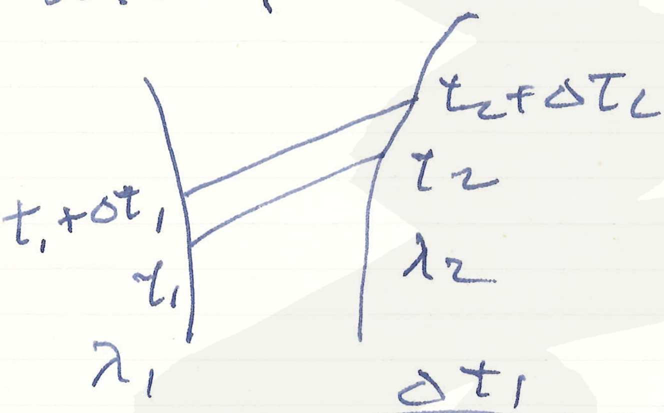
膨脹宇宙論

$$ds^2 = dt^2 - a(t)^2 dl^2$$

comoving coordinate

$ds = 0$:

$$l = \int_{t_1}^{t_2} \frac{dt}{a(t)}$$



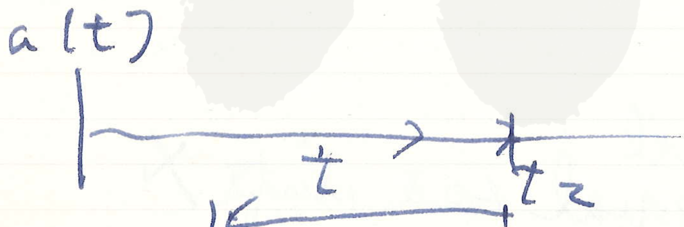
$$= \int_{t_1+\Delta t_1}^{t_2+\Delta t_2} \frac{dt}{a(t)}$$

$$\frac{\Delta t_1}{a(t_1)} = \frac{\Delta t_2}{a(t_2)}$$

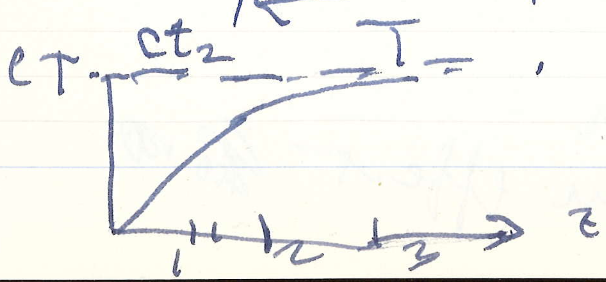
$$\nu \propto \frac{1}{\Delta t} \propto \frac{1}{\lambda}$$

$$\frac{\lambda_2}{\lambda_1} = \frac{a(t_2)}{a(t_1)} = 1+z > 1$$

$$a(t) \propto t^{2/3}$$



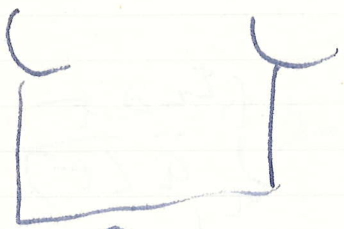
$$z+1 = \left(\frac{t_2}{t_2 - T}\right)^{2/3}$$



宇宙のくりかえし

100億年～200億年

Radioastronomy



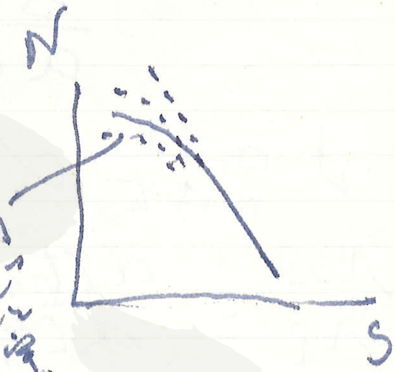
D
1 mile

Ryle

$$S = \frac{L}{r^2}\frac{1}{(1+z)^2}$$

$$N \propto r^3$$

$$N \propto S^{-3/2}$$



閉じた宇宙

最近問題
cosmological
gravitational red shift X
Doppler
(Photon - Photon
(Plasma Raman effect 説明

Aarp ('71)

"外延" 72年10月.（野家氏）

多重発生分布と粒子相関

談話会　1973.6.14

横山寛一

T-Y

M-T-Y

1) σ_T : const

2) $p_\perp$: const.　300~400 MeV/c

3) 多重度　$\langle n\rangle \sim s^{1/4}$ or $\log s$

4) 非弾性度　s について ゆっくり 変る.

多重度のPoisson分布からのずれ

NAL　200 GeV/c

Charlton et al. : $pp \to n$ charged particles

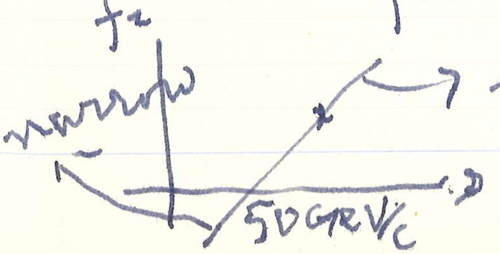
Correlation parameter $f_2 \gtrless 0$

$$f_2 = \langle n(n-1)\rangle - \langle n\rangle^2$$

($P_n = e^{-\langle n\rangle}\dfrac{\langle n\rangle^n}{n!}$ ならば

$\langle n(n-1)\cdots(n-k+1)\rangle = \langle n\rangle^k$

で $f_2 = 0$ のはず)



$$P_n = \frac{\sigma_n}{\sigma_{tot\ inel}}$$

相関がなければ Poisson 分布

f_2: 2体の相関

$\boxed{n = \alpha n_c}$　　n_c: cluster の数

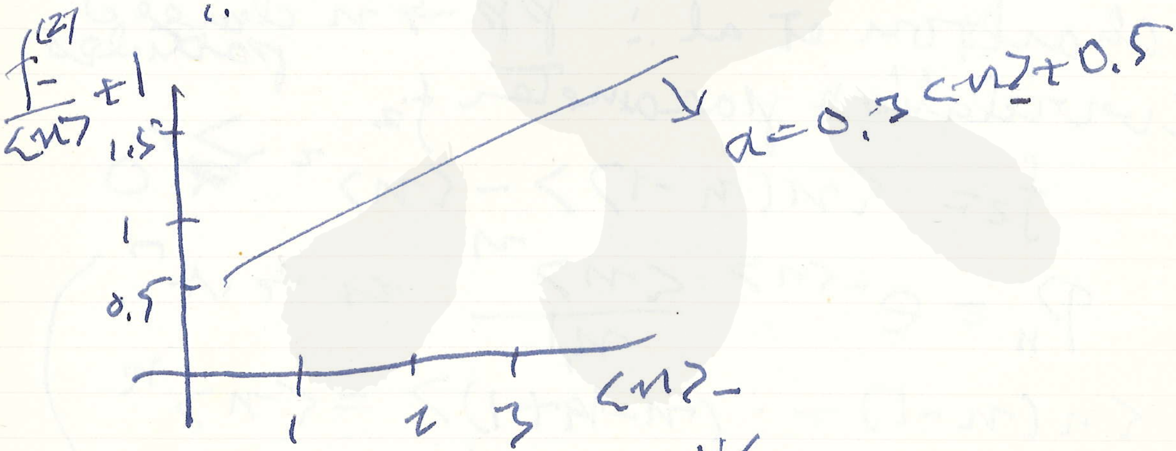
n_c の分布は Poisson とする

$f_{2c} = 0$ etc.

$f_2 = (\alpha - 1)\langle n\rangle$

$f_3 = (\alpha - 1)(\alpha - 2)\langle n\rangle$

⋮



30 ~ 200 GeV/c

Koba - Nielsen - Olsen scaling relation

$$P_n = \frac{\sigma_n}{\sigma_{tot}} \rightarrow P(n) = \frac{1}{\langle n \rangle} \psi\left(\frac{n}{\langle n \rangle}\right) + \frac{1}{\langle n \rangle^2} \psi^{(1)}\left(\frac{n}{\langle n \rangle}\right)$$

$z = \frac{n}{\langle n \rangle}$

$\langle n \rangle \sim \ln s$

$$\langle n^k \rangle = \sum_n n^k P_n \rightarrow \int n^k p(n)\, dn$$

$$= \langle n \rangle^k \int z^k \psi(z)\, dz$$

ψ : s independent

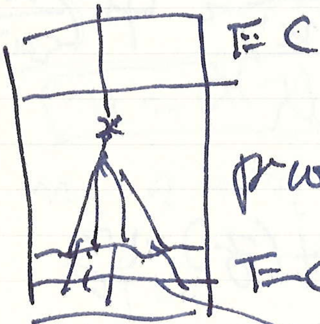
$$\langle n^k \rangle = \langle n \rangle^k C_k$$

50 GeV ~ 300 GeV/c (NAL)

$f^{(k)} \rightarrow P_n$

談話会
丹生潔 (名大・理)
Jet Shower analysis
1973年 7月12日 基研

X-particle について

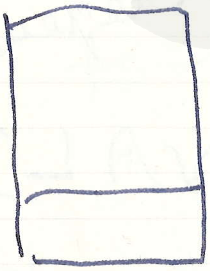


EC (鉛と乾板のサンドイッチ)

producer (プラスチック C, H, O) と film のサンドイッチ

EC

x ray film



producer

EC

風船で Jet Shower 3個

γ の幅 → mass $\eta^0 \to 3\pi^0$
($\to 6\gamma$)

Jet shower AEC-11-C-34

第四部：三

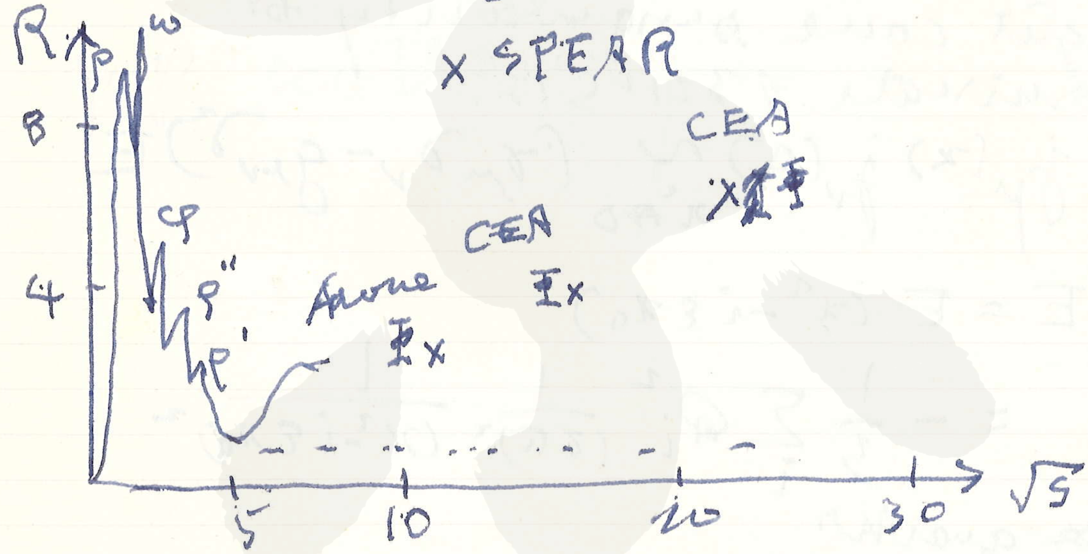
e^-e^+ annihilation と素粒子
模型

講演会　1974年1月24日

実験　ISR　Colliding beam　$\sqrt{s}$

$E_{e^-}+E_{e^+}=2E_e$

×	ACO (Orsay)	1.0 GeV
	VEP-2 (Novosibirsk)	1.5
	Adone (Frascati)	3.0
×	CEA (Cambridge)	5.0
1973	SPEAR (SLAC)	5.4(1973) → 9.0
1974	DORIS (Desy)	5.4(1974) → 8.4
1975	DCI (Orsay)	3.0



$$R=\frac{\sigma(e^+e^-\to \text{hadron})}{\sigma(e^+e^-\to\mu^+\mu^-)\to\frac{4\pi\alpha^2}{3s}}$$

c033-987～992挟込

理論　one-photon 近似

$$\sigma = \sum_X \left| \right. $$  $$\left. \right|^2 = \frac{8\pi^2\alpha^2}{s} w(s)$$

$$\left(\frac{k_\mu k_\nu}{k^2} - g_{\mu\nu} k^2\right) w(k^2) \equiv \int dx\, e^{ikx} \langle 0 | j_\mu(x) j_\nu(0) | 0 \rangle$$

$w(k^2)$: dimensionless

$$R = 6\pi w(s)$$

$$\sigma \underset{s\to\infty}{\longrightarrow} \frac{1}{s} \quad \longrightarrow \quad \underset{s\,大}{R = \text{const}}$$

light cone singularity が dominate するならば.

$$j_\mu(x) j_\nu(0) \underset{x^2\to 0}{\sim} (\partial_\mu \partial_\nu - g_{\mu\nu} \partial^2) E$$

$$E = E(x^2 - i\varepsilon x_0)$$

$$= -\frac{1}{3} \sum_i Q_i^2 \frac{1}{(2\pi)^2} \frac{1}{(x^2 - i\varepsilon x_0)^2}$$

(free quarks
$$j_\mu = \sum_i Q_i \bar{\psi}_i \gamma_\mu \psi_i \quad)$$

$$R \sim \sum_i Q_i^2$$

asymptotic で与えられる
charged scalar field

$$j_\mu(x) = -iQ\,\phi^\dagger(x)\overleftrightarrow{\partial_\mu}\phi(x)\,(+A_\mu\cdots)$$

$$R \sim Q^2\left(1-\frac{4m^2}{s}\right)^{3/2}\left[1+4\,\mathrm{Im}\,a_1(s)\right]$$

$$\mathrm{Im}\,a_1(s) \leq 1$$

$$\leq 5Q^2\left(1-\frac{4m^2}{s}\right)^{3/2}$$

q-q scattering

γ-γ scattering