XXIII

# NOTE BOOK

*Manufactured with best ruled foolscap*
*Brings easier & cleaner writing*

Feb. 1967

Aug. 1967? Rochester

VOL. XXIII

日章 S A 50

*Nissho Note*

# INDEX

標題 =: Compositeness Criteria of Particles in QFT and S-matrix theory

牟田 G 他

March 7, 1967

芸術 2に于り/4

( Forschritte der Physik Karlsruhe )

Lagrangian Field theory ---- 不 ---- S-Matrix Theory → 

Green Function Approach

Actual Particles Test ( $\begin{matrix}\pi & K\\ d & N\end{matrix}$ )

LFT　　$Z=0$ が複合粒子

Jouvet 1955 → Yukawa Coupling & Fermi coupling の equivalence

( Ida etc. 1965 )

$$L_Y = -g_0 \bar{B} B A$$

$$L_F = -\lambda_0 \bar{B} B \bar{B} B$$

$$(\square + \mu^2) A = \delta\mu^2 A - g_0 \bar{B} B$$

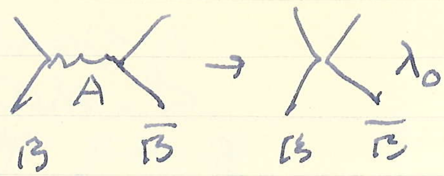
$$\delta\mu^2 = \mu^2 - \mu_0^2$$

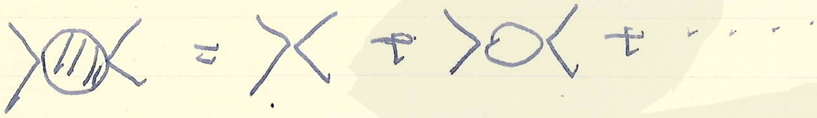
$$|\delta\mu^2| \to \infty, \quad g_0^2 \to \infty; \quad \mu^2 < \infty$$

$$A = \frac{g_0}{\delta\mu^2} \bar{B} B$$

$$\lambda_0 = \frac{g_0^2}{\delta\mu^2}$$

$$\lim_{\mu_0^2,\, g_0^2 \to \infty} \frac{g_0^2}{k^2-\mu_0^2} = \lambda_0 \qquad k^2 : \text{finite}$$



$$T_\gamma = \frac{g_0^2}{k^2-\mu_0^2+g_0^2\Pi(k^2)} : \quad \Pi(k^2) = \frac{i}{(2\pi)^4} \times$$

$$\times \int d^4p \frac{1}{(p^2-m_0^2)[(k-p)^2-m_0^2]}$$

$$= \frac{1}{\pi}\int_{4m_0^2}^{\infty} \frac{\rho(s')ds'}{s'-s} \qquad (s = k^2)$$

$$\rho(s) = \frac{1}{16\pi}\sqrt{\frac{s-4m_0^2}{s}}$$

$$\mu^2 - \mu_0^2 + g_0^2\Pi(\mu^2) = 0$$

$$T_\gamma = \frac{g_0^2}{s-\mu^2}\,\frac{1}{1+g_0^2\Pi_1(s)}$$

$$\Pi_1(s) = \frac{\Pi(s)-\Pi(\mu^2)}{s-\mu^2} = \frac{1}{\pi}\int_{4m_0^2}^{\infty}\frac{\rho(s')ds'}{(s'-s)(s'-\mu^2)}$$

$$T_\gamma = \frac{g_m^2}{s-\mu^2}\,\frac{1}{1+(s-\mu^2)g^2\Pi_R(s)}$$

$$\pi_R(s) = \frac{\pi_1(s) - \pi_1(\mu^2)}{s - \mu^2} = \frac{1}{\pi}\int_{4m_0^2}^{\infty} \frac{\rho(s')\,ds'}{(s'-s)(s'-\mu^2)^2}$$

$$\tilde{\Delta}'(s) = \frac{1}{s - \mu_0^2 + g_0^2\pi'(s)}$$

$$Z_3 = \left[\frac{d}{ds}\frac{1}{\Delta'(s)}\right]_{s=\mu^2} = [1 + g_0^2\pi_1(\mu^2)]^{-1}$$

$(Z_1 = Z_2 = 1)$ (chain <u>approximation</u>)

$$g^2 = Z_3 g_0^2$$

$$Z_3 = 1 - g^2\pi_1(\mu^2)$$

$$T_F = \frac{\lambda_0}{1 + \lambda_0\pi(s)}$$

$$1 + \lambda_0\pi(\mu^2) = 0$$

$$\boxed{\delta\mu^2 = \frac{g_0^2}{\lambda_0}}$$

$$T_F = \frac{1}{s - \mu^2}\frac{1}{\pi_1(s)}$$

$$= \frac{g^2}{s - \mu^2}\frac{1}{1 - Z_3 + (s - \mu^2)g^2\pi_R(s)}$$

$$\boxed{Z_3 = 0} \qquad g^2 = \frac{1}{\pi_1(\mu^2)}$$

SMT Potential scattering

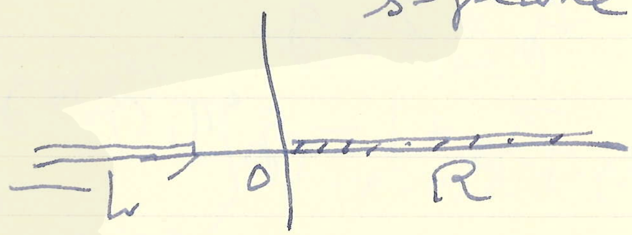
$$S_\ell(k) = e^{i\pi\ell}\,\frac{f_\ell(k)}{f_\ell(-k)}$$

$$T_\ell(k) = \frac{N_\ell(k)}{D_\ell(k)} \qquad (k^2 = s)$$

$$N_\ell(s) = \frac{1}{\pi}\int_L \frac{D_\ell(s')\,\mathrm{Im}\,T_\ell(s')}{s'-s}\,ds'$$

$$D_\ell(s) = 1 - \frac{1}{\pi}\int_R \frac{\sqrt{s'}\,N(s')}{s'-s}\,ds'$$

s-plane




relativistic $\sqrt{\frac{s-4m^2}{s}}$

unsubtracted N/D

$$\left.\begin{aligned} &D_\ell(\mu^2) = 0 \\ &\frac{N_\ell(\mu^2)}{D'_\ell(\mu^2)} = -g^2 \end{aligned}\right\}$$

Idea: $T(s) = \Gamma\Delta_F'\Gamma + U$

$$Z_3 = \lim_{s\to\infty} Z_3(s) \qquad Z_3(s) = \frac{\Delta_F(s)}{\Delta_F'(s)}$$

$$Z_1 = \lim_{s\to\infty}\frac{\Gamma(s)}{g} = d(\mu^2)$$

elementary

$Z_1 = 0 \quad Z_3 \neq 0$ "superelementary"

$Z_1 \neq 0 \quad Z_3 \neq 0$ "elementary"

composite

$Z_1 \neq 0 \quad Z_3 = 0$ "intermediate"

$Z_1 = 0 \quad Z_3 = 0$ "composite"

$\Updownarrow \qquad \Updownarrow$

$D(\mu^2) = 0 \qquad \dfrac{N(\mu^2)}{D'(\mu^2)} = -g^2$

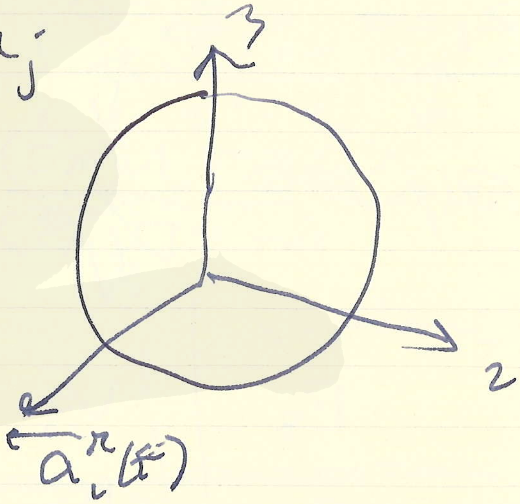
| | |
|---|---|
| $\Gamma_8$ | $V_9$ |
| $B_8$ | $B_{10}$ |
| int. | comp. |

原論: Deformable Body (sphere)
としての素粒子
要綱
March 22, 1967

$x_i = f(a_i, \tau)$

近似: $x_i = F_{ij} a_j$

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




$F = A^T A_0$

$(A)_{ri} = a^{r}_{i}$

$\dot{x}_i = \dot{F}_{ij} a_j$

$T = \frac{1}{2}\int v^2 dm = \frac{1}{2}\int \dot{x}_i^2 dm$

$= \frac{1}{2} \dot{F}_{ik} \dot{F}_{ik'} \int a_k a_{k'} dm$

$= \frac{I}{4} Sp\, \dot{F}\dot{F}^T$ for spherical $t=0$

$= \frac{I}{4} Sp\, \dot{A}\dot{A}^T$

$M_i \sim \int (r \times v)\, dm = \frac{I}{2}(A^T\dot{A} - \dot{A}^T A)_{jk}$

S: 方向余弦の body frame components

$$A = (1+B)\,C$$

$$B = B^T \qquad CC^T = C^T C = 1$$

$$T = \frac{I}{4}\,\mathrm{Sp}\left(\dot{B}^2 + \dot{C}\dot{C}^T + C\dot{C}^T[B\dot{B}]\right)$$

$$M_i = \frac{I}{2}\left[C^T\left\{[B\dot{B}] + (\dot{C}C^T - C\dot{C}^T)\right\}C\right]_{jk}$$

$$B = K^T \delta K \qquad \delta = \begin{pmatrix} \delta_1 & & \\ & \delta_2 & \\ & & \delta_3 \end{pmatrix}$$

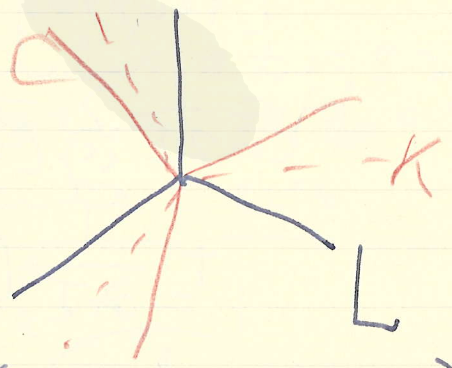
$$K^T K = K K^T = 1$$

$$V = \frac{\mu}{2}\,\mathrm{Sp}\,B^2 + \frac{\lambda}{2}(\mathrm{Sp}\,B)^2$$

$\lambda = 0$

$$V = \frac{\mu}{2}\,\mathrm{Sp}\,K^T\delta^2 K = \frac{\mu}{2}\,\mathrm{Sp}\,\delta^2$$

$$L = T - V$$




$C:\ \varphi, \theta, \psi$

$K:\ \alpha, \beta, \gamma$

$\delta:\ \delta_1, \delta_2, \delta_3$

$$\begin{cases} M_1 = -\sin\psi \cdot P_\theta + \dfrac{\cos\psi}{\sin\theta}(P_\varphi - \cos\theta \cdot P_\psi) \\ M_2 = \cos\psi\, P_\theta + \dfrac{\sin\psi}{\sin\theta}(P_\varphi - \cos\theta\, P_\psi) \\ M_3 = P_\psi \end{cases}$$

$L_1 = I\,[B\dot{B}]_{23} = -\sin\gamma\, P_\beta + \frac{\cos\gamma}{\sin\beta}(P_\alpha - \cos\beta$

$L_2 = I\,[\quad]_{31} = \cos\gamma\, P_\beta + \frac{\sin\gamma}{\sin\beta}(P_\alpha - \cos$

$L_3 = I\,[\quad]_{12} = P_\gamma$

vibrational angular momentum

$[L_i, L_j] = i L_k$

$L$ a body frame components:

$N_{rs} = (K L K^T)_{rs}$

$N_1 = \sin\alpha \cdot P_\beta - \frac{\cos\alpha}{\sin\beta}(P_\gamma - \cos\beta\, P_\alpha)$

$N_2 = \cos\alpha\, P_\beta + \frac{\sin\alpha}{\sin\beta}(P_\gamma - \cos\beta\, P_\alpha)$

$N_3 = P_\alpha$

$[N_i, N_j] = -i N_k$

$$H = \frac{1}{2I}\sum_{i<j}\frac{N_{ij}^2}{(\delta_i - \delta_j)^2} + \frac{1}{I}\sum p_i^2 + \frac{\mu}{2}\sum \delta_i^2$$

$$+ \frac{1}{2I}\left(S - \frac{L}{2}\right)^2 \qquad \delta \ll 1$$

$S = \frac{L}{2}$

$P_\gamma)$

$\cos(\beta - P_\gamma)$

$\max$

$$\beta = \beta' + \frac{1}{3}\delta_{rs}\rho$$

$$\rho = \mathrm{sp}\,\beta = \delta_1 + \delta_2 + \delta_3$$

$$\delta_i' = \delta_i - \frac{1}{3}\rho$$

$$H = \frac{1}{2I}\sum \frac{N_{ij}^2}{(\delta_i' - \delta_j')^2} +$$

保存量　$M^2,\ M_3^2$

$$L^2 = N^2$$

$$(\mathbb{S} - \mathbb{L})^2 \quad (\mathbb{S} - \mathbb{L})_3$$

$$H_\rho$$

$$\delta_r' = \beta \cos\left(\gamma - \frac{2\pi r}{5}\right)$$

$a^*_{\alpha r}$　$b^*_{\alpha r}$ ← 回転による
Coriolis の力による
表面 → 振動が
excite される.

---

$$\xi_{\alpha r} = \delta_r \beta_\alpha \qquad \beta^*_\alpha \beta_\alpha = 1$$

$$\dot{\xi} = \dot{\delta}\beta + \delta\dot{\beta}$$

$$\dot{\xi}^*\dot{\xi} = \dot{\delta}_i'^2 \beta^*_\alpha \beta_\alpha + \delta_r'^2 \dot{\beta}^*_\alpha \dot{\beta}_\alpha + \cdots$$

$$= \dot{\delta}_i^2 + \delta_r^2/4\ \omega^2$$

$$L = \dot{\xi}^*_{\alpha r}\dot{\xi}_{\alpha r} - \frac{\mu}{2}\xi^*_{\alpha r}\xi_{\alpha r}$$

$a_\alpha^{r*}$: quark

$b_\alpha^{r*}$: anti-quark

$\sum \delta_r = 0$ の条件

$\psi(\delta_1 \delta_2 \delta_3\ \alpha \beta \gamma)$

$\xi_{\alpha r} \to$ phase を $\frac{2\pi}{3}$ かえる

$n_B = n_a - n_b$

$n_a - n_b = 3n \qquad n = 0, 1, 2, \cdots$

quark → exciton

1) 統計

第22回 日本物理学会年会
仙台. 東北大学にて
素粒子 特別講演
1967年4月7日
"素粒子領域の理由"
13.30 ~ 14.20

河辺氏: D. Ferretti, Quantum Lorentz-Invariant Macrocausal Theory I–II
Nuovo Cimento 43 (1966), 507; 516
(基研コロキウム. April 18, 1967)

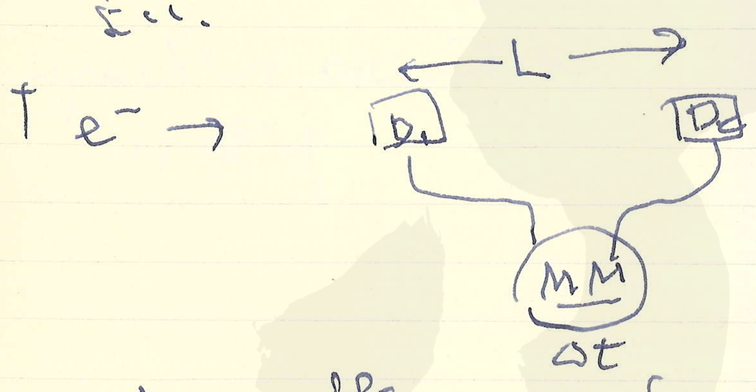
I: ultimate speed signal (exp.), → microcausal.
Lorentz inv. (theor.)

local observable の commutation が 0.

point の間の signal のやりとりは [illegible]

Bertozzi の exp. (Linac 1964 MIT) (signal is macrocausality)

Fictitious world
(Lorentz-inv. field eq.
microcausality は仮定; observable はこれ…
(macrocausal な) ultimate speed がなくてよい…




observable $J = \int g_\mu(x)\, e\bar{\varphi}(x)\gamma_\mu \varphi(x)\, dx$
$dx = dx_0 dx$

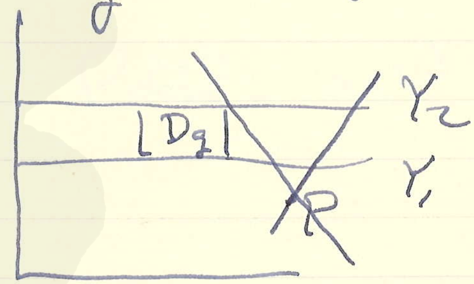
$J' = \int g_\mu(x)\, e\bar{\varphi}^{(-)}(x)\gamma_\mu \varphi^{+}(x)\, dx$

microcausality を満たさせて…

suitable function　　g-frame $F_g$

$g_\mu(X) = T(x_0) f(x) \begin{cases} \neq 0 & \text{finite space time region} \\ = 0 \end{cases}$

domain　$D(g(x)) \equiv D_g = [x : g(x) \neq 0]$




4-dimensional distance from $P(X)$ to $D_g$
$= $ lower limit of $|\sqrt{(x_\mu - y_\mu)^2}| \equiv l_{PD}$

g-space distance : lower limit of $|(X-Y)^2| \equiv L_g(P)$
g-time distance :　　" 　$|\sqrt{(x_0-y_0)^2}| \equiv T_g(P)$
(invariant)

source　$\Xi_1$　$g_1$　} signal velocity　asymp → upper limit $(= c)$
detector　$\Xi_2$　$g_2$
$g_2$-space distance $L_{g_2}(1,2) \to \infty$

"well-mixed"
$l_{12} \gg 1/M$　　M: mass of signal particle

II: non-local interaction
A. eq. of motion, C.R.: Lorentz inv.
B. prob. interpr.
C. unitary S-matrix

one dimensional model

W. Heisenberg

May 2, 1967

1. General Survey of Theory of El.

May 4, 1967

2. Ancient Greek Phil. and Mod. Science.

片山 [illegible] 様　May 9, 1967

Jerzy Rayski
Dynamical theory of Quarks
and Strong Interactions
~~N. C.~~ 87 (1967), 597~604,
Nuclear Physics

高林武彦　　基研 短スクール
May, 1967
23

I、Finsler 空間

空間の点がひろがりをもつと同様な運動量 ~~など~~ を持つような空間の性格をかんがえる.

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

$$F^2 = g_{\mu\nu}\dot{x}^\mu \dot{x}^\nu$$

$$l^\lambda = \dot{x}^\lambda / F(x, \dot{x})$$

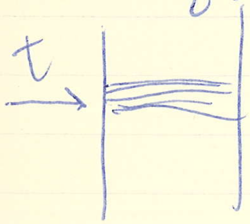
$$l_\lambda l^\lambda = 1$$

$l_\lambda \longrightarrow \dot{x}_\lambda$ (大きさに制限がない)

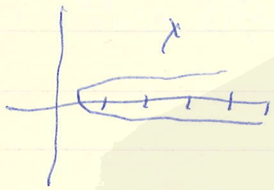
II、素粒子と時空のゆらぎ

田中正： Regge Pole
と Extended Particle
(Banno, Inoue, Takada, Tanaka)
ダムスクール　May 30, 1967

1) Regge pole の実験による動機




$$f(t,\cos\theta_t)=\sum_l(2l+1)\,a_l(t)\times P_l(\cos\theta_t)$$



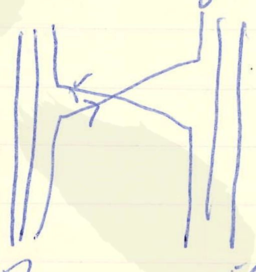
$$\to(2\alpha(t)+1)\,b(t,\alpha(t))\times\frac{P_\alpha(-\cos\theta_t)}{\sin\pi\alpha(t)}$$

+ background

それは $l$ についての $a_l$ の間に関係がある．
→ analyticity ? → Regge ?

2) OBE model

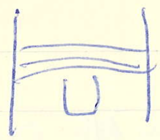
2-body Green Function




$(\xi\,\tilde{\xi})\Longleftrightarrow$ [illegible]
$\downarrow\quad\downarrow$
quasi-particle

3) Bilocal

$$\left.\begin{aligned}(r_\mu^2-\lambda^2)\,U(X,r)&=0\\ r_\mu\frac{\partial}{\partial X_\mu}U(X,r)&=0\end{aligned}\right\}$$



Propagator の ambiguity

$[A^l, A^l] = R(\partial)\Delta$

$\langle P[A, A] \rangle = R' \,\Delta_F$

$R' \sim (\Box - \kappa_l^2)^l$

(Lagrangianを作つておれば ambiguityはなくなる)

$\delta^4(x-x')$

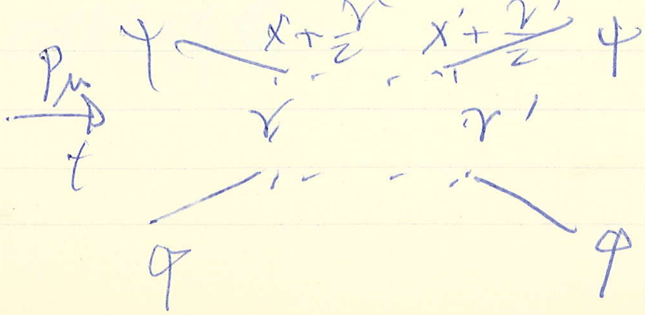
direct interaction

van Hove, Physics Letter 1967

$t$-channel:

$$\frac{P_\alpha(-\cos\theta_t)}{\sin\pi\alpha} = \sum_{l=0}^{\infty}\left(\frac{1}{\alpha-l} - \frac{1}{\alpha+l+1}\right)P_l(\cos\theta_t)$$

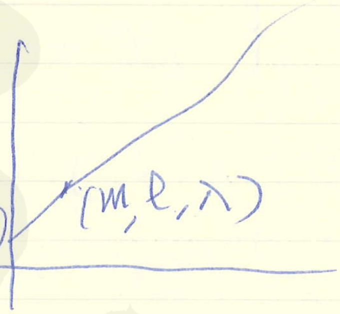
s-channel では [illegible]……




$P_\mu^2 = t$

田中ら (素研, 1967)
low energy
OBE in の Regge的整理づけ
ρ-meson
[illegible]

$$f(t, \cos\theta_t, \alpha(t)) = (2\alpha+1)\frac{b(t,\alpha)P_\alpha(-\cos\theta_t)}{\sin\pi\alpha}$$




$$\mathrm{Re}\,\alpha(m^2) = l$$

非局所時空と素粒子 . II.

片山泰久 .

6月1日 原子核工学教室

1967

内部自由度の問題 .

波動方程式 $\psi(X, r, e_\mu^a)$

$$\Gamma_\mu^{(1)} \frac{\partial \psi}{\partial X_\mu} + \kappa \psi = 0$$

$$\kappa(L^2, M^2)$$

$$\Gamma_\mu^{(1)} = t_i^* \gamma_\mu t^i$$

$$\psi = t^* \cdot e^{-f^{\mu\nu} \gamma_\mu \gamma_\nu} \psi_0(X)$$

$$t_\alpha^* e^{-f^{\mu\nu} \gamma_\mu \gamma_\nu} \left(\gamma_\mu \frac{\partial}{\partial x_\mu} + \kappa\right)_{\alpha\gamma} \psi_0$$

交換関係

$$\left[ \psi(X, r, e_\mu^i) \psi^*(X', r', e_\mu'^a) \right]_I$$

$$= 0$$

$$\text{for } (X - X')^2 < f^{\mu\nu} r_\mu r_\nu + f_\mu^{\prime\nu} r'_\mu$$

相互作用

河原林; J. Schwinger Partial Symmetry (May 1967) (P.R.L.)

収スツール June. 1967

Sources and Electrodynamics

R.R.

Chiral Dynamics

P.R.L. 24 B (1967) 473

## S. Weinberg

I. Chiral Symmetry

$SU(2)\times SU(2)$ — $f'$

$2^+$ — $A_2$ — $f$

$1^+$ — $D$, $B$, $A_1$ ?

$1^-$ — $\rho, \omega, \varphi$

$0^-$ — $\pi$ ....... $0^+$ ?

$SU(2)$ $J$-series

$\frac{3}{2}^+$ — $N^*\gamma_5$ — $\frac{3}{2}^-$ — $\frac{1}{2}^-$

$\frac{1}{2}^+$ — $N$

i) chiral symmetry から見て $\pi$ だけ mass が0

ii) $N$, $\gamma_5$-$N$ が縮退していなくて $(N, \pi N)$ の縮退になってる.

$\mathcal{L}(\varphi \ldots)$

$g$ $M$

$\Uparrow$ ?

$\mathcal{L}_{eff}(N, \pi, \rho \ldots)$

$f(g_i, m_i) = 0$

$\pi, N$ 系. low energy
S, P

$$\mathcal{L} = -\frac{1}{2}(\partial_\mu \pi)^2 - \frac{1}{2}\mu_\pi^2 \pi^2 - \bar{N}(-\partial_\mu \gamma_\mu + M)N$$

$$+ \frac{f}{\mu_\pi} \bar{N} i \gamma_\mu \gamma_5 \tau N \partial_\mu \pi \quad (ps - pv)$$

$$- \left(\frac{f_0}{\mu_\pi}\right)^2 \bar{N} \gamma_\mu \tau N (\partial_\mu \pi \times \pi)$$

S-wave $\quad a_{\pi^+ p} + a_{\pi^- p} = a_1 + 2a_3 \fallingdotseq 0$

$\quad a_{\pi^- p} - a_{\pi^+ p} = a_1 - a_3$

i) $\pi \to \pi - \delta\vec{\omega} \times \vec{\pi}$

$N \to (1 + \frac{i}{2}\vec{\tau}\,\delta\vec{\omega})N$

ii) $\pi \to \pi + \delta\pi + \cdots$

$N \to \quad (1 + i(\frac{f_0}{\mu_\pi})^2 \tau(\pi \times \delta\pi))N$

new chiral transformation

$$\mathcal{L} = -\frac{1}{2}\left(1 + \left(\frac{f_0}{\mu_\pi}\right)^2 \pi^2\right)^{-2} (\partial_\mu \pi)^2$$

$$- \frac{1}{2}(\mu_\pi^2 / f_0)^2 \log\left(1 + \left(\frac{f_0}{\mu_\pi}\right)^2 \pi^2\right)$$

$$+ \bar{N}(-\partial_\mu \gamma + M)N$$

$$+ \left[1 + \left(\frac{f_0}{\mu_\pi}\right)^2 \pi^2\right]^{-1} \left\{ \frac{f}{\mu_\pi} \bar{N} i \gamma_\mu \gamma_5 \tau N \partial_\mu \pi \right.$$

$$\left. - \left(\frac{f_0}{\mu_\pi}\right)^2 \bar{N} \gamma_\mu \tau N \partial_\mu \pi \times \pi \right\}$$

II. Partial Symmetry

$$-\frac{G_A}{G_V} = \frac{1}{\sqrt{2}}\,\frac{5}{3} = 1.18$$ 実験とよくあう。

$$= \frac{5}{3} \quad SU(6)$$

$$U(4)\times U(4) \supset \underset{\tau,\ \sigma}{U(4)}$$

$$\left.\begin{array}{l} B = (N\ N^*) \\ M = (\pi\ \omega\ \rho\ \cdots) \end{array}\right\} \begin{array}{l} Tr(\bar{B}BM) \\ Tr(MMM) \end{array}$$

模型と構造 研究会（拡大世話人会）

6月15日～16日　[illegible]

宮[illegible]氏: Quarkの話
基研. セミナール
June 20, 1967

藤原氏：素粒子の大きさと(局)所性
の相対論的問題. 基研談話会 June 20, 1967

ひろがり → non-local → 素領域

Lorentz 不変性

Heisenberg:
場の相互作用 — 非線型性 — 素粒子の統一
— spinor 方程式

発散の困難

対応原理

1948: McManus: 相互作用のひろがり
Feynman: $mc^2 = \frac{e^2}{2\lambda}$, $Mc^2 = g^2/2\lambda$

Stephenson 1957 $\frac{m}{M} = \left(\frac{e}{g}\right)^2$


space-like transition $F_0 = -\frac{e^2}{a^2}$

time-like transition
~~jump~~

non-causal propagator

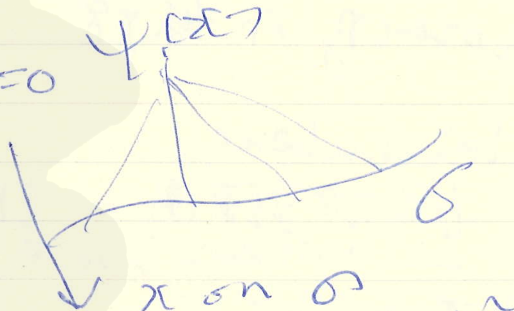
$$\psi(x) = \int_\sigma d\sigma_\mu(y)\, F(x-y)\, \gamma_\mu \varphi(y)$$

F: 4×4 matrix

$$(\gamma_\mu \partial_\mu + m)\varphi(x) = 0$$

$$(\gamma_\mu \partial_\mu + \mu)F(x) = 0$$

$$\frac{\delta}{\delta\sigma}\int_\sigma d\sigma_\mu f_\mu = \int_\tau \partial_\mu f_\mu dt = 0$$




x on σ
3次元空間域

$$(\gamma_\mu \partial_\mu + m)\psi(x) = 0$$

$$\{\psi_\alpha(x), \bar\psi_\beta(y)\}$$

$$= -i\int_\sigma d\sigma_\mu(z)[F(x-z)\gamma_\mu F(z-y)]_{\alpha\beta}$$

素粒子の時空記述 研究会
基研. June 26, 27, 1967

26日:
湯川: 素粒子の時空的描像
relativistic semi-micro
causality と elementary domain

片山: 素領域の自由度
intrinsic spin (Fierz)
half-integer spin? (Nakano)
unitary spin
4 次元 (Bopp-Bauer)
3 自由度 → $r_\mu$, $r'_\mu$ の6個の自由度を考えなければ 2価表現はでてこない

$$\left.\begin{aligned} L &= r \times p^0 \\ L' &= r' \times p^{0\prime} \end{aligned}\right\}$$

$L + L'$ について独立であるとすると 2価表現が許される。

$r_\mu^{(i)}$ $i = 1, 2, 3$

$r_\mu^{(i)} r_\mu^{(j)} = r^2 \delta^{ij}$ orthogonal

$12 - 1 - 5 = \underline{6}$

domain $D_x$

$$\Psi(D_x) = \frac{1}{\Omega} \int_{D_x} \psi(x, r)\, d^4 r$$

closed domain

$$a^{\mu\nu} = f^{\mu\rho} f^{\nu\sigma} \tilde{a}_{\rho\sigma}$$

$$f^{\mu\nu} = g^{\mu\nu} + 2 n^\mu n^\nu$$

$$\tilde{a}_{\rho\sigma} = \sum_{a=1}^{4} \frac{\varepsilon_\rho^a \varepsilon_\sigma^a}{\xi_a^2}$$

$$\Psi(J_\mu,\ n_\mu,\ \xi_a,\ e_\mu^a)$$

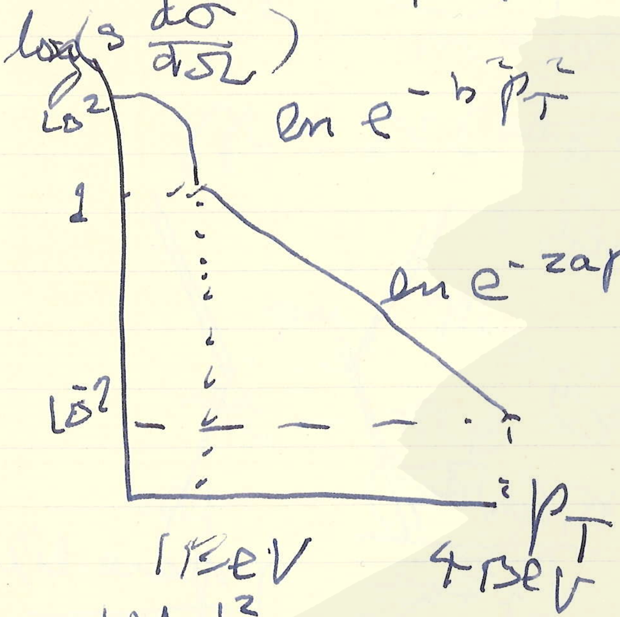
$$\begin{array}{cccc} \downarrow & \downarrow & \downarrow & \downarrow \\ 4 & 3 & 4 & 6 \\ & & \searrow & \end{array}$$

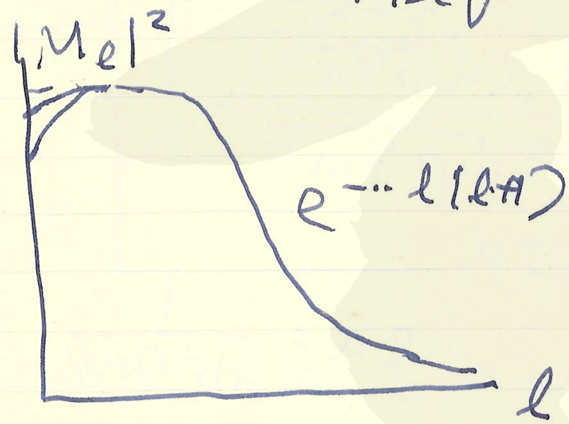
4次元 volume 一定; 3

問題;
[illegible]の対称性のために 2価表現が現われないか;

spin - isospin がそろうのはどうするか;

伊藤氏：p-p の散乱 と 構造.




散乱体の空間的構造

$$\int T(s,\Delta)\, e^{-i\vec{\Delta}\vec{r}}\, dv = T(\vec{r})$$

$$T(s,\Delta) = e^{-\text{?}a\Delta}$$

$$e^{i\vec{\Delta}\vec{r}} \sim \frac{1}{(r^2+a^2)^2}$$

$$T(\Delta) = \int \frac{e^{i\vec{\Delta}\vec{r}}}{(r^2+a^2)^2}\, dv = e^{-a\Delta}$$

$$U(r) = \frac{U(0)\,a^4}{(r^2+a^2)^2}$$

Rutherford scattering の逆

$$\frac{e^{-\mu r}}{r} \to \frac{e^{-\mu\sqrt{r^2+a^2}}}{\sqrt{r^2+a^2}}$$

Markov - Takano
- propagator

$$\Delta_F(x^2, m) \to \Delta_F(x^2+a^2, m)$$

$$\Delta_M(x) = \frac{2}{i}\frac{m^2}{2\pi^2}\frac{K_1(m\sqrt{x^2+a^2})}{\sqrt{x^2+a^2}}$$

space-like

$$\Delta_M(p) = \frac{2}{i}a^2\frac{K_1(a\sqrt{p^2+m^2})}{a\sqrt{p^2+m^2}}$$

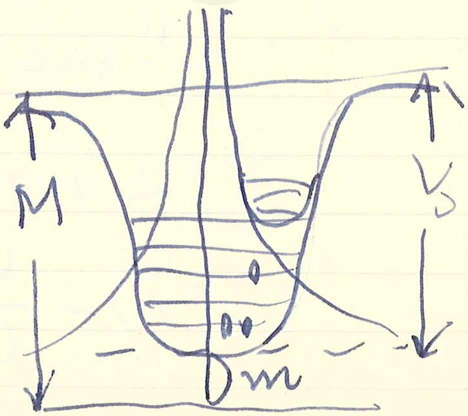
$p \rightleftarrows x$ $\quad m \rightleftarrows a$

(reciprocity) $\quad 2a = \frac{1}{0.15\ \mathrm{BeV}/c}$

$$g\int \bar{\Psi}(X,\xi)\gamma_5\Psi(X,\xi)\phi(X+\xi)d\xi$$

$$f(p) = e^{-a(\sqrt{m^2+p^2}-m)}$$

constructive force
数 BeV の U(0)
Quark potential

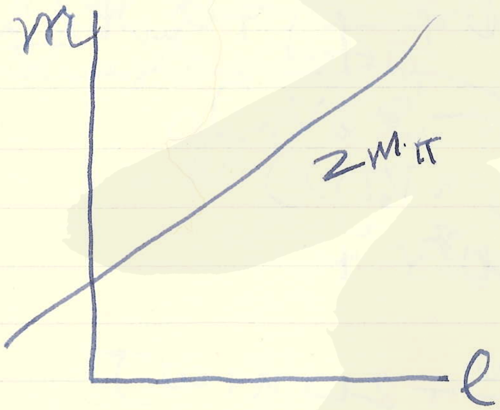


$$E_{n,l} = \underbrace{M - V_0}_{m} + A\sqrt{l(l+1)} + Bn$$

$$\mathcal{M} = N(\overbrace{M - V_0}^{m}) + A\sqrt{l(l+1)} + Bn$$

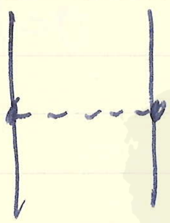
$$3m = \mathcal{M}_B$$

$$\mathcal{M} \sim \mathcal{M}_B + Al + Bn$$




$$U(r) = -U(0) + \kappa^3 r^2 + \cdots$$

droplet

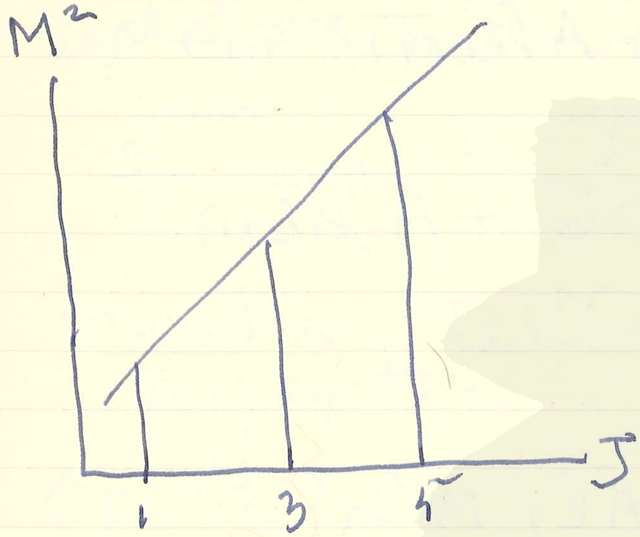


B.S.

$$U(a) = \cancel{\frac{4\pi}{3}a^3 u} + 4\pi\sigma a^2 + \frac{l(l+1)}{ma^2}$$

$$\frac{\delta U}{\delta a} = 0 \to U(a) = \sqrt{\frac{4\pi\sigma\, l(l+1)}{m}}$$

$$a = a_0\sqrt{l(l+1)} \qquad a_0 = 0.5\times 10^{-13}\,\mathrm{cm}$$



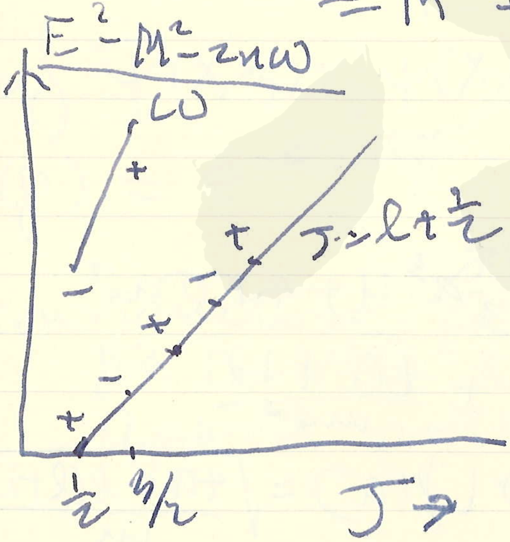

$$-L = \int \bar{\psi}(M+\gamma\partial)\psi\, d\omega + \frac{1}{4}\int \bar{\psi}\sigma_{\mu\nu}\psi\,(\partial_\mu V_\nu - \partial_\nu V_\mu)$$

$$V_\mu(r) = (0,0,0,\ iV_0(r))$$

$$V_0(r) = -V_0 + \omega^2 r^2 + \cdots$$

$$E^2_{J,l,n} = M^2 - \frac{\omega}{2} + 2\omega n + \omega J \qquad J = l + 1/2$$

$$= M^2 + \frac{5\omega}{2} + 2\omega n + 3\omega J \qquad J = l - 1/2$$



Regge pole

bilocal → 内部 Euclid

(Mori )

$$e^{-a\frac{\Delta^2}{m^2+\Delta^2}}$$

高野氏: 空間の extended structure
無限に分割可能性の制限
Finsler 空間
$g_{\mu\nu}(x_\mu, \dot{x}_\mu)$

27日:

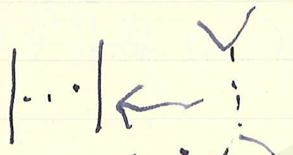
田中正氏:

ひろがった素粒子の time-like propagation と space-like propagation の違い:

$P_\mu^2$, $W_\mu^2$

mass spin ⇒ elementary particle

$P_\mu^2 > 0$ (0, 0, 0, E)



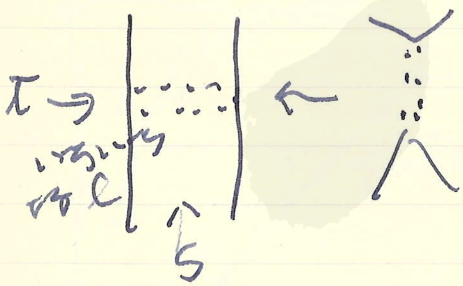
analytic continuation

$$\frac{P_l(\cos\theta)}{p^2+\kappa^2+i\varepsilon}$$

finite extension

$$\left.\begin{array}{l} \gamma_\mu P_\mu U = 0 \\ (\gamma_\mu^2+\lambda^2) U = 0 \end{array}\right\}$$

$P_\mu$: space-like ならひろがっている




van Hove:

Fierz: $U(X, r) \rightarrow$ intrinsic spin の ないひろがったものの運動

数学的 — 物理的でない spin

$P_\mu^2 < 0$ space-like

$(0, 0, p, 0) \to O(2,1)$

$$\Lambda^2 = L_x^2 + L_y^2 - L_0^2$$

$$\Lambda^2 P_\alpha = \alpha(\alpha+1) P_\alpha$$

原治氏: Deformable body

$A = B\ C$

$9 \quad 6 \quad 3$

野村氏: Infinite component Wave Eq.

bilocal

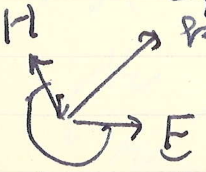
$O(3,1) > O(3,1)$

$SL(4, R) \simeq O(3,3)$

Majorana

$Sp(2,R) \simeq O(3,2)$

$\psi(X^\mu, \xi_\alpha)$




$\vec{k}$ (null vector)　　$\xi \sigma_\mu \tilde{\sigma}_i \sigma_2 \xi$

triad

[illegible] vector

$$\zeta = \begin{pmatrix} \xi \\ i\pi^* \end{pmatrix}$$ dirac spinor

$$\langle \psi, \varphi \rangle = \int \psi^*(X^\mu, \xi)\, \varphi(X^\mu, \xi)\, d\xi$$

$$d\xi = dx_1\, dx_2\, dy_1\, dy_2$$

$$\xi_\alpha = x_\alpha + i y_\alpha$$

$$(\upsilon^\mu P_\mu - \kappa)\psi = 0$$

$$\int \langle \psi, \upsilon_0 \varphi \rangle d^3X = (\psi, \varphi)$$

$$j^\mu(X) = \langle \psi, \upsilon^\mu \psi \rangle$$

$$\psi \to \psi(X_\mu; m_1, m_2; n_1, n_2)$$

[illegible] 氏:

$G_{int} \supset O(3,1)$

$\psi(\xi)$

unitary : [illegible]

non-compact : [illegible]

$\xi_\alpha$ : $\underline{O(4,2)}$

$\downarrow$

$O(4,1)$ or $O(3,2)$

$\downarrow$

$O(3,1)$

無限 component

中野氏: Euclid

大貫氏: one component 1/2 spin
wave function

2 component neutrino

$(\theta, \varphi)$ $\quad u(\theta, \varphi)$

$$u(\theta\varphi) \to e^{if(\theta,\varphi)}\, u(\theta\varphi - \theta\varphi \times \delta\omega)$$

$$J_1 = L_1 + \frac{k_1}{k + k_3} S$$

$$J_2 = L_2 + \frac{k_2}{k + k_3} S$$

$$J_3 = L_3 + S$$

one component
$\to S = 1/2$

$$[J_1, J_2] = i J_3$$

$$S = 0$$

$$S = \pm\frac{1}{2}, \pm 1$$

$$\pm\frac{3}{2}, \pm 2$$

---

$|S| = j$: $\quad Y_J^{\mu} \quad J \geq j$

で body に基動と
周り動と (2)「

$$Y_{1/2}^{1/2} \sim e^{[illegible]} \sqrt{1 + \cos\theta}$$

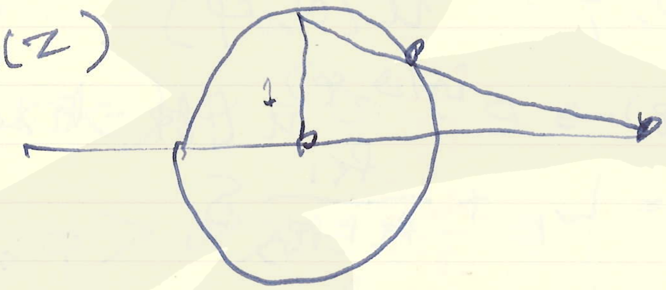
$$Y_{1/2}^{-1/2} \sim e^{-[illegible]} \sqrt{1 - \cos\theta}$$

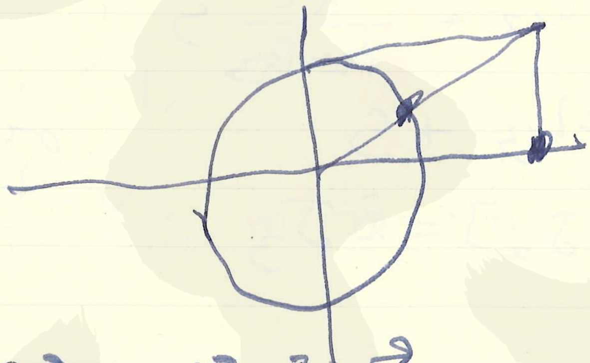
Schwinger

$$\vec{X} \to \vec{X} + \delta\vec{\Theta} \times \vec{X}$$

$$\left\{ \vec{X} \to \vec{X} + \delta\vec{\varphi} + [2(\delta\vec{\varphi}\,\vec{X})\vec{X} - \delta\vec{\varphi}(\vec{X})^2 \right.$$

$SO(4) = SU(2) \times SU(2)$





$$\vec{X} \to \vec{X} + \delta\vec{\varphi} + (\delta\vec{\varphi}\cdot\vec{X})\vec{X}$$

[illegible]; bilocal

$$S^{k} = \frac{1}{2}s^{k} - I_{0k}$$

$$\Vert \qquad\qquad \Vert$$

$$x^i p^j \quad \frac{1}{2}(x^0 p^k \underset{(-)}{+} x^k p^0)$$

田中 G. Feinberg: Superlight Particle
Maki-school
発表 [May 4, 1967]

superlight velocity の存在への objection

① $v > c$ : $E$, $p$ : pure imaginary
or $m = i\mu$

$$E = \frac{\mu c^2}{\sqrt{\left(\frac{v}{c}\right)^2 - 1}}$$

$$p = \frac{\mu v}{\sqrt{\left(\frac{v}{c}\right)^2 - 1}}$$

$$c^2 p^2 - E^2 = \mu^2 c^4$$

group velocity $\frac{p}{E} = \frac{v}{c} > 1$

$\infty > p \geq \mu c$

$\infty \geq E \geq 0$

Tachyon Tachys (swift)

② energy の符号 is Lorentz invariant でない。
違った座標系で energy ± の符号が変わる。

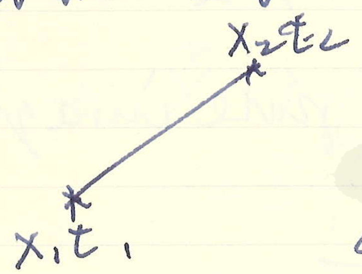
$N \to N' + \ominus$

$E' = \gamma(E - \vec{p}\cdot\vec{u})$

$\vec{p}' = \vec{p} + (\gamma - 1)\frac{\vec{p}\cdot\vec{u}\,\vec{u}}{u^2} - \frac{\gamma E \vec{u}}{c^2}$

$$E - \vec{p}\,\vec{u} < 0$$

(3) 時間の逆転.




$$\left|\frac{\Delta x}{\Delta t}\right| > 1$$

$$\Delta t = t_2 - t_1 > 1$$

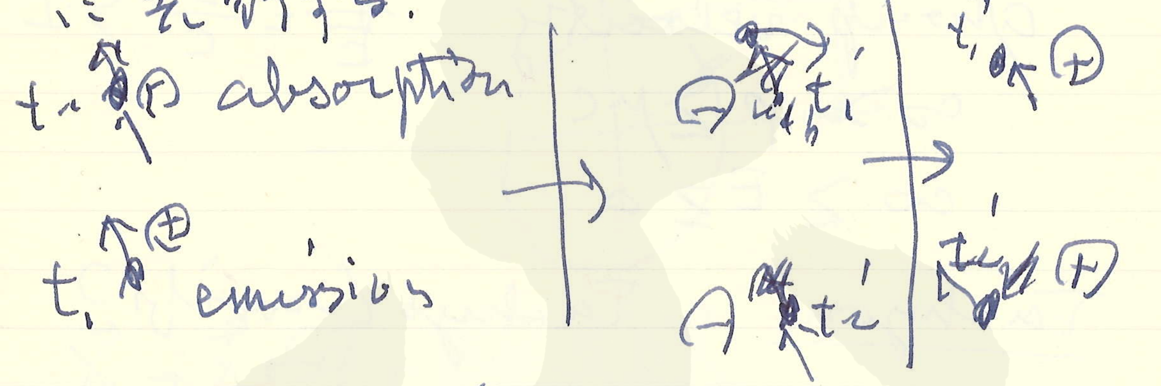
$$\Delta x' = (\Delta x - u\Delta t)\gamma$$

$$\Delta t' = \left(\Delta t - \frac{u\Delta x}{c^2}\right)\gamma$$

$$= \Delta t\left(1 - \frac{uv}{c^2}\right)\gamma$$

~~$\Delta t' <$~~ 時間の逆転は energyの符号の逆にすること.

causality : positive energy の emission or 〃 の absorption に見做す.





$$\Delta_F^+ = \Delta_R^+$$

$$\Delta_F^- = \Delta_A^-$$

④ sychronization

$(\vec{x}, t) \to (X, T)$

Tachyon にの；存在可能？

III. Imaginary Mass Scalar Field

$$(\Box + \mu^2)\phi = \left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2} + \mu^2\right)\phi = 0$$

$$\phi_{+,k} = \frac{1}{\sqrt{(2\pi)^3}} \exp\{i(\vec{k}\vec{x} - \omega t)\}$$

$$\phi_{-,k} = \quad \text{''} \quad \exp\{-i(\quad)\}$$

$$\omega \equiv \sqrt{k^2 - \mu^2} \qquad |k| \geq \mu$$

$$\sum_{|k| \geq \mu} \phi^*_{+k}(\vec{x}')\phi_{+,k}(\vec{x}, 0) = \overline{\delta^3(x - x')}$$

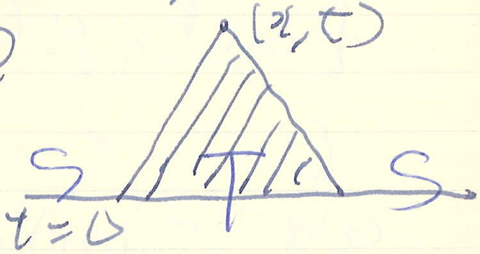
$$= \delta^3(x - x') + \frac{\lambda\cos\lambda - \sin\lambda}{|x - x'|^3\, 2\pi^2}$$

$$\lambda \equiv \mu|\vec{x} - \vec{x}'| \to \mu \to 0$$

$$\frac{1}{2}\mu^3/(2\pi)^2$$

① non-localizable for $\mu > 0$
② Cauchy problem

$\phi(\vec{x}, 0)$, $\frac{\partial}{\partial t}\phi(\vec{x}, 0)$




$G(\vec{x}, t)$

$$= \int \frac{d^4k}{(2\pi)^3}\,\delta(k^2 - \mu^2)\,\epsilon(k_0)\,e^{ikx}$$

normal dependent function

$a(k_0) \to \varepsilon(\lambda \zeta)$

$$D = D^{(n)}(x, \zeta) \quad (\text{normal}) \quad k \geq \mu$$
$$+ D^{(ab)}(x, \zeta) \quad k < \mu$$

$G \to D$ にすると solution は同じ

$$\phi(x,t) = \underbrace{\int_S D^{(n)} + \sum_T D^{(n)} + \int_S}_{0} \underbrace{D^{(a)} + \int_T D^{(a)}}_{0}$$

IV. Quantization

$$\phi(x,t) = \int \frac{d^3k}{\sqrt{2\omega_k}} \{\phi_{+,k}\, a(k) + \phi_{-k}\, a^\dagger(k)\}$$

$$[P_\mu, a(k)] = -k_\mu a(k)$$

$$P_\mu = \int_{|k| \geq \mu} k_\mu a^\dagger(\vec{k}) a(\vec{k})\, d^3k$$

$$\{a(\vec{k}), a^\dagger(\vec{k}')\} = \delta^3(\vec{k} - \vec{k}')$$

$$[\ \ ]_- = \delta^3 \quad \text{は困る!!}$$

結論: positive ~~def~~ definite
non-invariant (degeneracy)

V. Particle Aspects

$|0\rangle \to |\Omega_L\rangle$

$\vec{k}\vec{u} + \omega < 0$

$|k_1 \cdots k_n ; k_{n+1}, \cdots k_m\rangle$

$\to |k_1' \cdots k_n' ; \Omega_L(-k_{n+1} - \cdots - k_m)\rangle$

$a(\vec{k})|0\rangle = 0 \to |\Omega_L\rangle$

$P_\mu|0\rangle = 0$ | $P_\mu|\Omega_L\rangle = \sum k_\mu |\Omega_L\rangle$

$\vec{k}\vec{u} - \omega > 0$

Mach principle:

VI. Interaction (extended fermion spin 0)

$\{\phi(x,t), \phi(x',t')\} = D^{(1)}(x - x')$

$= \int \frac{d^4k}{(2\pi)^3} \delta(k_\mu^2 - \mu^2) \exp(ik(x - x'))$

$\langle 0|[\phi(x,t), \phi(x',t)]|0\rangle = G(x - x')$

$\downarrow$

$\delta(\ )\varepsilon(k_0)$

坂本泰氏 "高エネルギー準二体反応の現象論"

基研談話会 7.11.1967

$pp \to pN^*_{33} \to pN\pi$ 等 .. energy dep.

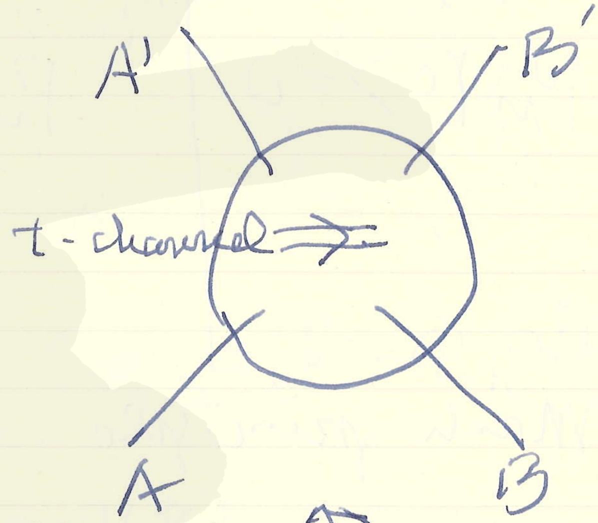
$\pi^- p \to \pi^0 n$

Morrison, Stoney brook conf.

Physics Letter

新しい ~~粒子~~ 見つかる

新しい組合せ




Morrison

(i) elastic-like

(diffraction-like

$n=0$

(ii) meson exchange

non-strange $n=1.5$ | strange $n=2$

$I, I_3, S$

$J, P \ldots$

(iii) baryon exchange

$n=3$

$$\sigma(AB \to A'B') = K\left(\frac{p}{p_0}\right)^{-n} \quad p_0 \simeq 1\,\mathrm{GeV}$$

Sawada: exchange される sakaton or quark の数

Q or $I_3$, S, B のやりとりと
E-dep. との関係
t: 小, u: 小

$\Delta S \neq 0$: $n_s > n_a$

$\Delta B \neq 0$: $n_B > n_s > n_a$

$\Delta S \neq 0$ $\quad \Delta J \neq 0$ $\quad \Delta J = 0$ $\quad n_{\Delta J \neq 0} > n_{\Delta J = 0}$

$pp \to pN^*$

$\pi p \to A_1 p$

$\to A_2 p$ ) $\Delta J \neq 0$ ) $n = 0$

$P = (-1)^L$

$J = L + \frac{1}{2}(-)^W$

$N \to N^*$

$\nu \equiv \frac{1}{2}(-)^W$ $\quad \Delta\nu = 0$ elastic-like

$\Delta\nu = \pm 1$ 〃

$M = (t\bar{E})$

$\Delta_J = (-)^{L+S}$

$\nu$

N-N: 10 ~ 30 GeV/c

π-N: 2 or 3 ~ 10 GeV/c

$n = \frac{3}{2}\left[|\Delta I_3| + \frac{1}{2}|\Delta S|\right] + 3|\Delta B|$

$+ \frac{3 - |3|}{2}|\Delta\nu|$

KN: ≲ 5 or 6 GeV/c

no backward peak

| | | $n_{exp}$ | $n$ |
|---|---|---|---|
| $\pi^- p \to p\pi^-$ | | 4 or 5 | 5.25 |
| $K^- p \to p K^-$ | | | 6.0 |
| $K^- p \to \phi \Lambda$ | non back | | $\begin{cases} f\ 3.0 \\ b\ 5.25 \end{cases}$ |
| $\to X^0 \Lambda$ | no back | | $\begin{cases} f\ 1.5 \\ b\ 3.25 \end{cases}$ |
| $\to \eta \Lambda$ | no back | | |

no forward peak

$K^- p \to \pi^+ \Sigma^-$

$\to \pi^+ Y_1^{*-}$

$\to K^+ \Xi^-$

Regge $s^{\alpha(t)}$

$$\sigma(AB \to A'B') \propto s^{2(\alpha(t)-1)}$$

$$n = 2(1 - \mathrm{Re}\,\alpha(t))$$

$$t = M^2 + C_1 + C_2 \mathrm{Re}\,\alpha(t)$$

$$n = 2(1 - J_0)$$

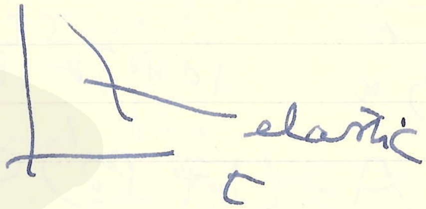
$$+ \frac{2}{C_2}\left[M_0(J_0) + a_1 Y_1 + b_1\left\{I(I+1) - \frac{Y^2}{4}\right\}\right]$$

$$C_2 = \frac{J_0' - J_0}{M_0^2(J_0') - M_0^2(J_0)}$$

backward?

$$\frac{d\sigma}{dt} = A e^{bt}$$

$b$



原子核 Deformable Body
取扱

荒木 July 12, 1967

$\xi^r_\alpha$ 自由度 12

$$A = (1 + B')C$$

$$CC^T = C^T C = 1$$

$$B'^T = B'$$

$$\begin{array}{ll} 3 & C \\ 6 \left\{ \begin{array}{l} 3 \\ 3 \end{array} \right. & \begin{array}{l} K \\ \delta \end{array} \\ \hline \text{自由度}\ 9 & \end{array}$$

$$\left. \begin{array}{l} B' = K^T \delta K \\ KK^T = K^T K = 1 \end{array} \right\}$$

C-frame の orientation : $\varphi, \theta, \psi$

K の C に対する orientation: $\xi\ \eta\ \zeta$
$\delta_1\ \delta_2\ \delta_3$

変形

$$L = T - V$$

$$T = \frac{1}{2}\int v^2 dm \qquad M = \int r \times v\, dm$$

$$B' = B'' + \frac{I}{3}\rho \qquad \rho = \Sigma \delta_i$$

$$\Sigma \delta'_i = 0$$

$$\delta'_r = \beta \cos\left(\gamma - \frac{2\pi}{3} r\right)$$

$$\delta_i \to \beta, \gamma, \rho$$

$\beta, \gamma, p \ll 1$

$$H = H_p + \frac{2}{3I} p_\beta^2 + \frac{1}{3I\beta^2} p_\gamma^2 + \frac{3\mu}{4}\beta^2$$

$$+ \frac{1}{6I\beta^2}\left\{ \frac{R_1^2}{\sin^2(\gamma - \frac{2\pi}{3})} + \frac{R_2^2}{\sin^2(\gamma - \frac{4\pi}{3})} + \frac{R_3^2}{\sin^2\gamma} \right\}$$

$$+ \frac{1}{2I}\left(S - \frac{\Omega}{2}\right)^2$$

$$M_1 = -\sin\psi \cdot p_\theta + \frac{\cos\phi}{\sin\theta}(p_\varphi - \cos\theta\, p_\psi)$$

$$M_2 = \cos\psi \cdot p_\theta + \frac{\sin\varphi}{\sin\theta}(p_\varphi - \cos\theta\, p_\psi)$$

$$M_3 = p_\psi$$

→ M の (laboratory) frame への projection

$M \to \Omega$

$\varphi\theta\psi \to \xi\eta\zeta$

$S \to R$

$S$ : ang. mom の C-frame ~~上の~~

偏

$$H_p = 3p_p^2/I + \left(\frac{\lambda}{2} + \frac{\mu}{6}\right)p^2$$

Space-Time Picture of
Elementary Particles
lecture at McMaster Univ.
Hamilton, Ontario, Canada
Tuesday, Aug. 22, 1967
Introduction by Nogami
Concluding Remarks by Sprung

Montreal Expo '67
Aug. 14, Monday, Noranda lecture
"Creative Thinking in Science"

General Physics

International Conference
on Particles and Fields

Aug. 28 ~ Sept. 1, 1967
Department of Physics and Astr.
University of Rochester,
Rochester, N. Y. 14627

Monday, Aug. 28
morning: 9 ~ 12.30 Experimental
chairman: Yang
Cronin: Weak Interaction

1. $\mu$ decay
$\delta = 0.758 \pm 0.010$.

2. Parity violation in nuclear force (Lobashov et al)
$P = -(6 \pm 1) \times 10^{-6}$
$F = (4 + 0.4) \times 10^{-7}$

3. Hyperon lepton decay
$\Sigma^+$ $V/A = 0.31 \pm 0.30$
CVC $\rightarrow 0$

$(\Sigma^+ \rightarrow \Lambda^0 + e^+ + \nu)/\text{all} = (0.20 \pm 0.03) \times 10^{-4}$
$\Sigma^- \rightarrow \Lambda^0 + e^- + \nu/\text{all} = \ldots$

4. Nonleptonic hyperon decay
$\Lambda \rightarrow \pi^- + p$
$\Sigma^- \rightarrow n + \pi^-$ pure S-wave
$\Sigma^+ \rightarrow n + \pi^+$ pure P-wave

5. $K_{e2}$ Oxford

$$\frac{K_{e2}}{K_{\mu 2}} = (1.9 {}^{+.7}_{-.5}) \times 10^{-5}$$

expect $2.6 \times 10^{-5}$ (pure axial vector)

$$f_{PS} < (2.3 \times 10^{-3}) f_A$$

6. $K \to \pi e \nu$

$$f_+(q^2) = f_+(0)\left(1 + \lambda_+ \frac{q^2}{m_\pi^2}\right)$$

$\lambda_+$

$K^+$ ...

$K_L^0$ ...

7. $K \to \pi \mu \nu$

$$\frac{f_+}{f_-} = \xi(q^2) = \xi(0) \frac{\left(1 + \lambda_+ \frac{q^2}{m_\pi^2}\right)}{\left(1 + \lambda_- \frac{q^2}{m_\pi^2}\right)}$$

$K \to 3\pi$

8. $$\frac{K_L^0 \to \pi^0\pi^0\pi^0}{K_L^0 \to \pi^+\pi^-\pi^0} = 1.77 \pm 0.14$$

$$\frac{K_L^0 \to \pi^0\pi^0\pi^0}{K_L^0 \to \text{all charged}} = 0.26 \pm 0.026$$

(CERN – )

9. $K^+ \to \pi^+\pi^+\pi^- = (4.496 \pm 0.030) \times 10^6 \sec^{-1}$

$\tau_{K_L} = 5.15 \pm 0.15 \times 10^{-8}$ sec

(Princeton)

Rate $\times 10^{-6} \sec^{-1}$

$K_L \, \pi^0\pi^0\pi^0$ $4.15 \pm 0.20$

$K_L \, \pi^0\pi^+\pi^-$ $2.40 \pm 0.07$

$K^+ \, \pi^+\pi^+\pi^-$ $4.47 \pm 0.05$

$K^+ \, \pi^+\pi^0\pi^0$ $1.75 \pm 0.04$

Check $|\Delta I| \geq \frac{5}{2}$ → very small

Check $|\Delta I| \geq 3/2$ → $0.82 \pm 0.09$ deviation from 1.

$$\frac{A_3}{A_1} = 0.06 \pm 0.015$$

---

10. $\Delta Q = -\Delta S$ ? → smaller

$$\frac{\Sigma^+ \to n + e^+ + \nu}{\Sigma^- \to n + e^- + \bar{\nu}} \ll 0.03 \text{ ?}$$

11. Neutral currents

$$\frac{K_L \to \mu^+\mu^-}{\text{all}} < 1.6 \times 10^{-6}$$ CERN

$$\frac{K_S \to \mu^+\mu^-}{\text{all}} < 7.3 \times 10^{-5}$$

12. CP

$K \to 2\pi$

$|\eta_{00}| = (4.3^{+1.1}_{-0.4}) \times 10^{-3}$ CERN

$= (4.9 \pm 0.5)$ 〃 Princeton

$= (4.17 \pm 0.3)$ 〃 new Princeton

$\pi^0 \gamma\gamma$?

$|\eta_{+-}| = (1.965 \pm 0.09) \times 10^{-3}$

$\arg \eta_{+-} = 78^0 \pm 15^0$

$$|\eta_{+-}| = \left| \frac{K_L \to \pi^+\pi^-}{K_S \to \pi^+\pi^-} \right|^{1/2}$$

$K_{e3}$ asymmetry $\frac{N^+ - N^-}{N^+ + N^-} = 2 \mathrm{Re}\,\varepsilon \frac{1-|x|^2}{|1-x|^2}$

$\frac{N_\mu^+}{N_\mu^-} \to$ $\mathrm{Re}\,\varepsilon = (2.0 \pm 0.7) \times 10^{-3}$

$\frac{N_e^+ - N_e^-}{N_e^+ + N_e^-} \to$ $\mathrm{Re}\,\varepsilon = (1.08 \pm 0.2)$ 〃

CP-violation

Hand, Electromagnetic Interaction
1. low energy QED
New value of Lamb shift
Robiscoe

2. New value of $\alpha$ from solid state

3. g-2 for $\mu^-$

4. g-2 for electron

Hyperfine $\alpha_{fs}$ $-43\pm12$ ppm
$\alpha_{gs}$ $0\pm8$ ppm

$\frac{\text{Theo} - \text{Exp}}{\text{Exp}}$

Pair creation
agreement $\lesssim 600$ MeV
disagreement $800$ MeV
$1000$ MeV

$\rho$-meson?
$\mu$-pair

$\gamma p \to p \rho^0$

$\gamma p \to p \omega$

$\gamma p \to p K^0 \bar{K}^0$
$\quad \to p \pi^+ \pi^-$

$\gamma p \to p \varphi$ small

electron scattering

$\frac{\text{positron}}{\text{electron}} \simeq 1$

○ $\gamma p \to p \pi^0$ : backward peak (Stanford)

Primakov effect : $\pi^0$ life-time

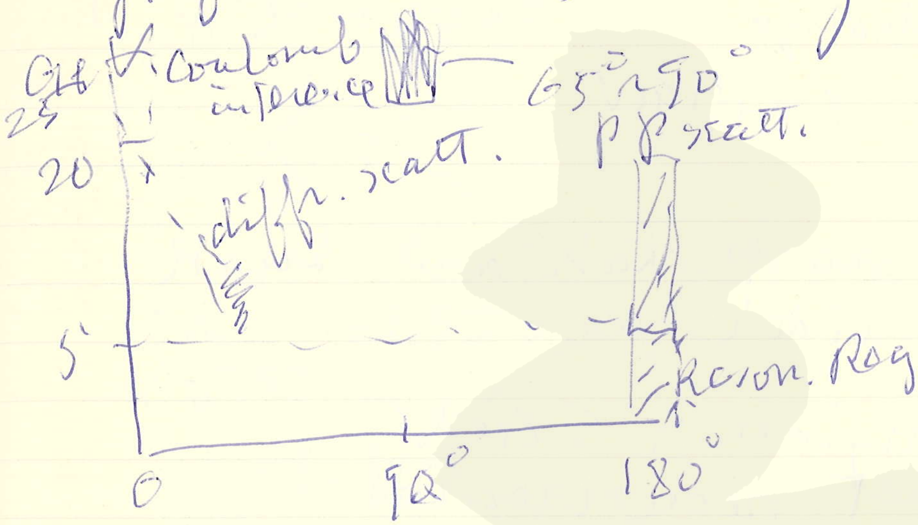
a effect

$\eta$-meson :

$\tau_\eta = 1.738.35 \times 10^{-19}$ sec.

$\gamma p \to \pi^+ n$ at $0°$ :

G. Goldhaber, Strong Interactions



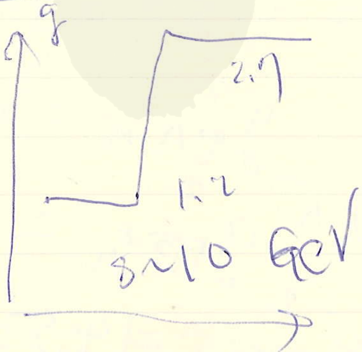

Orear

$$s\,\frac{d\sigma}{d\Omega} = 595\, e^{-p_\perp/.158} \rightarrow b\ (\text{Pine})$$

$p\bar{p}$-scatt. 65°~90°


$$\frac{d\sigma}{dt} \sim e^{-\frac{s\sin\theta}{g}}$$

contribution of
$p\bar{p}$-creation
etc ?



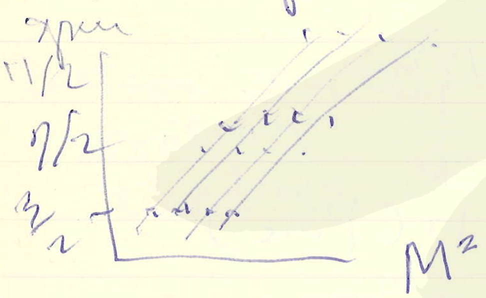
Backward (or)
baryon exchange

$\pi^+ p$ $\quad E \sim 17$ GeV

$\pi^- p$

1. $\pi^+ p$: sharp peak and break
2. $\pi^- p$ wider "

Low energy region $\lesssim 5$ GeV
doublet recurrences




$N^*_{9/2}(2060)$ does not fit

$K^- p$-scattering $\quad K^- p$ reactions

$g^2_{p\Lambda K} = 16.0 \pm 2.5$ $\quad$ (Kim)

N $\quad g^2_{p\Sigma^0 K} = 0.3 \pm 0.5$

SU(3)
good agreement

$g^2_{p\Lambda K} = g^2_{NN\pi}(1+2f)^2/3$

N $\quad g^2_{p\Sigma^0 K} = g^2_{NN\pi}(1-2f)^2$

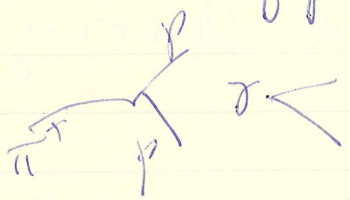
$g^2_{NN\pi} = 14.5 \pm 0.4$ $\quad f = 0.41 \pm 0.07$

$f = \frac{F}{F+D}$

$I^G$

$\eta$-decay

$\pi^+ d \to p p \eta^0$




$\frac{3\pi^0}{\pi^+\pi^-\pi^0} = 1.55 \pm 0.15$ ?

$\Delta I = \cancel{0}\ 1$

boson nonets

| $J^{PC}$ | $q\bar{q}$ | | |
|---|---|---|---|
| $0^{-+}$ | $^1S_0$ | | |
| $1^{--}$ | $^3S_1$ | | |
| $2^{++}$ | $^3P_2$ | $A_2$ | $^3P_2$ |
| | | B | $^1P_1$ |
| | | $A_1$ | $^3P_1$ |
| | | $\delta$?? | $^3P_0$ |

$| \to K^A$

Monday, Afternoon 2.15 ~ 6. p.m.
Aug. 28, 1967
New Approach to Field Theory
Chairman: Yukawa
Speakers (40 min.)
Feynman: Field Theory as guide to Strong Interaction
Schwinger: Back to the Sources

Katayama: Space-Time Picture of Elementary Particles

Short comment (10 min.)
Sudarshan:

Respondent:
Källen:

Tuesday, Aug. 29
Morning: Axiomatic Field Theory

Afternoon
Axiomatics

Broken Symmetry and Goldstone Theorem

Wednesday, Aug. 30
Morning:
1, Broken symmetry and Goldstone Theorem
Dürr
2, Infinite Component Wave Equation (or Infinite Multiplets)
Nambu:

Takabayasi:

Afternoon: Sightseeing

Thursday, Aug. 31
Current Algebras

Radiative Correction
$\pi \to \beta$ → Okubo

Evening: Banquet
Greeting: Yukawa.
Speach: Seaborg

Fresh water,
Old ~~Man~~ Alcohol &

Regge pole
(Strong Int. Dynamics)

Friday, Sept. 1
from Rochester, N.Y. to
Toronto, Ont.

~~Frid~~ Saturday, Sept. 2
from Toronto to Vancouver, B.C.

Tuesday, Sept 5, 1967
Lecture at Univ. B.C.
" Space-Time Description
of Elementary Particles
Introduction by Volkoff

加速器と超高エネルギー
Sept.

$\boxed{\text{Cosmic Rays}}$

藤本 $p_T \sim m_\pi < m_N$

① $\Delta (=t) \sim (1\sim 3)\, m_N \neq m_\pi$

$\sigma \neq \frac{1}{m_N^2} = \frac{1}{m_\pi^2}$

1962
- pion的 : $\sigma$, $p_T$ } $m_\pi$
- nucleon的 : $\Delta$, 粒子の数 } $m_N$
- super-nucleon的

EAS ($10^{14}\sim 10^{16}$ eV) : large $p_T$

$\boxed{\text{Machine}}$

n-n collision : core がとれるか？

数百 MeV → pion的

12 GeV → nucleon的 (Lorentz contract)

$\pi$-N backward

{ H-quantum (meson)
{ アレフ粒子 (baryon)

$\mathfrak{M}$(SH quantum) $\simeq (5 \sim 10)\, \mathfrak{M}_H$

$\sum p_\tau$