XII

NOTE BOOK

Manufactured with best ruled foolscap
Brings easier & cleaner writing

研究メモ
Sept. 1959〜
〜小倉・大学・沁(?)縮(?)(Nov. 1959)
〜Feb. 1960

VOL. XII

YUKAWA

Nissho Note

場の理論相談会
学術サロン　Sept. 8, 1959

湯川　片山　福留　木下
宗像　田中　中西
松岡　藤本

1. Non-local
   One-body problem → quantization
2. Mathematical structure of field theory (many-body problem)
   (direct approach to)

談話会：月曜　午後4時～6時
中西：Mandelstam
福留：Wightman の理論
藤本：Minardi - Vigier

数理物理研究会研究班と連絡会
第1班．第2班
数理　永田　伊藤　吉田

物理　湯川　片山　福留　木下
宗像　田中　中西　松岡　藤本
[illegible]　伊豆山

湯川研 相談会

井上	素粒子論
宗像	素粒子不特論
田中正	非統計論
堀田	理論物理学演習

大学院	DIII	中西		1
	DII	石田	宮西	2
	DI	西穂	下橋	2
	MII	西園	長沢 内山	3
	MI	中沢	静田 田中	3
				11

morning Weisskopf's Lectures Sept. 11, 1959

1: Nuclear Physics in Nineteen-Thirties

Afternoon : Discussions on Nuclear Forces

Otsuki : Pion Theory

Sasakawa
Terasawa
Jancovich } Spin-orbit coupling

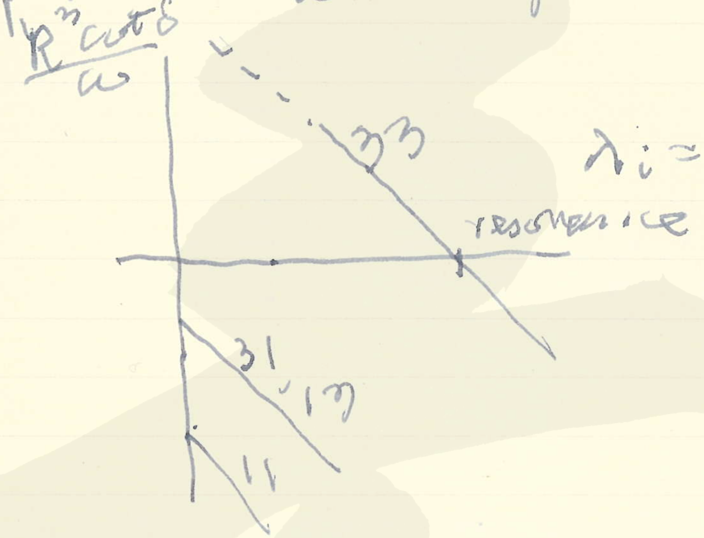
Sept. 12. Morning

2. Weisskopf: Static Meson theory
effective range appr.

$$\frac{k^3 \cot\delta}{\omega} = \frac{3}{g^2\lambda_i} - \frac{\omega}{\omega_0}$$

J	T
1/2	1/2
3/2	3/2

p-state scattering



	11	31	13	33
$\lambda_i =$	-8	-2	-2	4

$$\ddot{\phi} - \nabla^2\phi + \phi = 0 \qquad r > r_0 \qquad r_0 \ll 1$$
?

Two nucleon force at large distance $R \gg 1$

$$E = g^2(\tau_1\tau_2)(\sigma_1\nabla)(\sigma_2\nabla)(e^{-R}/R)$$

$$\phi_\alpha^{(e)} = g\,\tau_\alpha(\sigma\nabla)\frac{e^{-r}}{r} \qquad r \gg 1$$

Energy of nucleon in an external static field ϕ (weak)

$$H = g(\sigma\nabla)\tau\cdot\phi$$

incident $\phi^{(i)}$

p-wave

scattered $\phi^{(scat)} = \sum_j \eta_j (P_j \phi^{(i)}) \frac{e^{ikr}}{r}$

$$\eta_j = \frac{3}{2ik}(e^{2i\delta_j} - 1) \simeq \frac{3}{k}\,\frac{1}{\cot\delta_j - i}$$

$\phi = \phi^{(i)} + \phi^{(scat)}$

$P_j(\phi) = \frac{u_j(r)}{r} Y_j$

$f_j = r_0 \left(\frac{du_j/dr}{u_j} \right)_{r_0}$

slowly varying function

$f_j\ \omega$

$z = k r_0 i$

$z^3 \cot \delta_j \equiv Q_j = 3\left(\frac{f_j + 1}{2 - f_j} \right) \Leftarrow g_j$

$- C(f_j) z^2 + O(z^4)$

$C = \frac{2}{5} \frac{f^2 - 3f + 1}{(2-f)^2} \left(\cong \frac{1}{3} \frac{1 - g_0 - \frac{1}{5} g_0^2}{1 + g_0} \right)$

$\eta_j = \frac{\frac{3}{2} z^3}{Q_j - i z^3}$

$\omega^2 = k^2 + 1$

$q_j = q_0 + q_1 \omega + q_2 \omega^2 + \cdots$

$Q_j = 3(q_0 + q_1 \omega + (q_2 - C r_0^2)\omega^2 + C r_0^2 + \cdots)$

To prove:

$q_0 = 0$

$q_1 = \frac{r_0^3}{g^2 \lambda_j}$

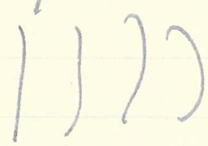
$q_2 \ll C r_0$

Low frequency weak meson field due to the nucleon very far away

$\omega \ll 1 \qquad \vec{k} = \sqrt{\omega^2 - 1} \sim i$

$\phi^{(i)} = A e^{-\vec{n}_i \vec{r}} e^{-i\omega t}$

$\phi^{(i)}$



How does $\phi^{(e)}$ change, if $\phi^{(i)} \neq 0$?

$\phi^{(e)}$

$$\frac{d\phi^{(e)}}{dr} = i[H, \phi^{(e)}]$$

$$H = g(\sigma \cdot \nabla)\tau\phi^{(i)}$$

$$= ig^2 \underbrace{[\tau_i\sigma_i, \tau_e\sigma_e]}_{\lambda_j} \phi^{(i)} \frac{e^{-r}}{r}$$

$$= ig^2 \sum_j \lambda_j (P_j \phi^{(i)}) e^{-r}/r$$

$$\phi^{(scatt)} = -\frac{g^2}{\omega} \sum_j \lambda_j (P_j \phi^{(i)}) e^{-r}/r$$

$$\boxed{\omega \to 0: \; \eta_j = -\frac{g^2}{\omega}\lambda_j}$$

$$Q_j = r_0^3\left(1 - \frac{3}{\eta_j}\right)$$

$$Q_j = r_0^2 + \frac{3r_0^3}{g^2\lambda_j}\omega + \cdots$$

$$q_0 = \frac{1}{3}(r_0^2 - (r_0^{\eta}) \sim 0$$

$$q_1 = \frac{r_0^3}{g^2\lambda_j}$$

$f \simeq -1$ for $r\omega \ll 1$.

$$\frac{k^3 \cot\delta}{\omega} = \frac{1}{\omega} + \frac{3}{g^2\lambda_j} - \frac{\omega}{r_0}$$

$\frac{1}{\omega}$: Serber term

for $\omega > 1$ $\quad \frac{1}{\omega} \ll \frac{3}{g^2\lambda_j}$

resonance: $\omega_{res} = \frac{3q_{1/2}}{r_0}$

$$r_0 = \frac{1}{3} g^2 \lambda_{33}\, \omega_{res}$$

$r_0 \simeq 0.1 < 1$ (cut-off)

$q_2\omega^2 \ll q_1\omega$ for $\omega \ll \omega^*$

$q_2 = \frac{q_1}{\omega^*} \to \frac{q_2}{C r_0^2} = \frac{\omega_{res}}{\omega^*}$

$q_2 \ll C r_0^2$ if $\omega_{res} \ll \omega^*$

Sept. 14, Morning. Weisskopf

3. Deformation of Nuclei

~~Independ~~ indep. particle approx.
closed shell
open shell

Belyaev. force
superconductivity

$$H_p = -G \sum_{\substack{m>0 \\ m'>0}} (a^\dagger_m a^\dagger_{-m})(a_{-m'} a_{m'})$$

exact solution
Weisskopf - Carlson
Davidson
Fukuda - Wada

Afternoon: 4 p.m. chairman: Hayakawa
Kobayasi: Collective Nuclear excitation

Iwamoto: Motion of holes in Brueckner theory

Sept. 1, morning
Discussions; chairman: Takagi
Sano:

Weisskopf: Nuclear matter
mean distance >> core radius
$d >> c$

$$E \simeq \frac{A}{(d-c)^2} - \frac{B}{d^{3-\alpha}}$$

$$\frac{\partial E}{\partial d} = 0, \quad E \sim 0$$

$$\frac{2}{d-c} = \frac{3-\alpha}{d}$$

$$\frac{c}{d} = \frac{1-\alpha}{3-\alpha} = \frac{1}{5} \quad \text{for } \alpha = 1/2$$

Sasakawa: Optical model

Afternoon chairman: Toyoda
Morinaga: Direct capture of slow neutrons
Yoshizawa (Osaka)
(α, n), (α, 2n), (α, 3n)
Mori, stripping Reaction
Tamura, Vibration, rotation

Sept. 16 湯川 Kiev. I.

Alvarez: Strange Particle 小林稔君

mass

K^+ 494.0 ± 0.2 } 3.9 ± 0.6
K^0 497.9 ± 0.6
Ξ^- 1319.1 ± 0.5
Ξ^0 1311 ± 8

$K^\pm$ interaction

$K^+ + p \to K^+ + p$ 450~600 MeV/c
(175~275 MeV)

16 mb.

σ, $\frac{d\sigma}{d\Omega}$: energy indep.
I = 1 repulsive
1000~2500 MeV/c 17 mb.

$K^+ + n \to K^0 + p$
225 MeV 3.74 ± 0.5 mb.

Yukawa:

野上G: Dalitz. Hyperfragment

Σ^--n が在る.

芸野氏. Weak Interaction
Glaser; Non-leptonic
$\Lambda \to p + e^- + \nu$

Ξ ×

$m_{K^-} - m_{K^0} = -3.7 \pm 0.7$ MeV

$m_{K^+} - m_{K^0} = -4.8 \pm 1.1$ MeV

Rare strange Particle decays

Alichanov; Leptonic
$\mu^- + C^{12} \to B^{12*} \to C^{12} + e^-$

$$\frac{G^2_{GT\mu^-}}{G^2_{GT\beta}} = 1$$

Sept. 14. Kiev II.
$\gamma - \pi$

N-N　π-N
Segrè, Anti-nucleon
$n_\pi = 5.3 \pm 0.3 \to 4.7 \pm 0.1$
K: $3 \pm 1\%$
intensity ~ 10倍.

角分布：[Gell-Chew で行う],
π-π-ang. corel.
N-N (Smorodinsky)

Veksler
M-M　p-M-interaction

場の理論研究会

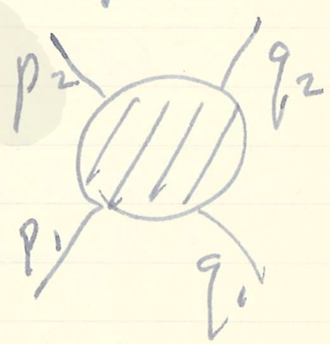
Sept. 21 '59

中西氏: S. Mandelstam
π-N Scattering Amp. from
Dispersion Relation and
Unitarity (P. R. 112 (1958), 1344)

disp. relation + unitarity condi.
→ eq.s → scatt. ampl.
(static : Chew-Low
p-wave only)
1) all ang. momentum
2) unphysical region

T. D. renorm. ができぬ
bare meson は入る余地がない
crossing sym. がなりたたぬ
(ghost がでるだろう)
B. S. redundant

(I) $\pi_1 + N_1 \to \pi_2 + N_2$ } crossing
(II) $\pi_2 + \overline{N}_1 \to \pi_1 + N_2$ } sym.
(III) $N_1 + \overline{N}_2 \to \pi_1 + \pi_2$



double disp. relat.

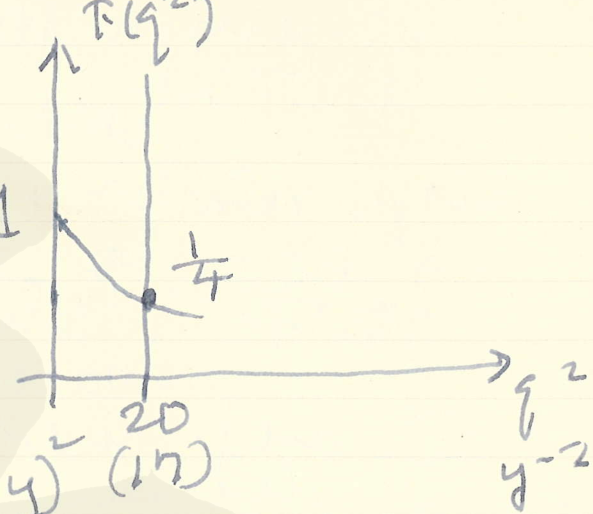
[illegible]

Sept. 22

[illegible]の：核子の電磁構造

$q^2 \simeq 20\, y^{-2}$

$r \simeq 0.5\, y$

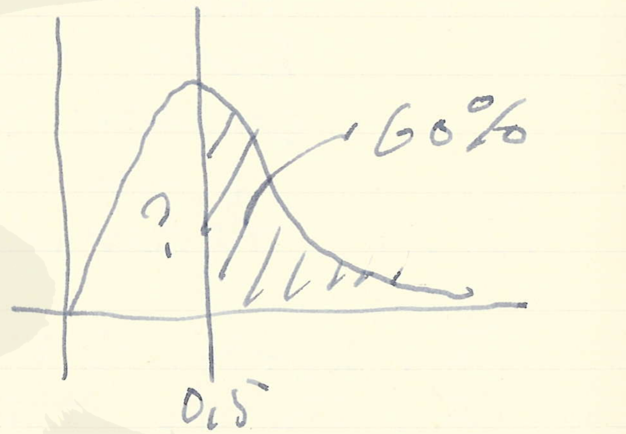


Stanford exper.

1) charge
moment) total

2) r.s.r.
$\langle r^2 \rangle \simeq (0.80 y)^2$

3) partial amount (外側にしてあるから)
$r \gtrsim 0.5\, y$



exp.	0.62
C.A.	0.61
Y X	0.50
Y + core	0.62
S.Y.X	0.41
S.Y. + core	0.62

$$Q(r) = \int_r^{\infty} 4\pi r^2 \rho(r)\, dr$$

$$\simeq 1 - 1.6\, F[(2.1)^2 / r^2]$$

$q^2 = 20 \rightarrow r = 0.47$

$\simeq 0.60$

monotonic decrease
i) normalize
ii) tan at 0
iii)

ρ $\quad V(r) \quad E(r)$

$$F(q^2) = \frac{1}{\pi}\int \frac{g(m^2)}{q^2+m^2}\, dm^2$$

$m_n - m_p$.

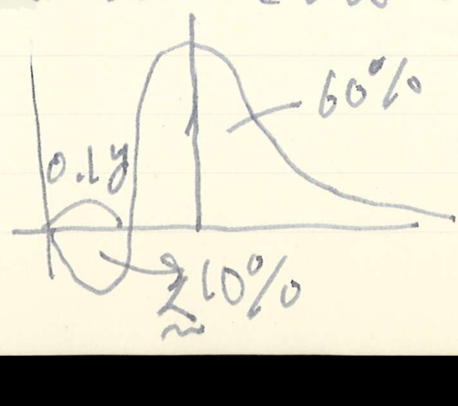
$$F(q^2) = \frac{c_0}{q^2+\Lambda_0^2} + \frac{c_1}{q^2+\Lambda_1^2}$$

$$\frac{5}{6} \geq \lambda_0 \geq \frac{1}{2}$$

$\lambda_1 = 0$ $\quad$ $\lambda_1 = 1/2$
C.V. $\quad$ exp.

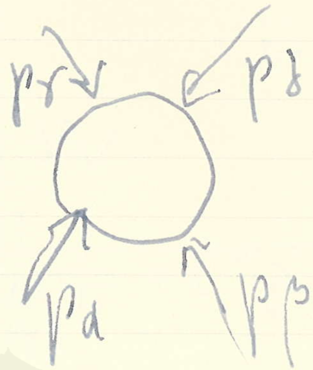
mass difference
i) $F(q^2) \equiv F(\vec{q}^{\,2})$ $\quad$ O
ii) $F(q^2)$. complex (Feynman cut?)
iii) $F(q^2)$ real (diverge)

$F_{1p} = F_{2p} = F_{2n}$
$= F$
$F_{1n} \neq 0$



細谷氏 review III.　　Sept. 23

Chew, strong coupling of Ord. Particles
double dispersion : Mandelstam
effective range analysis の一般化
→ rel. local
N-N, π-N, π-π



伊藤氏
Shirkov, Dispersion Relations
Ordinary
1) general principle →
2) perturbation

Lehmann General Properties of Transition Amplitudes and Spectral Functions

Landau, Analytic Properties of Vertex Parts in Q.F.T.

宮沢氏
van Hove, Physica 25 ('59), 365

Wightman,

Touschek,

Thirring, 3-2-comp. spinor

Markov,

Kiev IV Sept. 25

井上G

Wataghin, Non-local
  causal description
  statistical description
  unitarity?

Drell, spin-statistics

相原G;

Panofsky, Q.E.D,
  nucleon structure

Hofstadter, Nucleon Form Factor

Schiff, Theory.

福留氏.　Wightman の批評.
Sept. 28, 1959

Euclid invariant
new

S 波 散乱.

南部君,　　Sept. 29, 1959

$\boxed{\pi - N}$　　K - N

L　$1/2$

$a_1 = 0.16$
$a_3 = -0.11$

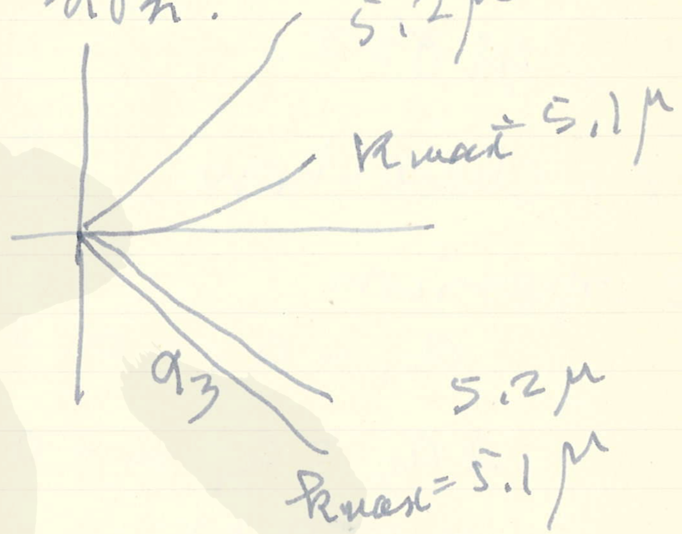
1) 摂動　ps　$\frac{2a_3 + a_1}{3}$　大きすぎる

$a_1 - a_3$　O.K.

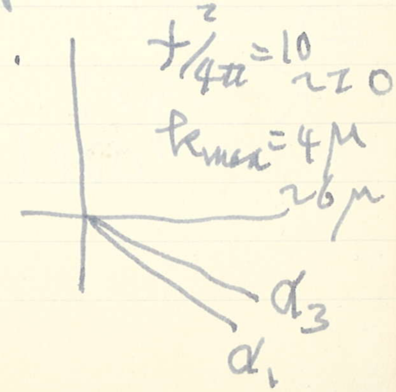
pv　$\frac{2a_3 + a_1}{3}$　O.K.

$a_1 - a_3$　小さすぎる

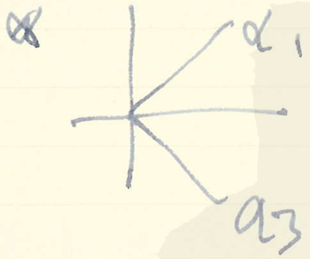
2) Tani-Foldy 変換.

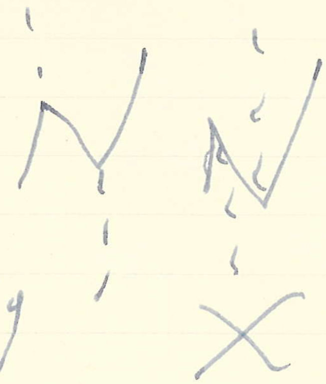


3) Tamm-Dancoff. ps-ps
π 2, n-pair 2.



4) Bosco and ~~Stro~~ Stroffolini





Crossing symmetry がつかえる.

5) Michida, Ataka
磁気モデル

6) Chew-Low Sugano

7) 胡寧ら.

8) Chew-Low, Wrell et al.

dispersion

$$a_1 - a_3 = 0.27$$

$$2a_3 + a_1 = -0.06$$

$$a_3 = -0.11 \qquad a_1 = 0.16$$

$\boxed{K-N}$

K^+-p:

$\sigma_{el}(K^+ + p) = 13.5 \pm 2.8$ mb (20~100) MeV
14.2 ± 2.6 mb (100~200)
21.3 ± 4.5 mb (200~350)

$T = 1$. s-wave
(isotropic)

$K^- - p$: σ_{el} Σ_i Ξ .. isotropic

1) Matthew, Salam

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

25 MeV

Σ^* ; $J = 1/2$ s-state

2) Jackson ~~and~~ and Wyld

$\Sigma\pi$ - resonance

~~Di~~ Dispersion

Amati et al.

ps - ps

"偏の理論"の流れ

藤森氏：中野氏：剛紐モデル (1956)

~~Sept.~~ Oct. 5, 1959

$[\tau_{AB}, \mu_{ij}] = 0$

$\tau_{AB}\,\tau_{AB} = \mu_{ij}\,\mu_{ij}$

On Relativistic Wave Equations
with a Mass Spectrum
(Acta Physica Polonica 15 (1956),
163)
V. L. Ginzburg
(Lebedev Institute, Moscow)

H. Yukawa, P. R. 91 (1953), 415, 416
J. Rayski, Nuovo Cimento
10 (1953), 1729 ; 2 (1955), 235
Shirokov,
Hara, Marumori (1954) Y. T. P.
Markov
Zhirnov

第14回 物理学会年会
広島大学. 34年10月

10月9日："かもめ". 元城旅館. 晩は[illegible]
2時半～5時：素粒子シンポジウム.
キエフ会議報告. 武田. 大槻. 湯川

10月10日 夜. 急に涼しくなる
午前：物性分科会に出て委員会.
1時半～4時半：総会講演. [illegible].
招待講演：今井功
半導体の物理学：菊池? 前田寛一
ソビエトの物理学：湯川 (50分)
(約1時間. 25枚. 大槻氏)
4時半～7時
原子力懇談会：平和記念館. 千田町
森戸学長. 広島県知事. 広島市長. 浜井前市長.
三村教授
理論側 武谷. 片山. 伏見. 福田. 小林.

10月11日 午後1時半～
素粒子論分科会
原子核研究所懇談会
物理学会会計報告(年会) [illegible] ; [illegible]. 東京
研究費 (内山) 計算機(長期研究費) 福田氏提案
基礎物理学研究所 東京研究所
[illegible] 問題. [illegible]
(荒木 [illegible]) → 調査することを要請
学術振興会 研究計画 → 原子核分野の要望
(荒木) (田中一)
夕食：田中一. 相原.

10月12日 午後1時半〜
核融合シンポジウム.

[illegible]（基研） Oct. 19

藤原, J. P. Vigier, D. Bohm and P. Hillion, Q. T. of Internal Motions of Relat. Rotators (Preprint)

$m^{+\prime} = I_3$ (isospin)

$m^{-\prime} = S/2$ (strangeness)

$m = s_z$ (spin)

D. Finkelstein, Internal Structure of Spinning Particles (P. R. 100 (1955), 924)

場の理論談話会 (基研)

Oct. 26

[illegible], D. Finkelstein, Internal structure of Spinning Particles (P.R. 100 (1955), 924)

$\psi(X, \Theta\Phi X)$

(1) (2) (3)

integer　　half-integer

rel. rigid body : 6 + 200

Hom. Lorentz Transf.

$X \to bX$

$q \to b \circ q \qquad (b'b) \circ q = b' \circ (b \circ) q$

$G(q_0) \qquad b \circ q_0 = q_0$

$G(q_0) \subset G \qquad G$: Lorentz group

coset $G / G(q_0) \qquad \{\forall\, b\} = G(q_0)$

q_0

half-integer spin : [6], [5], [4]

場の理論談話会(基研)

Nov. 2, 1959

湯川：非局所理論

H. R. Coish, Canada

Elementary Particles in a Finite World Geometry

(P. R. 114 (1959), 383)

"素粒子の模型" 研究会

Nov. 9, 1959

[illegible]: Bohm, Takabayasi, Vigier の理論

rotation energy $\hbar^2/I \sim \Delta M \cdot c^2$

$I = 10^{-49}\ \mathrm{gr \cdot cm^3}$

$\sim M l^2$

$M \simeq 10\,\Delta M$: $l \sim 10^{-13}$ cm

$[M_\xi, M_\eta] = -i\hbar M_\zeta$

M_ξ, M_η, M_ζ: scalar

$M_\xi^2 + M_\eta^2 + M_\zeta^2 = M_x^2 + M_y^2 + M_z^2$

$\vec{M}^2, M_z, M_\zeta$

4次元　6つ commute するものがある

湯川: 非局所理論

[illegible]: 剛体モデル.

D. Finkelstein

composite-rigid model

$\Psi(X, \dot{U}, Z)$

4次元 → 2成分 spinor

$1/2 \geq s$

$1 \geq I$

strangeons

	S	I	
N	1/2	1/2	
Λ	1/2	0	
Σ	1/2	1	
K $\bar{K}$	~~1/2~~ 0	1/2	
Ξ	1/2	1/2	
π, $\bar{\pi}$	0	1	
N′	1/2	1/2	0
Σ′Λ′	1/2	1, 0	1
ρ	0	1, 0	2

strong interaction は Lorentz 変換 に対して invariant

K, $\bar{K}$; π, $\bar{\pi}$; parity indefinite

CP-invariance

坂田： 複合模型

原子核との analogy

$\Sigma^+ \to e^+ + \nu + N$?

小川： 複合模型をめぐって

大理論

池田・大貫・小川： P, N, Λ の同等性

$\Delta n_p = 0$ charge cons.

$\Delta n_\Lambda = 0$ strangeness cons.

$\Delta n_N = 0$ baryon number cons.

(strong int.)

C. I. + exchange inv.

$\chi = \begin{pmatrix} P \\ N \\ \Lambda \end{pmatrix}$ $\chi \to \chi' = e^{iM_{ij}}\chi$

$I^2, S, N_B, I_3,$

$M = \Sigma (M_{ij})^2$

$M' = (M_{ij})^3 + \cdots$

$\overbrace{M, M', N_B}^{J^2}$ $\overbrace{I^2, S, I_3}^{J_z}$

2種 (particle-anti-particle)

π T^μ $T_\mu{}^\nu$ T_μ

$\overset{(2)}{T}_\mu{}^\nu = T_\mu{}^\nu - \text{const}\, T_\mu{}^\mu$ $\overset{(2)}{T}_\mu{}^\mu = 0$

Nov. 10, 1959

武谷: 素粒子の構造

μ と e　　π: Sakata model ?

non-local

1947: matter と field

space-time continuum　　　　　　matter [illegible]

↓　　→ sing. norm. ←　　(0, 1)　$(\frac{1}{2}, -\frac{1}{2})$

boson　　　　　　　　　　↓ fermion

ν e μ ⇄ P N Λ

片山: 非局所的な構造の探求

細田:

小沢: 高エネルギーでの場の理論の破綻,

早川: 高エネルギーの実験.

π_0'　3

π_0　10

Δp, ΔE: 大

エネルギー準位:

衛星:　　3000 mWe　　3×10^{12} eV

[illegible], 10000 mWe　　10^{13} eV

ν による electron shower

山[illegible]: non-local + Lorentz invariance

→ microcausal

→ macrocausal

$\{|out\rangle\}$: complete
$\{|in\rangle\}$: 〃

F. L. Scarf (CERN)
Equations of Motion for Renormalized Fields (Preprint, 34.10.7)

$L(\bar{\psi}_i, \psi_i, \lambda_i)$, $i = 1, \dots k$)
$(i\gamma^\mu \partial_\mu + m_i)\psi_i + f_i(\bar{\psi}_j, \psi_j, \lambda_j) = 0$

hermitian, local, covariant
$P_\nu(\bar{\psi}_i, \psi_i, \lambda_i)$
$N_i = \int d^3x \; j_i^{(0)}(\bar{\psi}_i, \psi_i, \lambda_i)$ } const. of motion
for $m_i = 0$: pseudo-current is also conserved.
symmetry properties of Lagrangian → additional constants.

physical particle fields: $\phi_i, \bar{\phi}_i$.
$(i\gamma^\mu \partial_\mu + M_i)\phi_i = 0$
$P_\nu = P_\nu^{(0)}(\bar{\phi}_i, \phi_i) + \text{const.}$
$P^{(0)}$ means all $\lambda_i = 0$
Now $\psi_i = \phi_i \, g_i(\lambda_j, \bar{\phi}_j, \phi_j, \partial_\mu)$
so that $\psi_i \to \psi_i^{in} = \phi_i$ as $t \to -\infty$
and free-field anti-commutation relations are imposed on ϕ operators.

Modified Lagrangian
$L' = :L: = L + \text{const.}$
$P'_\nu = :P_\nu:$ . . . .
Hilbert space defined by
$a_i|0\rangle = b_i^*|0\rangle = 0$
is not the correct one.

The correct one is defined by
$$a|0\rangle = b|0\rangle = 0$$
with $|0\rangle = T|0)$
$$T = \prod_{n,i} b_i(p_n)$$
which is well-defined, if the momentum space is cut-off so that ~~there~~ there are only a finite number of degrees of freedom. However, one cannot have an exact solution with cut-off.

○ Thirring model

Ordering operation is non-local.

○ neutral scalar theory with fixed source.
(van Hove, Physica 18 (1952), 145)

Renormalized field quantities are ~~do~~ not likely to obey local equations. Products of renormalized operators are undefined at a short time if $\lambda \neq 0$ and various averaging and limiting processes must accompany the manipulations.

Scarf, Anticommutator ~~for~~ for a Nonlinear Field Theory
(P.R. 115 (1959), 463)

素研 例の討論　　Nov. 16, 1959

片山氏：

J. L. Ferreira, Non-local el. mg. model for μ and e.

$m=0$ から出発，

el. mg. int. により $m\neq 0$

$$e\gamma_\mu A_\mu G_1 + \eta \sigma_{\mu\nu} F_{\mu\nu} G_2$$

hermite 型では増殖は許せない．

九州・広島旅行
昭和35年

11月24日 朝 西海にて小倉市, 田川旅館着
(記念碑の碑の西の安国寺のすぐそば)
午後 雨降り出す. 小倉高校にて
講演 15分位.
小林[illegible]氏と話す 中村先生の書道論.
夜7時より 中央公会堂にて, 岩波主催
文化講演会. "科学文明のゆくえ".
田川旅館に泊る

11月25日
朝 7時51分 小倉発 11時 [illegible] 別府着
清風園にて [illegible], 2時30分より大分市
碩田中学校にて, 科学教室生のために講演.
別府観海寺, 杉の井ホテルへ行き, 夕食, 休憩
午後7時〜8時; 大分市[illegible]公会堂にて 岩波文化
講演 "科学文明のゆくえ"
杉の井に泊る. 眺望絶佳. (由布の間)
11月26日
朝 8時5分 別府[illegible]に[illegible]. 岩波一行と別れ
る
門司にて"かもめ"に乗りかえ. 広島まで行き.
駅にて呉線に乗りかえ, 5時15分 竹原着
三村氏. [illegible] (三井[illegible]. 竹原[illegible]町長)の出
迎で 佐々木旅館に泊る.
11月27日
朝 10時〜13時40分: 理論研.
竹原[illegible]所 — [illegible]所にて 世界連邦[illegible]

夜10時のために放送 — 会館室†（"[illegible]会室"）
— 三井会館にて一時の放送 "物質微細の中心"
それは本日録音し放送
† 竹原の家族はなつかし 安ひきや 天学館
にまためぐりある。

11月28日
朝竹原を出発 → 宮島 "宮島"にて昼食。
† 光の苦 海賊すみし島にか
今は静かにて眠るがごとし

11月25日 ジュネーブ発 AFP:
24日 CERN の proton synchrotron
25 BeV の beam を出すことに成功。
（直径 200 meter 周囲 700 meter
John Adams, $4.5 \cdot 10^6$ 弗）

内の記録

講演：相対論的剛体

Nov. 20, 1959

$X^\mu = x^\mu + r^\mu$ $\qquad r^\mu = B^\mu{}_\nu \xi^\nu$

外部からの変換 $B \to LB \qquad \to AZ$

内部変換 $B \to BL^{-1} \qquad \to ZA^{-1}$

(回転及び回転(など)) $\sigma_\mu \equiv (\sigma, 1)$

$$\sigma_\mu B^\mu{}_\nu = Z \sigma_\nu Z^\dagger$$

Z : unimodular matrix

parity transf.

$r \to Pr$

$\xi \to P\xi$

$$\Psi(x^\mu, Z_{aA}, \bar{Z}_{aA})$$

$$\underbrace{Z_{aA} \cdots Z_{nN}}_{2S} \underbrace{\bar{Z}_{bB} \cdots \bar{Z}_{mM}}_{2S'}$$

縮退: $(2S+1)(2S'+1)$

$D_{S,S'}$

S, S' : 両[外]不変

$K = \frac{1}{2}(n(1) - n(2))$

K, K' : 外不変

M, M' : 内不変

$$S + S' \geq I \geq |S - S'|$$

$$\quad '' \geq s \geq ''$$

$I_3 = K - K'$

核子剛体、

完全剛体の場合

$$X = x + r \qquad \dot r^\mu = \dot B^\mu{}_\nu \xi^\nu$$

$$= \dot B^\mu{}_\nu B_\lambda{}^\nu r^\lambda$$

(τ は正に proper time)

$$= \omega^\mu{}_\nu r^\nu$$

$$\dot x^\mu r_\mu = 0 \qquad \dot x^\mu r^\nu \omega_{\mu\nu} = 0$$

Yukawa　　　Nakano

$$\frac{d\tau}{dT} = (1-\omega_{\mu\nu}\omega^\mu{}_\lambda r^\nu r^\lambda)^{-\frac{1}{2}}$$

$$\frac{dX^\mu}{dT} = (\dot x^\mu + \omega^\mu{}_\nu r^\nu)(1-\omega_{\mu\nu}\omega^\mu{}_\lambda r^\nu r^\lambda)^{-\frac{1}{2}}$$

$$m(r) = \delta(\dot x^\mu r_\mu)\,\mu(r)$$

$$P^\mu = \int \frac{dX^\mu}{dT} m(r)\, d^4 r$$

$$= \dot x^\mu \underbrace{\int (1-[\omega\times r]^2)^{-\frac{1}{2}} \mu(r)\, d^3 r}_{M}$$

$$T^{\mu\nu} = \int \left(X^\mu \frac{dX^\nu}{dT} - X^\nu \frac{dX^\mu}{dT}\right) m(r)\, d^4 r$$

$$= L^{\mu\nu} + S^{\mu\nu}$$

重心静止系:

$$S = \frac{2\omega}{3}\int r^2 (1-[\omega\times r]^2)^{-\frac{1}{2}} \mu(r)\, d^3 r$$

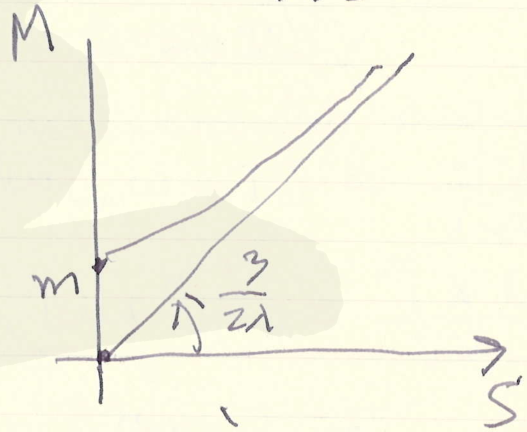
$$\mu(r) = \frac{m_0}{4\pi\lambda^2}\,\delta(r-\lambda)$$

$$M = \frac{m}{2\lambda\omega}\log\left(\frac{1+\lambda\omega}{1-\lambda\omega}\right)$$

$$S = \frac{m\lambda}{3}\,\frac{\omega}{\omega}\log\left(\frac{1+\lambda\omega}{1-\lambda\omega}\right)$$

$$M = \frac{3}{2\lambda}\,S\coth\left(\frac{3S}{2m\lambda}\right)$$

half-integer
spin では[illegible],



electromagnetic interaction

$$\int \frac{dx^\mu}{d\tau} A_\mu e(r)\, d^4 r$$

$$= \dot{x}^\mu \int \left(1-\omega_{\mu\nu}\omega^\mu{}_\lambda r^\nu r^\lambda\right)^{-\frac{1}{2}} A_\mu(X+r)\, e(r)\, d^4 r$$

$$+\,\omega^{\mu\nu}\int \quad '' \quad r_\nu A_\mu(X+r)\, e(r)\, d^4 r$$

$$\varepsilon = \int \left(1-[\omega\wedge r]^2\right)^{-\frac{1}{2}} \rho(r)\, d^3 r$$

$$\mathfrak{M} = \frac{1}{3}\int r^2 \left(\quad\right)^{-\frac{1}{2}} \rho(r)\, d^3 r$$

$$\rho(\mathbf{r}) = \frac{\eta}{4\pi\lambda^2}\,\delta(r-\lambda)\,P_2(\cos\theta)$$

$$\varepsilon = \frac{3\eta}{16}\{3I_3^2/S^2)-1\} \cdots\cdots$$

理研数学講義

I. 佐藤氏：超函数
11月4日, 5日

II. 一松氏：多変数函数論
11月7日, 8日
Osgood, Lehrbuch der Funktionentheorie
II, 1924, 再1929
Behnke-Thullen, 1934
Bochner-Martin, Several Complex Variables, Princeton 1948.
Stein, ~~Lecture~~ Leçons sur la théorie ....., Roma 1956.
Malgrange, Lectures on ..... Tata, 1958
Siegel, Princeton Lecture 1948/49

歴史：abel 函数　積分の逆函数
Weierstraß
Hartogs (1904~09)　解析 境界 がない 函数存在 (領域)
正則領域 は 何であるかもの.
E. E. Levi (1910~11)
擬凸性.　擬凸 $\overset{?}{\rightleftarrows}$ 正則領域

1921 Reinhardt
1922 Almer　中函数
S. Bergman(n)　核函数
1926 Julia　正規族
Stein, Bremermann, Grauert, Remmert

Münster学派：Behnke, Thullen,
Paris学派：H. Cartan (1926) (1932), Serre
正則凸.

・Oka (岡潔); i) Levi の予想
1936 〜 1953　ii) 近似の問題
I　IX　iii) Cousin の問題

多変数 → 解析空間,　　sheaf
函数　Grauert, Remmert　層.

正則函数;

$f(z_1 \cdots z_n)$　　$z_j = x_j + i y_j$

R^{2n}　$2n$次元

$f(z_1+h_1, \cdots z_n+h_n)$

$= f(z_1 \cdots z_n) + \alpha_1 h_1 + \cdots \alpha_n h_n + \varepsilon$

$\lim_{h_1 \cdots h_n \to 0} \frac{|\varepsilon|}{|h_1| + \cdots + |h_n|} = 0$　全微分可能.

$\alpha_j = \frac{\partial f}{\partial z_j}$

Hartogs の定理; 各変数で正則なら
正則 ...

$$f(z_1 \cdots z_n) = \frac{1}{(2\pi i)^n} \int_{C_1} \cdots \int_{C_n} \frac{f(\zeta_1 \cdots \zeta_n) d\zeta_1 \cdots}{(\zeta_1 - z_1) \cdots}$$

(Cauchy の積分公式)
巾級数展開可能.

D; Reinhardt領域
完全Reinhardt領域

解析拡大; D; Reinhardt領域
$(|z_1|, \cdots |z_n|) = \Delta$　(n次元)

$r_j < |z_j| < R_j$

f が D で正則なら

$f(z_1 \cdots z_n) = \sum_{-\infty}^{\infty} a_{k_1 \cdots k_n} z_1^{k_1} \cdots z_n^{k_n}$

D が座標平面と交わる $\{z_j = 0\}$

D: $\frac{1}{2} < |z_1|^2 + \cdots |z_n|^2 < 1$

$z_j = 0$　negative power の係数は0.

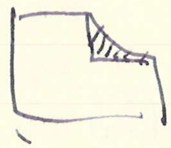
従って $f(z_1 \cdots z_n) = \sum_0 \cdots$

従って f は

$\tilde{D}$: $|z_1|^2 + \cdots |z_n|^2 < 1$

で正則.

解析函数を保つて凸領域に拡張.



正則凸 $\Longleftrightarrow$ 正則領域

Cartan-Thullen

多項式凸領域

Oka: 多項式凸領域は正則領域の極限である. (Oka II, 1937)

Runge の多項式近似.

擬凸性:

多重劣調和函数

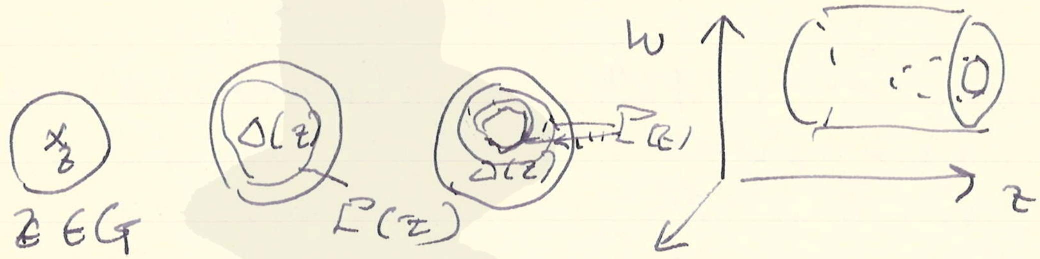
$\varphi(z_1 \cdots z_n)$ 実数値

$\sum_{j,k=1}^{n} \left(\frac{\partial^2 \varphi}{\partial z_j \partial \bar{z}_k} \right) \xi_j \bar{\xi}_k \geq 0$

$\frac{\partial^2 u}{\partial z_j \partial \bar{z}_k} = 0$　(正則な場合)

積分表示

$$D = \{ w \in \Delta(z),\ z \in G \}$$



$$g(z,w) = \frac{1}{2\pi i} \oint_{\Gamma(z)} \frac{f(z,\zeta)}{\zeta - w}\, d\zeta$$

$\Delta(z)$ が穴がないなら

$g(z,w) = f(z,w)$

そういう~~近傍~~領域があれば，全解析領域で

$g(z,w) = f(z,w)$

超球：　$|z_1|^2 + |z_2|^2 > 1$

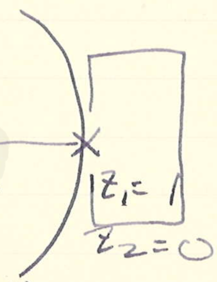
外側。

~~$|z_1| \geq 1$~~ z_1 は $z_1 = 1$ の

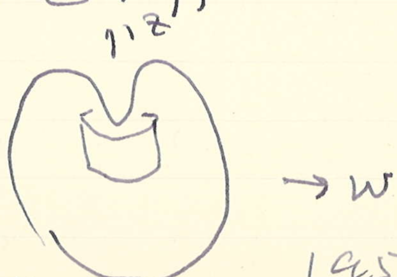
近傍，

$z_2 \in \Delta(z_1) = \{ |z_1|^2 + |z_2|^2 > 1 \}$

$|z_2| < \delta$。



球の外部で正則なら，中まで正則。



Okaの擬凸

$\Longleftrightarrow -\log \delta(z_1 \cdots z_n)$

が多重劣調和。

δ：z から境界への距離 (Bremermann) 1952.

擬凸領域 ⟹ 正則領域 (Leviの問題.
(Okaの論文 VI, IX 参 Grauert 1958)
(1942), (1953)

Cousinの問題. (P. Cousin 1895)
i) 加法的
ii) 乗法的.
1936 Oka I.
1937 Oka II. D が正則域なら解ける.
Oka III. 要注.
[illegible]

Riemann

O. W. Greenberg
Haag's Theorem and Clothed Operators
(P. R. 115 (1959), 706)

Haag's theorem:
Assumptions on quantum field theory:
I. Relativistic Transformation properties.
II. Unique, normalizable, invariant, vacuum state Ψ_0 and no negative-energy states or states of spacelike momenta.
III. Canonical commutation relations at equal times.
IV. It is related to the free-field theory at a given time by a unitary transformation.
Conclusion: It is completely equivalent to the free-field theory

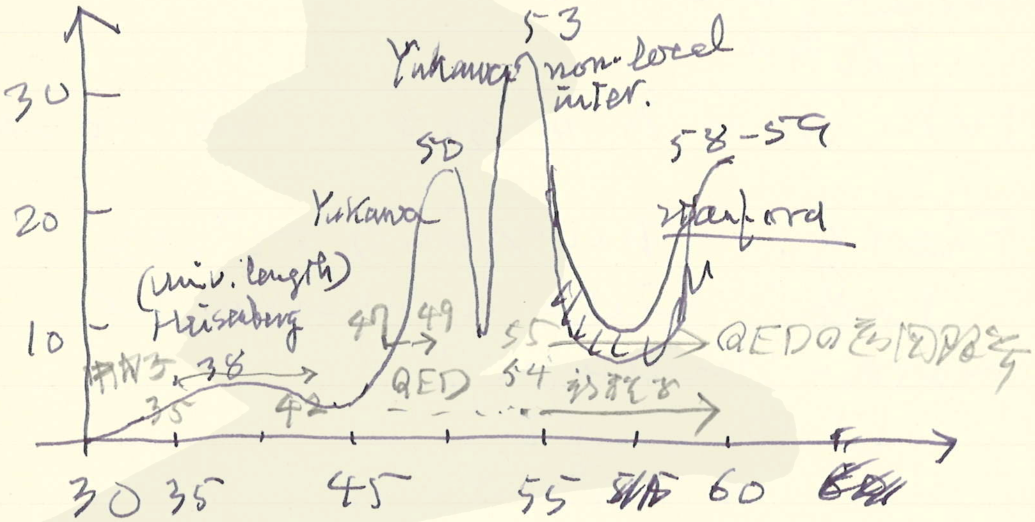
場の理論討論会.

Dec. 12, 1959

片山氏：非局所場理論の7年. 文献

Review

Fortschritte 1959?



Markov 1940

$$[x_\mu, U] \neq 0$$

$$\text{〃} = \lambda_\mu U \quad \text{組織的研究.}$$

$$U \propto \delta(x_\mu - x'_\mu - \lambda_\mu)$$

field 中身

木庭 (四元.) Snyder.

Yukawa 1950

$$[x_\mu[x_\mu U]] = \lambda^2 U$$

$$[p_\mu[x_\mu, U]] = 0$$

$$[p_\mu[p_\mu U]] = -m^2 U$$

reciprocity

i) bilocal: $U(X, r)$

ii) λ^2 ← 大きさ? (何の)

iii) 強いかどうか. 方程式は

iv) m と λ が独立してるのかどうか?

ii) Fierz: 高いspinのむすびつき local field a superposition

Hara-Shimazu:

$$U \to T U T^{-1}$$

$$\lambda^2 \to \lambda^2 = 0.$$

Yukawa: interaction.

iii) 既知素子をとり出す?

S-matrix, いろいろある

量子化　$U(X, r)$, $U(X', r')$

強　湯川, 高橋

弱　片山, 後藤.

略記しない.

iv) mass spectrum とspin → mass operator

1953 Yukawa

自由度が足りない?

$U(X, r)$ → 剛体モデル

spin と isospin がそろう.

$U(X, r, r')$ ....

半径,

点状体. → Non-linear?

causality の問題?

Weak Interaction 研究会.

第一回: Dec. 15, 1959

中山(君): ~~[illegible]~~ Introduction

I. Current-current Interaction (Feynman-Gell-Man) (1957)

(1) N, P, e, ν, μ, ν;

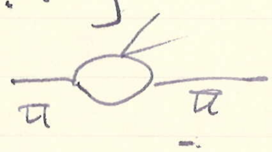
μ: $\mathcal{L}_\mu = \sqrt{2}G\,(\bar{e}\,\gamma_\mu \frac{(1+\gamma_5)}{\sqrt{2}}\nu)(\bar{\mu}\ \ \nu)$ + h.c.

β: $\mathcal{L}_\beta = \sqrt{2}G_\beta(\bar{n}\,p)(\bar{e}\,\nu)$ + h.c.

$\frac{G_\beta}{G} \simeq 1$ (with 1~2%)

$(\bar{n}\,p) \to (\bar{n}\,p) + \overbrace{(\pi^+\pi^0)}^{j^L} + \overbrace{(\bar{\Sigma}^-\Sigma^0) + \cdots}^{J_\alpha^{(1)}}$

$\mathcal{L} = J_\alpha^+ J_\alpha \qquad J_\alpha = \sqrt{G}\,[(\bar{e}\,\nu) + (\bar{\mu}\,\nu) + (\bar{n}\,p) + (\pi^+\pi^0) + \cdots]$



(1) $\pi^+ \to \pi^0 + e^+ + \nu$

新しい現象と関係

$\frac{\pi^+ \to \pi^0 + e^+ + \nu}{\pi^+ \text{ decay}} \sim 10^{-8}$

(2) Weak magnetism

$N^{12}, B^{12} \to C^{12}$

μ-capture

(3) $e + \nu \to e + \nu$

(4) 核力 $(\bar{n}\,p)\ (\bar{p}\,n)$

(2) $\Delta S \neq 0$;

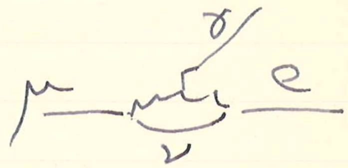
$\mathcal{L} = J_\alpha^+ J_\alpha$

$J_\alpha = \underbrace{j^L + J_\alpha^{(1)}}_{\Delta S = 0} + \overbrace{\underbrace{J_\alpha^{(2)}}_{\frac{\Delta S}{\Delta Q} = +1} + \underbrace{J_\alpha^{(3)}}_{\frac{\Delta S}{\Delta Q} = -1}}^{|\Delta S| = 1} + \underbrace{J_\alpha^{(4)}}_{|\Delta S| = 2}$

$J_\alpha^{(2)} = (\bar{\Lambda} p), (\bar{\Sigma}, n)$

$J_\alpha^{(3)} = (\bar{n} \Sigma^+)$

$J_\alpha^{(4)} = (\bar{\Xi}^- n), (\bar{\Xi}^0, p)$



1) $|\Delta Q| = 1$

2) V − A　　ν: left.

J^3, J^4の問題

(1) $\Sigma^+ \to n + e^+ + \nu \leftarrow (j^L J^{(3)})$

(2) J^4はない方がよい。

(3) $\Xi \to N + \pi \quad \leftarrow (J^{(3)} J^{(2)})$

$K^0 \to \bar{K}^0 \qquad 10^{-17}$ sec.

$\downarrow 10^{-10}$ sec

J^3はない方がよい。

$\Delta I = 1/2, \; 3/2$

neutral current

II. Iso-selection Rule

Okubo - Marshak

Λ-decay: $\frac{\Delta S}{\Delta Q} = +1$,　　n, p, Λ.

$\mathcal{H} = G(\bar{\Lambda} p)(\bar{p} n)$

$R = \frac{\Lambda \to p + \pi^-}{\Lambda \to n + \pi^0} \cong 2$　　$-\sqrt{\frac{2}{3}} B_1)$の項

$M(\Lambda \to p + \pi^-) = (\frac{1}{3} A_3 - \sqrt{\frac{2}{3}} A_1) + (\sqrt{\frac{1}{3}} B_3 \quad)$

$M(\Lambda \to n + \pi^0) = (\qquad) + (\qquad)$

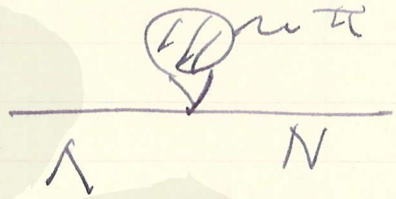
$2\sqrt{2}(A_1 A_3 + B_1 B_3) \sim -(A_3^2 + B_3^2)$

$\frac{A_3}{A_1} = \frac{B_3}{B_1} \rightarrow$ (i) $A_3 = B_3 = 0$, $\Delta I = 1/2$

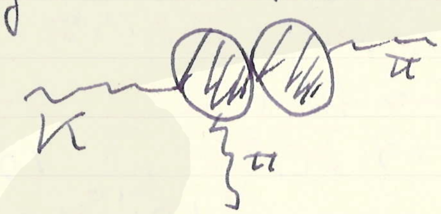
(ii) $\begin{cases} A_3 = -2\sqrt{2} A_1 \\ B_3 = -2\sqrt{2} B_1 \end{cases}$

$\Delta I = 1/2,\ 3/2$

$\frac{\alpha_-}{\alpha_0} = +1$



K-decay: $\Delta I = 1/2$ ($3/2$ ~10%)



$\mathcal{H}$ ではうまくいかぬらしい。

Σ-decay: ? ($\Delta I = 1/2$)

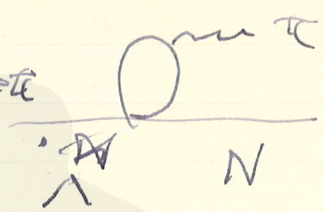
III. $\mathcal{H}_W = f_0 j^L j^L + f_1 j^L J^{(1)} + f_2 j^L J^{(2)}$
$+ f_3 J^{(1)} J^{(2)} + f_4 J^{(1)} J^{(1)} + f_5 J^{(2)} J^{(2)}$

$\Delta I = 1/2$
$+ \Delta I = 3/2$

(1) $f_0 = f_1$
(2) $f_2 = f_0$: $\frac{\Lambda \to p + e + \bar{\nu}}{\text{all}} \simeq 1.6\%$

実験 $\lesssim 0.2 \sim 0.3\%$

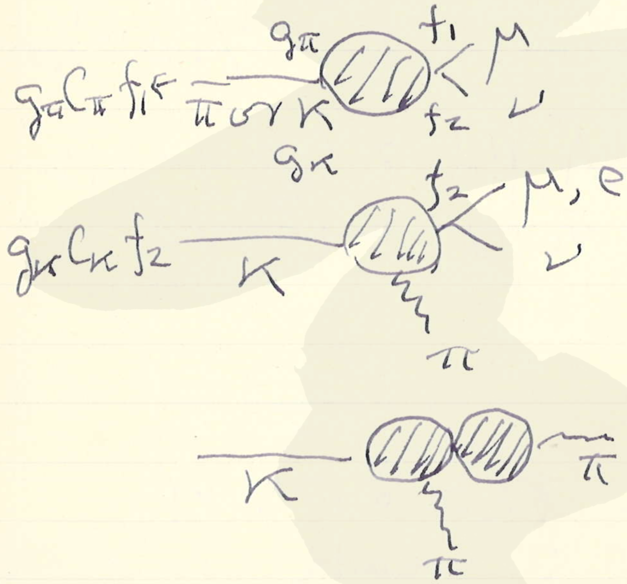
(3) $f_3 \simeq f_0$
for $\Lambda \to N + \pi$

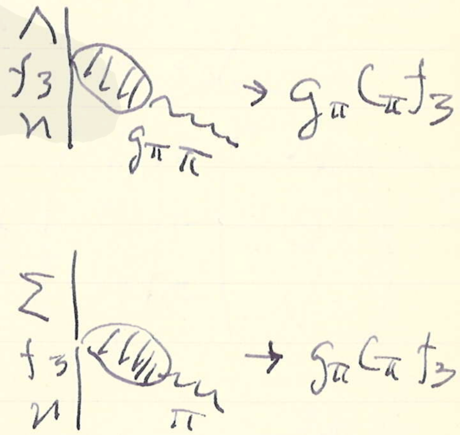


$$\frac{\Sigma^- \to p + e + \nu}{\text{all } \Sigma} \simeq 5.8\%$$

実験 $\lesssim 0.2 \sim 0.4\%$

(4). F. K. O. S. M.



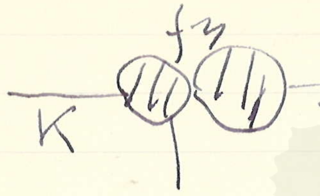


$$\frac{(\Lambda \to p + \pi)}{(\pi \to \mu + \nu)} \to f_1 \simeq f_3$$

$$\frac{(K^+ \to \mu + \nu)}{(\pi \to \mu + \nu)} \to \left| \frac{g_K C_K f_2}{g_\pi C_\pi f_1} \right| \sim \frac{1}{4}$$

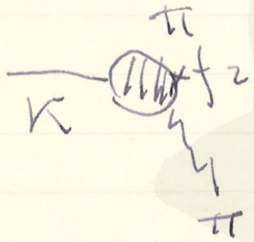
Ogawa symmetry: $\left| \frac{f_2}{f_1} \right| \sim \frac{1}{4}$

neutron の polarizability　+ or − ?
実験　Foldy



$$\frac{K^+ \to \pi + \pi}{K^+ \to \pi + e + \nu} \to f_2 \simeq f_3$$

($\Delta I = 3/2$ の part)



$$f_0 \cong f_1 \cong f_3^{(\frac{1}{2})}$$

$$f_2 \cong f_3^{(\frac{3}{2})} \sim \alpha f_0 \qquad \alpha^2 \sim 1/10 \sim 1/100$$

$$\begin{pmatrix} \mu^- \\ e \\ \nu \end{pmatrix} \begin{matrix} \to \\ \to \\ \to \end{matrix} \begin{pmatrix} \Lambda \\ n \\ p \end{pmatrix} \qquad \begin{matrix} J^2 & (\bar{\Lambda} p) \to (\bar{\mu} \nu) \\ J^1 & (\bar{n} p) \to (\bar{e} \nu) \end{matrix} \Big\} j^L$$

大林:

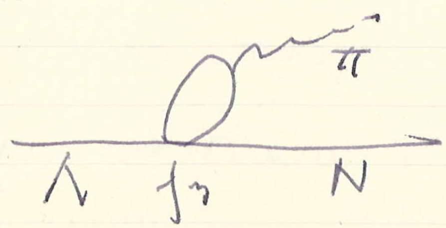
Oneda-Sakida 現象論的分析

$\rho m \bar{\Lambda} (1+\gamma_5) n$: weak, $\Delta I = 1/2$

$$\left. \begin{matrix} f_0 \sim f_1 \\ f_3 \sim f_2 \sim \frac{1}{5} f_0 \end{matrix} \right\}$$

$\rho \sim 3 \times 10^{-8}$ 　　m : nucleon mass

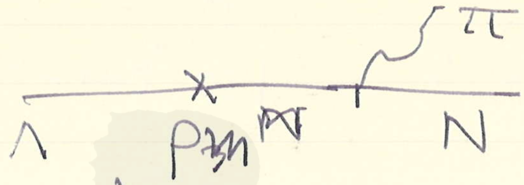
t'F :



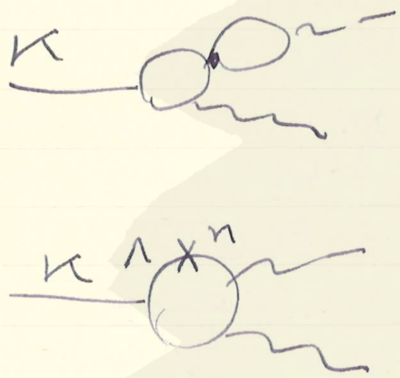
(1)

(8)

$\frac{\rho m g_\pi}{m_\Lambda^2 - m^2}$:



↓
main



K^0, K^+　　　K^0

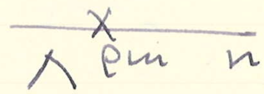
$f' \frac{m_\pi^2 + m_K^2}{2} : \rho m g_\pi$

$1 \quad : 20$

K^0が早く decay.

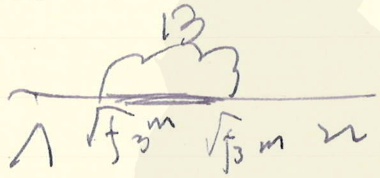
a)

→



$\rho \sim 10^{-8}$

b)



$m_B \sim m_n$

$\rho \sim 10^{-8}$

模型：

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

$H \sim f J_\mu J_\mu^\dagger + \alpha f \bar{\Lambda} O_\mu p \cdot J_\mu^\dagger$

$+ f \bar{n} O_\mu \Lambda \cdot [\bar{p} O_\mu p + \bar{n} O_\mu n + \bar{\Lambda} O_\mu \Lambda]$

$J_\mu = \bar{e} O_\mu \nu + \bar{\mu} O_\mu \nu + \bar{n} O_\mu p$

$\alpha^2 = 10^{-1} \sim 10^{-2}$

Compound particle : $10^{-13} \sim 10^{-14}$ cm
C.P.のS.I.のひろがり : 10^{-13} cm　) l_2

		A	B
$p\,n\,\Lambda$ の拡がり $\nu\,e\,\mu$	$\sim$	10^{-14} cm	10^{-17} cm
$p\,n\,\Lambda$ の (S, I, 9 拡がり)	$\sim$	10^{-14}	10^{-14} cm
$p\,n\,\Lambda$, weak int. $\nu\,e\,\nu$) の拡がり	$\sim$	10^{-14}	10^{-17} cm
		$\downarrow$ l_1	$\downarrow$ l_0

(B) $J_\mu \quad (\bar{\mu} O_\mu \nu \rightarrow \bar{\mu} O_\mu \nu^c) = j_\mu$

$\Delta S = \pm 1 \quad f \qquad \Delta S = \pm 2 > f^2$

$$j_\mu j_\mu^\dagger + f\,\bar{n}\, O_\mu \Lambda [\bar{p}\, O_\mu P e \cdots]$$

(A) $l_1 \ll l_2$

第2回: Dec. 16

類似:

$$\begin{pmatrix} \mu \\ e \\ \nu \end{pmatrix} \leftrightarrow \begin{pmatrix} \Lambda \\ n \\ p \end{pmatrix}$$

基礎には { 物質の究極? 素粒子
物質の階層? ひろがり

相互作用 } 強の論理? N.G.
弱の論理?

strong
weak
particle が変らぬ
数る.

S.I.:
Ikeda-Ohnuki-Ogawa-sym.
charge independence

W.I.:
universality (Klein-Wheeler-Ogawa)
F.G. $J_\mu J_\mu$
Gamba-Okubo-Marshak-sym.

$$B^+ \quad \begin{matrix} \Lambda \\ \uparrow \\ \mu^- \end{matrix} \quad \begin{matrix} p \\ \updownarrow \\ \nu \end{matrix} \quad \begin{matrix} N \\ \uparrow \\ e^- \end{matrix}$$

(weak: ~~vect~~ $V^{\pm}$: q.e.d. からまるか?)

model:
1. 水素原子の型　Nagaoka-Rutherford.
2. 芯型　J. J. Thomson?
3. 二流型
4. 混合型 系

大要;

Baryon family　　　　Lepton family

p　　　　ν
n　　　　e^-
Λ　　　　μ^-

ν B^+　　$e^{(+)}$　　$\mu^{(-)}$

p　　n　　Λ

軽さ; 139; e^+ B^+ . . .

反転; $\tilde{\nu}$ B^-　　e^+ B^-　　μ^+ B^-

$\bar{p}$　　$\bar{n}$　　$\bar{\Lambda}$

重さ; Saturation

νe^- B^+

(I) i) charge conservation
ii) lepton number の保存.
→ B の number の保存
iii) Lorentz inv. (macro では なし)

Weak int.

4の lepton が発見されたが、
これは weak int. で
通じてのみおこる。

$\{(\bar{\mu}\gamma_\mu(1+\gamma_5)\nu)$
$(\bar{e}\gamma_\mu(1-\gamma_5)\nu)\}\nu_\mu$

Y. O. F. G.

strong int.

strong int. は
Bどーしでおこる

| C. I.
| I. O. O. sym.
$(\bar{n}n+\bar{p}p+\bar{\Lambda}\Lambda)^2$

anti-particle

$B^0 = p + \bar{\nu}$ (Miyatake)

試：Λ^0- ~~part~~ boson

Λ
p
N

λ : Λと[illegible]相互作用するもの

(1) $\Lambda - N$ mass difference
(2) $\lambda^{*} \to$ decay
$\left.\begin{matrix}K\\ \pi\end{matrix}\right\} \to \lambda^{*}$

$$\frac{\text{mass}(\Lambda - N)}{\text{mass } N} > 0$$

λ : $I = 0$ $\quad g\bar{\Lambda}\Lambda\lambda$

		cut-off M	$m_\lambda = 500 m_e$ / $2M$
$S(S)$	$-$		
X $S(V)$	$+$	0.5	0.2
$V(V)$	$+$	0.5	0.2
$ps(ps)$	$-$		
$ps(ps)$	$+$	2	0.7
$pv(pv)$	$-$		

V(ν)

(i) $m_\lambda < m_\pi$

$\pi^0 \to \lambda^0 + \gamma$

(ii) $m_\pi < m_\lambda < 2m_\pi$

$\lambda^0 \to \pi^0 + \gamma$

$K^0 \to \lambda^0 + \gamma$

$K^0 \to \lambda^0 + \pi^0$ $< \pi + \pi$

$K^+ \to \lambda^0 + \pi^+$

Ps(ps)

小川：ΔI = 1/2 の問題.

universality

charge

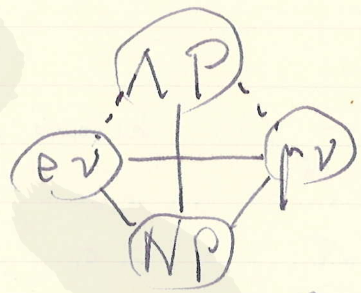
parity

① Λ が入ってきた時の coupling const. のずれ.

② ΔI = 1/2

$K^0 \to \pi^+ + \pi^-$

$K^+ \to \pi^+ + \pi^0 \to 1/500$



strong interaction のない時.

full symmetry

	S	I
K^+, K^0	1	1/2
π_0	0	0
π^+, π^0	0	1
π^-, π_0, K^-	−1	1/2

M = 6

M′ = 8

$\boxed{\Delta M = \Delta M' = 0}$ とおく!!!

M, M': quantum numbers in Sakata-Ogawa model

$K^0 \to \pi^+ + \pi^-$: allowed

$K^+ \to \pi^+ + \pi^0$: forbidden

仮定: $H \sim f J_\mu J_\mu + \alpha f\, \overline{P} O_\mu \Lambda J_\mu$
$+ f\, \overline{n} O_\mu \Lambda \{ \overline{P} O_\mu P + \overline{n} O_\mu n + \cdots \}$

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

$J_\mu = \overline{e} O_\mu \nu + \overline{\mu} O_\mu \nu + \overline{n} O_\mu P$

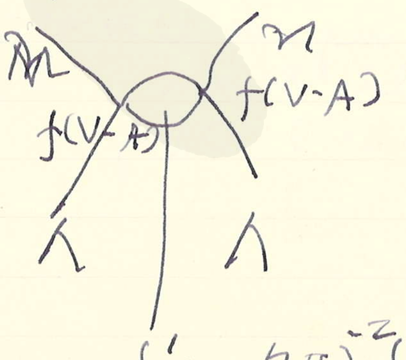
$\alpha \sim 10^{-1}$

	S.I. $(pn\Lambda)$ の拡がり	W.I. $\left(\begin{smallmatrix} pn\Lambda \\ \nu e \mu \end{smallmatrix}\right)$ の拡がり	
A	$\sim 10^{-14}$ cm	$\sim 10^{-14}$ cm	(二次効果 大)
B	$\sim 10^{-14}$ cm $\to l_2$	$\sim 10^{-17}$ cm $\to l_1$	(二次効果 小)

(B) ① W.I. の二次効果がきく。

$\Delta S = 2$

$\mu O_\mu \nu^c$ $\left(\begin{smallmatrix} \mu \to 3e \\ \mu \to e+\gamma \end{smallmatrix}\right)$



② $f\, \alpha f\, \overline{P} O_\mu \Lambda J_\mu$ の二次効果。

$f' = -(2\pi)^{-2} f^2 \left(\frac{1}{l_1}\right)^2$

第34 : Dec. 17.

武谷 : e, μ の電磁構造 (T. K.)

$\pi < {}^{\mu}_{e}$ Ruderman-Finkelstein

Takatani 1950

V. or A. [illegible].

Mach : parity

non-local → } Pauli term → mass

[illegible] a) weak int. のひろがり。

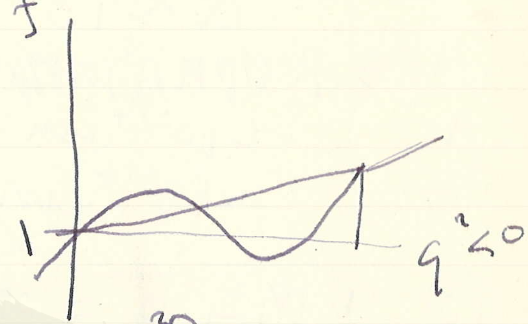
i) $\pi < {}^{e}_{\mu}$ ratio $\frac{f_e}{f_\mu}$

ii) $\mu \to e + \nu + \bar{\nu}$ $f_e f_\mu$

i) $f_\mu \sim 1\ y$ f^2

ii) $\rho_{\cdot} \geq \frac{3}{4}$ $(\rho \propto f'^{-2})$

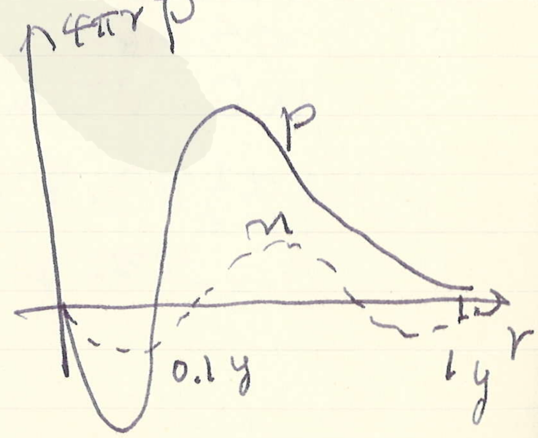
$\xi \leq 1$ $(\xi \propto f'^{-1})$



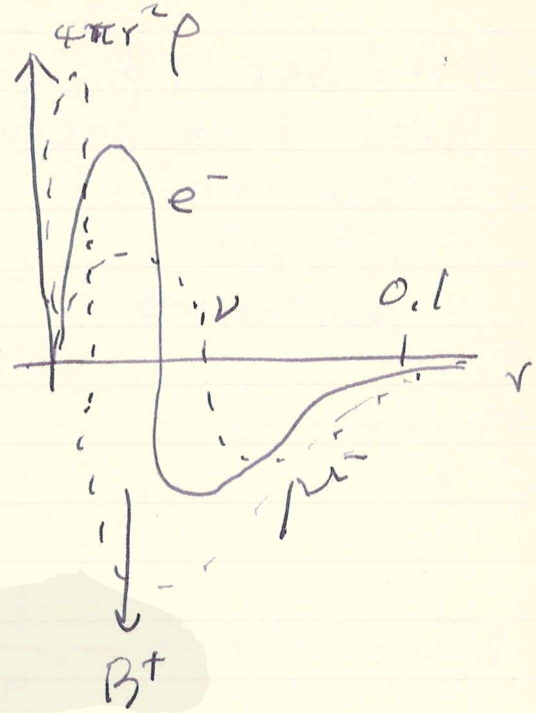
b) el. mg. のひろがり

Pauli term

ひろがり : 0.1 y



$B^+ \rightarrow \Xi$



gauge invariant

↓ ○ — 縦 photon

scalar photon

起源： W.I. のひろがり，

I, 素粒子の拡がり

II, 素粒子の S.I. の拡がり

III, 素粒子の W.I. の拡がり

$\mathcal{L} \simeq J_\mu J_\mu$

	r
$\mu \rightarrow e\ (\rho)$	0.17×10^{-13} cm
$R_K = \frac{K\nu e}{K\nu\mu}$	0.13
R_Λ (β-decay)	0.2
R_Σ (β-decay)	~1

第4回: Dec. 18

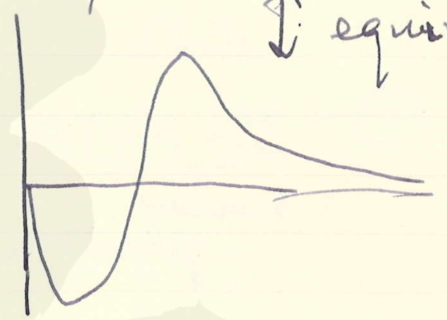
片山: Form factor

Nakano: K^0-K^+

Mathews

$\left(\frac{\partial\phi^*}{\partial x_\mu}\frac{\partial\phi}{\partial x_\nu}\right) F_{\mu\nu}$

↕ equivalent



$\lim_{q^2\to\infty} F(q^2) \to -\frac{1}{q^2}$

$j_\mu' A_\mu F_1$　　$\cancel{\left(\frac{\partial\phi^*}{\partial x_\mu}\frac{\partial\phi}{\partial x_\nu}\right)} F_{\mu\nu} F_2$

$F_1 + c q^2 F_2$

谷川: Weak Interaction の channel

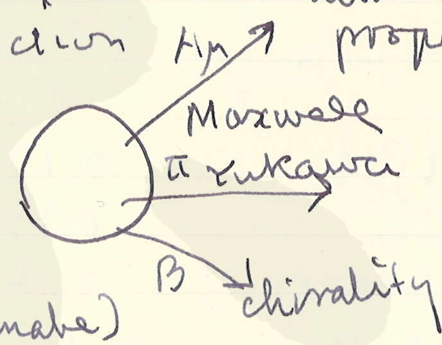
parity → 角分布

chirality

→ helicity

(Tanikawa-Watanabe)

↑ baryon number



baryon	B
A, π, K	lepton μ_+, e_-, ν

$N + B \rightleftarrows \nu$

$(1,0) + (1,1)$　$(0,1)$

$B\ (1,1)$

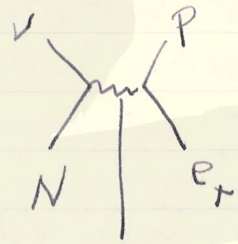
$B'\ (0,2)$　→ lepton

(K: $U_c = \frac{1}{\sqrt{2}}(U_s \pm U_p)$)

$\bar{\Lambda}(1-\gamma_5)\nu^c + \bar{n}(1-\gamma_5)\nu^c$ $B(1,1)$
$+ \bar{p}(1-\gamma_5)e^c$ β-decay

$\bar{\Lambda}(1-\gamma_5)\nu + \bar{n}(1-\gamma_5)\nu + \bar{p}(1-\gamma_5)\mu^+$
μ-capture
$B(1,-1)$

V−Aとの違い:



2300 m_e

renormalizable
marshak symmetry には入り難い

μ-decay: charged boson
$\mu \to e + \gamma$ は出ないですむ.
$K^+ \to \pi^+ + \nu + \bar{\nu}$?

湯川: I: non-local ; general relat. 回転運動
II: dichotomy continuum) trichotomy
素粒子の構造

我々まとめ
g.m.o. symmetry
N.N.G. scheme

(Sakata model
I.O.O. symmetry
M.S.Y. mass formula

Nagoya model

(0) charge の保存
Lorentz 不変性
(sub-macro)

L
B^+

① lepton 数の保存 ← charge exchange V−A

② saturation

mass ν, e^-, μ^-

$$\mathcal{H}_w = \sqrt{F}\left[(\bar{\mu} O_\mu \nu) + (\bar{e} O_\mu \nu)\right] V_\mu^+ + h.c.$$

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

(素粒子の模型と
μ中間子研究会
合同

Dec. 19.
夜： 模型まとめ
⋮
5. 励起型

午前：

μ研究会
Dec. 20: 日曜日
[illegible]： pair creation, a.m.m.
.. radiative K-μ-decay ...
μ-mesic hydrogen

$$x^2 = a^2 + b^2$$

$a \to p$, $b \to e, \mu$

level separation

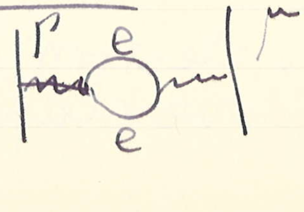
$$\sim c\,\frac{x^2}{d^3}$$

$$F_1 F_2 = \left(1 - \frac{a^2}{6} k^2 + \cdots\right) \times \left(1 - \frac{b^2}{6} k^2 + \cdots\right) = \left(1 - \frac{a^2+b^2}{6} k^2 + \cdots\right)$$

hydrogen { 2S-2P : 1057 Mc/sec
size effect -0.1 Mc/sec

size effect -9 × 10^5 Mc/sec
x = 0.8 γ } μ-mesic hydrogen
2S-2P: 2 × 10^5 Mc/sec

?
-4 × 10^7 Mc/sec
(recoil 2 × 10^4 Mc/sec)



level sep.	e	μ
size effect	10^4	40

— s　　— p

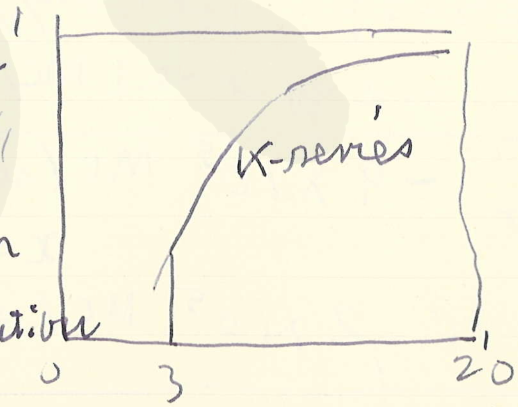
— p　　— s

4×10^7 Mc/sec → 10^{-3} cm(波長)

infrared
maser

嶋洒. μ-mesic atom
$Z \sim 20$ 　1%　実験精度
Zの小さい所で 精度が悪い
auger effect の効果が大きい

1. nuclear size effect
π : $Z \sim 10$
μ : $Z \sim 30$
2. vac. polarization
3. nucleus の polarization
4. electron cloud との overlapping



fine structure Z^4

$2p_{3/2} - 2p_{1/2}$ 0.55 MeV

e.d.m.

$n < 10^{-20}$ cm

$p < 10^{-15}$

$\mu < 10^{-15}$

$e^- < 10^{-13}$

$e^+ < 10^{-13}$

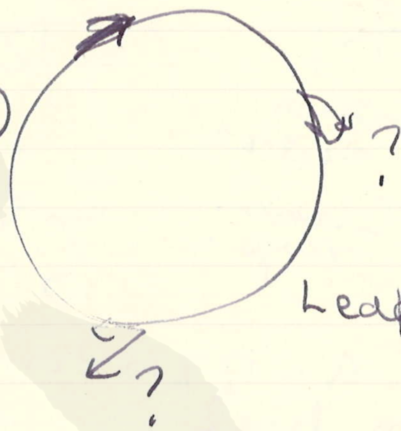
h.f.

$\to 10^{-16}$

g-2: μ a.m.m.

$2\left(1 + \frac{\alpha}{2\pi}(1.3 \pm 0.5)\right)$

$\frac{\alpha}{2\pi}\left\{1 + c\frac{m^2}{\Lambda^2} + \cdots\right\}$



?

Lederman

?

μ-e scattering

V, a

高エネルギー 散乱 $\sim \left(\frac{Ze^2}{\hbar c}\right)^2 \frac{1}{q^2}$ $\frac{k^2}{q^2}$

$\delta\sigma \sim (Va^2)^2$

低エネルギー 準位 $E \sim \frac{Ze^2}{R}$

$\delta E \sim V\left(\frac{a}{R}\right)^3$

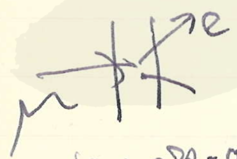
$R \sim \frac{\hbar^2}{2me^2}$

$$\frac{\delta\sigma}{\sigma} \sim \left(\frac{Va^2}{2e^2}\right)^2 (aq)^2 \quad \propto Z^{-2}$$

$$\frac{\delta E}{E} \sim \frac{Va}{2e^2}\left(\frac{a}{R}\right)^2 \quad \propto Z$$

$\frac{Va}{2e^2}$	10^{-2}	10^{-4}	10^{-6}
$\frac{\delta\sigma}{\sigma}$	10^{-4}	10^{-8}	10^{-12}
$\frac{\delta E}{E}$	10^{-6}	10^{-8}	10^{-10}

μ-e-scattering



knock-on electron

$\Lambda \sim 4\, m_\mu$

$E_\mu \gtrsim 2\times 10^{11}\,\mathrm{eV}$ $\qquad \sigma \propto E_\mu^{-1/2}$

$\sigma \sim 3\times 10^{-30}\,\mathrm{cm}^2$

Cosmic rays: $I_\mu \sim 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{sec}^{-1}\,\mathrm{sterad}^{-1}$

> 1 event/month

$a \sim 17\times 10^{-13}\,\mathrm{cm}$.

Carbon level

nuclear size effect $\qquad 10^{-3}$

isotope shift $\qquad 10^{-4}$

10^{-4} までいける.

Dec. 21:

後藤: Form factor による おさえ込み,

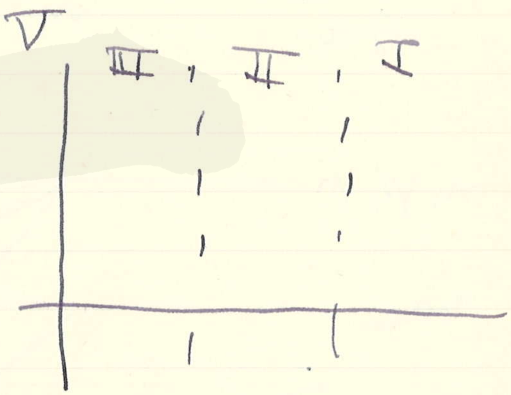
$F(p) = e^{-p^2/\lambda^2}$　　$\lambda \sim 10^{13}\,\mathrm{cm}^{-1}$

high energy limit ?

$\sigma \sim 4\pi \frac{p^2}{\lambda^4}$?

multiplicity

町田: deuteron の binding にも high energy limit がきいてる.



hyperfragment の binding

atom ?　$-\frac{e^2}{r}$

$\underline{\underline{Va^2}}$

positronium
$e^+ - e^-$　^3S
^1S

δ-potential
bind

武田: μ meson をどう考えるか.

exp: 1.001225 ± 0.000008 (~~Exp~~)

theory: 1.00116

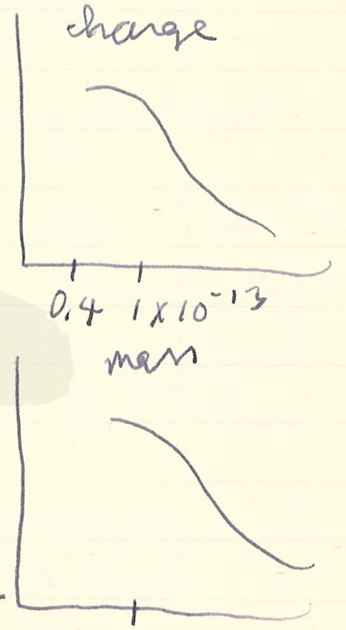
Kato, Takada, ~~素研 1月~~ 1959 vol 18. No. 5

μ mass

n, p　　charge
　　　　mass

$g_\pi = 0$　　m_0

g_π　　m



Tamm-Dancoff

$$m - m_0 = \frac{g_\pi^2}{4\pi} \frac{3}{\pi} \int^{k_0} \frac{dk}{\omega_k (m_0 + m + \omega_k)}$$

$$\sim 15 \times \frac{3}{\pi m} \times 4\pi \frac{k_0^2}{2}$$

$$\approx 90 \frac{k_c^2}{m} \qquad k_c \sim m_0$$

(μ, N)　　$G \bar{\mu} O \mu \cdot \bar{N} O N$

藤岡; B決定. X. process

x 1) direct に observe する

○ 2) e.m. process と競争させる
Burst

x 3) 吸収

1) μ の nuclear int. (たぶん無い)
3) μ と湯.

Discussion

藤本氏　Dec. 26, 1959

E. Minardi, Nuclear Physics 12 (1959), 35

Strangeness 2 Meson

T. Yamanouchi
P.R.L. 3 (1959), 480.

T. Yam. and M.F. Kaplon, P.R.L. 3 (1959), 283.
$-e$, -2, 700 MeV.

isotopic singlet
$$Q = \cancel{\tfrac{1}{2}} I_3 + \frac{S}{2}$$

particle +e +2 D^+ (Dubna?)
anti-particle −e −2 D^-

Nonlocal Interaction of local fields
Jan. 23, ~~1959~~ 60

1) { Bloch
Møller
片山
2) { Pauli
3) 内山
林

1) Lagrangian density は unique でない..
但し:
$$P_\nu(\infty) = \int_{t=\infty} T^4{}_\nu d^3x = \int_{t=-\infty} T^4{}_\nu d^3x = P_\nu(-\infty)$$
constant of collision
nucleon number:
$$Q(\infty) = Q(-\infty) \neq Q(t)$$
Hamiltonian formalism はないらしい.
$$u^{out} = S^{-1} u^{in} S \ ?$$

2) Pauli: Normal class form factor
(→ dynamically deformable form factor)
(Katayama: surface integral を つけたもの.)
canonical ~~set~~
energy-momentum ~~set~~ tensor for arbitrary time

3) 内山:
Schwinger variation principle
$$\frac{\partial}{\partial g}(\varphi' \infty | \varphi'' -\infty) = i (\varphi' \infty | \frac{\partial W}{\partial g} | \varphi'' -\infty)$$

$$W = \int_{-\infty}^{+\infty} L\, d^4x$$

$$\lim_{t\to\pm\infty} \varphi(x) = \begin{cases} \varphi^{in}(x) \\ \varphi^{out}(x) \end{cases}$$

$$\lim_{g\to 0} \varphi(x, g) = \varphi^{in}(x)$$

$$\frac{d(S^{-1})^{\dagger}}{dg} = i(S^{-1})^{\dagger}\frac{dW^{H}}{dg}$$

? $$\frac{d\varphi^{out}(x)}{dg} = i\left[\varphi^{out}(x) \cdot \frac{dW}{dg}\right]$$

Møller: Dynamics of particles with internal angular momentum

第1回: Jan. 30, 湯川.

[illegible]一 : Nagoya Model
Feb. 2, 1960

Sakata-model　P N Λ
I.O.O. symmetry　ν e μ
G.M.O.) symmetry
(Kiev)

Nagoya model

ν → P
e B粒子 N
μ → Λ

II kinematics

$\Lambda\Lambda\bar{N}\bar{N}$　$S = \pm 2$
$I = 0, 1$
$\sim 1700\, m_e$ ($\underbrace{1450 m_e}_{}$ exp.)
{Dubna
{Y. K.

neutral 中間子?

(1) lepton　四体結合の中に
(2)　→ B粒子
B粒子相互の int. energy.

$B-B$: $C\bar{C}$
$B-\bar{B}$: CC
$\bar{B}-\bar{B}$: $\bar{C}\bar{C}$
$C = -\bar{C}$　charge character

classical minimum energy $= M$

$$M = m_B(n_B + n_{\bar{B}}) - V_B(n_{B\bar{B}} - n_{BB} - n_{\bar{B}\bar{B}}) + \cdots$$

1800　3400

$\nu \xrightarrow{\text{e-charge (T, Ki)}} e, \mu$

$\downarrow$ B-charge (Nagoya)

$P \longrightarrow N \ \Lambda$

(1) $\nu, \tilde{\nu}$ mass 0, spin 1/2

e charge
B charge

(2) charge

(3) $\nu \to e, B \nrightarrow \bar{e}, \bar{B}$

l_0
?

田中正 : Indefinite metric

Feb. 6, 1960

一般論 :

Ascoli - Minardi

Uhlman :

Schlieder :

multi-mass

n. pair : Uhlenbeck

R. J. Phillips N. C. 1, 822 ('55)

[illegible]

Nagy, N. C. 10 1071 ('58)

dipole ghost

Lee model

Heisenberg

議題：流体模型

Feb. 13, 1960

Euler frame — 観測系から見た流体 — field aspect
Lagrange frame — 流体自身から見た流体 — particle aspect

U^μ $\qquad$ A_μ

$T_{\mu\nu}$ $\qquad R_{\mu\nu}$ $\qquad g_{\mu\nu}$

$\left.\begin{array}{l}\xi^k = \xi^k(x)\\ \xi^4 = t\end{array}\right\}$ trajectory の方程式

$\dot{\xi}^k = 0$ $\qquad \frac{D\xi^k}{D\tau} = U^\mu(x)\frac{\partial\xi^k}{\partial x^\mu} = 0$

$\frac{D}{D\tau} = \frac{1}{\sqrt{1-v^2(x)}}\frac{D\xi}{Dt}$

$\frac{\partial\xi^k}{\partial x^\mu} = A^k_\mu(x)$ $\qquad U^\mu A^k_\mu = 0$

$L^\mu_\nu(x)$ local Lorentz transf.

rest frame への

$U'^\mu = L^\mu_\nu U^\nu$

$(0,0,0,1)$

$\tilde{A}^k_4 \equiv L^\mu_4 A^k_\mu = 0$

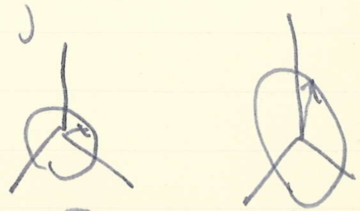
$\tilde{A}^k_j = L^\mu_j A^k_\mu$

$\xi^k(x+dx) = \xi^k(x) + A^k_j d\tilde{x}^j$

$d\xi^k = \tilde{A}^k_j d\tilde{x}^j$

$\tilde{A} = UDV^{-1}$

$\because A^T A = VD^2V^{-1}$



$AA^T = UD^2U^{-1}$

permutation a ambiguity
U, V : proper, rotation ters
even permutation

$$dx = A^{-1} d\xi = V D^{-1} U^{-1} d\xi$$

$$\Lambda^{R}_{\mu} = \cancel{K}^{R}_{i} D_i \Lambda^{R}{}_{\mu}$$

$$\rho(x) = D_1 D_2 D_3 \rho(\xi)$$

$$\frac{\partial}{\partial x^{\mu}} (\rho(x) U_{\mu}) = 0$$

$$\frac{\partial}{\partial x^{\mu}} (\Delta U_{\mu}) = 0$$

$$1 = \begin{pmatrix} 1 & & \\ & 1 & \\ & & 1 \end{pmatrix} \quad P = \begin{pmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix} \quad P^2 = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$$

$$\sigma_\nu \Lambda^{\nu}_{\mu} = Z \sigma_\mu Z^{\dagger} \qquad S(x) \xi_0 = \xi(x)$$

$$\sigma_i K^{k}_{i} = Y \sigma^{k} Y^{\dagger} \qquad T(x) \eta_0 = \eta(x)$$

$$\sigma_i P_{ij} = P \sigma_j P^{\dagger}$$

$$P = \pm \begin{pmatrix} \frac{1+i}{2} & \frac{1-i}{2} \\ -\frac{1+i}{2} & \frac{1-i}{2} \end{pmatrix} \to \begin{pmatrix} e^{\frac{i\pi}{3}} & \\ & e^{-\frac{i\pi}{3}} \end{pmatrix}$$

$$u_+ = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \qquad u_- = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

$$\xi_0 = \begin{pmatrix} u_+ \\ \sigma_2 u_- \end{pmatrix} \qquad \eta_0 = u_+$$

$P: \xi'(x) = e^{\frac{i\pi}{3}} \xi(x)$

$\eta'(x) = e^{\frac{i\pi}{3}} \eta(x)$

$\bar{\xi} \gamma_\mu \xi = U_\mu$ $\qquad \bar{\xi} \frac{1+\gamma_5}{2} \xi = 1$

(unimodular)

$= \mathrm{Det}\, Z$

$\bar{\zeta} \gamma_\mu \zeta = \Delta \cdot U_\mu = j_\mu \qquad \zeta = \sqrt{\Delta}\, \xi$

Lorentz: spin

Lagrange rotation: isospin

permutation: strangeness

$1, \quad e^{\pm \frac{i\pi}{3}}, \quad e^{\pm \frac{2i\pi}{3}}$