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京都大学基礎物理学研究所 湯川記念館史料室

N15

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Research Institute for Fundamental Physics
Kyoto University, Kyoto 606, Japan

NOTE·BOOK

研究日記

Jan, 1948 ~

XV

s04-08-21

11月17日(土) 三四巻 物理学

宇藤 隆夫 Radiation Damping

$\frac{v_0}{\lambda} < 1$ Lorentz $\frac{2}{3} \frac{e^2}{c^3} \ddot{v}$

Heider, Wilson.

宇藤 - 隆夫. 理論物理学.

宇藤 R: On the Origin of the Soft Component of Cosmic Radiation.

(Phys. Rev. Aug. 15, 1947, 72, 266)
 Heider and Power.

Rocket experiment in primary γ rays
 ~ 10 70% of proton, 3% of γ rays
 ~ 15.2 lead γ rays from proton.
 従って primary electron γ rays ~ 10
 30% 以下 γ rays. 従って soft component
 の起源は γ rays の secondary origin
 の γ rays による γ rays である.

M, H, P,

M, W

M, P

ΔE

M, γ

\downarrow

M, γ'

\downarrow

M, γ'

(I) $E \ll E$

(II) $E - E' \ll M$

Janovsky: \rightarrow の nucleon or
 \rightarrow の π meson or γ rays
 の可能性がある.

その結果 soft の max の
 depth の 深さ (厚さ) は γ rays とは
 異なる。

2. Cross sections for Meson Production

transverse meson, pseudoscalar meson

$$\Phi_{\text{tNR}}^{\text{I}} d\varepsilon = \frac{8}{3} f^2 (D_t + D_p) \frac{d\varepsilon}{\varepsilon^3} \left(1 - \frac{\varepsilon}{M}\right)$$

$$\frac{1}{f} < \varepsilon < \frac{M}{2}$$

$$\Phi_{\text{tER}}^{\text{I}} d\varepsilon = \frac{16}{3} \frac{f^2}{M} D_t d\varepsilon \left[\frac{1}{\varepsilon^2} - \varepsilon \left(\frac{\varepsilon}{M}\right)^3 \right]$$

$$\frac{M}{2} < \varepsilon < \frac{M}{2}$$

$$\Phi_{\text{tNR}}^{\text{II}} d\varepsilon = \frac{4}{9} M f^2 (D_t + D_p) \frac{E - \varepsilon}{E^2} \left[\left(f^3 - \frac{8}{M}\right) \frac{d\varepsilon}{\varepsilon^3} \left(\frac{\varepsilon^3}{M} - 1\right) \right]$$

$$\Phi_{\text{tER}}^{\text{II}} d\varepsilon = \frac{32f^2}{M} D_t \frac{d\varepsilon}{E^2} (E - \varepsilon) \left(\frac{E - \varepsilon}{M} - 1\right) \quad 1 <$$

$$f^2 = 0.13$$

$$c = \hbar = \mu = 1$$

unit length,
 $\approx 3.2 \text{ cmHg}$

$$\left(\frac{\hbar}{\mu c}\right)^2 = 4.3 \times 10^{-26} \text{ cm}^2$$

$$\mu c^2 = 0.94 \times 10^8 \text{ eV}$$

$$1 \text{ atm press} = 29.$$

meson scattering

$$\Phi_{\text{tER}}^{\text{I}'} d\varepsilon =$$

$$\left(\frac{M}{2} < \varepsilon < \frac{E}{2}\right)$$

$$\Phi_{\text{tER}}^{\text{II}'} d\varepsilon =$$

$$(1 < \varepsilon < E)$$

3. Total Number of Electrons Produced

4. Cascade Multiplication

Difficulty: east-west α vs β ...
手廻り. angular spread α or β ..

$$1 < \epsilon < \frac{2E}{Mf}$$

$$\frac{2E}{Mf} < \epsilon < E$$

$$\epsilon < E - M$$

n)

1923rd (金)

研究会 懇話会 第一回

素粒子論の問題分類

- a) i) Subtraction Method
ii) λ -limiting process
iii) S -matrix theory
iv) Super-many-time theory
v) space quantization
vi) Generalized Field.
- b) i) mixed field theory, two meson theory
ii) meson pair theory
- c) i) cosmic ray analysis
ii) neutral loss
iii) meson decay
iv) neutron-proton, proton-proton interaction
v) β -decay

即同の. 箱本の, 水素の, 陽子の, 中性の,
電子の.

即同の.

β -decay Damping の 33%

箱本の.

δ -matrix

Blatt, P.R. 72, Sept.

$$(\Delta + k^2)\varphi = L\varphi$$

$$\varphi = \varphi_{inc.} + \varphi_{scat.}$$

Heider $\varphi_{scat.} = \varphi_{rad}$

$1/24^N(I) \equiv \text{同の } 23\%$.

M.R. 13, R. 1. simple characteristic of
a finite group

2. Direct product

3. Principal characteristic of the
symmetric group on n letters

4. simple character^{in the} of symmetric group.

予取 予取 [予取]

橋本 芳 氏.

I. Bloch, Production of Mesotrons in
the Stratosphere Phys. Rev. 69 ('46)
575.

I. Introduction

Proton Primary Hypothesis

$$p_0(\epsilon) = N_0 \epsilon^{-2.9}$$

$$\epsilon > 2.5 \times 10^9 \text{ eV}$$

$$\sigma = \pi r_0^2 Z^2 \approx 2.5 \times 10^{-25} \text{ cm}^2$$

meson-production

multiplicity 9.

$$\frac{9 \times 9}{9 \times 9}$$

$$\tau_0 = 2.15 \pm 0.07 \mu \text{sec.}$$

予取

Stanton, Phys. Rev. 66 48 ('44)

Swann versus M.H.P.

II. Theory

1. Proton Flux as a Function of
Altitude

$$p(z_0) = p_0 e^{-\alpha z_0}$$

$$p_0 = 1.970 \times 10^{-3} \text{ gr. cm}^{-1}$$

$$\alpha = 1.550 \times 10^{-6} \text{ cm}^{-1}$$

$$p(\epsilon, z_0) = p_0(\epsilon) \exp[-\alpha \exp(-a z_0)]$$

$$\alpha = \frac{6.03 \times 10^{23} \times 2 \rho_0 \theta}{29a} = 13.2$$

2. Spectrum of Mesotrons at Points of Production

3. Spectrum of Mesotron at Any Height
 maximum

4. Mesotron Spectrum at Points of Altitude

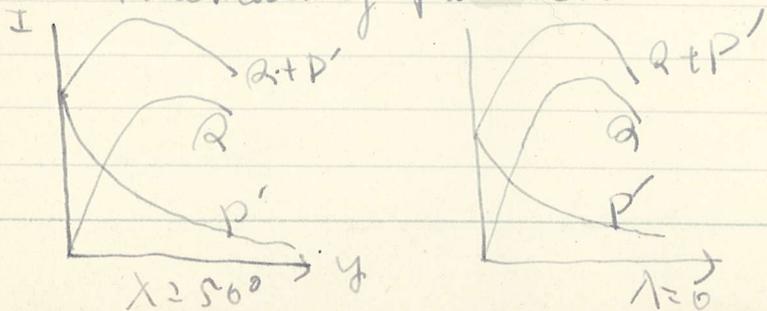
5. Latitude Effect

$$E^* = 2.39 \times 10^{-2} \cos^4 \lambda$$

$$F_0^* = \frac{E^*}{g}$$

6. Integral Mesotron Spectrum

7. Integral Spectrum for all Penetrating Particles



8. Intensity of Cosmic Rays Underground.

III Discussion

1. Total Number of Penetrating Particles
as function of Altitude

Strood and Schein, Phys. Rev. **67**, 62 (45)

2. Absolute Number of Primaries

3. Latitude Effect

4. Indication from other experiments
 $\epsilon > 2 \times 10^9 \text{ eV}$ $N_0 \epsilon^{-2.9}$ multiplicity
 $\epsilon < 2 \times 10^9 \text{ eV}$ $\frac{1}{2}$ of $B \sim 4$.

⊙ transverse meson

2月6日 (火)

研究所 湯川記念館

場の理論) Generalized Field

場の理論: Damping Theory of Tanihara

2月11日 (土)

≡ 10¹⁶ cm⁻¹

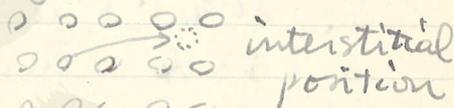
場の理論: 湯川記念館と 10¹⁶ cm⁻¹

~~NaCl KCl~~

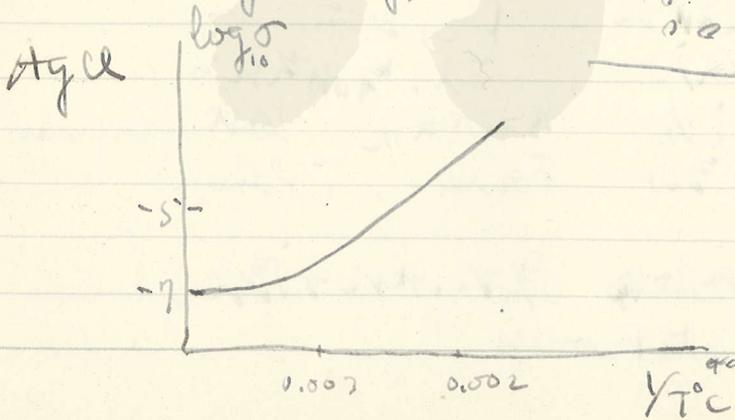
$$\sigma = 10^3 \sim 10^6 \text{ ohm}^{-1} \text{ cm}^{-1}$$

NaCl 10^{-16}

Fehlerrangsthermscheinung
 Frenkel's Type



Shockley's Type



2/1 理論物理学
場論：中核子理論の最近の進展

2/14 (土) 理論物理学
高野 敬一郎：Heisenberg S-matrix. II.

2/15 理論物理学
金井 英三郎：新理論反応の理論

1. 序論
2. 遷移子算
3. 遷移子算の解法
4. 理論の数学的構成
5. 核素反応・原子反応の適用 (遷移子算の比較)
6. 理論の適用比較

参考文献

- §1. ① 一階微分方程式 { a) 一次方程式
② 二階微分方程式 { b) 二次方程式
③ 非線形方程式 { c) 三次方程式
d) 非線形方程式

A. 遷移子算の理論 $k = x k_{rel}$ Eyring
B. 遷移子算の理論 Fowler, Tolman

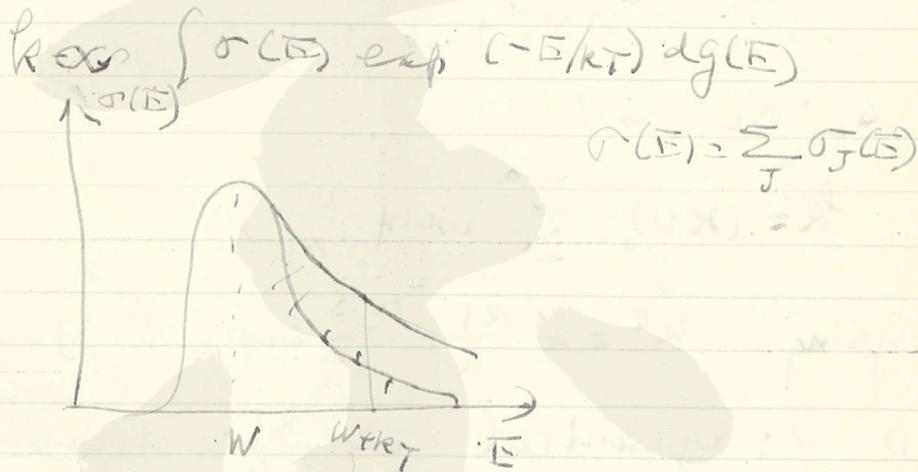
A. 理論：核素反応論 (高野, 湯川, 湯川)
Eyring: Rate Process

15. Fowler, Statistical Mechanics ch. 18.

- (i) 分子の衝突
- (ii) 衝突の方法
- (iii) 在場分子

極速論 $\frac{H.L}{E.W}$ 定常論
 速速論 $\frac{E.W}{?}$ 衝突論

§2. $k = k_0 \exp(-W/kT)$



§3. Bohr's Theory of Nuclear Reaction

① 粒子 \rightarrow 原子核力
 ② $\lambda \text{ 核} \ll \text{核} \text{ 核} E$

Hilshfelder, Gyring and Topley, J.C.P. 4 (1930) 120.

Activated Complex

vibration frequency \ll life
 10^{14} sec. 10^{-13} sec.

mean time between collisions: 10^{-10} sec.
 ($0^\circ\text{C} - \sqrt{1/2}$)

\therefore a.c. \sim ~~...~~

§4. Gamow-Breit



$$\Psi = \sum \lambda_a(A) \lambda_{bc}(BC) \psi_{s,l}^{A,BC} \times r_a^{-1} f_{a,bc;s,l;T,T_0}(r_a)$$

$A_a; BC_{bc} \rightarrow N$

$$k = (\kappa v)_{av} \frac{\sum^a}{\sum^i} \exp\left(-\frac{W}{kT}\right)$$

spring $k^E = \kappa \frac{kT}{h} \frac{\sum^a}{\sum^i} \exp\left(-\frac{W}{kT}\right)$

(1) v : dynamical $\Leftrightarrow \frac{kT}{h}$: statistical

(2) κ : ~~...~~ $\Leftrightarrow \kappa$: ?

§5. Ortho-Para Conversion

by ~~...~~

Pelzer, Wigner

$$v \approx \frac{\omega_0}{8} \quad \kappa \approx \frac{1}{4} \quad [= \frac{1}{4}]$$

h	h^E	obs.	
1.8×10^{-7}	2.3×10^{-7}	2×10^{-7}	$250^\circ K$
1.1×10^{-12}	1.5×10^{-12}	2.2×10^{-12}	$1500^\circ K$

§6. 理論の適用例等.

2月20日(金) 新発見・研究会

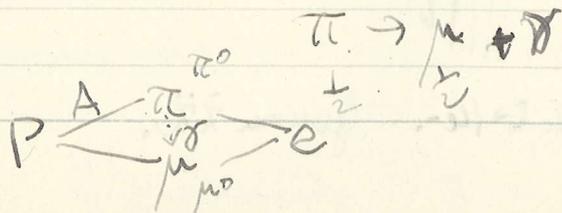
出席者: 湯川氏の letter 等.

Nehe-Oppenheimer の ~~論文~~ 論文を改題して
 Z. Meiler の Damping Theory を基礎として
 した.

Blatt, Damping & Inertia (P.R. 12, Nr. 6)

⑩ P-R. Eli C. Gerasimatos, Eliezer,
 The Interaction of Electrons and
 an El. Mg. Field
 (R.M.P. 19(47), 148).

⑪ ~~論文~~ π : $\pi \rightarrow \mu + \mu^0$
 $\frac{1}{2} \quad \frac{1}{2} \quad 0$



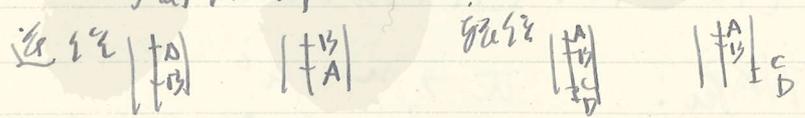
甲 2月20日(金) 午後5時の 学生会
 加藤の日記、本屋、天野、小野、市川、田中
 徳田御宿、生物進化論
 銀の分帳、
 物 亜物 数物、
 数量の遺傳

gene mutation: 加藤、進化の階梯として
 (chromosomal mutation 改造)
 遺傳 — マンデルの法則 — 人為的交配
 中間型 (世の類) — 自然の交配
 連続数量 — 分類不可能
 (不連続数量) — 分類可能



小の類 = 系統の相違
 Blakistonの法則 = 古地理学的

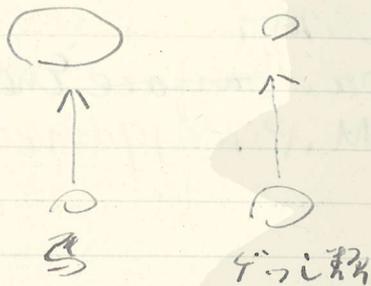
chromosomal mutation: 物、亜物の減色と
 量的相違



position effect

本屋、本屋、Genom 説、

進化の過程を origin 流明のり



relative growth (個体成長)
 house: face length = 0.3 * (skull length)^{1.2}

高知の進化 = Eohippus (初期の馬)
 special: 高知の進化
 general: 高知の進化
 simple complex

neotony (高知の進化)
 人間 → general (高知の進化)
 塔生の初期の進化を表現する
 Keimgangs mutation
 vestigial (退化) → relative growth

小即花洗 — 天変地異論

Darwinism

Lamarckism — 此の世に可成

Radiation の作用, 環境の作用,

- 1) gene mutation, 此の世に可成
- 2) probability の変化

2/21th (土)

量子力学講義. 7/1/47

Feenberg, Nuclear Surface Energy
Surface (R.M.P. 19(1947))

3/25th (金)

量子力学講義. 7/1/47

Sebe, Infrared Catastrophe in the
Problem of Electron Scattering

$$\left\{ \frac{p^2}{2m} - \frac{e}{mc} (\vec{A} \cdot \vec{p}) + \frac{e^2}{2mc^2} A^2 - E \right\} \Psi = 0$$

$$\Psi(\vec{p}) = \left[\varphi(\vec{p}) \Phi_{\text{rad}}(0) - \int_0^{q_{\text{max}}} C q^{-3/2} \varphi(\vec{p}-\vec{q}) \varphi(\vec{q}) \times \Phi_{\text{rad}}(\vec{q}) dq \right] \frac{1}{1+R}$$

$$C = \frac{e}{2\pi \hbar^{3/2} mc^{3/2}}$$

$$q_{\text{max}}^* = \frac{p^2}{2m}$$

\tilde{R} : normalization factor

Eliezer, R.M.P. July 1947 19, 148.
Chapter IV. Q.E.D.

3(19)日(火)

午後2時半 中子物理学研究会
榑部知、岡本、谷山、小林、井上、

(櫻村、八束)

1. 中子物理学の起源

石井

2. 一次中子物理学の発展

中子物理学の全エネルギー

陰子

3. 生成法と検出法

石井

石井

4. 中子物理学理論との関係

中子物理学の発展

中子物理学と原子核との相互関係

5. 中性粒子の問題

中性粒子の検出

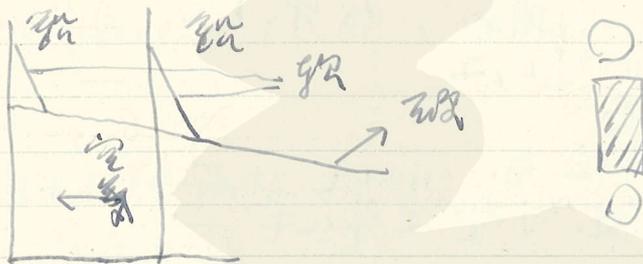
6. 中子物理学の発展

Oppenheimer 説, Jan. 15, 1948.

3/19 10日 (水) 午後一時 物理学会

関川博士の報告: 宇宙線研究の現状

A. 宇宙線の二次作用の研究 (素粒子物理学の研究)



1. 組成成分 → 軽粒子

光子: 中間子の自然崩壊

中性化損失 - 中性粒子

$$\frac{1}{2} \sim \frac{1}{3}$$

* Neutronumdektion?

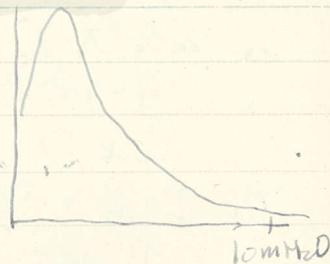
(- 成分)

air shower (1000 m)

burst

早い方の観測

高精度から観測?



2. 組成成分 → 中間子

光子: none

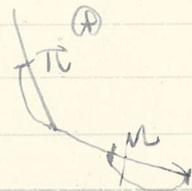
電子

吸収

± C-Pb

中間子観測

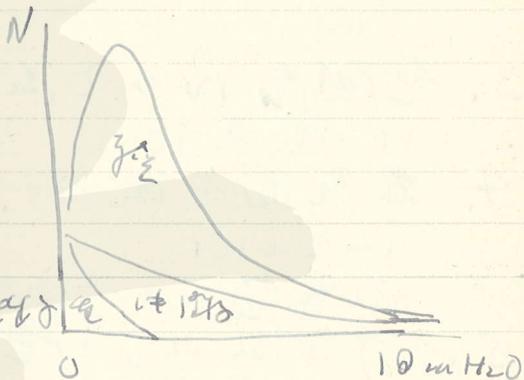
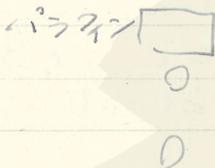
μ -decay: $10^{-6} \sim 10^{-11}$ sec



中性中子
解也; 電粒子から



4. 一次線 → 電粒子
陽子



3. 電粒子成分 → 陽子・中性中子

陽子

東西效果, 緯度效果,

V-2 流: original cosmic ray?

13. 一次宇宙線の研究 (宇宙物理学の問題)

起源

途中 一層層

1. 地球大層の形成

形成
形成

二次理論の散乱

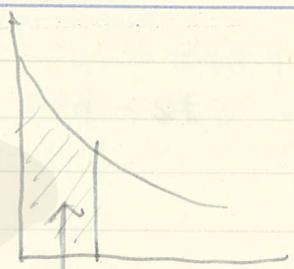
2. 地球磁場の形成 eccentric dipole

緯度效果

東西效果

南北效果

charge
energy spectrum
fine structure
Millikan



3. 電離層内の電流の形成
日周変化 max: 14 hour o'clock
4. 赤道面電流環 equatorial ring current

5. 磁気嵐 → 宇宙線減少
宇宙線減少は地球環境
悪化の要因

6. 太陽磁場の形成
allowed cone の変遷 — 日周変化
宇宙線の急激増加 — 磁気嵐

7. 太陽地球現象としての宇宙線
太陽面の急激な活動 → 宇宙線急激増加(14%)
(極地の観測)

8. 銀河系の形成
Compton-Getting 現象の一日変化
磁気嵐発生 Blackett

9. 宇宙線の起源
1. 加速説 電磁誘力 (古来の説)
2. 原子核崩壊による説明

3. 宇宙の流明、
増加。
143 表 14 伸 3 層 5

3月12日(金) 研究会 総演習

核子. Element abundance
Weizsäcker, Phys. ZS. 39(1938), 633

Chandrasekhar & Menick, AP. J.
95(1942), 288.

Klein, Beskow, Arkiv. f. Math. Astrofysik
33(46), 1.

Lattes, Wataghin, P.R. 69(46), 237
70(46), 430

Gamow, P.R. 20(46), 572

Wataghin, P.R. 73(48), 29, 80.

" P.R. 66(44), 149.

Gamow: neutron capture non-equilibrium theory

Wataghin: equilibrium theory
photon
electron \pm
nucleon - nucleus

i (核子) p_s (光子) n_s^i E_s^i A^i Z^i M^i

$$n_s^i = \frac{g_s}{e^{Z^i \alpha + A^i \delta + E_s^i / \beta} + 1} = n_s^i(p_0, p_0)$$

$$g_s = \frac{8\pi}{h^3} p_s^2 dp_s \times (\text{spin factor})$$

$$\times (\text{excitation factor})$$

$$\sum_i \sum_s Z_s^i n_s^i = 0$$

$$\sum_c \sum_s E_s^i n_s^i = \rho_{00} c^2$$

$$\sum_i \sum_s A_s^i n_s^i = \rho_0$$

(M_H)

$$p^i = \frac{1}{3} \sum_s n_s^i p_s v_{p_s}^i = p^i(\rho_0, \rho_{00})$$

$$= \frac{1}{3} \rho_{00}^i c^2 \quad (\text{ext. rel.})$$

n

$$\sum_s E_s^i n_s^i = \rho_{00}^i c^2$$

$$n_s^i \sim e^{-2\alpha - A\sigma - \frac{M_s^i}{kT}} \left(\frac{2\pi M_s^i kT}{h^2} \right)^{\frac{3}{2}}$$

$\log n_s^i$

2
0
-2
-4
-6

$kT = 40 \text{ MeV}$

Time: 10^9 yr

$\rho_0 = 10^{13} \text{ g/cm}^3$

$\alpha = 1.5$

$R_0 = 10^{13} \text{ cm}$

50 100 150 200 $A \rightarrow$

本: excitation fun $\sum_n e^{-E_n/kT}$

liquid drop model
 $\propto 0.14A^{2/3}t^{2/3} + 0.0035At^3$

$$t = \left(\frac{T}{10^{10}}\right)$$

expanding universe: gamma

$T > 50 \text{ MeV}$ $n \bar{n}$ neutron $\nu \bar{\nu}$
 $n + \bar{n} \rightarrow p + \bar{p}$ capture \bar{n}
 capture & decay a competition

$$\frac{1}{l_0} \frac{dl_0}{dt} = \sqrt{\frac{8\pi}{3} \rho_{00} + \frac{\Lambda}{e g(t) 3} - \frac{1}{R_0^2} \left(\frac{l}{l_0}\right)^2}$$

$$ds^2 = - \frac{c^2 dt^2}{\left[1 + \frac{r^2}{R_0^2}\right]^2} (dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2) + dt^2$$

$$\rho_{00} \approx 10^{-30} \text{ g/cm}^3$$

$$10^{-37} \text{ sec}^{-2}$$

$$10^{-34} \text{ sec}^{-2}$$

$$\rho_{00} \propto \frac{1}{l_0^3}$$

$$\rho_{00} = 10^{13} \text{ g/cm}^3$$

$$T_{\text{exp}} = \frac{l_0}{c} = 5 \times 10^{-4} \left(\frac{10^{13}}{\rho_{00}}\right)^{1/2} \text{ sec}$$

$$\tau_{\text{cap}} \approx 10^{-16} \text{ sec.}$$

$$\tau_{\text{d. cap}} \approx \frac{1}{\rho c} = 5 \times 10^{-3} \left(\frac{mc^2}{W} \right)^2 \text{ sec.}$$

W : neutrino energy

$$\frac{d}{dt} (\rho \omega d^3) = -\rho \frac{d}{dt} (d^3)$$

3/11/94 (金)

研究員 湯川記念館
 研究員 湯川記念館

Radiation Damping Theory
 and the Propagation of Light

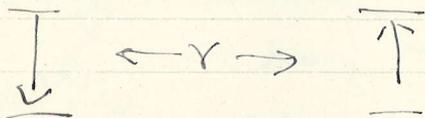
B. Feretti and R. E. Peierls
 (Nature 160 (1947), 531)

Heitler, Quantum Theory of Radiation

2nd ed. 1949

$$K \left(1 + \frac{1}{2} R \right) = \frac{1}{2\pi c} R$$

$$\sum_{n=0}^{\infty} T^n H' = K$$



non-vanishing first term } direct trans.
 round about trans.

3/18 23rd (土)

物. Pauli, Meson Theory of Nuclear Forces, 論文, 第一回. *edition*
Chap. I, II.

3/18 26th (火) 研究室・懇話会.
陸永凡

On the Heitler theory of radiation damping

J. M. Blatt, Phys. Rev. 72 (1947), 466

$$H' + H' \bar{R} \mp \frac{1}{2\pi i} T R + \frac{1}{2\pi i} R$$

$$(\bar{R}) = (R) \delta(E_q - E_0)$$

$$(q|T|q') = \frac{(q|H'|q')}{E_0 - E_{q'}}$$

$$= \frac{1}{2\pi i(E_0 - E_{q'})} + \frac{1}{2} \delta(E_0 - E_{q'})$$

(Weitzel:

§ 1. Introduction

§ 2. Classical derivation of Heitler's eq.

$q_{scat} \sim q_{rad}$

$$\sim \frac{1}{2} \left[f(\omega \leftarrow \omega_0) \frac{e^{-ikr}}{r} - f(\omega \leftarrow \omega_0) \frac{e^{ikr}}{r} \right]$$

§3.

§4. Examples

1. Scalar meson, extended source model & Heitler model method of R. J. G.

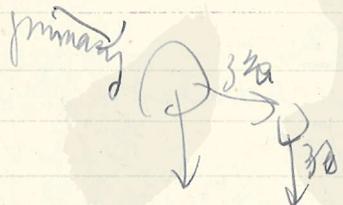
3/13 30th (4)

参考 Pauli, meson theory 第 2 卷
第 12 章, Chapter III.

7/17 17th (±)

理論研究会, 全井君.

Multiple Production of Mesons
Lewis, Oppenheimer, Wouthuysen,
Phys. Rev. 23 (1948), Jan. 15.



10¹⁰ eV 参考 — 3卷) structure (meson or nucleus)
参考 — 3卷

{ Weisskopf, nucleus a long life metastable state.
Marshall-Bethe, two meson metastable meson observed meson

exchange force

neutron magnetic moment

Felix Villars, 23 (1947), 256

virtual current

meson Production

- 1) cross-section \sim nuclear dimension (10^{10} eV)
 - 2) multiplicity ~ 5
- 1) 造方の特徴: spin, isotopic spin が 無い, 陽子中子
の 数比が 無い, 元の 陽子中子として 放射される.
- 2) multiple, 陽子中子 1 個の, 数比が 1:1, 陽子の
中子 1:1 の 場合 (pseudoscalar, vector)

中子 \rightarrow soft comp.

Mills, Christy 11, 225 (1947)

$\lesssim 10^{-12}$ sec

\geq collision time

reaction of μ meson

Block, Nordstreck 52

- 1) collision time \ll radiation period
- 2) radiation reaction \sim 電流の
- 3) 電流 \sim 電場の 2 倍の 大きさになる.
- 4) 衝突前の 陽子中子 と 衝突後の 陽子中子.

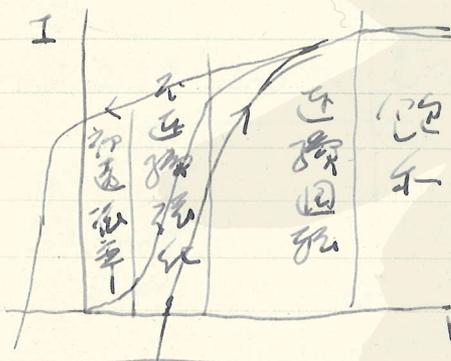
cross-section

10^{-26} cm² per nucleon

反応物?

II. Bloch-Nordsieck Method
 A. Symmetrical scalar Theory
 B. Symmetrical pseudoscalar Theory

4/1 22日(木) 物理力学講座
 高木繁吉氏. 磁気的現象.



遷移磁気的現象
 飽和 " "
 加速 " "

磁気的現象

Ewing
 Langevin
 Weiss

model 実験
 為磁性的の理論
 分子磁気的

$$H = H_{eff} + gI$$

$$gI \sim 10^6 \text{ Oe}$$

Barkhausen

磁気的現象

$10^{-3} \sim 10^{-5} \text{ cm}$

磁気的現象

Edwards - Webster

磁気的現象の磁化

inhibitory

(Kaya)

磁気的現象の磁化

Nickel, Cobalt

1915 Einstein - de Haas
 Gyromagnetic effect - electron spin

1928 Heisenberg
 Exchange energy

磁歪

$$\frac{\Delta l}{l} \lesssim 10^{-5}$$

Joule 効果

transverse effect

Wiedemann 効果

Heisenberg 効果

Skulov

Weber 効果

Takagi

Kaya 効果

$$I_R = \frac{I_S}{\beta_1 + \beta_2 \tau / \beta_3}$$

Murakawa

Skulov - Becker

Van Vleck

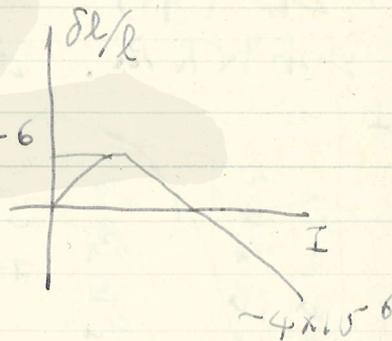
energy

Katayama

Brooks

isotropy -

効果



鋼のσ = 2.4

Becker internal stress

N_i $\rho^2 - \rho_{12} \uparrow$

Kaya Murefeld 2019 論文

鋼素鋼 $\sigma_i < 4\%$

4月 23日 (金) 研究費-研究費

田中 Pn. Self energy - scattering
 meson theory

斎藤 Pn. Pair theory in π meson β -decay

$N \rightarrow \gamma^- + p$ strong process \sim の damping
 $\nu \rightarrow \gamma^+ + e$ $\sim \frac{1}{2} \frac{1}{2}$

$$A_f = (f|H|i) - i\alpha \int (f|H|f') \rho_f A_f d\Omega$$

single meson theory:

$$|A_f|^2 = \frac{|A_{f0}|^2}{1 + \kappa f(k-l)}$$

$$\kappa = \frac{f^2}{\hbar c} \left(\frac{m^2}{m_n} \right)$$

meson pair theory:

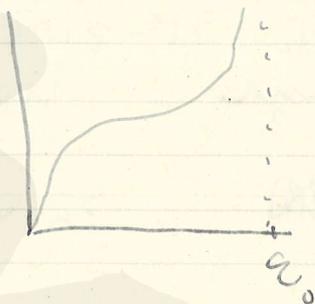
$$A_{f0} = \dots I \int \dots + \dots J \int \dots$$

$$A_f = \frac{A_{f0}}{\dots I \dots + \dots J \dots}$$

$$\rho(\epsilon) d\epsilon = \frac{2\pi}{\hbar} k^3 k l^2 \int (A_f)^2 \rho_f d\Omega$$

$$\frac{1}{M^2} f(p) \quad p = |\vec{k} - \vec{l}|$$

$$P(\epsilon) d\epsilon = \frac{2\pi}{h} k_0 k |\vec{M}|^2 \left(\frac{1}{\epsilon^2} + \dots \right)$$



2012 R

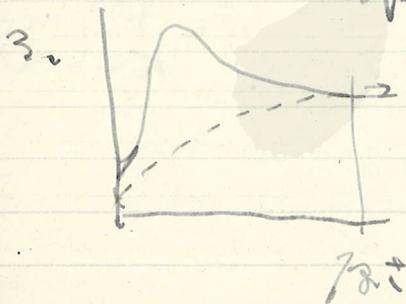
40

on the Neutral Meson in Cosmic Rays

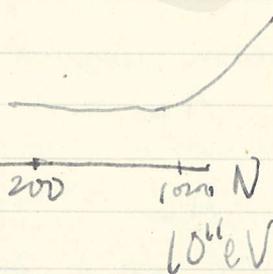
K. I. Greisen

P.R. 72 521 '48

1. Anderson meson decay
2. 地下の meson absorption
3. $\pi^0 \rightarrow \gamma + \gamma$ 過程
4. giant air shower
5. 中性の electron spectrum と meson spectrum の関係



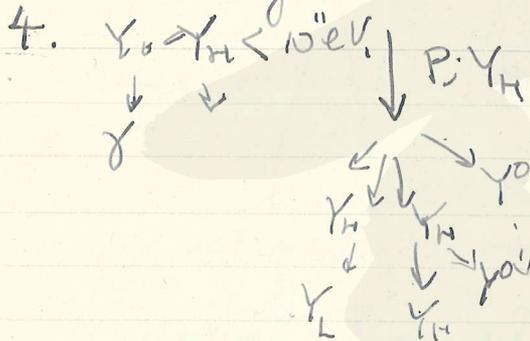
$$\frac{F_{\pi^0 \rightarrow \gamma\gamma}}{F_0}$$



proton primary or heavy meson or
 nucleon \rightarrow π^+ \rightarrow meson group π^0, η^\pm
 \rightarrow η, η' , Υ^0 or Sakata Process \rightarrow ρ, ω, ϕ .
 or or baryon origin etc.

Υ_H a type of $\Xi, \Sigma, \dots \rightarrow \pi$ or η or ω .

Mill-Christy
 Tomonaga
 Schein-jesse-Wollan



4/24 W (土) 早稲 - 木 幸

1. 林 正, Lewis-Coppensheimer 論文

III. Perturbation method

A. Neutral Pseudoscalar

B. A Pair Theory

IV. Some Applications

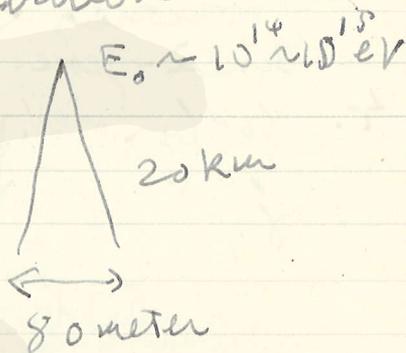
A. Angular distribution

muon shower

B. Primary Spectrum

C. Positive Excess
 $\propto E^2$

D. Range of Fields and Distances
Involved



{ Lewis - Epstein
Tomonaga, Progress
Lewis On the Reactive Terms in
Quantum Electrodynamics
On the Radiation Reactions in
Collision Processes. I (Prog.)
Tomonaga and others

Application of Self-Consistent subtraction method to the elastic scattering of an electron.

{ inertial effect
 radiative effect } → reactive term
 mechanical mass perturbation mass

$$\delta m = \frac{3e^2 m}{2\pi} \int_0^\infty \frac{dk}{k} \quad (\text{Weiskopf})$$

+ finite term

(P.R. 56 (1959), 72)

$m + \delta m =$ experimental mass = m_0
 phenomenological theory

Counter Self-Energy Term

$$-\delta m \int \psi^* \psi dx$$

Conservative subtraction method

Dancoff, P.R.

mass type

$$\frac{\delta \sigma}{\sigma_0} = -\frac{3e^2}{4\pi} \int_{l \neq 0} \frac{dl}{l} + \frac{3e^2}{2\pi} \frac{m^2 (p-q)^2}{\{E^2 + p \cdot q + m^2\}}$$

Polarization type

$$\int_0^\infty \frac{dk}{k} + f.t.$$

Mass Type
 Tomonaga

$$\frac{\delta\sigma}{\sigma_0} = -2\delta m$$

$$+ \langle \psi, \psi \rangle$$

$$= \frac{1}{4\pi} \delta m \frac{m^2 (\rho - q)^2}{E^2 \{ E^2 + (\rho - q)^2 + m^2 \}} \int_{-\infty}^{\infty} \frac{dk}{k}$$

$$\delta m \approx \frac{ze^2}{3\pi} \int \frac{dk}{k} + \text{f.t.}$$

system

$$\frac{\delta\sigma}{\sigma_0} = \frac{1}{\sigma_0} \frac{\partial\sigma_0}{\partial m} \delta m$$

$$\sigma_0 \propto \frac{E^2 + (\rho - q)^2 + m^2}{E^2}$$

$$\delta m - \delta m = O(e^4)$$

$$\therefore \frac{\delta\sigma}{\sigma_0} = \frac{m(\rho - q)^2}{E^2 \{ E^2 + (\rho - q)^2 + m^2 \}} \delta m$$

$$= -\frac{3e^2}{2\pi} \int \frac{dk}{k}$$

Polarization Type

$$H_{int} = e \int \psi^\dagger (\mathbf{A}) \psi d\mathbf{x} + \frac{e^2}{2} \int \frac{\psi^\dagger \psi \psi^\dagger \psi}{|\mathbf{x} - \mathbf{x}'|} d\mathbf{x} + \int \psi^\dagger V \psi d\mathbf{x}$$

$$\frac{e^2}{(2\pi)^3} \int \psi^* \psi \frac{e^{ijx}}{|x-x'|} j^i \zeta(j) V_j dx dx'$$

$$W = \frac{e^2}{\pi^2} \iint \psi^* \psi \zeta(0) V_j e^{ijx} dx dx'$$

$$= \frac{e^2}{\pi^2} \zeta(0) \int \psi^* V \psi dx$$

$$- \frac{e^2}{2\pi} \zeta''(0) \int \psi^* \nabla^2 V \psi dx$$

$$\zeta(0) = -\frac{2\pi}{3} \int_0^\infty \frac{dl}{l} + \text{finite}$$

$$V \rightarrow V + \delta V = \overset{\text{Assume}}{\underset{\text{given potential}}{V}}$$

$$\text{Hint} = \dots + \frac{e^2}{2} \int \text{Coulomb}$$

$$+ \int \psi^* \underset{\underset{V}{\parallel}}{(V + \delta V)} \psi dx - \int \psi^* \underset{\underset{\delta V}{\parallel}}{V} \psi dx$$

$$\int dx dx' \quad \dot{V} = \left(1 - \frac{2e^2}{3\pi} \int \frac{dl}{l} \right) V$$

$$\delta V = -\frac{ze^2 v}{3\pi} \int \frac{dl}{l}$$

$$\delta \dot{V} - \delta V = O(e^4)$$

4/127 (10%)

Pauli meson theory 雑記
 藤本氏! chapter IV.
~~etc~~

4/130 (10%)

藤本氏 雑記
 two meson theory
 4/130 藤本の 雑記. 至本氏

(1) Proton 放射

(2) 放射理論

(3) multiplicity of π^\pm

(4)

(4)

(5)

$\pi^\pm \rightarrow \mu^\pm + \nu$

μ

\rightarrow soft

\rightarrow hard

intensity
 p

π

μ

$$dp = -p a dH$$

$$da = -m a p - \pi dH / e_\pi M p$$

$$d\mu = -d\pi - \mu dH / e_\mu M p$$

$$\left[+ \frac{\pi dH}{e_\pi M p} \right]$$

#12 R, Sakata-Inoue Model
 { Capture Process
 { μ -decay

$$\mu = (\text{charged } \mu\text{-meson mass}) \times c h$$

$$\nu = (\text{neutral } \mu\text{-meson mass}) \times c h$$

$$m_{\pi} = \pi\text{-meson mass} \quad \omega_{\pi} = \frac{m_{\pi} c^2}{h} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \frac{3}{2}$$

$$W_{\text{cap}} = \frac{m_{\pi} c^2}{h} \left(\frac{1}{hc} \right) \left(\frac{\gamma^2}{hc} \right) \frac{\mu}{\omega_{\pi}^4 a^3} \left\{ 1 + \frac{\omega}{\mu} + \frac{\nu}{\mu} \right\}$$

a : meson Bohr radius
 (μ^-)

energy

$$\left\{ 1 + \frac{\omega}{\mu} - \frac{\nu}{\mu} \right\}^2 M^2 Z$$

M

$$M = \left| \int \Phi \omega \Phi^* d\tau \right|$$

$\omega =$

N

$$W_{\text{exp}} \sim 10^6 \sim 10^7$$

$$\left(\frac{1}{hc} \right) \left(\frac{\gamma^2}{hc} \right) \sim 10^{-11}$$

核力 $\rightarrow \left(\frac{1}{hc} \right) \sim 10^{-1} \quad \left(\frac{\gamma^2}{hc} \right) \sim 10^{10}$

$$\left. \begin{aligned} \tau &: 200 \sim 400 \\ \mu &: 150 \sim 200 \\ \nu &: 100 \sim 200 \end{aligned} \right\}$$

$$W_{pd} = \frac{m_a c^2}{\pi} \left\{ \frac{\sigma_1^2}{\hbar c} + \frac{\sigma_2^2}{\hbar c} \left(\frac{\mu - \nu}{\omega} \right)^2 \right\} \\ \cdot \left\{ 1 - \left(\frac{\mu + \nu}{\omega} \right) + 4 \left(\frac{\mu \nu}{\omega^2} \right)^{3/2} \left[1 - \left(\frac{\mu + \nu}{\omega} \right)^2 \right]^{3/2} \right\}$$

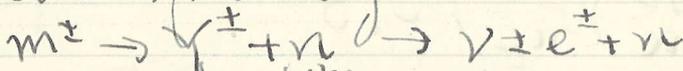
実験 μ -neutrino K.E. ~ 4 MeV,

$$\left. \begin{aligned} \pi &: m_\pi = 350 \sim 400 \text{ MeV} \\ &\text{charged } \mu \quad 400 \text{ MeV} \\ &\text{neutral } \mu \quad 200 \text{ MeV} \\ &\quad \quad \quad 180 \text{ MeV} \end{aligned} \right\} \frac{\mu - \nu}{\omega} \sim 3 \times 10^{-3}$$

σ_1 - interaction only $\tau_{\sigma_1} \approx 10^{-11} \sim 10^{-12}$ sec.

σ_2 - interaction only $\tau_{\sigma_2} \approx 10^{-9} \sim 10^{-8}$ sec
 $\tau_1 = 0$

μ -neutrino β -decay



$$W_{\mu\beta} \approx \frac{1}{6\pi} \left(\frac{g^2}{\hbar c} \right) \frac{m_\mu c^2}{\pi} \left(\frac{g^2}{\hbar c} \right) \left(1 - \frac{\nu + \mu}{m} \right)^6 \left(\frac{m}{\nu} \right) \left(\frac{m}{\omega} \right)^2$$

exp: $\tau_{pp} \approx 10^6$; $\left(\frac{f^{1c}}{\hbar c}\right) \left(\frac{\sigma^{1c}}{\hbar c}\right) \approx 10^{-18}$

$$\left(\frac{f^{1c}}{\hbar c}\right) \approx 10^{-8}$$
$$(10^{-13})$$

鈴木.

Block-Nordieck

$$P = p + \sum_{n \neq 0} \sigma_n \cos nkr$$

$$Q = q + \sum_{n \neq 0} \sigma_n \sin nkr$$

interaction

$$\frac{1}{r} \hat{H}_0(ikr) \propto \frac{e^{-kr}}{r} \quad \text{for } r \gg 1$$
$$\propto \frac{1}{r} \log \frac{1}{kr} \quad \text{for } r \ll 1$$

5月4日(火)

物

Pauli, Neutron theory 論文

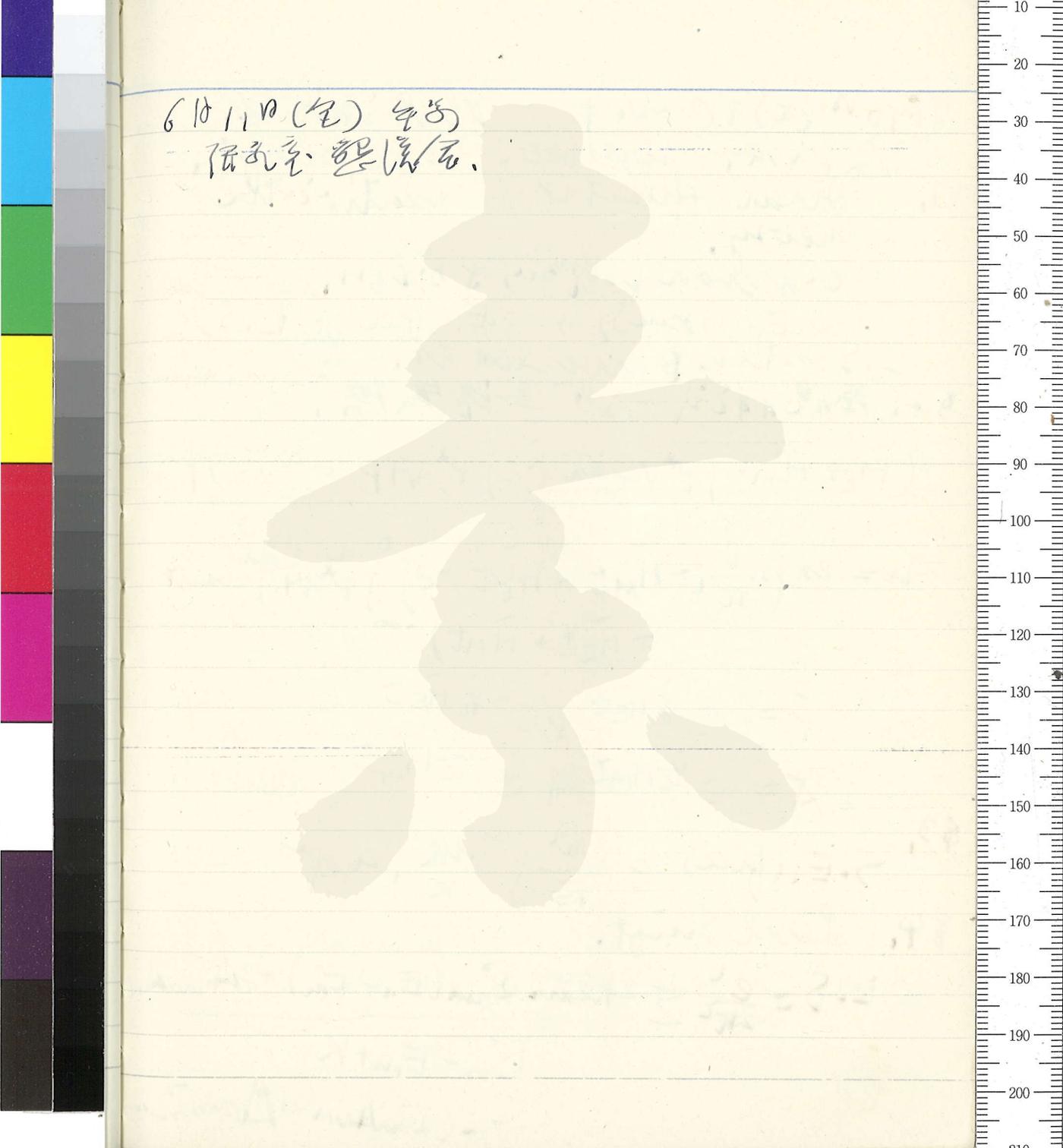
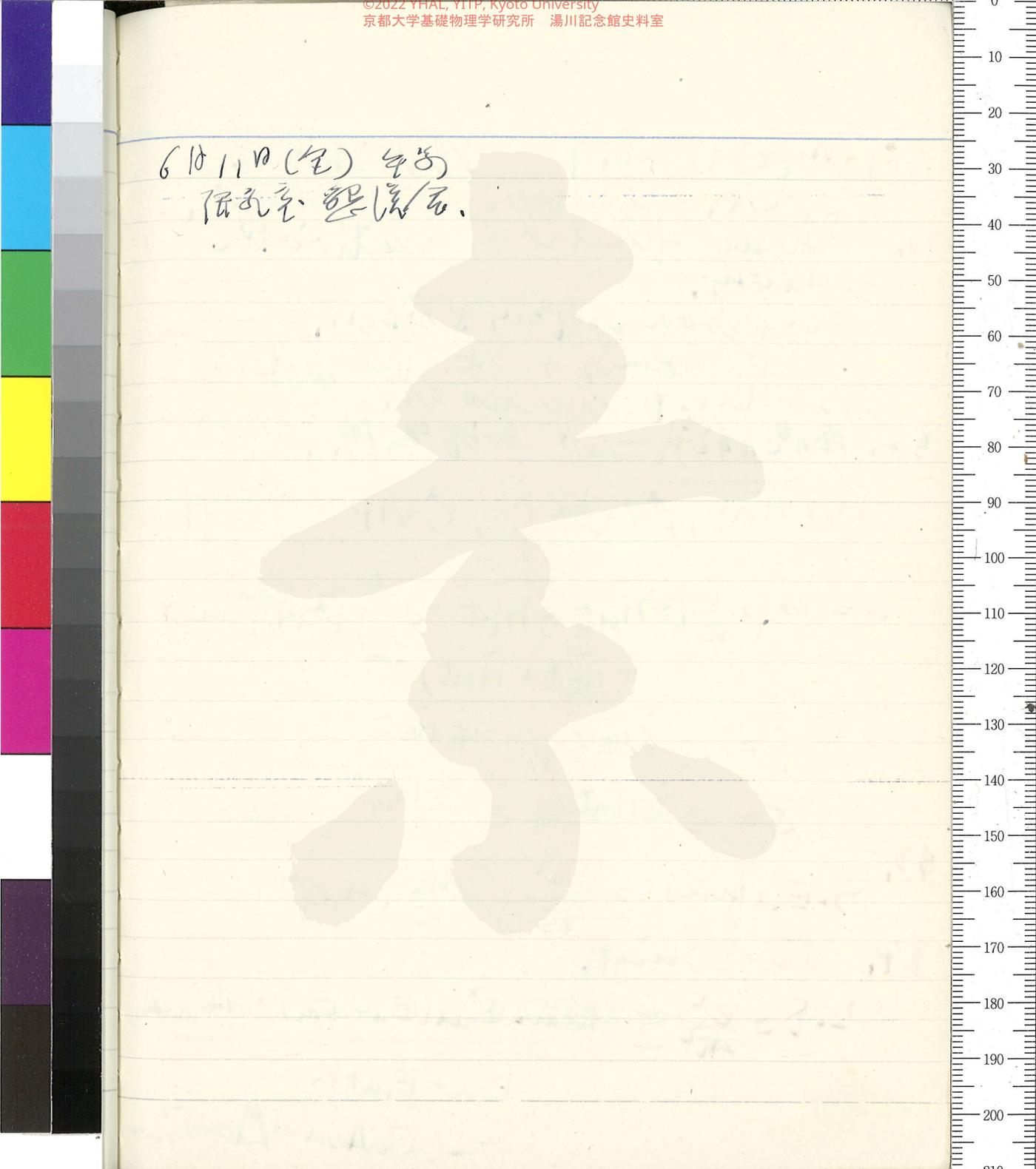
鈴木, Chap. V.

N-P Scattering



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京都大学基礎物理学研究所 湯川記念館史料室

6月11日(金) 午会
- 湯川先生 懇話会.



7) 10^8 (E) 及び $\lambda \sim 10^{-8}$ cm 程度の波長。
 原子の R, Hydrogen level shift.

§1. Dirac electron relativistic theory.

c-meson $\lambda \sim 10^{-10}$ cm, $\omega \sim 10^{10}$ s $^{-1}$.

S.E. (bound) \rightarrow S.E. (free) + L.S.

L.S. term is divergence.

§2. 基礎方程式 $\Delta \psi = 0$ の場合。

$$\left(\overline{H}_E + \overline{H}_M + \int \psi^* V \psi dx - e \int \psi^* A \psi + \frac{\hbar c}{2} \frac{\partial}{\partial t} \right) \phi$$

$$u = \exp \frac{i}{\hbar} \left(-\overline{H}_M t - \overline{H}_E t - e \int \psi^* A \psi dx dt + \overline{H}_E t + \overline{H}_M t \right)$$

$$\tilde{\psi} = e^{\frac{i}{\hbar} \overline{H}_E t} \psi e^{-\frac{i}{\hbar} \overline{H}_E t}$$

$$\tilde{A} = e^{\frac{i}{\hbar} \overline{H}_M t} A e^{-\frac{i}{\hbar} \overline{H}_M t}$$

§3. S.E. (free) $\sim \frac{3\pi^2}{E} \int \frac{dk}{k} |a_{k\ell}|^2$

§4. Level shift.

$$L.S. = \frac{e^2}{2\hbar c} \sum_{n,m} \frac{2k \Sigma_{nm} \Sigma_{nm} (E_n - E_m) + 2A_{nm} A_{nm}}{E_n - E_m + k}$$

$$E_n - E_m + k$$

$$- (\Sigma_{nm} A_{nm} - A_{nm} \Sigma_{nm})$$

9/15th (木) 70の10. 理論講習会,
 2000年夏期研修会, R空間での積分,
 (矢印) $\int \frac{d^3k}{(2\pi)^3} \dots$ (Amstex)

vector interaction

$$V_1 = - \frac{2g^2}{(2\pi)^2 \lambda^2} P \int \frac{k^4 e^{i\vec{k}\cdot\vec{r}}}{k^2 + \lambda^2} d\Omega dk \quad \hbar = c = 1$$

$$\begin{aligned} \frac{k^4}{k^2 + \lambda^2} &= k^2 - \frac{k^2 \lambda^2}{k^2 + \lambda^2} = d_1 k^2 + \dots \\ &= k^2 - \lambda^2 + \frac{\lambda^4}{k^2 + \lambda^2} \\ &\quad \downarrow \quad \quad \quad \downarrow \\ &\quad \quad I_2 \quad \quad \quad I_3 \end{aligned}$$

$$I_2 = \lambda^2 \int e^{i\vec{k}\cdot\vec{r}} d\Omega dk = \frac{2\pi^2 \lambda^2}{r}$$

$$I_3 = \lambda^4 \int \frac{e^{i\vec{k}\cdot\vec{r}}}{k^2 + \lambda^2} d\Omega dk = \frac{2\pi^2 \lambda^4}{r} (1 - e^{-\lambda r})$$

tensor interaction

$$V_2 = - \frac{2g^2}{(2\pi)^2 \lambda^2} P \int \frac{k^4 e^{i\vec{k}\cdot\vec{r}}}{k^2 + \lambda^2} d\Omega dk$$

$$\begin{aligned} \frac{k^4}{k^2 + \lambda^2} &= k^2 - \lambda^2 + \frac{\lambda^4}{k^2 + \lambda^2} \\ &\quad \downarrow \quad \quad \quad \downarrow \\ &\quad \quad I_2 \quad \quad \quad I_3 \\ &\quad \quad \times \{ (\vec{\sigma}_1 \cdot \vec{\sigma}_2) - \frac{(\vec{\sigma}_1 \cdot \vec{k})(\vec{\sigma}_2 \cdot \vec{k})}{k^2} \} \end{aligned}$$

Pauli, self-energy strong coupling
 $C = N - \frac{\text{const}}{a} + \text{finite term}$

$$J_2 = \lambda^2 \int e^{i\vec{k}\cdot\vec{r}} (\vec{\sigma}_1 \cdot \vec{k})(\vec{\sigma}_2 \cdot \vec{k}) / k^2 \cdot dk d\Omega$$

$$= (\sigma_1^x \sigma_2^x + \sigma_1^y \sigma_2^y) \frac{4\pi^2}{r}$$

$$J_3 = \lambda^4 \int \frac{e^{i\vec{k}\cdot\vec{r}} (\vec{\sigma}_1 \cdot \vec{k})(\vec{\sigma}_2 \cdot \vec{k})}{k^2 + \lambda^2} \cdot dk d\Omega$$

$$= \frac{2\lambda^2 \pi^2}{r} (1 - e^{-\lambda r}) \sigma_1^z \sigma_2^z$$

$$+ \frac{4\pi^2 \lambda^2}{r} (\sigma_1^x \sigma_2^x + \sigma_1^y \sigma_2^y - 2\sigma_1^z \sigma_2^z)$$

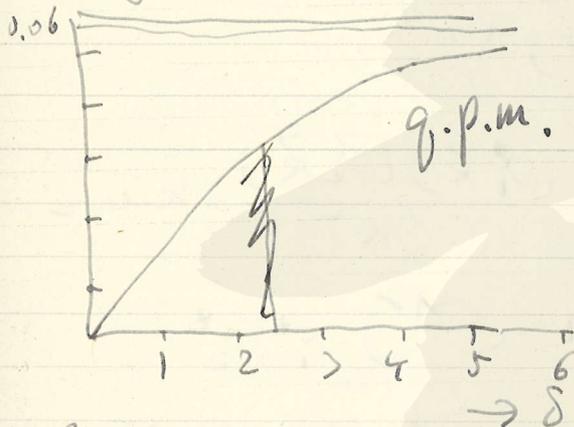
$$- \frac{2\pi^2 \lambda^2}{r} \left(\frac{e^{-\lambda r}}{\lambda r} - (-\lambda r + 1) + \frac{1}{(\lambda r)^2} \right)$$

(' ')

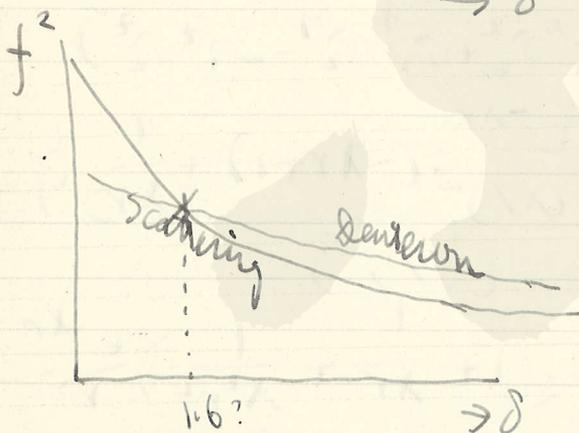
$$V_2 = f^2 P(\vec{\sigma}_1 \cdot \vec{\sigma}_2) \left[\left(1 + \frac{1}{\lambda r} + \frac{1}{\lambda^2 r^2} \right) \frac{e^{-\lambda r}}{r} - \frac{1}{\lambda^2 r^3} \right] - \frac{(\vec{\sigma}_1 \cdot \vec{r})(\vec{\sigma}_2 \cdot \vec{r})}{r^2} \left(1 + \frac{3}{\lambda r} + \frac{3}{\lambda^2 r^2} \right) \times \frac{e^{-\lambda r}}{r} - \frac{3}{\lambda^2 r^3}$$

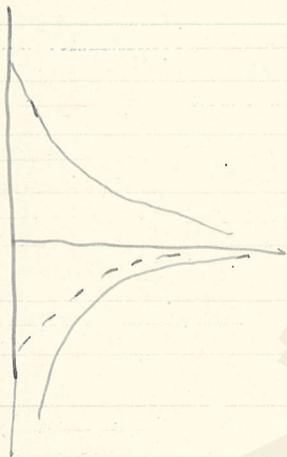
D^2 ground state
N-P scattering
quadrupole moment

Jauch-Hu: $\delta = \frac{1}{\mu}$



Schwinger-Mixtur





$\delta \rightarrow \infty$

long range tensor force

H^3, He^3 a magnetic moment 9.27 μ_N

20 MeV N-p scatt.

$$R \approx \frac{\sigma(\infty)}{\sigma(\frac{\pi}{2})} \approx 3 \text{ (exp)}$$

$$R \approx 3 \text{ (theor.)}$$

Bethe-Lambert range 2×10^{-13} cm.

Wu : $= 4.2 \times 10^{-13}$ cm slow neutron $\sigma_{tot} = 283$.