6元模型誕生をめぐって

小林　誠

C, P, T

- P parity

  Wigner 1928

- T time reversal

  Wigner 1932

- C charge conjugation

  Krammers 1937

CPT theorem 1954~

P Violation

θ - τ Puzzle

$$\theta \to \pi\pi \qquad P = +1$$

$$\tau \to \pi\pi\pi \qquad P = -1$$

Lee-Yang （1956）

Wu （1957）

$$Co^{60} \to Ni^{60} + e^{-} + \bar{\nu}$$

→ V-A theory

CP Violation

CP eigenstates

$$K_1 = (K^0 - \bar{K}^o)/\sqrt{2} \qquad CP = +1$$

$$K_2 = (K^0 + \bar{K}^o)/\sqrt{2} \qquad CP = -1$$

$$K_1 \to \pi\pi \qquad \text{short life}$$

$$K_2 \not\to \pi\pi \qquad \text{long life}$$

Gell-Mann Pais 1955

$$BR(K_2 \to \pi\pi) < 0.3\% \qquad \sim 1960$$

→ Christenson, Cronin, Fitch, Turlay (1964)

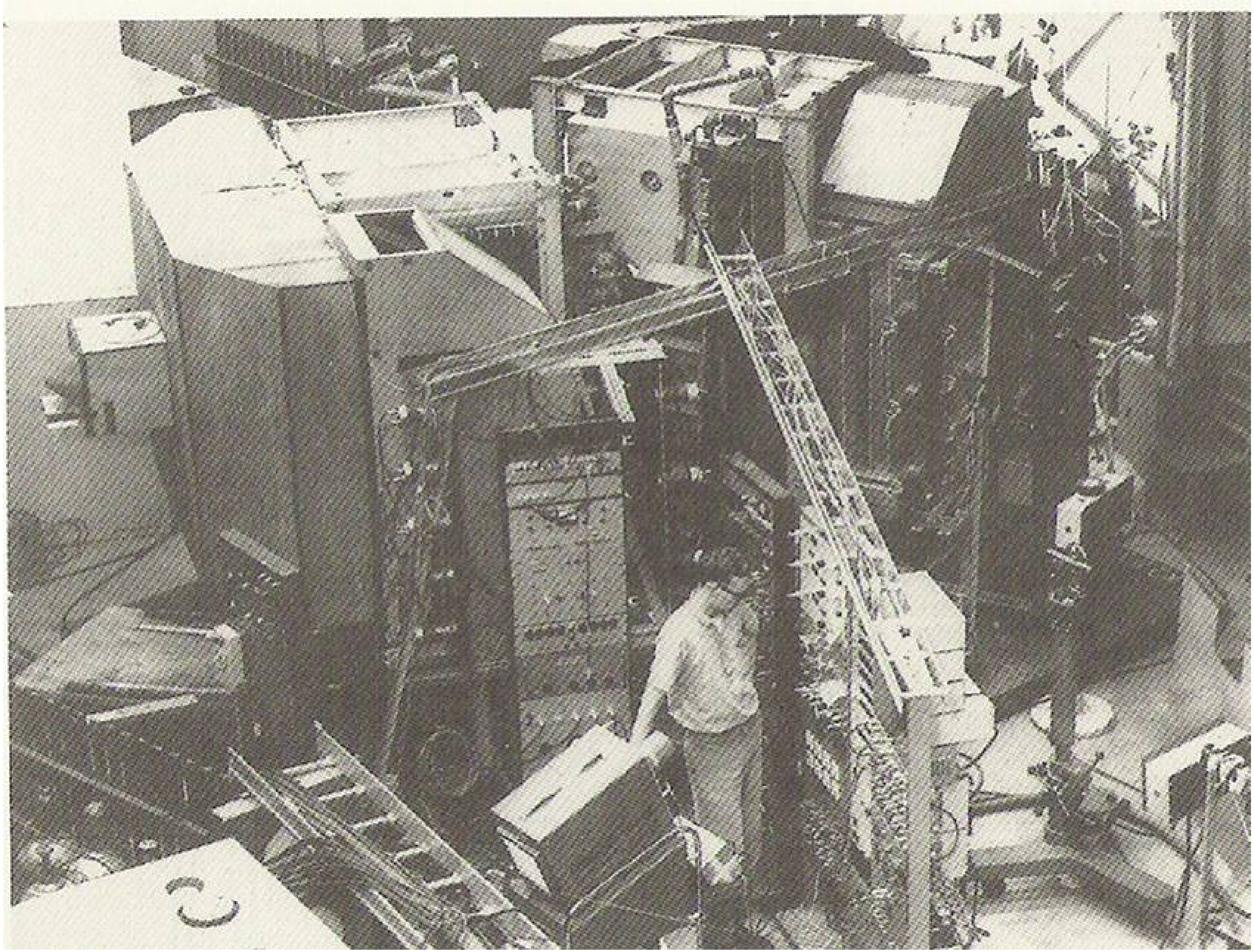
PROPOSAL FOR K^o_2 DECAY AND INTERACTION EXPERIMENT

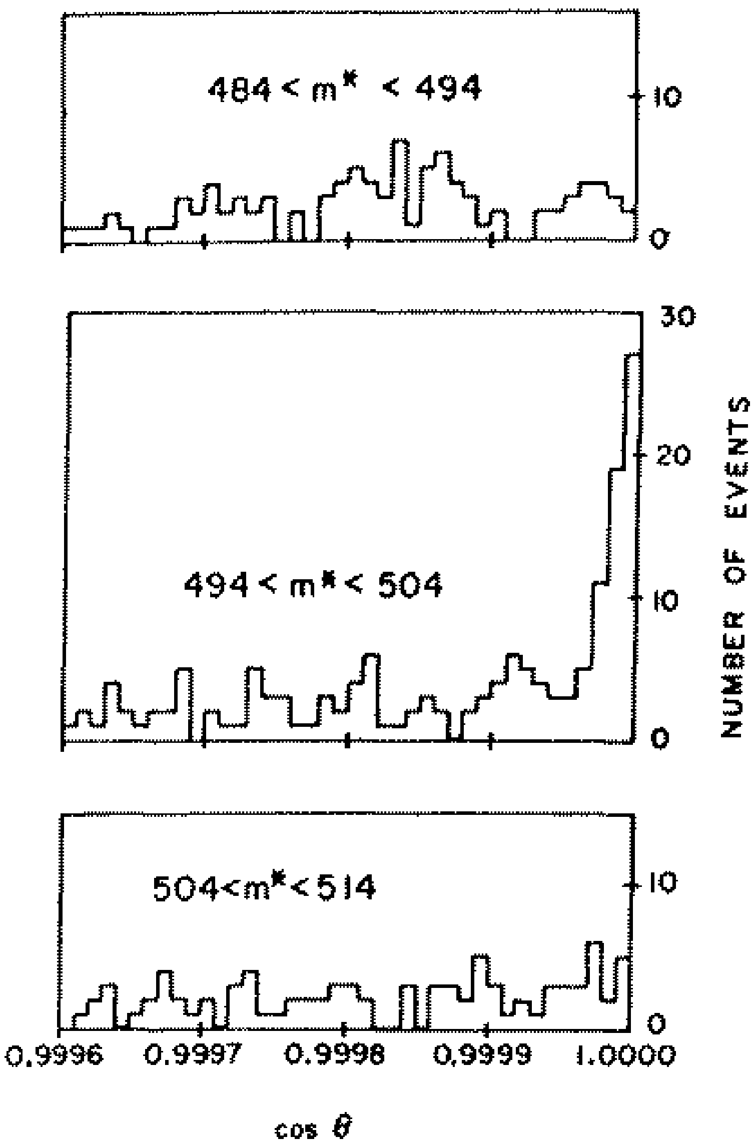
J. W. Cronin, V. L. Fitch, R. Turlay

(April 10, 1963)

I. INTRODUCTION

The present proposal was largely stimulated by the recent anomalous results of Adair et al., on the coherent regeneration of K^o_1 mesons. It is the purpose of this experiment to check these results with a precision far transcending that attained in the previous experiment. Other results to be obtained will be a new and much better limit for the partial rate of $K^o_2 \to \pi^+ + \pi^-$, a new limit for the presence (or absence) of neutral currents as observed through $K_2 \to \mu^+ + \mu^-$. In addition, if time permits, the coherent regeneration of K_1's in dense materials can be observed with good accuracy.





$$BR(K_2 \to \pi\pi)$$
$$= (2.0 \pm 0.4) \times 10^{-3}$$

1953 Nakano, Nishijima, Gell-Mann

$$Q = I_3 + \tfrac{1}{2}B + \tfrac{1}{2}S$$

1956 Sakata

Sakata model $p, \quad n, \quad \Lambda$

1959 Gamba, Marshak, Okubo

$$\begin{array}{ccc} p\ , & n\ , & \Lambda \\ \updownarrow & \updownarrow & \updownarrow \\ \nu & e & \mu \end{array}$$

1960 Maki, Nakagawa, Ohnuki, Sakata

Nagoya model

$$p = \left\langle B^{+}\nu \right\rangle, n = \left\langle B^{+}e \right\rangle, \Lambda = \left\langle B^{+}\mu \right\rangle$$

Discovery of two neutrinos

1962 Danby etal.

$$p = \langle B^+ \nu_1 \rangle, n = \langle B^+ e \rangle, \Lambda = \langle B^+ \mu \rangle, p' = \langle B^+ \nu_2 \rangle$$

$$\nu_1 = \cos\theta\, \nu_e + \sin\theta\, \nu_\mu$$

$$\nu_2 = -\sin\theta\, \nu_e + \cos\theta\, \nu_\mu$$

1962 Maki, Nakagawa, Sakata

1962 Katayama, Matumoto, Tanaka, Yamada

Progress of Theoretical Physics, Vol. 28, No. 5, November 1962

Remarks on the Unified Model of Elementary Particles

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(Received June 25, 1962)

A particle mixture theory of neutrino is proposed assuming the existence of two kinds of neutrinos. Based on the neutrino-mixture theory, a possible unified model of elementary particles is constructed by generalizing the Sakata-Nagoya model.*) Our scheme gives a natural explanation of smallness of leptonic decay rate of hyperons as well as the subtle difference of G_ν's between μ-e and β-decay.

Starting with this scheme, the possibility of K_{e3} mode with $\Delta S/\Delta Q=-1$ is also examined, and some bearings on the dynamical role of the B-matter, a fundamental constituent of baryons in the Nagoya model, are clarified.

§ 1. Introduction and summary

In recent years, a considerable progress has been made in accumulationg detailed knowledge on the structure of interaction of elementary particles. Various kinds of excited particles have been discovered in succession, and the systematization of them from a unified point of view turns out to be an urgent problem of particle physics. In this connection, we can expect that the full-symmetry (or unitary-symmetry) theory of strong interactions would provide workable systematics as have been suggested by many authors.[1] O assume that there exists a representation which defines *the true neutrinos* through some orthogonal transformation applied to the representation of weak neutrinos;

$$\left.\begin{array}{l}\nu_1=\nu_e\cos\delta+\nu_\mu\sin\delta,\\ \nu_2=-\nu_e\sin\delta+\nu_\mu\cos\delta.\end{array}\right\}\quad(\delta:\text{real constant})\tag{2·4}$$

Then, in terms of ν_1 and ν_2, (2·1) is expressed as

$$\begin{aligned}j_\lambda=&(\bar{e}\,\nu_1)_\lambda\cos\delta+(\bar{\mu}\,\nu_1)_\lambda\sin\delta\\ &-(\bar{e}\,\nu_2)_\lambda\sin\delta+(\bar{\mu}\,\nu_2)_\lambda\cos\delta.\end{aligned}\tag{2·1'}$$

It is conceivable to assume that the true neutrinos are basic particles together with e and μ from which corresponding baryons should be constructed along the line of the Nagoya model. Various models can be constructed in this way, but one of the most simple models may be given *under the postulate that the true neutrinos should be so defined that* B^+ *can be bound to* ν_1 *to form a proton but cannot be bound to* ν_2, symbolically

$$p=\langle B^+\nu_1\rangle,\quad n=\langle B^+e^-\rangle,\quad \Lambda=\langle B^+\mu^-\rangle,\tag{2·5}$$

and $\langle B^+\nu_2\rangle$ corresponds no baryons.**) We call this correspondence *the modified B-L symmetry*. The baryonic weak current J_λ obtained from (2·1′) is written as

$$J_\lambda\equiv\langle j_\lambda\rangle_B=(\bar{n}p)_\lambda\cos\delta+(\bar{\Lambda}p)_\lambda\sin\delta.\tag{2·6}$$

Progress of Theoretical Physics, Vol. 28, No. 4, October 1962

Possible Unified Models of Elementary Particles with Two Neutrinos*)

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(Received June 5, 1962)

Possible unified models of elementary particles are discussed assuming the existence of two kinds of neutrino accompanying with electron and muon respectively. The discussions are focused on the Nagoya model which is based on the Sakata model of baryons and mesons and the Gamba-Marshak-Okubo symmetry. In its connection the following assumptions are taken: i) Fundamental particles among baryons and mesons have one-to-one correspondence with leptons or their linear combinations. The correspondence is realized through a kind of "matter". ii) Basic leptons do not transmute each other by the strong interaction between the fundamental baryons.

There are two essentially different types of model. One depends on the existence of two neutrinos which are Dirac particles, and the other is related with two Majorana neutrinos. With regard to the models, the difference between electron and muon and the asymmetry of Λ-pionic decay are also discussed.

1971 Niu et al.

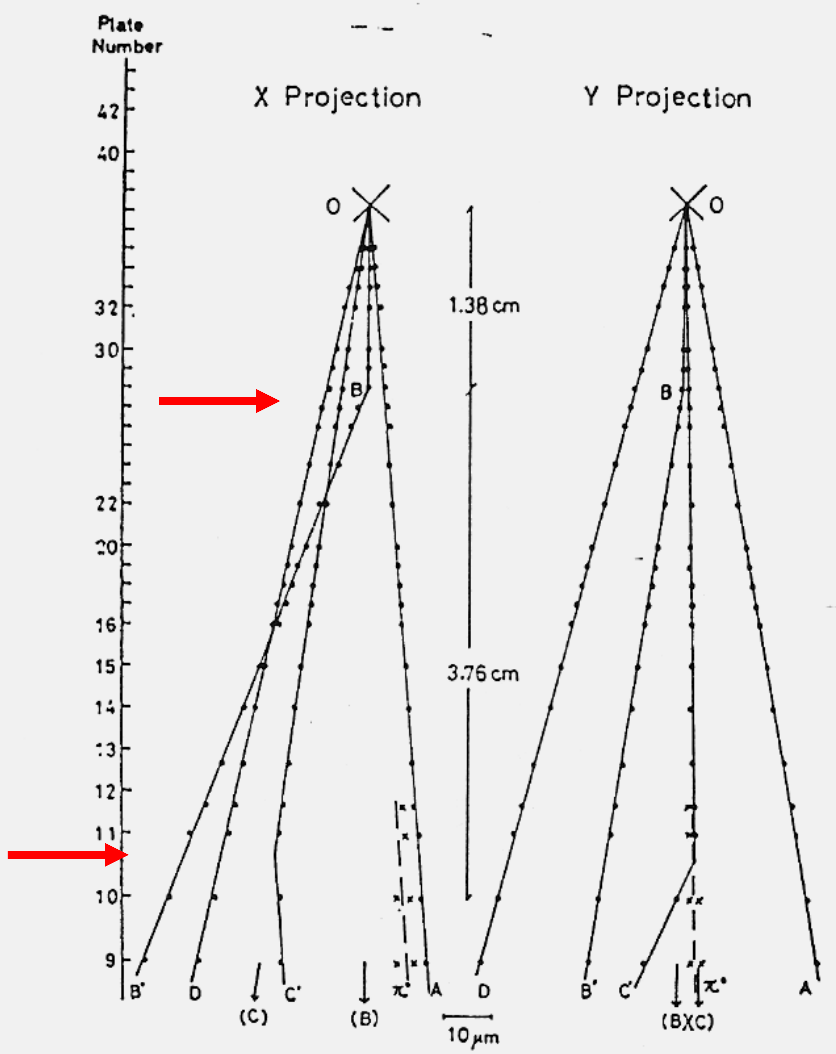

Fig. 3(a). Fig. 3(b).

大学院時代 （1967－1972）

Chiral Dynamics／Chiral Symmetry

クォーク模型の視点から理解する

自発的対称性の破れetc

４元模型

⟶ 全体像を描くことを目指す

～1971　電・弱相互作用が繰り込み可能
（Weinberg−Salam−Glashow, ‘t Hpoft）

→ CPの破れをどう繰り込み可能な枠組みで記述するか

1973　Kobayashi, Maskawa

・４元模型ではCPは破れない
・未知の粒子の存在
・6元模型は可能性の一つとして指摘

- 1974 discovery of J/ψ
- 1975 discovery of τ
- 1975 Pakvasa, Sugawara
- 1976 Ellis, Gaillard, Nanopoulos
- 1977 dicovery of Υ
- 1979 CP in B-meson system

→ **B–Factory**

Conclusion

CP violation will continue to be challenging both experimentally and theoretically

Electric Dipole Moment (edm) and θ–term

$$L_\theta = \frac{\theta}{64\pi^2}\varepsilon^{\mu\nu\lambda\tau}F_{\mu\nu}F_{\lambda\tau}$$ → ~~P~~, ~~T~~ → edm

N=2 supersymmetric gauge theory

Dyon ⟷ Charged particle

dual

$$\vec{d}_e = -\frac{e^2\theta}{2\pi^2}\frac{e}{2m}\vec{S}$$

Kugo, Tokunaga, M.K.