Supported by tetfund TERTIARY EDUCATION TRUST FUND

# An Evaluation of Weak Interactions for Conservation Laws, Symmetries and Lorentz Structure In Two Body Decays of Kaons and Pions

**E. W. Likta, D. I. Malgwi and N. Yakubu**
University of Maiduguri, Department of Physics, P.M.B 1069, Maiduguri, Borno State. Nigeria. West Africa.
E-Mail Address: emmalikta2014@gmail.com

**Received:** March 20, 2022 **Accepted:** June 18, 2022

Abstract: The goal of this paper is to achieve the weak interaction in the two body decay. Weak interaction for the conservation laws symmetries and Lorentz structure has been observed. The symmetries processes are sensitive in the mass matrices eigenvalue has been observed. Limit on nanocanonical Lorentz Structure in the Kaons and Pions have been observed.

**Keywords:** Kaons, Pions, Symmetries, Lorentz structure and Weak interaction

## Introduction

In Particle Physics, a pion or pi meson, denoted with the Greek letter pi: $\pi$ is any of three subatomic particles. Each pion consists of a quark and an antiquark and is therefore a meson. Pions are the lightest meson and more generally, the lightest hadrons. They are unstable, with the charge pions $\pi^+$ and $\pi^-$ decaying after a mean lifetime of 26.033 nanoseconds (Riazuddin, 1959). Charged pions most often decay into mouns and muons neutrinos while neutral pions , along with vector, rho and omega mesons provides an explanation for the residual strong force between nucleons. Pions are not produced in radioactive decay but commonly are in high-energy collision between hadrons (Fazzini et al., 1958). Pions also play a crucial role in cosmology by imposing an upper limit on the energies of cosmic rays surviving collisions with cosmic microwave. In the standard understanding of the strong force interaction as defined by quantum chromodynamics, pions are loosely portrayed as Goldstone bosons of spontaneously broken chiral symmetry. That explain why the masses of three kind of pions are considerably less than that of the other mesons, such as scalar or vector meson (Vieria, et al., 2014). If their current quark were massless particles, it could make the chiral symmetry exact and thus the Goldstone theorem would dictate that all pions have a zero mass.

The standard model of Particle Physics is a collection of theories that can explain the electromagnetic weak and strong interactions in terms of a few guiding principle (local gauge symmetries) and at least 26 fundamental parameter (Anthony, 2013). Among these parameters, there are assuming three generations of fermions and university of the weak interactions) six quark masses three quark-mixing parameter and one CP-violating phase (Bjorklund et al., 1950). The interplay of CP symmetry violation and the mixing of quarks remains one of the most active areas of research in high-energy physics (Amsler, 2008). The LHC energy regime all but fully explored and without a collider with larger center of mass energy for at least two more decades (Rosner, 2013).

For atleast two decades the LHC energy regime has yet to be fully explored and is still without a collider which has a larger centre mass of energy (Rosner, 2013).

The linear momentum in pion decay at rest was measured to be

$$P_{\mu+} = (29.79139 \pm 0.00083) MEV/C \quad 1$$

Substitute $m_{\mu+}$ and $m_{\pi+}$ into kinematics which leads to

$$m(v_\mu) < 0.25\ MEV/C^2 (90\%\ C.L) \quad 2$$

Equation (2) is the new upper limit. For $V_\tau$ is the best and recent upper limit comes from a study of the decays $\tau \to 3\pi^{\pm}\pi^{o}V_\tau$

$$m(v_\tau) < 164\ MEV/C^2 (95\%\ C.L) \quad 3$$

Equation (3) and (2) refers t the dominant mass eigen states $n_2\ and\ n_3$.

The connection the two bases is

$$(v_f)_l = \sum_i U_{fi}(n_i)_l \quad 4$$

Where $U$ is a unitary matrix about which we know that the diagonal matrix element are much larger than the non diagonal. $\nabla L_f \neq 0$ that is processes such as

$$\begin{Bmatrix} \mu \to e \\ \mu \to e\bar{e}e \\ K_L^o \to \mu e \\ \mu^- \to e^{\pm} \end{Bmatrix} \quad 5$$

Changing processes have considered in equation (5), gauge bosons would mediate between different families

$$\binom{V_e}{e} \binom{V_\mu}{\mu} \binom{V_\tau}{\tau} \quad 6$$

For the nuon decay

$$\mu^+ \to e^+ + [V_e + \bar{V}_\mu] \quad 7$$

The relevant kinematic variable and observables are defined. The double differential decay probability has the form

$$\frac{d^2\Gamma}{dxd(\cos\theta)} = \Gamma \begin{Bmatrix} F_1(X;\eta;\mathcal{P}) + P_\mu\xi\cos\theta\, f_2(X;\delta) + \text{term giving rise to} \\ P_l, P_{T1} \text{ and } P_{T2} \text{ of position} \end{Bmatrix} \quad 8$$

Where $P_\mu$ is the degree of polarization of the nuon, $\eta$ and $\rho$ are isotropic spectrum, $\boldsymbol{\delta}$ is an isotropic spectrum, ξ is the μ-spin, $e^+$ is the momentum correlation (Sokolovski et al., 1987). The pure V-A interaction these parameter have the values

$$\begin{Bmatrix} \mathcal{P} = \delta = \frac{3}{4} \\ \xi = \xi = 1 \\ \alpha = \beta = 0 \\ \alpha' = \beta' = 0 \end{Bmatrix} \quad 9$$

The lifetime is about $18ppm$

$$\text{Ţ}\mu = 2.19703 \pm 0.00004\mu s \quad 10$$

For $E \gg Me$ is the function $f_1$ and $f_2$ equation (8) become

$$f_1 \simeq 6(1-X) + \frac{3}{4}\mathcal{P}(4X-3) \quad 11$$

$$f_2 \simeq 2(X-1) + \frac{4}{3}\mathcal{P}(3-4x) \quad 12$$

An asymmetry measurement near X=1 yields the parameter

$$\omega = \xi\frac{\delta}{\mathcal{P}} \quad 13$$

From a spin holding measurement in a strong longitudinal magnetic field the group had obtained earlier

$$P_\mu\omega > 0.9959(90\% C.L) \quad 14$$

An independent measurement of moun spins rotation in weak transverse field

$$P_\mu\omega > 0.9948(90\% C.L) \quad 15$$

Preliminary value for $\delta$

$$\delta = 0.784 \pm 0.004 \pm 0.003 \quad 16$$

Measurement of the isotopic decay spectrum at low energies the group obtains

$$\eta = +0.027 \pm 0.098 \quad 17$$

the polarization component is measure in series as

$$P_l = 0.998 \pm 0.045 \equiv \xi \quad 18$$

Where $P_l$ is indicts independent of X and θ. The average energy is

$$\left.\begin{aligned}&< P_{T1} >= 0.016 \pm 0.023\\&< P_{T2} >= 0.007 \pm 0.023\end{aligned}\right\} \quad 19$$

Where $P_{T1}$ and $P_{T2}$ can be analyze the terms of $\beta$ and $\beta'$ as

$$\left.\begin{aligned}&\frac{\beta}{A} = -0.002 \pm 0.017\\&\frac{\beta'}{A} = -0.007 \pm 0.016\end{aligned}\right\} \quad 20$$

**Results and Discussion**

Combination of co-variants which for massless particles into states of definite helicity

$$H_{eff} = \frac{G_F}{\sqrt{2}}\Big[g_{11}(V^\alpha + a^\alpha)_{\bar{e}Ve}(V^\alpha + a^\alpha)_{\bar{\nabla}_\mu^\mu} + g_{22}(V^\alpha + a^\alpha)_{\bar{e}Ve}(V^\alpha + a^\alpha)_{\bar{\nabla}_\mu^\mu} + g_{12}(V^\alpha + a^\alpha)_{\bar{e}Ve}(V^\alpha + a^\alpha)_{\bar{\nabla}_\mu^\mu} + h_{11}(S \pm P)_{\bar{e}_{Ve}}(S \pm P)_{\bar{\nabla}_\mu^\mu} + h_{12}(S \pm P)_{\bar{e}_{Ve}}(S \pm P)_{\bar{\nabla}_\mu^\mu} + f_{\frac{11}{22}}\left(t^{\alpha\beta} \pm t'^{\alpha\beta}\right)_{\bar{e}_{Ve}}\left(t_{\alpha\beta} \pm t'_{\alpha\beta}\right)_{\bar{\nabla}_\mu^\mu} + h.C\Big] \quad 21$$

Supersymmetric decay mode can be

$$\mu \to e + [\bar{\mathrm{Y}} + \bar{\mathrm{Y}}] \quad 22$$

Equation(22) is indistinguishable from the neutrino made as long as only the positron is observed. Equation(22) can be simplified as

$$\mu \to e[\bar{V}_e + \bar{V}_\mu] \quad 23$$

Equation(22) is kinematically allowed if the scalar neutrinos are light. If $m(\tilde{V}_f) \lesssim m_e$ the only free parameter is the mass ratio $\frac{m_\omega}{m_{\tilde{\omega}}}$. For the parameters in $\mu$-decay can be

$$\left.\begin{aligned}&\mathcal{P} = \frac{3}{4}\left(1 + \frac{1}{2}\varepsilon\right)\\&\delta = \frac{3}{4}\left(1 - \frac{3}{2}\varepsilon\right)\\&\xi = 1 + 2\varepsilon\end{aligned}\right\} \quad 24$$

Where $\varepsilon = \left(\frac{M_{\tilde{\omega}}}{M_{\bar{\omega}}}\right)^4$. The complex coupling constants in charge relation form and let

$$\cos\phi_{V_A} = \frac{-1}{g_V g_A} Re(C_V C_A'^* + C_V' C_A^*) \quad 25$$

Measure of departure from material parity violation it can be

$$\phi_{VA} 0^0 \pm 3.8^0 \quad 26$$

Equation (25) can be reformulate in to limit on the phase $\Psi_{VA}$ defined by

$$\sin\Psi_{VA} = -\frac{1}{g_V g_A} Im(C_V C_A^{1*} + C_V^1 C_A^*) \quad 27$$

Obtaining

$$\Psi_{VA} = -1.6^O \pm 3.5^O \quad 28$$

The moment of their production of particle is of particular interest is the asymmetry

$$\beta_i = \frac{(\overline{K^o} \to e^+) - (k^o \to e^-)}{(\overline{K^o} \to e^+) + (k^{o \to e^-})} \quad 29$$

**Table1: First and Second body of Decay for Kaons**

| U | First body | Second body |
|---|---|---|
| -0.1 | - | 40 |
| -0.14 | 10 | 40 |
| -0.16 | 10 | 42 |
| -0.18 | 11 | 46 |
| -0.2 | 15 | 50 |
| -0.22 | 18 | 58 |
| -0.23 | 20 | 65 |
| -0.25 | 23 | - |
| -0.27 | 25 | - |
| -0.28 | 35 | - |
| -0.27 | 50 | - |
| -0.25 | 55 | - |
| -0.23 | 65 | 65 |
| -0.22 | 66 | 80 |
| -0.2 | 68 | 81 |
| -0.18 | 68 | 84 |
| -0.16 | 68 | 86 |
| -0.14 | 69 | 88 |
| -0.1 | 70 | 90 |

**Table2: First and Second body of Mass Eigenvalue for Kaons**

| U | First body | Second body |
|---|---|---|
| -0.3 | 47 | 80 |
| -0.36 | 50 | 82 |
| -0.4 | 55 | 90 |
| -0.48 | 65 | 105 |
| -0.5 | 71 | 116 |
| -0.55 | 85 | 133 |
| -0.59 | 90 | 165 |
| -0.6 | 105 | 220 |
| -0.61 | 110 | 300 |
| -0.66 | 150 | - |
| -0.67 | 185 | - |
| -0.68 | 300 | - |

**Table3: First and Second body of Decay for Pion**

| U | First body | Second body |
|---|---|---|
| -0.14 | - | 10 |
| -0.16 | - | 12 |
| -0.18 | 10 | 15 |
| -0.2 | 15 | 20 |
| -0.26 | 20 | 35 |
| -0.28 | 31 | 50 |
| -0.37 | 50 | - |
| -0.4 | 60 | - |
| -0.47 | 80 | - |
| -0.48 | 100 | - |
| -0.49 | 120 | - |
| -0.48 | 140 | - |
| -0.47 | - | - |
| -0.4 | - | - |
| -0.37 | - | - |
| -0.28 | - | 50 |
| -0.26 | - | 54 |
| -0.2 | - | 59 |
| -0.18 | - | 60 |
| -0.16 | - | 67 |
| -0.14 | - | 70 |

**Table4: First and Second body of Mass Eigenvalue for Pions**

| U | First Body | Second Body |
|---|---|---|
| -0.27 | 10 | 10 |
| -0.3 | 10 | 10 |
| -0.36 | 10 | 10 |
| -0.37 | 10 | 17 |
| -0.4 | 10 | 18 |
| -0.43 | 10 | 20 |
| -0.5 | 20 | 40 |
| -0.56 | 30 | 58 |
| -0.57 | 40 | 60 |
| -0.58 | 55 | - |

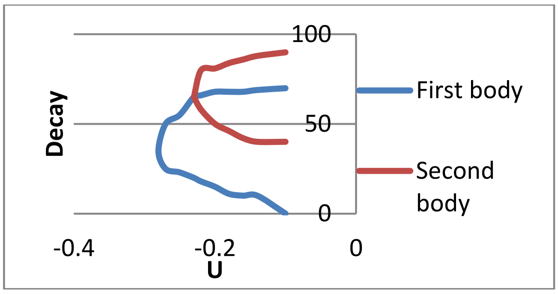


**Fig 1a: Decay against U for Kaons**

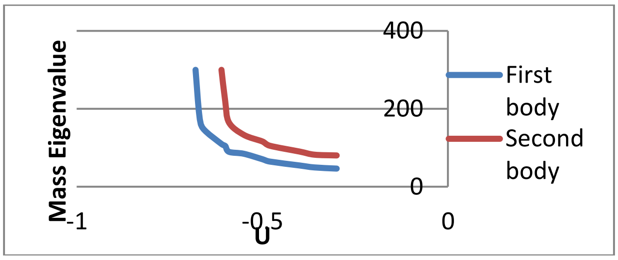


**Fig 1b: Mass Eigenvalue against U for Kaons**

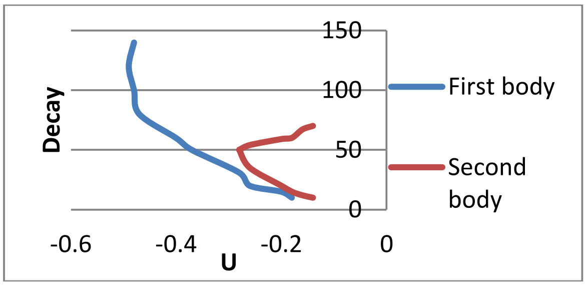


**Fig 2a: Decay against U for Pions**

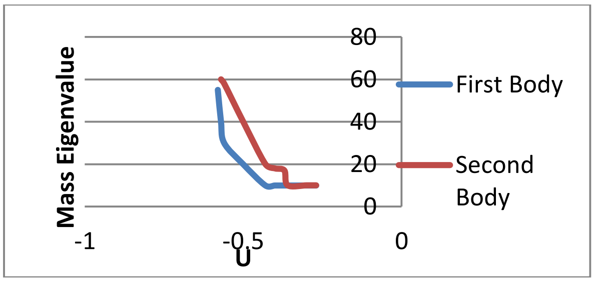


**Fig 2b: Mass Eigenvalue against U for PIons**

Fig 1a. Incident quantity of unitary matrix with $2 \equiv \mu$ versus decay in MeV for Kaons. It shows an intercept between the first and second body decay for Kaons. Also it indicate that the two body decay made a shape of an irregular shape like letter C but there are not close.

Fig 1b. Shows quantity of unitary matrix versus mass eigenvalue for kaons. The figure indicates that the two body are parallel line which are slightly curve in shape. The limit of the studies shows on both masses and absolute matrix which the state indicates excellent shrock

Fig 2a. Proves quantity of unitary matrix versus eigenvalue for pions. The figure prove that for Pions the first and second body decay indicate at the starting points are close but for second body shows a shape like letter C while for the first body it indicate a line with a slight curve. The figure 2a shows very good possible neutrino state limits.

Fig 2b indicates non-degenerate neutrino mass giving rise to neutrino oscillations. This shows that the first and second body started at same points while it late it change and have a distance between them which it shows a shape of line with a slight curve.

In the case of kaons and Pions for the two body occurrence with the strength of processes are unrelated to the physical properties within each family which depend on only gauge coupling $g_H$ and the masses of the interfamily gauge bosons. The mass matrices of neutral or change kaons and pions are non-trival that are not diagonal in the interaction eigenstates and have non degenerate eigenvalues then the weak interactions will depend on state mixing analogous for quark states with charge $-\frac{1}{3}$.

The predicting power for processes is limited to the state mixing that depends on the choice of parameters in the symmetry. The extension of model have the interesting property that now many more sets of states can mix scalar fermion with Higgs.

**Conclusion**

Information on kaons and Pions of weak interactions has been observed with great deal, primarily through the new series of high precision on muon decay. The significant issue being to either confirms or disproves the result on the decay. The complex of CP violation in the neutral kaons system, present results are on the edge of series conflict with each other

**Reference**


Anthony Z. (2013): Quantum Field Theory. McGraw Hill New York, pp 43-50.

Amsler C. (2008): Quark Model. John Wiley & Son, 1nd edition pp 480-483

Bjorklund R., Crandall W. E., Moyer B. J. and York H. E. (1950): High Energy Photons from Proton-Nucleon collisions. Physical Review 77: 213-218

Fazzini T., Fidecaro G., Merrison A., Paul H., Tollestrup A (1958): Electron Decay of the Pion. Annual Nuclear Energy, Vol., 11, pp 39-44.

Riazuddin A. (1959): Charge radius of the Pion. Physical Review, 114 (4): 1184-1186.

Rosner J. L and Stone S (2013): Leptonic decays of charged Pseudo-scalar meson. John Wiley & Son, 4nd edition pp 220-232.

Sokolovski D and Baskin L. M (1987): Introduction to Quantum Mechanics. 5th editions, pp 63-68

Vieria C. L, Videira P. A. A (2014): Cesar Latter, Nuclear Emulsions and the Discovery of the pi-meson. Physics in Perspective. 16: 2-6.