Journal of Modern Physics, 2019, 10, 1-7
http://www.scirp.org/journal/jmp
ISSN Online: 2153-120X
ISSN Print: 2153-1196

On the Nature of π and μ Mesons

Boris V. Vasiliev

Independent Researcher, Dubna, Russia
Email: bv.vasiliev@yandex.com

How to cite this paper: Vasiliev, B.V. (2019) On the Nature of π and μ Mesons. *Journal of Modern Physics*, **10**, 1-7.
https://doi.org/10.4236/jmp.2019.101001

Received: December 21, 2018
Accepted: January 8, 2019
Published: January 11, 2019

Abstract

Earlier it was shown [1], that neutrino is a specific magnetic γ-quantum, which as any γ-quantum carries away the reaction energy. This allows taking a fresh look at the chain of reactions pion$^\pm$ → muon$^\pm$ → e$^\pm$, which is accompanied by the emission of three neutrinos, but in which no other particles are generated. Since the role of neutrinos is a throwing away the energy of the initial particles, it is easy to conclude that both pion and muon are excited states of electron. The introduction of an additional assumption about the possible mechanism of the excited state of an elementary particle allows us to estimate the mass of these excited states. The obtained estimates are in good agreement with the experimentally measured values of the pion and muon masses.

Keywords

Neutrino, Pion, Muon, Electron

1. Introduction

According to modern concepts, mesons are an integral part of the Standard model.

It is assumed that μ-mesons, being leptons, do not have a quark structure and do not participate in reactions with strong interaction, unlike charged π-mesons, which consist of quarks and are characterized by strong interaction with other particles.

However, it is important that there is a characteristic chain of transformations:

Pion$^-$ → muon$^-$ → electron, in which these particles are connected only by successive radiation of several neutrinos (**Figure 1**).

Therefore, the key to understanding the nature of peonies and muons is given by neutrino physics.

Neutrinos are fundamental neutral stable particles with extremely high penetrating

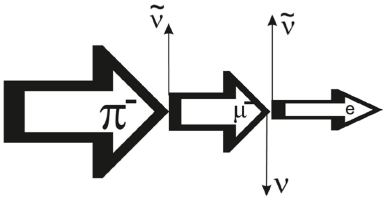

Figure 1. Schematic representation of the chain of π^--meson transformations into μ^--meson and then into an electron together with accompanying neutrinos.

power. This property distinguishes them from all other particles.

The fact that neutrinos propagate through space at the speed of light suggests that they have a unique specific electromagnetic nature.

Radiation and propagation of electromagnetic excitations in the ether with all the completeness and accuracy has been studied by classical electrodynamics.

The question about fields generated by oscillating electric or magnetic moments is considered in detail in all courses of classical electromagnetic theory.

However, these courses do not address the issue of radiation, which should accompany the very quickly (relativistically quickly) turn on of the magnetic moment. The reason for this, apparently, is that it is technically impossible to turn on a magnetic moment relativistically quickly.

However, this phenomenon exists in nature.

The magnetic moment arises relativistically quickly at beta decay when an electron is ejected from the decaying nucleus, since the electron has a large (on the microcosm scale) magnetic moment.

Let consider briefly the description of electromagnetic wave radiation in vacuum, which is given by the standard Maxwell theory.

2. Radiation of Electromagnetic Waves in Vacuum

For simplification we will assume that electric charges and their currents, electric dipoles and quadrupoles are absent initially.

Let the only source of electromagnetic fields in the subsequent consideration be the time-varying magnetic dipole moment $\boldsymbol{m}(t)$.

The time-varying electromagnetic field created by a wavering magnetic dipole can be represented by its vector potential [2]

$$\boldsymbol{A}(R,t)=\frac{\left[\dot{\boldsymbol{m}}(t^*)\times\boldsymbol{n}\right]}{cR}, \tag{1}$$

(to account for the delay of the electromagnetic signal, the retarded time is entered here $t^*=t-\frac{R}{c}$).

By definition ([2], Eq.46.4), in the absence of free charges (*i.e.* at $\varphi=0$), the electric field of the electromagnetic wave

$$\boldsymbol{E}(R,t)=-\frac{1}{c}\frac{\mathrm{d}\boldsymbol{A}(R,t)}{\mathrm{d}t^*}=-\frac{1}{c^2R}\left[\ddot{\boldsymbol{m}}(t^*)\times\boldsymbol{n}\right]. \tag{2}$$

The magnetic field in this wave

$$\boldsymbol{H}(R,t)=rot\,\boldsymbol{A}(R,t)=\left[\nabla\times\frac{\left[\dot{\boldsymbol{m}}\left(t^*\right)\times\boldsymbol{n}\right]}{cR}\right]=\frac{1}{c}\left[\nabla\times\left[\dot{\boldsymbol{m}}\left(t^*\right)\times\boldsymbol{n}\right]\cdot\frac{1}{R}\right] \tag{3}$$

That is, the magnetic field in the electromagnetic wave generated by the magnetic dipole

$$\boldsymbol{H}(R,t)=-\frac{1}{c^2R}\left[\boldsymbol{n}\times\left[\ddot{\boldsymbol{m}}\left(t^*\right)\times\boldsymbol{n}\right]\right]+\frac{1}{cR^2}\left[\boldsymbol{n}\times\left[\dot{\boldsymbol{m}}\left(t^*\right)\times\boldsymbol{n}\right]\right] \tag{4}$$

2.1. Ordinary Electromagnetic Waves

The problem of electromagnetic wave generation by a magnetic dipole, whose oscillations are described by a differentiable function from time, is considered in electrodynamics courses in detail. A typical example of this movement is the harmonic oscillation of the dipole $\boldsymbol{m}(t)=\boldsymbol{m}\cdot\sin\omega t$.

In this case, in the wave zone, *i.e.* if the distance R is much greater than the wavelength $\lambda=c/\omega$, the relation exists

$$\frac{\ddot{\boldsymbol{m}}(t)}{\dot{\boldsymbol{m}}(t)}\approx\frac{R}{\lambda}\gg 1. \tag{5}$$

Therefore, in the wave zone, the electromagnetic wave (photon) has electric and magnetic fields of equal intensity

$$\boldsymbol{E}(R,t)=-\frac{1}{c^2R}\left[\ddot{\boldsymbol{m}}\left(t^*\right)\times\boldsymbol{n}\right] \tag{6}$$

$$\boldsymbol{H}(R,t)=-\frac{1}{c^2R}\left[n\times\left[\ddot{\boldsymbol{m}}\left(t^*\right)\times\boldsymbol{n}\right]\right] \tag{7}$$

and only they are turned relative to each other by 90 degrees.

Tasks where the oscillations of the magnetic moment are described by more complex formulas have the same solution if spectra of these oscillations can be decomposed into harmonic components.

2.2. Magnetic Excitation of the Aether

The task on generation of electromagnetic radiation in vacuum, at the very rapid birth of the magnetic moment earlier in the courses of electrodynamics has never been considered.

An example of such a phenomenon is β-decay of neutron, in which a free electron bearing a large (in microcosm scale) magnetic moment arises relativistically quickly.

Another example is the transformation of π^--meson into μ^--meson and then into electron.

π-meson has no magnetic moment, but μ-meson and electron have it.

The uncertainty relation makes it possible to estimate the time of π-meson into μ-meson transformation:

$$\tau_{\pi\to\mu}\approx\frac{\hbar}{\left(M_\pi-M_\mu\right)c^2}\approx 10^{-23}\,\text{sec} \tag{8}$$

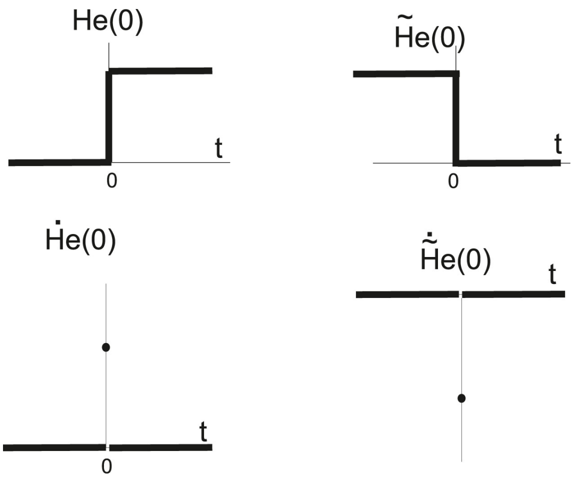

Figure 2. Two Heaviside's step functions—up and down—responsible for the birth of neutrinos and antineutrinos. Below are derivatives of these functions in time.

Thus, the vacuum excitation that occurs at β-decay due to the birth of the magnetic moment should be classified as a kind of particle, since it is characterized by a very short time interval.

The process of birth (or disappearance) of the magnetic moment can be described by the Heaviside's step function (**Figure 2**).

The first time derivative of the Heaviside's step function is δ-function, and the second derivative, due to the exceptional brevity of the process, is zero. So for this case from Equations (2) and (4) we receive

$$\boldsymbol{E}(R,t)=0 \tag{9}$$

$$\boldsymbol{H}(R,t)\sim\dot{\boldsymbol{m}}\left(t^{*}\right) \tag{10}$$

An unusual property, which should have such a particle, which can be called a magnetic γ-quantum, occurs due to the lack of magnetic monopoles in nature. The fact that normal photons, with the electric component, scattered and absorbed in matter with electrons. In the absence of magnetic monopoles, the magnetic γ-quantum of small energy should interact extremely weakly with the substance and its free path in the medium should be approximately two dozen orders of magnitude greater than that of a conventional photon [3].

In addition, being circularly polarized, a photon having both a magnetic and an electric component has a spin equal to $\hbar$. It seems natural to assume that a circularly polarized magnetic photon devoid of an electrical component should have a spin equal to $\hbar/2$.

The existence of two types of Heaviside's steps (up and down) suggests that there should be two types magnetic gamma-quanta (forward and reverse).

Since magnetic γ-quanta arise at β-decay, they can be identified with neutrinos (or antineutrinos), since all their basic physical properties coincide.

3. Mesons as Excited States of Electron

The chain of transformations pion$^{\pm}$ → muon$^{\pm}$ → electron$^{\pm}$ gives rise to three antineutrino-neutrino. That is, three times there is a removal of energy, which is carried away by these particles. The fact that there are no products other than neutrinos and antineutrinos in these reactions means that the pion and muon are excited states of the electron. This circumstance makes it possible to calculate their masses [1].

How can you imagine electron in an excited state? It can be assumed that the excitation energy of an electron is the kinetic energy of its internal motion.

We can assume that a quasi-stable excited state can be created when the electron rotates along a circle of radius R provided that the ratio of the length of its de Broglie wave to the length of this circle is equal to an integer (the same condition that determines the motion of electron in Bohr atom):

$$\frac{\lambda_{dB}}{2\pi R} = k. \tag{11}$$

Given that the de Broglie wavelength is determined by the electron momentum p_e

$$\lambda_{dB} = \frac{2\pi\hbar}{p_e} \tag{12}$$

we obtain a condition for the existence of an excited state of electron which can be hypothetically quasi-stable :

$$R \cdot p_e = \frac{\hbar}{k}. \tag{13}$$

The generalized particle momentum depends on the vector potential A

$$p_e^* = p_e - \frac{e}{c}A. \tag{14}$$

In the case of relativistic circular motion, the vector potential A is determined by the magnetic moment of the circular current μ_0

$$A = \frac{\mu_0}{R^2\sqrt{1-\beta^2}} \tag{15}$$

Since for a circular current

$$\mu_0 = \frac{eR\beta}{2} \tag{16}$$

finally, for the case $\beta \to 1$, we obtain an expression for the generalized electron momentum

$$p_e^* = p_e - \gamma\frac{\alpha\hbar}{2R}. \tag{17}$$

where

$\gamma = \frac{1}{\sqrt{1-\beta^2}}$ is the relativistic factor of electron,

$\alpha = \frac{e^2}{\hbar c}$—the fine structure constant.

Since the generalized momentum of rotation (spin) of the particle

$$S = R \times p_e^* \tag{18}$$

from condition (13) we have

$$S = \hbar \left| \frac{1}{k} - \frac{\alpha\gamma}{2} \right| \tag{19}$$

3.1. *π*-Meson

Spin of *π*-meson

$$S_\pi = 0 \tag{20}$$

If we assume that for this case $k = 1$, we obtain the mass of the particle close to the mass of $\pi^\pm$-meson:

$$m_{calc} = \gamma_{s=0,k=1} m_e = 274.08 m_e \tag{21}$$

3.2. *μ*-Meson

Spin of *μ*-meson

$$S_\mu = \frac{\hbar}{2}. \tag{22}$$

If we choose $k = 4$ for this case, then by simple calculations we obtain the mass of the particle close to the mass of $\mu^\pm$-meson:

$$m_{calc} = \gamma_{s=\frac{1}{2},k=4} m_e = 205.56 m_e. \tag{23}$$

For clarity, the results of this simulation are summarized in **Table 1**.

4. Conclusions

The concept of neutrinos as magnetic excitations of ether [1] explains all basic of their properties:

- extremely weak interaction with substance is the result of absence of magnetic monopoles in nature,
- spin neutrinos is equal to $\hbar/2$ due to the fact that they have only the magnetic component,
- the birth of neutrinos in beta-decays is due to the fast appearance of magnetic moments of the generated particles,
- the existence of neutrino and antineutrino is explained by the presence of two types of Heaviside's steps.

At the same time, the awareness of the electromagnetic nature of neutrinos

Table 1. The results of model calculations of meson masses.

		meson mass		calculated mass	
meson	spin	M_m	k	m_{calc}	$\frac{m_{calc} - M_m}{M_m}$
π	0	$273.13 m_e$	1	$274.1 m_e$	3.5×10^{-3}
μ	$\hbar/2$	$206.77 m_e$	4	$205.6 m_e$	-5.8×10^{-3}

makes it possible to take a fresh look at the nature of mesons, which is an important step in understanding the microcosm.

In the 20th century at the study of the microcosm a new method was formed. The construction of various tables (as table of quark structure of Gell-Mann particles or standard model of Weinberg-Salam particles) played an important role in it. These tables seem informative and beautiful. And at first glance seems quite reliable. But any theoretical construction should be based on experimental data confirming this construction [4].

The very possibility of building a classification is not a confirmation of its correctness, because the uniqueness of such construction is not proved.

The fact that the Gell-Man's quark model has not found an experimental confirmation is clear at least because, that no fractional-charge quarks were found. The confinement model cannot save this situation, because it does not satisfy the principle that in the natural Sciences there cannot be objects that are fundamentally unobservable as angels of medieval beliefs.

In addition, the neutron is not an elementary particle [5], since all measurements of its properties proof that it is a kind of Bohr hydrogen atom, but with a relativistic electron. Since the reaction of neutron → proton transformation is the cornerstone of the Gell-Mann model, the loss of the neutron from this construction simply makes it meaningless.

The exclusion of neutrinos, neutrons and charged mesons from the number of independent elementary particles should also lead to a change in the Weinberg-Salaam table.

What tau-neutrino and neutral mesons have to do with this concept remains unclear.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Vasiliev, B.V. (2017) *Journal of Modern Physics*, **8**, 338-348.
http://www.scirp.org/Journal/PaperInformation.aspx?PaperID=74443
https://doi.org/10.4236/jmp.2017.83023

[2] Landau, L.D. and Lifshitz, E.M. (1971) The Classical Theory of Fields (Volume 2 of A Course of Theoretical Physics). Pergamon Press, New York.

[3] Vasiliev, B.V. (2015) *International Journal of Modern Physics and Application*, **3**, 25-38. http://www.aascit.org/journal/archive2?journalId=909&paperId=3935

[4] Vasiliev, B.V. (2018) *Journal of Modern Physics*, **9**, 2101-2124.
http://www.scirp.org/Journal/PaperInformation.aspx?PaperID=87652
https://doi.org/10.4236/jmp.2018.912132

[5] Vasiliev, B.V. (2015) *Journal of Modern Physics*, **6**, 648-659.
http://www.scirp.org/Journal/PaperInformation.aspx?PaperID=55921
https://doi.org/10.4236/jmp.2015.65071