شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

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MONA MAGHRABY

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قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
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تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

MONA MAGHRABY

Study of Some Possible Textures of Neutrino Mass Matrix

A Thesis submitted in partial fulfillment of the requirement for the degree of

Master of Science in Physics

By

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Cairo, Egypt

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To my beloved son..

Abstract

Neutrinos are elementary particles that have spin $\frac{1}{2}$ integer, so they are called fermions. They have small masses compared to the other leptons (e, μ, τ). Even though neutrinos are one of the most abundant particles in the universe, they are incredibly difficult to detect. They have neither an electric charge nor a color charge. Thus, they interact with matter only via weak and gravitational interactions. Neutrinos are created by different sources such as in beta decay of the nucleus, in nuclear reactions that occur in the core of the stars, in nuclear reactions inside the core of the reactors, during the explosion of the stars, etc. The first one who postulated the existence of neutrinos was Pauli in 1930 to preserve energy, momentum, and angular momentum conservation in beta decay. In 1956, neutrinos were first detected by Frederick Renines, F.B.Harrison, H.W.Kruse, and A.D.McGuire [1]. There are three different types of neutrinos which are called flavors ν_e, ν_μ and ν_τ produced along with e, μ and τ in the weak interactions. For many years physicists considered a neutrino to be a massless particle, but after neutrino oscillations observations [2, 3, 4, 5, 6], we have to consider neutrinos as massive particles, and their mass eigenstates are not degenerate. The interactions between neutrinos and other elementary particles are described within the standard model of the elementary particle physics, which is $SU(3)_c \otimes SU(2)_L \otimes U(1)_Y$ gauge theory. However, the matter content of the standard model does not contain right-handed neutrinos. Therefore, the neutrinos are massless particles in that model, but this assumption contradicts the neutrino oscillation observations. To overcome this problem, we have to go beyond the standard model to explain naturally how neutrinos acquire small masses compared to the other leptons. Therefore, the neutrino oscillations were the first firm sign of physics beyond the standard model.

The neutrino oscillation experiments give clear and strong evidence that the neutrinos are massive and lepton flavors are mixed. If we assume that neutrino is a Majorana type and also we are working on the basis, where the charged lepton mass matrix is diagonal, all mixing comes solely from the neutrino sector. The neutrino mass matrix is in general a complex symmetric matrix that has 12 real parameters. It can be parametrized by three mixing angles, three real masses, and six complex phases. One can absorb three complex phases out of the six one by rephasing both left and right-handed charged leptons. The experiments put constraints on the mixing angles $(\theta_{12}, \theta_{23}, \theta_{13})$, three neutrino masses (m_1, m_2, m_3), and the Dirac phase δ. However, there are no experimental constraints on the Majorana phases ρ and σ till now.

There exist many phenomenological models have been presented to reduce the number of free parameters such as zero textures [7, 8, 9, 10], zero minors [11, 12], vanishing traces [13, 14], equality textures [15, 16], hybrid textures [17, 18, 19], $\mu - \tau$ symmetry textures [20, 21], etc.

The plan of the thesis is as follows: In chapter 1, we present the standard model of elementary particles as a gauge theory and concentrate on the $SU(2)_L \otimes U(1)_Y$ gauge sector. We also discuss how the elementary particles acquire their mass without spoiling the gauge symmetry via the Higgs mechanism. In the second chapter, we explain the theory of the neutrino oscillations together with type-I and type-II seesaw mechanisms to show how observed neutrinos acquire small masses. In the last chapter, we introduce a phenomenological and analytical study of the one vanishing subtrace model. We find that all six possible textures can accommodate the experimental data. We also find that four singular textures are viable in the case of inverted hierarchy. Finally, we introduce different symmetry realization methods to enforce a vanishing subtrace condition in the neutrino mass matrix. The realization methods used in our study are called direct and indirect. In the direct method, we use $Z_2 \times Z_6$, $Z_2 \times Z_2'$, and $Z_2 \times Z_4 \times U(1)^3$ symmetries within type-I, type-II, and type-I+II respectively in order to realize four viable textures. In the indirect method, we obtain the desired symmetry assignments for the matter fields that impose the texture condition from the counterparts in the one zero texture model. We use $Z_8 \times Z_2$ and Z_5 symmetries within type-I and type-II seesaw scenarios. However, $Z_{12} \times Z_2$ is used to realize some viable singular textures.

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Contents

List of Tables