Theoretical Studies of Cosmological Models In The Light of Experimental Observations

A Thesis

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By

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To

my parents

DECLARATION

I, **Mrs. Moumita Das**, D/o Dr. Chitta Ranjan Kar, resident of A-1, PRL residences, Navrangpura, Ahmedabad 380009, hereby declare that the research work incorporated in the present thesis entitled, **"Theoretical Studies of Cosmological Models In The Light of Experimental Observations"** is my own work and is original. This work (in part or in full) has not been submitted to any University for the award of a Degree or a Diploma. I have properly acknowledged the material collected from secondary sources wherever required. I solely own the responsibility for the originality of the entire content.

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Signature of the candidate

CERTIFICATE

I feel great pleasure in certifying that the thesis entitled, **"Theoretical Studies of Cosmological Models In The Light of Experimental Observations"** by Mrs. Moumita Das under my guidance. She has completed the following requirements as per Ph.D regulations of the University.

(a) Course work as per the university rules.

(b) Residential requirements of the university.

(c) Regularly submitted six monthly progress reports.

(d) Presented her work in the departmental committee.

(e) Published/accepted minimum of one research paper in a referred research journal.

I recommend the submission of thesis.

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ABSTRACT

Measurement of large angle correlations in the cosmic microwave background (CMB) anisotropy by COBE and WMAP experiments indicates that the universe went through a period of accelerated expansion in the past known as inflation. Inflation not only explains the long standing horizon and flatness problems of standard hot-big bang cosmology, it can also describe the structure formation very well in addition to the cosmic microwave anisotropy. In general, inflation is driven by the scalar field, which is known as inflaton. In this thesis we study the consequences of assumption that the Higgs field of the standard model can be the inflaton.

It is known that non-minimal coupling of the Higgs and gravity sector is needed to create a successful model of Higgs inflation. In this thesis we study magnetic field generation in the curvature coupled Higgs inflation model. It not only explains the magnitude of experimentally observed magnetic field at large scales, we also show that in this model there is no problem of back-reaction on the inflaton potential, which is normally seen in the generation of magnetic field studied in generic inflation model.

It is also known that in a potential with a large negative quartic coupling of a conformally coupled scalar field, one can generate scale invariant density perturbations to explain the structure formation of the universe and the CMB anisotropy. In this thesis we have implemented this idea in realistic inert doublet model. We show that we can generate the observed spectrum of the CMB anisotropy in this model by a suitable choice of the scalar Higgs couplings. With this choice of parameter one can tune the couplings to give a Higgs mass around 125.6 GeV along with light scalar dark matter candidate of mass 33.7 GeV which may be detected in the experiments.

In last part of this thesis we discuss the study of vacuum stability of the standard model Higgs potential which is the condition that the Higgs quartic coupling does not become negative under renormalization, all the way upto the Planck scale. In particular we study the phenomenological constraints on the heavy neutrino of Type-I seesaw models from the criterion of Higgs

vacuum stability. We find that the Dirac mass of the neutrino is constrained to $m_D \leq 24.36$ GeV through the bound on the neutrino Yukawa coupling, $Y_\nu \leq 0.14$. This has application on the phenomenology of TeV scale heavy neutrinos, which can be tested in Large Hadron Collider. The three aspect of the heavy neutrino phenomenology, namely, Neutrino-less double beta decay ($0\nu\beta\beta$), Lepton flavor violating decays like $\mu \to e\gamma$ and Like-sign dilepton signals are studied in the light of the vacuum stability condition.

LIST OF PUBLICATIONS

1. **"Magnetic Field Generation in Higgs Inflation Model"**
   Moumita Das and Subhendra Mohanty
   Int. J. Mod. Phys. A **27**, 1250040 (2012)
   [arXiv:1004.1927 [astro-ph.CO]]

2. **"Constraints on background torsion from birefringence of CMB polarization"**
   Moumita Das, Subhendra Mohanty and A.R. Prasanna
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3. **"Generation of scale invariant density perturbations in a conformally invariant Inert Higgs doublet model"**
   Moumita Das and Subhendra Mohanty
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4. **"Constraints on TeV scale Majorana neutrino phenomenology from the Vacuum Stability of the Higgs"**
   Joydeep Chakrabortty, Moumita Das and Subhendra Mohanty
   [arXiv:1207.2027 [hep-ph]] (Communicated for publication)

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