Theoretical Studies of Cosmological Models In The Light of Experimental Observations

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By

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Year of submission: 2012

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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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.

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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 backreaction 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 $\mu \rightarrow e\gamma$ and Like-sign dilepton signals are studied in the light of the vacuum stability condition.

LIST OF PUBLICATIONS

- "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]]
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Contents

Abstract							
List of Publications v							
1	Intr	roduction					
2	\mathbf{Re}	view of cosmological theory of Inflation					
	2.1	1 Standard Model of Cosmology					
		2.1.1	Flatness problem	8			
		2.1.2	Horizon problem	8			
	2.2	Histor	ical developments of Inflation	9			
	2.3	Inflation solves the Flatness and Horizon problems		0			
		2.3.1	Flatness problem	0			
		2.3.2	Horizon problem	1			
	2.4	Basic of Inflation Model					
		2.4.1	Inflationary Dynamics	2			
		2.4.2	Slow roll approximation	4			
		2.4.3	Duration of inflationary era 1	5			
		2.4.4	Generation of scale invariance density perturbation 1	5			
		2.4.5	Curvature power spectrum	9			
		2.4.6	Observable parameters	1			
	2.5	Reheating		1			
	2.6	Different models of Inflation		2			
		2.6.1	Chaotic inflation	3			
		2.6.2	Hybrid inflation	4			

		2.6.3 Power-law inflation	25
		2.6.4 Warm inflation	26
	2.7	Higgs inflation	27
		2.7.1 Higgs minimally coupled with gravity	27
		2.7.2 Higgs non-minimally coupled with gravity	29
	2.8	Vacuum stability	31
	2.9	Conclusion	32
3	Mag	gnetic field generation in Higgs Inflation	33
	3.1	Introduction	34
	3.2	Conformal transformation	34
	3.3	Higgs inflation model	35
		3.3.1 Conformal transformation in Higgs inflation model \ldots	37
		3.3.2 Renormalization of tree level potential	39
		3.3.3 Dynamics of Higgs inflation	41
	3.4	Cosmological magnetic field	43
		3.4.1 Magnetic field generation in inflation model	44
		3.4.2 Generation of magnetic field during Higgs inflation	45
	3.5	Conclusion	49
4	Hig	gs inflation in Inert Doublet Model	51
	4.1	Introduction	52
	4.2	Inert doublet model	52
		4.2.1 Tree level potential of the model	53
		4.2.2 Loop correction to the potential	55
		4.2.3 Renormalization group equations for IDM model	57
		4.2.4 Values of coupling constants	57
		4.2.5 Variation of potential in early era	59
		4.2.6 Variation of potential in present era	59
	4.3	Generation of the scale invariant density perturbation	61
	4.4	Scalar mass spectrum	66
	4.5	Conclusions	66

5	Phe	nomen	ology of vacuum stability of standard model Higgs	69			
	5.1	Introd	uction	70			
	5.2	Vacui	um stability of the Standard Model Higgs potential \ldots	71			
	5.3	Renor	malization Group Equations	72			
		5.3.1	Higgs Quartic coupling λ_h	72			
		5.3.2	Yukawa coupling for Top quark λ_t	73			
		5.3.3	Gauge couplings g_1, g_2 and g_3	73			
	5.4	Higgs	coupling with heavy neutrino	75			
	5.5	Gauge	interactions of heavy neutrinos	78			
		5.5.1	Neutrinoless double beta decay	78			
		5.5.2	Lepton flavor violation	80			
	5.6	Same-	Sign-Dilepton signal at LHC	81			
	5.7	Conclu	$1sion \ldots \ldots$	83			
6	Sun	nmary	and conclusions	85			
Bi	Bibliography						

List of Figures

2.1	Schematic diagram of Hybrid inflation model	24
3.1	Running of λ as with the renormalization scale μ	39
4.1	Running of scalar couplings from present to early era	58
4.2	Running of Yukawa coupling λ_t and gauge couplings g_1, g_2 and	
	g_3 from present to early era $\ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots$	59
4.3	Effective potential in the early universe for SM Higgs doublet	60
4.4	Effective potential in the early universe for inert Higgs doublet .	60
4.5	Effective potential the present universe for SM Higgs doublet	61
4.6	Effective potential the present universe for inert Higgs doublet .	62
4.7	Variation of the potential at different era	63
5.1	Running of λ_h for different values of m_t in Standard Model	
	$(m_h = 125 \ GeV, \ \alpha_s = 0.1184).$	75
5.2	Running of λ_h for different values of m_h in Standard Model	
	$(m_t = 172.5 \ GeV, \ \alpha_s = 0.1184).$	76
5.3	Running of λ_h for different values of neutrino Yukawa coupling	
	Y_{ν} with $M_R = 0.1$ -1 TeV, $(m_t = 172.5 \text{ GeV}, \alpha_s = 0.1184)$	77
5.4	Neutrinoless double beta diagrams involving heavy Majorana field	79
5.5	Lepton Flavour Violating process $\ell_i \rightarrow \ell_j \gamma$	80
5.6	Production cross-section Fig. 4 (right) with $\sqrt{s}=7$ TeV in the	
	LHC	82
5.7	Production cross-section of the process Fig. 4 (right) with \sqrt{s} =14	
	TeV in the LHC.	83