

*Dedicated to my parents*



## DECLARATION

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I hereby declare that the thesis titled “**Probing physics beyond the Standard Model via the phenomenological study of neutrino masses, mixings, and resonant leptogenesis in neutrino mass and  $S_4$  flavour models**” is being submitted to the **Department of Physics, Tezpur University** under the School of Sciences in partial fulfillment for the award of the degree of Doctor of Philosophy in Physics. This thesis is based on research work carried out by me and it has not been submitted elsewhere for any other degree, diploma, fellowship, or recognition from any University or other organization.

Whenever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature and acknowledgment of collaborative research and discussions.

**Date:** 27-07-2024

**Place:** Tezpur, Assam



(Bikash Thapa)

Signature of the candidate





TEZPUR UNIVERSITY

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TEZPUR-784028::ASSAM

Dr. Ng. K. Francis  
Associate Professor  
Department of Physics

Phone: 03712-275559  
Email: francis@tezu.ernet.in

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CERTIFICATE OF THE PRINCIPAL SUPERVISOR

This is to certify that the thesis entitled “**Probing physics beyond the Standard Model via the phenomenological study of neutrino masses, mixings, and resonant leptogenesis in neutrino mass and  $S_4$  flavour models**” submitted to the School of Sciences, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Physics is a record of research work carried out by **Mr. Bikash Thapa** under my supervision and guidance.

All help received by him from various sources has been duly acknowledged.

No part of this thesis has been submitted elsewhere for award of any other degree.

Date: 27-07-2024

Place: Tezpur, Assam

(Dr. Ng. K. Francis)

Principal Supervisor





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**CERTIFICATE OF THE EXTERNAL EXAMINER AND ODEC**

This is to certify that the thesis entitled “**Probing physics beyond the Standard Model via the phenomenological study of neutrino masses, mixings, and resonant leptogenesis in neutrino mass and  $S_4$  flavour models**” submitted by **Mr. Bikash Thapa** to the School of Sciences, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Physics has been examined by us on \_\_\_\_\_ and found to be satisfactory.

The Committee recommends for the award of the degree of Doctor of Philosophy.

(Dr. Ng. K. Francis)

Principal Supervisor

Date: 27-07-2024

External Examiner

Date:





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Bikash Thapa

# List of Abbreviations

SM	Standard Model
BSM	Beyond Standard Model
EWSB	Electro Weak Symmetry Breaking
LHC	Large Hadron Collider
CC	Charged Current
NC	Neutral Current
PMNS	Pontecorvo-Maki-Nakagawa-Sakata
CKM	Cabibbo-Kobayashi-Masakawa
GUT	Grand Unified Theory
CP	Charge-Parity
TBM	Tri-bimaximal
NH	Normal Hierarchy
IH	Inverted Hierarchy
ISS	Inverse seesaw
eV	Electron Volt
GeV	Giga Electron Volt
TeV	Tera Electron Volt
RH	Right Handed Neutrino
VEV	Vacuum Expectation Value
BBN	Big Bang Nucleosynthesis
CMB	Cosmic Microwave Background
WMAP	Wilkinson Mass Anisotropy Probe



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