DECLARATION BY THE CANDIDATE

I, Animesh Barman, hereby declare that the subject matter in this thesis entitled, **"Phenomenology of Neutrino Masses and Mixing with Discrete Flavour Symmetry in the context of the latest neutrino oscillation data."**, is a presentation of my original research work. 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.

The work is original and has not been submitted earlier as a whole or in part for a degree or diploma at this or any other Institution or University.

This thesis is being submitted to the Tezpur University for the degree of Doctor of Philosophy in Physics.

Animesh Barman

Place: Tezpur
Date: 17-04-2025

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Signature of the candidate

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This is to certify that the thesis entitled **"Phenomenology of Neutrino Masses and Mixing with Discrete Flavour Symmetry in the context of the latest neutrino oscillation data."** submitted to the School of Sciences of 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. Animesh Barman** under my supervision and guidance. All help received by him from various sources have been duly acknowledged.

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

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CERTIFICATE OF THE EXTERNAL EXAMINER AND ODEC

This is to certify that the thesis entitled **"Phenomenology of Neutrino Masses and Mixing with Discrete Flavour Symmetry in the context of the latest neutrino oscillation data."** submitted by **Mr. Animesh Barman** to the School of Sciences of Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Physics has been examined by us on 17/ 04/ 2025 and found to be satisfactory.

Prof. Ng. K. Francis **External examiner**

LIST OF PUBLICATIONS

- Animesh Barman(Tezpur U.), Ng. K. Francis(Tezpur U.), Bikash Thapa(Tezpur U.), Ankur Nath(Tezpur U.), "Nonzero θ_{13}, CP-violation and neutrinoless double beta decay for neutrino mixing in the $A_4 \times Z_2 \times Z_3$ flavor symmetry model", Int.J.Mod.Phys.A 38 (2023) 02, 2350012

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- Hrishi Bora(Tezpur U.), Ng.K. Francis(Tezpur U.),Animesh Barman(Tezpur U.), Bikash Thapa(Tezpur U.), Neutrino Mass Model in the Context of $\Delta_{54} \times Z_2 \times Z_3 \times Z_4$ Flavor Symmetries with Inverse Seesaw Mechanism, Phys.Lett.B 848 (2024) 138329

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BOOK CHAPTER

- Animesh Barman(Tezpur U.), Ng. K. Francis(Tezpur U.), Bikash Thapa(Tezpur U.), Bichitra Bijay Boruah(Tezpur U.),Ankur Nath(Tezpur U.),"Nonzero θ_{13} and Neutrinoless Double Beta Decay for neutrino mixing and A_4 discrete flavor symmetries" published in "Advances in Physics and its Applications", Duliajan College, Duliajan, Dibrugarh, Assam, India, November 26-27,2021

- Animesh Barman(Tezpur U.), Ng. K. Francis(Tezpur U.), and Hrishi Bora(Tezpur U.),"Study on Minimal Modification of Tri-bimaximal Neutrino Mixing matrix and its Phenomenological Implications" to be published in PANE-2022, Manipur University, Manipur, India, November, 08-10,2022

- Hrishi Bora(Tezpur U.), Ng. K. Francis(Tezpur U.) and Animesh Barman(Tezpur U.), and" Δ_{54} flavor model for Dirac neutrinos: inverse seesaw" to be published in PANE-2022, Manipur University, Manipur, India, November, 08-10,2022

PAPER PRESENTED IN WORKSHOP / CONFERENCE

- Animesh Barman(Tezpur U.) and Ng. K. Francis(Tezpur U.), "Non-zero θ_{13} and Neutrinoless Double Beta Decay for neutrino mixing and A_4 discrete flavor symmetries"-paper presentation in an International Conference on "Advances in Physics and its Applications (APA-2021)", Duliajan College, Duliajan, Dibrugarh, Assam, India, November 26-27,2021

- Animesh Barman(Tezpur U.) and Ng. K. Francis(Tezpur U.)-"Nonzero θ_{13} and Deviation of Tri-bimaximal neutrino mixing and A_4 discrete flavor symmetries" Poster

Presented at XII Biennial National Conference of Physics Academy of North East (PANE2021), Tripura University, Assam, India, December 15-17,2021

- Animesh Barman(Tezpur U.) and Ng. K. Francis(Tezpur U.)-"Study on Minimal Modification of Tri-bimaximal Neutrino Mixing Matrix and its Phenomenological Implications" Poster Presented at XII Biennial National Conference of Physics Academy of North East (PANE2022), Manipur University, Manipur, India, November, 08-10,2022

- Animesh Barman(Tezpur U.) and Ng. K. Francis(Tezpur U.)-"Deviation from Tri-bimaximal neutrino mixing in the context of A_4 discrete flavor symmetry " paper Presented at "International Conference on Advanced Physics: IEMPHYS-2022" Department of Basic Science and Humanities, Institute of Engineering and Management Kolkata, India, September 22-24, 2022

- Animesh Barman(Tezpur U.) and Ng. K. Francis(Tezpur U.) participated at Particles and Nuclei International Conference, PANIC-2021, LIP, Lisbon, Portugal. September 05-10, 2021

Declaraton

The work in this thesis is based on research carried out at the Institute of Tezpur University, Department of Physics, Tezpur, Assam, India. No part of this thesis has been submitted elsewhere for any other degree or qualification and it is all my own work unless referenced to the contrary in the text.

Animesh Barman

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Date: 17-04-2025 Animesh Barman

Abbreviations

Abbreviation	Meaning
SM	Standard Model
CP	Charge-Parity
BSM	Beyond Standard Model
LHC	Large Hadron Collider
keV	Kilo Electron Volt
PMNS	Pontecorvo–Maki–Nakagawa–Sakata
CKM	Cabibbo–Kobayashi–Maskawa
MSW	Mikheyev-Smirnov-Wolfenstein
SAGE	Soviet–American Gallium Experiment
GALLEX	Gallium Experiment
GUT	Grand Unified Theory
KamLAND-Zen	Kamioka Liquid Scintillator Anti- Neutrino Detector-Xenon
LSND	Liquid Scintillator Neutrino Ditector
MiniBOONE	Mini Booster Neutrino Experiment
MINOS	Main Injector Neutrino Oscillation Search
BNL	Brookhaven national laboratory
TBM	Tri-bimaximal Mixing
HM	Hexagonal Mixing
GRM Golden Ratio Mixing	
WMAP	Wilkinson Mass Anisotropy Probe
eV	Electron Volt
TeV	Tera Electron Volt

VEV	Vacuum Expectation Value
NH	Normal Hierarchy
NO	Normal Ordering
IH	Inverted Hierarchy
IO	Inverted Ordering
B+L	Baryon+Lepton
CERN	European Organization for Nuclear Research
LEP	The Large Electron-Positron Collider
ISS	Inverse Seeasw
NDBD(0ββν)	Neutrinoless double beta decay
DM	Dark Matter
BAU	Baryon Asymmetry of Universe
BBN	Big Bang Nucleosynthesis
CMB	Cosmic microwave background
LNV	Lepton Number Violation
LFV	Lepton Flavour Violation
DW	Dodelson-Widrow

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Dedicated to my Parents and Sister Anima