Neutrino Activity at Institute of Physics

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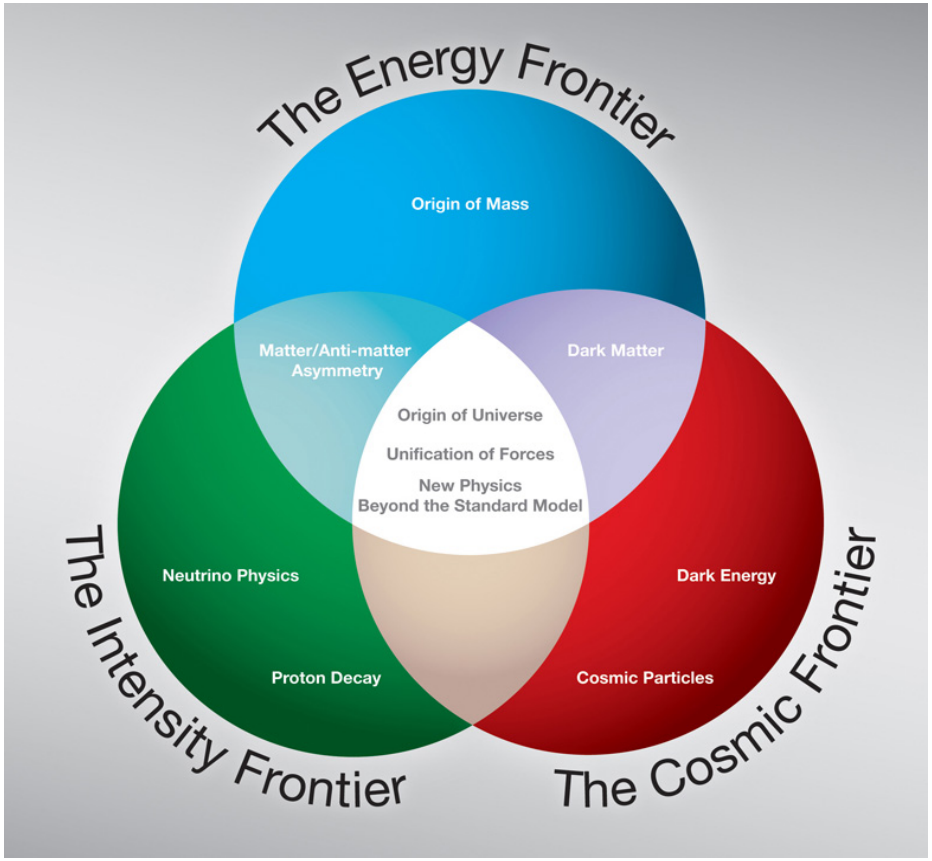
Exciting Phase in High Energy Physics



New Findings in all the Three Frontiers

The Energy Frontier:
Discovery of Higgs at LHC

The Intensity Frontier:
Discovery of the smallest mixing angle θ_{13}

The Cosmic Frontier:
First Direct Detection of Gravitational Wave at Advanced LIGO

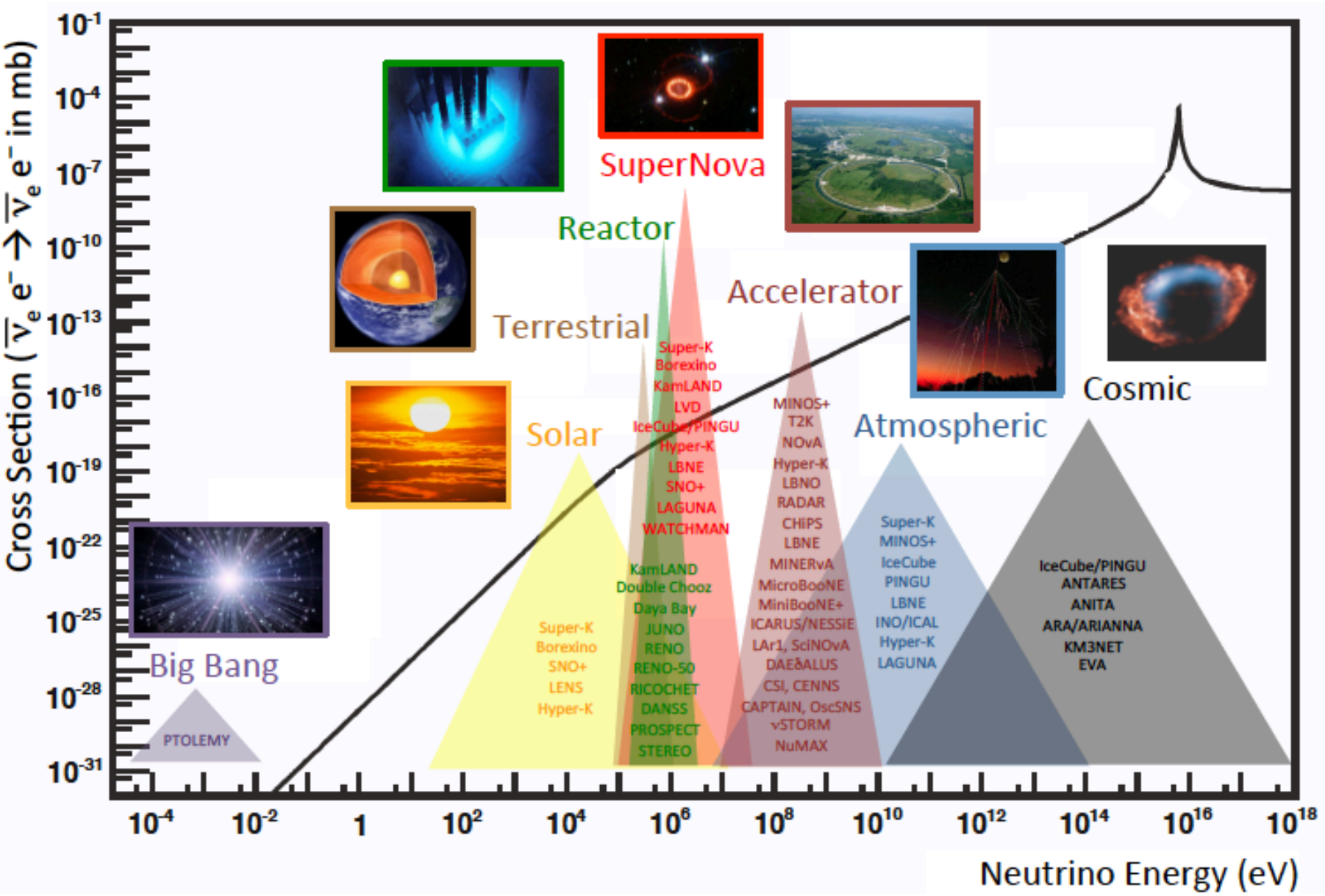
A New Era of Gravitational Wave Astronomy

Intensity Frontier: Neutrino properties: A window to our Universe and New Physics

Discovery of moderately large value of θ_{13} has crucial consequences for future theoretical and experimental efforts

Non-zero θ_{13} is the gateway to discover leptonic CP violation & to measure δ_{CP}

Neutrinos are omnipresent: Friends across 23 orders of magnitude



J. L. Hewett et al., arXiv:1310.4340v1, Snowmass 2013 Neutrino Working Group

HEP Group at IOP (Theory, Phenomenology, Experiment)

1) Sudhakar Panda: (String Theory, Cosmology)

2) Ajit M. Srivastava: (QGP, Astro-particle Physics, Topological defects)

3) Pankaj Agrawal: (New Physics Searches at Colliders, Radiative Corrections)

4) Sudipta Mukherji: (String Theory, Black Hole Physics)

5) Pradip Kumar Sahu: (ALICE Experiment, Nuclear Physics Theory)

6) Amitabh Virmani: (String Theory, Black Hole Physics)

7) Sanjib Kumar Agarwalla: (Neutrino Physics, INO, Borexino, Dark Matter)

8) Aruna Kumar Nayak: (CMS Experiment)

9) Shamik Banerjee: (String Theory, Black Hole Physics)

10) Debottam Das: (Beyond Standard Model Physics, Collider Physics, Neutrino Mass Models)

11) Manimala Mitra: (BSM Physics, $0\nu\beta\beta$-decay, Higgs Physics)

12) Kirtiman Ghosh: (Collider Physics, Neutrino Mass Models)

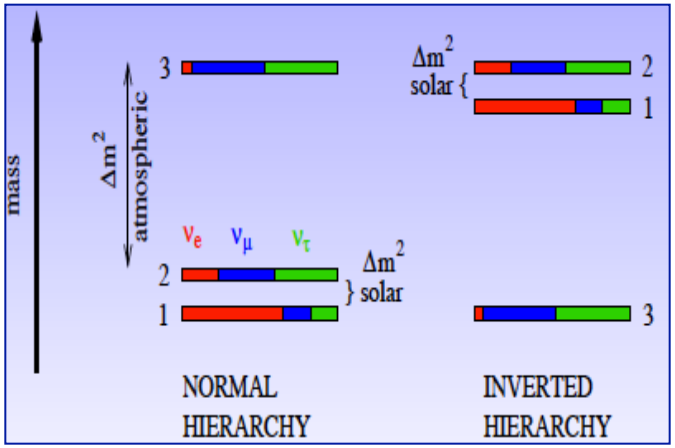
Students working on neutrino at IOP

Mr. Sabya Sachi Chatterjee
IOP Ph.D. student
working on neutrino phenomenology

Ms. Amina Khatun
INO Ph.D. student at IOP
Physics and Detector Simulation Studies

Fundamental Unknowns in Neutrino Oscillation

1. What is the hierarchy of the neutrino mass spectrum, normal or inverted?



- *The sign of* $\Delta m^2_{31} = m^2_3 - m^2_1$ *is not known*
- *Currently do not know which neutrino is the heaviest?*
- *Only have a lower bound on the mass of the heaviest ν*

$$\sqrt{2.5 \cdot 10^{-3}\text{eV}^2} \sim 0.05\ \text{eV}$$

2. What is the octant of the 2-3 mixing angle, lower ($\theta_{23} < 45°$) or higher ($\theta_{23} > 45°$)?

Measure θ_{23} precisely, Establish deviation from maximality at higher C.L. Then look for Octant

2. Is there CP-violation in the leptonic sector, as in the quark sector?

Mixing can cause CP-violation in the leptonic sector (if δ_{CP} differs from 0° and 180°)
Need to measure the CP-odd asymmetries: $\Delta P_{\alpha\beta} \equiv P(\nu_\alpha \to \nu_\beta;\ L) - P(\bar{\nu}_\alpha \to \bar{\nu}_\beta;\ L) \quad (\alpha \neq \beta)$

With current knowledge of θ_{13}, resolving these unknowns fall within our reach
Sub-leading 3 flavor effects are extremely crucial in current & future oscillation expts

Neutrino Activity at Institute of Physics

- The neutrino group at IOP has made several insightful contributions in neutrino physics. We have made far-reaching contributions in identifying methods to determine the neutrino mass ordering, mixing angles, and CP-violation in the lepton sector, all of which are pressing unsolved issues.

- The neutrino group at IOP is playing a leading role in the physics and detector simulation studies related to the Iron Calorimeter (ICAL) detector at the upcoming India-based Neutrino Observatory (INO) facility.

- The INO graduate students are being trained at IOP to develop the necessary tools needed for the simulation of this experiment.

- IOP is also very active in the outreach activities related to the INO project.

- We have made significant contributions in addressing the fundamental issues related to neutrino mixing and oscillations

- Recently, in a series of papers, we have explored in detail the physics reach of various currently running, upcoming, & future neutrino oscillation experiments, focusing on sub-leading three flavor effects, which will be the key to discover the ν mass hierarchy, octant of θ_{23}, & leptonic CP-violation

- We are playing a leading role in optimizing the vital parameters of the oscillation facilities, and to perform a detailed physics comparison among them, useful for future neutrino roadmap

- Is there a light eV-scale sterile neutrino? Do neutrinos feel new non-standard interactions arising from effective four-fermion dimension six operator? These issues are extremely important in the precision era and recently, we have performed some new studies along this direction

Recent Studies

1. A hybrid setup for fundamental unknowns in neutrino oscillations using T2HK (ν) and μ-DAR (antineutrino)
   S.K. Agarwalla, M. Ghosh, S.K. Raut
   e-Print arXiv: 1704.07151 [hep-ph] [Accepted in JHEP]

2. Indirect searches of Galactic diffuse dark matter in INO-MagICAL detector
   A. Khatun, R. Laha, S.K. Agarwalla
   e-Print arXiv: 1703.10221 [hep-ph] [Accepted in JHEP]

3. Degeneracy between θ_{23} octant and neutrino non-standard interactions at DUNE
   S.K. Agarwalla, S.S. Chatterjee, A. Palazzo
   e-Print arXiv: 1607.01745 [hep-ph] [Phys.Lett.B762 (2016) 64-71]

4. Octant of θ_{23} in danger with a light sterile neutrino
   S.K. Agarwalla, S.S. Chatterjee, A. Palazzo
   e-Print arXiv: 1605.04299 [hep-ph] [Phys.Rev.Lett. 118 (2017) no.3, 031804]

5. Physics Reach of DUNE with a Light Sterile Neutrino
   S.K. Agarwalla, S.S. Chatterjee, A. Palazzo
   e-Print arXiv: 1603.03759 [hep-ph] [JHEP 1609 (2016) 016]

Recent Studies

6. Discovery Potential of T2K and NOvA in the presence of a Light Sterile Neutrino
   S.K. Agarwalla, S.S. Chatterjee, A. Dasgupta, A. Palazzo
   Journal of High Energy Physics 1602, 111 (2016)

7. Exploring Flavor-Dependent Long-Range Forces in Long-Baseline Neutrino Oscillation Experiments
   S.S. Chatterjee, A. Dasgupta, S.K. Agarwalla
   Journal of High Energy Physics 1512, 167 (2015)

8. Running of Neutrino Oscillation Parameters in Matter with Flavor-Diagonal Non-Standard Interactions of the Neutrino
   S.K. Agarwalla, Y. Kao, D. Saha, T. Takeuchi
   Journal of High Energy Physics 1511, 035 (2015)

9. Probing Non-Standard Interactions at Daya Bay
   S.K. Agarwalla, S. Bagchi, D.V. Forero, M. Tortola
   Journal of High Energy Physics 1507, 060 (2015)

10. Probing Neutrino Oscillation Parameters using High Power Superbeam from ESS
    S.K. Agarwalla, S. Choubey, S. Prakash
    Journal of High Energy Physics 1412, 020 (2014)

Lots of Enthusiastic Students in Odisha

During last three and half years, I have met with huge number of young and motivated students who are studying in several Universities, Institutions, and Colleges across Odisha

Many of them are interested to pursue their research career in high energy particle physics. They are eager to take part in world class experiments

Here Indo-Japan Collaboration can be quite useful to provide them the right Platform where they can participate in the cutting edge experiments like Super-K, Hyper-K, ICAL-INO