Student grouping & min-projects

Son Cao (IFIRSE)

6th Vietnam School on Neutrinos, July 10th - 22nd, 2022, ICISE, Quy Nhon

School students and grouping plan

- 19 students: 14 Vietnamese (*7 USTH, 2 U.Edu, 1 FUV, 1 DT, 1 IU, 1 HCM-VNU, 1 HN-VNU*), 3 Indian, 1 Japanese, 1 Malaysia
- 8 females and 11 males
- We plan to have
  - **Four groups** (*4-5 students per group*) for hardware and software trainings
  - **Six groups** (*3-4 students per group*) for mini-projects

A grouping scheme

A, B, C, D for hardware training and software training

$\nu_1, \nu_2, \nu_3, \nu_e, \nu_\mu, \nu_\tau$ **groups for mini-projects**

Group A

1. A1
2. A2
3. A3
4. A4
5. A5

Group B

1. B1
2. B2
3. B3
4. B4
5. B5

Group C

1. C1
2. C2
3. C3
4. C4
5. C5

Group D

1. D1
2. D2
3. D3
4. D4

$\nu_1 - group$

$\nu_2 - group$

$\nu_3 - group$

$\nu_\tau - group$

$\nu_e - group$

$\nu_\mu - group$

Grouping

A, B, C, D for hardware training and software training

$\nu_1, \nu_2, \nu_3, \nu_e, \nu_\mu, \nu_\tau$ **groups for mini-projects**

Group A

1. Dang H. An (UEdu)
2. Hoang D. N. Trinh (F, USTH)
3. Huan Phan Nhut (DT)
4. Tin Mai (USTH)
5. Riya Gaba (F)

Group B

1. Naoto Onda (M)
2. Binh N. T. Yen (F, USTH)
3. Phu Nguyễn (FUV)
4. Linh Pham (F, IU)
5. Trong D. Q. (USTH)

Group C

1. Bhavna Yadav (F)
2. Thang N. T (USTH)
3. Thien H. Le (UEdu)
4. Thu N. H. (F, USTH)
5. Phat Thai (VNUHCM)

Group D

1. Nikhil Krishna
2. Hien N. (F, USTH)
3. Giang H. T. T. (F, HUS)
4. Nur Hidayah (F)

Grouping

A, B, C, D for hardware training and software training

$\nu_1, \nu_2, \nu_3, \nu_e, \nu_\mu, \nu_\tau$ groups for mini-projects

Group A $\nu_1 - group$

1. Dang H. An (UEdu)
2. Hoang D. N. Trinh (F, USTH)
3. Huan Phan Nhut (DT)
4. Tin Mai (USTH)
5. Riya Gaba (F)

Group B $\nu_2 - group$

1. Naoto Onda (M)
2. Binh N. T. Yen (F, USTH)
3. Phu Nguyễn (FUV)
4. Linh Pham (F, IU)
5. Trong D. Q. (USTH)

$\nu_e - group$ (A4, A5, B4, B5)

Group C $\nu_3 - group$

1. Bhavna Yadav (F)
2. Thang N. T (USTH)
3. Thien H. Le (UEdu)
4. Thu N. H. (F, USTH)
5. Phat Thai (VNUHCM)

Group D $\nu_\tau - group$

1. Nikhil Krishna
2. Hien N. (F, USTH)
3. Giang H. T. T. (F, HUS)
4. Nur Hidayah (F)

$\nu_\mu - group$ (C4, C5, D4)

Enjoy group working

Provisional mini-projects

"Theoretical"-oriented topics:

1. [Supervisor TBA] Discuss the necessity to use wave-packet treatment for neutrino oscillation rather than the plane-wave description. Elaborate the complete set of conditions for observing the neutrino oscillation.

2. [Supervisor TBA] The "standard" neutrino oscillation frameworks assumes the existence of three neutrino mass eigenstates and three flavor eigenstates and their states are mixed by an unitary matrix U^{PMNS} $|\nu_i>=\sum_\alpha U_{\alpha i}|\nu_\alpha>$ While three flavor neutrinos are observed, number of mass eigenstates are unknown (we know at least we have three). In case there are more than three mass eigenstates, the mixing matrix U^{PMNS} we are measuring with neutrino oscillation experiment is an effective matrix and can be non-unitary. In this case, how many parameters you need to describe the effectively non-unitary U^{PMNS} matrix? Propose method(s) to test the unitarity of the leptonic mixing matrix.

3. [Supervisor TBA] Discuss the difference between Dirac neutrino mass term and Majorana neutrino mass term. If neutrino is Majorana particle, i.e, their mass eigenstates are their own antiparticles, shall we expect that the neutrino and antineutrino oscillation for example $\nu_\mu \to \nu_e$ and $\bar{\nu}_\mu \to \bar{\nu}_e$ are the same? How can we tell experimentally if neutrino is Dirac or Majorana particle?

4. [Supervisor TBA] Discuss the standard parameterization of the leptonic mixing matrix. Is there any other parameterization(s)? Does δ_{CP} phase in the standard parameterization characterize well the amount of the leptonic CP violation?

5. [Supervisor TBA] To explain the lightness of neutrinos, one very popular method is to introduce the see-saw mechanism (it is by no means established or necessary). Discuss this mechanism and how it can connect with the leptogenesis scenario in order to provide an explanation for the matter domination with respect to antimatter at the present time.

6. [Supervisor TBA] Neutrino oscillation experiments essentially aim to extract the oscillation parameters (three mixing angles, one CP-violation phase, and two mass-square splittings in the "standard" leptonic mixing scenario) by measuring the flavor transition probabilities such as $\nu_\mu \to \nu_\mu$, $\nu_\mu \to \nu_e$, etc... However the probability can not define uniquely the value of the oscillation parameters. This situation is called "parameter degeneracy" in the neutrino oscillation measurements. Identify these degeneracies and discuss how neutrino experiments can deal with these degeneracies for the precise measurement of neutrino oscillation parameters.

7. [Supervisor TBA] Summarize what we have known so far about the neutrino mass spectrum. How does it compare to the other fundamental particles? Discuss two trains of though on what behind of the Neutrino mass spectrum: the flavor symmetry and the anarchy.

Provisional mini-projects (cont'd)

"Experimental"-oriented topics:

1. [Supervisor TBA] What is the probability that a neutrino will interact in your body over the course of your lifetime? Calculate neutrino event rate at Super-K detector from atmospheric neutrino source and from J-PARC neutrino beam. How does your calculation differ from reported event rate by Super-K?

2. [Supervisor TBA] Calculate the Jarlskog invariance and graphically present the unitary matrices with the present constraint on the oscillation parameters.

3. [Supervisor TBA] Neutrino oscillation measurements mostly relies on neutrino energy reconstruction in order to measuring oscillation parameters. Neutrino energy reconstruction: using lepton kinematic vs hadron information. What is the current limit and issue of neutrino energy reconstruction?

4. [Supervisor TBA] Discuss principle of off-axis neutrino beam (narrower band beam, such as T2K, NOvA). Pro and cons. in comparing to on-axis neutrino beam (wider band beam, such as MINOS, DUNE proposal)?

5. [Supervisor TBA] CP violation phase δ_{CP} can be measured from the difference between P ($\nu_\mu - \nu_e$) and P($\overline{\nu}_\mu - \overline{\nu}_e$). Calculate the CP violation effect in T2K, NOvA and Hyper-K if second-tank proposed to put in Korea. What is the Earth matter effect on this CP asymmetry? You can define CP asymmetry by

$$A_{CP} = \frac{P(\nu_\mu - \nu_e) - P(\overline{\nu}_\mu - \overline{\nu}_e)}{P(\nu_\mu - \nu_e) + P(\overline{\nu}_\mu - \overline{\nu}_e)}$$

6. [Supervisor TBA] Review of neutrino experiments with nuclear emulsion technology

7. [Supervisor TBA] One of the most striking usage of neutrinos is to look inside of the nuclear reactor. Present the concept and the recent developments of neutrino monitors for the reactor.

8. [Supervisor TBA] Why measuring the absolute mass of neutrino is so challenging? What are the methods we can come up and recent progress.

9. [Supervisor TBA] Discuss the possibility of using neutrino for communication between New York and Tokyo. What you can gain with neutrino-based combination in comparison to the conventional communication? What's the most challenging for developing this kind of communication?

10. [Supervisor TBA] Explore the sensitivity of neutrino mass ordering with the reactor-based medium-baseline JUNO experiment. How does it differ and compensate to the measurement with the accelerator-based long-baseline neutrino experiments such as NOvA, T2K and future DUNE and Hyper-K.

11. [Supervisor TBA] Discuss the energy at which the Earth becomes opaque to neutrinos, as a function of the zenith angle, if neutrino cross sections are described by the standard model. [Suggest to Retrieve: i) models for the Earth density profile ii) cross-sections for interactions with nucleons and electrons Both ingredients are needed to compute the "optical depth" to neutrinos along the line of sight.]

Select topics for your group by 12:00pm, Jul 13th, 2022

It’s okie if two groups select the same projects, but can’t more than two.