

# Neutrino Physics

Warwick Week 2018

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## **Lecture 1 : Neutrino History, Production and Detection**

- History of the neutrino
- Neutrino properties
- Design and properties of accelerator-driven neutrino beams
- Methods of neutrino detection - benefits and drawbacks
  - Radiochemical detection
  - Water Cerenkov experiments
  - Scintillations
  - Tracking detectors

## **Lecture 2 : Neutrino Mass : Theory and Experiment**

- Dirac and Majorana neutrinos
- The See-saw mechanism
- Attempts at direct measurement of neutrino mass using
  - $\beta$ -decay
  - Muon decay
  - Cosmology
- Neutrinoless double beta decay

## **Lecture 3 : Neutrino Flavour Oscillations I**

- Solar neutrinos and the Solar Neutrino Problem
- Atmospheric neutrinos and the Atmospheric neutrino Anomaly
- The theory of neutrino flavour oscillation
- Explaining the Solar Neutrino Problem
  - The effect of matter on flavour oscillations
- Explaining the Atmospheric Neutrino Anomaly
- Unravelling the PMNS matrix

## Lecture 4 : Neutrino Flavour Oscillations II

- Oscillation anomalies and sterile neutrinos
- The next generation : DUNE and Hyper-Kamiokande
- Mass heirarchy measurements - future
- CP violation - future
- The problem with neutrino cross-sections

## References and other interesting papers

There is a large array of papers and books devoted to neutrino physics out there. Here we offer a subset.

- **Books:**

- “Fundamentals of Neutrino Physics and Astrophysics”, C. Giunti and C. W. Kim
- “Neutrino Physics”, K. Zuber
- “Physics of Massive Neutrino”, F. Boehm and P. Vogel
- “Neutrino”, F. Close

- **Review articles:**

- “From eV to EeV : Neutrino Cross Sections Across Energy Scales”, J. Formaggio and G. P. Zeller, Rev.Mod.Phys. 84 (2012) 1307-1341
- “Double Beta Decay, Majorana Neutrinos, and Neutrino Mass”, F. T. Avignone III et al, Rev.Mod.Phys. 80 (2008) 481-516
- “Neutrino Oscillations: the rise of the PMNS paradigm”, G. Giganti et al, <https://arxiv.org/pdf/1710.00715.pdf>
- “Neutrino masses, mixing and oscillations”, Review in the Particle Data Group (PDG) book, [http://pdg.lbl.gov/2017/reviews/contents\\_sports.html](http://pdg.lbl.gov/2017/reviews/contents_sports.html)

- **Other papers:**

- “Theory of Neutrinos : a White Paper”, R. N. Mohapatra et al, <https://arxiv.org/pdf/hep-ph/0510213.pdf>
- “Neutrino Mass, Mixing and Oscillation”, B. Kayser, <https://arxiv.org/pdf/hep-ph/0104147.pdf>