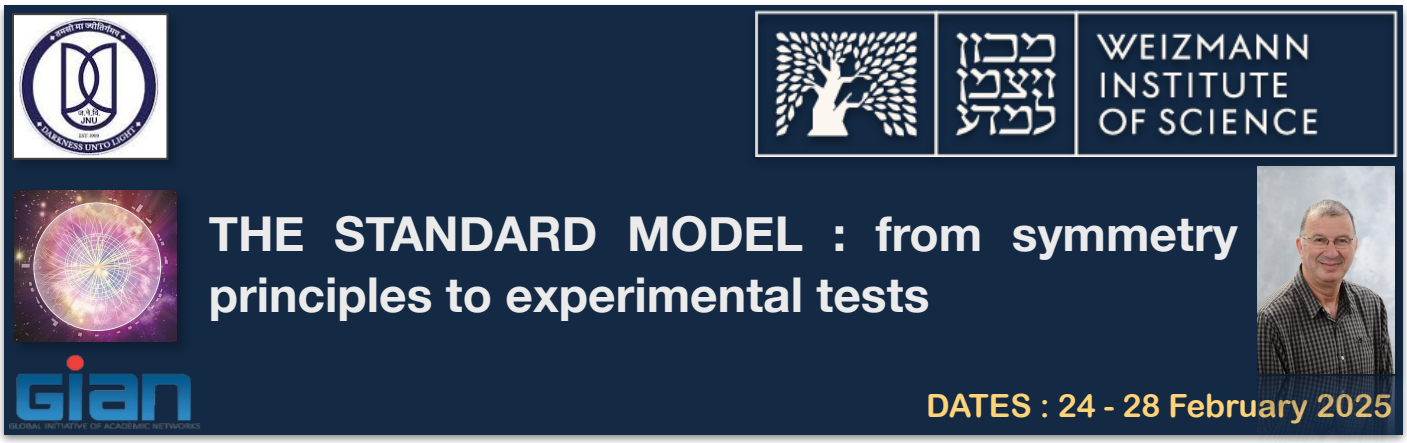
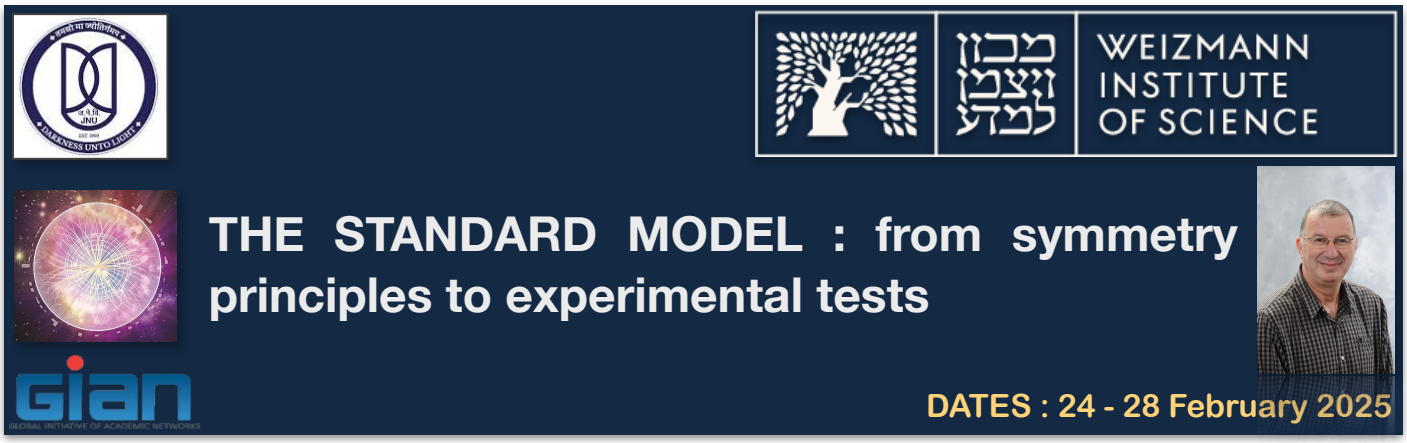


Overview

The currently accepted theory of particle physics is called the Standard Model. The basic ingredients of the Standard Model were conceived in the late 1960s and early 1970s by Sheldon Lee Glashow, Abdus Salam, and Steven Weinberg. At that time, many of the particles that now constitute part of it were yet to be discovered. By 2012, the full list of particles have been directly produced and detected, and the full list of the Standard Model parameters have been measured with impressive accuracy. Our current understanding of the basic laws of nature is based on very elegant symmetry principles. Once we know the symmetries of the universe and how the fundamental fields respect them, much of nature is explained. In particular, local continuous symmetries require the existence of certain types of interactions, and predict many characteristics of these interactions. The Standard Model is based on a local SU(3) × SU(2) × U(1) symmetry, spontaneously broken into an SU(3) × U(1) symmetry. This symmetry principle predicts the existence of the strong, electromagnetic and weak interactions, mediated by the spin-1 massless gluon, massless photon, and massive W- and Z-bosons, respectively. These interactions act on twelve matter particles - three up-type quarks, three down-type quarks, three charged leptons and three neutrinos. In addition, the matter particles experience the Yukawa interactions, mediated by the spin-0 Higgs boson. The Standard Model has been tested by numerous experimental measurements, and it has passed almost all of them with flying colors. The very few failures - neutrino masses and mixing, the baryon asymmetry of the universe, and dark matter - constitute the starting point for the road to an even deeper level of understanding nature.



Objectives

At the end of these lectures, the student should gain knowledge and understanding in two areas:

- The Standard Model : the symmetry principles that define it, the fundamental interactions and elementary particles that it describes, the ways in which it has been tested, its many successes, and its very few failures.

- The principles of model building in particle physics : the tools that are used to interpret new experimental results and, in particular, to extend the Standard Model if future measurements cannot be explained by it.

Actually, there is a third goal for this course. We think that the Standard Model is a scientific masterpiece, beautiful and elegant, and we hope to convey this sense of appreciation and intellectual joy to the students.

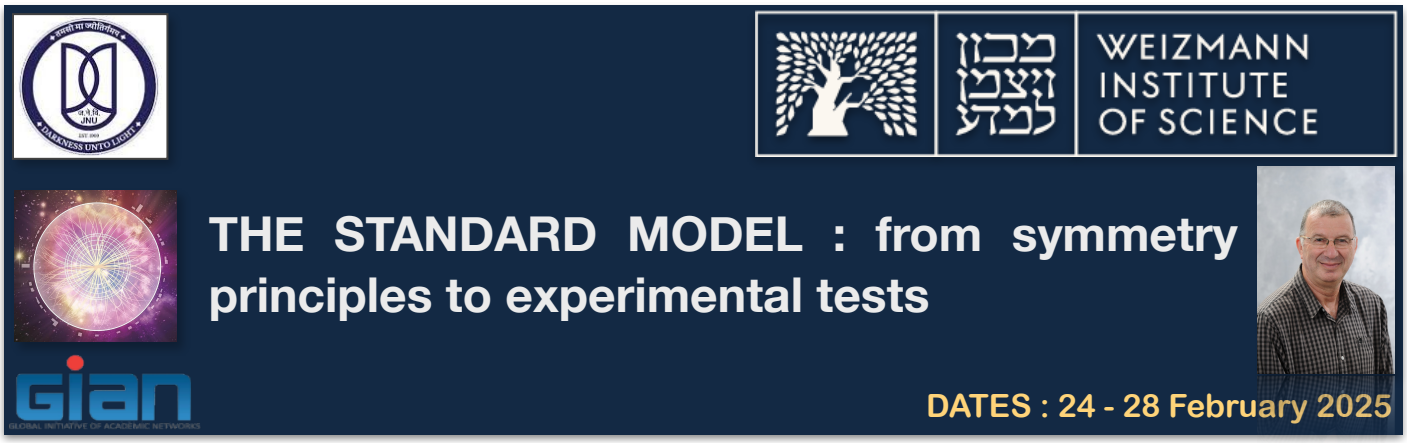
The Faculty

Yosef (Yossi) Nir
Professor of Physics
Weizmann Institute of Science, Israel

Yossi (Yosef) was educated in Israel. He obtained his B.Sc. in physics from the Technion, and his M.Sc. and Ph.D. from the Weizmann Institute of Science (1988). He did his post-doctoral research at SLAC, Stanford University, and then returned to Weizmann Institute, first as a senior researcher (1990) and then as a Professor (1994). He was a member of the Institute for Advanced Study in Princeton during 1999-2000. Yossi Served as the Dean of the Faculty of Physics of Weizmann Institute (2008-2015). He was a member of the Scientific Policy Committee (SPC) of CERN (2016-2022), the High Energy Physics board of the European Physical Society (2011-2019), the Scientific Advisory Board of the Munich Institute of Particle and Astroparticle Physics (MIAPP, 2016-2022), and more.

Yossi is a theorist, in the field of phenomenology of high energy physics. His research on CP violation, in the context of both particle physics and cosmology, phenomenology of supersymmetric models, and flavor physics, has been of high impact. He wrote, in collaboration with Professor Yuval Grossman, a textbook on the Standard Model (Princeton University Press, 2023), and in collaboration with Professor Helen Quinn, a popular science book on the matter-antimatter asymmetry of the Universe (Princeton University Press, 2008).

In recent years, Yossi has been conducting research, in collaboration with sociologists, on the under-representation of women in physics. He published research papers on this topic, delivered lectures and workshops around the world, and acted for promoting gender equality in Israel, and in the framework of the GENERA organization in Europe.



Course coordinator

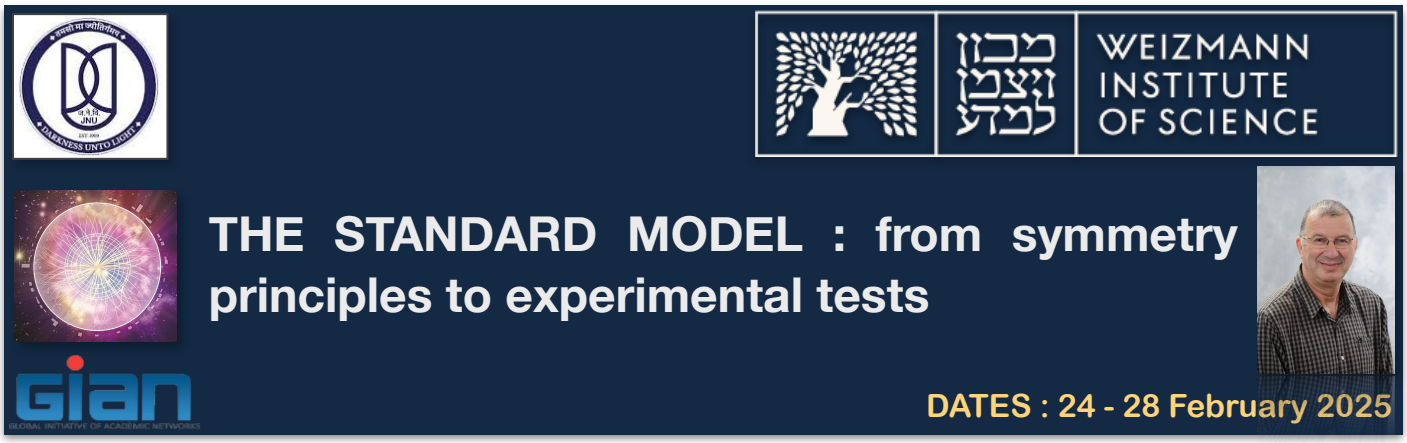
Poonam Mehta
Assistant Professor
School of Physical Sciences, Jawaharlal Nehru University

Poonam did her PhD in theoretical high energy physics from the Department of Physics and Astrophysics, University of Delhi in 2004. Thereafter she has held different positions at Harish-Chandra Research Institute (Post-doctoral fellow, 2004-2005), Weizmann Institute of Science (Visiting Scientist, 2005-2007), Raman Research Institute (Research Associate, 2008-2011) and University of Delhi (Dr D S Kothari Post-doctoral fellow, 2011-2013). Since 2013, she has been working as a faculty member at the School of Physical Sciences, JNU. Currently, she is a Visiting Associate (2024-2027) of Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune.

Her primary research interests involve neutrino oscillation phenomenology, astroparticle physics and new physics scenarios. Her group has been working on topics related to CP violation at long baseline neutrino experiments and in close collaboration with experimentalists at Brookhaven National Laboratory. She has been a member of international neutrino experimental collaborations such as Deep Underground Neutrino Experiment (DUNE) and India based Neutrino Observatory (INO). She is also listed as Friends of Invisibles Plus and Elusives which are European networks.

She is also interested in foundations of quantum mechanics, geometric phases in optics and condensed matter and in topics related to quantum information such as Leggett-Garg inequalities in the context of neutrino oscillations.

She has been mentoring and supervising Ph.D. students (3 awarded, 4 ongoing) and several Masters students since 2013.



Lecture Schedule

Day 1

Lecture 1: 1:30 hr - YN

Lagrangian and symmetries

Lecture 2: 1:30 hr - YN

Abelian symmetries and Quantum Electrodynamics (QED)

Tutorial 1: 2:00 hr - PM

Problem solving session/Talks by participants

Day 2

Lecture 3 : 1:30 hr - YN

Non-Abelian symmetries and Quantum Chromodynamics (QCD)

Lecture 4 : 1:30 hr - YN

Spontaneous symmetry breaking and the leptonic Standard Model

Tutorial 2: 2:00 hr - PM

Problem solving session/Talks by participants

Day 3

Lecture 5 : 1:30 hr - YN

The Standard Model

Lecture 6: 1:30 hr - YN

Beyond the Standard Model

Tutorial 3.: 2:00 hr - PM

Problem solving session/Talks by participants

Day 4

Lecture 7 : 1:30 hr - YN

Higgs decays

Lecture 8: 1:30 hr - YN

Flavor changing neutral currents

Tutorial 4: 2:00 hr - PM

Problem solving session/Talks by participants

Day 5

Lecture 9: 1:30 hr - YN

Neutrino masses and mixing

Lecture 10: 1:30 hr - YN

Particle cosmology

Tutorial 5: 2:00 hr - PM

Problem solving session/Talks by participants

Assessment: 2:00 hr

Examination and feedback from participants

Date of Examination: 28 February 2025

Reference : Y. Grossman and Y. Nir, The Standard Model, Princeton University Press (2023).

THE STANDARD MODEL : from symmetry principles to experimental tests

DATES : 24 - 28 February 2025

Who can attend

- Ph.D. students working in the areas of Particle Physics and Astro-particle or Cosmo-particle Physics
- Post-doctoral fellows or young researchers
- M.Sc. students and advanced under-graduate students
- Faculty members from reputed academic institutions and universities who may find the course useful for their current or future research

Important Information

- For course registration, please visit:

  http://www.jnu.ac.in/GIAN/

- Registration Deadline: **31 December 2024**

Registration

The participation fees for taking the course is as follows:

- M.Sc./B.Sc. Students (India) : NIL
- Ph. D. Students (India) : Rs. 2000
- Faculty from JNU : Rs. 3000
- Faculty from Academic Institutions (India): Rs. 10000
- Industry and Private Institutions (India): Rs 30000
- Participants from abroad : 500 US Dollars

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