Course unit English denomination	**Neutrino Physics**
Teacher in charge (if defined)	● **Riccardo Brugnera** ● **Stefano Dusini** ● **Massimiliano Lattanzi**
Teaching Hours	**24**
Number of ECTS credits allocated	**3**
Course period	**March 2025-May 2025**
Course delivery method	☒ **In presence** ☐ Remotely ☐ Blended
Language of instruction	**English**
Mandatory attendance	☒ Yes (50% minimum of presence) ☐ No
Course unit contents	*1st part: Direct measurements of neutrino masses* • Neutrinos masses – theoretical aspects • Beta decay experiments: general aspects • Past experiments and the KATRIN experiment • Bolometric experiments • Alternative approaches • ν_μ and ν_τ mass determination • Neutrinoless double-beta decay: general aspects • The GERDA/LEGEND experiments • Other important double-beta experiments *2nd part: Introduction to Neutrino Oscillation* • 3 neutrino oscillation formalism • PMNS matrix • Neutrino oscillation in vacuum and matter • Neutrino oscillation experiments with beam, solar, atmospheric and reactor neutrinos • Current and future experimental activity o CP violation o Neutrino Mass Ordering o Sterile Neutrinos *3nd part: Neutrino Cosmology* • The Standard Cosmological Model • Cosmological observables: cosmic microwave, background anisotropies, large scale structure, geometrical

probes
• The cosmic neutrino background
• Effects of massive neutrinos on cosmological observables
• Cosmological constraints on neutrino masses and on the effective number of neutrinos
• Prospects for next-generation experiment

Learning goals	**The course aims to give a concise summary of all the main topics of the neutrino physics (from the attempt to measure the neutrino mass and determine its nature to the study of the oscillation phenomenon and what we can learn about our Universe using neutrinos).** **The spirit of the course is phenomenological/experimental so the goal is to give to the student all the elements to judge critically the experimental program of the neutrino research field.**
Teaching methods	**Frontal lessons with the use of slides**
Course on transversal, interdisciplinary, transdisciplinary skills	☐ Yes ☒ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	
Examination methods (if applicable)	**Oral presentation of a topics extracted from the arguments touched during the lessons**
Suggested readings	● C. Giunti and C. W. Kim, Fundamentals of Neutrino Physics and Astrophysics, Oxford University Press, 2007. https://galileodiscovery.unipd.it/permalink/39UPD_INST/prmo4k/alma990023993520206046 ● J. Lesgourgues, G. Mangano, G. Miele, S. Pastor, Neutrino Cosmology, Cambridge University Press, 2013 ● S. Navas et al. (Particle Data Group), Phys. Rev. D 110, 030001 (2024): chapters "Neutrino masses, mixing and oscillations" and "Neutrinos in Cosmology"
Additional information	