**PhD Physics course at Bari University ( XXXIII Cycle)**

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| **Title** | Multi-messenger Astroparticle Physics |
| **Proponent** | Marco Circella |
| **# CFU**  **(1 CFU = 8 hours)** | 2 |
| **Schedule** | It will comprise 8 lectures of 2 hours each, but it can be also modulated as 5 lectures of ~3 hours each. It can be held in spring or fall, depending on the students’ needs |
| **Brief Summary of the course** | The aim is to provide the graduate students with an overview of the field, highlighting the recent results and the most promising areas for discovery. The focus will be on the complementarity of the information conveyed by different probes: charged cosmic rays, neutrinos, photons and gravitational waves. The students are required to have at least a basic understanding of particle physics. Basic knowledge in cosmology and astrophysics is helpful (but not needed). |
| **Programme** | 1. Basics of cosmology and astrophysics (Big Bang model, Big Bang nucleosynthesis, galaxy formation, stellar evolution, nuclear reactions in astrophysical objects)  2. Gravitational waves  3. Cosmic rays: acceleration and propagation, galactic vs. extra-galactic sources, the highest-energy dilemmas  4. Cosmic rays on Earth: solar modulation, geomagnetic effects, anomalous components, atmospheric showers  5. Antiparticles and antimatter in the cosmos  6. Dark matter and dark energy  7. Gamma-ray and neutrino-astrophysics  8. The Multi-messenger approach |
| **Recommended texts** | T. K. Gaisser, Cosmic Rays and Particle Physics for the basics in cosmic ray physics;summary reports for the other topics |
| **Assessment methods** | Questionnaire regarding the key concepts of the course + seminar on a topic of the course chosen by the student |