TITLE

"*Experimental Methods in Astroparticle Physics"*

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Email: rossella.caruso@unict.it

Office: Room 316, 3rd floor, DFA

Telephone: +39 095 3785402

Reception hours: Tuesday, h 17:00-19:00; Thursday 13:00-15:00

Program of the course:

0) Introduction

Introduction to the Astroparticle Physics: historical developments, fields of interest, fundamental questions. Particles as messengers from the Universe: the "multi-messenger" approach.

1) Charged particles: Cosmic Rays

Cosmic Rays: brief historical overview and general properties. The Energy Spectrum. Acceleration processes: the Fermi mechanism. Sources of cosmic rays. The GZK cut-off. Extensive Air Showers. Direct detection techniques for low, medium and high energy cosmic rays: main experiments and scientific results. Indirect detection techniques for very high, ultra high and extreme energy cosmic rays. Surface detectors and Fluorescence detectors. Main experiments and scientific results. The Pierre Auger Observatory for ultra high energy cosmic rays: the hybrid technique; performances and scientific results. Future perspectives, new projects and innovative techniques and detectors in the field.

2) Neutral particles: Cosmic Photons (Gamma Rays)

Astroparticle Physics of high, very high and ultra high energy photons: sources of gamma rays. Detection techniques: from the space with detectors on satellites to ground level with Cherenkov telescopes. Main experiments and scientific results. Future perspectives, new projects and innovative detectors & techniques according to the international road-maps in the field.

3) Neutral particles: Cosmic Neutrinos

Brief historical overview on neutrino theory and historical experiments on neutrino detection. Natural sources of neutrinos: neutrinos from the Earth (geo-neutrinos), atmospheric neutrinos; solar neutrinos, neutrinos from stellar collapses and SuperNovae, cosmogenic neutrinos, cosmological neutrinos. Detection techniques, main experiments and scientific results in the research of neutrinos for different sources. Future perspectives, new projects and innovative detectors & techniques according to the international road-maps in the field.

4) Gravitational Waves

Gravitation waves: theoretical explanation. Search for gravitational waves: detection techniques; use of interferometers. Main experiments and scientific results. Future perspectives, new projects and innovative detectors & techniques according to the international road-maps in the field.

5) Dark Matter

Dark matter: experimental evidences and gravitational lensing. Short outline of dark matter theories. Direct detection techniques: main experiments and scientific results. Indirect detection techniques: main experiments and results. Future perspectives, new projects and innovative detectors & techniques according to the international road-maps in the field

Bibliography:

- T.K. Gaisser "**Cosmic Rays and Particle Physics**", Cambridge University Press (Cambridge, 1990) •
- D. Perkins "**Particle Astrophysics**", Oxford University Press (Oxford, 2003)
- A. De Angelis, M.Pimenta **"Introduction to Particle and Astroparticle Physics - Multimessenger Astronomy and its Particle Physics Foundations**" - Springer (1st edition, 2015)
- M. Spurio **"Particles and Astrophysics: A Multi-Messenger Approach"** - Springer (2015)