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Radio emission from Air Showers. Comparison of theoretical approaches.

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While the fluorescence and the ground counter techniques of the ultra-high energy cosmic rays (UHECR) detection were being developed for decades, the interest in the radio detection diminished after the initial experiments in the 1960s. As a result, the fluorescence and the surface array techniques are more mature today, providing more reliable measurements of the primary cosmic particle energy, chemical composition and the inelastic cross-section. The advantages of the radio technique are 100% duty cycle and lower deployment and operational costs. Thus, the radio technique can greatly complement the fluorescence and the ground array detection and can also work independently. With the ANITA balloon detector observing UHECRs and the success of LOPES, CODALEMA and other surface radio detectors, the radio technique got a significant boost in recent years. Reliable Monte Carlo (MC) simulations are needed in order to obtain the energy and other parameters of the primary cosmic ray particle from the radio observations. Several MC techniques like, ZHairesS and the Endpoint Formalism, were proposed in recent years. While they seem to reproduce some of the observed data quite well, there is a divergence between the different approaches under certain conditions. In this work we derive these approaches from Maxwell''s equations, discuss their similarity and limitations that are applicable to the UHECR air showers and to the proposed experiment at SLAC.

Primary author: Dr BELOV, Konstantin (UCLA)

Presenter: Dr BELOV, Konstantin (UCLA)

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