Contribution ID: **84** Type: **not specified**

Electromagnetic processes in strong crystalline fields: Toward a high-performance calorimeter for future HEP experiments

Thursday, 12 September 2024 09:00 (30 minutes)

high-energy physics and astrophysics, yet their crystalline structure and lattice orientation are often overlooked in detector design. However, the electromagnetic field experienced by particles impinging on a crystal at small angles relative to a lattice axis can significantly influence interaction mechanisms. Specifically, for electrons or photons with energies of O(10 GeV) or higher striking a high-Z crystal at angles of a few mrad, the strong field regime is reached. In this regime, bremsstrahlung and pair production cross sections are enhanced compared to the Bethe-Heitler model, which applies to amorphous or randomly oriented materials. The SF-induced enhancement accelerates the development of the electromagnetic shower.

The OREO (ORiEnted Calorimeter) team is thoroughly investigating these effects, aiming to develop innovative calorimeters with higher energy resolution, improved photon detection efficiency, and better particle identification capabilities due to the relative enhancement of electromagnetic interactions over hadronic ones. Additionally, such a detector could achieve the same resolution as current models with reduced thickness. Here, we provide an overview of the lattice effects that drive the shower boost and discuss the current status of developing a functional calorimeter prototype. An oriented-crystal calorimeter could be transformative for both accelerator fixed-target experiments and satellite-based γ-ray observatories.

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Session Classification: Radiation: Generation & Interaction