Dynamic acoustic bending of crystalline structures for the generation of gamma radiation via undulation of super-relativistic electron/positron beams

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In the frame of Horizon Europe EIC-Pathfinder Project TECHNO-CLS: "Emerging technologies for crystal-based gamma-ray light sources", we present the scientific and technological aspects of Dynamical Acoustic Bending (DAB) of crystalline structures for the generation of gamma rays by undulation motion of super-relativistic electron or positron beams inside crystal lattices. Spatial modulation of the crystalline structure can lead to the formation of appropriately shaped channels in the lattice and electrons/positrons are guided to predefined trajectories and thus emission of coherent gamma radiation is achieved [1-4]. Here, two methods for DAB of crystalline structures are proposed and discussed: a) the Acousto-Optic Modulation (AOM) method based on the formation of longitudinal Standing Waves (SW), appropriate for inducing undulation motion of super-relativistic beams propagating diagonally inside the crystal and b) the vibrating rod or plate method, based on the formation of shear standing waves on a crystal structure constrained at its first and acoustically vibrated at its second end by a piezoelectric transducer. Two sub-variations of the AOM method are presented, based on piezoelectric and laser excitation, respectively. For the laser-based variation, the acoustic waves are induced by optoacoustic transduction through the thermoelastic excitation of thin metallic films coated on the undulation crystals. Moreover, diagnostic methods are presented for the characterization of the DAB methods based on laser interferometry. The thermomechanical aspects are discussed, with respect to the generated pressures, under approximation schemes of the physical boundary and loading conditions by the FEM.

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