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Linear Theory of Self-Amplified Parametric X-ray Radiation from High Current Density Electron Bunches

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The operation of synchrotron x-ray light sources and free electron lasers opened new era in the investigation of matter on Angstrom lengthscale with fs time resolution. However, need for GeV electron accelerators and hundreds meter long undulator modules results in high construction, which makes the existing facilities extremely overbooked. In recent years there were investigated several mechanisms that could lead to compact lab-size bright and coherent x-ray sources. In this contribution we will theoretically analyze the possibility to achieve the x-ray lasing from 100 MeV electrons in mm thick crystals based on the parametric beam instability effect. This effect was predicted by Baryshevsky and Feranchuk in 1983, they showed that above threshold current density value the interaction between parametric x-ray radiation electric field and relativistic electrons leads to instability and exponential growth of radiated intensity. This effect was realized in the THz range with artificial periodic structures, but for x-rays and crystals the threshold current density was estimated to be 10^9 A/cm^2; such current density values became recently available from short electron bunches. In this contribution we will review the linear theory of parametric beam instability, discuss the optimal geometries for the instability growth and generation of induced radiation from shot noise.

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