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Coherent Cherenkov Diffraction Radiation in Super-radiant Regime

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Cherenkov diffraction radiation (ChDR) appears when a fast charged particle moves in the vicinity of and parallel to a dielectric interface. This is a member of polarization radiation family, because the radiation arises as a result of dynamic polarization of a medium. Coherent ChDR is generated in the wavelength range longer than or comparable to the longitudinal size of the bunch. In this case all electrons emit radiation more or less in phase stimulating each other's emission. In this case the radiation intensity is proportional to a square of bunch charge resulting in an enormous increase in the number of photons.
When the coherent ChDR is generated by a periodical sequence of bunches, the radiation fields from all bunches in a train interfere resulting in further amplification of the light at discrete frequencies defined by the accelerating (RF) frequency and its harmonics. This regime is known a super-radiant emission and can be used to produce ultra-monochromatic lines of radiation with intensity defined by single bunch length. For example, if the bunch length is a 100 fs, multi-THz frequencies can be produced. If the number of bunches in a train is a 104, relative monochromaticity of 10-4 –10-7 can be achieved. Generating such a short bunch is rather challenging. Nevertheless, the generation mechanisms can be investigated in a lower frequency range. This lecture will summarize the experimental results obtained by our collaboration on generation of intense ultra-monochromatic ChDR radiation in mm-wavelength range.

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