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Multi-Particle Time-Domain Analysis of Coherent Synchrotron Radiation

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A Coherent Synchrotron Radiation source is under construction at Inter University Accelerator Centre, New Delhi. In this project, a train of super-radiant electron microbunches will be created inside a 2.6 cell normal conducting photo-injector and injected in to a compact undulator to produce coherent radiation in the frequency range of 0.18 - 3.0 THz. The synchrotron radiation emitted by an ensemble of electrons traversing through an insertion device is well understood in the frequency-domain. In this paper, the detailed time-domain analysis of the emission of radiation in the case of a single electron extended up to an electron bunch has been performed. The exact formula to calculate the phase-difference between the electro-magnetic waves emitted by different electrons occupying different spatial coordinates inside the electron bunch has been derived. The calculation is aimed at understanding the super-radiant emission of coherent synchrotron radiation in time domain and to explicitly understand the effect of the longitudinal and the transverse beam size on the emitted radiation. It is shown that the transverse electron beam size has only a second order effect on the radiation emitted along the axis of the trajectory but in the case of off-axis radiation, its intensity is dependent on the transverse and longitudinal distribution of the electron beam.

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