# Numerical Method and Parallelization for the Computation of Synchrotron Radiation

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## ABSTRACT

The purpose of this work is to develop and parallelize an accurate and efficient numerical method for the computation of synchrotron radiation from relativistic electrons in the near field. The high-brilliance electron beam and coherent short-wavelength light source provide a powerful method to understand the microscopic structure and dynamics of materials. Such a method supports a wide range of applications including matter physics, structural biology, and medicine development. To understand the interaction between the beam and synchrotron radiation an accurate and efficient numerical simulation is needed. With millions of electrons, the computational cost of the field would be large. Thus, multilevel parallelism and performance portability are desired since modern supercomputers are getting more complex and heterogeneous. The performance model and the performance analysis are presented.

## CCS CONCEPTS

• **Applied computing** → **Physics**; • **Computing methodologies** → *Shared memory algorithms*; *Parallel programming languages*; *Massively parallel and high-performance simulations.*

## KEYWORDS

Synchrotron Radiation, Performance Portability, Hybrid parallelization, Bandwidth bound

## 1 INTRODUCTION

Synchrotron and X-Ray Free Electron Lasers (XFELs) are extremely powerful sources of light, such as X-Ray. In the synchrotron, the accelerated Electrons emit energy While passing through a strong bending magnetic field. The electron is accelerating along a circular trajectory. The radiation is at X-ray wavelength when the acceleration is large enough.

In this work, we simulate the coherent synchrotron radiation which has much large power emission respect to incoherent emission. With the same number of electrons, the power generated from incoherent emission is proportional to the number of electrons and the power generated from coherent emission is proportional to the number of electrons square. At the same time, the electron beam will be disturbed by the powerful radiation generated from previous coherent emission 1. In order to obtain a high-quality electron beam and have a better design of particle accelerator, we want to understand more about this instability behavior through the coherent synchrotron radiation (CSR) simulation.

The poster is organized as follow: In section 2, we introduce a new numerical method to compute the electromagnetic field for the electron beam. In section 3, we show the multilevel parallelization scheme of the simulation. In section 4, we introduce the performance portability and the library, Kokkos. In section 5, the performance and the performance limitation are presented.

The contributions of this poster are: 1. we showed a novel method to compute the field with high accuracy. 2. we introduced the concept of performance portability and the library to the audience. 3. We analyzed the performance and identified the limitation of the performance in our scheme.

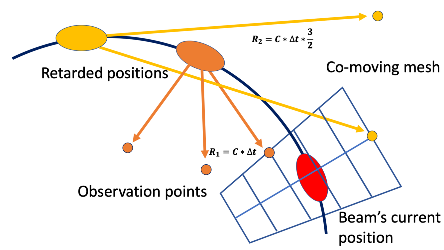


**Figure 1: Radiation form retarded position**

## 2 FIELD SOLVER

Compared to particle-in-cell type method, the CSR field solver [2], [3] is more accurate due to low numerical dispersion. At each time step. At each time, we discretize the wavefront and emit it from each electron. Next, we advance all the wavefronts that emitted at a previous time step and compute the field directly using the Lienard-Wiechert equation for those in the region of moving mesh. And then we interpolate the field at the wavefronts to the co-moving truncated sector mesh (see figure 2).

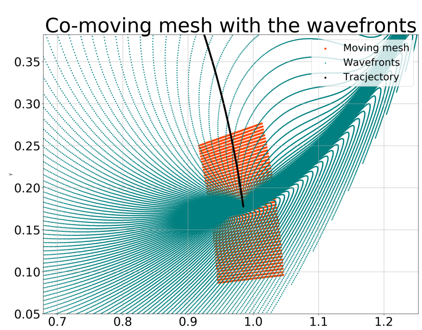


**Figure 2: The wavefronts and the co-moving mesh**