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High Efficiency Terahertz Generation in Periodically Poled Lithium-Niobate by Pulse Recycling

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1.Motivation
High energy multi-cycle (narrow band) terahertz pulses are necessary for linear electron acceleration [1]. Due to the low damage threshold of periodically poled Lithium Niobate (PPLN) crystals, high absorption of the material at the terahertz frequencies and low quantum efficiency, efficient generation of high energy terahertz beams is extremely challenging.
Here, we consider a consecutive arrangement of PPLNs as shown in Fig.1 that recycles the pump pulse for further terahertz generation. The arrangement increases the effective length (Leff) and circumvents excessive terahertz absorption through the out-coupling of the terahertz pulse after each stage. An quartz out-coupler is designed. The terahertz experiences Brewster's angle refraction at both S1,S2 surfaces, whereas the pump refracts at Brewster's angle at S3 surface (see Fig.1(a)). The transmission efficiency and terahertz beam profile with respect to incident angle, terahertz beam size and variation of the refractive index are examined.
The simulation is based on 2-D cylindrical coordinate using the split step Fourier method, 3-point finite difference method and low storage Runge-Kutta update scheme [2], which largely enhances computational performance and saves memory. The entire problem is updating in propagation direction z explicitly rather than in time t. The calculation is performed in C++ with MPI and openmp for parallelization. The illustration of the numerical method is shown in Fig.2.

2.Conclusion
A 2-D simulation from terahertz generation in PPLN to out-coupling though quartz is developed to calculate high efficiency terahertz generation with pump recycling.

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