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利用太赫兹高次谐波补偿产生阿秒超短电子束

摘要

获得超短电子束是超快科学研究的关键，然而二次及更高阶的非线性限制了束团的压缩极限，目前在不进行非线性补偿情况下，电子束仅能压缩到几飞秒的水平。传统射频高次谐波补偿方法可以将束长优化到亚飞秒尺度，但同时会带来无法忽略的能量损耗和射频抖动。本研究通过介质加载波导，利用太赫兹脉冲进行二次非线性补偿。模拟表明，通过高次谐波补偿，10fC 电荷、MeV 能量范围的电子束的长度可以被压缩到亚飞秒，同时，横向束流尺寸也可以优化至小于 20 微米。此类方法可应用于超快电子衍射（UED）、超快电子显微镜（UEM）和其他超快、时间分辨装置中，以实现更高的时间分辨率。

关键词

束团压缩，超快电子衍射，太赫兹

Keywords

beam compression, ultrafast electron diffraction, terahertz

Abstract

Obtaining ultrashort electron bunches is the key to the studies of ultrafast science, yet second and higher order nonlinearities limits the bunch length to a few femtoseconds after compression. Traditional regulation methods using rf higher order harmonics have already optimized the bunch length to sub-fs scale, yet the energy loss and rf jitter are not negligible. In this paper we demonstrate the second order regulation with THz pulses through a dielectric-loaded waveguide. Simulations suggest that with higher order regulations, the MeV electron bunches with tens of fC charges can be compressed to sub-fs rms and the second order distortion can be compensated. The transverse beam size is also optimized to less than 20um rms. This scheme is feasible for a wide range of electron charges. The relatively short bunch length is expected to find a better time resolution in UED, UEM and other ultrafast, time-resolved studies.

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