An Electron Dispersion Compensator

A Dispersion Compensator for UltraFast Electron Pulses

Untimed Pulse Compression For Electron Dispersion

Untimed Dispersion Compensation for Ultrafast Electron Pulses

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1 Introduction

1.1 Purpose

1.2 Ultrafast Electron Diffraction

1.3 Idea History

To use short electron pulses that emanate from a source, the pulse has to be delivered to a target at a different location. At the source, the pulse has an energy spread. The dispersion that arises from this initial energy spread limits the resolution at the target. The basic idea of an electron dispersion compensator is to alter the electron paths to compensate for the energy differences present in the electron pulse.

The electron dispersion compensator is modelled after the optical dispersion compensator. The dispersive element is a pair of magnetic fields which disperse the electrons according to velocity, similarly to the angled gratings in an optical compensator which disperse light according to wavelength. The time spent in these magnetic fields is independent of velocity so they do not contribute any delay. The compensation Δt in the optical compensator depends only on the path length difference Δl, so $\Delta t = \frac{\Delta l}{c}$ where c is the speed of light. For electrons Δt depends on a velocity change Δv, so $\Delta t = \frac{l}{\Delta v}$ where l is the path length. We use a Wien Filter, a pair of crossed magnetic and electric fields. The electric field sets up a linear potential which slows down the higher energy electrons and speed up the lower energy electrons.

The difference between the optical dispersion in a vacuum and electron dispersion is the dispersion relationship, given by (1). The group velocity of light in a vacuum $v_{g\gamma}$is equal to the phase velocity $v_{p\gamma}$, but for particles, $v_{ge} = 2v_{pe}$.

$$E_\gamma = p_\gamma c \qquad E_e = \frac{p_e^2}{2m} \tag{1}$$

$$w_\gamma = k_\gamma c \qquad w_e = \frac{\hbar^2 k_e^2}{2m} \tag{2}$$

$$v_{p\gamma} = c \quad v_{g\gamma} = c \qquad v_{pe} = \frac{\hbar^2 k_e}{2m} \quad v_{ge} = \frac{\hbar^2 k_e}{m} \tag{3}$$

1.4 Theory

2 Simulation

3 Conclustion