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THz SOURCES

Measurement and Control of the Spatial Amplitude of Bloch Oscillations in Semiconductor Superlattices

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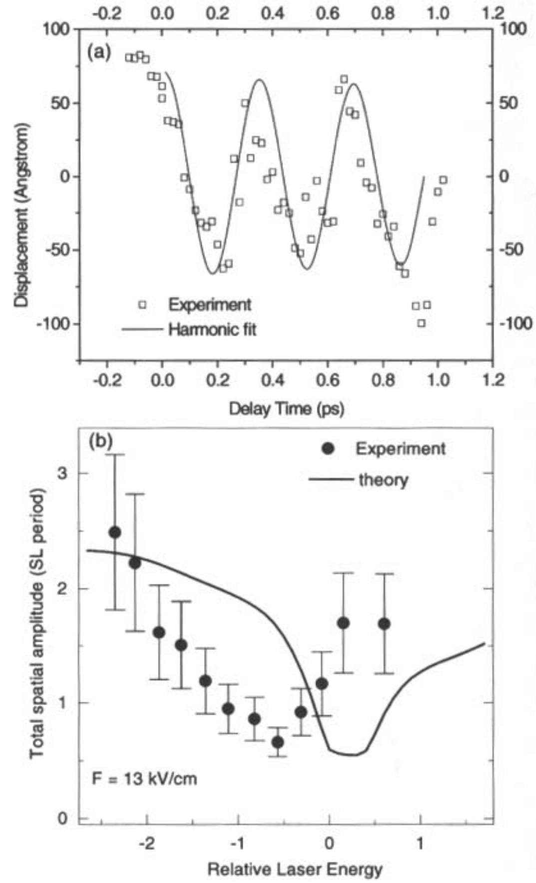
Bloch oscillations are one of the most basic effects in solids: If an electron is put into a static field, it will accelerate until it reaches the edge of the first Brillouin zone. It is then Bragg-reflected and returns to its original position, where it starts to accelerate again. The resulting spatial oscillation has never been observed in bulk solids since it is suppressed by scattering events. Bloch oscillations have recently been observed in semiconductor superlattices.[1–3] These experiments demonstrate that the frequency of the oscillations is tunable over a large range by the static electric field and that the electron oscillations lead to emission of THz radiation, which is promising for applications.

Recently, the spatial oscillation of the electrons (which was originally predicted by Zener in 1934) was observed for the first time. In these experiments, the small dipole field created by the oscillating Bloch wave packets in GaAs/AlGaAs superlattices is detected using the field shift of the optical transitions of the superlattices, which form a ladder (the so-called Wannier-Stark ladder).

Figure 1a shows the displacement of the center-of-mass of the electron wave packet as a function of time. For the given excitation conditions, the electron wave packet performs an oscillation with a total amplitude of about 150 Å. With increasing static field, the oscillation amplitude decreases as expected by theory.[3]

An exciting possibility in superlattices is to control the electron wave packet amplitude by changing the spectral laser position. For excitation below the center of the Wannier-Stark ladder, one creates a harmonic motion as shown in Figure 1a, for excitation above the motion is similar, but with an initial velocity in the opposite direction. For excitation on the center of the ladder, the electron wave packet only performs a breathing mode motion,[4] without a significant center-of-mass motion. Figure 1b shows the amplitude in units of the superlattice period in the dependence of the various excitation condition versus the excitation energy (given in units of the Stark ladder splitting). For excitation below and above the Wannier-Stark ladder center, the wave packet spatially oscillates. While exciting near the center, one finds a minimum of the oscillation amplitude, which is associated with the breathing mode motion.[5]



Sudzius Figure 1. (a) Bloch electron displacement as a function of delay time. (b) Amplitude of the Bloch-oscillatin wave packet as a function of the excitation energy.

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A New Tunable Coherent FIR-THz Source

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The electron beam in an SEM and a diffraction grating mounted in the focal region of the e-beam have been used to produce coherent radiation in the far-IR (FIR) region of the spectrum.[1] The device, termed a grating coupled oscillator (GCO), could also be described as a Smith Purcell free-electron laser.

As the beam moves over the grating, the incoherent superposition of the radiation wakes produced by indi-