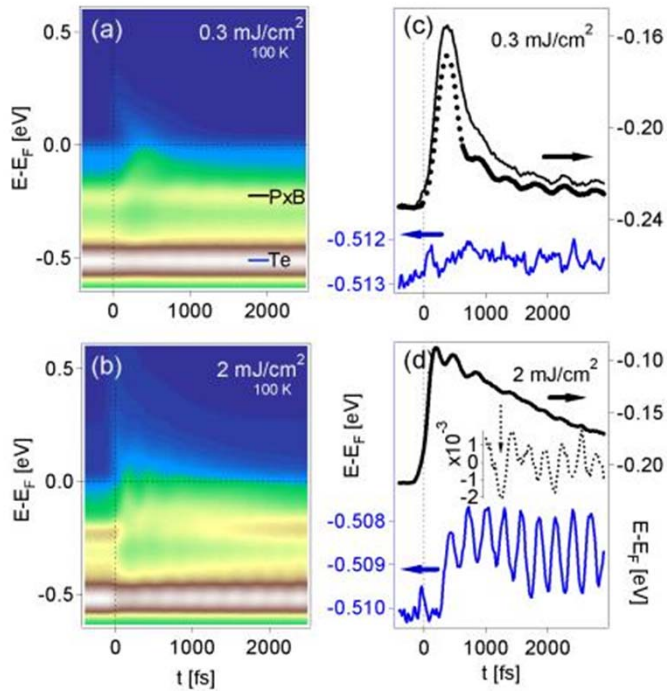
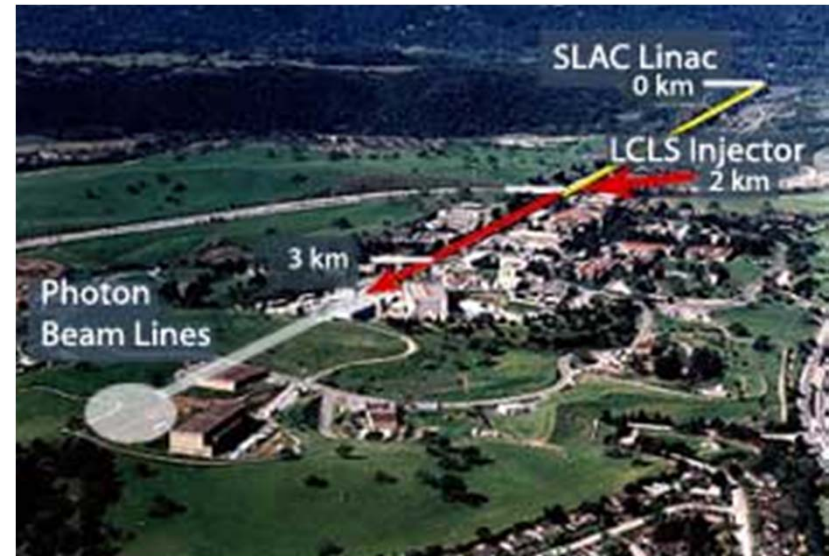
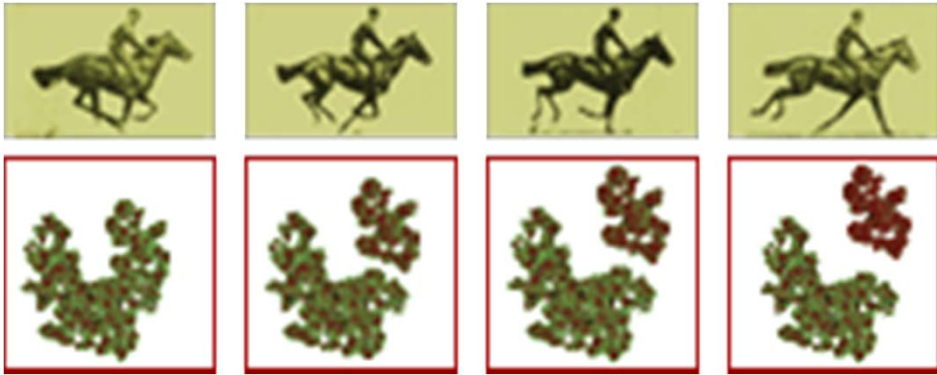


High-order Harmonic Generation in Bulk Crystals

Alexander F. Kemper, Brian Moritz,
Thomas P. Devereaux

Time domain spectroscopy

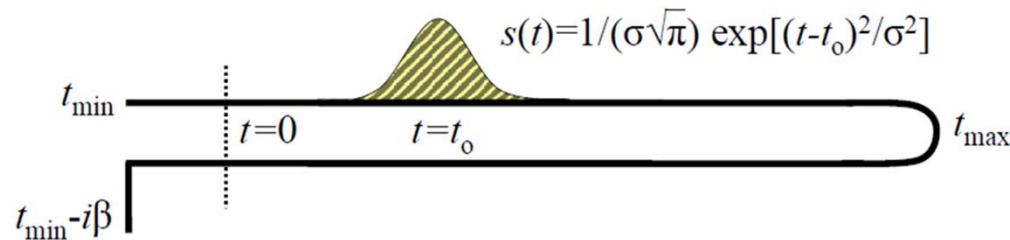


We can now see electron oscillations in real time!

F. Schmitt et al., Science 321 (2008)

Simulations of time domain spectroscopy

Experiments break time-translation invariance; so should theory!



Calculations are done on the Keldysh contour, which encodes all time information

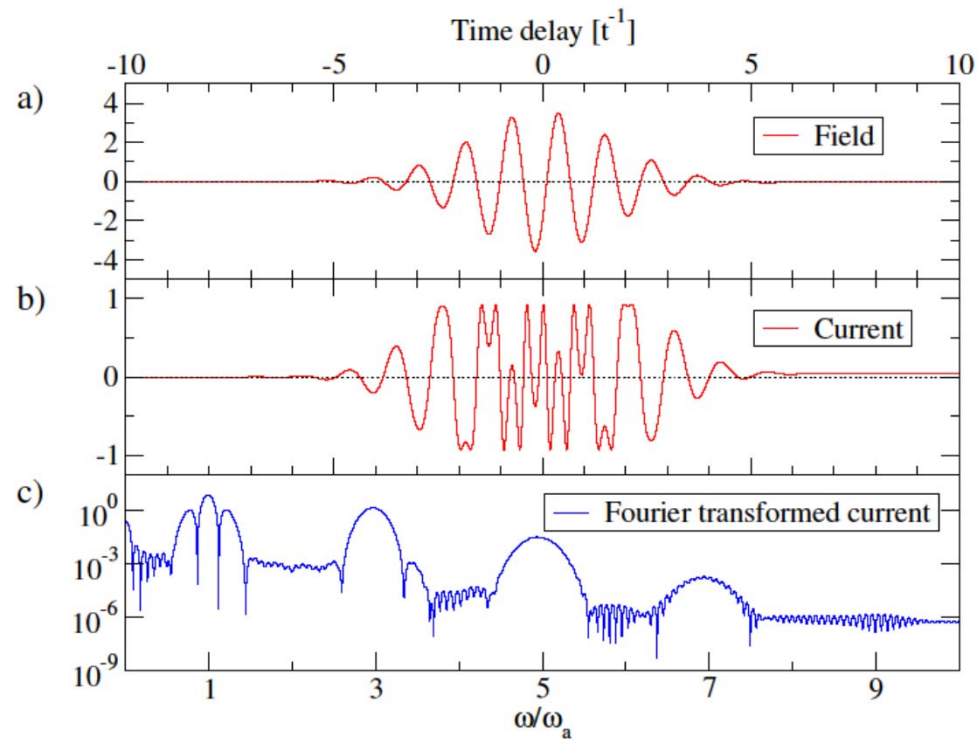
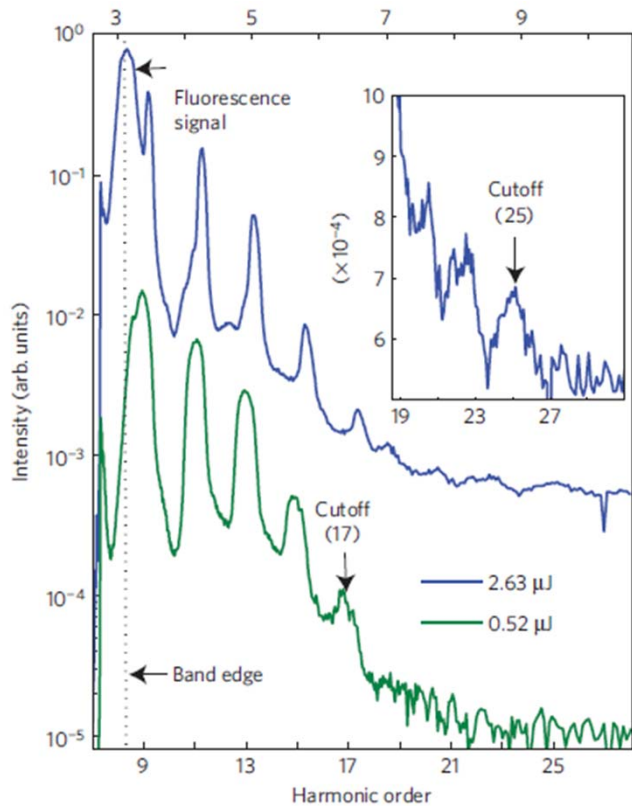
Fields are included through the Peierls substitution

Discretize the contour into ~ 5000 slices along the real-time legs, and ~ 100 along the imaginary spur, leading to a matrix of $\sim 10,000$ by $\sim 10,000$

Most calculations linearly scalable (up to memory constraints)

High-order harmonic generation

- Crystals under strong fields exhibit Bloch oscillations when they scatter off band gaps in a crystal



High-order harmonic generation

