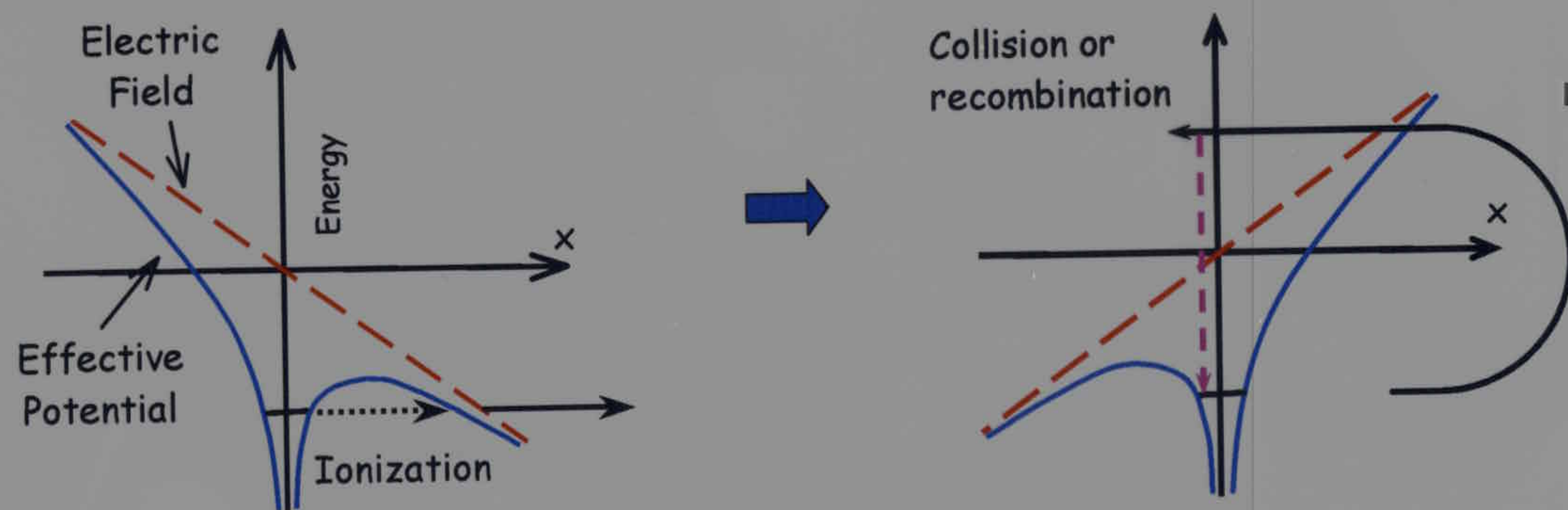
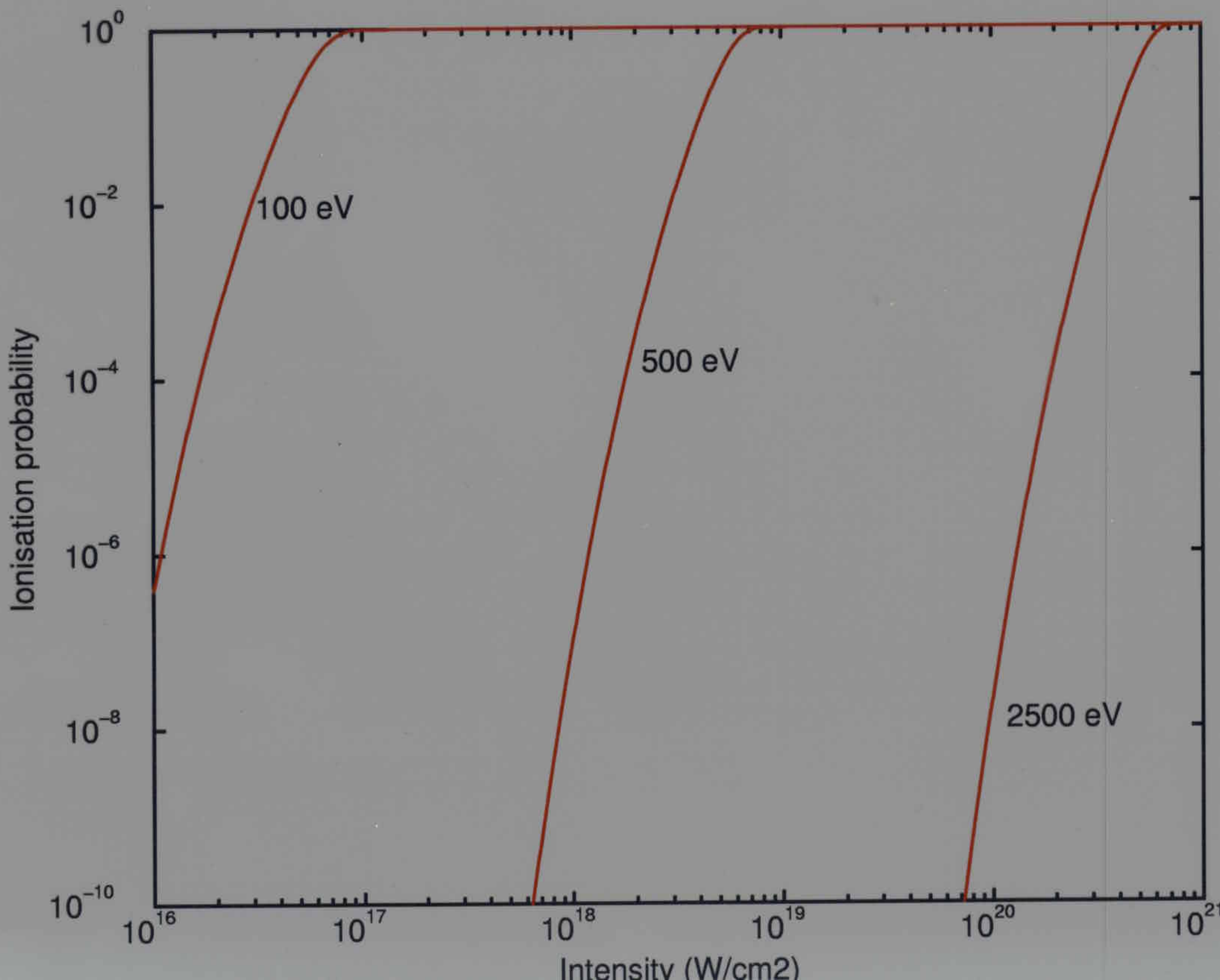
THE SIMPLEMAN'S MODEL

1. For low laser frequencies, the valence electron ionizes by tunnelling
2. The electron moves as a free particle in the laser field
3. The electron can gain kinetic energy from the field
4. The electron collides with the core or recombines radiatively



Maximum kinetic energy at return: 3.2 U_p
where U_p is the ponderomotive energy

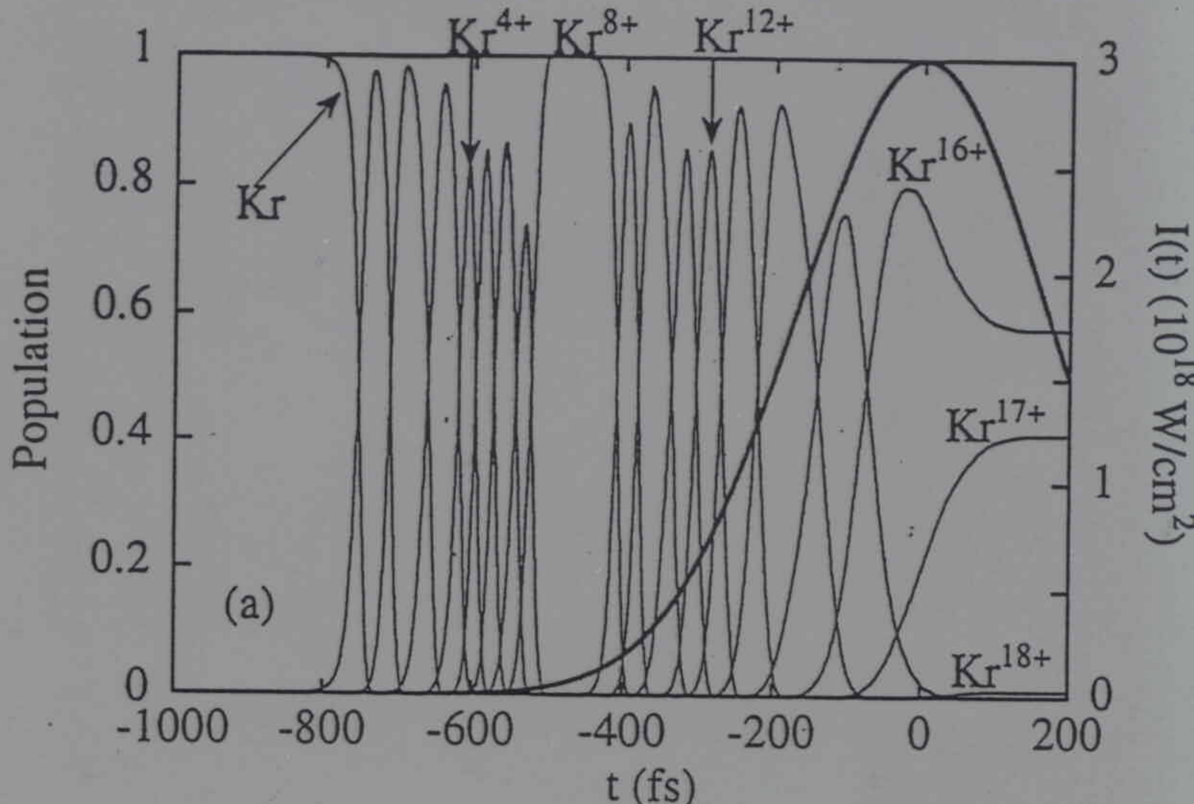
Muller and van Linden van den Heuvel; Corkum; Kulander and Shafer,...


Ionisation probability
10^0
10^-2
10^-4
10^-6
10^-8
10^-10
10^16
10^17
10^18
10^19
10^20
10^21
Intensity (W/cm2)
100 eV
500 eV
2500 eV

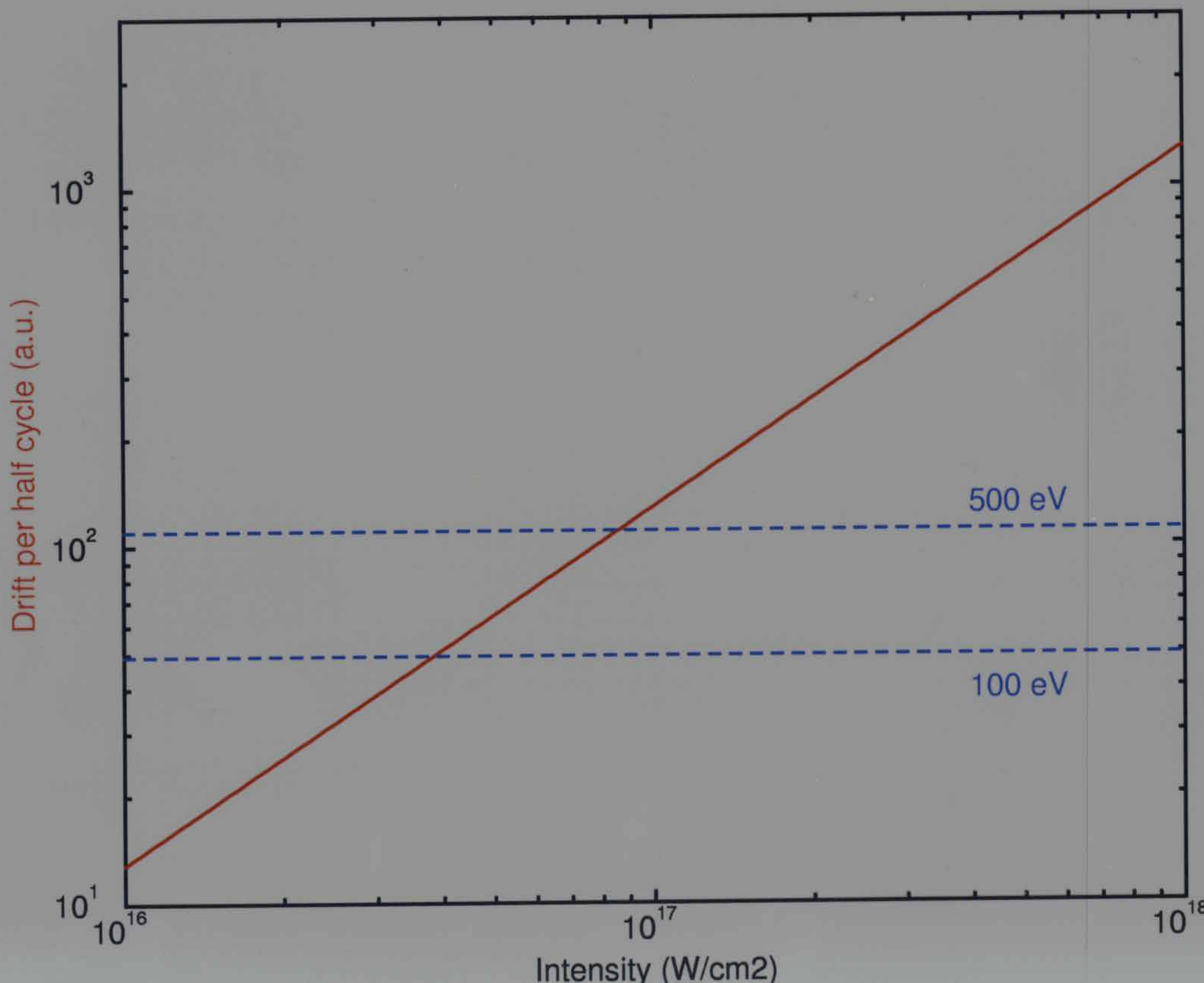
Photoionization in ultra-intense puls[e]

- C. I. Moore et al, PRL 82, 1688 (1999)
- R. Taïeb et al, PRL 87, 053002 (2001)

Nd:YAG, 3×10^{18} W/cm^2, $\tau = 400$ fs



Moore et al predict the emission of 1 GeV electrons from ionisation of hydrogenlike Ar at 5×10^{21} W cm^{-2}.



Drift per half cycle (a.u.)
10^3
10^2
10^1
500 eV
100 eV
10^{16}
10^{17}
10^{18}
Intensity (W/cm2)

STRONG FIELD APPROXIMATION

M.Lewenstein et al. PRA **49**, 2117 (1994), M. W. Walser et al. PRL **85**, 5082 (2000)
C.C.Chirilă et al. PRA **66** (December, 2002)

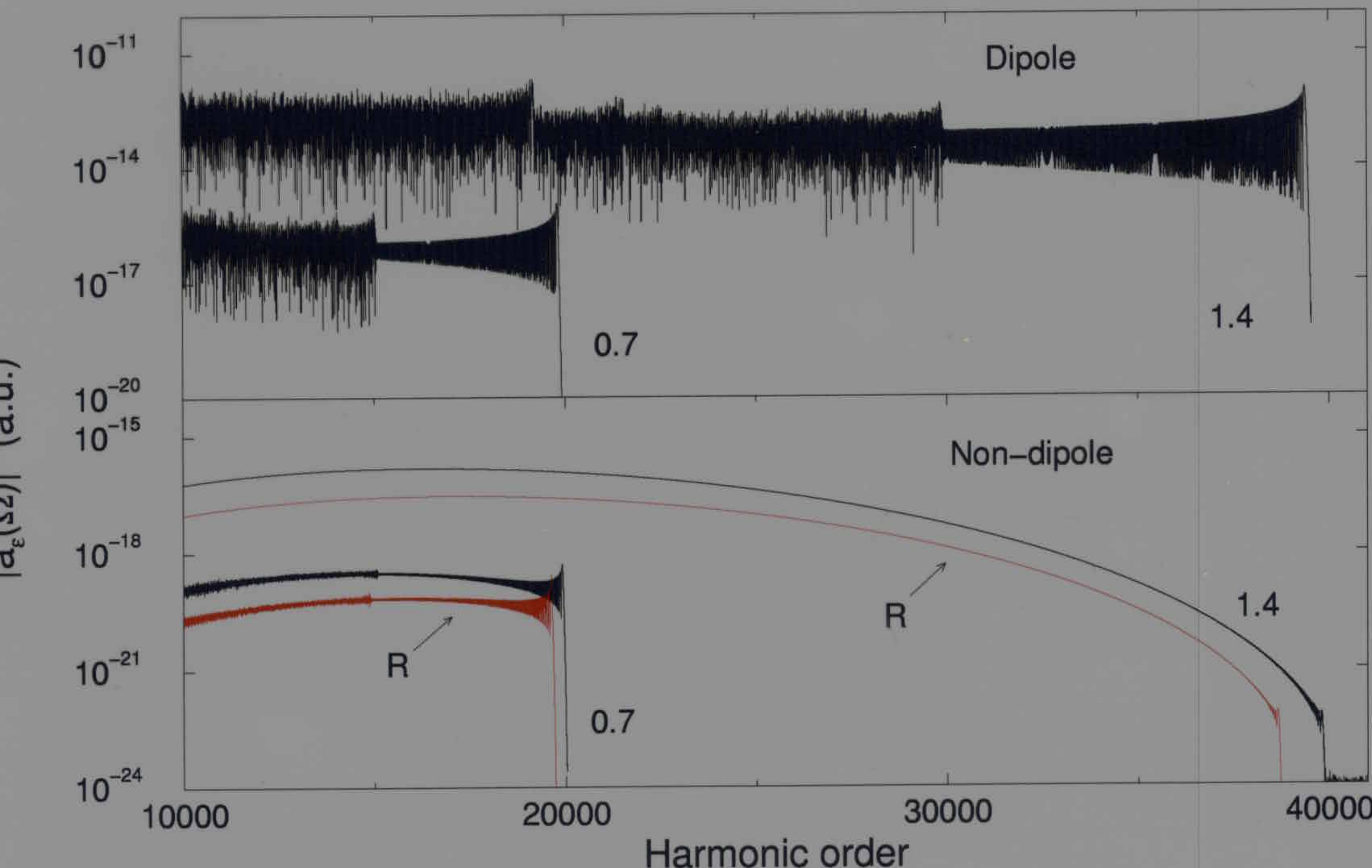
- Time-dependent dipole moment of the atom is approximated by:

$$d(t)=2\,\mathrm{Re}\int_0^t dt' \;\langle \text{Final state}(t)| \times \text{Dipole operator} \times [\text{Volkov Green's operator}(t,t')] \times [\text{Interaction Hamiltonian}(t')] \times |\text{Initial state}(t')\rangle$$

- Beyond the dipole approximation:

Use non-relativistic non-dipole interaction Hamiltonian and Volkov Green's function

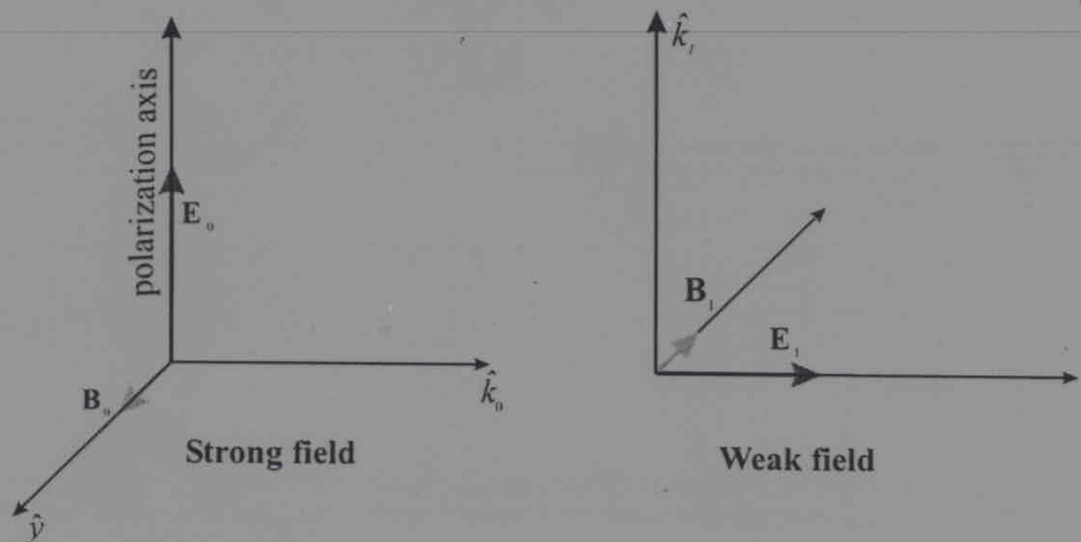
Ne^{6+}, stationary field, 1054 nm, 0.7 or 1.4×10^{17} W cm^{-2}



R: relativistic results of Milošević, Hu and Becker [PRA 63, 011403(R) (2001)]

COMPENSATING THE MAGNETIC DRIFT USING A SECOND LASER PULSE

- The second, weak laser pulse is polarized along $\hat{\mathbf{k}}$, the propagation direction of the intense field:



- The vector potential describing the two pulses is

$$\mathbf{A}(\mathbf{r},t) = \mathbf{A}(0,t) + \frac{1}{c}(\hat{\mathbf{k}}_0 \cdot \mathbf{r})\mathbf{E}_0(\omega_0 t)\,,$$

  with

$$\mathbf{A}(0,t) \;=\; \hat{\epsilon}_0\, A_0(t) + \hat{\mathbf{k}}_0\, A_1(t-\tau_d)$$

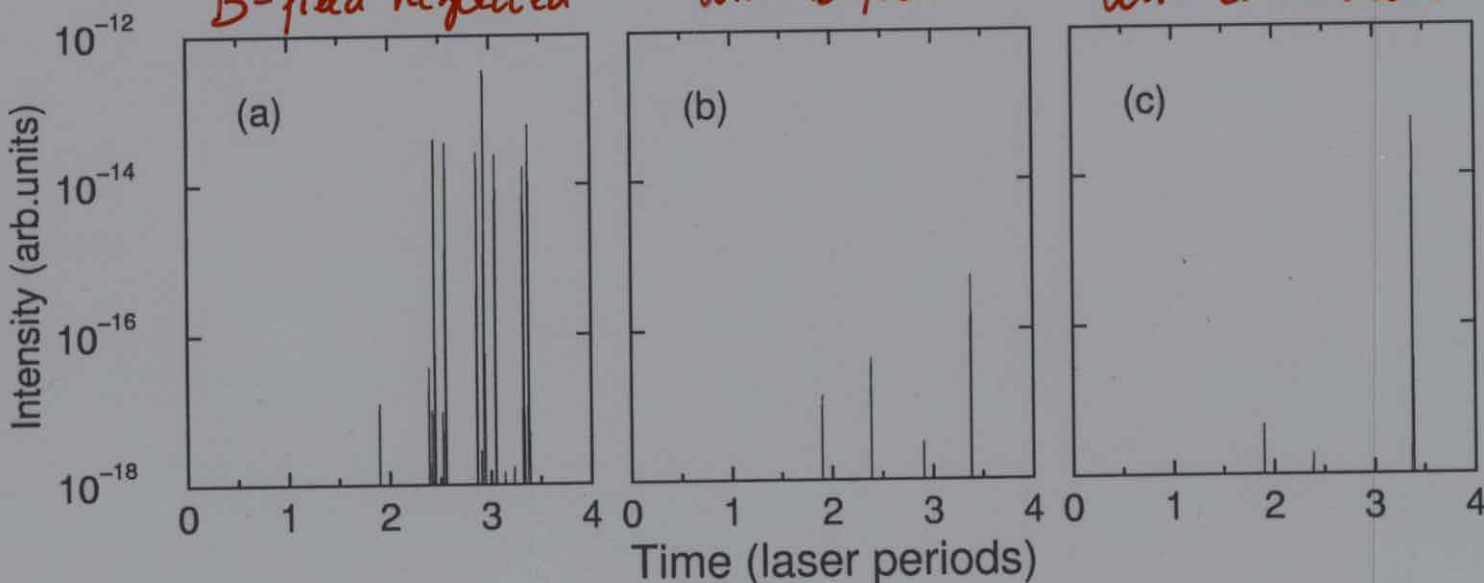
  and τ_d is the delay of the second pulse.

- We take both pulses to have the same wavelength and profile.

800 nm, 4-cycle pulse, Ne^{6+}

$\Omega = 2500\,\omega$ (3.9 keV photons)

B-field neglected | with B-field | with correction



S. X. Hu et al, JPB 35 (2002) 627

"NONTUNNELLING HIGH-ORDER HARMONICS

2-d calculations for 248 nm, 1.9×10^{18} W/cm^2