Transient Effects in the Optical Pumping of Rubidium

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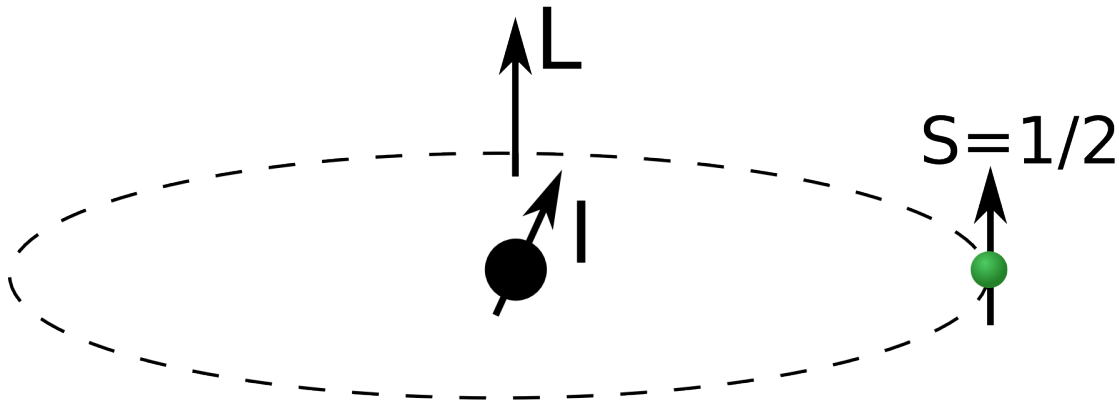
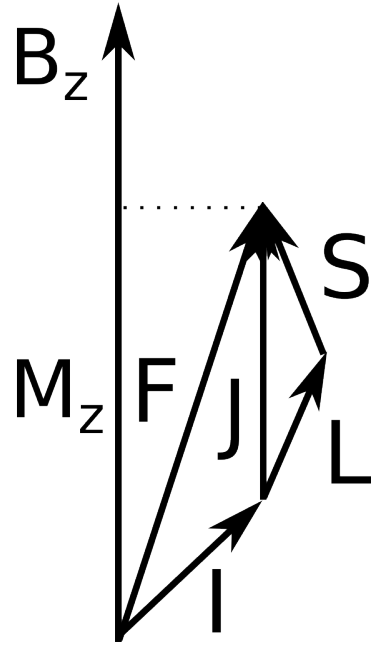
Transient Effects

- Measurements of re-population rate with varying,
  - Light Intensity
  - Vapor Temperature
  - Magnetic Field Tangent to Optical Axis
  - Magnetic Field Along Optical Axis
- Measurements of Rabi oscillation period with varying,
  - RF Amplitude
  - RF Frequency

Energy Structure of Hydrogen-Like Atoms in a Magnetic Field B_z





Photon Induced Energy Transitions in a Magnetic Field

Circularly-Polarized Light

$$\text{Right-Handed} \rightarrow \sigma^+$$
$$\text{Left-Handed} \rightarrow \sigma^-$$

$\Delta M_z = +1$

$$\mathbf{B_z} \cdot \sigma^+ > 0 \qquad \Delta M_z = +1$$
$$\mathbf{B_z} \cdot \sigma^- < 0 \qquad \Delta M_z = +1$$

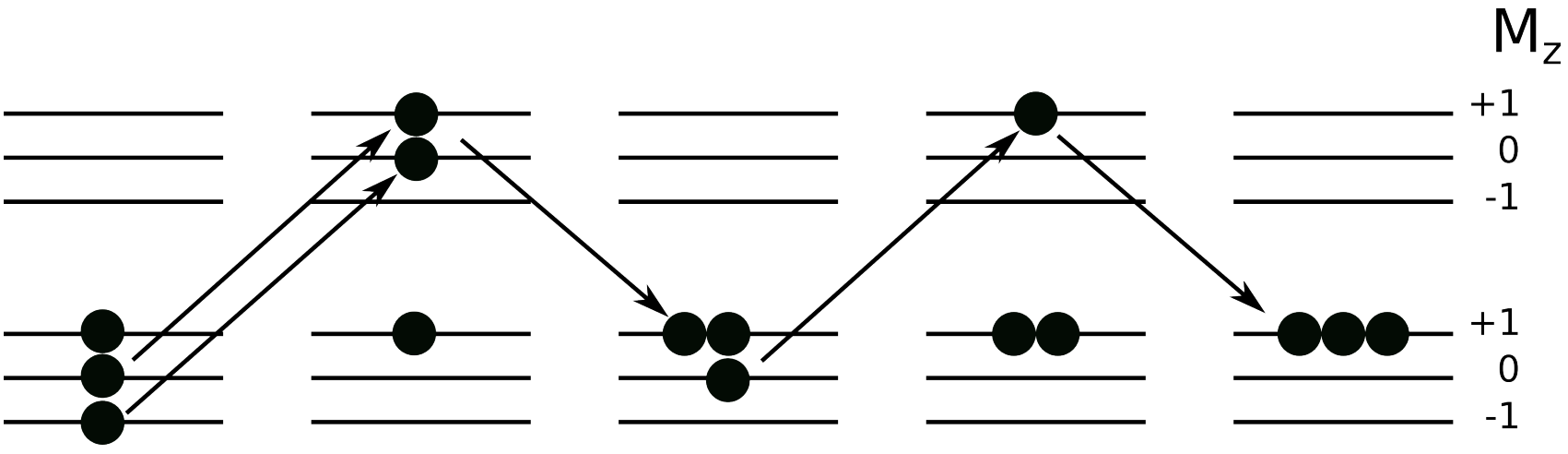
$\Delta M_z = -1$

$$\mathbf{B_z} \cdot \sigma^+ < 0 \qquad \Delta M_z = -1$$
$$\mathbf{B_z} \cdot \sigma^- > 0 \qquad \Delta M_z = -1$$

Optical Pumping of Hydrogen

Right-Handed Circularly Polarized Light

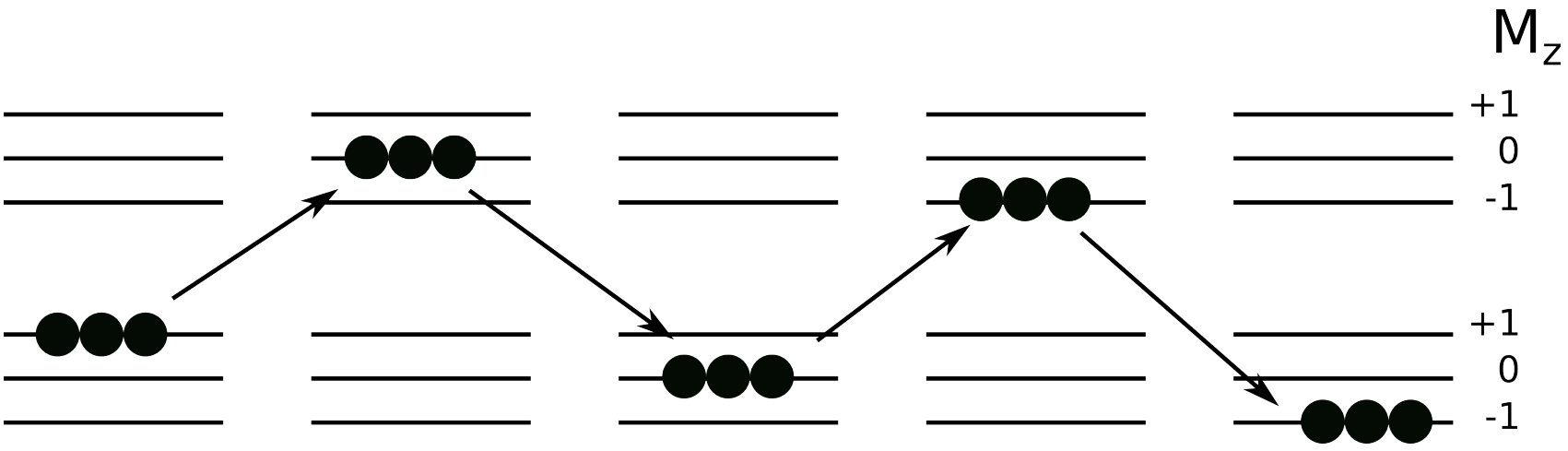
$\mathbf{B_z} \cdot \sigma^+ > 0$ $\Delta M_z = +1$



Optical Pumping of Hydrogen Following B_z Reversal

Right-Handed Circularly Polarized Light

$$\mathbf{B_z} \cdot \sigma^+ < 0 \qquad \Delta M_z = -1$$



Experiment Apparatus

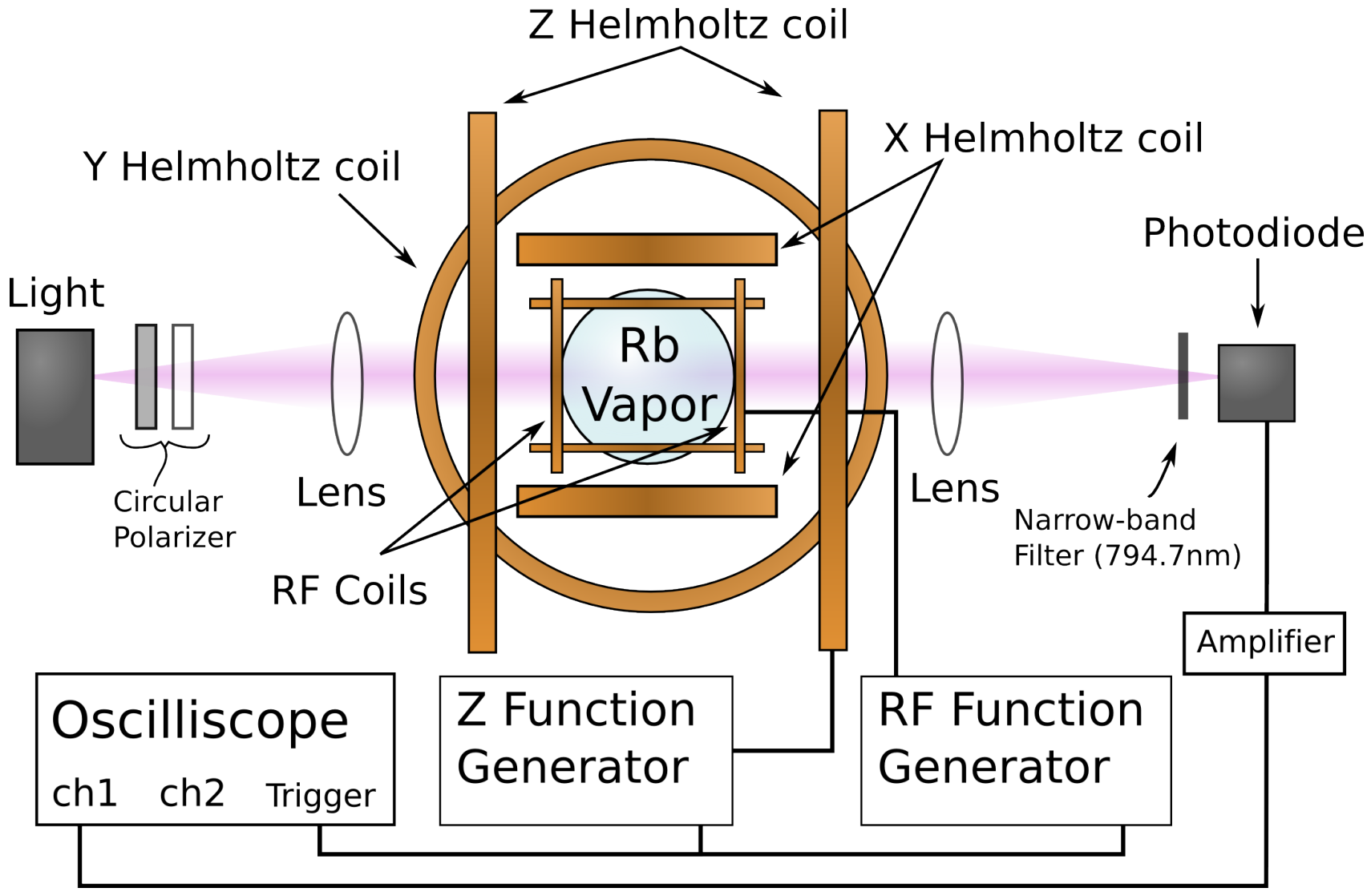
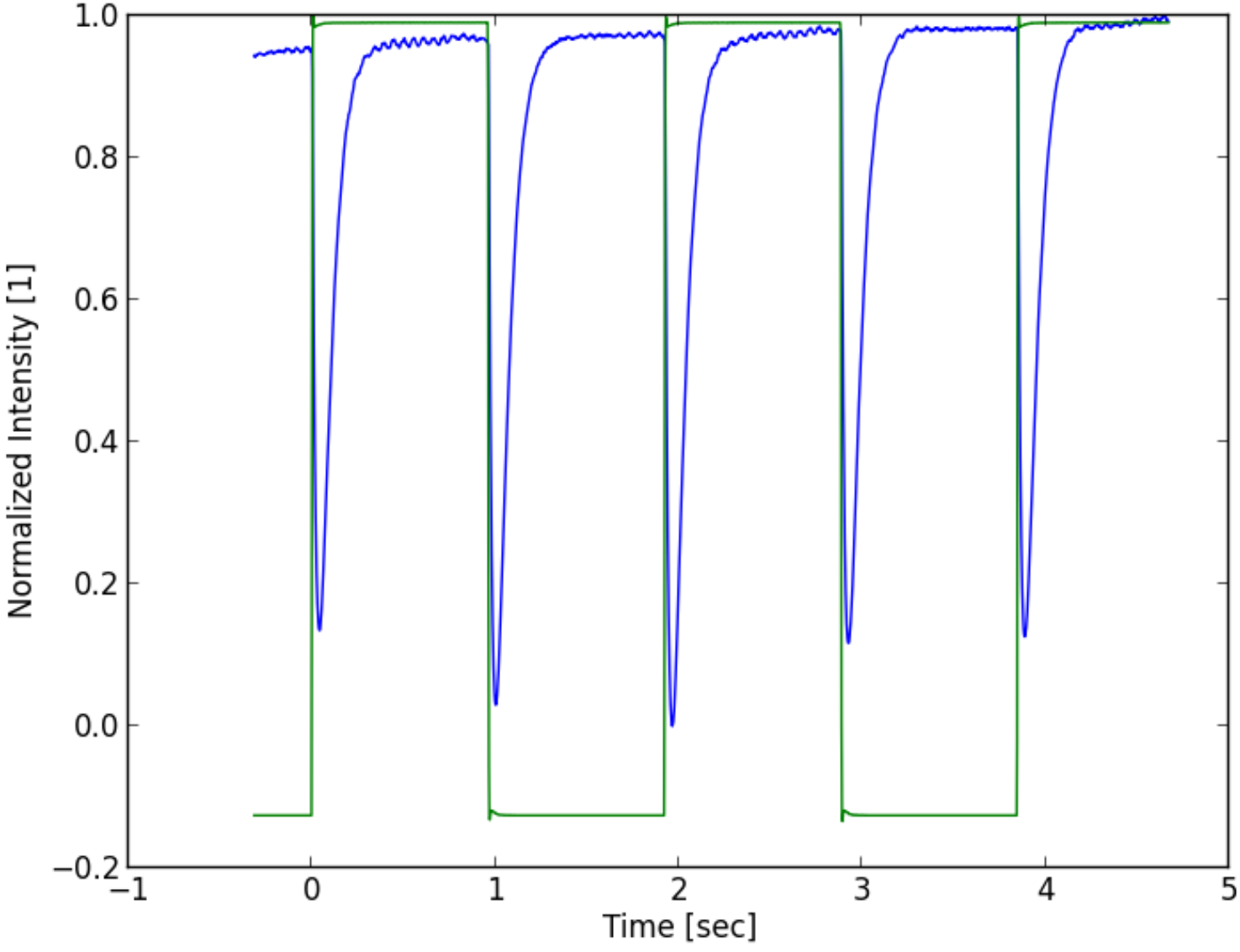
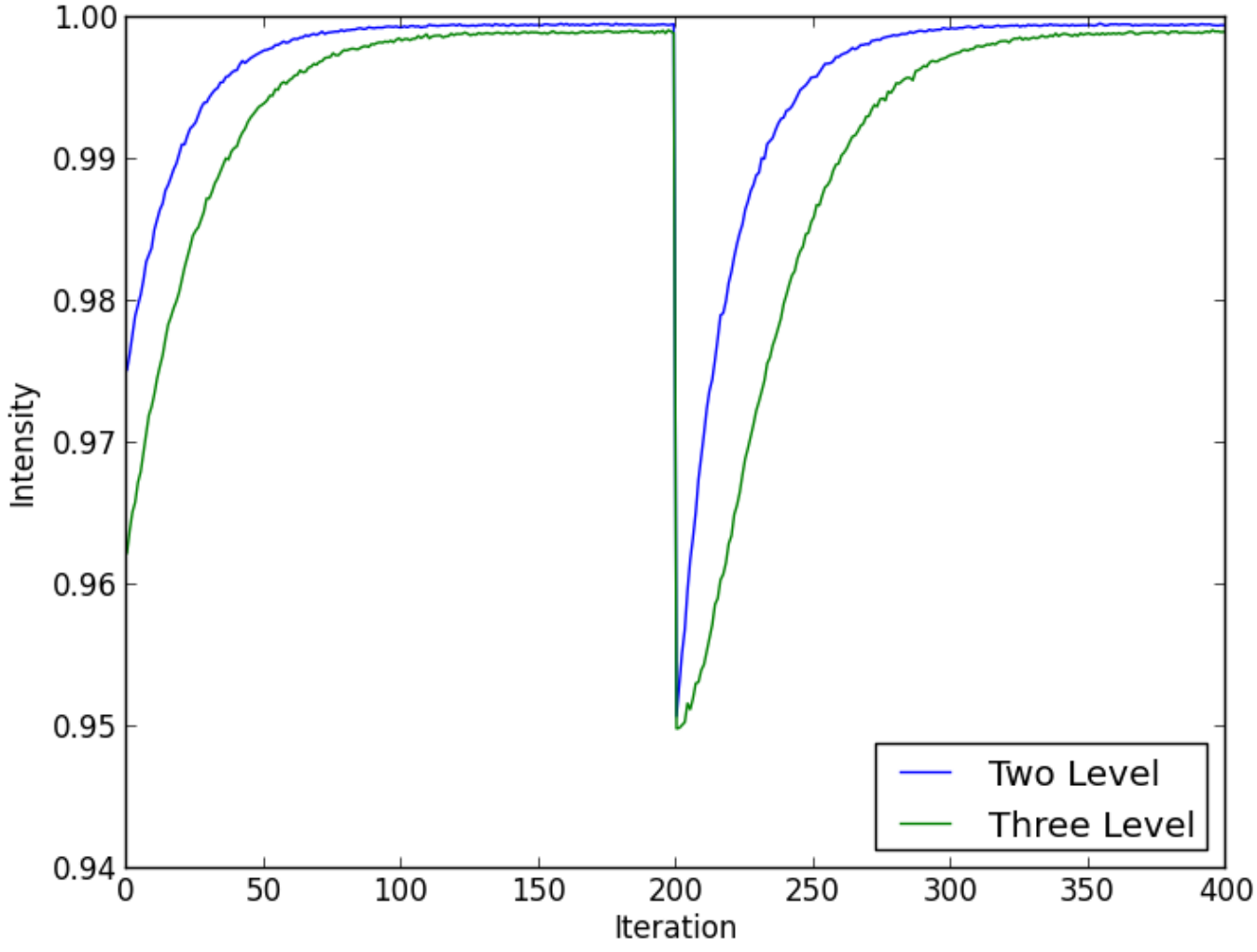


Photo-diode Voltage With B_z Current



Simulation of Optical Pumping of Atomic Models with Different Numbers of M_z Levels



Towards a Functional Approximation for Rubidium Signal

Assuming a Hydrogen like, three M_z level structure,

$$\begin{aligned}\frac{dn_1}{dt} &= n_0 a_0 \\ \frac{dn_0}{dt} &= -n_0 a_0 + n_{-1} a_{-1} \\ \frac{dn_{-1}}{dt} &= -n_{-1} a_{-1}\end{aligned}$$

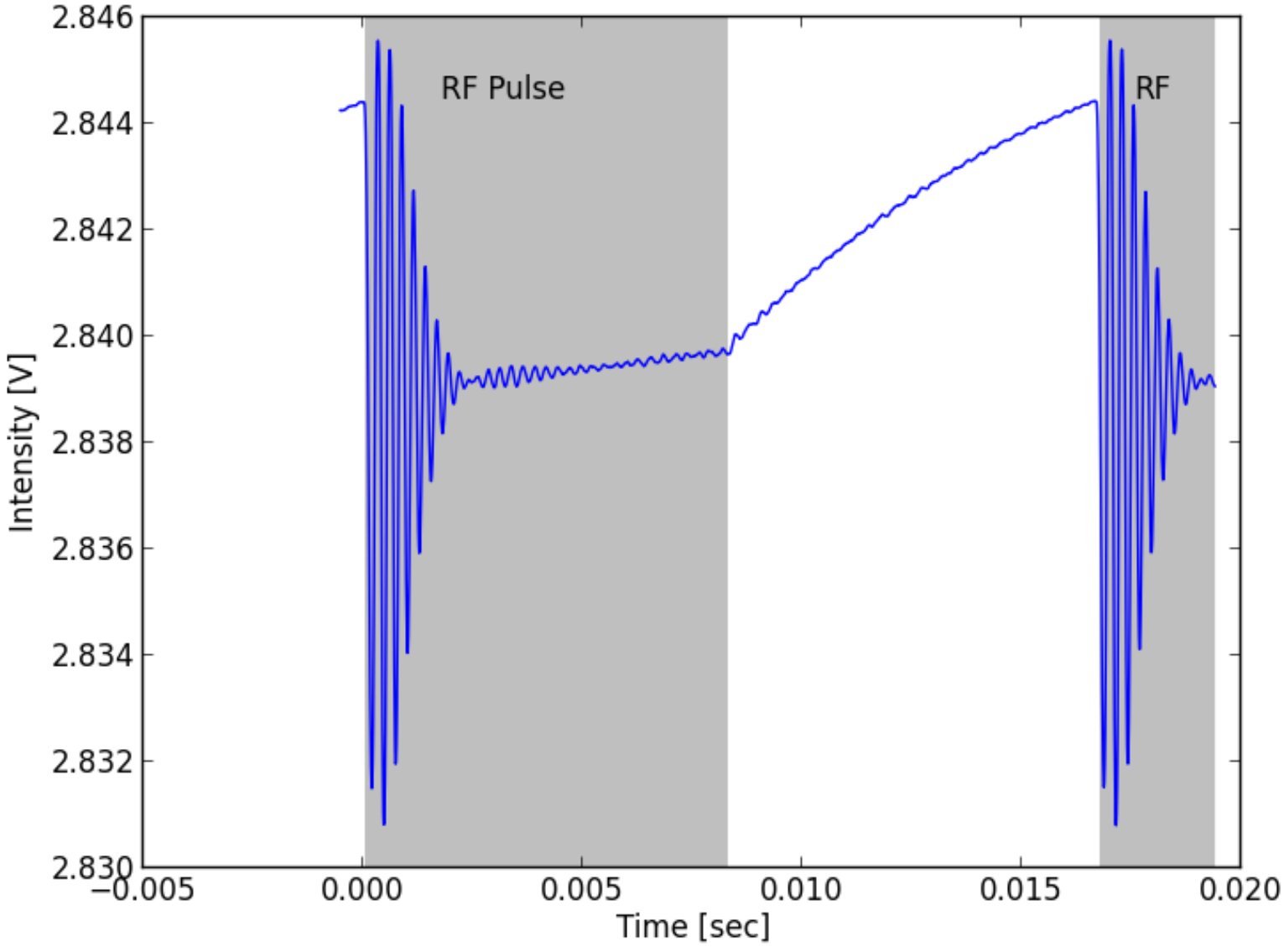
hence,

$$\frac{d^2 n_0}{dt^2} = -(a_{-1} + a_0)\frac{dn_0}{dt} - a_{-1} a_0 n_0$$

Assuming $a_{-1} = a_0$,

$$I(x) = c_4 - c_0(t + c_1)\exp\left(-c_2(t - c_3)\right)$$

Rabi Oscillations Signal Overview



Rabi Oscillation Period vs RF Amplitude