Describe the basics of an optical quantum memory

Quantum Engineering II

3rd of June 2021

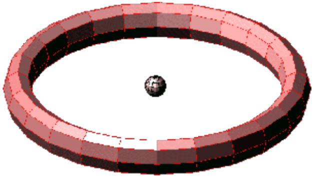
Introduction

$$|\psi\rangle = \frac{1}{\sqrt{2}}(|H\rangle + |V\rangle)$$

Light - Carrier of information

Atoms - Storing units

Transfer and save quantum information

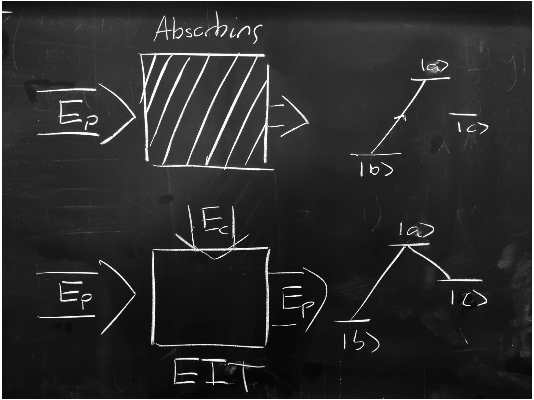


Problem

Problems:

- Temporal Control
- Spontaneous Decay
- Decoherence

Electromagnetic Induced Transparency



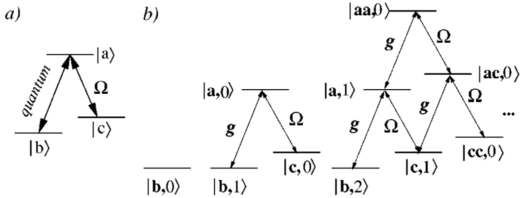
Three Levels

A collection of N-three-level atoms with two metastable lower states $|b\rangle$ and $|c\rangle$

$|b\rangle \Leftrightarrow |a\rangle$ - quantized radition mode

$|a\rangle \Leftrightarrow |c\rangle$ - driven by a classical field Ω

$$\hat{V} = \hbar g \sum_{i=1}^{N} \hat{a}\sigma_{ab}^{i} - \hbar\Omega(t)e^{-i\nu t}\sum_{i=1}^{N}\sigma_{ac}^{i} + h.c.$$



States with zero eigenvalue $|D,1\rangle$ called dark states

$$|D,1\rangle = \cos(\theta(t))|b,1\rangle - \sin(\theta(t))|c,0\rangle, \quad \tan(\theta(t)) = \frac{g\sqrt{N}}{\Omega(t)} \tag{1}$$

No part is $|a,0\rangle \rightarrow$ (no spontanous emission)

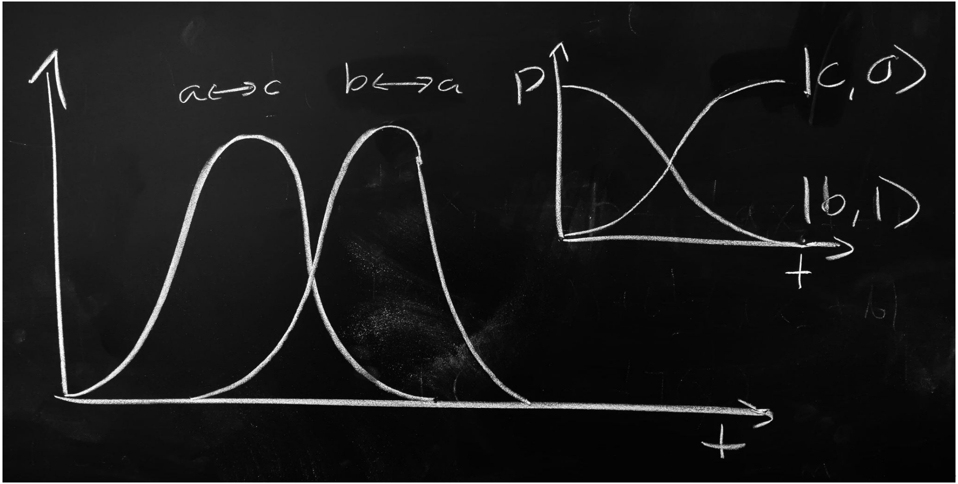
For $\theta = 0$

$$|D,1\rangle = |b,1\rangle \qquad \text{(pure light state)} \tag{2}$$

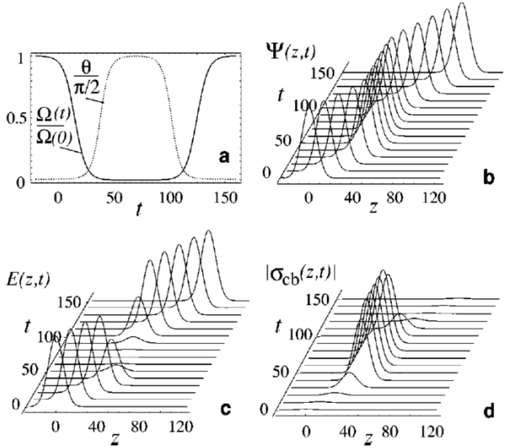
For $\theta = \frac{\pi}{2}$

$$|D,1\rangle = |c,0\rangle \quad \text{(atomic state)} \tag{3}$$

Counterintuitive Pulse Sequence



Stopped Light



Quantum Network Relay