Multi-component slow light in atomic media

Julius Ruseckas, Viačeslav Kudriašov and Gediminas Juzeliūnas

Institute of Theoretical Physics and Astronomy, Vilnius University, Lithuania

July 19, 2012

Outline

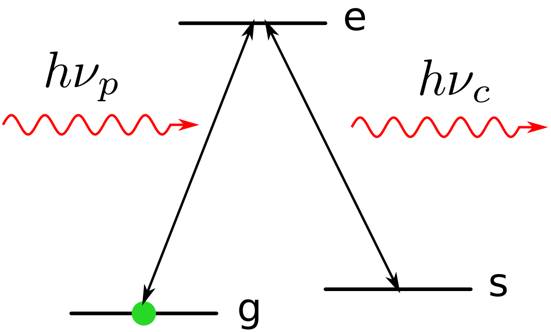
Outline

Outline

Slow light

18 February 1999
International weekly journal of science
nature
£5.45 €7.59 FFr51 DM15 Lire 15000 A$16.50
www.nature.com
Cycling at the speed of light?

Three level Λ system



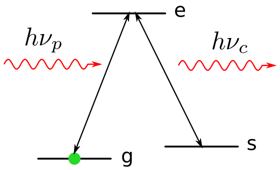
Probe beam: $\Omega_p = \mu_{ge} E_p$
Control beam: $\Omega_c = \mu_{se} E_c$

Three level Λ system

- Dark state

$$|D\rangle \sim \Omega_c|g\rangle - \Omega_p|s\rangle$$

- Transitions $g \rightarrow e$ and $s \rightarrow e$ interfere destructively
- Cancellation of absorption
- Electromagnetically induced transparency—EIT
- Very fragile
- Very narrow transparency window

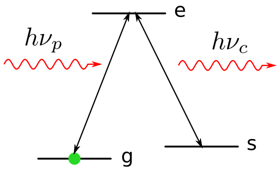


Three level Λ system

- Dark state

$$|D\rangle \sim \Omega_c|g\rangle - \Omega_p|s\rangle$$

- Transitions $g \to e$ and $s \to e$ interfere destructively
- Cancellation of absorption
- Electromagnetically induced transparency—EIT
- Very fragile
- Very narrow transparency window

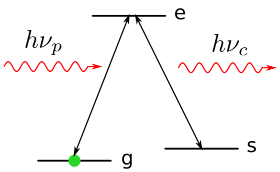


Three level Λ system

- Dark state

$$|D\rangle \sim \Omega_c|g\rangle - \Omega_p|s\rangle$$

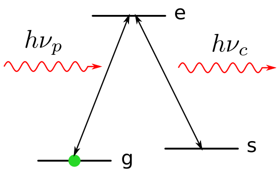
- Transitions $g \rightarrow e$ and $s \rightarrow e$ interfere destructively
- Cancellation of absorption
- Electromagnetically induced transparency—EIT
- Very fragile
- Very narrow transparency window



- Dark state

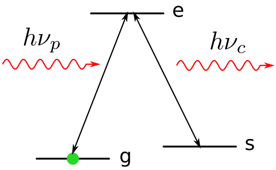
$$|D\rangle \sim \Omega_c|g\rangle - \Omega_p|s\rangle$$

- Transitions $g \to e$ and $s \to e$ interfere destructively
- Cancellation of absorption
- Electromagnetically induced transparency—EIT
- Very fragile
- Very narrow transparency window



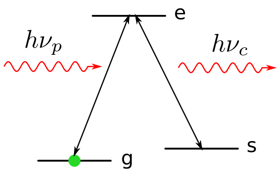
Three level Λ system

- Dark state
$$|D\rangle \sim \Omega_c|g\rangle - \Omega_p|s\rangle$$
- Transitions $g \to e$ and $s \to e$ interfere destructively
- Cancellation of absorption
- Electromagnetically induced transparency—EIT
- Very fragile
- Very narrow transparency window

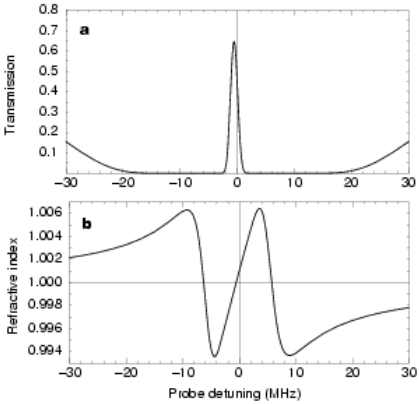


Three level Λ system

- Dark state
$$|D\rangle \sim \Omega_c|g\rangle - \Omega_p|s\rangle$$
- Transitions $g \to e$ and $s \to e$ interfere destructively
- Cancellation of absorption
- Electromagnetically induced transparency—EIT
- Very fragile
- Very narrow transparency window

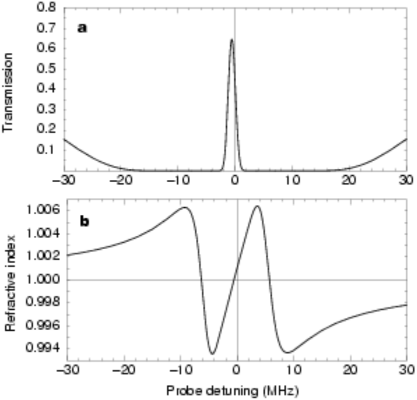


Slow light



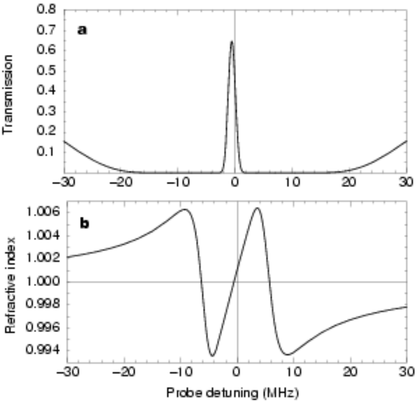
- Narrow transparency window $\Delta\omega \sim 1\,\mathrm{MHz}$
- Very dispersive medium
- Small group velocity — slow light

Slow light



- Narrow transparency window $\Delta\omega \sim 1\,\mathrm{MHz}$
- Very dispersive medium
- Small group velocity — slow light

Slow light



- Narrow transparency window $\Delta\omega \sim 1\,\mathrm{MHz}$
- Very dispersive medium
- Small group velocity — slow light

Storing of slow light

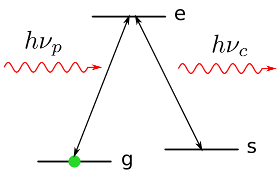
Nature, Hau *et al*, 2001

Storing of slow light

- Dark state

$$|D\rangle \sim |g\rangle - \frac{\Omega_p}{\Omega_c}|s\rangle$$

- Information on probe beam is contained in the atomic coherence
- Storing of light—switching off control beam;
  information in the atomic coherence is retained
- Releasing—switch on control beam

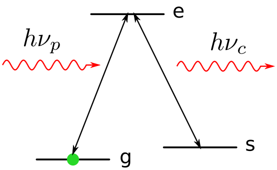


Storing of slow light

- Dark state

$$|D\rangle \sim |g\rangle - \frac{\Omega_p}{\Omega_c}|s\rangle$$

- Information on probe beam is contained in the atomic coherence
- Storing of light—switching off control beam; information in the atomic coherence is retained
- Releasing—switch on control beam

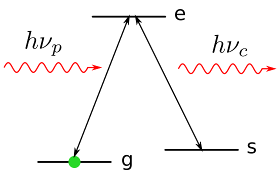


Storing of slow light

- Dark state

$$|D\rangle \sim |g\rangle - \frac{\Omega_p}{\Omega_c}|s\rangle$$

- Information on probe beam is contained in the atomic coherence
- Storing of light—switching off control beam;
  information in the atomic coherence is retained
- Releasing—switch on control beam

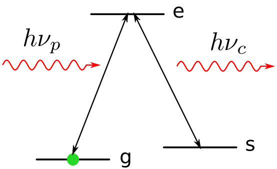


Storing of slow light

- Dark state

$$|D\rangle \sim |g\rangle - \frac{\Omega_p}{\Omega_c}|s\rangle$$

- Information on probe beam is contained in the atomic coherence
- Storing of light—switching off control beam;
  information in the atomic coherence is retained
- Releasing—switch on control beam



Storing of slow light

- Initial storage times (L. V. Hau *et al*, Nature 2001): 1 ms
- Later improvement:
  - Storage time 240 ms:
    U. Schnorrberger *et al*, Phys. Rev. Lett. **103**, 033003 (2009).
  - storage time $> 1\,\mathrm{s}$
    R. Zhang *et al*, Phys. Rev. Lett. **103**, 233602 (2009).

Storing of slow light

- Initial storage times (L. V. Hau *et al*, Nature 2001): 1 ms
- Later improvement:
  - Storage time 240 ms:
    U. Schnorrberger *et al*, Phys. Rev. Lett. **103**, 033003 (2009).
  - storage time $> 1\,\mathrm{s}$
    R. Zhang *et al*, Phys. Rev. Lett. **103**, 233602 (2009).

Stationary light

Stationary light:

Storing without switching off the control fields

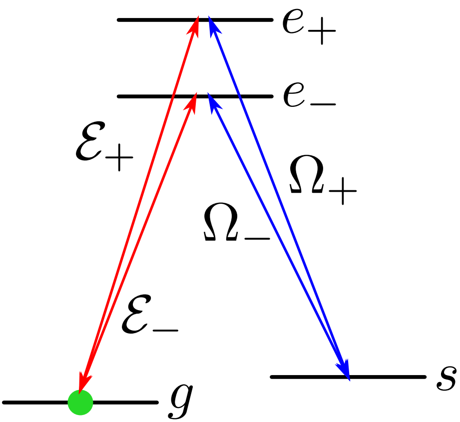
Theory:

- A. Moiseev and B. S. Ham, Phys. Rev. A **73**, 033812 (2006).
- F. E. Zimmer, J. Otterbach, R. G. Unanyan, B. W. Shore, and M. Fleischhauer, Phys. Rev. A **77**, 063823 (2008).
- M. Fleischhauer, J. Otterbach, and R. G. Unanyan, Phys. Rev. Lett. **101**, 163601 (2008).
- J. Otterbach, J. Ruseckas, R. G. Unanyan, G. Juzeliūnas, and M. Fleischhauer, Phys. Rev. Lett. **104**, 033903 (2010).

Experiment:

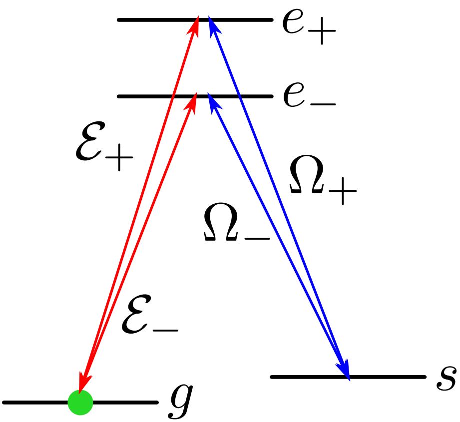
- Y.-W. Lin *et al.*, I. A. Yu, Phys. Rev. Lett. **102**, 213601 (2009).

Double Λ scheme



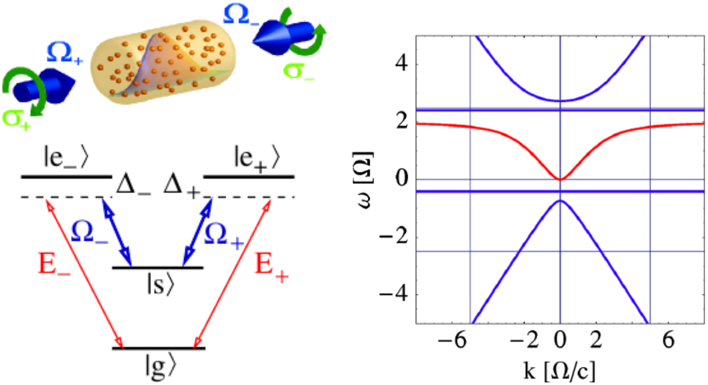
- An additional excited state
- An additional, counter-propagating control laser beam

Double Λ scheme



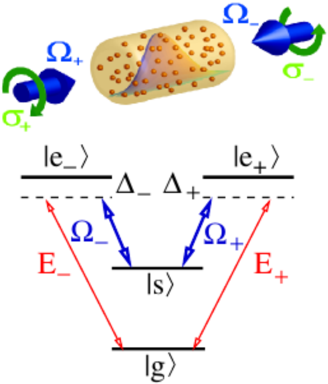
- An additional excited state
- An additional, counter-propagating control laser beam

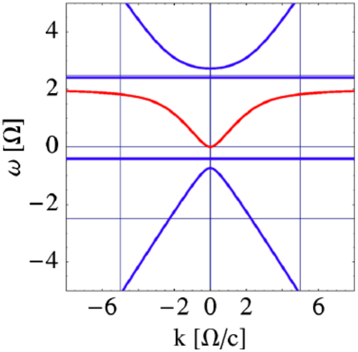
Stationary light



- Quadratic dispersion
- Stationary polariton (normal mode of the radiation) with non-zero m_{eff}
- Stationary light

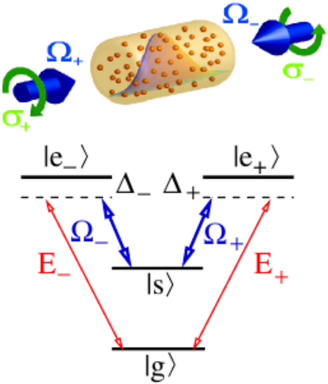
Stationary light

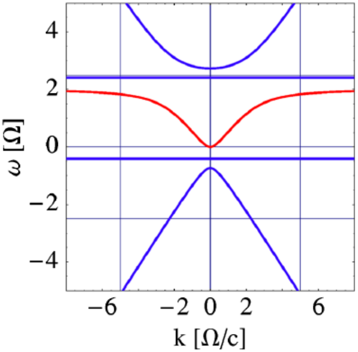




- Quadratic dispersion
- Stationary polariton (normal mode of the radiation) with non-zero m_{eff}
- Stationary light

Stationary light



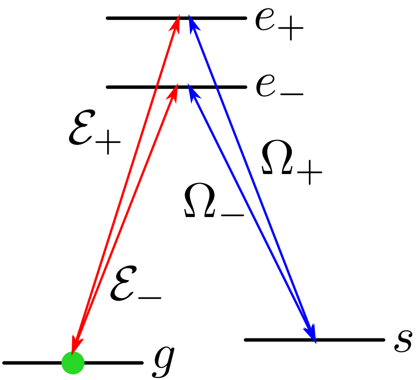


- Quadratic dispersion
- Stationary polariton (normal mode of the radiation) with non-zero m_{eff}
- Stationary light

Multi-component slow light

Slow light consisting of several connected fields?

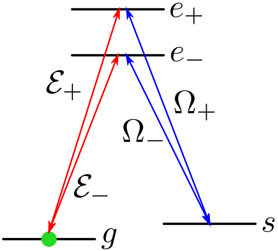
First try: double Λ scheme



Used for stationary light

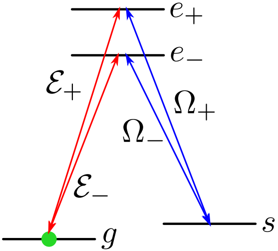
Double Λ scheme: bad for our purposes

- Only one dark state can be formed
- Only one dark state polariton (propagating without absorbtion)
- For multicomponent slow light we need to add more levels.



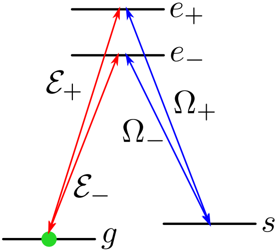
Double Λ scheme: bad for our purposes

- Only one dark state can be formed
- Only one dark state polariton (propagating without absorbtion)
- For multicomponent slow light we need to add more levels.



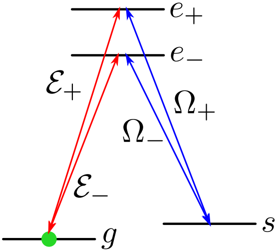
Double Λ scheme: bad for our purposes

- Only one dark state can be formed
- Only one dark state polariton (propagating without absorbtion)
- For multicomponent slow light we need to add more levels.

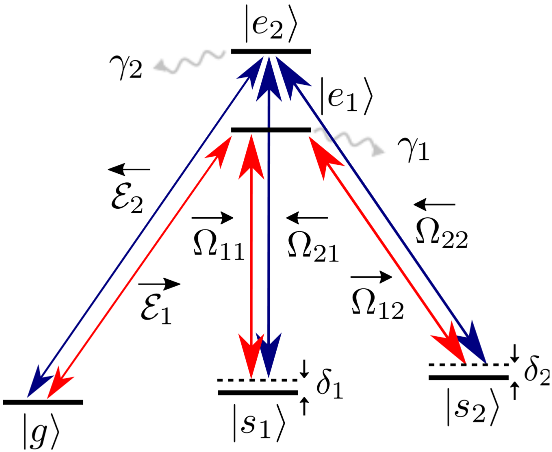


Double Λ scheme: bad for our purposes

- Only one dark state can be formed
- Only one dark state polariton (propagating without absorbtion)
- For multicomponent slow light we need to add more levels.

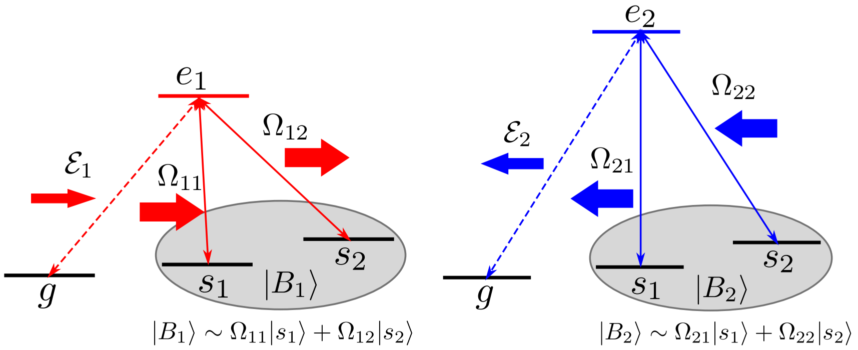


Double tripod setup



- R. G. Unanyan, J. Otterbach, M. Fleischhauer, J. Ruseckas, V. Kudriašov, G. Juzeliūnas, Phys. Rev. Lett. **105**, 173603 (2010).
- J. Ruseckas, V. Kudriašov, G. Juzeliūnas, R. G. Unanyan, J. Otterbach, M. Fleischhauer, Phys. Rev. A **83**, 063811 (2011).

Double tripod setup

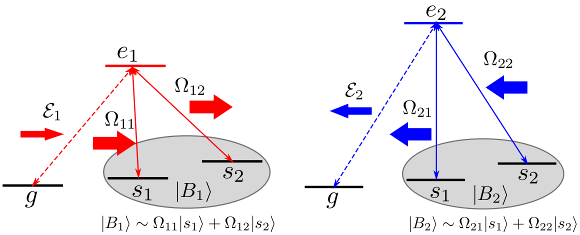


Probe fields $\mathcal{E}_1$ and $\mathcal{E}_2$ are coupled via atomic coherences if $\langle B_1|B_2\rangle \neq 0$

Double tripod setup

Limiting cases:

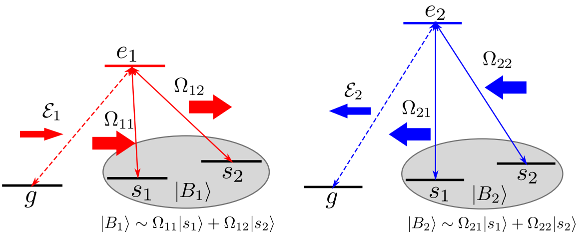
- $\langle B_1 | B_2 \rangle = 0$ — two not connected tripods
- $\langle B_1 | B_2 \rangle = 1$ — double Lambda setup
- $0 < |\langle B_1 | B_2 \rangle| < 1$ — two connected tripods



Double tripod setup

Limiting cases:

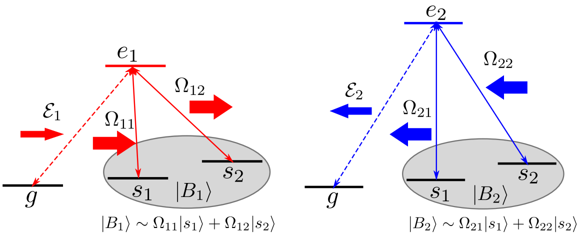
- $\langle B_1 | B_2 \rangle = 0$ — two not connected tripods
- $\langle B_1 | B_2 \rangle = 1$ — double Lambda setup
- $0 < | \langle B_1 | B_2 \rangle | < 1$ — two connected tripods



Double tripod setup

Limiting cases:

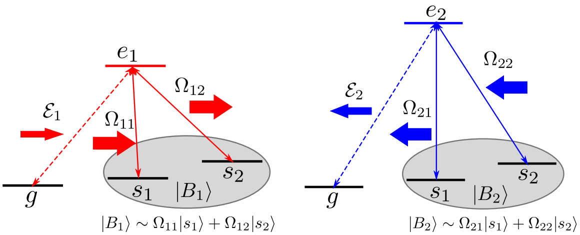
- $\langle B_1|B_2\rangle = 0$ — two not connected tripods
- $\langle B_1|B_2\rangle = 1$ — double Lambda setup
- $0 < |\langle B_1|B_2\rangle| < 1$ — two connected tripods



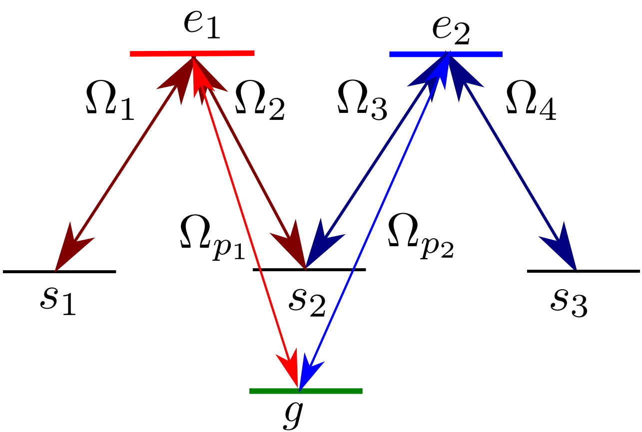
Double tripod setup

Limiting cases:

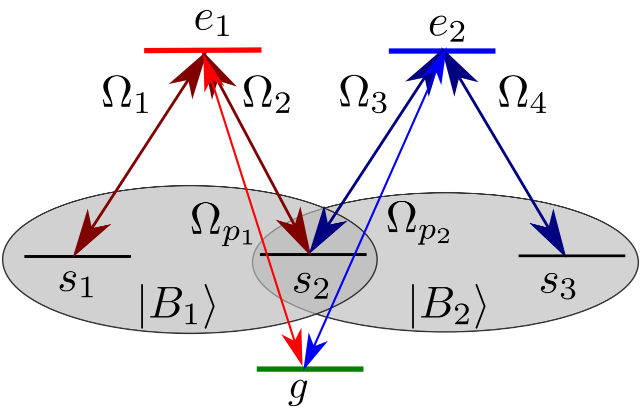
- $\langle B_1 | B_2 \rangle = 0$ — two not connected tripods
- $\langle B_1 | B_2 \rangle = 1$ — double Lambda setup
- $0 < | \langle B_1 | B_2 \rangle | < 1$ — two connected tripods



Another scheme



Another scheme



Propagation of slow light

Matrix representation — Spinor slow light:

$$\mathcal{E} = \begin{pmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \end{pmatrix}$$

Equation for two-component probe field in the atomic cloud:

$$(c^{-1} + \hat{v}^{-1})\frac{\partial}{\partial t}\mathcal{E} + \frac{\partial}{\partial z}\mathcal{E} + \mathrm{i}\hat{v}^{-1}\hat{D}\mathcal{E} = 0$$

Similar to the equation for probe field in Λ scheme, only with matrices. Here $\hat{v}^{-1}$ is a matrix of inverse group velocity (not necessarily diagonal).

Propagation of slow light

Matrix representation — Spinor slow light:

$$\mathcal{E} = \begin{pmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \end{pmatrix}$$

Equation for two-component probe field in the atomic cloud:

$$(c^{-1} + \hat{v}^{-1})\frac{\partial}{\partial t}\mathcal{E} + \frac{\partial}{\partial z}\mathcal{E} + \mathrm{i}\hat{v}^{-1}\hat{D}\mathcal{E} = 0$$

Similar to the equation for probe field in Λ scheme, only with matrices. Here $\hat{v}^{-1}$ is a matrix of inverse group velocity (not necessarily diagonal).

Propagation of slow light

Matrix representation — Spinor slow light:

$$\mathcal{E} = \begin{pmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \end{pmatrix}$$

Equation for two-component probe field in the atomic cloud:

$$(c^{-1} + \hat{v}^{-1})\frac{\partial}{\partial t}\mathcal{E} + \frac{\partial}{\partial z}\mathcal{E} + \mathrm{i}\hat{v}^{-1}\hat{D}\mathcal{E} = 0$$

Similar to the equation for probe field in Λ scheme, only with matrices.
Here $\hat{v}^{-1}$ is a matrix of inverse group velocity (not necessarily diagonal).

Propagation of slow light

Matrix representation — Spinor slow light:

$$\mathcal{E} = \begin{pmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \end{pmatrix}$$

Equation for two-component probe field in the atomic cloud:

$$(c^{-1} + \hat{v}^{-1})\frac{\partial}{\partial t}\mathcal{E} + \frac{\partial}{\partial z}\mathcal{E} + \mathrm{i}\hat{v}^{-1}\hat{D}\mathcal{E} = 0$$

Similar to the equation for probe field in Λ scheme, only with matrices. Here $\hat{v}^{-1}$ is a matrix of inverse group velocity (not necessarily diagonal).

Neutrino-type oscillations for slow light

- The group velocity is a non-diagonal matrix
- Individual probe fields do not have a definite group velocity
- Only special combinations of both probe fields (normal modes) propagate in the atomic cloud with the definite (and different) velocities
- This difference in velocities causes interference between probe fields

Neutrino-type oscillations for slow light

- The group velocity is a non-diagonal matrix
- Individual probe fields do not have a definite group velocity
- Only special combinations of both probe fields (normal modes) propagate in the atomic cloud with the definite (and different) velocities
- This difference in velocities causes interference between probe fields

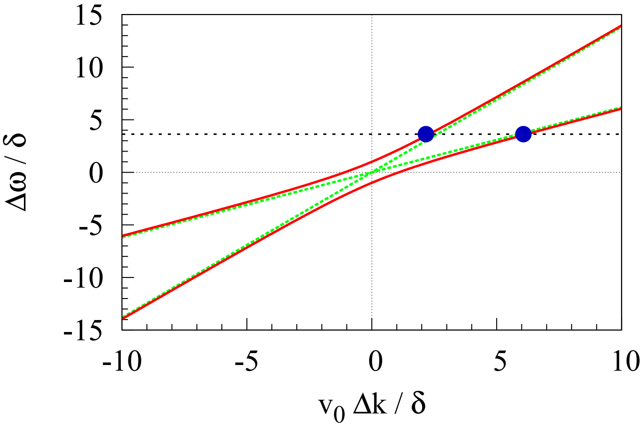
Neutrino-type oscillations for slow light

- The group velocity is a non-diagonal matrix
- Individual probe fields do not have a definite group velocity
- Only special combinations of both probe fields (normal modes) propagate in the atomic cloud with the definite (and different) velocities
- This difference in velocities causes interference between probe fields

Neutrino-type oscillations for slow light

- The group velocity is a non-diagonal matrix
- Individual probe fields do not have a definite group velocity
- Only special combinations of both probe fields (normal modes) propagate in the atomic cloud with the definite (and different) velocities
- This difference in velocities causes interference between probe fields

Neutrino-type oscillations for slow light



Light is converted to a superposition of modes with different wave vectors.

Neutrino-type oscillations for slow light

- Copropagating beams, only one probe beam $\mathcal{E}_1$ is incident on the atomic cloud.
- Oscillations of transmission probabilities T_1 and T_2 occur.
- Inclusion of non-adiabatic losses leads to attenuation of the intensity of transmitted beams $\sim \exp(-2\phi^2/\alpha)$, where ϕ is a phase of oscillations.

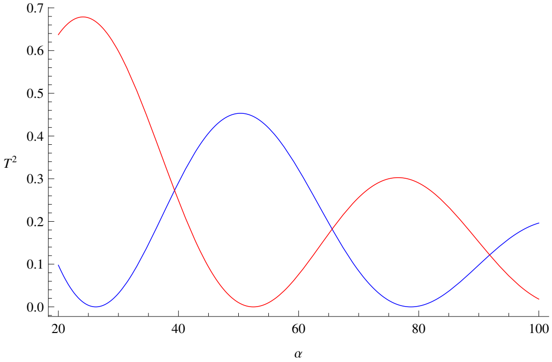
Neutrino-type oscillations for slow light

- Copropagating beams, only one probe beam $\mathcal{E}_1$ is incident on the atomic cloud.
- Oscillations of transmission probabilities T_1 and T_2 occur.
- Inclusion of non-adiabatic losses leads to attenuation of the intensity of transmitted beams $\sim \exp(-2\phi^2/\alpha)$, where ϕ is a phase of oscillations.

Neutrino-type oscillations for slow light

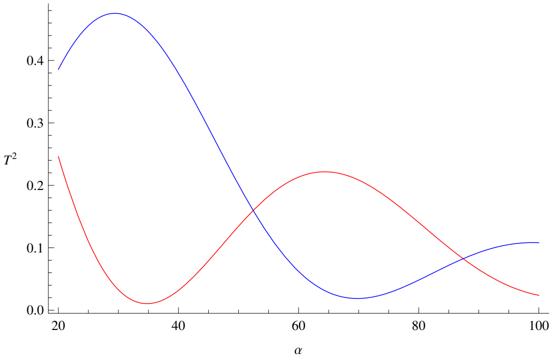
- Copropagating beams, only one probe beam $\mathcal{E}_1$ is incident on the atomic cloud.
- Oscillations of transmission probabilities T_1 and T_2 occur.
- Inclusion of non-adiabatic losses leads to attenuation of the intensity of transmitted beams $\sim \exp(-2\phi^2/\alpha)$, where ϕ is a phase of oscillations.

Oscillations in double tripod setup



Dependence of transmission probabilities $|T_1|^2$ (blue line) and $|T_2|^2$ (red line) on the optical density α.

Oscillations in another scheme

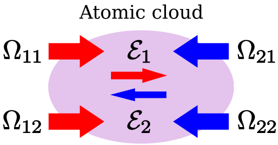


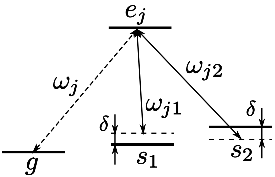
Dependence of transmission probabilities $|T_1|^2$ (blue line) and $|T_2|^2$ (red line) on the optical density α.

- Counter-propagating beams in double tripod setup
- Non-zero two photon detuning $\delta_1 = -\delta_2 \equiv \delta \neq 0$
- Dirac type equation with non-zero mass for two component slow light:

$$\mathrm{i}\frac{\partial}{\partial t}\tilde{\mathcal{E}} = -\mathrm{i}v_0\sigma_z\frac{\partial}{\partial z}\tilde{\mathcal{E}} + \delta\sigma_y\tilde{\mathcal{E}}$$

  Here $v_0 = \frac{c\Omega^2}{g^2 n}$
- A gap in dispersion (“electron-positron” type spectrum)



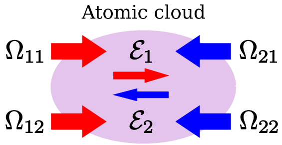


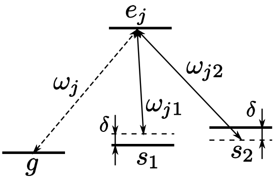
Photonic band-gap for two-component slow light

- Counter-propagating beams in double tripod setup
- Non-zero two photon detuning
  $\delta_1 = -\delta_2 \equiv \delta \neq 0$
- Dirac type equation with non-zero mass for two component slow light:

$$\mathrm{i}\frac{\partial}{\partial t}\tilde{\mathcal{E}} = -\mathrm{i}v_0\sigma_z\frac{\partial}{\partial z}\tilde{\mathcal{E}} + \delta\sigma_y\tilde{\mathcal{E}}$$

  Here $v_0 = \frac{c\Omega^2}{g^2 n}$
- A gap in dispersion ("electron-positron" type spectrum)





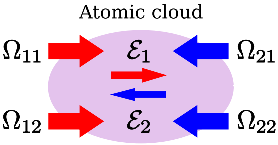
Photonic band-gap for two-component slow light

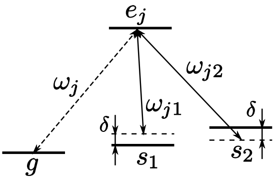
- Counter-propagating beams in double tripod setup
- Non-zero two photon detuning
  $\delta_1 = -\delta_2 \equiv \delta \neq 0$
- Dirac type equation with non-zero mass for two component slow light:

$$\mathrm{i}\frac{\partial}{\partial t}\tilde{\mathcal{E}} = -\mathrm{i}v_0\sigma_z\frac{\partial}{\partial z}\tilde{\mathcal{E}} + \delta\sigma_y\tilde{\mathcal{E}}$$

Here $v_0 = \frac{c\Omega^2}{g^2 n}$

- A gap in dispersion (“electron-positron” type spectrum)



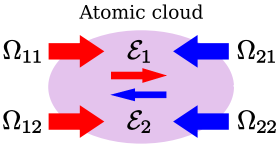


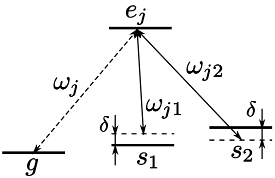
Photonic band-gap for two-component slow light

- Counter-propagating beams in double tripod setup
- Non-zero two photon detuning
  $\delta_1 = -\delta_2 \equiv \delta \neq 0$
- Dirac type equation with non-zero mass for two component slow light:

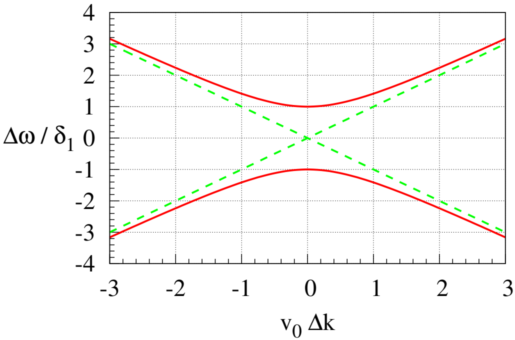
$$\mathrm{i}\frac{\partial}{\partial t}\tilde{\mathcal{E}} = -\mathrm{i}v_0\sigma_z\frac{\partial}{\partial z}\tilde{\mathcal{E}} + \delta\sigma_y\tilde{\mathcal{E}}$$

  Here $v_0 = \frac{c\Omega^2}{g^2 n}$
- A gap in dispersion ("electron-positron" type spectrum)



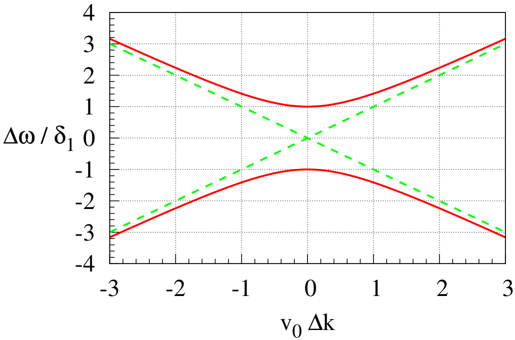


Photonic band-gap for two-component slow light



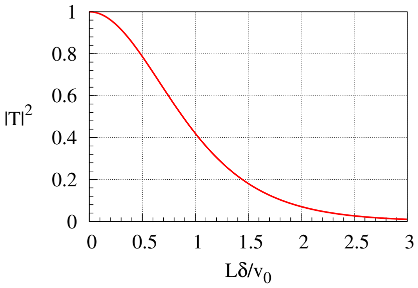
- Relativistic particle-antiparticle dispersion:
  $\Delta\omega^{\pm} = \pm\sqrt{v_0^2 \Delta k^2 + \delta^2}$
- $\hbar\delta = m v_0^2$ — gap width, m — polariton effective mass

Photonic band-gap for two-component slow light



- Relativistic particle-antiparticle dispersion:
  $\Delta\omega^{\pm} = \pm\sqrt{v_0^2 \Delta k^2 + \delta^2}$
- $\hbar\delta = m v_0^2$ — gap width, m — polariton effective mass

Dirac equation for two-component slow light

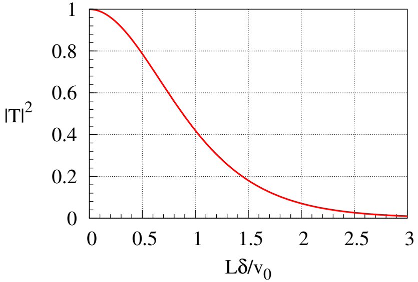


- Reflection and transmission coefficients at the gap center ($\Delta\omega = 0$):

$$T = \cosh^{-1}(L/\lambda_\mathrm{C})\,, \quad R = \tanh(L/\lambda_\mathrm{C})$$

- $\lambda_\mathrm{C} = \hbar/mv_0 = v_0/\delta$ — Compton wave-length of the polariton.
- The Compton wave-length determines the polariton tunneling length.

Dirac equation for two-component slow light

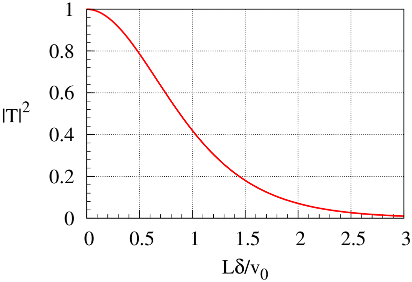


- Reflection and transmission coefficients at the gap center ($\Delta\omega = 0$):

$$T = \cosh^{-1}(L/\lambda_{\mathrm{C}})\,, \quad R = \tanh(L/\lambda_{\mathrm{C}})$$

- $\lambda_{\mathrm{C}} = \hbar/mv_0 = v_0/\delta$ — Compton wave-length of the polariton.
- The Compton wave-length determines the polariton tunneling length.

Dirac equation for two-component slow light



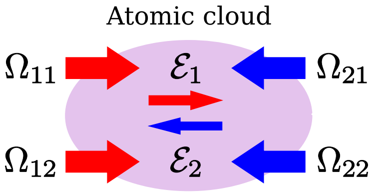
- Reflection and transmission coefficients at the gap center ($\Delta\omega = 0$):

$$T = \cosh^{-1}(L/\lambda_{\mathrm{C}})\,, \quad R = \tanh(L/\lambda_{\mathrm{C}})$$

- $\lambda_{\mathrm{C}} = \hbar/mv_0 = v_0/\delta$ — Compton wave-length of the polariton.
- The Compton wave-length determines the polariton tunneling length.

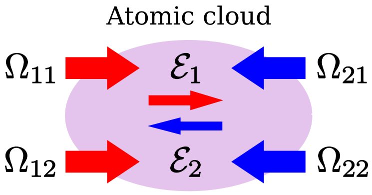
Multi-component stationary light

- Double tripod configuration with counter-propagating beams.
- Initially two-photon detuning δ is zero
- and only one probe beam $\mathcal{E}_1$ with central frequency $\Delta\omega = 0$ is incident on the atomic cloud
- resulting in slow light, propagating with the velocity v_0



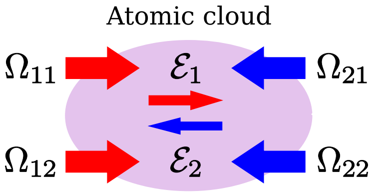
Multi-component stationary light

- Double tripod configuration with counter-propagating beams.
- Initially two-photon detuning δ is zero
- and only one probe beam $\mathcal{E}_1$ with central frequency $\Delta\omega = 0$ is incident on the atomic cloud
- resulting in slow light, propagating with the velocity v_0



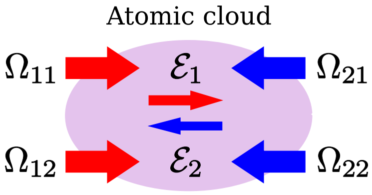
Multi-component stationary light

- Double tripod configuration with counter-propagating beams.
- Initially two-photon detuning δ is zero
- and only one probe beam $\mathcal{E}_1$ with central frequency $\Delta\omega = 0$ is incident on the atomic cloud
- resulting in slow light, propagating with the velocity v_0



Multi-component stationary light

- Double tripod configuration with counter-propagating beams.
- Initially two-photon detuning δ is zero
- and only one probe beam $\mathcal{E}_1$ with central frequency $\Delta\omega = 0$ is incident on the atomic cloud
- resulting in slow light, propagating with the velocity v_0



Multi-component stationary light

- When the wave packet of the beam $\mathcal{E}_1$ is inside the cloud, the two-photon detuning is suddenly increased from 0 to δ
- A gap in the dispersion forms
- If the width in frequency space is smaller than the width of the gap 2δ
- two-component stationary light is created

Multi-component stationary light

- When the wave packet of the beam $\mathcal{E}_1$ is inside the cloud, the two-photon detuning is suddenly increased from 0 to δ
- A gap in the dispersion forms
- If the width in frequency space is smaller than the width of the gap 2δ
- two-component stationary light is created

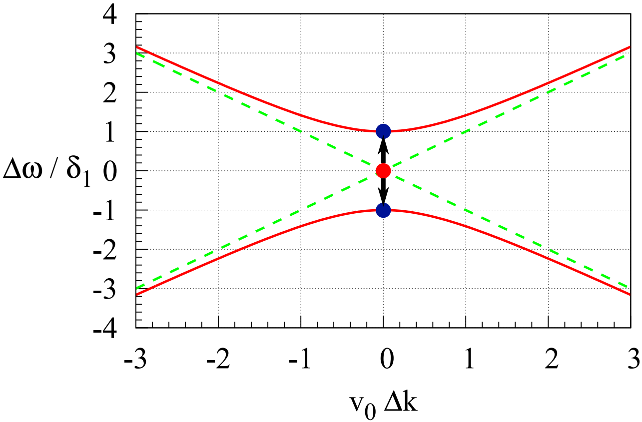
Multi-component stationary light

- When the wave packet of the beam $\mathcal{E}_1$ is inside the cloud, the two-photon detuning is suddenly increased from 0 to δ
- A gap in the dispersion forms
- If the width in frequency space is smaller than the width of the gap 2δ
- two-component stationary light is created

Multi-component stationary light

- When the wave packet of the beam $\mathcal{E}_1$ is inside the cloud, the two-photon detuning is suddenly increased from 0 to δ
- A gap in the dispersion forms
- If the width in frequency space is smaller than the width of the gap 2δ
- two-component stationary light is created

Multi-component stationary light



Light is converted to superposition of eigenstates with positive and negative frequencies.

Multi-component stationary light

- Instead of propagating, light oscillates between two probe fields:

$$\begin{pmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \end{pmatrix} = \begin{pmatrix} \cos(\delta t) \\ \sin(\delta t) \end{pmatrix}$$

- At later time $t = t_r$, decreasing the two-photon detuning δ back to zero, the stationary light is converted back to slow light

Probe beam can be frozen in the medium forming a two-component stationary light and subsequently released.

Multi-component stationary light

- Instead of propagating, light oscillates between two probe fields:

$$\begin{pmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \end{pmatrix} = \begin{pmatrix} \cos(\delta t) \\ \sin(\delta t) \end{pmatrix}$$

- At later time $t = t_r$, decreasing the two-photon detuning δ back to zero, the stationary light is converted back to slow light

Probe beam can be frozen in the medium forming a two-component stationary light and subsequently released.

Multi-component stationary light

- Instead of propagating, light oscillates between two probe fields:

$$\begin{pmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \end{pmatrix} = \begin{pmatrix} \cos(\delta t) \\ \sin(\delta t) \end{pmatrix}$$

- At later time $t = t_r$, decreasing the two-photon detuning δ back to zero, the stationary light is converted back to slow light

Probe beam can be frozen in the medium forming a two-component stationary light and subsequently released.

Summary

- Two component slow and stationary light exhibits a number of distinct properties, such as the neutrino type oscillations between the components of light.
- Under certain conditions the slow light can be described by a relativistic equation of the Dirac-type for a particle of a finite mass, dispersion branches are separated by an energy gap.
- The corresponding Compton length determines the tunneling length of multicomponent light though the sample.
- The probe beams can be frozen in the medium forming a two-component stationary light and subsequently released.

Summary

- Two component slow and stationary light exhibits a number of distinct properties, such as the neutrino type oscillations between the components of light.
- Under certain conditions the slow light can be described by a relativistic equation of the Dirac-type for a particle of a finite mass, dispersion branches are separated by an energy gap.
- The corresponding Compton length determines the tunneling length of multicomponent light though the sample.
- The probe beams can be frozen in the medium forming a two-component stationary light and subsequently released.

Summary

- Two component slow and stationary light exhibits a number of distinct properties, such as the neutrino type oscillations between the components of light.
- Under certain conditions the slow light can be described by a relativistic equation of the Dirac-type for a particle of a finite mass, dispersion branches are separated by an energy gap.
- The corresponding Compton length determines the tunneling length of multicomponent light though the sample.
- The probe beams can be frozen in the medium forming a two-component stationary light and subsequently released.

Summary

- Two component slow and stationary light exhibits a number of distinct properties, such as the neutrino type oscillations between the components of light.
- Under certain conditions the slow light can be described by a relativistic equation of the Dirac-type for a particle of a finite mass, dispersion branches are separated by an energy gap.
- The corresponding Compton length determines the tunneling length of multicomponent light though the sample.
- The probe beams can be frozen in the medium forming a two-component stationary light and subsequently released.

Thank you for your attention!