Guiding and polarization shaping of vector beam in an anisotropic media

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Vector beams (VB) have a great advantage over their scalar counterparts, due to their spatially inhomogeneous polarization distribution. Coherent control of polarization, phase and amplitude gives complete freedom to manipulate fully structuring light(FSL). A vector superposition of two orthogonally polarized components can produce VB or FSL beam. This lecture discusses a scheme to guide a weak vector beam using optically written waveguides inside atomic vapor, whilst controlling its polarization rotation. The polarization rotation control is achieved using the anisotropic property of a four-level tripod atomic system which under a specific configuration, can generate different refractive indices for the left and right circularly polarized components of the vector beam. The refractive indices of the two vector beam components can be varied by changing their detunings. The waveguiding of the vector beam is achieved through a strong control field with an appropriate transverse intensity profile, which generates a ``core and cladding" type refractive index profile inside the medium.

"Physics with Trapped Atoms, Molecules and Ions (HYBRID)"

International Centre for Theoretical Sciences of the Tata Institute of Fundamental Research (ICTS-TIFR), Bengaluru

Maxwell's equations in charge free and current free medium

$$\vec{\nabla} \cdot \vec{D} = 0$$

$$\vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \times \vec{H} = \frac{1}{c}\frac{\partial \vec{D}}{\partial t}$$

Additive relations

$$\vec{D} = \vec{E} + 4\pi\overrightarrow{\mathcal{P}}, \quad \vec{B} = \vec{H} + 4\pi\overrightarrow{\mathcal{M}}$$

Free space EM radiation propagation

$$\varrho = 0, \quad \vec{J} = 0, \quad \vec{D} = \vec{E}, \quad \vec{B} = \vec{H}$$

Scaler and Vector Potential

$$\vec{E} = -\nabla\Phi - \frac{1}{c}\frac{\partial \vec{A}}{\partial t}, \quad \vec{B} = \nabla \times \vec{A}$$

$$\left(\nabla^2 \vec{A} - \frac{1}{c^2}\frac{\partial^2 \vec{A}}{\partial t^2}\right) - \nabla\left(\nabla \bullet \vec{A} + \frac{1}{c}\frac{\partial \Phi}{\partial t}\right) = 0$$

Lorentz gauge condition

$$\nabla \bullet \vec{A} + \frac{1}{c}\frac{\partial \Phi}{\partial t} = 0$$

$$\left(\nabla^2 \vec{A} - \frac{1}{c^2}\frac{\partial^2 \vec{A}}{\partial t^2}\right) = 0$$

Vector potential polarised along x

$$\vec{A} = \hat{x}\, u\left(x, y, z\right) e^{ikz - i\omega t}$$

The Magnetic Field Induction

$$\vec{B} = \nabla \times \vec{A}$$

$$\vec{\nabla} \times \vec{A} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ u(x,y,z)e^{ikz} & 0 & 0 \end{vmatrix}$$

$$= ik\left\{ \hat{y}\left(ue^{ikz} + \frac{1}{ik}\frac{\partial u}{\partial z}e^{ikz} \right) - \hat{z}\frac{1}{ik}\frac{\partial u}{\partial y}e^{ikz} \right\}$$

Slowly Varying Envelope Approximation

$$|ku| \gg \left| k^2 \frac{\partial u}{\partial z} \right| \gg \left| \frac{\partial^2 u}{\partial^2 z} \right|$$

$$\vec{B} = ik\left(\hat{y}u + \frac{i}{k}\frac{\partial u}{\partial y}\hat{z} \right)e^{ikz}$$

The Ampere's Law

$$\vec{\nabla}\times\vec{H} = \frac{1}{c}\frac{\partial\vec{D}}{\partial t} = ik\vec{E}$$

$$\vec{B} = ik\left\{\hat{y}\left(ue^{ikz} + \frac{1}{ik}\frac{\partial u}{\partial z}e^{ikz}\right) - \hat{z}\frac{1}{ik}\frac{\partial u}{\partial y}e^{ikz}\right\}$$

$$\vec{\nabla}\times\vec{\nabla}\times\vec{H} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ 0 & ik\left(ue^{ikz} + \frac{1}{ik}\frac{\partial u}{\partial z}e^{ikz}\right) & -\frac{\partial u}{\partial y}e^{ikz} \end{vmatrix}$$

$$= \hat{x}\left(-\frac{\partial^2 u}{\partial y^2}e^{ikz} - ik\left(2\frac{\partial u}{\partial z}e^{ikz} + ik\,ue^{ikz} + \frac{1}{ik}\frac{\partial^2 u}{\partial z^2}e^{ikz}\right)\right)$$

$$+\hat{y}\left(\frac{\partial^2 u}{\partial x\partial y}e^{ikz}\right) + \hat{z}\left(ik\left(\frac{\partial u}{\partial x}e^{ikz} + \frac{1}{ik}\frac{\partial^2 u}{\partial x\partial z}e^{ikz}\right)\right)$$

$$ik\vec{E} = \hat{x}\left(-\frac{\partial^2 u}{\partial y^2}e^{ikz} - ik\left(2\frac{\partial u}{\partial z}e^{ikz} + ik\,ue^{ikz} + \frac{1}{ik}\frac{\partial^2 u}{\partial z^2}e^{ikz}\right)\right)$$

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Slowly Varying Envelope Approximation

$$|ku| \gg \left|k^2\frac{\partial u}{\partial z}\right| \gg \left|\frac{\partial^2 u}{\partial^2 z}\right|$$

$$ik\vec{E} = \hat{x}\,k^2\,ue^{ikz} + \hat{z}ik\frac{\partial u}{\partial x}e^{ikz}$$

Electric and magnetic fields under Paraxial Wave Equation

$$\vec{E} = ik\left(\hat{x}\,u + \frac{i}{k}\frac{\partial u}{\partial x}\hat{z}\right)e^{ikz}$$

$$\vec{B} = ik\left(\hat{y}\,u + \frac{i}{k}\frac{\partial u}{\partial y}\hat{z}\right)e^{ikz}$$

The time averaged Poynting vector

$$\langle \vec{S} \rangle = \frac{c}{4\pi}\langle \vec{E}\times\vec{B}\rangle = \frac{c}{8\pi}(\vec{E}^*\times\vec{B}+\vec{E}\times\vec{B}^*)$$

$$\langle \vec{S} \rangle = \frac{ick}{8\pi}(u\nabla u^* - u^*\nabla u) + \frac{ck^2}{4\pi}|u|^2\,\hat{z}$$

cylindrically symmetric solutions

$$u(r,\phi,z) = u_0(r,z)e^{-il\phi}\, e^{-\frac{ikr^2z}{2(z^2+z_R^2)}}\, e^{i(2p+l+1)tan^{-1}\left(\frac{z}{z_R}\right)}$$

The phase part of $\boldsymbol{u}$**(r,** $\boldsymbol{\phi}$**, z)** is important and plays the key role in spiral motion of Poynting vector for a LG beam.

$$\langle \vec{S} \rangle = \frac{ck}{8\pi}\left(\frac{2krz}{z^2+z_R^2}|u|^2\,\hat{r} + \frac{2l}{r}|u|^2\,\hat{\phi}\right) + \frac{ck^2}{4\pi}|u|^2\,\hat{z}$$

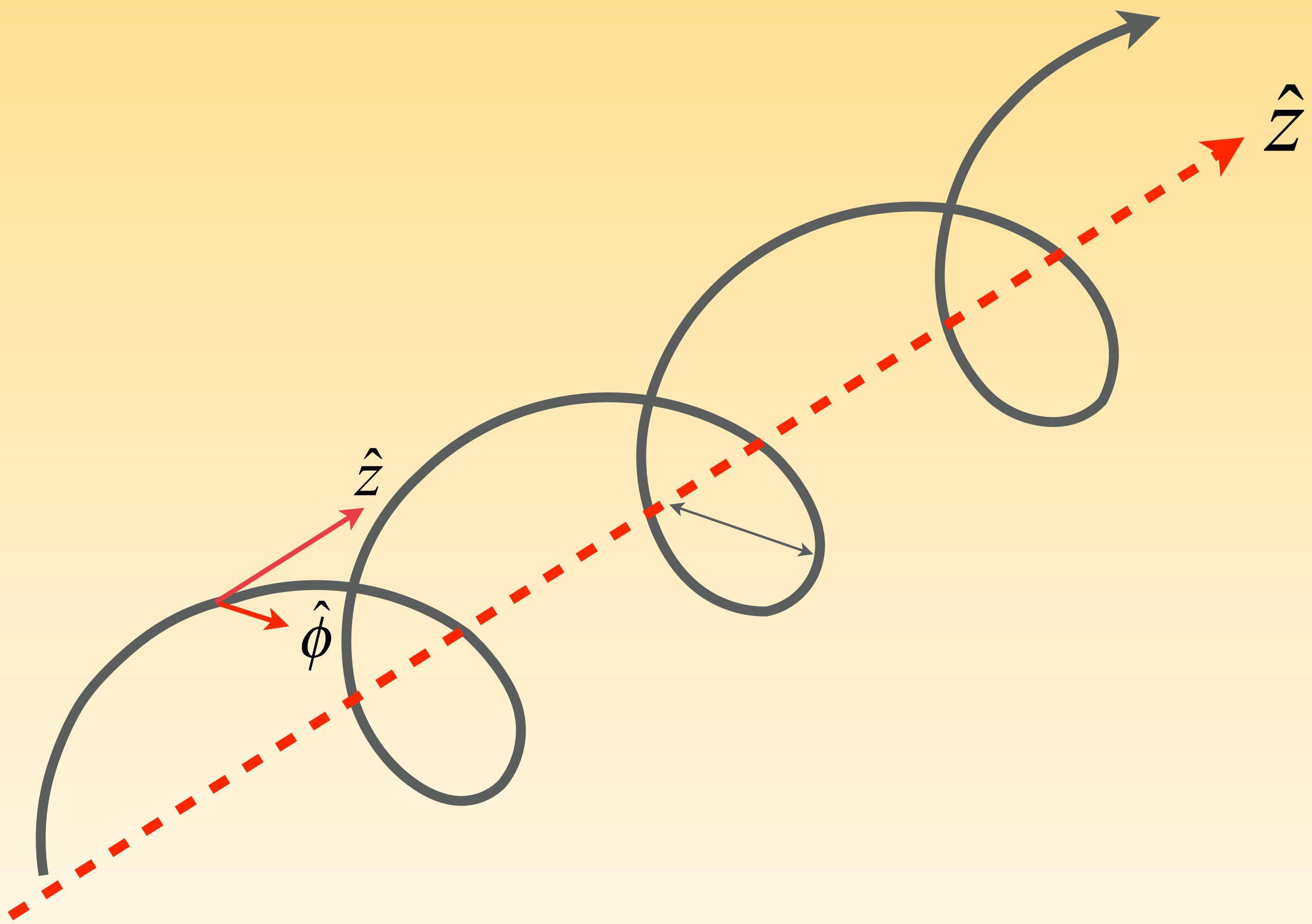
For a LG beam, $\langle \vec{S} \rangle$ possesses nonzero component along $\hat{r}, \hat{\phi}, \hat{z}$ *direction*.

$$\langle \vec{S} \rangle_r = \frac{ck}{4\pi}\frac{krz}{z^2+z_R^2}|u|^2; \quad \langle \vec{S} \rangle_\phi = \frac{ck}{4\pi}\frac{l}{r}|u|^2; \quad \langle \vec{S} \rangle_z = \frac{ck}{4\pi}k^2|u|^2$$

The component $\langle \vec{S}(r,\varphi,z) \rangle_r$ relates to the spread of the beam as it propagates

The component $\langle \vec{S}(r,\varphi,z) \rangle_\phi$ gives rise to orbital angular momentum in the z-direction

The component $\langle \vec{S}(r,\varphi,z) \rangle_z$ relates to the linear momentum in the direction of propagation



L. Allen, M. J. Padgett and M. Babiker, Progress in Optics 39, 291-371(1999)

Inhomogeneous Wave equation

$$\nabla^2 \vec{E} - \frac{1}{c^2}\frac{\partial^2 \vec{E}}{\partial t^2} = \frac{4\pi}{c^2}\frac{\partial^2 \vec{P}}{\partial t^2}$$

Electric field and induced polarization

$$\vec{E}(r,t) = \hat{e}\,\varepsilon_0(x,y,z)\,e^{-i\omega t + ikz} + c.c. \qquad \vec{P}(r,t) = \hat{e}\,p_0(x,y,z)\,e^{-i\omega t + ikz} + c.c.$$

$$\nabla^2 \vec{E} - \frac{1}{c^2}\frac{\partial^2 \vec{E}}{\partial t^2} = \hat{e}\frac{\partial^2 \varepsilon_0}{\partial x^2}e^{-i(\omega t - kz)} + \hat{e}\frac{\partial^2 \varepsilon_0}{\partial y^2}e^{-i(\omega t - kz)} + 2ik\hat{e}\frac{\partial \varepsilon_0}{\partial z}e^{-i(\omega t - kz)}$$

$$+\hat{e}\frac{\partial^2 \varepsilon_0}{\partial z^2}e^{-i(\omega t - kz)} - k^2\hat{e}\,\varepsilon_0 e^{-i(\omega t - kz)} + \frac{\omega^2}{c^2}\hat{e}\,\varepsilon_0 e^{-i(\omega t - kz)}$$

$$\frac{4\pi}{c^2}\frac{\partial^2 \vec{P}}{\partial t^2} = \frac{4\pi\omega^2}{c^2}\hat{e}\,p_0 e^{-i(\omega t - kz)}$$

Paraxial Wave Equation for Electric field

$$\nabla_\perp^2 E_0 + 2ik\frac{\partial E_0}{\partial z} = \frac{4\pi\omega^2}{c^2}P_0$$

$$\frac{\partial E_0}{\partial z} = \frac{i}{2k}\nabla_\perp^2 E_0 + 2\pi i k \chi E_0$$

OAM of Light

- Some light beams rotates, as they travel through space. Such beams have angular momentum.

- There are two ways a beam can rotate

    1. If polarization vector rotates – spin

    2. If the phase structure rotates - orbital

- These light beams are able to spin microscopic objects, creates new forms of imaging systems, etc.

- One such example of a rotating beam is a Laguerre-Gaussian beam (LG)

Scalar Beam

Electric field of a scalar vortex beams of degree p and order m

$$\overrightarrow{E}(r,\phi,z) = \hat{e}_i \mathscr{E}_{p,m}(r,\phi,z) e^{-i\omega t + ikz + im\phi} + \text{c.c.}$$

$$\mathscr{E}_{p,m}(r,\phi,z) = E_{(0)} \frac{w_0}{w(z)} \left[\frac{\sqrt{2}r}{w(z)}\right] L_p^{|m|}\left[\frac{2r^2}{w^2(z)}\right] e^{-r^2\left[\frac{1}{w^2(z)} - \frac{ik}{2R(z)}\right]} e^{\left[ikz - i(2p+|m|+1)\psi(z)\right]}$$

Minimum beam radius at z=0 w_0

Beam waist $w(z) = w_0\sqrt{1 + z^2/z_R^2}$

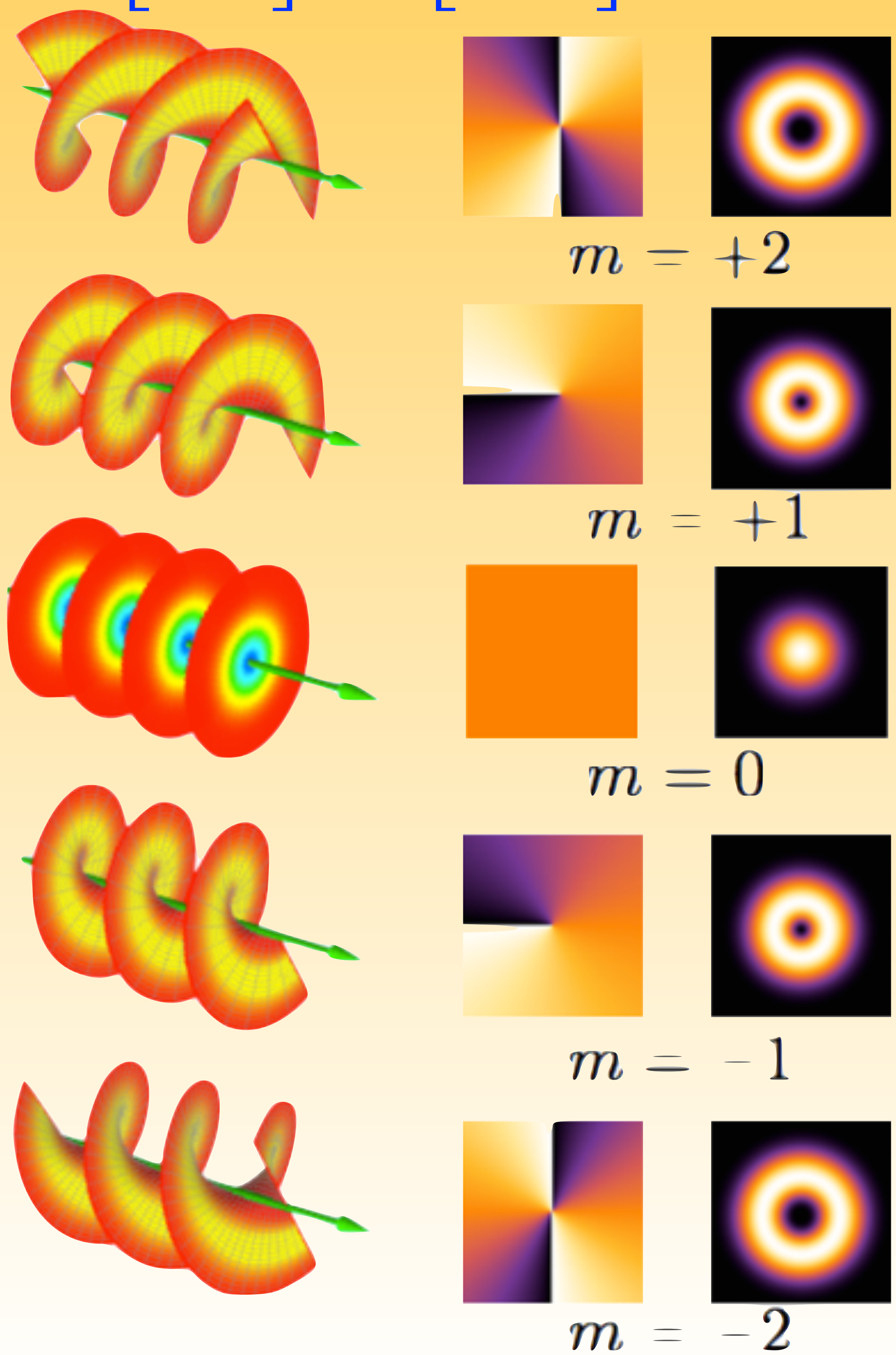
Rayleigh length $z_R = kw_0^2/2$

Laguerre polynomial $L_p^{|m|}(x)$

Radius of wave front curvature $R(z) = (z^2 + z_0^2)/z$

The Gouy phase shift $(2p + |m| + 1)\psi(z)$ $\psi(z) = \tan^{-1}(z/z_R)$

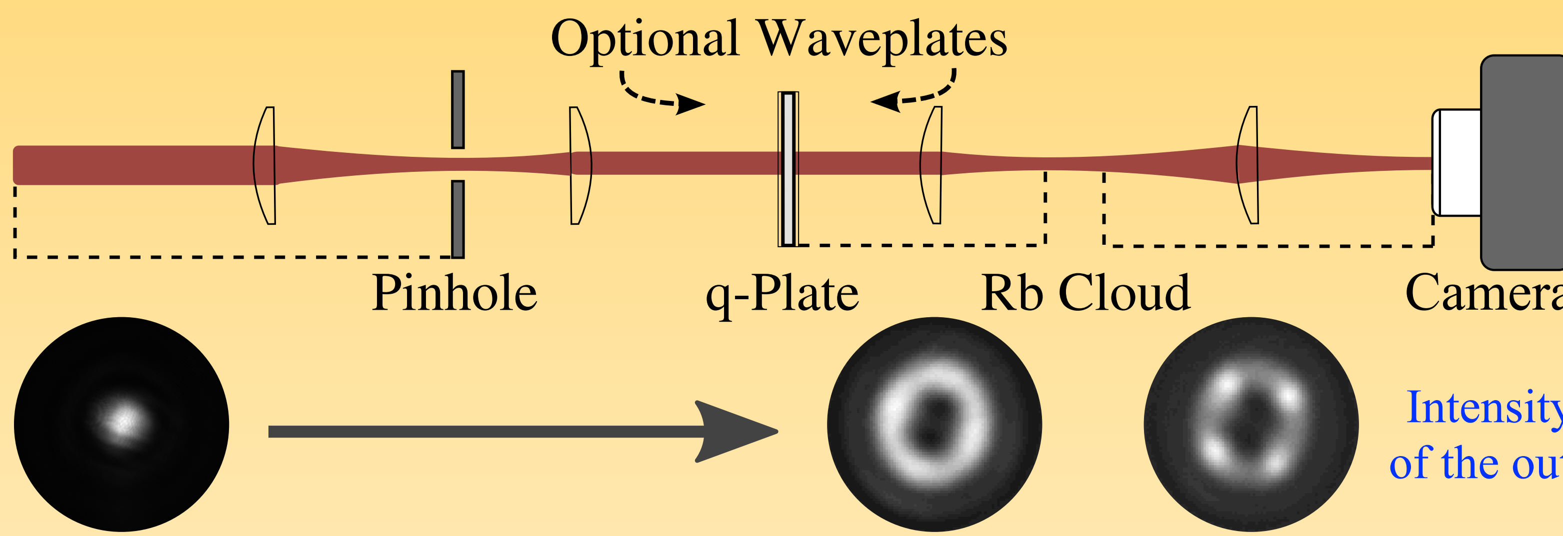
$$\mathcal{E}_{p,m}(r,\phi,z) = E_{(0)}\frac{w_0}{w(z)}\left[\frac{\sqrt{2}r}{w(z)}\right] L_p^{|m|}\left[\frac{2r^2}{w^2(z)}\right] e^{-r^2\left[\frac{1}{w^2(z)}-\frac{ik}{2R(z)}\right]} e^{[ikz-i(2p+|m|+1)\psi(z)]}$$



Spatially Dependent Electromagnetically Induced Transparency

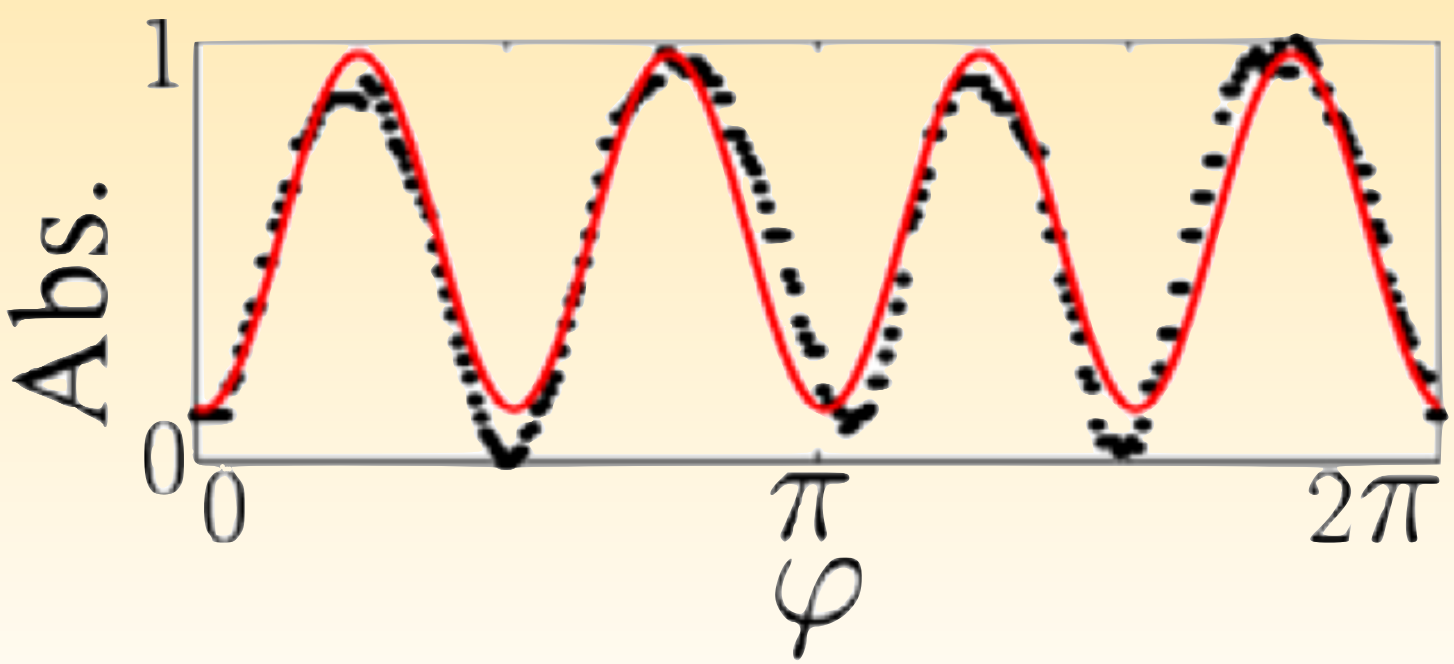
N. Radwell, T. W. Clark, B. Piccirillo, S. M. Barnett, and S. Franke-Arnold
SUPA, School of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, United Kingdom

Intensity profile of the input beam

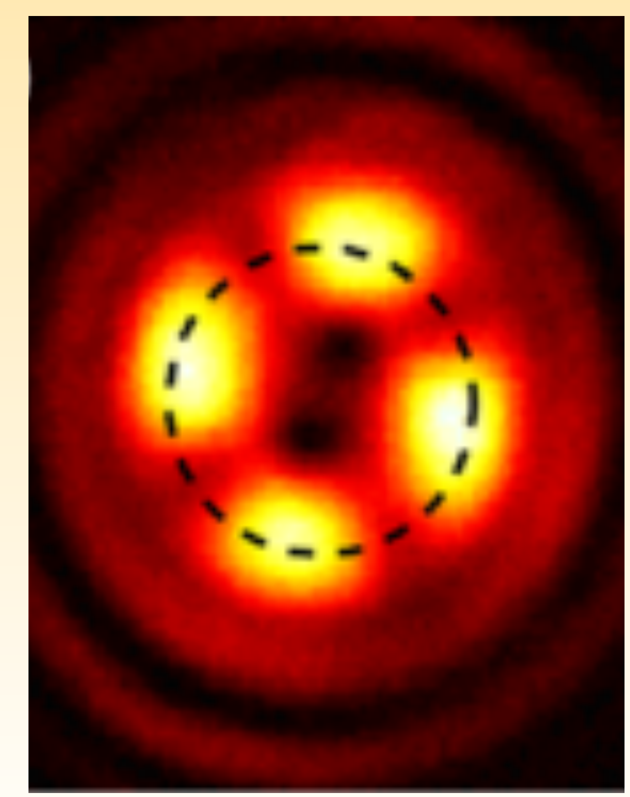


Intensity profiles of the output beam

Experimental beam path



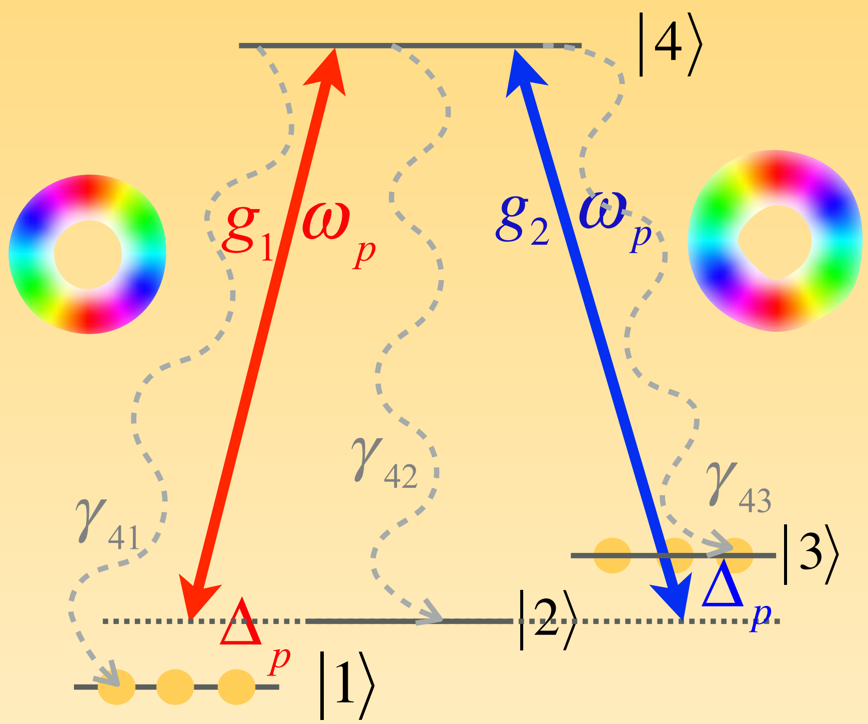
Polar plot at radius of maximal contrast

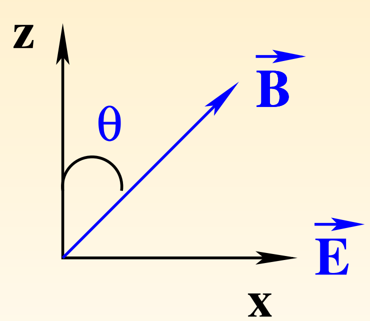


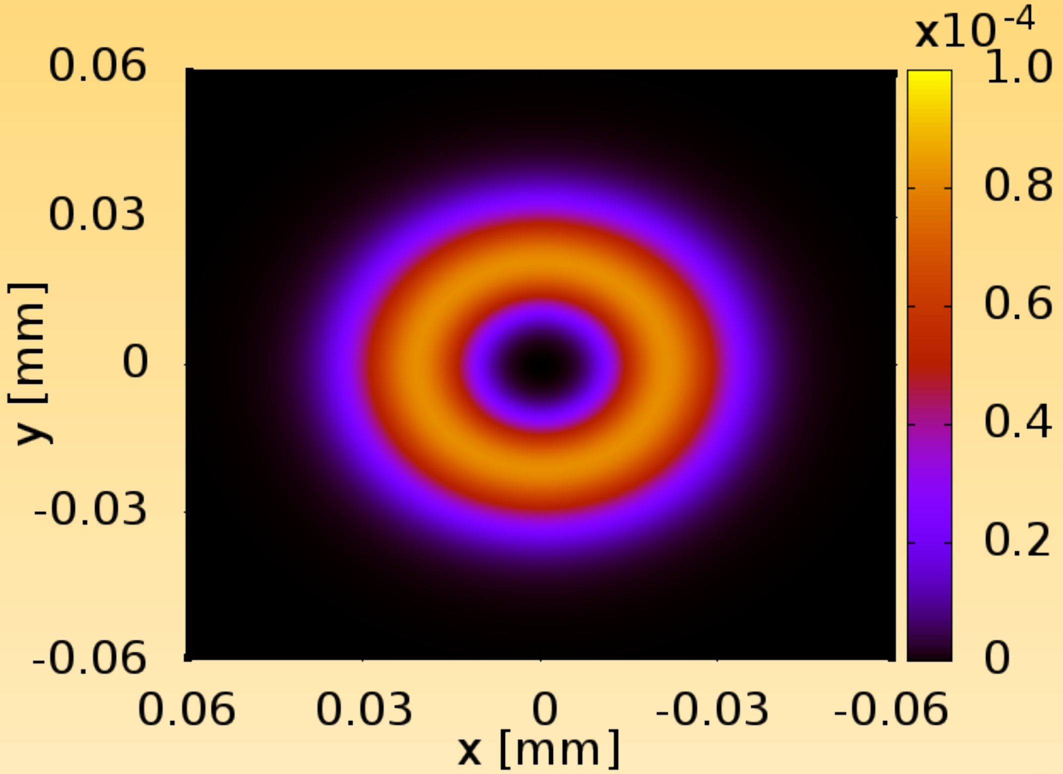
PHYSICAL REVIEW A 96, 033811 2017

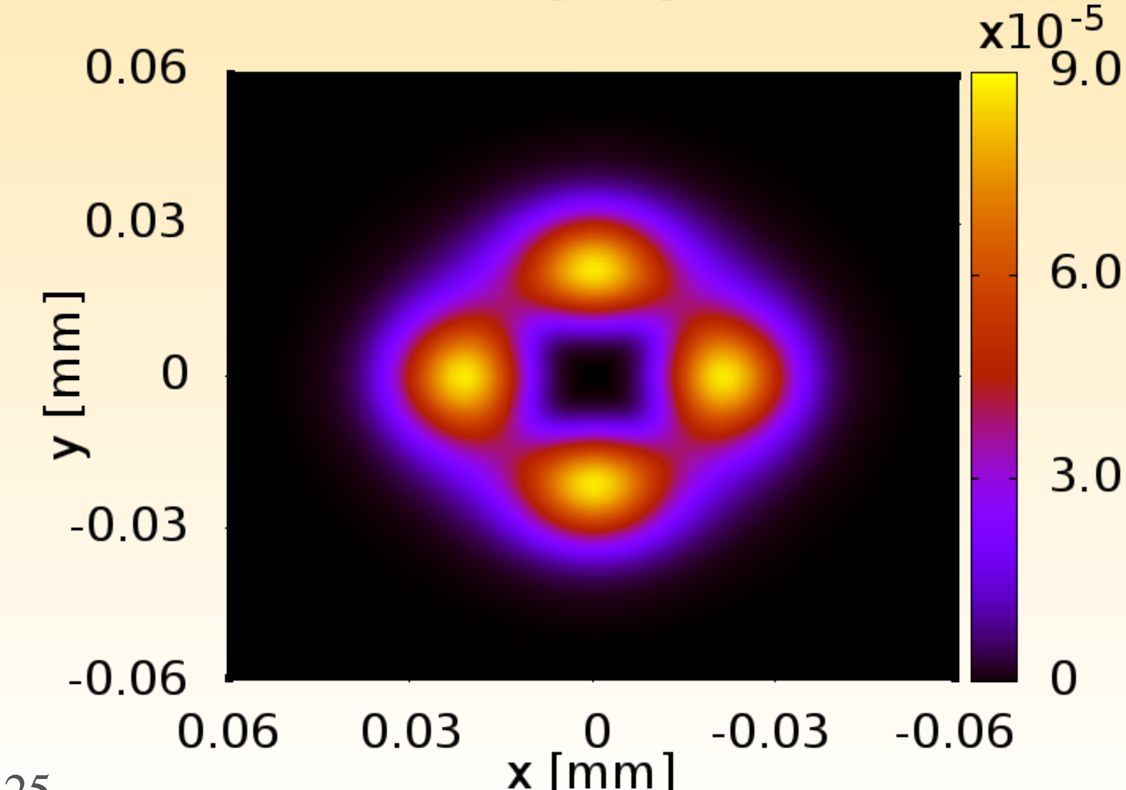
Phase-induced transparency-mediated structured-beam generation in a closed-loop tripod configuration

Sandeep Sharma and **Tarak N. Dey**









Vector beams

Vector vortex beams are optical beams with polarization sigularities

In the circular polarization basis as

$$\overrightarrow{E}(r,\phi,z) = \mathscr{E}_L(r,\phi,z)\hat{e}_L + \mathscr{E}_R(r,\phi,z)\hat{e}_R$$

$\mathscr{E}_L(r,\phi,z) = \cos(\alpha)\ LG_0^{l_L}$, and $\mathscr{E}_R(r,\phi,z) = e^{i\theta}\sin(\alpha)\ LG_0^{l_R}$

$$LG_0^{l_i}(r,\phi,z) = E_i^{(0)}\sqrt{\frac{2}{\pi|l_i|!}}\exp\left(\frac{-r^2}{w(z)^2}\right)\left(\frac{r\sqrt{2}}{w(z)}\right)^{|l_i|}\exp(il_i\phi)$$

Rayleigh length $z_R = \dfrac{k_i w_0^2}{2}$ beam waist $w(z) = w_0\sqrt{1 + z^2/z_R^2}$

The Gouy phase $(|l_i| + 1)\eta(z)$ $\eta(z) = \tan^{-1}(z/z_R)$

The Stokes parameters in the circular polarization basis

$$S_0 = |\mathscr{E}_R|^2 + |\mathscr{E}_L|^2; \quad S_1 = 2\mathrm{Re}[\mathscr{E}_R^*\mathscr{E}_L] \quad S_2 = 2\mathrm{Im}[\mathscr{E}_R^*\mathscr{E}_L]; \qquad S_3 = |\mathscr{E}_R|^2 - |\mathscr{E}_L|^2$$

The ellipticity, ζ, and orientation ξ of the polarization at each point on the transverse plane

$$\frac{S_1}{S_0} = \cos(2\zeta)\cos(2\xi); \quad \frac{S_2}{S_0} = \cos(2\zeta)\sin(2\xi); \quad \frac{S_3}{S_0} = \sin(2\zeta)$$

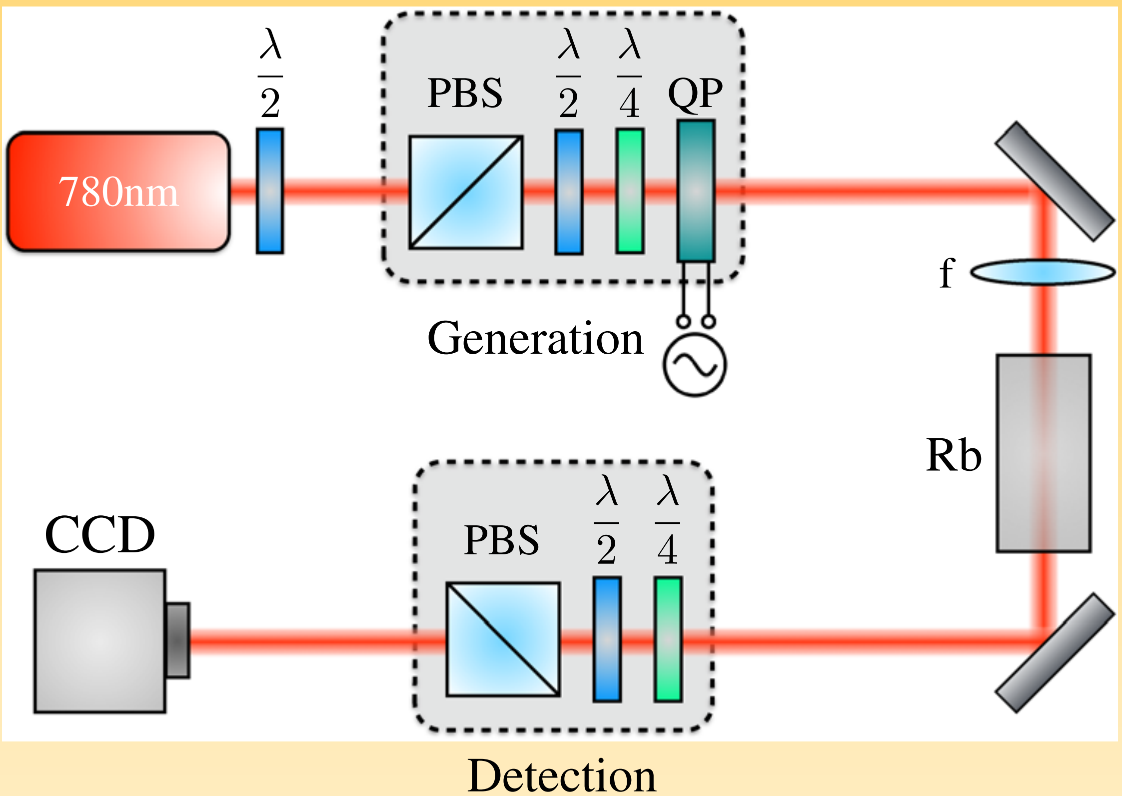
$$\zeta = \frac{1}{2}\sin^{-1}\left(\frac{S_3}{S_0}\right) = \frac{1}{2}\sin^{-1}\left(\frac{|\mathscr{E}_R|^2 - |\mathscr{E}_L|^2}{|\mathscr{E}_R|^2 + |\mathscr{E}_L|^2}\right), \quad \xi = \frac{1}{2}\tan^{-1}\left(\frac{S_2}{S_1}\right) = \frac{1}{2}\tan^{-1}\left(\frac{\mathrm{Im}[\mathscr{E}_R^*\mathscr{E}_L]}{\mathrm{Re}[\mathscr{E}_R^*\mathscr{E}_L]}\right)$$

$$\Delta\xi = \xi(z) - \xi(0) = -\frac{1}{2}\Delta|l_{L,R}|\eta(z) - \frac{kr^2 z\Delta(n_{R,L})}{4(z^2 + z_R^2)} - \frac{1}{2}kz\Delta(n_{R,L})$$

$\Delta|l_{L,R}| = |l_L| - |l_R|$ and $\Delta(n_{R,L}) = n_R - n_L$

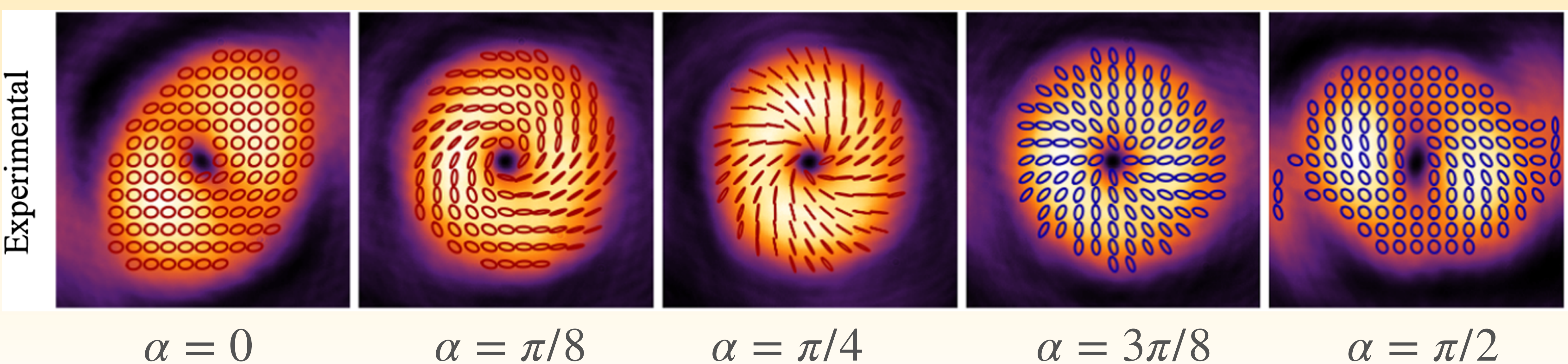
Polarization Shaping for Control of Nonlinear Propagation

Frédéric Bouchard, Hugo Larocque, Alison M. Yao, Christopher Travis, Israel De Leon, Andrea Rubano, Ebrahim Karimi, Gian-Luca Oppo, and Robert W. Boyd



$$\frac{\partial E_1}{\partial \zeta} = \frac{i}{2}\nabla_\perp^2 E_1 + i\mu \frac{|E_1|^2 + 2|E_2|^2}{1+\sigma(|E_1|^2+2|E_2|^2)} E_1,$$

$$\frac{\partial E_2}{\partial \zeta} = \frac{i}{2}\nabla_\perp^2 E_2 + i\mu \frac{|E_2|^2 + 2|E_1|^2}{1+\sigma(|E_2|^2+2|E_1|^2)} E_2.$$



Polarization rotation control of a vector beam with four level tripod system

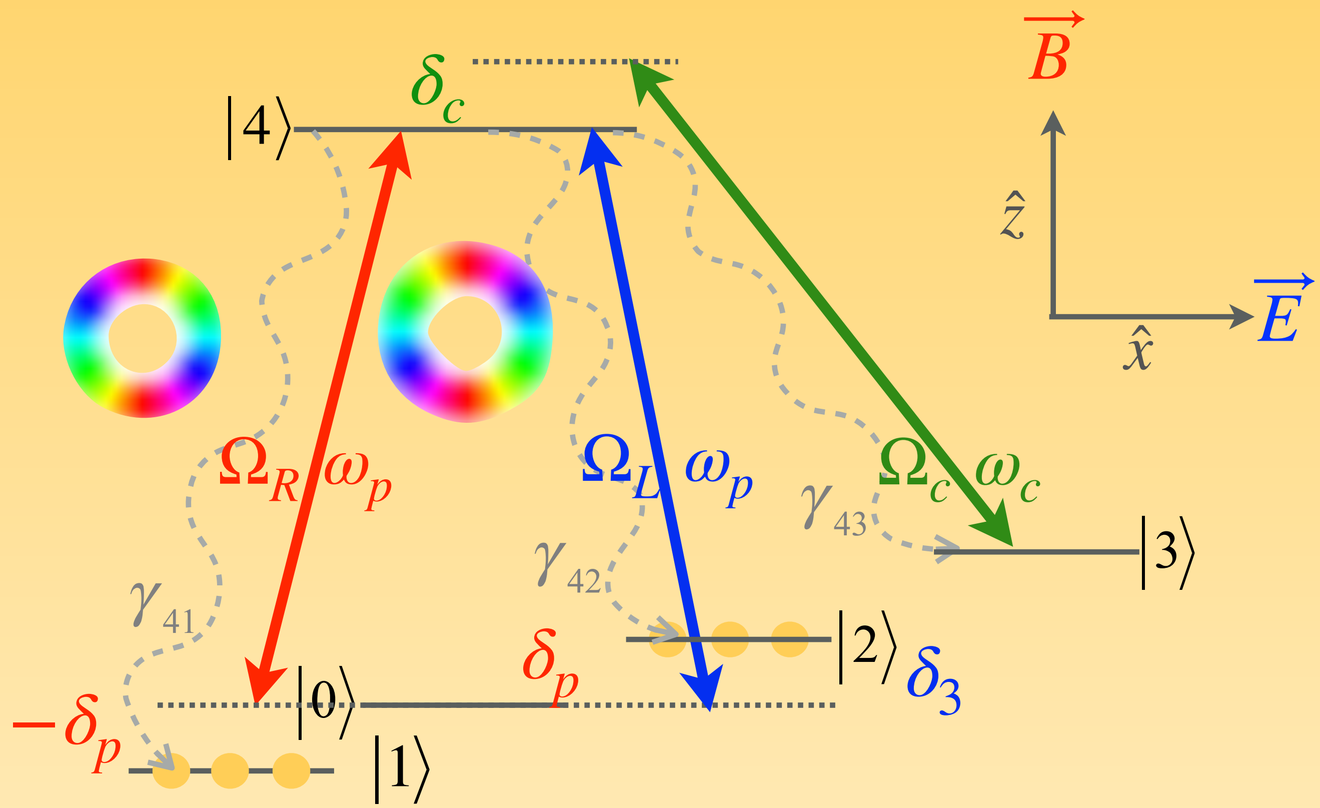
Nilamoni Daloi and Tarak N. Dey

Rabi Frequency

$$\Omega_i = \frac{\overrightarrow{d}_{j4}\,.\,\hat{e}_j\mathscr{E}_i}{\hbar}e^{ik_iz}$$

Detuning

$$\delta_i = \omega_j - \omega_{4i}$$



$|4\rangle = |5\ {}^2P_{3/2}, F = 0, m_F = 0\rangle$ $|3\rangle = |5\ {}^2s_{1/2}, F = 2, m_F = 1\rangle$ $|2\rangle = |5\ {}^2s_{1/2}, F = 1, m_F = 1\rangle$ $|1\rangle = |5\ {}^2s_{1/2}, F = 1, m_F = -1\rangle$

The electric field of vector vortex beam propagating along the z-axis

$$\vec{E}_p(\vec{r},t) = \hat{x}\mathcal{E}(\vec{r})\ e^{-i\left(\omega_p t - k_p z\right)} + c.c.,$$

$$= (\hat{\sigma}_R\mathcal{E}_R(\vec{r}) + \hat{\sigma}_L\mathcal{E}_L(\vec{r}))\ e^{-i\left(\omega_p t - k_p z\right)} + c.c..$$

The magnetic field along the z-axis

$$\overrightarrow{B} = B_0\hat{z}$$

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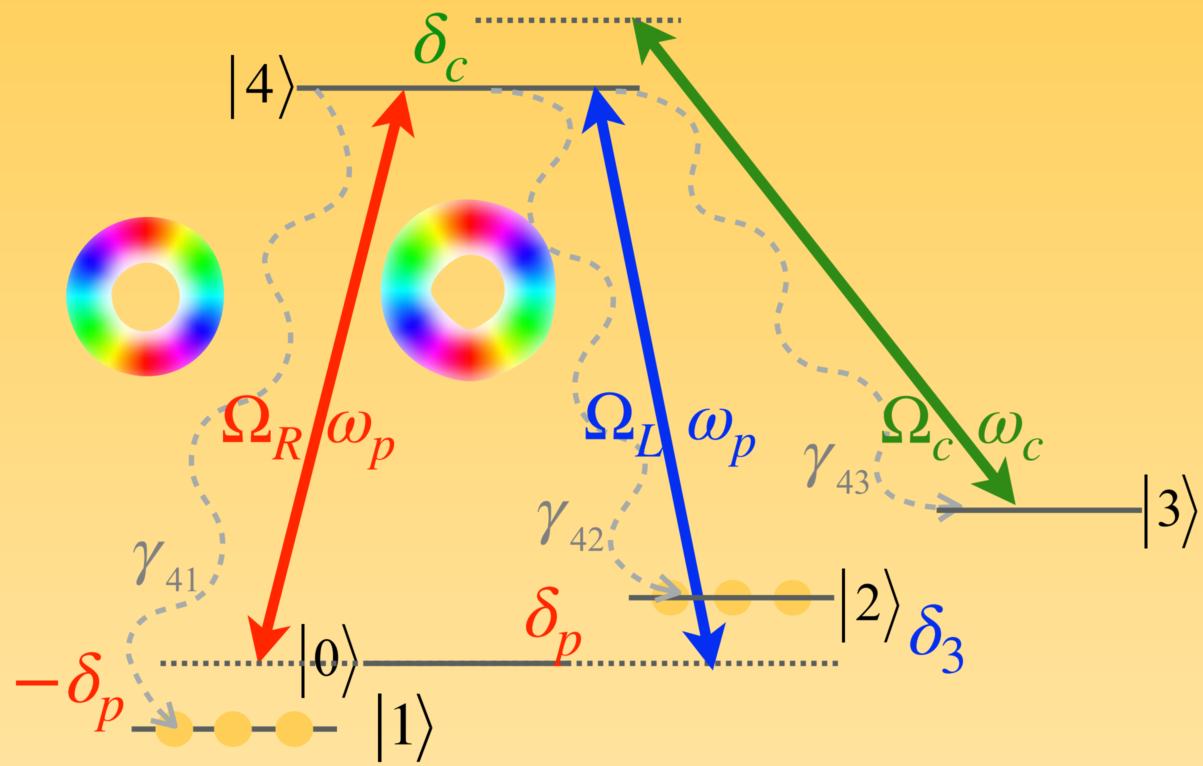
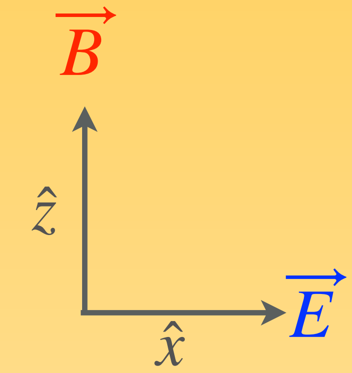
Polarization rotation control of a vector beam with four level tripod system





The effective Hamiltonian

$$\mathscr{H} = -\hbar\left[\left(\delta_c - \delta_p\right)|3\rangle\langle 3| - \delta_p|4\rangle\langle 4| + \beta_L\left(|2\rangle\langle 2| - |1\rangle\langle 1|\right) + \Omega_R|4\rangle\langle 1| + \Omega_c|4\rangle\langle 3| + \Omega_L|4\rangle\langle 2|\right]$$

The dynamics of atomic state populations and coherences

$$\frac{\partial\rho}{\partial t} = -i\hbar[\mathscr{H},\rho] + \mathscr{L}_\rho\,.$$

Incoherent processes

$$\mathscr{L}_\rho = -\sum_{j=1}^{3}\frac{\gamma_{4j}}{2}\left(|4\rangle\langle 4|\rho - 2|j\rangle\langle j|\rho_{44} + \rho|4\rangle\langle 4|\right)$$

Response of the atomic medium

$$\rho_{41} = -\frac{\Omega_R}{2}\left[\frac{1+\frac{|\Omega_L|^2}{A}}{\Delta_{14}+\frac{|\Omega_c|^2}{\Delta_{13}^*}+\frac{|\Omega_L|^2}{\Delta_{12}^*}\left(1+\frac{|\Omega_R|^2}{A}\right)}\right]$$

$$A = \Delta_{24}^*\Delta_{12}^*\left[1-\left(\frac{|\Omega_R|^2}{\Delta_{24}^*\Delta_{12}^*}+\frac{|\Omega_c|^2}{\Delta_{24}^*\Delta_{23}}\right)\right]$$

$$\Delta_{12} = 2\beta_L + i\Gamma_{12}$$

$$\Delta_{13} = \delta_c - \delta_p + \beta_L + i\Gamma_{13}$$

$$\Delta_{14} = \delta_p - \beta_L + i\Gamma_{14} \qquad \Delta_{24} = \delta_p + \beta_L + i\Gamma_{24} \qquad \Delta_{23} = \delta_c - \delta_p - \beta_L + i\Gamma_{23}$$

$$\Gamma_{12} = \Gamma_{13} = \Gamma_{23} = \gamma_c = 0.001\gamma$$

$$\Gamma_{14} = \Gamma_{24} = \Gamma_{34} = \gamma/3 \qquad (\gamma_{41} = \gamma_{42} = \gamma_{43} = \gamma)$$

$$\rho_{42} = -\frac{\Omega_L}{2}\left[\frac{1-\frac{|\Omega_R|^2}{B}}{\Delta_{24}-\frac{|\Omega_c|^2}{\Delta_{23}^*}-\frac{|\Omega_R|^2}{\Delta_{12}}\left(1-\frac{|\Omega_L|^2}{B}\right)}\right]$$

$$B = \Delta_{14}^*\Delta_{12}\left[1+\left(\frac{|\Omega_L|^2}{\Delta_{14}^*\Delta_{12}}+\frac{|\Omega_c|^2}{\Delta_{14}^*\Delta_{13}}\right)\right]$$

$$\Delta_{12} = 2\beta_L + i\Gamma_{12}$$

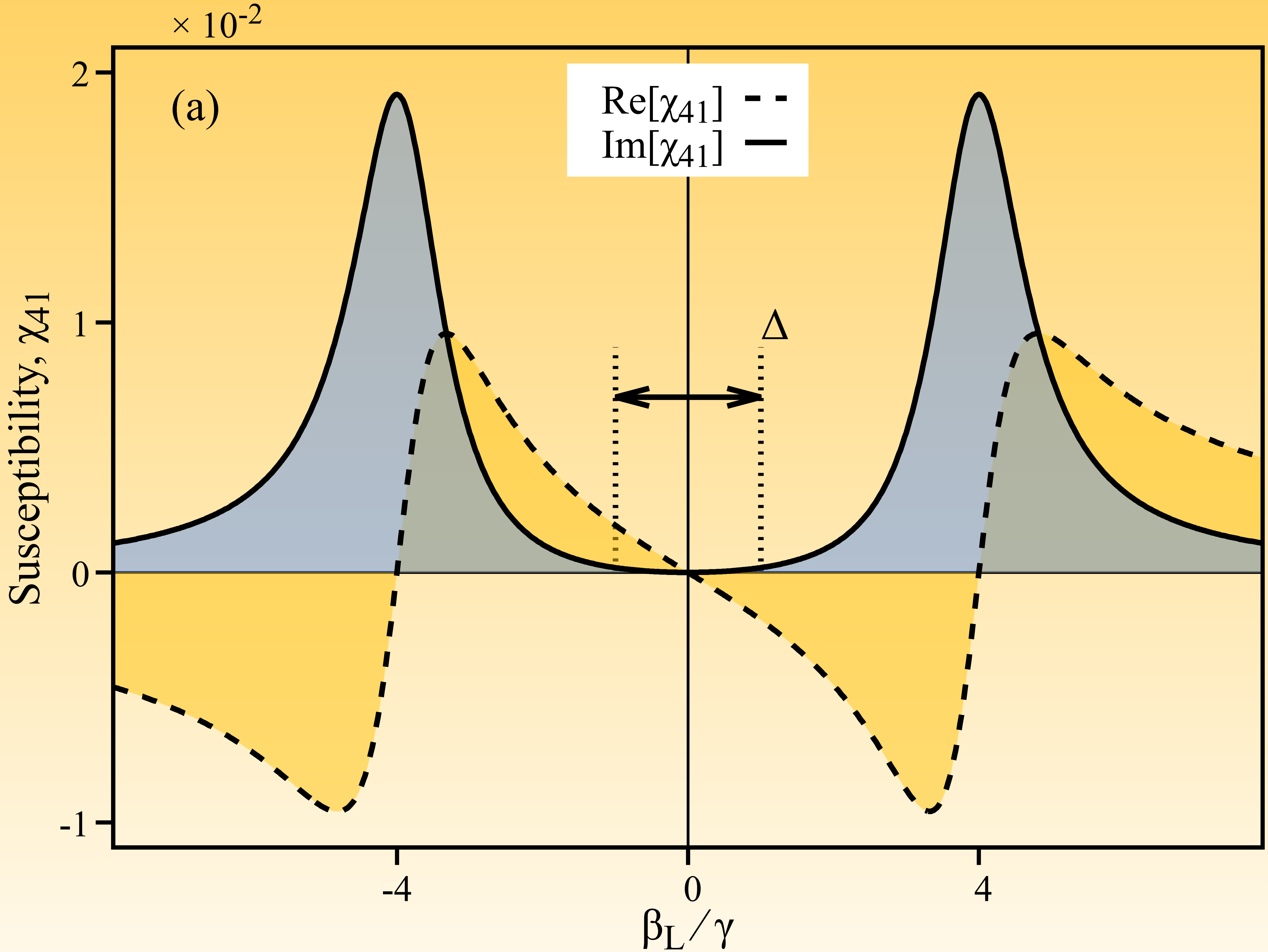
$$\Delta_{13} = \delta_c - \delta_p + \beta_L + i\Gamma_{13}$$

$$\Delta_{14} = \delta_p - \beta_L + i\Gamma_{14} \qquad \Delta_{23} = \delta_c - \delta_p - \beta_L + i\Gamma_{23} \qquad \Delta_{24} = \delta_p + \beta_L + i\Gamma_{24}$$

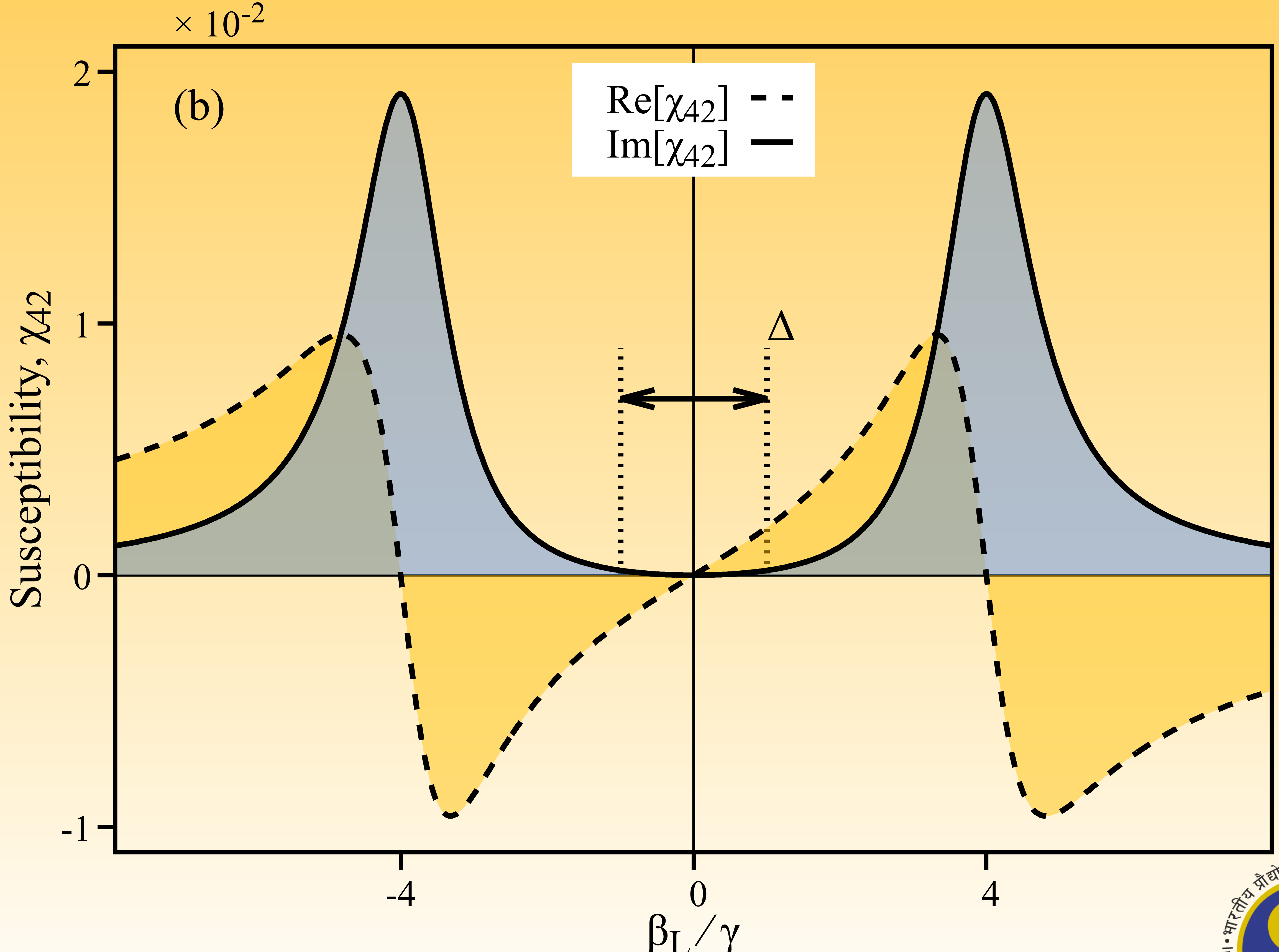
$$\Gamma_{12} = \Gamma_{13} = \Gamma_{23} = \gamma_c = 0.001\gamma$$

$$\Gamma_{14} = \Gamma_{24} = \Gamma_{34} = \gamma/3 \qquad (\gamma_{41} = \gamma_{42} = \gamma_{43} = \gamma)$$

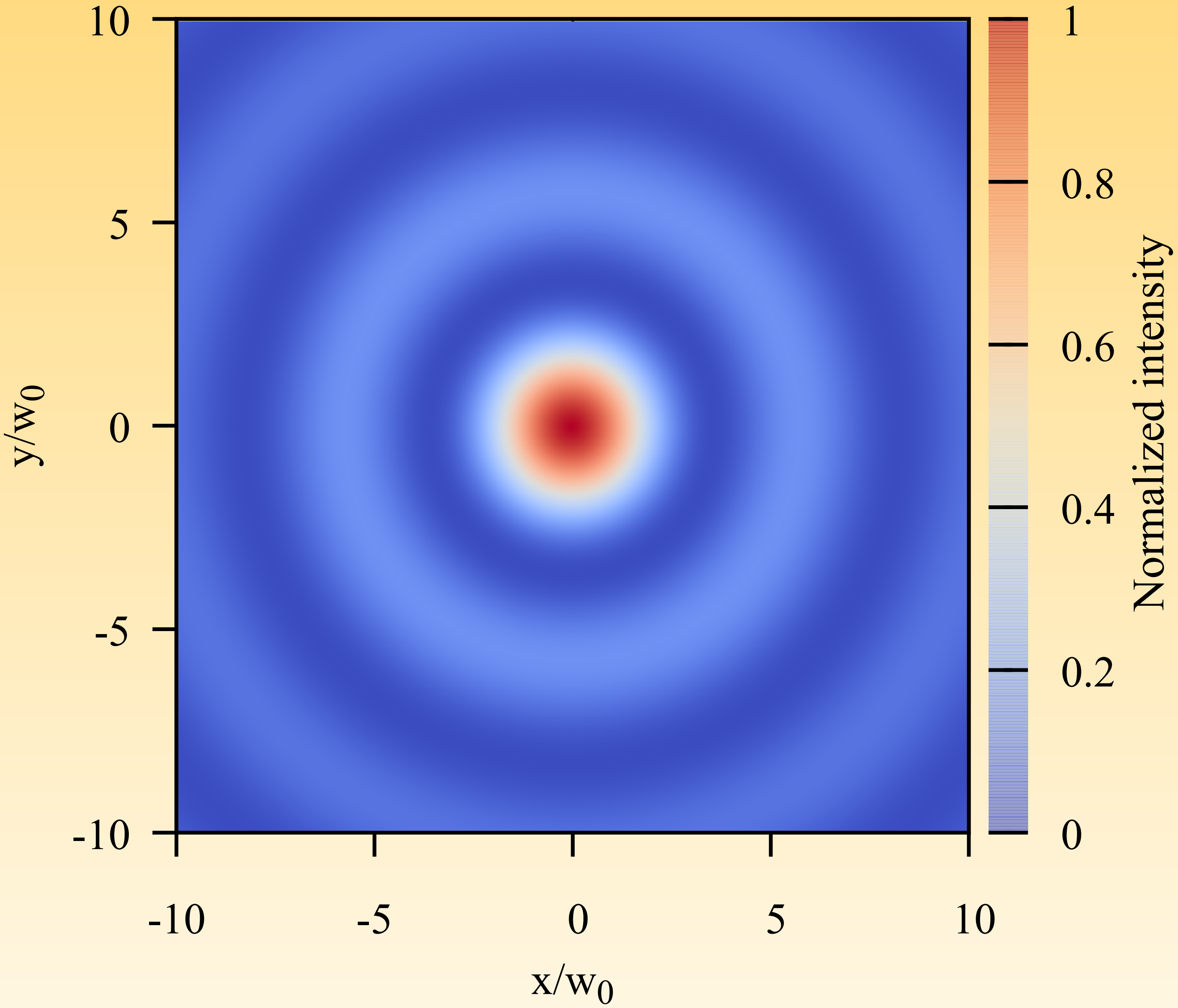
Absorption & Dispersion

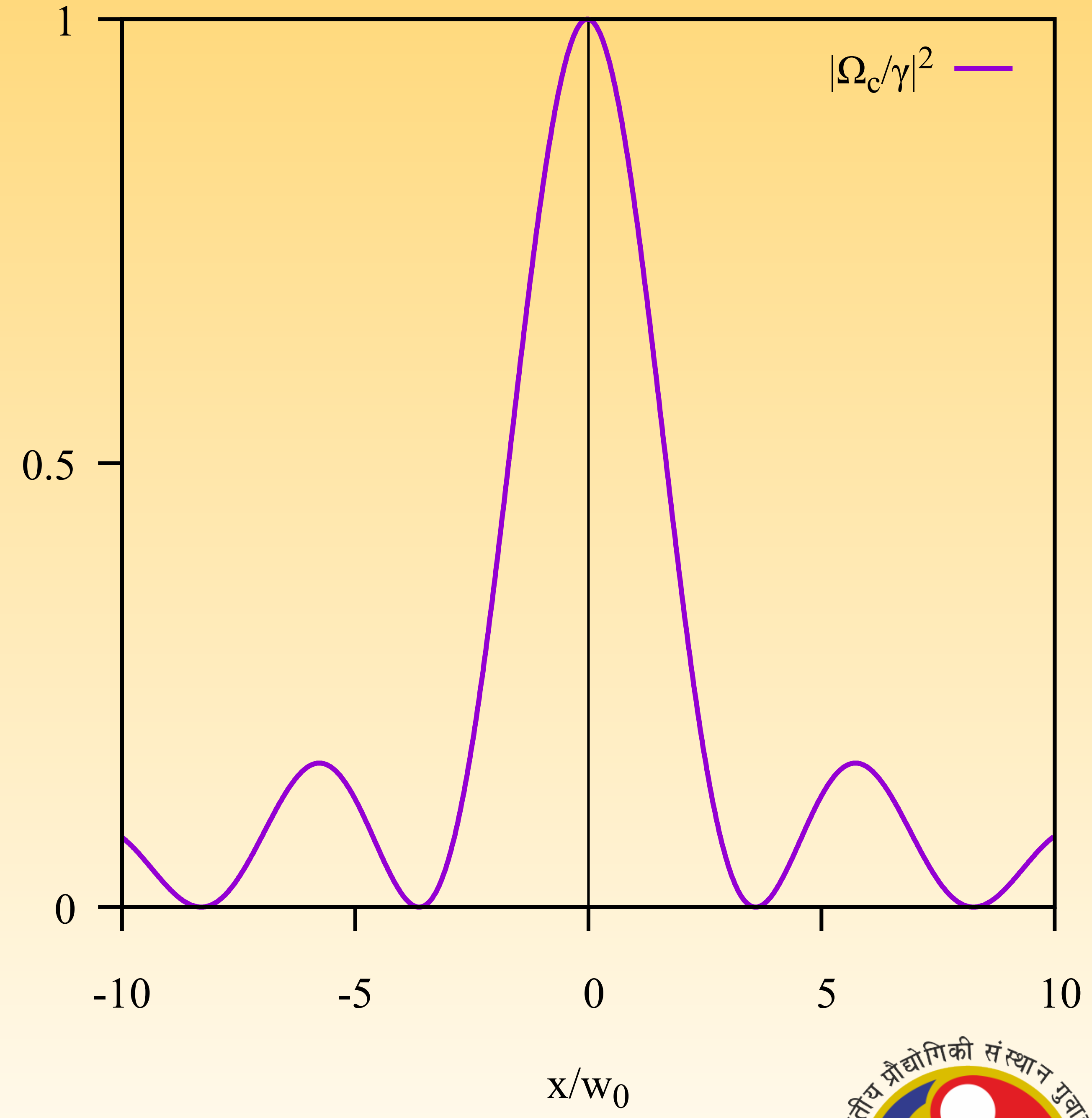


Absorption & Dispersion

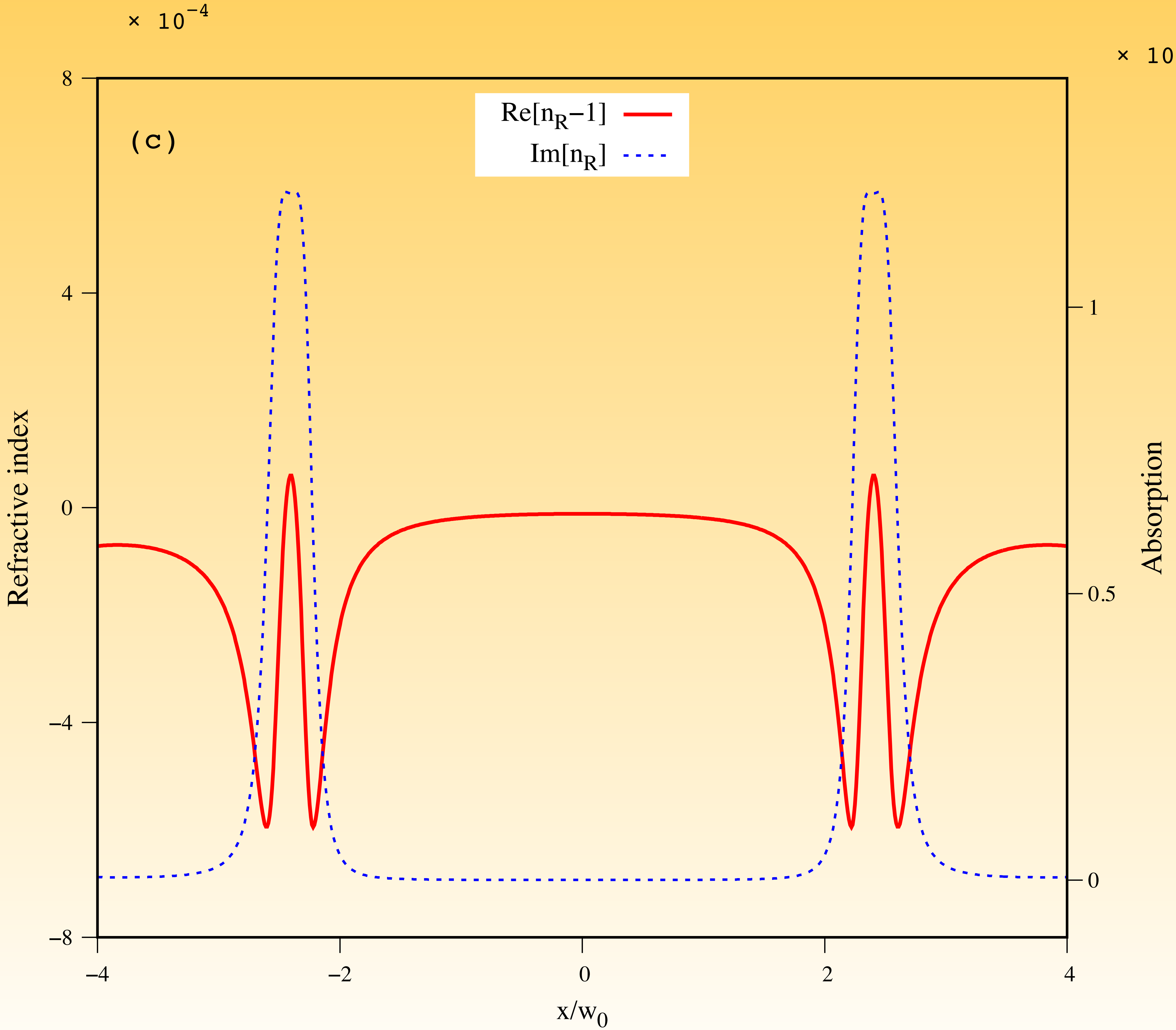


Control Field Spatial Envelope





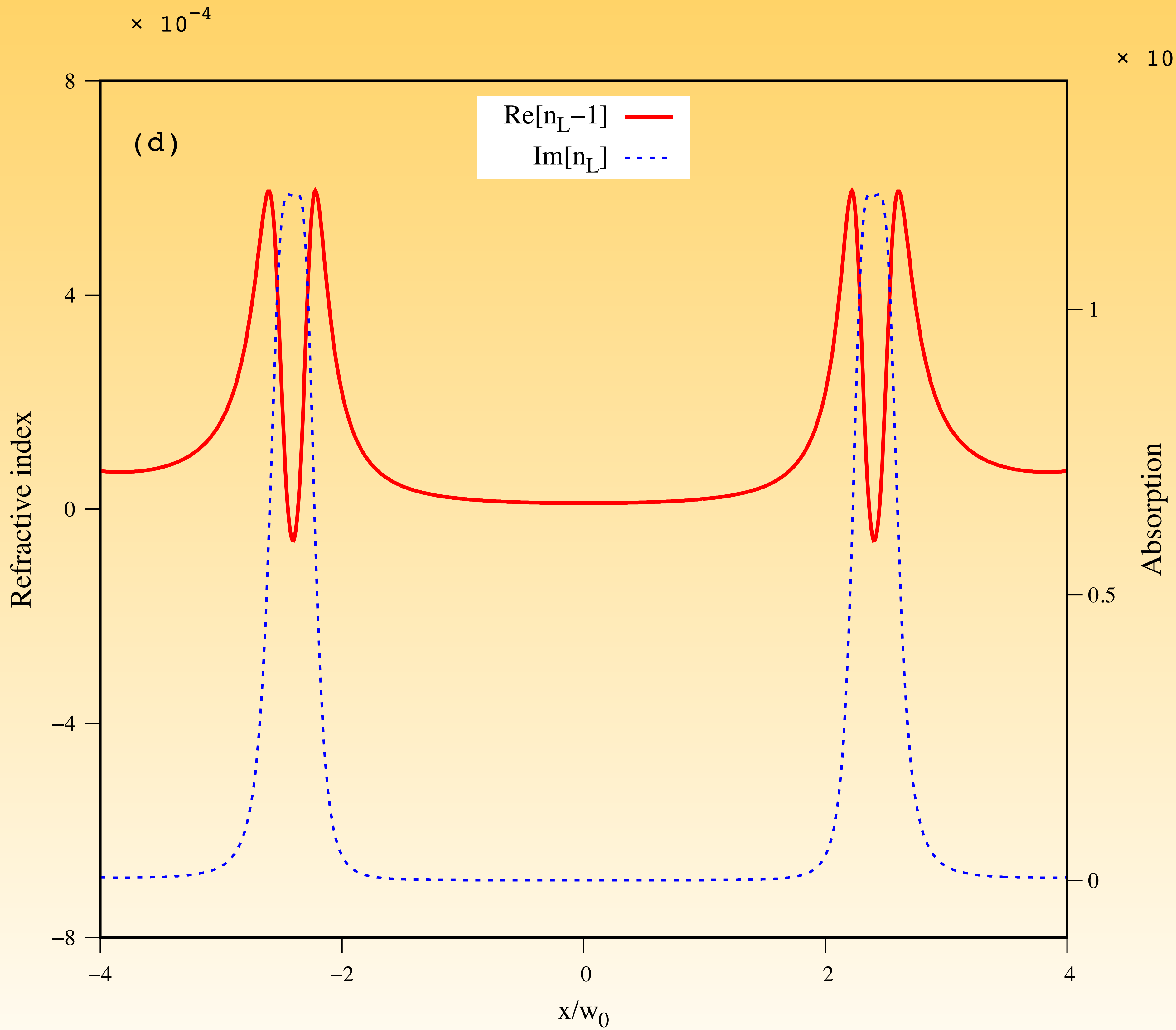
Spatial Absorption in presence of BG control field



$\Omega_c = 4\gamma, \Omega_p = 0.05\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.1\gamma$

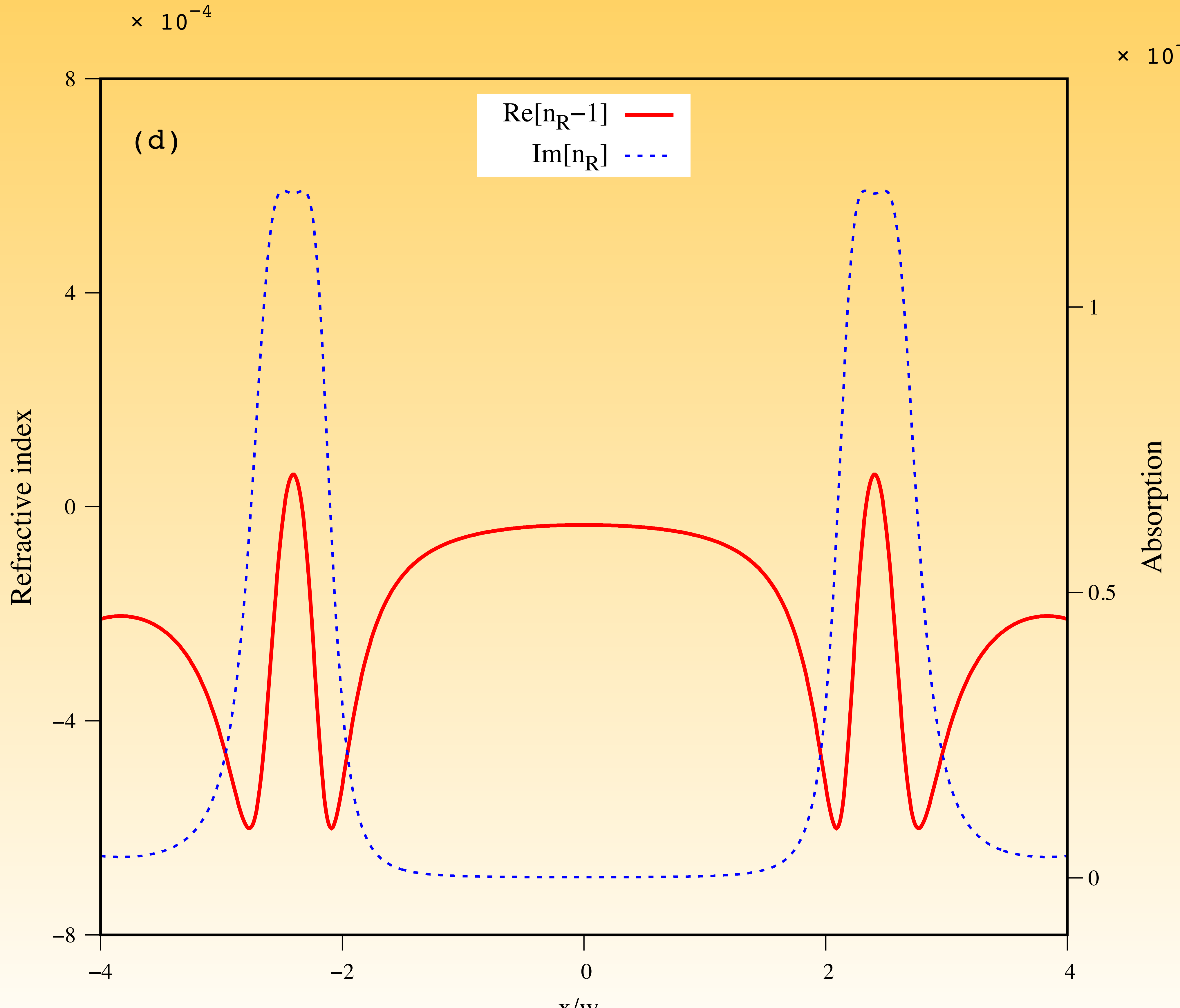
Spatial Absorption in presence of BG control field



$\Omega_c = 4\gamma, \Omega_p = 0.05\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.1\gamma$

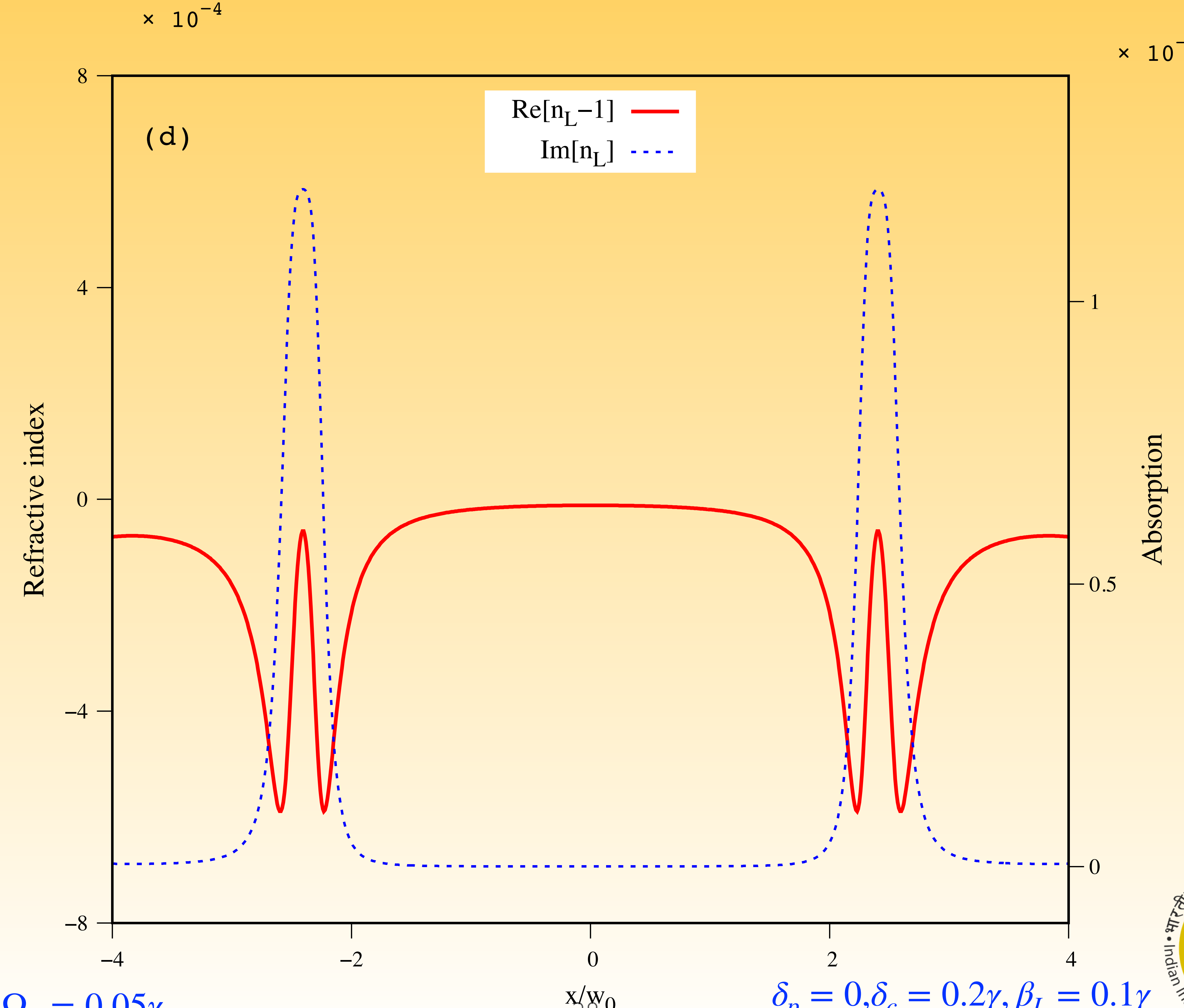
Spatial Refractive index in presence of BG control field



$\Omega_c = 4\gamma, \Omega_p = 0.05\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.1\gamma$

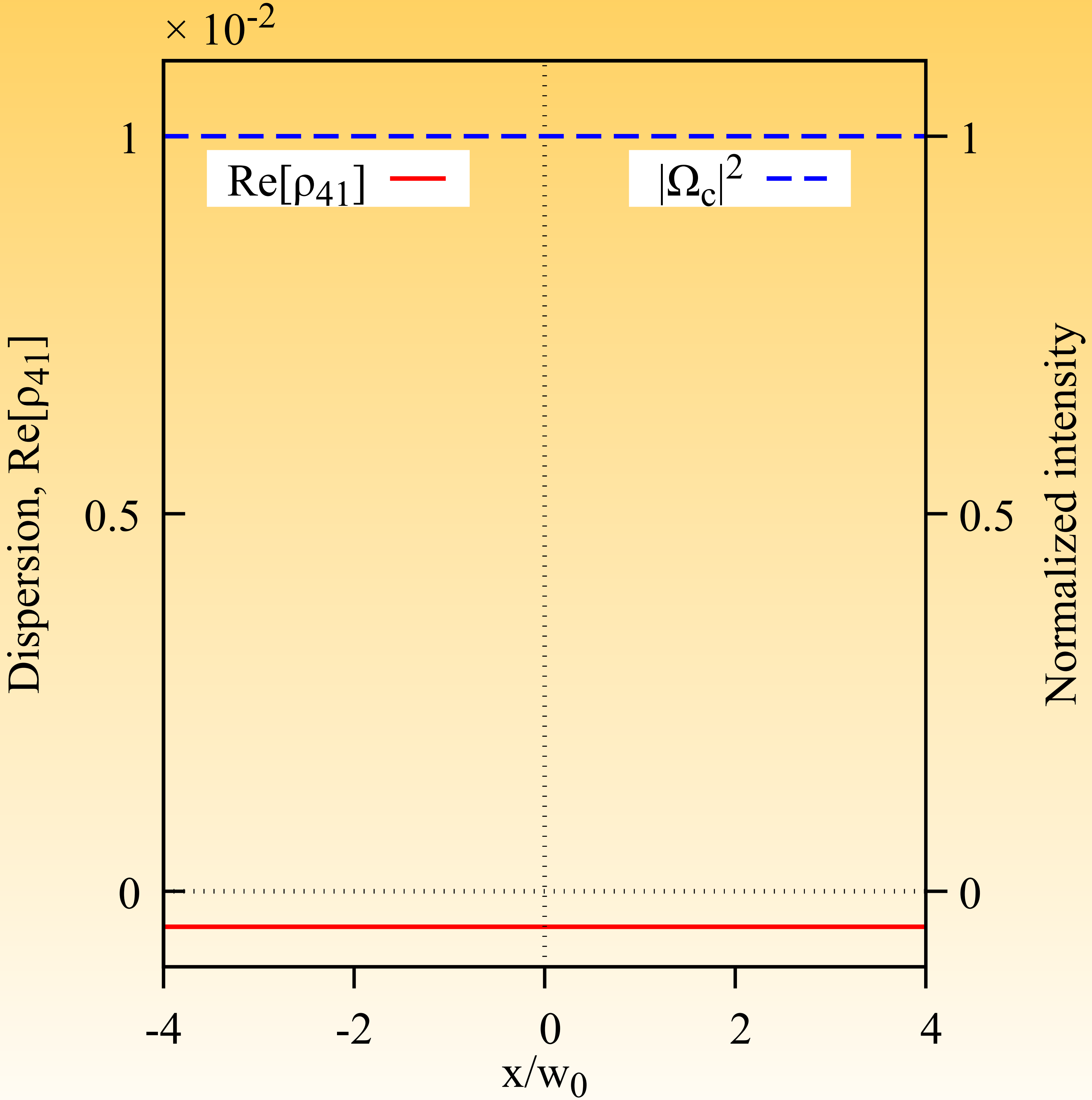
Spatial Refractive index in presence of BG control field



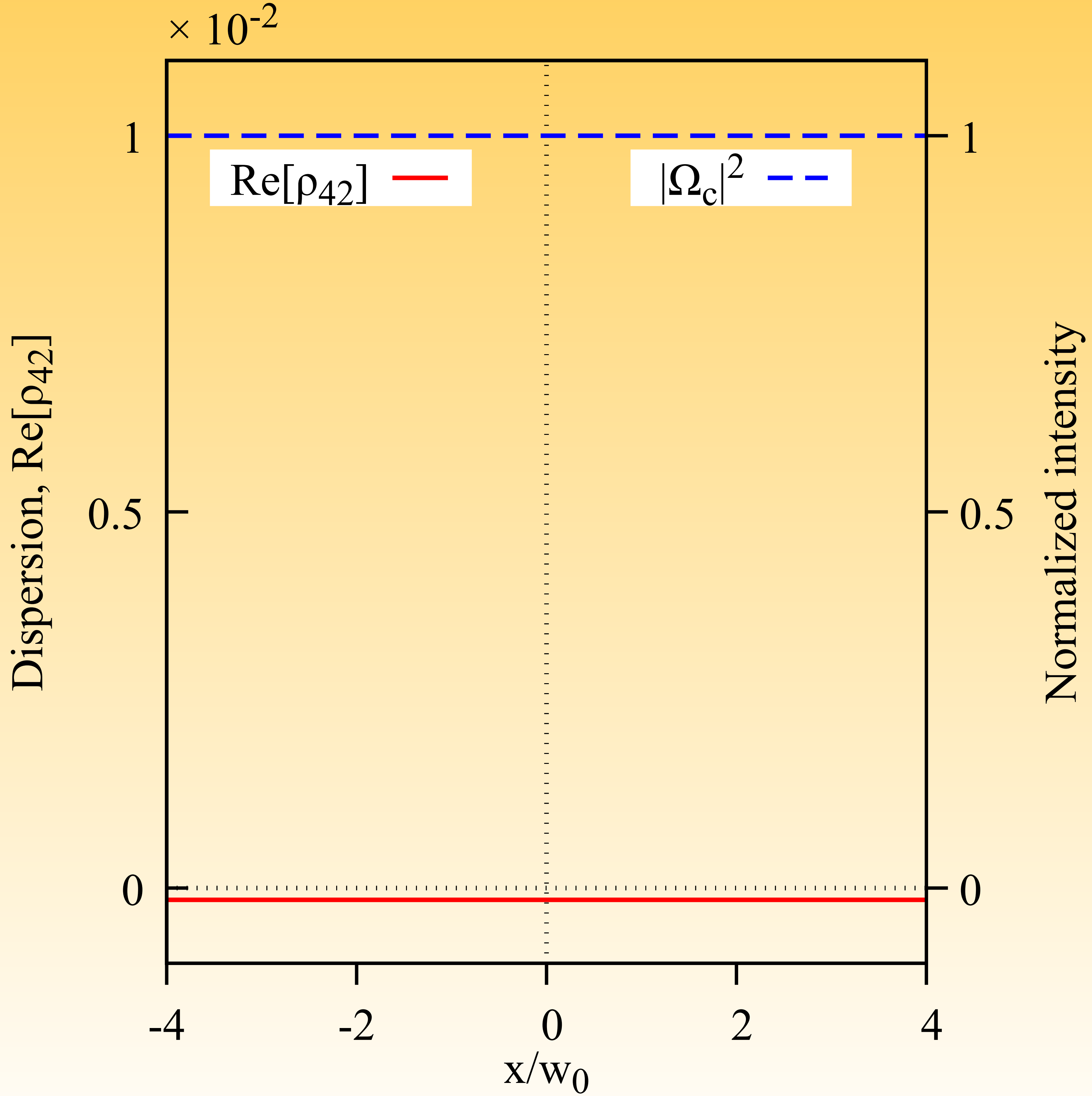
$\Omega_c = 4\gamma, \Omega_p = 0.05\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.1\gamma$

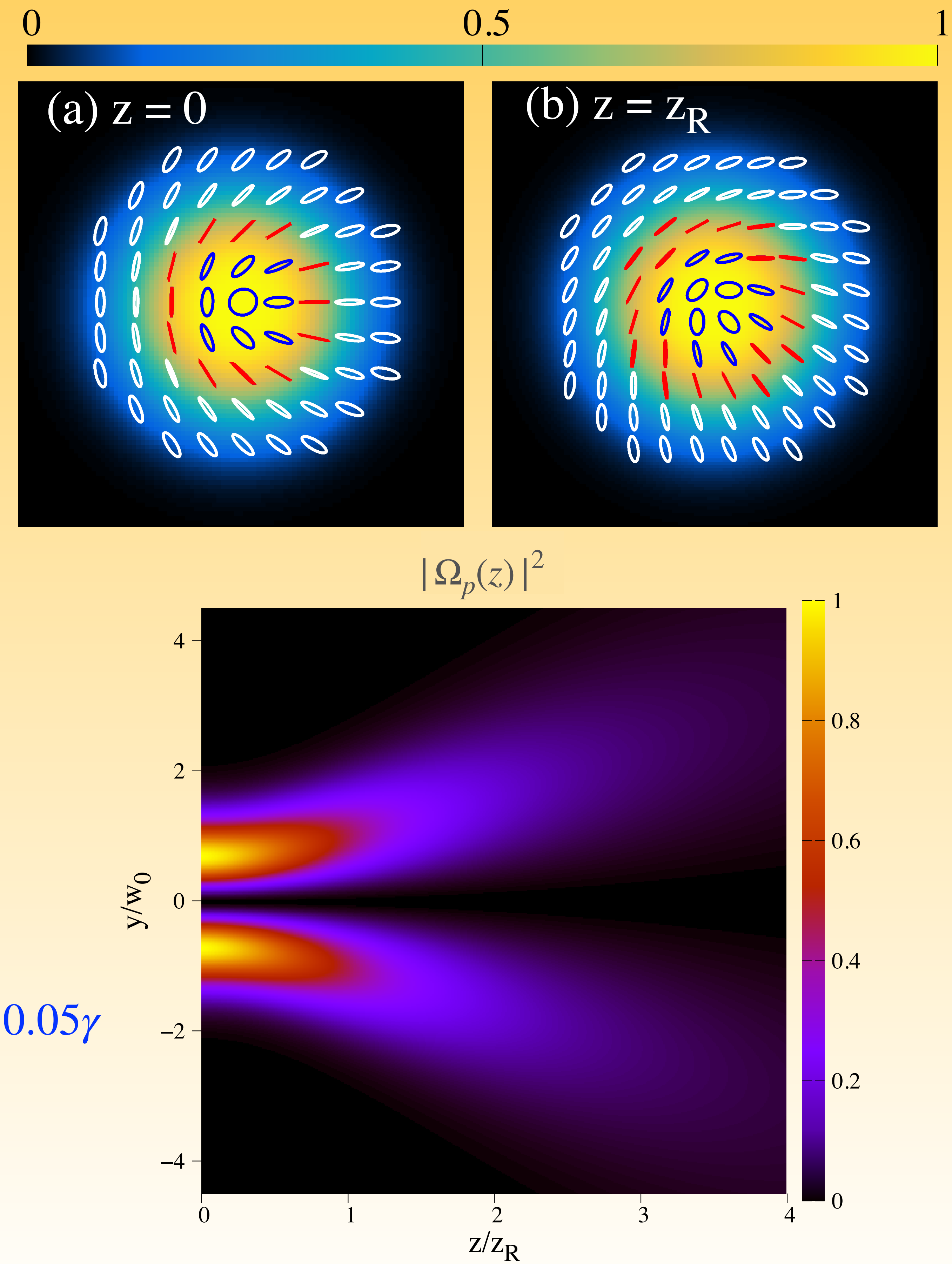
Spatial Refractive index in presence of CW control field



Spatial Refractive index in presence of CW control field



Free Space Propagation of Vector Beam



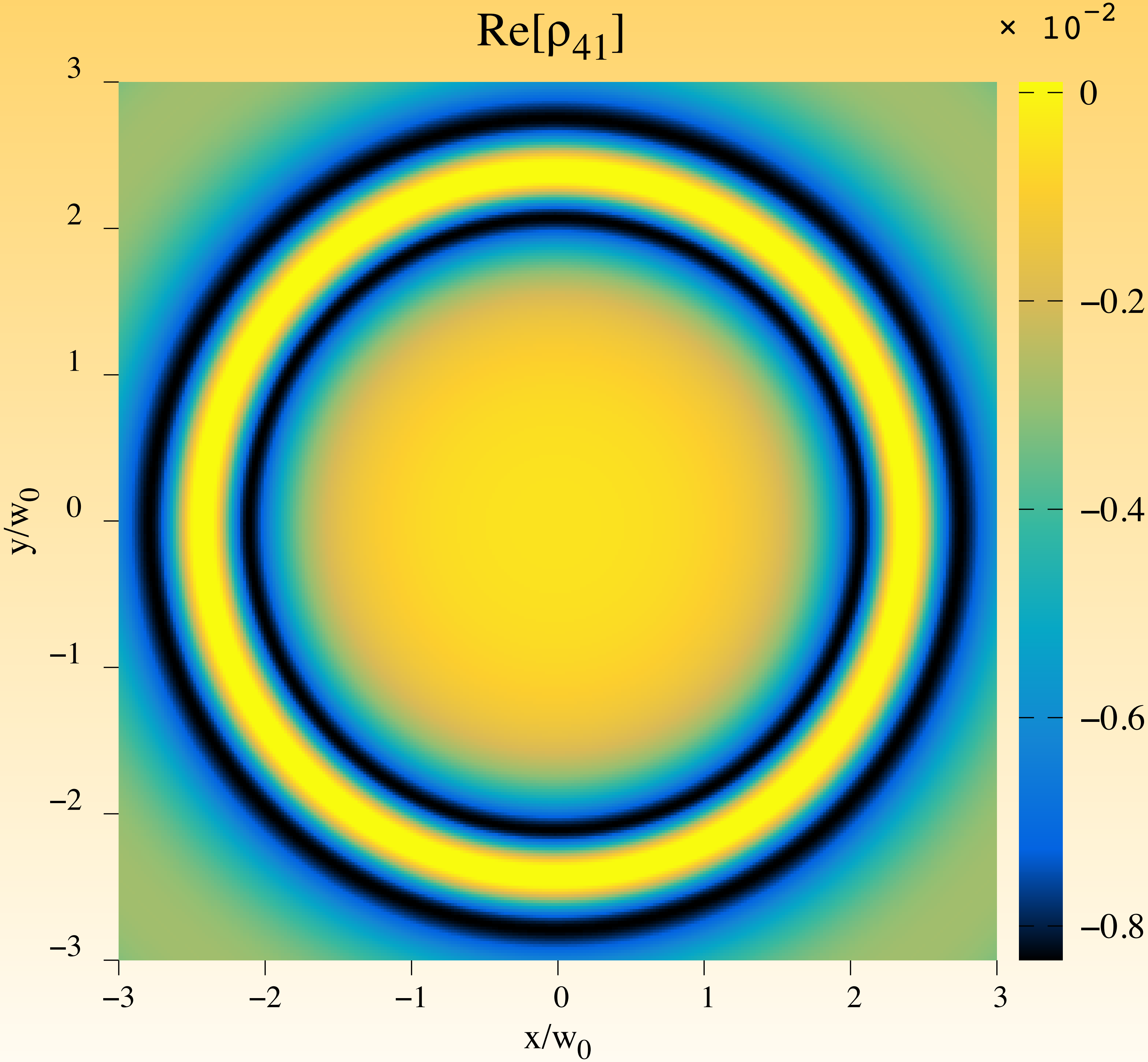
$\Omega_c = 4\gamma, \Omega_p = 0.01\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.05\gamma$

Atomic waveguide

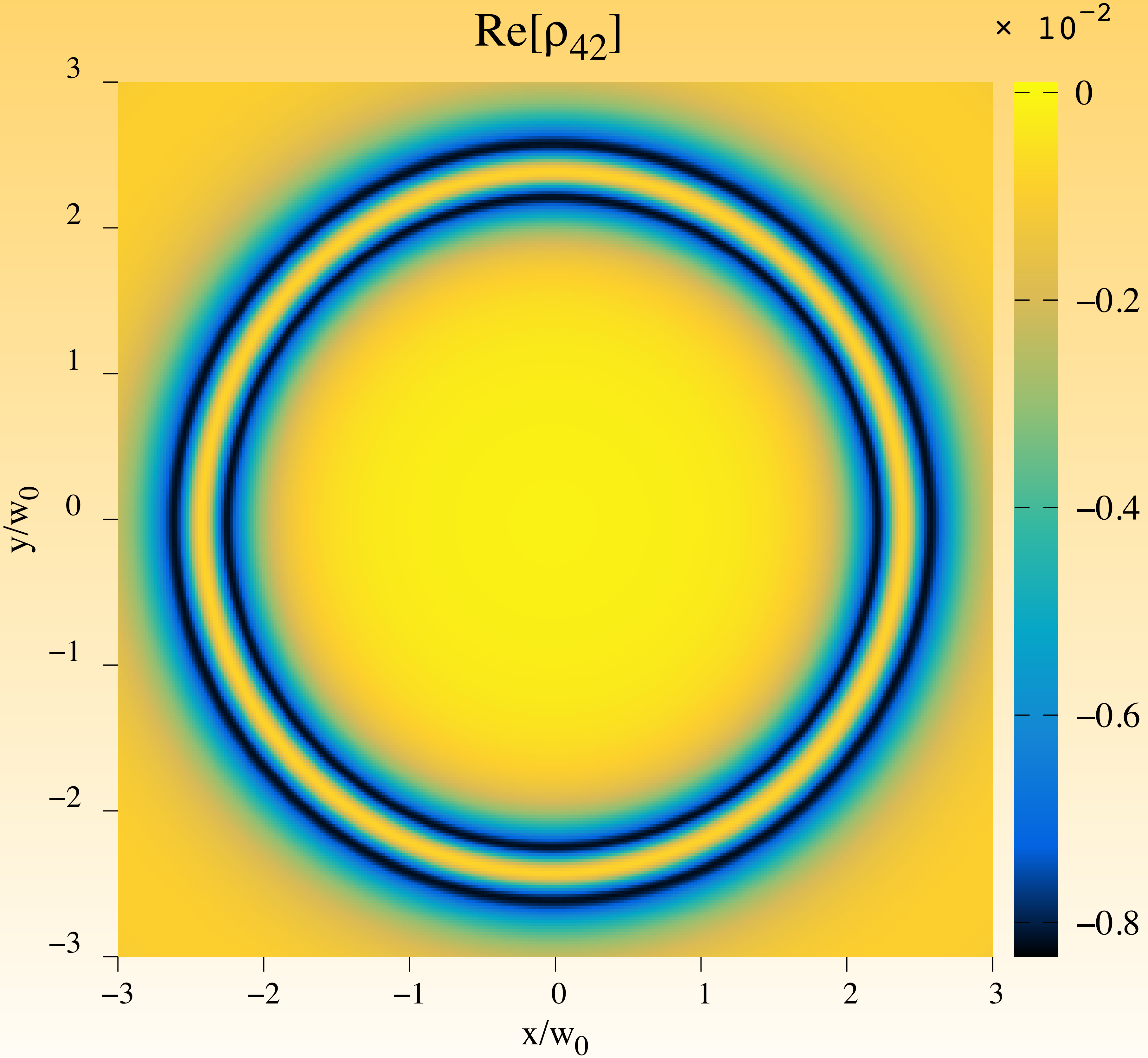
$\Omega_c = 4\gamma, \Omega_p = 0.01\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.05\gamma$



Atomic waveguide

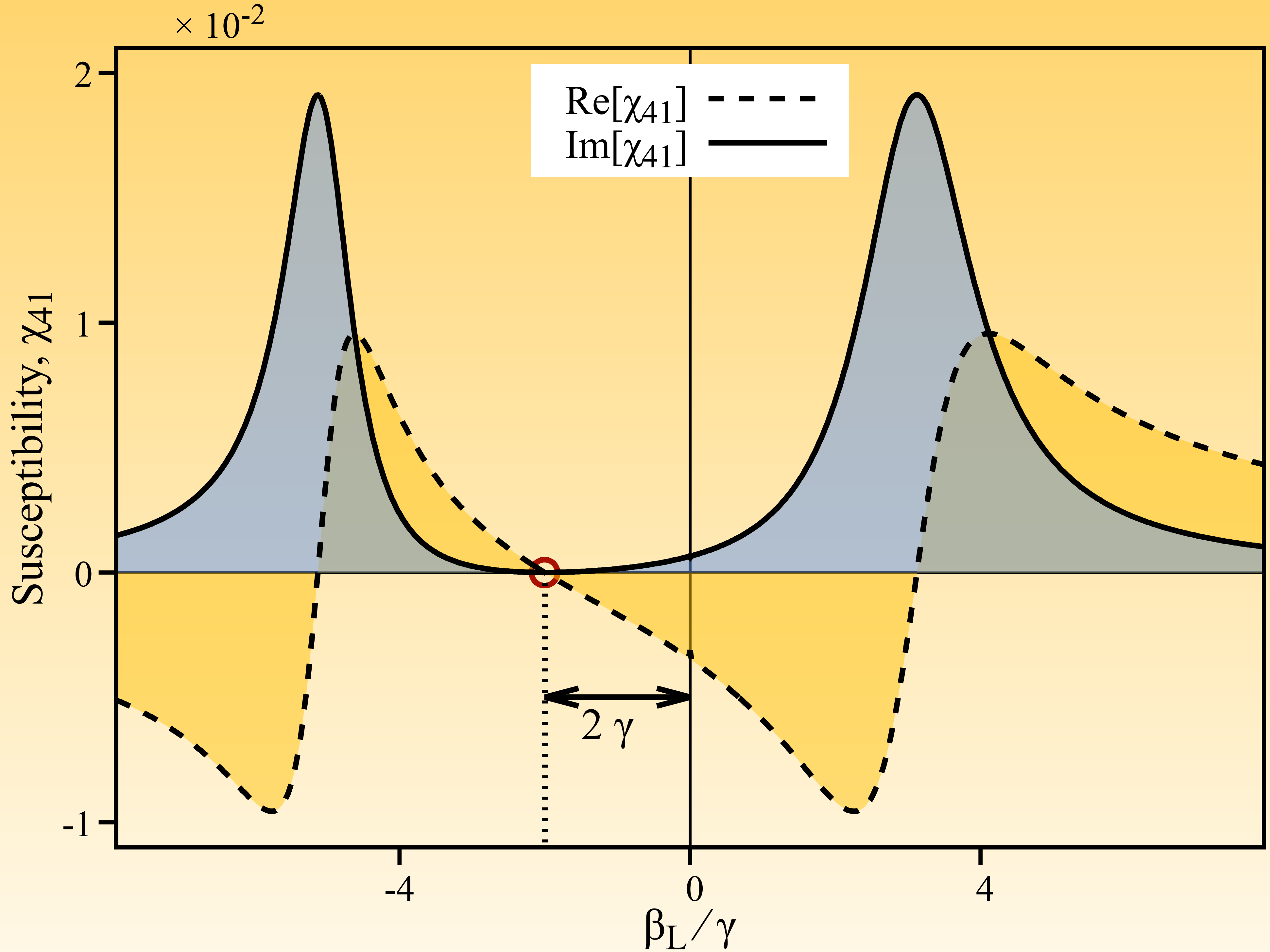
$\Omega_c = 4\gamma, \Omega_p = 0.01\gamma$ $\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.05\gamma$



Atomic waveguide

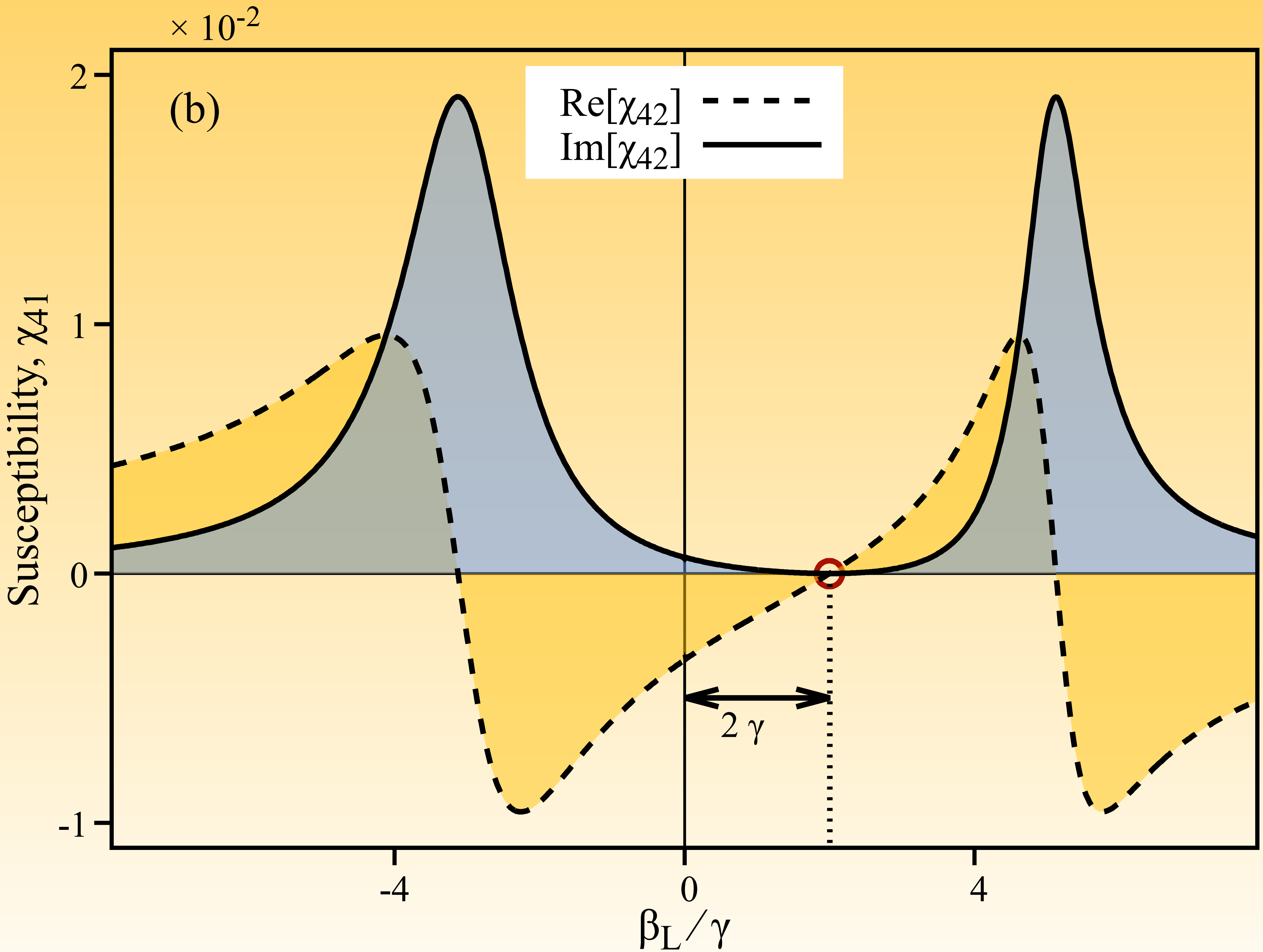
$\Omega_c = 4\gamma, \Omega_p = 0.01\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.05\gamma$

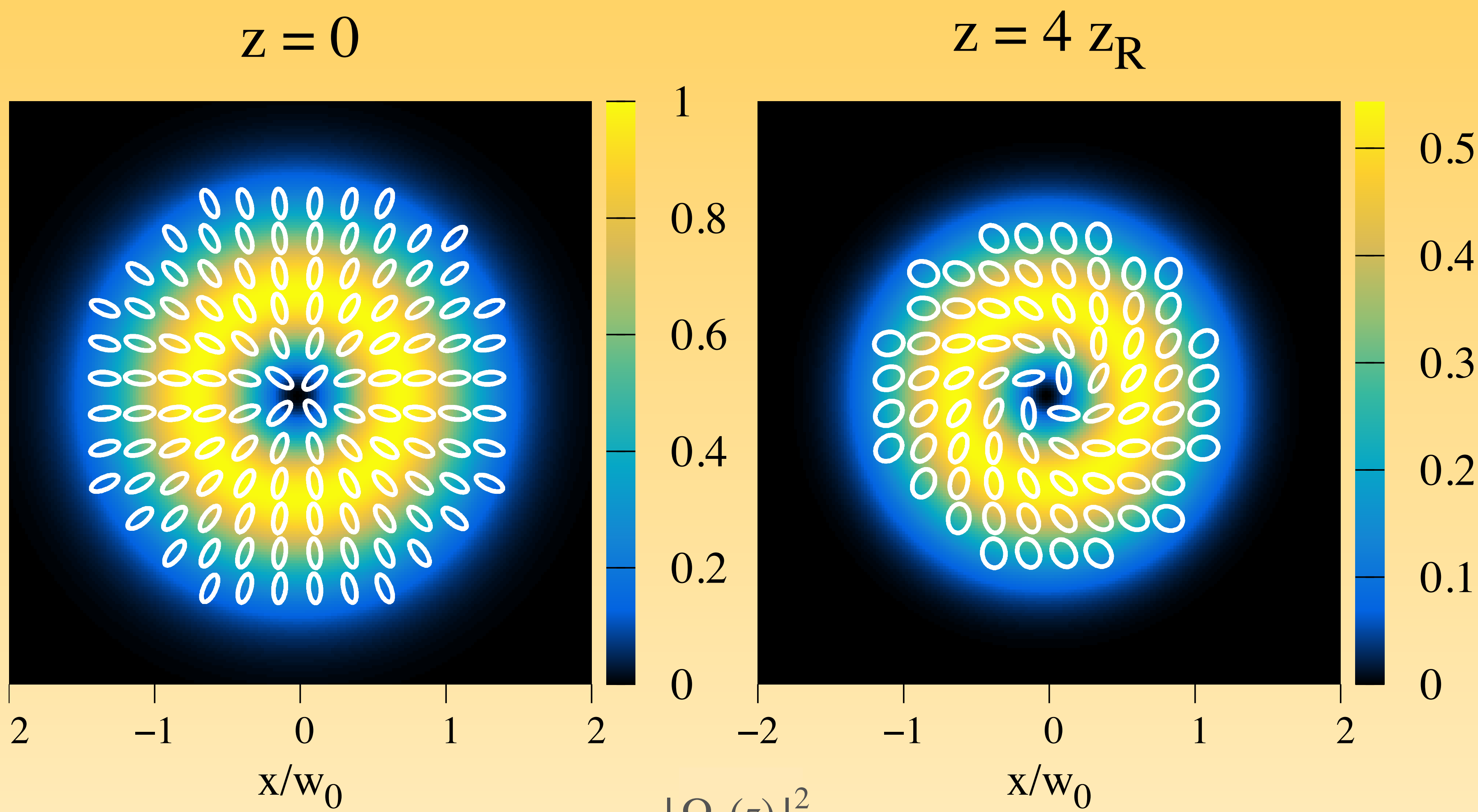


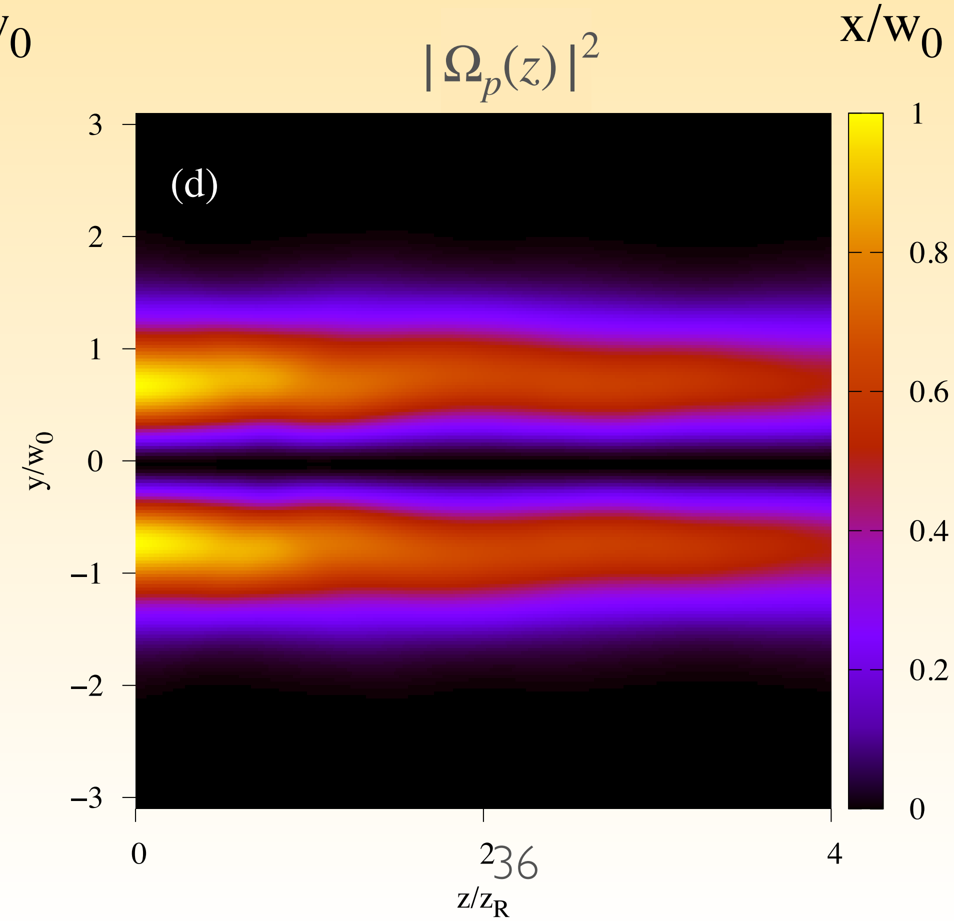
Atomic waveguide

$\Omega_c = 4\gamma, \Omega_p = 0.01\gamma$ $\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.05\gamma$



Propagation of Vector Beam Through Medium





$\Omega_c = 4\gamma, \Omega_p = 0.01\gamma$

$\delta_p = 0, \delta_c = 0.2\gamma, \beta_L = 0.05\gamma$

Concluding remark

1. The absorptive properties of a resonant systems can be well controlled by the application of the strong input control field
2. Transverse polarization structure can be rotated as desired with appropriate magnetic field strength
3. The mechanism of efficient polarization control and manipulation of a vector beam can open up a new avenue for high-resolution microscopy and high-density optical communications.

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