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# Rotational Displacement of Optical Intensity by Linear Polarisation in Nano Antenna

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**ABSTRACT**

Study of rotational displacement of optical intensity by linear polarization in nanoantennas was made using finite difference time domain. In this study analysis of simulation was used. It was found that rotationally displayed distribution of intensity occurred near excitation field for each linear polarization. This finding contributed circular polarization for phase distribution. The creation of phase distribution was found due to superposition of plasmonic modes. Phase distribution produced rotational displaced intensity distributions around square antenna. Square nanoantennas and electric intensity was found isotropic at longer wavelength. It was found that intensity distribution was found in the direction of electric field rotation for light of shorter wavelength.

**Keywords** Square Antenna, Excitation, Circularly Polarized Light, Simulation, Plasmon Mode, Superposition.

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## INTRODUCTION

Okamoto et al. and Horrer et al. studied that spatial distribution of electric field was created by circularly polarized light for excited structure was affected by incident light and was used for preparation of photochemical device of chiral nanostructures [1,2,3]. In nanoantennas hardredness dependent distribution was found as localization of electric field for pairs of diagonal vertices. Oshikiri et al. studied that the localization was described by superposition of plasmon modes related to major axis [4]. It was found that time average electric field intensity around nanoantenna provided rotational displacement of spatial distribution and was dependent on wave length. Ishida et al. and Besteiro et al. studied that rotational displacement for regular polygons and structures having rotational symmetry were used for fabrication of chiral structures [5,6]. Giannini et al. presented that plasmonic antennas were used to modulate many optical properties [7]. Cheng et al., Mun et al. and Hu et al. studied the properties of circularly polarized light [8,9,10]. Baliokh and Nori studied that enhancement of optical properties were found due to circular polarization as chiral structures [11]. Yamane et al. used photochemical fabrication for chiral nanostructures and enantioselective trapping or sensing of chiral molecules [12, 13]. Matthaisakakis et al. used simulation for uniform phase distributions along the edges for rotationally displayed form then distribution was found in concave distribution in phase difference between perpendicular and parallel electric fields. This mechanism was dependent on simplified spatial electric field distributions [14]. Pellarin et al. presented that nanoantennas having finite area provided multiple modes and depended on size and shape of nanoantennas [15].

## METHOD

Non uniform phase distribution was produced due to superposition of multiple resonant modes charge densities excited by polarized light for dipole mode and hexapole for the combined excitation in the simplified pattern is given by

$$\rho_{di}\left(y=\pm\frac{L}{2};t\right)=\pm\cos(\omega t).$$

$$\rho_{he}\left(y=\pm\frac{L}{2};t\right)=\pm\cos\left(\frac{2\pi x}{L}\right)\cos(\omega t).$$

$$\rho_{co}(t)=A_{di}\rho_{di}(\omega t)+A_{he}\rho_{he}\left(\omega t+\phi_{diff}\right)$$

where $\omega$ is the angular frequency, t is the time, $A_{di}$ and $A_{he}$ are the scalar coefficients,. Resonant contained different values in response to different electric fields having different phase decays-charge distributions for $x$-polarized light was found due to rotation of each distribution. Electric field distribution was obtained by the use of coulomb's law for each charge density distribution. Dipole and hexapole modes were different. Combined excitation was larger concave at the centre and have larger degree of curvature. In this mechanism rotational displaced intensity distribution was found by means of simplified spatial electric field components due to excitation of $x$ and $y$-directions polarized components of light given as

$$E_{\perp}^{xpol}\left(x=\pm\frac{L}{2},y,t\right)=A_{\perp}(y)\cos\left[\omega t+\phi_{\perp}(y)\right].$$

$$E_{\parallel}^{xpol}\left(x,y=\pm\frac{L}{2},t\right)=A_{\parallel}(x)\cos\left[\omega t+\phi_{\parallel}(x)\right]$$

where $A_{\perp}$ and $A_{\parallel}$ are the amplitudes, $\phi_{\perp}$ are the phase distributions for $E_{\perp}$ and $E_{\parallel}$. Phase distributions are given by the relations as

$$\phi_{\perp}\left(x=\frac{L}{2},y\right)=-\phi_{add}.$$

$$\phi_{\parallel}\left(x,y=\pm\frac{L}{2}\right)=-\pi\Theta(\pm x)$$

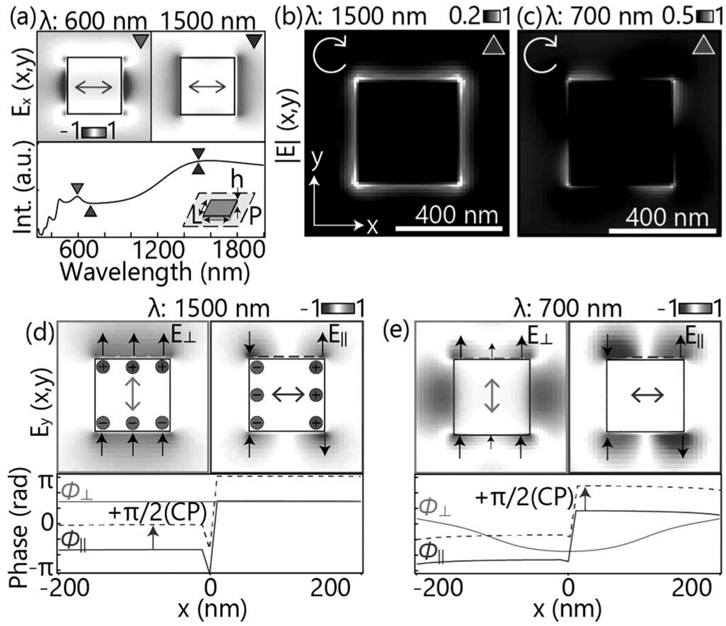
where $y=\frac{L}{2}$ is the upper edge of model, $E_{\perp}$ is perpendicular electric field, $E_{\parallel}$ is the parallel electric field, $\Theta(x)$ is the step function, $\phi_{add}$ is the hypothetical phase difference of circularly polarized light, then excited field distribution is given by the relation.

$$E^{CP}\left(t,\phi_{add}\right)=E^{xpol}\left(\omega t+\frac{\pi}{2}\right)+E^{ypol}(\omega t)$$

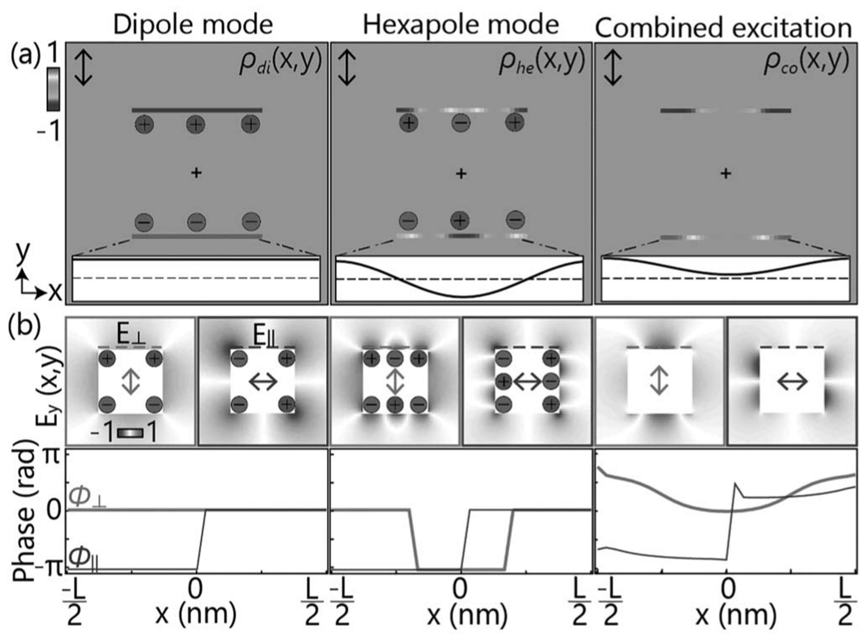
calculation of spatial distribution of $\left|E^{CP}(x,y)\right|$ is $\phi_{add}$ was made, which provided curve phase distribution.

## RESULTS AND DISCUSSION

Graph (1) shows the plot of spectra of nanoantenna excited by polarized light in the $x$-direction. Graph (1) (a) presented scattered spectra for multiple resonance. In this graph top curve showed presence of spatial distributions for $E_x$ component of phase around nanoantenna due to excitation by $x$-direction polarized light. Graph (1) (d) represented the distribution of electric field $E_y(x,y)$ for a certain wavelength. It was found that the excited fields were due to polarized light parallel to edge. Graph (1) (e) shows electrons of dipole mode. It also indicated relation between edge and incident light. Graph (2) (a) shows charge density distribution for each modes. It was found that charge distributions for polarized light in $x$-direction due to rotation of distribution. Graph (2)(b) shows electric field distribution due to coulomb law for each charge density distribution. It was found that combined excitation provided large concave shape spectrum at the centre and contained large degree of curvature in respect of parallel phase.




**Graph 1:** Plot of spectra of nanoantenna excited by polarized light in the *x*-direction.




**Graph 2:** Plot of density distribution with excitations modes.

## CONCLUSION

Optical intensity distribution was produced due to superposition of multiple modes. The calculated results showed that rotationally displaced shapes of square nanoantenna. Analyzation was made by means of finite difference domain simulation mechanism. In the case of overlapped fields the intensity distribution was produced in response to square shape of nanoantenna.

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