



Direct and indirect coupling mechanisms in a chiral plasmonic system

Yuyan Chen, Yongkai Wang, Zhongyue Zhang

School of Physics and Information Technology, Shaanxi Normal University, Xi'an, Shaanxi. 710119

Abstract: Artificial chiral plasmonic nanostructures (ACPNs) are widely studied and used in biological monitoring, analytical chemistry, and negative-refractive-index media. The mechanism of direct coupling between two twist metal nanorods has been obtained in usual ACPNs. In this work, we proposed a nanosystem of twist nanorods separated by a metal film (TNMF) (figure 1), and a new indirect coupling mechanism is found.

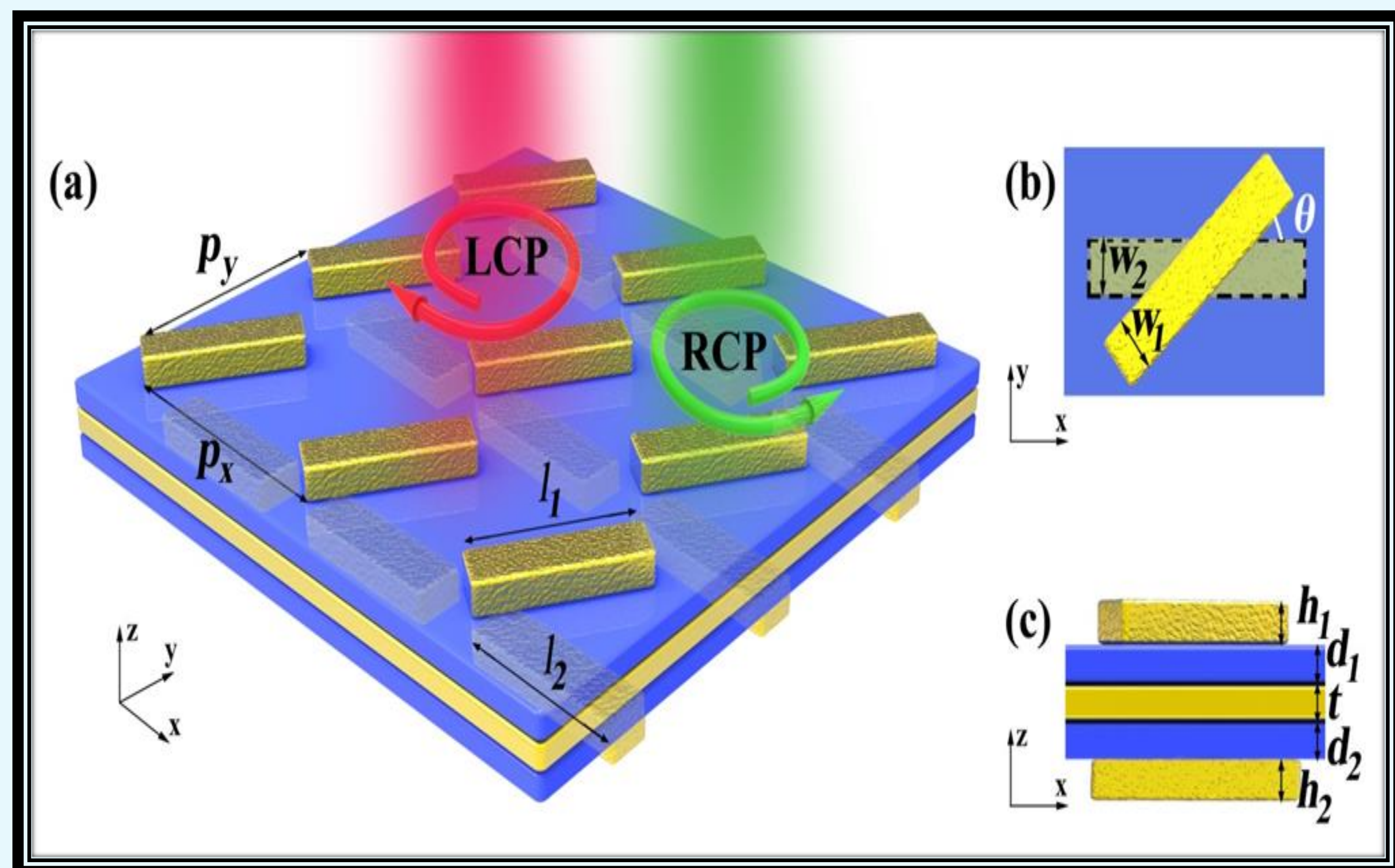


Figure 1. Schematic of (a) TNMF arrays and parameters definition, where the unit cell with the associated geometric features is designated in (b) x-y plane and (c) x-z plane.

Computational Method:

The Radio Frequency, Electromagnetic Waves, Frequency Domain interface of COMSOL Multiphysics® is used to calculate the transmittance spectra of TNMF arrays. The known interpolation functions are used to set the refractive index of gold. The excitation sources are RCP light (T_{++}) and LCP light (T_{--}) along the $-z$ direction and the magnitude of the incident electric field is set at 1 V/m. The infinite array is simulated using unit cell with periodic boundary conditions along the x and y directions.

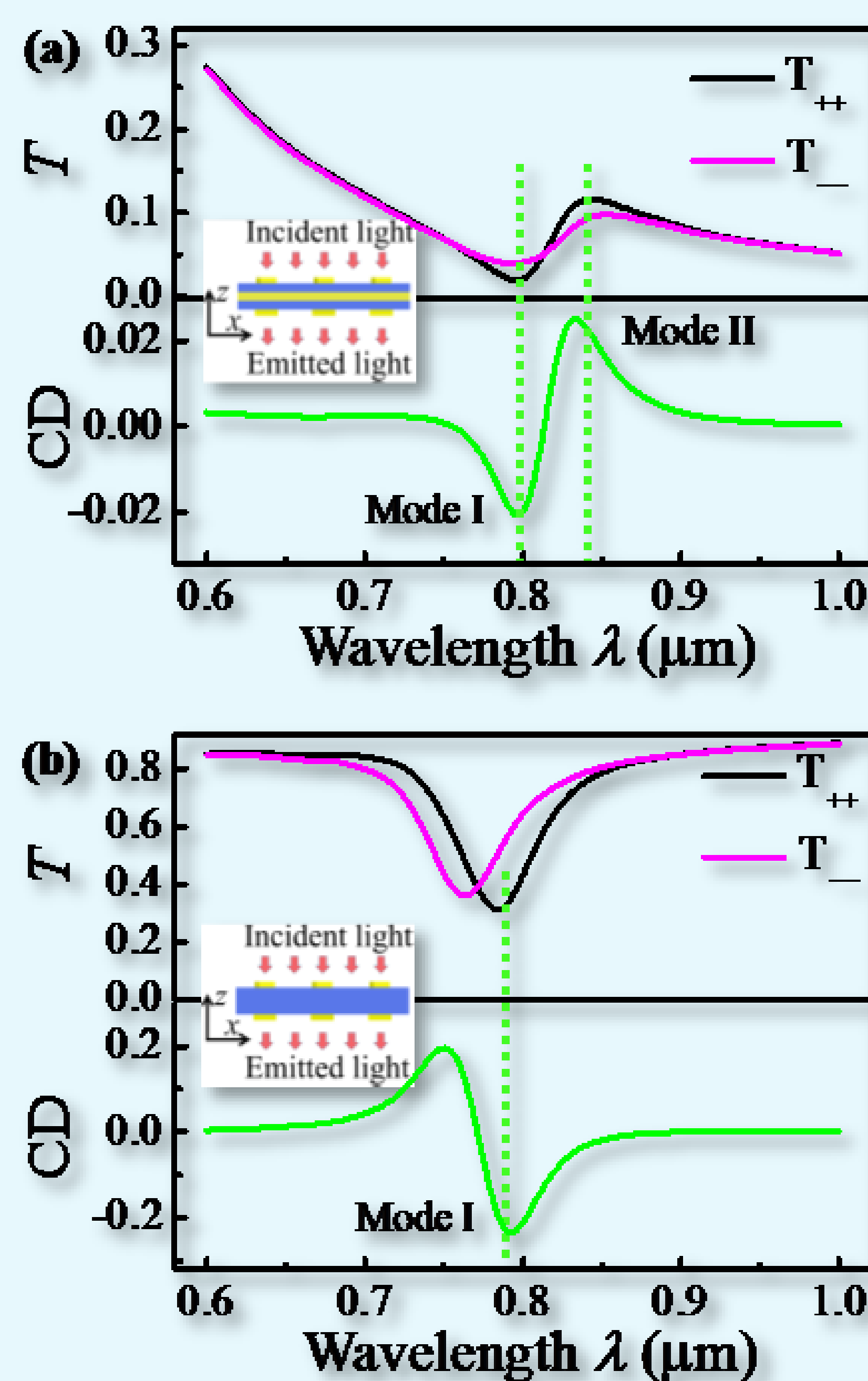


Figure 2. Simulated T_{++} , T_{--} , and CD spectra of (a) TNMF arrays and (b) TNGF arrays. Insets are the schematic of TNMF arrays and TNGF arrays.

Results: The transmission spectra, CD spectra (figure 2), and charge distributions (figure 3) of TNMF arrays are investigated to understand the direct and indirect coupling modes. For indirect coupling mode, top and bottom nanorods form resonators can be regarded as receivers and emitters, respectively (figure 4).

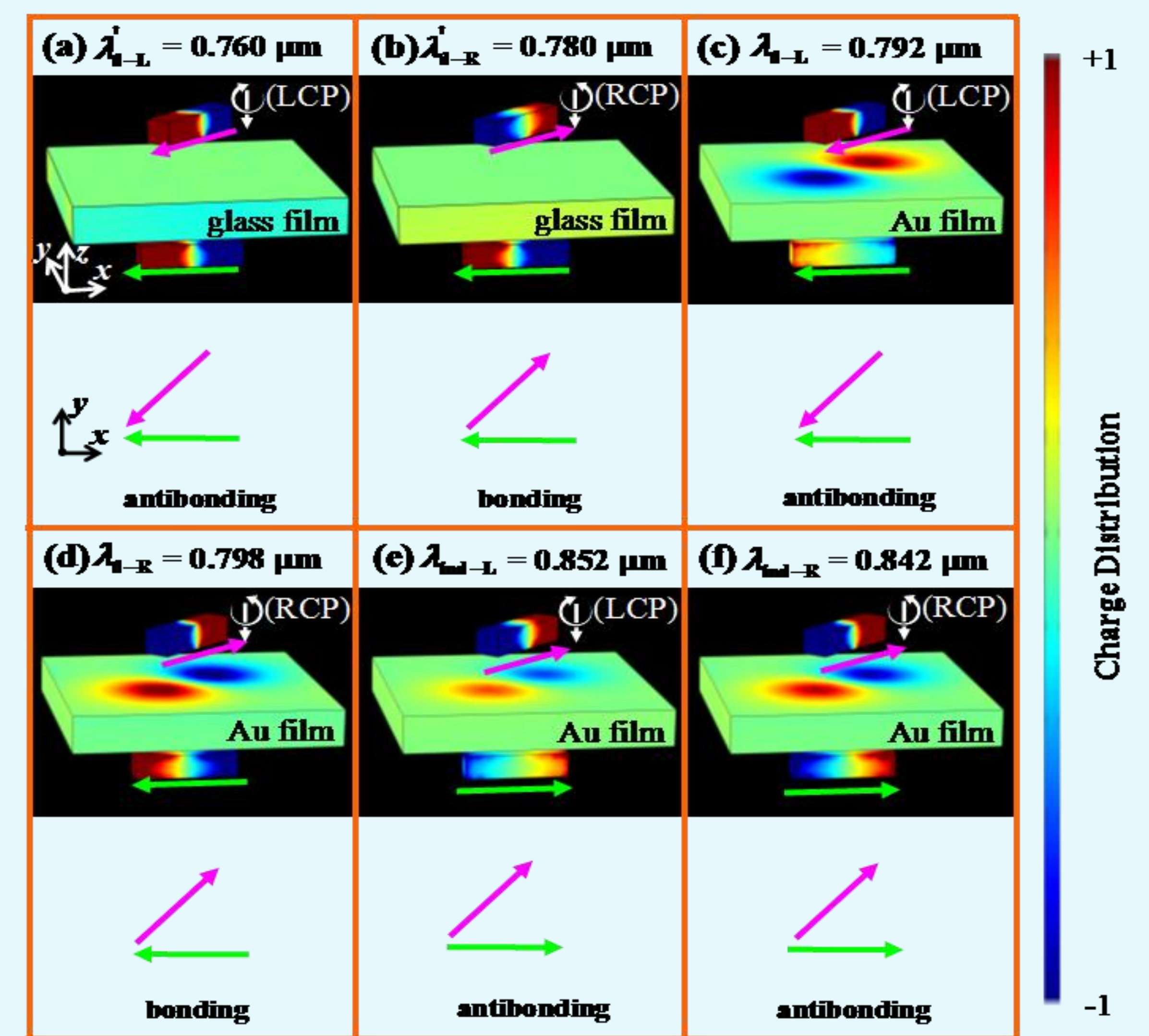


Figure 3. The charge distributions (color distributions) and Born-Kuhn modes (magenta and viridity arrows) at resonant wavelength.

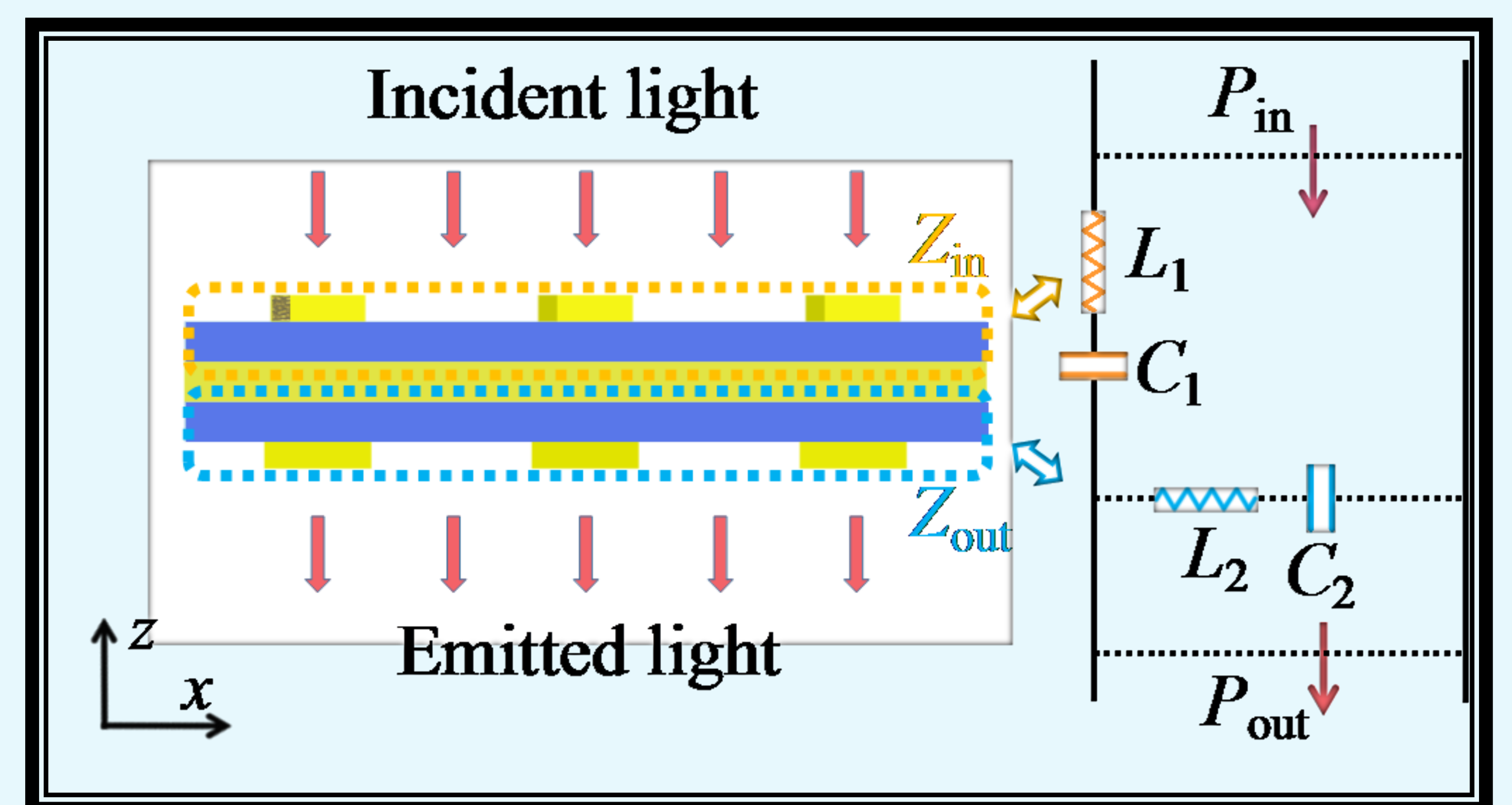


Figure 4. Schematic of TNMF arrays in x - z plane and schematic of equivalent transmission line.

Conclusion: The direct and indirect coupling modes occur in the CD spectra. For indirect coupling mode, when impedances of receivers and emitters match, the CD signal of the indirect coupling mode reaches the maximum. These results can help elucidate the chiral plasmonic mechanism and design new optical materials.

References:

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2. Yin X, et al., Interpreting chiral nanophotonic spectra: the plasmonic Born-Kuhn model, *Nano Lett.*, 13, 6238-6243, (2013).