Research and Creative Experience for Undergraduates Program (RCEU) Summer 2022

Polarization Switching in Gold Nanostructure Array

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Background

Metallic nanoparticles resonate upon incident light, forming localized surface plasmon resonances (LSPRs). In arrays of such nanoparticles, these resonances can couple to each other via light diffraction, forming photonic-plasmonic resonances (PPRs). In this project we study in-plane scattering of light in such arrays and polarization switching between LSPRs and PPRs.

Methodology:

Samples of Au nanoparticle arrays in a glass slide are placed under a white light source. Initially, a stationary collecting objective is placed underneath to measure extinction. Afterwards, a moveable objective scans the sides of the sample to measure in plane diffraction patterns along the length of the sample while changing the polarization state of the incident light (Figure 3 below.)

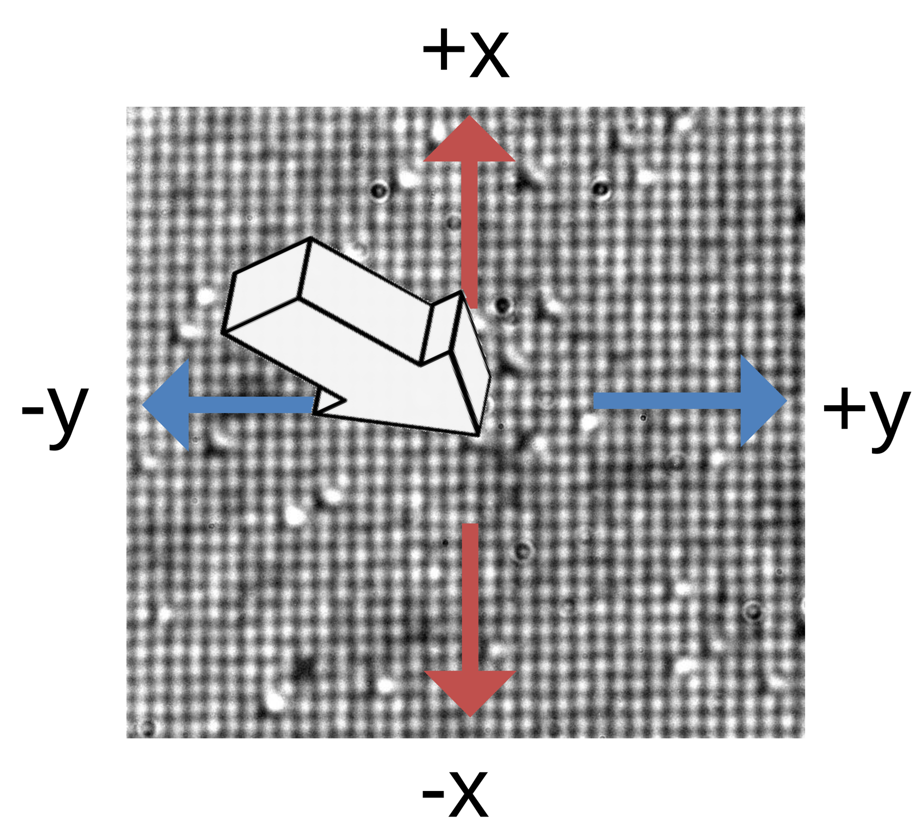

Figure 1: Incident white light scatters across the metallic nanoparticle array either to the left and right (-y and +y) or up and down (+x and –x) based on its polarization.

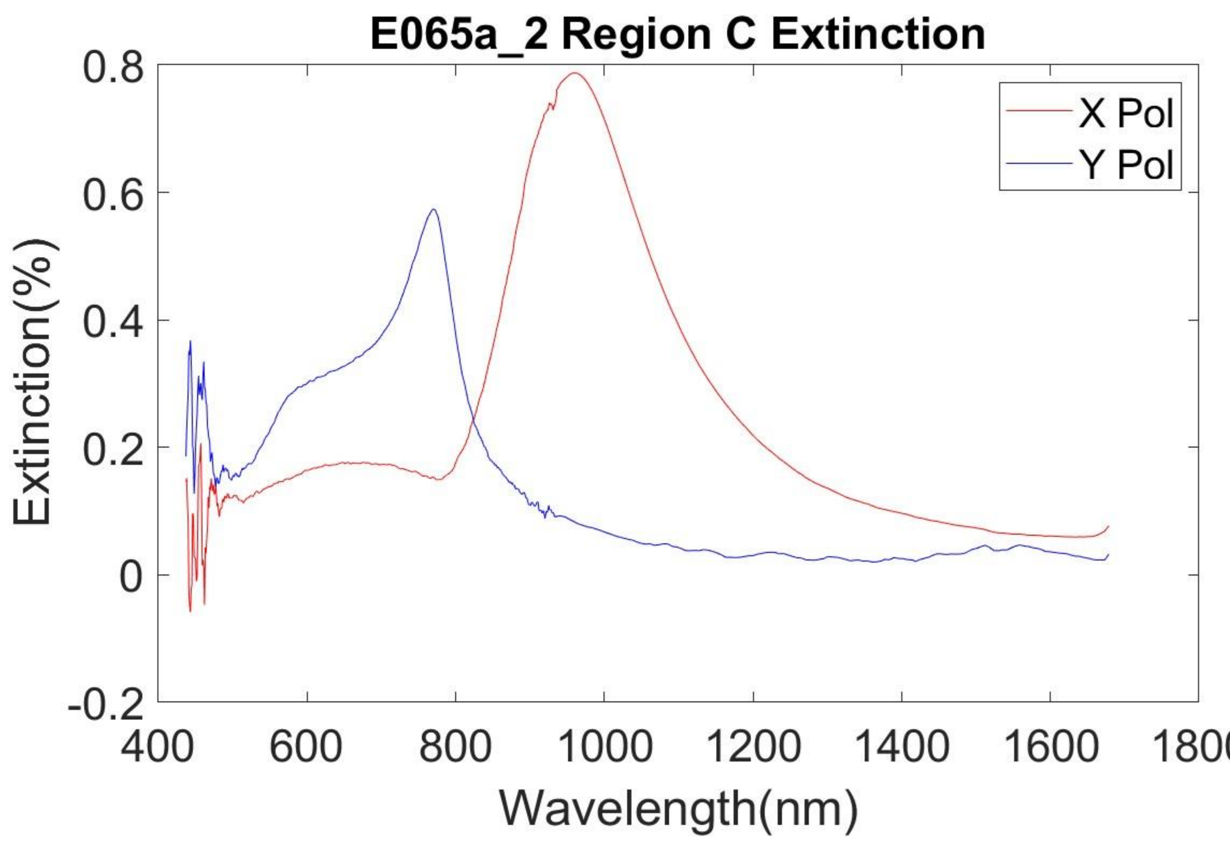

Figure 2: Extinction of incident white light shows how the spectrum of light reflected and scattered (in the plane of the array) is different if polarized along the X or Y directions.

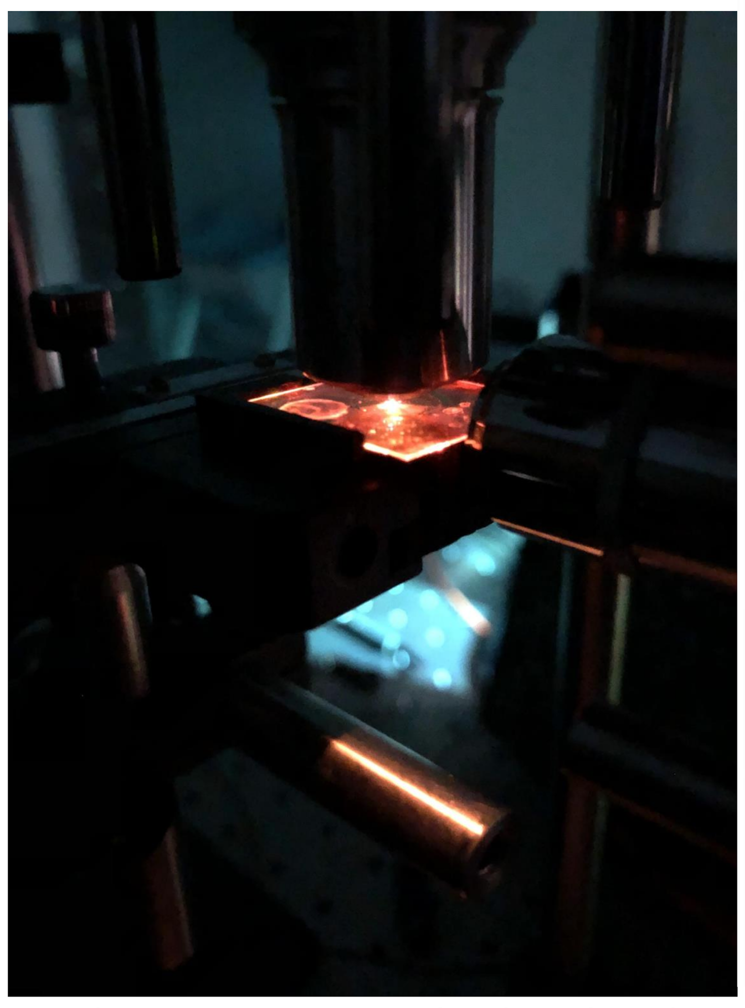

Figure 3: A sample is placed underneath a white light source with a scanning objective on one side.

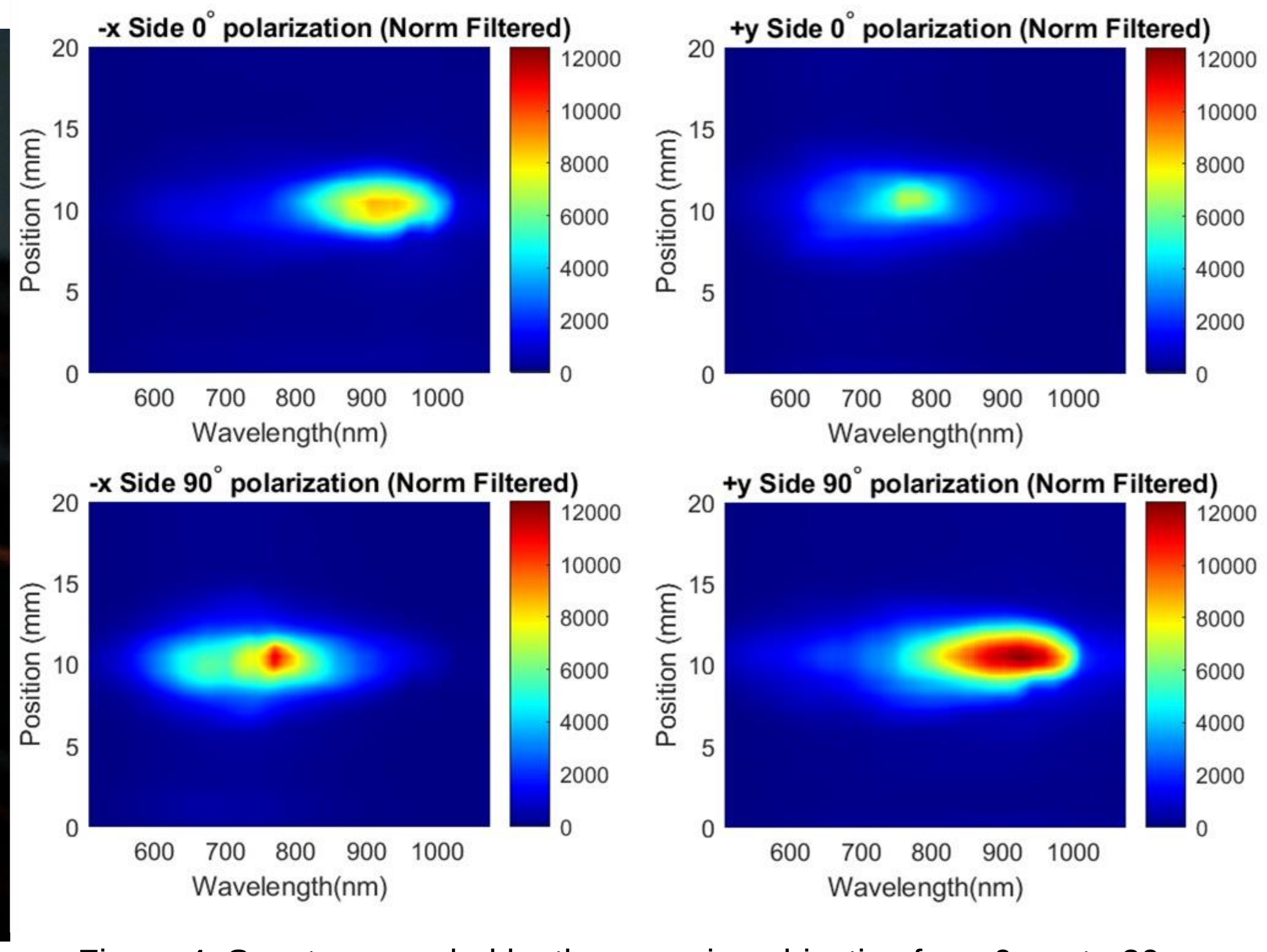

Figure 4: Spectra recorded by the scanning objective from 0mm to 20mm in 0.5mm steps are organized into 3D surface plots, where we see high intensity regions in red and low intensity in blue.

Results:

Extinction of this sample shows two unique spectra for both X and Y polarized light (Figure 2 above.) These represent distinct resonance modes, identified as an LSPR by X polarization and a PPR by Y polarization. Figure 4 shows surface plots generated of the spectra along the –x side of the sample show the LSPR at 0˚ polarization and the PPR at 90˚, while plots of the +y side show the opposite (at notably different levels of intensity.) This material can be used for chemical identification and biosensing methods, improvements to photovoltaic devices, and advancements in optical computing technology.

Conclusion

Interpreting Figure 4 above, we see that for Au nanoparticle arrays, the resonance modes switch with the polarization of the incident light from an LSPR to PPR with ultrafast response times.

Reference:

V. G. Kravets et al (2018)
Plasmonic Surface Lattice Resonances: A Review of Properties and Applications
Chemical Reviews 118 (12), 5912-5951

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