Polarization mapping of nanoparticle plasmonic coupling

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By –
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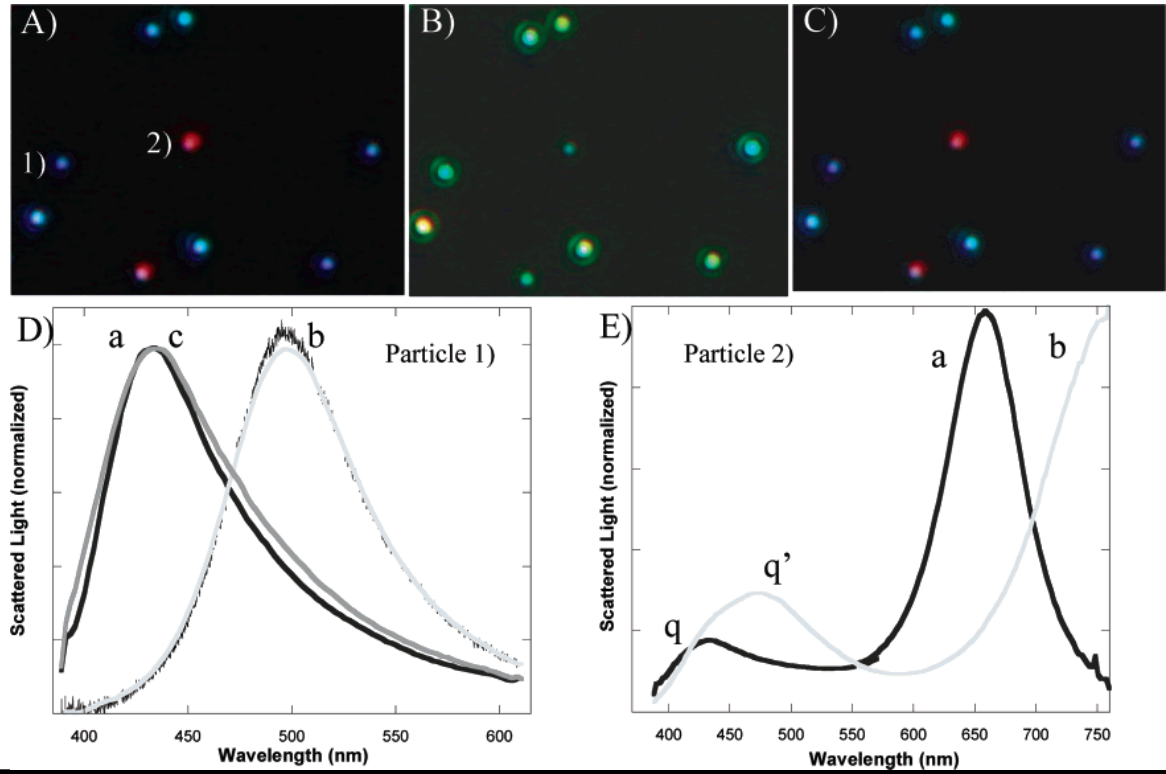
Introduction and objectives -

- To separate the effects of plasmonic coupling from the effect of local refractive index.
- Identification of the orthogonal excitation mode when the particle dimer orientation is unknown.
- Coupling has the drawback of complicating interpretation of data in dielectric sensing applications of plasmonic NPs if the particle spacing is unknown.



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Introduction and objectives -

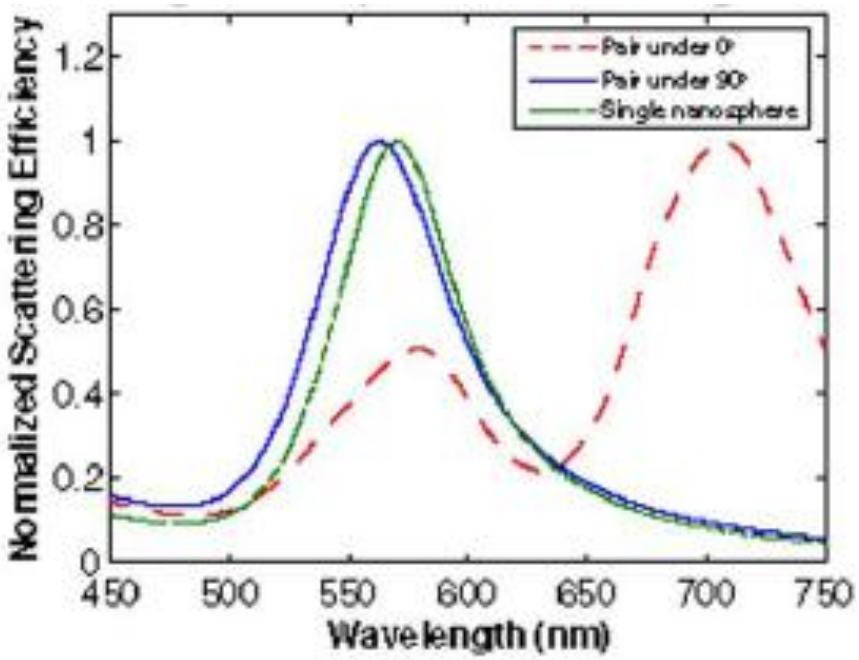
- Plasmonic coupling is primarily dependent on excitation of the mode parallel to the long pair axis.
- Discrete dipole approximation (DDA) simulations were used to evaluate the shift in the peak wavelength of the localized surface plasmon resonance of a nanoparticle pair under varying separations and incident polarization.

The discrete dipole approximation (DDA) is a method for computing scattering of radiation by particles of arbitrary shape and by periodic structures.

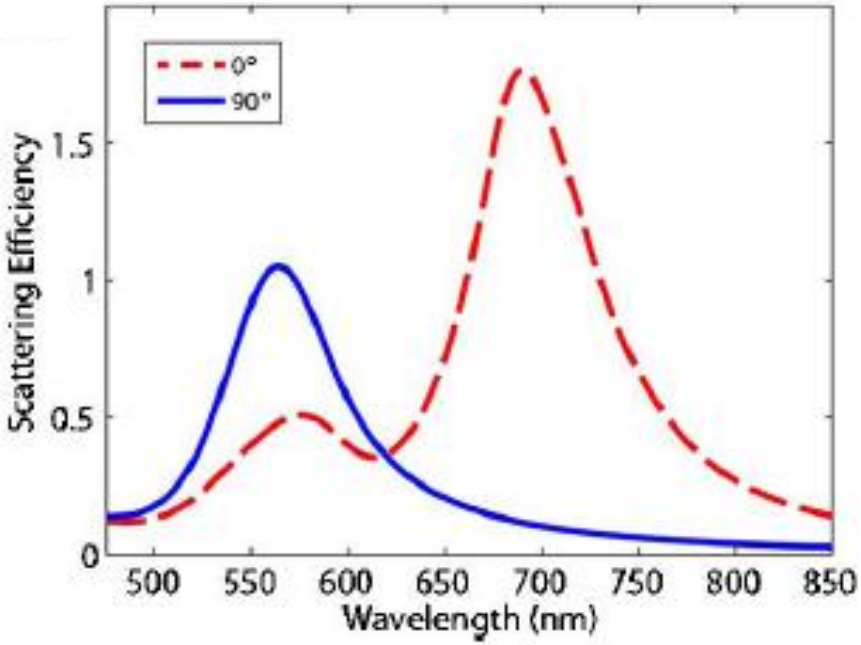
DDA simulations -

- Simulations for isotropic sphere and touching NP pair (60 nm) and pair with 4 nm separation.

Touching pair



4 nm separation

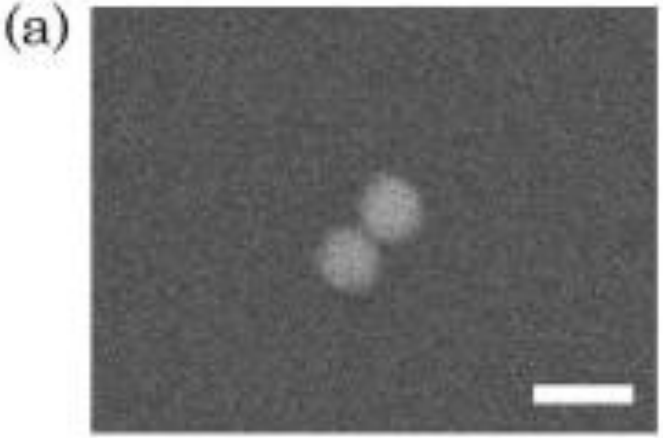


Dark field observations -

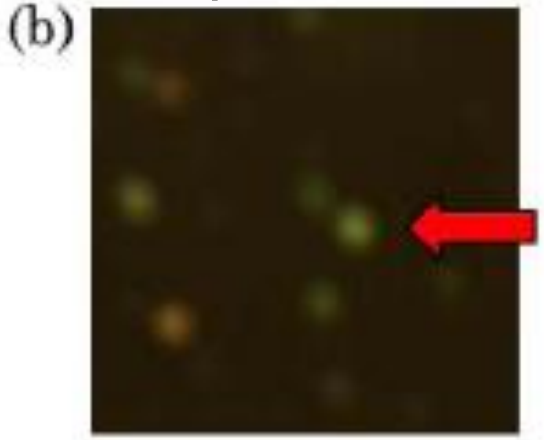
- NP (60 nm) pair (4 nm separation), scale bar = 100 nm

The shift between parallel and orthogonal polarizations is quantified by microspectroscopy to be 143.9 nm (difference between 703.7 and 559.8 nm). These experimental findings are in close agreement to DDA results, which indicate a shift of 128.7 nm (difference between 694.1 and 565.4 nm)

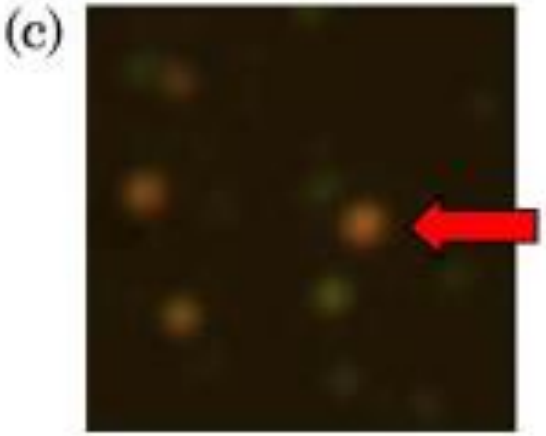
SEM



Perpendicular

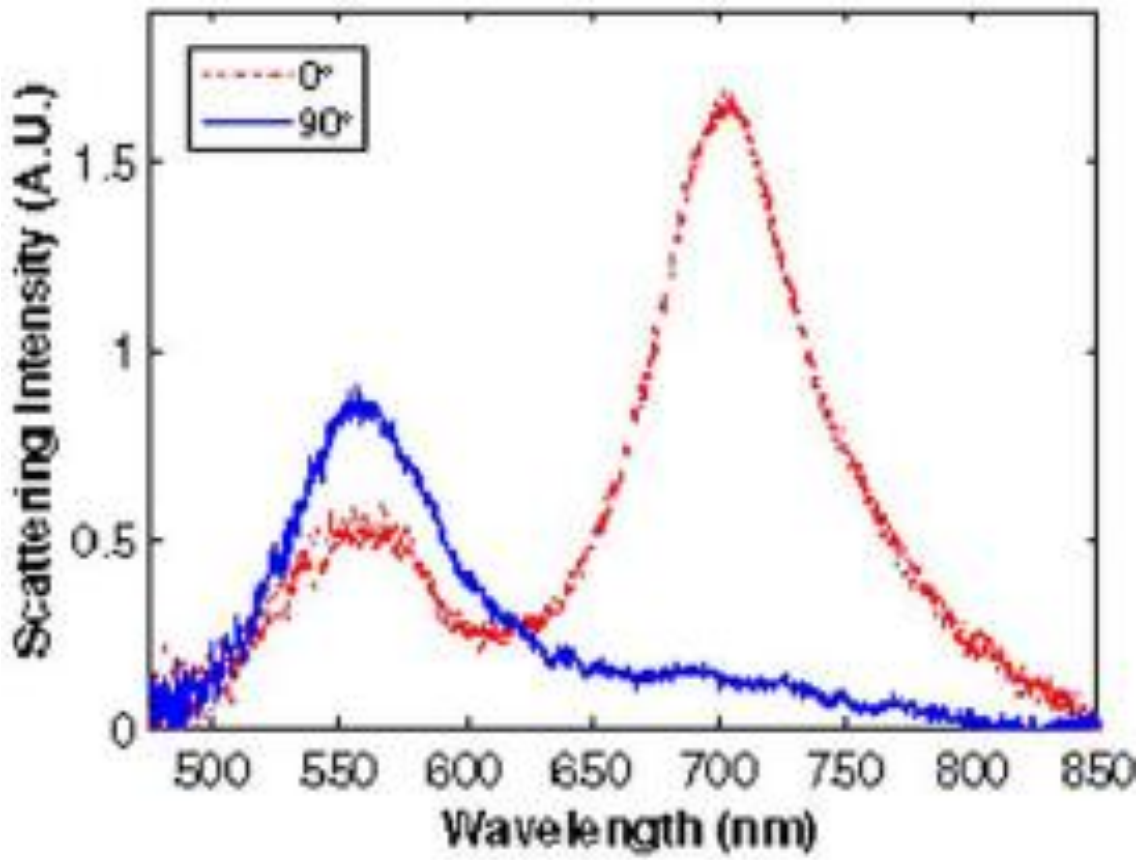


Parallel



Observations from the experiment -

- NP (60 nm) pair (3 nm separation)



Changes in sensing ability with RIU -

- The single particle case had 87.4 nm/RIU, where RIU stands for refractive index unit.

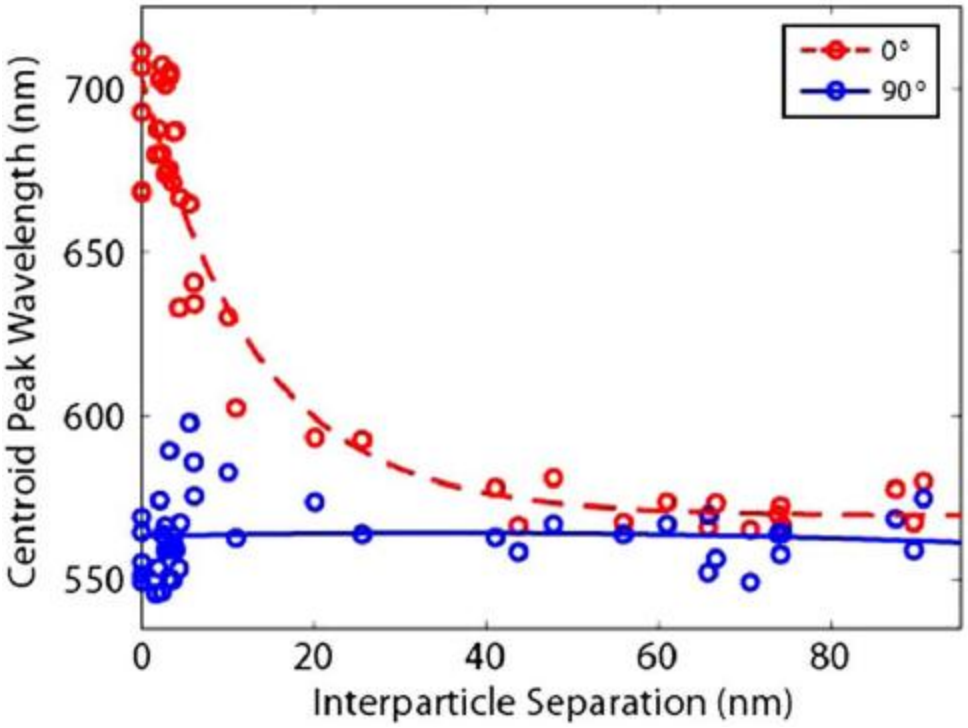
- The parallel and orthogonal polarizations of the particle pair offered sensing abilities of 230.3 nm/RIU and 75.9nm/RIU, respectively.

- Thus, the parallel polarization case presents a 2.6-fold increase in sensing ability.

Experimental peak scattering -

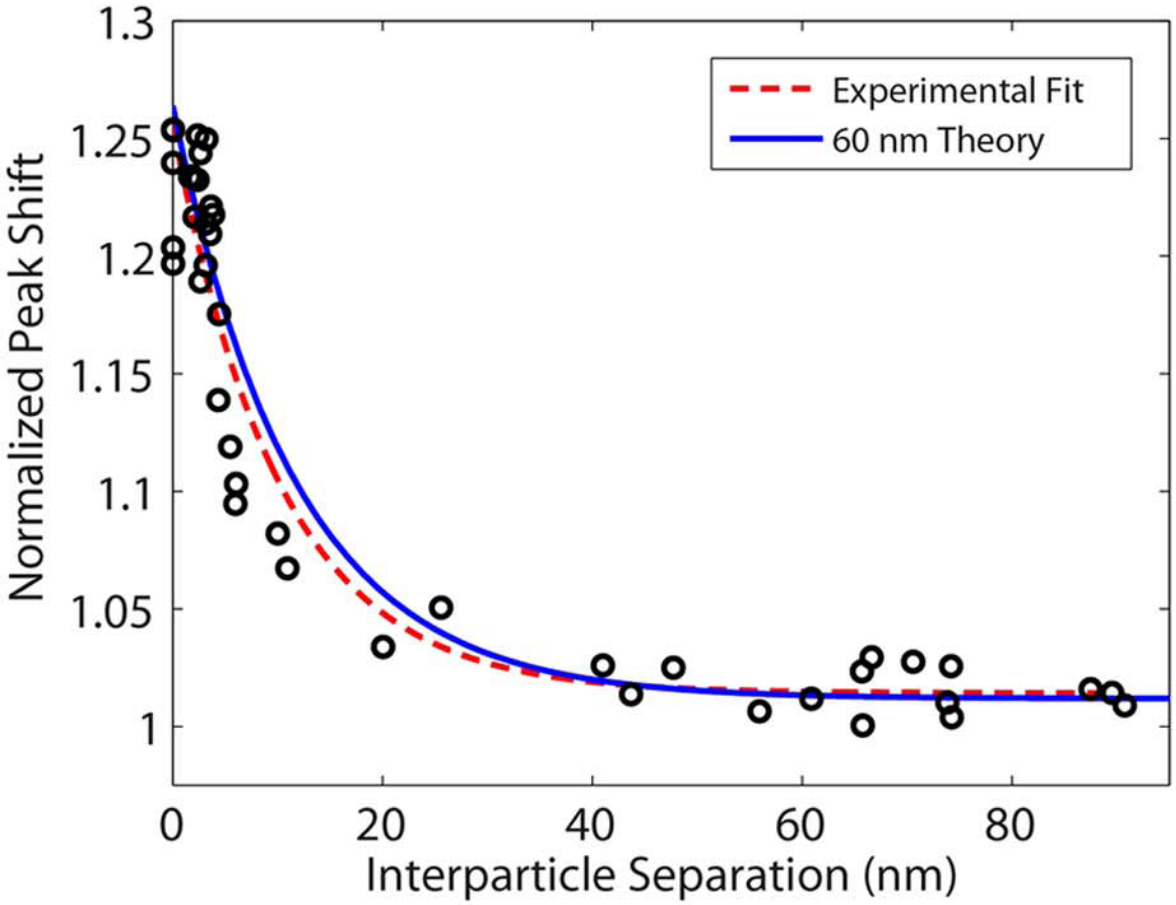
- Experiments demonstrate the relationship between peak scattering wavelength of the parallel and orthogonal polarizations for 42 nanosphere pairs.

Normalized spectral shift →



Introduction and objectives -

Peak shift between 0° and 90° polarizations.



Conclusions -

- Polarization mapping can be used to separate the contributions of plasmonic coupling from the dielectric environment.

- Method allows to measure changes in RI of surrounding medium (interparticle distance unknown) and to measure local RI (interparticle distance known).

- If absolute interparticle distance is constant throughout the NP pairs, first at constant RI, interparticle distance can be determined and then local RI measurements can be done.

Future scope -

- Sensing based on interparticle separation.

- Sensing the receptor dimerization and another dimension to study intracellular kinetics-dynamics of particles on binding with other molecules.

Thank you