# Eigen and Coupled Modes on Nanoparticle Aggregate Arrays

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**Abstract**: Novel class of artificial optical antennas are of great interest in biosensing applications of nanoplasmonics due to their unique and widely tunable spectral properties. Silver colloid spheres wrapped with L-cysteine covering were studied experimentally by UV-visible spectroscopy and TEM and numerically by COMSOL Multiphysics® software package. The experimental studies revealed that the Ag NP-Cys core-shell conjugates prefer to compose aggregates of versatile geometry. To inspect the nanophotonical origin of UV and red-shifted maxima simple one and two dimensional chain geometries were selected. The Radio Frequency Module makes it possible to apply eigenvalue study as well as time-dependent frequency study based on the same model. During modeling we paid attention to the symmetry features of our models by using a mesh with appropriate symmetry. It was demonstrated that by illuminating periodic aggregate arrays of very closely packed Ag NPs in close proximity of their eigenfrequencies one can achieve very large EM-field confinement.

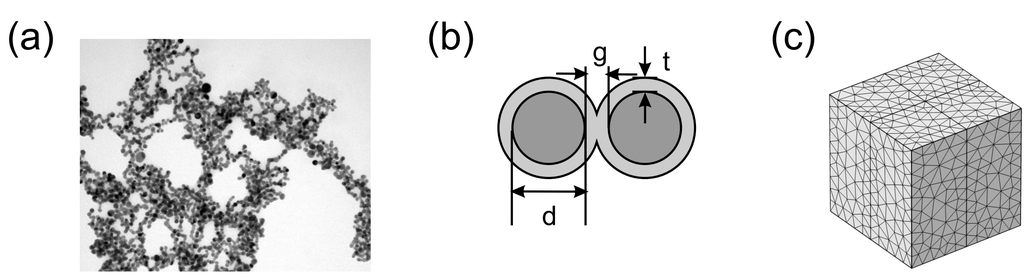


**Figure 1**. (a) TEM image of Ag NP-Cys aggregates. (b) The parameters in computation: d diameter, g gap and t thickness. (c) The 180° rotational symmetry-preserving mesh for the unit cell around the chains, while swept mesh was applied for PML regions. Periodic array consisting of (d) linear chain of 11 Ag NPs and (e) wavy chain of 20 Ag NPs.

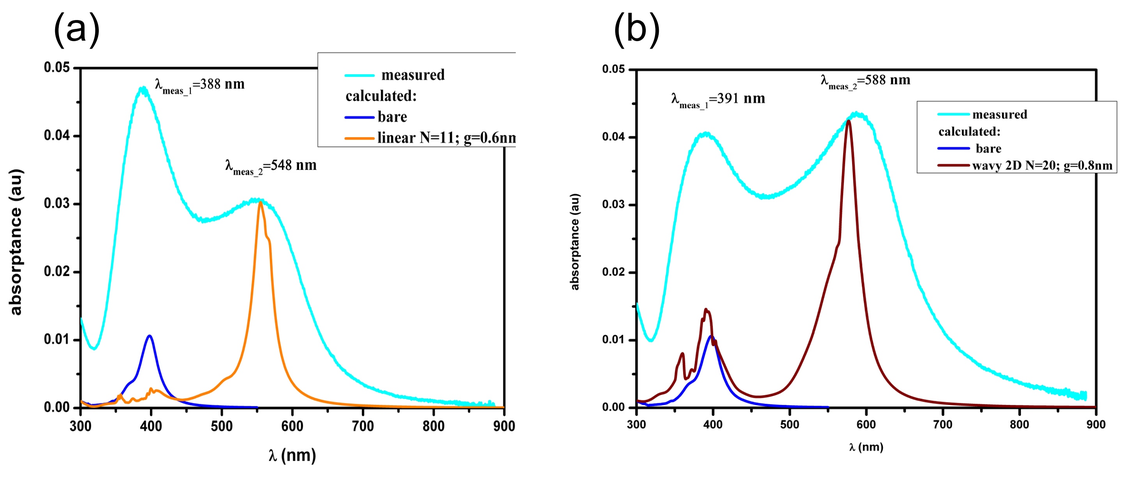


**Figure 2**. Experimetally registered spectra at pH (a/b) 5.7/4.92; computed spectra of periodic arrays consisting of (a/b) linear chains of 11 Ag Nps / wavy chains of 20 Ag NPs

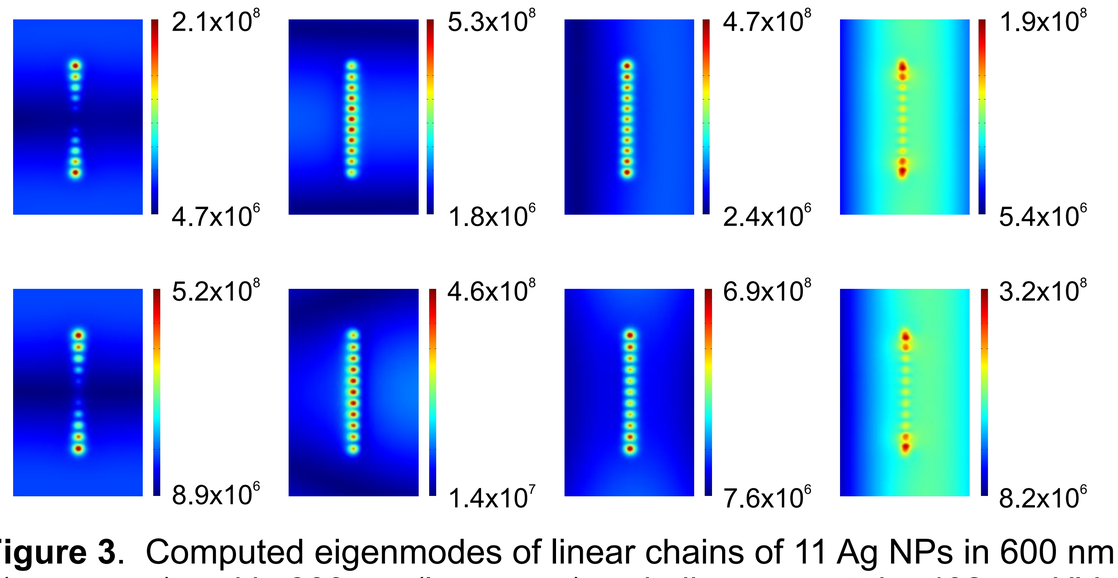


**Figure 3**. Computed eigenmodes of linear chains of 11 Ag NPs in 600 nm (upper row) and in 300 nm (lower row) periodic arrays at the 402 nm UV absorptance peak.

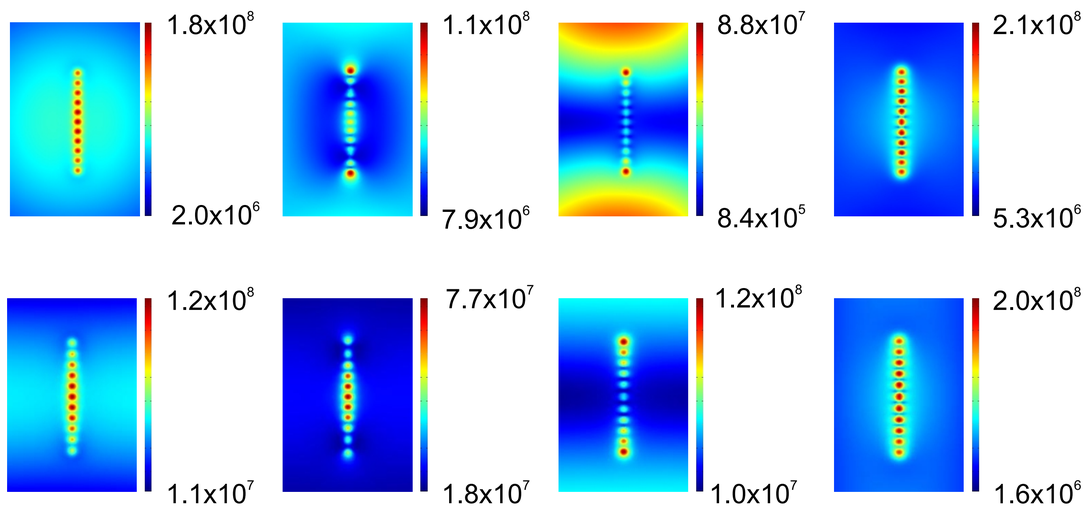


**Figure 4**. Computed eigenmodes of linear chains of 11 Ag NPs in 600 nm (upper row) and in 416 nm (lower row) periodic arrays at the 555 nm red-shifted absorptance peak.

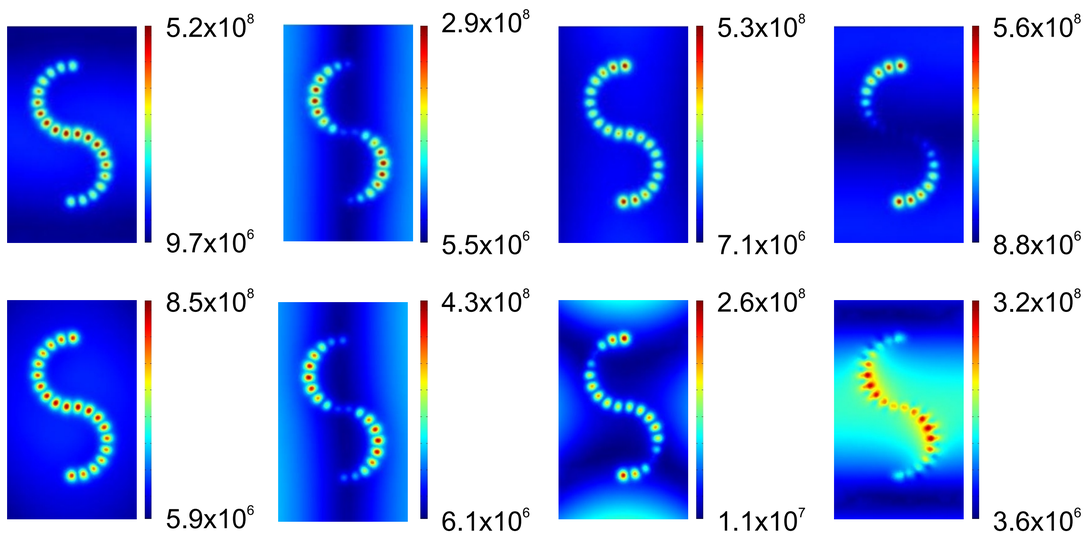


**Figure 5**. Computed eigenmodes of wavy chains of 20 Ag NPs in 600 nm (upper row) and in 297nm (lower row) periodic arrays at the 398 nm UV absorptance peak.

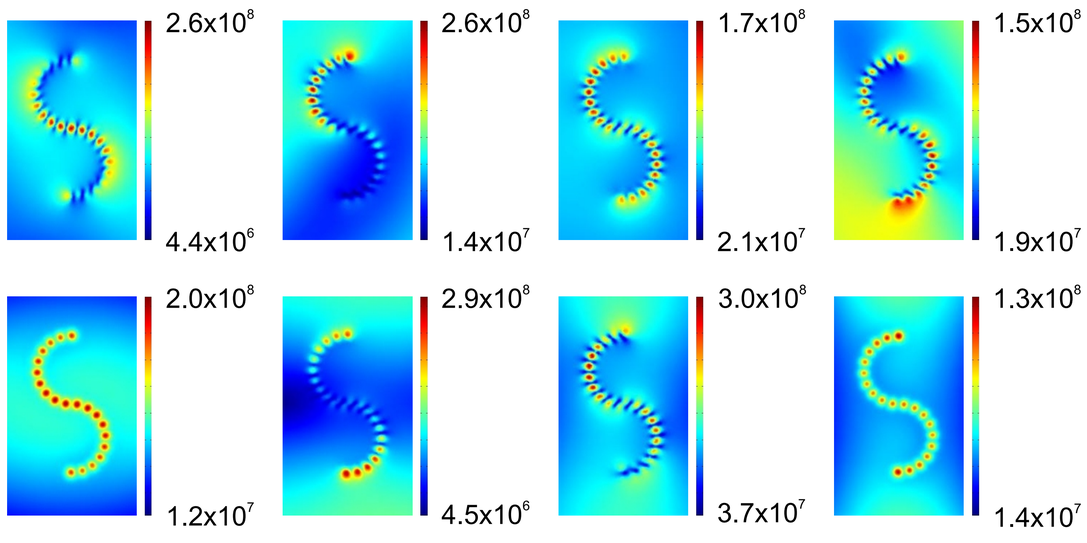


**Figure 6**. Computed eigenmodes of wavy chains of 20 Ag NPs in 600 nm (upper row) and in 434 nm (lower row)periodic arrays at the 577 nm red-shifted absorptance peak.

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## References

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2. M Csete, A Szalai, E Csapó , L Tóth, A Somogyi, I Dékány: "Collective Plasmonic Resonances on Arrays of Cysteine-Functionalized Silver Nanoparticle Aggregates" Journal of Physical Chemistry C (2014) DOI 10.1021/jp503465r

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