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BOOK OF ABSTRACTS

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Vortex Electron Energy Loss Spectroscopy

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Abstract

The theory of vortex electron energy loss calculation using finite-difference time-domain (FDTD) regularized Green function (GF) is introduced. This theory is used to map out magnetic properties of a metal split ring resonator (SRR) at the nanometric scale. These results are promising in the development of negative refractive index metamaterials in visible regime.

Metal nanostructures exhibiting negative permeability in optical regime play an important role in many applications such as optical cloaking and superlensing. To design a nanostructure with strong magnetic properties, it is desirable to probe its magnetic characteristics at the nanometric scale.

Electron energy loss spectroscopy (EELS) gives nanometric information of metal nanostructures including localized plasmons, surface plasmon polaritons (SPPs), and dark mode excitations with the highest spatial resolution. We show that the electron energy loss spectroscopy of a "twisted" electron trajectory (vortex-EELS) which carries an orbital angular momentum can map out the magnetic response of nanostructures.

The theory of vortex-EELS is similar to common EELS except that the electric charge is substituted with magnetic one and the electric and magnetic fields are exchanged. The magnetic field can be represented by the regularized magnetic GF which is obtained directly from the FDTD method in the presence of a magnetic dipole [1].

Figure 1 shows the map of the maximum vortex-EELS probability of a split ring resonator (SRR) as a function of position at 0.86eV for a 100keV beam. This peak occurs exactly in the place of magnetic plasmon resonance of the SRR which verifies the feasibility of vortex-EELS in probing the magnetic properties of metal nanostructures.

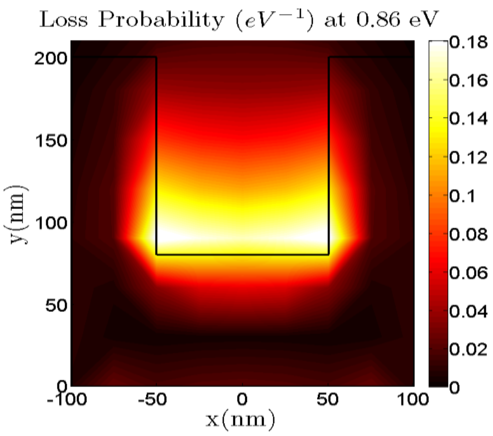

Fig.1. Vortex-EELS probability for 0.86 eV loss peak and a 100keV beam.

References

[1] Z. Mohammadi, C. P. Van Vlack, S. Hughes, J. Bornemann, R. Gordon, "Vortex Electron Energy Loss Spectroscopy for Near-Field Mapping of Magnetic Plasmons", *Optics Express*, **20**, 14., 15024--15034. (2012).