A Study of Asymmetric Epsilon-Negative and Near-Zero Metamaterial-Lined Plasmonic Nanoapertures as Metasurface Unit Cells

Mitchell Semple* and Ashwin K. Iyer
University of Alberta, Edmonton, AB, Canada

Arrays of plasmonic nanoantennas were one of the first technologies to demonstrate anomalous refraction metasurface behaviour. They have been studied for their ease of fabrication, their ability to support resonances at subwavelength scales, their high field enhancement, and their ability to induce a full 0-2π phase range with constant amplitude for varied geometries. With plasmonic nanoantennas, the full 0-2π phase range was first demonstrated with asymmetric V-shaped nanoantennas that support two resonances at the same frequency: one symmetric and one antisymmetric (N. Yu et al., Science, 334, 333-337, 2011). Although nanoantennas with high width:length aspect ratios and close spacings can be created with a variety of nanofabrication techniques, plasmonic nanoapertures have lagged behind because fabrication options are much more limited, especially as dimensions fall below 20 nm.

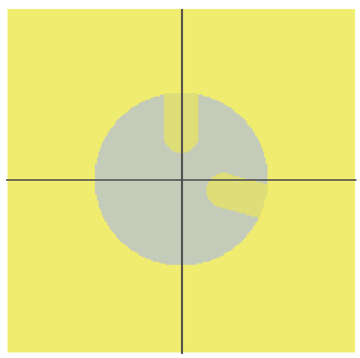

Figure 1: Asymmetric ENNZ-MTM-lined Aperture

Epsilon-negative and near-zero metamaterial-lined apertures support resonances at deeply subwavelength scales across the entire electromagnetic spectrum. We have previously shown that in the near-IR through visible regimes, epsilon-negative and near-zero metamaterial-lined apertures can be created by lining the inside of an aperture symmetrically with sub-resonant straight plasmonic nanowires. Although this unit cell has very high field enhancement and a number of applications in imaging and sensing at a subwavelength scale, its reliance on a single electric dipolar resonance limits the achievable phase range required for applications such as anomalous refraction. In this presentation, we will show a numerical study of a class of *asymmetric* nanoapertures (e.g. Figure 1) based on the plasmonic epsilon-negative and near-zero metamaterial-lined aperture metasurface unit cell that resonate at visible wavelengths. This geometry exhibits a richer spectrum of resonances and improved phase range across the resonances. It can be fabricated with extremely fine features with a helium ion beam microscope.