Electromagnetic properties of ultrathin quadrifilar spirals and their complementary structures

Nina Meinzer, Alastair P Hibbins and J Roy Sambles

Electromagnetic and Acoustic Materials Group
School of Physics and Astronomy
University of Exeter

Metallic spiral structures have been employed as subwavelength antenna elements in the microwave regime for some time. Recently they also been shown to support localised magnetic spoof plasmons similar to corrugated surfaces or cylinders [1]. Following on from these results we, in this paper, study the electromagnetic properties of ultrathin quadrifilar copper spirals and of their complementary structures, spiral-shaped apertures in an extended copper film. The samples are fabricated by a wet-etching technique using a mask printed onto a thin copper film on top of a mylar substrate. We experimentally map the near-fields of the samples. We further perform numerical finite-element modelling for comparison with our experimental data and to provide further information to aid our understanding of the system.

We start from single spiral elements and compare the electro-magnetic response of a direct copper spiral with that of its complementary (spiral aperture in a copper sheet) structure. From this starting point we move on to an investigation of combinations of small numbers of such spiral elements, both in the direct and inverse case, which exhibit the mode coupling one expects from a system of closely spaced or connected antennas. Depending on the excitation geometry or the arrangement of elements specific eigenstates of the coupled systems can be selectively addressed or suppressed, which adds an additional degree of control over the resonant behavior of these ensembles of a few spiral (spiral aperture) antennas. This latter part of our work is related to previous studies on the channeling of electromagnetic waves.

[1] PA Huidobro *et al*., Phys. Rev. X **4**, 021003 (2014).