A Study in Asymmetry: Resonances in Arrays of Asymmetric Disc Dimers

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Symmetry is one of the most fundamental concepts in nature. From elementary particles to complex protein molecules it impacts on the properties of a physical entity and on the interaction with its environment. In photonics, for example, the symmetry of a system determines if and how strongly it couples to an electro-magnetic field. In the specific case of a symmetric plasmonic antenna, which can support several multipolar eigenmodes only modes with a non-vanishing net dipole moment can couple to a normally-incident plane wave; all other modes are non-radiating, or *dark*, meaning that although the antenna can support these modes they cannot be observed under the given conditions. However, one can render such modes *grey*, i.e. weakly radiating, by symmetry breaking, either by deviating from normal incidence and thus lowering the symmetry of the excitation or by introducing an asymmetry to the antenna itself. There has recently been significant interest in *grey* modes because their small net dipole moment results in narrow spectral features with high quality factors, which are desirable for many applications.

In this paper we study the resonance behaviour of asymmetric disc dimers (ADD), both as individual dimer structures and within periodic arrays, ranging from the non-diffractive metamaterial regime to the diffractive case, where they exhibit interesting surface-lattice resonances (SLR), which are very narrow and appear as a double resonance for the right excitation conditions. We discuss the ADD resonances in all three regimes (single dimers, non-diffractive, diffractive) both experimentally and with additional data from numerical modelling but we focus specifically on the SLR of asymmetric dimers, for which we have also modified a previous analytical model to incorporate the effect of an asymmetric two-element base.