Self-Anticrossing Band Knots
in Plasmonic Arrays with Broken Symmetries

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The band structures in periodic media govern their electrical or optical properties. Artificial media and metamaterials have shown that it is possible to engineer with a large degree of freedom the band diagram of periodic media, supporting many intriguing phenomena and corresponding applications, e.g., electromagnetic bandgap materials, zero-index propagation, and extreme material parameters. Recently, strong interest has also been raised around what happens when the periodicity in these media is broken. Here we study self-anticrossing in the dispersion diagram of periodic plasmonic arrays when suitably broken symmetries are considered.

We first consider a one-dimensional infinite periodic array of polarizable particles, designed to support a slow transverse wave with backward properties. We then consider the scenario in which every other particle in the array is translated longitudinally by a small amount, or alternatively every other particle's polarizability is perturbed. By using the coupled dipole approximation, we derive a closed-form solution of the dispersion equation. In both cases, the dispersion curves are expected to fold due to the shrinking of the first Brillouin zone. Interestingly, for tightly packed and transversely excited arrays, the dispersion curve then shows an unusual anti-acrossing, forming a knot in reciprocal space.

We then study self-anticrossing knots in more general scenarios in which additional local symmetries are broken, showing that these problems can be all reduced to closed-form eigenvalue problems, for which it is possible to study the anti-crossing, local bandgap opening at the knot, and the electromagnetic features of the corresponding modes.

In general, our work showcases extreme dispersion engineering induced by symmetry breaking, with opportunities in high-gain leaky-wave antennas and unusual guided wave phenomena. In our presentation, we will discuss the opportunities of this concept in higher dimensions and for more advanced symmetries, e.g., glide symmetry, and quasi-periodic media.