Computation of Large Arrays of Plasmonic Metematerials: A Modal Profile Approach

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An acceleration technique for the MoM solution of large-area metamaterial arrays is proposed that relies on numerical extraction of the modal profile associated with the individual array elements followed by projection of the global system equations onto a judiciously constructed reduced solution space. Like all other projection (reduction)-based techniques, the success of the methodology heavily relies on compatibility of the reduced space to that of the final solution. Hence, a multilevel strategy is proposed for the systematic construction of the reduced solution space in which both plane waves and secondary excitations due to the presence of nearby neighbours (and even higher order excitations) are accounted for. In order to deal with the low frequency instability associated with the deep subwavelength structures present in nanomaterial and metamaterial arrays, a JMCFIE formulation is adopted for the underlying surface integral equation (SIE) solver. Higher order quadrilateral surface elements are used to help minimize the computational costs associated with of SIE solver. To further enhance the performance of the underlying MoM couplings, an IE-FFT engine is developed that is compatible with the underlying JMCFIE formulation and higher order quadrilateral discretization. A number of large-area metamaterial arrays are solved and the computational statistics are presented to reflect the advantage of the the proposed methodology. Besides computational efficiency, the proposed macrobasis function approach has advantages with respect to intuitive physical understanding and design of array structures. Particularly, the availability of the modal profile as the spanning basis for the reduced solution space is a valuable tool when it comes to judging whether the array elements are efficiently performing their intended role. The results are verified against solutions obtained using direct MoM and various large nanomaterial arrays are solved using the proposed method in their practical frequency range of operation.