Decomposition of the Time Reversal Operator for a Small Scatterer of General Shape

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Many applications of time reversal to imaging and target characterization require decomposition of the time reversal operator. This is typically accomplished by applying the singular value decomposition to the multistatic response matrix of an array. The number and character of the singular values depends not only on the number of resolvable targets, but also on the particular scattering characteristics of each target. An understanding of how the scattering physics determines the singular values could lead to new methods of characterizing targets when direct imaging is difficult. In this paper we review the decomposition of the time reversal operator for a general planar array and a single small spherical target. We show how the conductivity and permittivity of the sphere can create up to six distinguishable singular values for a fully polarimetric array. We then extend this analysis to a small ellipsoidal scatterer and show how orientation and eccentricity modifies the behavior of the singular values and singular vectors. Results for the limiting cases of a disk and a rod will be presented. We show how orientation could be estimated by rotating an array and tracing the behavior of the singular values as a function of rotation angle.

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48. Research partially supported by DARPA.