Computation of the Scattering From Nearly Symmetric Objects

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Many industrial objects have some geometrical symmetry properties. When a boundary integral formulation is used to compute the scattering of an object with plane or rotation symmetries, it is well-known that the symmetry can be used to reduce significantly the storage requirement and the computation time. The method consists in building a block circulant matrix and solving it by a cyclic solver. But in most industrial cases, the symmetry is not perfect, and some small non symmetric features are present on the scatterer.
By using a mixed circulant/noncirculant solver, it has been shown (P. Soudais, P. Leca, J. Simon, T. Volpert, IEEE Trans. Antennas Propagat., vol. 50, No 2, 168-173) that the use of symmetry properties could be extended in the case of objects with a prominent symmetric part and some symmetry defects.

An industrial methodology was developed in the SPECTRE code to use this technique. The first step is the generation of a primary mesh containing only one symmetry cell and the non symmetric part of the object. Some attributes must be defined to distinguish these parts, as well as to mark the symmetry plane, the symmetry axis or the connection with other cells. Then the unknowns of the problem are built in an appropriate way, which means setting them in the right order : all the unknowns of the successive symmetry cells are sorted in a respective order, and the non symmetric unknowns are added at the end.

The whole process was validated on many test cases, and is used for industrial problems. It allows to deal with some complex computations, and to push away the limits of a direct solution, since a symmetry of order k approximately yields a division by k^2 on the linear solution time, and a division by k on the matrix assembly time and on the matrix storage.