Analytical, Numerical and Experimental Scattering by a Metallic Disk-Sphere Target

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Abstract

The scattering of a plane electromagnetic wave by a disk-sphere metallic target is studied via several approaches: separation of variables, method of moments, high-frequency techniques, and measurements in anechoic chamber. The results obtained by the different methods are compared and discussed.

1. Description of Research

The geometry analyzed in this work consists of a metallic sphere that is equatorially intersected by a thin metallic disk whose diameter is larger than the sphere's. The primary field is a plane wave of arbitrary direction of incidence and polarization, and the goal is to determine the bistatic radar cross-section of the target. This problem constitutes a validation tool for computer codes developed for the remote detection of hidden ordnance, such as mines. The study is performed in the frequency domain by utilizing four analytical, numerical and experimental techniques. Some preliminary analytical and numerical results were given in [1-3]; these are here complemented by additional theoretical approaches and verified by comparison with experimental data.

The first approach is an analytical-numerical method based on separation of variables. The space surrounding the target is subdivided into three regions: two semi-spherical shells bounded by the radii of sphere and disk and the disk itself, and the space surrounding the sphere of radius equal to the disk's radius. The field components in each region are written as infinite series of spherical harmonics that are determined with the aid of Debye potentials. The determination of the modal expansion coefficients in the infinite series requires the inversion of an infinite matrix. An approximate solution is obtained by truncating the matrix, i.e. by considering only a finite number of terms in the field expansions. This approach yield good results for the bistatic radar cross section (RCS), provided that the frequency is not too high The results are compared to those obtained by an application of the Method of Moments to the determination of the surface current densities on the target, from which the RCS is obtained by integration.

The third approach, that is confined to backscattering for simplicity, consists in the application of high-frequency asymptotic techniques, such as GTD and UTD, to the target. Finally, measurements of the backscattering RCS were undertaken on a model of the target in the anechoic chamber of the UIC Andrew Electromagnetic Laboratory. A critical comparison of the results obtained by the four methods is conducted.

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2. References

1. P. L. E. Uslenghi, "Electromagnetic Signature of a Metallic Disk-Sphere," *Days of Diffraction 2007*, St. Petersburg, Russia, May 2007.

2. P. L. E. Uslenghi, "Backscattering from the Saturn Configuration," *IEEE International Symposium on Antennas and Propagation*, Honolulu, HI, June 2007.

3. P. L. E. Uslenghi, “Scattering by a Metallic Sphere Concentric with a Metallic Disk,” *Proc. International Conference on Electromagnetics in Advanced Applications (ICEAA’07)*, Torino, Italy, Sept. 2007.