MOM Analysis of Apertures in Chiral Bodies of Revolution

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Abstract

A chiral body of revolution which is partially covered by a thin conducting shield is analyzed using the Method of Moments (MOM). The axisymmetric system is excited by a plane wave. The total internal fields and the far scattered fields are computed. The problem is solved using the surface equivalence principle. The scattered fields outside the structure are assumed to be produced by an equivalent magnetic surface current that exists on the unshielded part of the BOR surface, and an external equivalent surface electric current that exists over all of the BOR surface. These two currents are assumed to radiate in the unbounded external medium. Similarly, the total internal fields are assumed to be produced by the negative of the above magnetic current and an internal electric surface current that exists over all of the BOR surface, but is an independent unknown only on the shielded part of the BOR surface. These two currents radiate in the unbounded internal medium. Enforcing the boundary conditions at the surface of the BOR results in a set of coupled integral equations for the three equivalent surface currents. These equations are solved numerically using the MOM. The computed results for the partially shielded spherical chiral body are in excellent agreement with other data.

1. Introduction

Figure 1 shows a chiral body of revolution that is partially covered by a perfectly conducting shield. The system is excited by a plane wave. We are interested in finding the total field that penetrates into the chiral body through the apertures on its surface, and the total far field scattered by the structure. The problem of electromagnetic penetration into a regular dielectric body of revolution that is partially covered by a perfectly conducting shield is analyzed in [1], [2]. The problem of electromagnetic transmission through an arbitrary aperture in an arbitrary 3-D conducting surface enclosing chiral material is analyzed in [3]. The electromagnetic analysis of general bodies of revolution is given in [4].

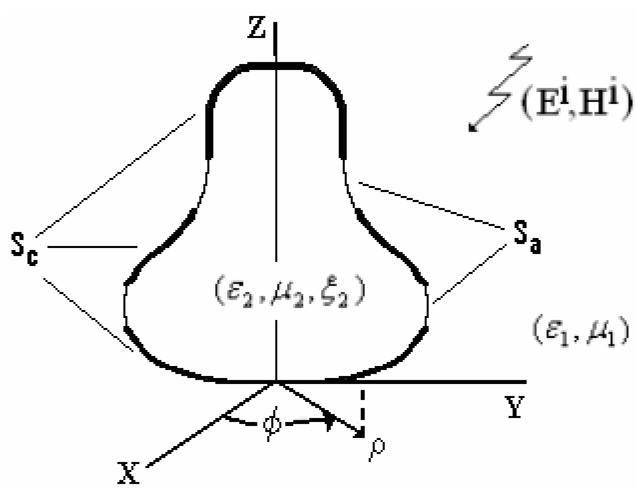

Figure 1. A chiral body of revolution with two apertures

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2. Analysis

In Fig. 1 S_a denotes the unshielded part of the surface of the chiral BOR, and S_c denotes the surface of the conducting shield. The union of these two surfaces is denoted by S. The surface equivalence principle is used to separate the problem of Fig.1 into two simpler parts, namely, the region external to surface S, and the region internal to S. The scattered fields in the external problem are produced by equivalent magnetic surface current M and equivalent electric surface current J_e radiating in the unbounded external medium. The current M exists on only S_a and the current J_e exists on the whole surface S. The total field in the chiral medium is produced by an equivalent magnetic surface current –M, and an equivalent surface electric current J_i radiating in the unbounded chiral medium. J_i exists on the whole surface S. Enforcing continuity of the tangential components of total **E** and **H** on S gives a set of coupled integral equations for the three unknown surface currents. The method of moments as applied to bodies of revolution is used to solve the integral equations numerically. Piecewise linear variations of the currents are assumed along the generating curve of the BOR. The variations of the currents along the circumferential direction are represented by Fourier series. An approximate Galerkin's method is used for testing.

3. Results and Conclusion

Numerical results for a chiral sphere are given here. The sphere has relative permittivity of $\varepsilon_r = 2.0$, relative permeability of $\mu_r = 1$, and relative chirality of varying ξ_r . The size of the sphere is given by $k_0 a = 1.5$ where a is the radius of the sphere and k_0 is the free space wave number. Except for a 30^0 aperture, the surface of the sphere is covered by a perfect conductor. The structure is illuminated by a z-traveling incident plane wave where its electric field is x-directed. Figure 2 shows the structure considered.

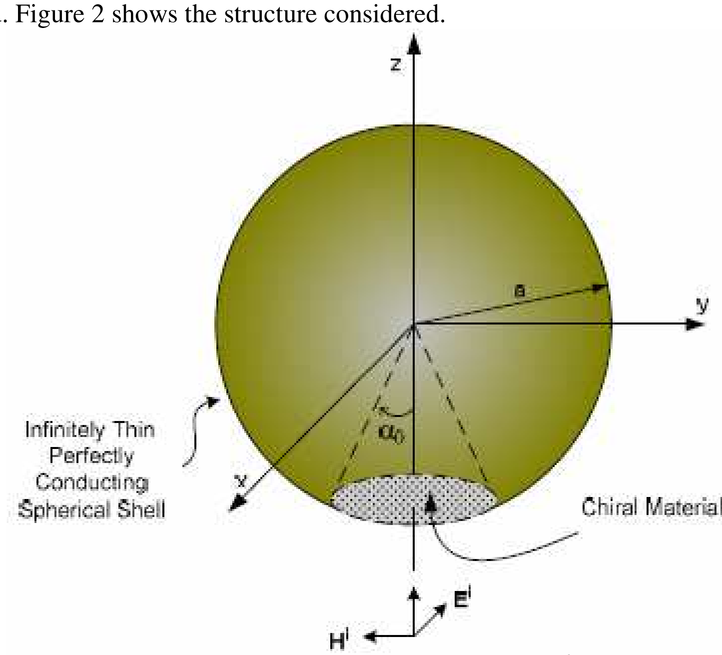

Figure 2. A plane wave incident on a sphere with α_0=30^0 aperture.

The generating curve was approximated by 408 linear segments. Using overlapping expansion functions each of which covers four segments resulted in a moment matrix of order 812. Figure 3 shows the computed bistatic radar cross section in the plane of incidence for various chirality values. These results are in excellent agreement with those in [3]. Figure 4 and Fig. 5 show the magnitudes of the x and y components of the total internal electric field along the z-axis. Again, the results are in very good agreement with those of [3]. The effect of the chirality is evident in the presence of the cross polarized component as shown in Fig. 5.

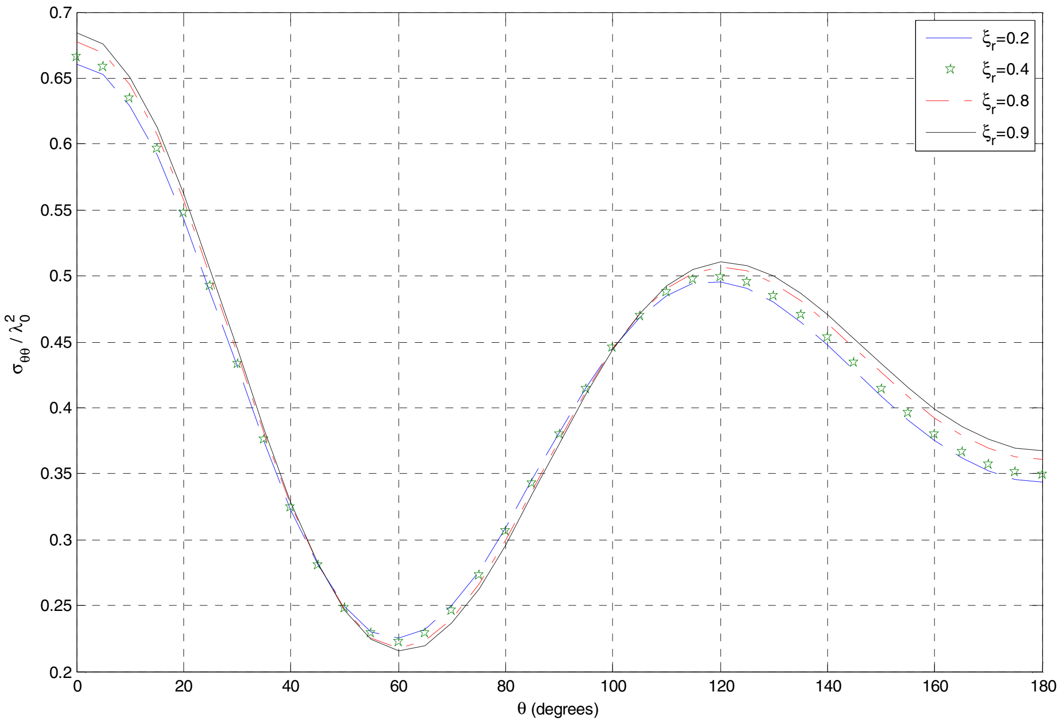

Figure 3. Bistatic radar cross section $\sigma_{\theta\theta}$ for the structure in Fig. 2.

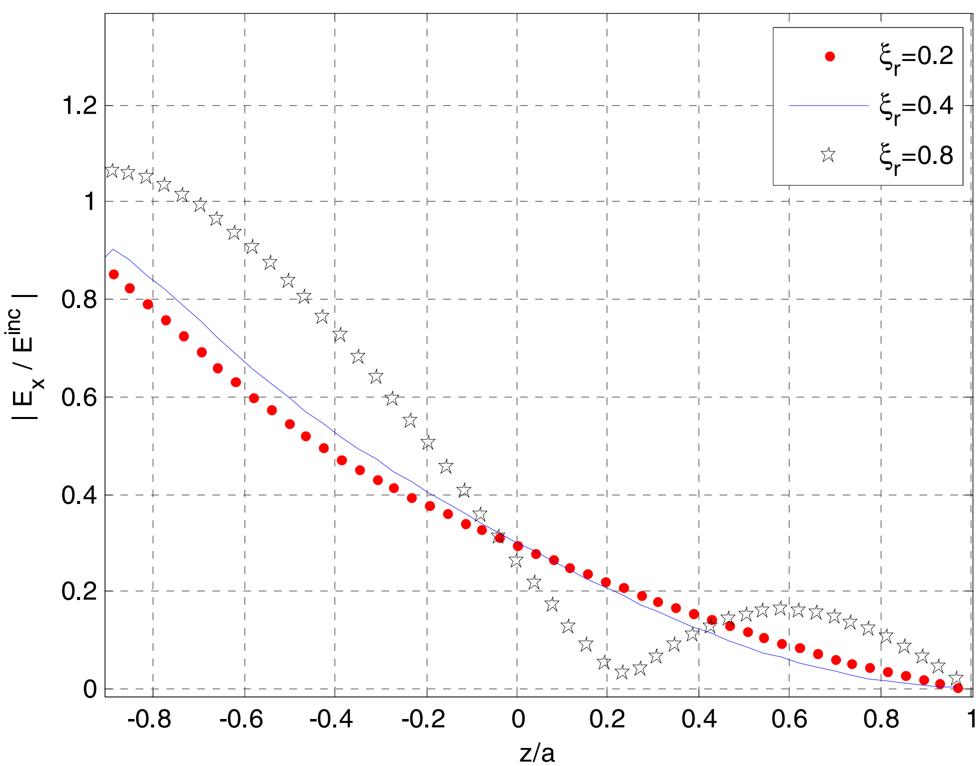

Figure 4. Magnitude of the x-component of total internal electric field along the z-axis.

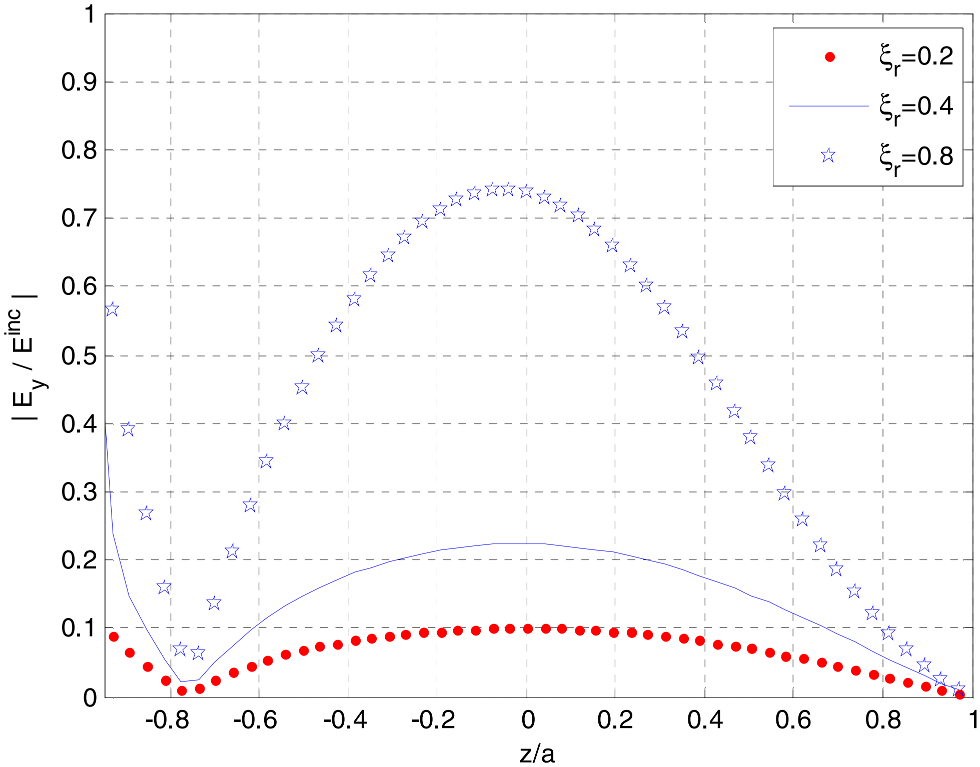

Figure 5. Magnitude of the y-component of total internal electric field along the z-axis.

4. References

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