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BACKSCATTER ANALYSIS OF CORNER STRUCTURES BY COMPLEX RAY EXPANSION

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INTRODUCTION

Complex ray expansion (CRE) composes a very important and useful technique for the backscatter analysis of complicated targets with a wide variety of geometrical configurations[1-4]. The method relies on an incident plane wave expansion into a set of complex source points (CSP), and the paraxial approximation evaluation of individual CSP backscattering field from the target. As an example, the corner structures are analyzed, and the numerical results are compared with the ones from other methods or experimental studies.

PROCEDURE

1. Plane wave expansion into complex source points

A z-directional plane wave can be expanded into a set of equally spaced CSPs with the same amplitude, phase and beam vector[1], and the incident wavefield E_i can be expressed as a superposition of CSP fields

$$E_i = d^2 \sum_m \sum_n \widetilde{W}(m,n)\widetilde{G}(x,y;m,n) \tag{1}$$

where m and n denote the CSP ordinal number, d is the CSP interval, $\widetilde{W}(m,n) = \widetilde{W}_0$ denotes the constant expansion coefficient for a uniform plane wave, and $\widetilde{G}(x,y;m,n)$ expresses the CSP field at the expansion plane $z=0$, given in the paraxial region by

$$\widetilde{G}(x,y;m,n)=\frac{C\exp\{-k[(x-md)^2+(y-nd)^2]/2b_0\}}{[(x-md)^2+(y-nd)^2-b_0^2]^{1/2}} \tag{2}$$

where b_0 is the beamwidth parameter. By trial and error in choosing free parameters d and b_0, eq. (1) can be satisfied with a given relative error, e. g, less than 0.01%.

2. **Ray tracing and reflected field expression**

According to complex ray paraxial approximation[5], the on-axis (central) complex ray trajectory can be traced by geometrical optics in real space, and the reflected far field $\widetilde{E}_r(m,n)$ of an individual CSP from the target can be expressed approximately by

$$\widetilde{E}_r(m,n)=\widetilde{E}_{r0}(m,n)\exp(jk\widetilde{\delta}) \tag{3}$$

where $\widetilde{E}_{ro}(m,n)$ denotes the corresponding central complex ray field, and $\widetilde{\delta}$ is the phase correction from the central to an arbitrarily given observer. Both $\widetilde{E}_{ro}$ and $\widetilde{\delta}$ can be easily obtained by paraxial appraximation[5].

3. **Total scattering field and radar cross section (RCS)**

The total scattering field from a corner reflector is a phasor summation of all CSP reflected and diffracted fields

$$E_s=\widetilde{W}_0d^2\sum_m\sum_n\widetilde{E}_r(m,n)+\widetilde{E}_d \tag{4}$$

where the diffracted field $\widetilde{E}_d$ from the edges of corner structure can be evaluated by geometrical or uniform theory of diffraction. Finally, the backscattering RCS from a corner reflector is given by the definition

$$\sigma=4\pi\lim_{R\to\infty}R^2|E_s/E_i|^2 \tag{5}$$

RESULTS

The geometry of calculation model is shown in Fig. 1, where $a=b=l=5.6088\lambda$, $f_0=9.4\text{GHz}$, $b_0=10\lambda$, $d=0.1\lambda$. Fig. 2 and Fig. 3 show the RCS of dihedral reflector, respectively, for orthogonal and nonorthogonal corner structures, where the CRE results (dashed line) are compared with the physical optics results (point line)[6] and experimental results (solid line)[7]. It is obvious from the figures that the dihedral angle 2α has a substantial effect on RCS pattern. Fig. 4 shows the RCS at the bisector direction versus the dihedral angle, where the number of maximum is corresponding to the number of internal reflection.

CONCLUSIONS

1. Complex ray expansion offers a useful and effective RCS prediction approach for a wide variety of complex targets. In this paper, the computations were performed on an IBM-PC/XT, and for a whole curve with 181 observers in Fig. 2 or Fig. 3, the CPU time required is only about 720 seconds.

2. For an electrically large structure, the CSP interval d can be enlarged proportionally, and the CPU time, therefore, will not increase substantially.

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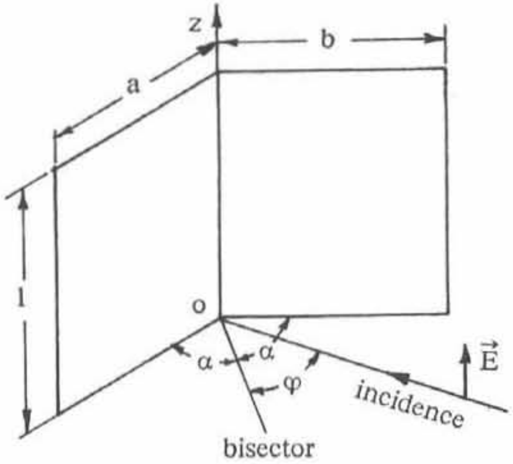

Fig. 1 Geometry of dihedral reflector

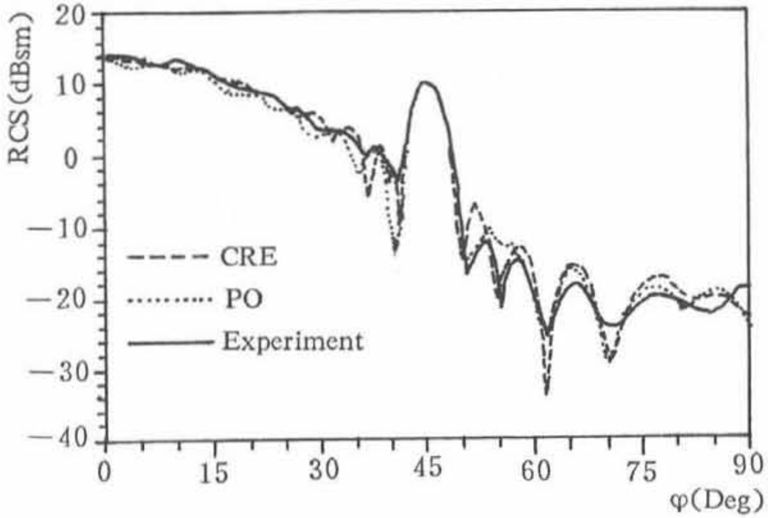

Fig. 2 RCS of orthogonal dihedral reflector ($2\alpha = 90°$)

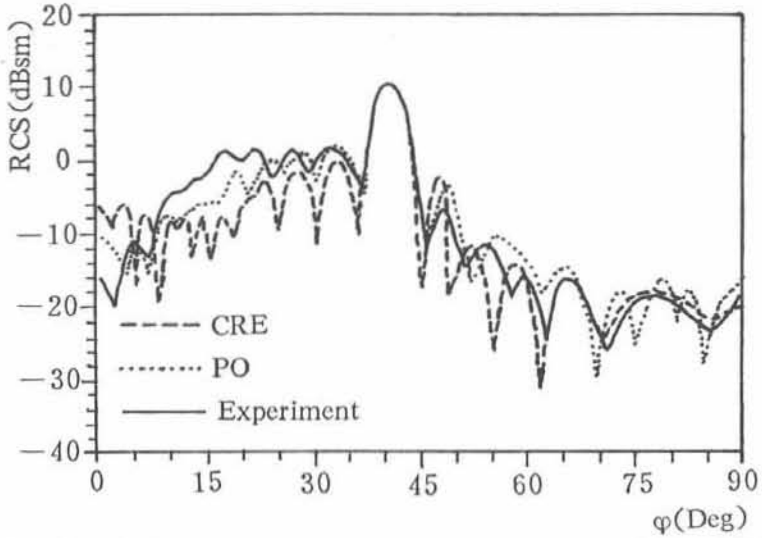

Fig. 3 RCS of nonorthogonal dihedral reflector ($2\alpha = 98°$)

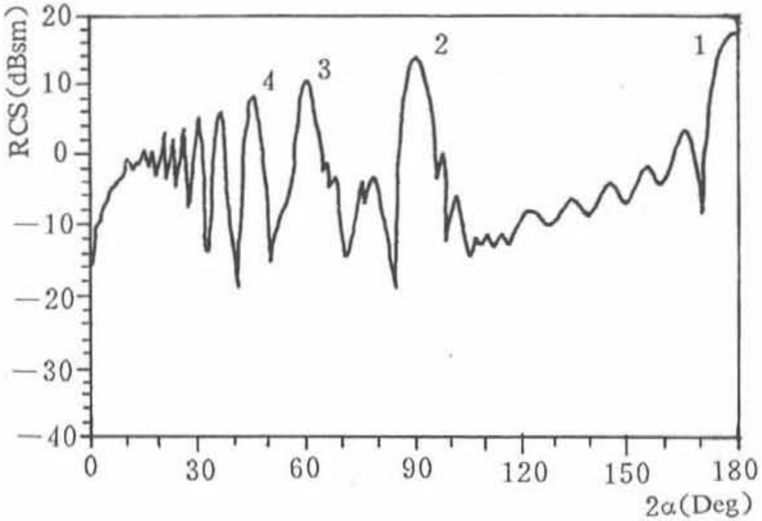

Fig. 4 On-axis RCS ($\varphi = 90°$) versus the dihedral angle 2α