RECENT ADVANCES IN THE DEVELOPMENT OF THE PHYSICAL OPTICS INVERSE SCATTERING THEORY FOR CONVEX CONDUCTING CLOSED SHAPES —— THE DEPOLARIZING EFFECTS FOR THE MONOSTATIC AND BISTATIC CASES

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ABSTRACT

An analytical time-domain expression derived by Kennaugh for the early time impulse response for smooth, convex, perfectly conducting scatterers under the physical optics approximation for the bistatic case is re-interpreted. A crude polarization correction to the leading edge of the physical optics impulse response is obtained for the bistatic case, leading to a simple asymptotic relation between the specular principal curvature difference and certain co-polarized phase terms in the bistatic scattering matrix.

1. INTERPRETATION OF THE BISTATIC PHYSICAL OPTICS IMPULSE RESPONSE

The results in [1] are reassessed and rephrased. Fig. 1 depicts an impulse traveling towards the scatterer for the TM case. The origin is arbitrarily chosen as the point where the incident impulse first touches the scatterer, at which instant, time is referenced as zero. The incident H-field is then represented by the Dirac delta function,

$$\bar{H}^i = \hat{y}\ \delta(t+z) \tag{2}$$

where the unit of time is chosen as the light-meter as in [2] to normalize the propagation speed c to unity.

On defining

$$A(t) = A_p\left(\frac{t-r}{2\cos\theta/2}\right) \tag{3}$$

where $A_p(p)$ is the cross-sectional area formed by the plane (tranverse to the bisector direction) at displacement p from the origin with the scatterer, θ is the bistatic angle, and r is the far-field distance to the observation point $\bar{r}$, the scattered far-field in response to the impulse can be written

$$r\bar{H}(\bar{r},t) = \frac{\cos\theta/2}{2\pi}\,\frac{\partial^2 A(t)}{\partial t^2} \tag{8}$$

A result similar to (4) holds for the TE-case in which the incident field is transverse to the target-transmitter-receiver plane. In either case, the impulse response takes the form of the second derivative of the cross-sectional area formed by the smooth, convex perfectly conducting scatterer and a fictitious plane delineating the scatterer along the bisector direction at a speed given by

$$\frac{dp}{dt} = \frac{1}{2\cos\theta/2} \tag{5}$$

where $$p = \frac{t - r}{2\cos\theta/2} \tag{6}$$

for times so early that the fictitious plane has not touched the shadow region. The above results imply that the directions of the incident H-field and the E-field are not altered on scattering in the TM case and the TE case, respectively. This is certainly true for the sphere, but not in general; i.e., the physical optics assumption needs to be corrected to give the proper depolarization contributions.

2. LEADING EDGE POLARIZATION CORRECTION TO PHYSICAL OPTICS

For the bistatic case, a derivation [3] parallel to Bennett's monostatic correction [2] leads to the correction to the impulse response:

$$r\bar{H}^{s}_{corr} = -\frac{K_{ub} - K_{vb}}{4\pi}\frac{\partial A}{\partial t}\,[\hat{a}\,(\cos\psi\,\cos2\psi_b\,\cos\tfrac{\theta}{2} + \sin\psi\,\sin2\psi_b)$$
$$+\,\hat{y}\,(\cos\psi\,\sin2\psi_b\,\cos\tfrac{\theta}{2} - \sin\psi\,\cos2\psi_b)\,\cos\tfrac{\theta}{2}\,] \tag{7}$$

in which the area function A(t) along the bisector direction defined by (3) is used in lieu of the monostatic silhouette area function, and K_{ub} and K_{vb} are principal curvatures at the specular point touched by the fictitious plane moving along the bisector direction. In addition, this correction also depends on the bistatic angle θ, the incident polarization angle ψ, and the orientation angle ψ_b of the principal curves at the specular point with respect to the transmitter-scatterer-receiver plane, as defined in Fig. 2.

By adding the fields due to physical optics and the derived polarization correction, the total impulse response can be investigated in four special cases, in which the incident magnetic field is either along $\hat{a}_t$ ($\psi = 0$) or $\hat{y}$($\psi = \pi/2$), and the receiver polarization is either along $\hat{a}_r$ or $\hat{y}$. The resulting responses are designated by S_{HH}, S_{VV}, S_{VH} and S_{HV}, with the r dependence removed. The first and second subscripts respectively denote receiving and transmitting polarizations, with 'H' associated with $\hat{a}_t$ or $\hat{a}_r$, and 'V' with $\hat{y}$. Then,

$$S_{HH} = \frac{\cos\theta/2}{2\pi}\frac{\partial^2 A}{\partial t^2} - \frac{K_{ub} - K_{vb}}{4\pi}\frac{\partial A}{\partial t}\cos2\psi_b\,\cos\theta/2 \tag{8}$$

$$S_{VV} = \frac{\cos\theta/2}{2\pi} \frac{\partial^2 A}{\partial t^2} + \frac{K_{ub} - K_{vb}}{4\pi} \frac{\partial A}{\partial t} \cos 2\psi_b \cos\theta/2 \tag{9}$$

$$S_{VH} = - \frac{K_{ub} - K_{vb}}{4\pi} \frac{\partial A}{\partial t} \sin 2\psi_b \cos^2 \frac{\theta}{2} \tag{10}$$

$$S_{HV} = - \frac{K_{ub} - K_{vb}}{4\pi} \frac{\partial A}{\partial t} \sin 2\psi_b \tag{11}$$

Equations (8) to (11) imply that in general S_{HV} is not equal to S_{VH} except for the following cases: (i) monostatic case, (ii) locally spherical scatterer, (iii) one of the principal directions at the specular point is parallel to the transmitter-scatterer-receiver plane. In the last two cases both S_{HV} and S_{VH} will vanish. In the first case, (8) to (11) reduce to Bennett's results.

3. CONCLUSIONS

The Kennaugh-Cosgriff formula is reiterated in the bistatic case under the physical optics approximation and polarization correction terms are introduced. Applications to both direct and inverse scattering are discussed in [3], in which a bistatic phase curvative relationship is derived.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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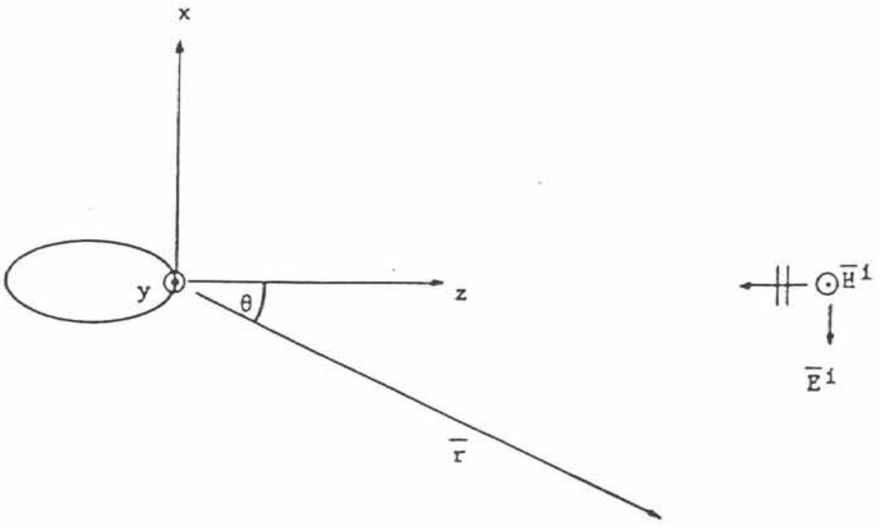

Fig. 1 Scattering Coordinate System

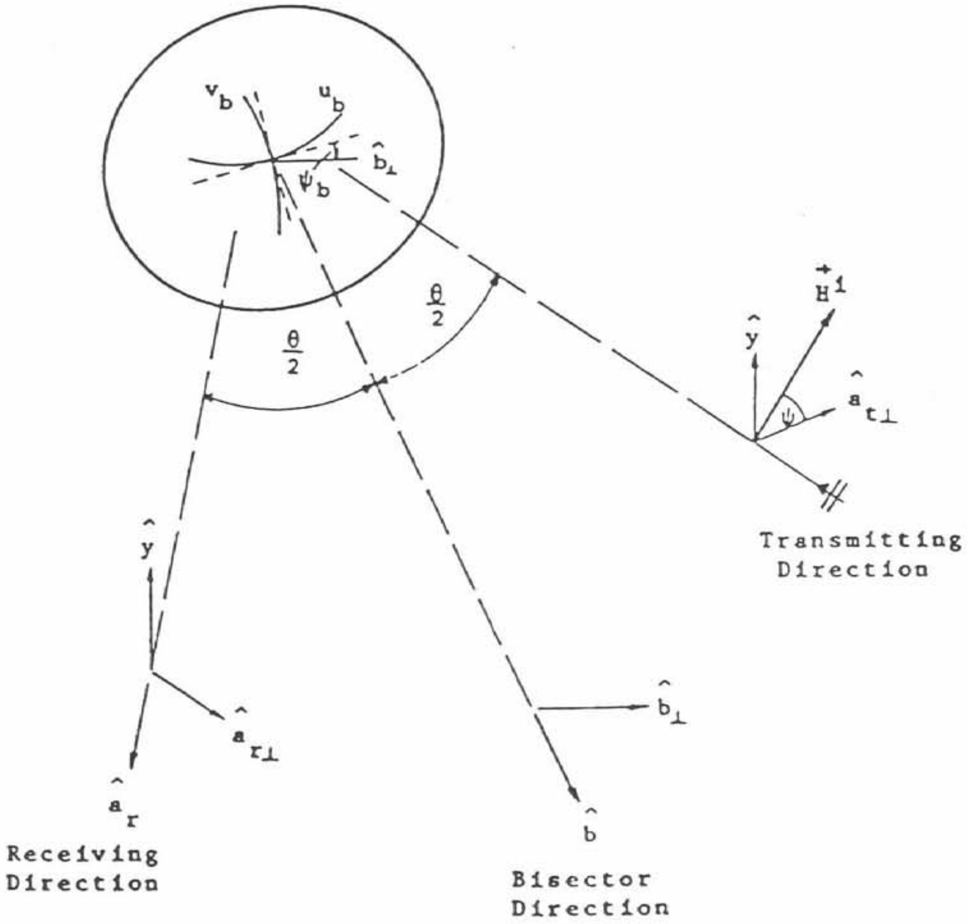

Fig. 2 Coordinate System for Polarization Correction