BISTATIC RADAR CROSS SECTION OF AN COMPLEX TARGET ON SEA SURFACE

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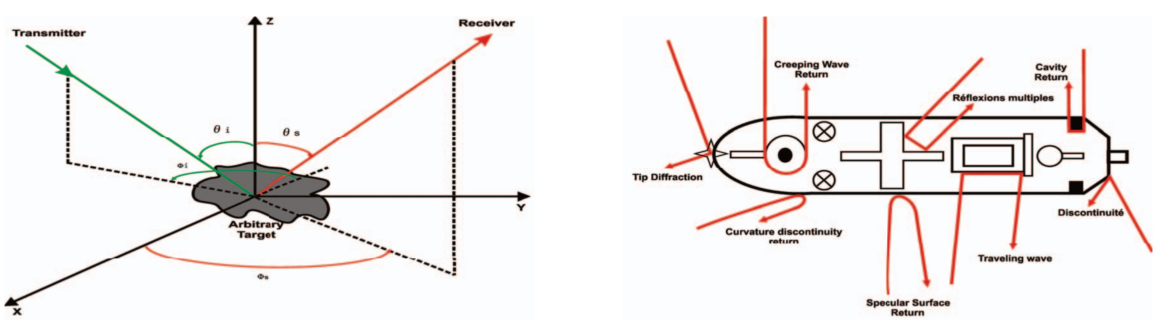
1. INTRODUCTION

Technological advances in radar and telecommunications have been accompanied by the development of modeling tools, to apprehend the best interaction phenomena of electromagnetic waves with natural environment. Applications of these modeling tools are calculating the Radar Cross Section (RCS) [1] of complex targets which can be use for detection, characterization, radar imagery. The present paper deals with an efficient approach based on the high frequency asymptotic methods (HFA). Physical optics (PO) [2] and the equivalents currents method (ECM) [2] are used to estimate the RCS of an arbitrary metallic or dielectric target integrated on the sea surface. This paper contains two parts, the first part presents the calculation of monostatic and bistatic RCS of complex targets without considering the influence of the environment. The second part deals with the calculation of the RCS of a target on the sea surface by taking into account electromagnetic interaction between target and environment, we give in this abstract a first result of a perfectly conducting cube over a perfectly conducting plate in monostatic and bistatic configuration. For the final paper, the RCS of a complex target complex over a rough sea surface will be given.

2. RADAR CROSS SECTION OF COMPLEX TARGETS

In this paper physical optics and equivalents currents method are used for the formulation and calculation of complex target RCS. They are well suited for RCS calculation of a target. So, we will use those methods in our approach with consideration of bistatic configuration and some scattering mechanisms. A typical RCS simulation scenario is composed of the transmitter,



(a) (b)

Fig. 1. (a) Typical RCS simulation scenario. (b) Several scattering mechanisms.

receiver and target as shown in figure 1. We give here, the principle of the physical optics and the equivalent currents method.

2.1. Physical Optics (PO)

The physical optics approximation is one of the most convenient RCS prediction methods. The current is used in the radiation integrals to compute the scattered far field. Physical Optics gives best results for electrically large bodies, and is most accurate in the specular directions [1].

2.2. The equivalent currents method (ECM)

The equivalent currents method is a technique involving integrals of radiation. The source of diffracted field is attributed to the fictitious equivalent currents, both electric and magnetic, which flowing along the edge. The expressions given by Michaeli [3] are used to determine the diffracted far-field by an edge, and are based on the fringe currents existing on the edge.

2.3. Scattering mechanisms

The computation of the RCS of large and complex targets involves different scattering mechanisms, such as specular reflexion, diffraction by edge, multiple scattering, shadowing effects, creeping waveetc, the reader may refer to figure 1. In this paper we consider the following mechanisms: specular reflexion, multiple scattering [4], diffraction by edges [5], and shadowing effects [6].

3. INTERACTION OF WAVE WITH TARGET AND ENVIRONNEMENT

The purpose of this part is to study of the RCS of a complex target located in a rough sea surface [7, 8, 9]. The complexity of the target and multiple interactions between the target and a rough surface make the simulation model more difficult. We give here a summary of the geometrical and physical characterization of the sea surface to be used in the full paper to generate a rough sea surface using Elfouhaily [10] spectrum and asymptotic method [1] to calculate RCS of complex target is over rough surface.

3.1. Physical characteristic of sea surface

The scattering of electromagnetic waves by a rough sea surface requires knowledge of the physical characteristics of seawater and surface state [11]. The physical parameters that characterize the sea surface are the magnetic permeability and dielectric constant. The relative magnetic permeability is unitary because we assume that the sea surface is non magnetic. The dielectric constant is a physical property that describes the response of a given medium to an electric field [12].

3.2. Geometrical characterization of sea surface

The sea surface can be considered as a random rough surface whose evolution is controlled mainly by wind and gravity. The waves at each point on the surface resulting from a summation of waves generated locally by wind and waves from other regions and directions. These interactions make the problem difficult to quantify. That is why a statistical approach has been favoured by researchers to equate the geometry of the sea surface, using either the slopes distribution and rough spectrums. The Elfouhaily's spectrum [10] established in 1997 due to a synthesis of all works done since the 70's. This model is semi-empirical and takes into account the fetch, speed and wind direction.

4. NUMERICALS RESULTS

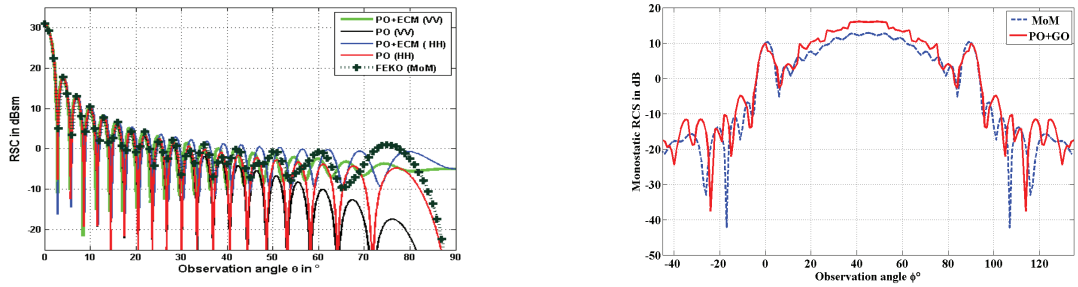
In order to validate our method, monostatic RCS of a perfectly conducting plate is presented here. Then a perfectly conducting dihedral illustrate multiple scattering contributions. Another more complex case of a cube over a flat surface is presented here in Monostatic and bistatic configuration.

4.1. Rectangular plate

Monostatic RCS of a square plate with side lengths of $10 \times \lambda$ and zero thickness is calculated at a frequency equal to 3 GHz. To demonstrate the contributions of edge, the simulation shown in figure 2 presents a comparison between the results obtained only by the physical optics, and another obtained with the PO and ECM. We can observe the ECM contribution from 80 compared to the physical optics results. In comparaison with FEKO (MoM) [5] solution, our approach yields quite accurate results.

4.2. Corner reflector dihedral

The dihedral corner reflector is very interesting target to study the multiple scattering. The specific dihedral for which experimental results are available in the literature [4], is constructed of two sheets of square planar sides $A = B = 5.6088 \times \lambda$. These experimental measurements were performed at a frequency of 9.4 GHz. A mesh model is used to define the geometry of the target. The monostatic RCS is presented on the figure 2. The result obtained by the model developed here shows a good agreement with results obtained using FEKO (MoM) [5] and those given in [4].



(a) (b)

Fig. 2. (a)Monostatic RCS of square plate at 3GHz . (b)Monostatic RCS for perfectly conductor dihedral .

4.3. Cube over plane surface

It is mentioned in [11] that changes in the RCS of a complex target caused by a rough sea surface can be taken into account by studying the RCS of a target located in a flat surface, because the surface of the sea at the local level in vicinity of the target tends to look like a flat plane. In order to give a first result for interaction between target and sea surface, we have calculated monostatic and bistatic configuration. The RCS of a $2 \times \lambda$ perfectly conducting cube over an $8 \times \lambda$ square conducting plate figures 4 and 5 show good agreement of our results and those obtained by FEKO (MoM) [5]and those given in [9]. In figure 5 (a) results are given for transmitter is located by $\theta_i = -45$ and $\phi_i = 0$, the receiver position defined by $\phi_s = 0$ ans $\theta_s = 0\ to\ 90$. In figure 5 (b)transmitter postion is $\theta_i = 45$ and receiver position $\theta_s = -90\ to\ 0$

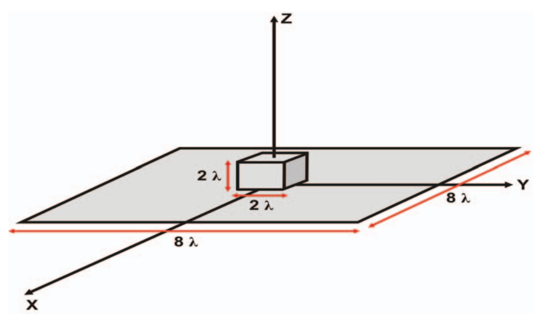
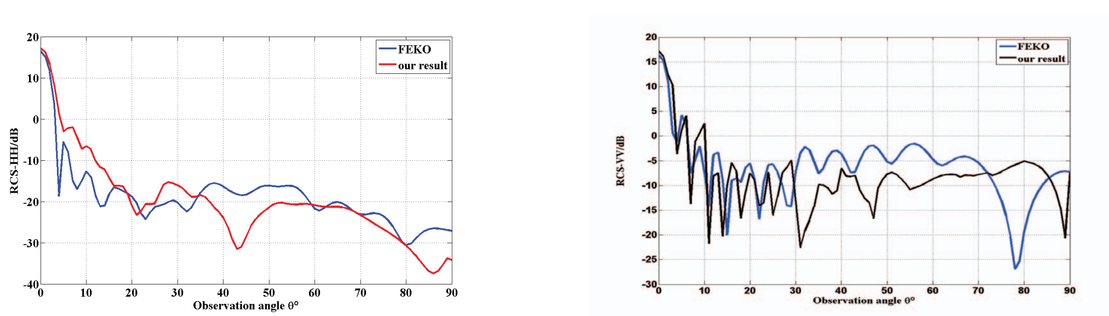
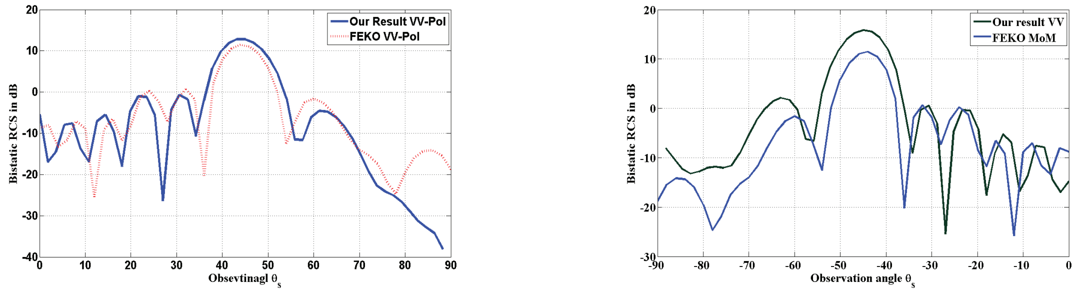


Fig. 3. Geometrical configuration of a cube over square plate



(a) (b)

Fig. 4. (a)Monostatic HH-RCS at 10 GHz . (b)Monostatic VV-RCS at 10 GHz.



(a) (b)

Fig. 5. (a). Bistatic VV-RCS at 10 GHz . (b)Bistatic VV-RCS at 10 GHz.

5. CONCLUSION

Using physical optics and the equivalent currents method for modelling of the RCS of a complex target provides good results compared with FEKO (MoM), by taking into account the shadowing effects, multiple scattering and diffraction by edges. Results for the dielectric surfaces and the bistatic calculations follow in the final paper to complete the developed model. Other results will be given in the full paper to show the influence of rough sea surface on the RCS of complex targets.

6. REFERENCES

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