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MOM Application for Calculating the RCS Dielectrics and Arbitrary Two- Dimensional Geometric Shape Formulation of Integral Equations Cylindrical Dielectric

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***Abstract*— This work focuses on the study of the dispersion of electromagnetic waves caused by two-dimensional structures: it is to develop a numerical code called TMHD, which is based on the method of moments (MoM), to calculate the Radar Cross Section (RCS or SER) of arbitrary two-dimensional geometry structures. Examples: homogeneous dielectric cylinder circular and square.**

***Index Terms*—MoM method, RCS dielectrics, cylindrical dielectric.**

I. INTRODUCTION

The use of powerful computers, do not have only helped accelerate the speed of long and complicated calculations, but also to contribute to the development of numerical methods and to develop new algorithms that allow to turn , solve equations governing concrete physical phenomena, the analytical solutions are often tedious and time-consuming or even impossible. In the past, there was a huge effort to find analytical approximations to reduce the number and time calculations. Currently, the use of computers and numerical methods, we increase the number of calculations while reducing the analytical effort.

Among the currently existing numerical methods, we include the method of moments (MoM) [1] which is fixed on our choice to make this work. Admittedly, this is not the method most used in the world of scientific research, but it remains the most accurate and most cited as a reference to the time to compare the results obtained by other numerical methods (finite differences, finite elements ...) [2-3] . The basic idea of the MoM is to reduce the integral equation, which is a functional to a matrix equation (Equation N unknown system) easily solved by known techniques.

In this work we will try to calculate the Radar Cross Section (RCS or SER) [4] of some two-dimensional structures in a homogeneous dielectric material. But first we begin by studying the theoretical basis of integral equations that allow reaching the calculation of this amount, which is the RCS. In the section below, we describe the theoretical foundations on which is based the digital program that we developed to calculate the SCR undefined cylindrical dielectric, and arbitrary cross-section, which falls on an incident wave TM (Hz = 0).

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II. CALCULATION OF THE RCS FOR TWO DIMENSIONAL PROBLEMS

A. Definition of the RCS

The cross section of radar estimated power or diffracted electromagnetic energy in a given a target illuminated by an incident wave direction [5-6] . It is normalized by the power of the incident wave illuminating the object, is independent of the distance from the exciting source of the target object, the power from the source, it is an echo area characterizing the target or the object.

The radar cross section of the RCS is defined as a surface intercepting an amount of power which, when it is radiated in a uniform manner in all directions in space, produces a power density equal to that scattered by the real object [7].

B. Expression of RCS

Because of the magnitude of the far field of dimensional problems decreases $p^{-1/2}$ instead of r^{-1} and three-dimensional problems, the radar cross section is defined as for the incident wave TM.

$$\sigma_{TM} = \lim_{\rho\to\infty} 2\pi\rho \frac{|E_z^s(\rho,\emptyset)|^2}{|E_z^i|^2} \qquad (2.1)$$

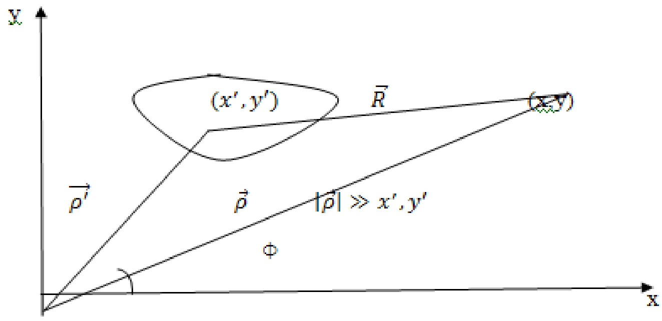


Figure 1: Far-field approximation.

Given:

$$E_z^i(x,y) = e^{-jk(x\cos\emptyset + y\ sen\ \emptyset)} \qquad (2.2)$$

And using

$$E_z^s(x,y) = -jk\eta A_z - \frac{\partial F_y}{\partial x} + \frac{\partial F_x}{\partial y} \qquad (2.3)$$

where $\vec{A}(x,y) = \iint \vec{J}(x',y')\frac{1}{4j} H_0^{(2)}(kR)dx'\,dy'$ (2.4)

$$\vec{F}(x,y) = \iint \vec{M}(x',y')\frac{1}{4j} H_0^{(2)}(kR)dx'\,dy' \qquad (2.5)$$

R=

$$\sqrt{(x-x')^2 + (y-y')^2} = \sqrt{(\rho\cos\emptyset - x')^2 + (\rho sen\emptyset - y')^2} \cong \qquad (2.6)$$

$$p \to \infty^{\rho}\sqrt{1-\frac{2}{\rho}(x'cos\emptyset + y'sen\emptyset)} \cong p - x'cos\emptyset - y'sen\emptyset$$

It takes into account the asymptotic behavior of the Hankel function

$$\lim_{\alpha\to\infty} H_0^{(2)}(\alpha) = \sqrt{2\,\frac{j}{\pi\alpha}}\,e^{-j\alpha} \qquad (2.7)$$

obtained

$$\sigma_{TM} = \frac{k}{4}\left|\iint(\eta J_z + M_x sen\emptyset - M_y cos\emptyset)e^{jk(x'cos\emptyset+y'sen\emptyset)}\,dx'dy'\right|^2 \qquad (2.8)$$

The theoretical expression of the RCS is given by [8]:

$$\sigma_{TM} = \lim_{\rho\to\infty}\left[2\pi\rho\frac{|E_z^s|^2}{|E_z^i|^2}\right] = \frac{4}{k}\left|\sum_{n=-\infty}^{+\infty}\frac{-J_n(k_i a)J'_n(k_e a)+\frac{\eta_e}{\eta_i}J'_n(k_i a)J_n(k_e a)}{J_n(k_i a)H_n^{(2)}(k_e a)-\frac{\eta_e}{\eta_i}J'_n(k_i a)H_n^{(2)}(k_e a)}e^{jn\emptyset}\right|^2 \qquad (2.9)$$

Where $\eta_i = \sqrt{\frac{\mu_i}{\varepsilon_i}}$ et $\eta_e = \sqrt{\frac{\mu_e}{\varepsilon_e}}$

i: the inner dielectric e: outdoor thereto.

k_i : Constant internal propagation

k_e : Constant outdoor propagation

a : radius of cell

$H_n^{(2)}$: Hankel function of order n, species 2

j_n : Bessel function of order n

η_e : Impedance external wave

η_i : Impedance internal wave

j'_n : Bessel function of the source

$\emptyset$: Angle of incidence

k : wave number

III. TO VERIFY RESULTS

the EFFICIENCY of the code produced, based on the method of moments (MoM), we presented in Figure 2, the results of overlap, that is to say, the results from our code and those obtained by the theoretical formula of equation (2.9). We see clearly the influence of modulation (number of cells in the structure) the accuracy of the results.

Figure 3 shows the radar cross section (RCS) bistatic a circular dielectric cylinder homogeneous and indefinite, for two values of the constant relative ε_r : 4 and 10. The results are compared to theoretical resolution, during the modulation of the structure of 30 cells per unit wavelength. We note, in this figure, the perfect coincidence of results (the oretical and MoM).

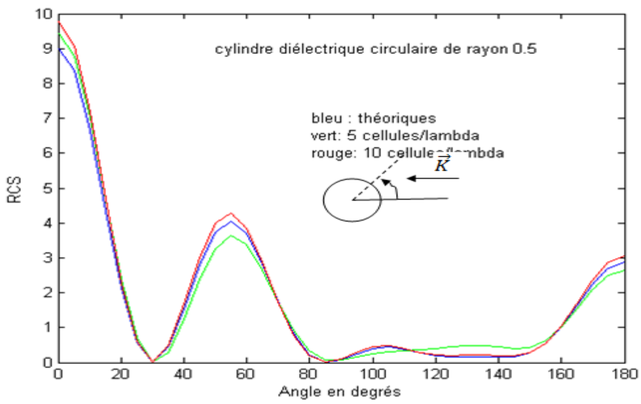


Figure 2: shows the RCS of a homogeneous dielectric cylinder square for two values of side and on a constant: 0.2 λ and 0.5 λ, ε_r= 4 et μ_r= 1.

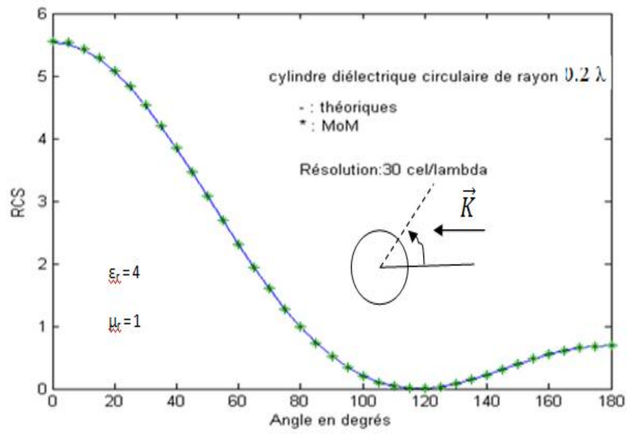
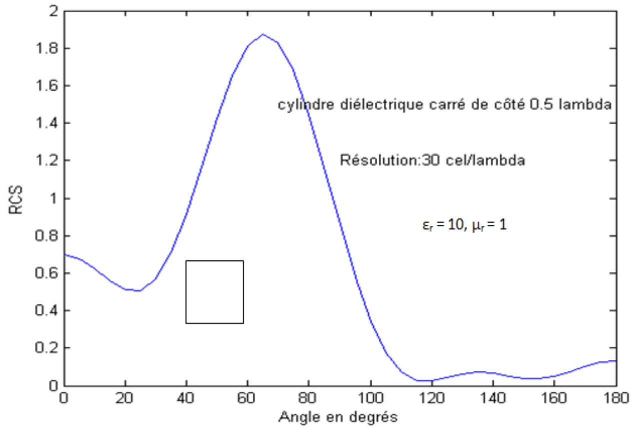
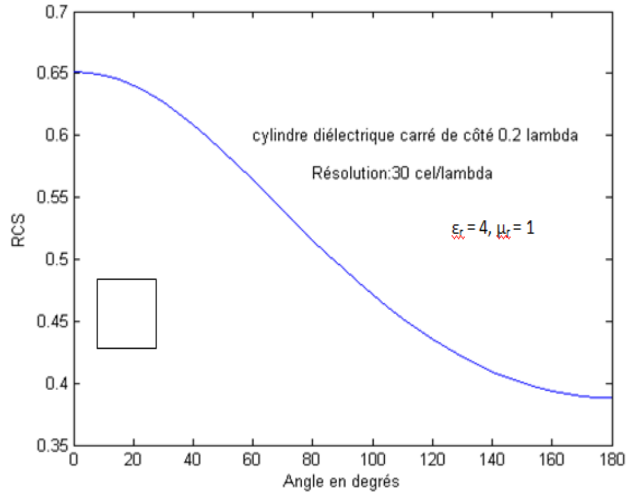


Figure 3: bistatic RCS of a circular radius 0.2 λ incident wave dielectric cylinder: TM; incidence angle: 0 degrees.





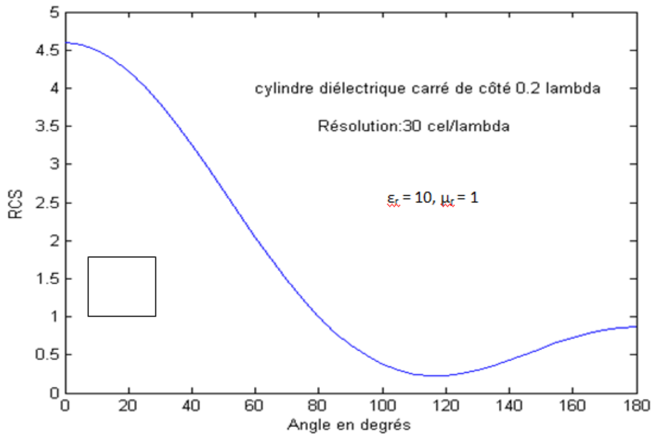


Figure 4: bistatic RCS of a dielectric cylinder square of side 0.2 λ incident wave: TM; incidence angle: 0 degrees.

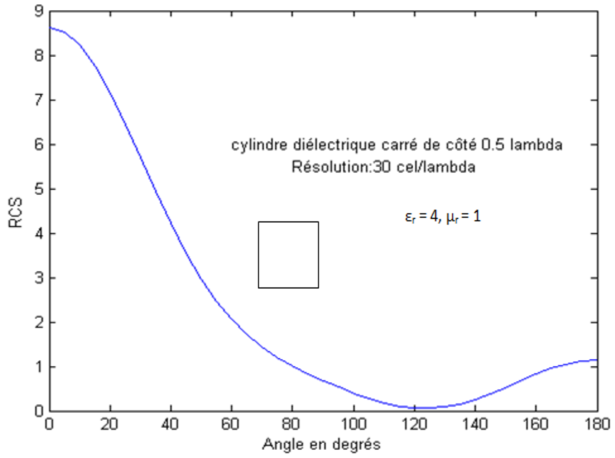


Figure 5: bistatic RCS of a dielectric cylinder square of side 0.5 λ incident wave: TM; incidence angle: 0 degrees.

IV. CONCLUSION

This work has allowed us to learn about the numerical simulation of physical problems, that is, here, the calculation of the RCS and indefinite homogeneous dielectric cylinder, through the implementation of computer programs based on the numerical method called: method Moments (MoM).

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