THE GMT APPLIED TO ANTENNA PROBLEMS

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Abstract
The concept GMT (**G**eneralized **M**ultipole **T**echnique) is a generic name recently choosen by different groups of at least four continents working on similar methods. The MMP–programs (**M**ultiple **M**ulti**P**oles) are a programm package which have been developped for the last 8 years in our group and are now installed on PC's.

The aim of this paper is to show the possibilities of the method for the calculation of various types of antennas. For some of the following examples the method is particularly adapted, but the limits of the method will be shown. The computation time for all the examples will be given.

For this purpose, an elliptical cylinder with elliptical hat and a cubic rod (both body with ideal material) have been investigated. The results of the computations for the different fields will be shown.

1 The MMP- Method, now called GMT

Different groups, from Japan, Europe, USA and Israël were working on similar methods involving multipoles as basis functions. They have agreed to use a common generic name [1], which is GMT (Generalized Multipole Technique), so the name MMP–method [2] used in previous publications, is now replaced by GMT, and the name MMP is kept for the program package.

For the MMP–programs, the domains have to be piecewise linear, homogeneous and isotropic. The time dependency is harmonic. Work is actually in progress to allow the computation with transient fields and also with non linear materials. The programs are based on a direct expansion of the electrical and magnetical field (Helmholtz equation). More precisely, for scattering problems in 3D, we have to find a vector function f, which fulfills the partial differential equation $H_i f = g_i$ in each subdomains D_i of the field region D. H_i $(\Delta + k_i^2)$ is the Helmholtz operator and g_i the source of the field (plane wave, dipole, etc.).

Additionally, f must fulfill continuity conditions on the bondary between D_i and D_j. The solution to this problem leads to expand the function f –in each D_i– in a series of basis functions:

$$f = A_{i0} f_{i0} + \sum_{k=1}^{N} A_{ik} f_{ik}$$

with $H_i A_{ik} f_{ik} = 0$ and $H_i A_{i0} f_{i0} = g_i$

The expansion functions f_{ik} are exact solutions of the field equation in a domain. In general, we use multipoles. They also may have different origins. The A_{ik} are calculated with the boundary equations, using an generalized point matching technique (GPMT). This GPMT simply uses an overdetermined system of equations which is solved in the least–squares sense. The weighting of each equation is given by the the error method (EM), whith a good definition of the error.

Only the boundary of the domains has to be discretized (even in the case of lossy materials), which is a major advantage, especially for installation on PC's. Another advantage of the method is that when you have the A_{ik}, the calculation of the field anywhere (near and farfield) and the zooming are very easy.

2 Power and limits of the method

The first body (ideal elliptical cylinder, $\epsilon = 0.745$) has 3 planes of symmetry and a smooth geometry. The second one (the cubic rod) has also 3 planes of symmetry but the geometry is not anymore smooth (corners and edges). These geometric singularity are a problem for the method. We need the boundary conditions (as we have seen in the first paragraph) to determine the parameters and for that purpose the direction of the tangents must be well defined. At the geometrical singularity, this is clearly not the case. We have to consider a surface which is continuous but not differentiable everywhere. As there are no tangents at the singularity, no points for the fulfilling of the boundary conditions can be placed there. So what are the possibilities to overcome that difficulty? Well, as soon as we are leaving the singularity, the boundary conditions can be fulfilled. So a special treatment for a sharp edge with the MMP–method is needed. This can be solved in a few simple steps. For example, extra multipoles (they always have a very local behavior) for the (sharp) edges, division of the bulk of the lossy body in fictitious subdomains, appropriate weighting for ideal conductors, etc.

It is not necessary to implement additional numerical conditions as for example the Meixner edge condition or the Sommerfeld radiation condition as the multipoles fulfill all these conditions implicitely. A multipole in 3D has the following typical form:

$$f_{in} = \frac{1}{\sqrt{r}} H^{(1)}_{m+1/2}(\underline{k}r) P^n_m(\cos\theta) \sin(n\phi)$$

With simple limit considerations, it is possible to show that all these conditions are satisfied. On the other hand, an analytical treatment of the sharp edge (when possible) shows that the field should be infinite at the singularity. Of course, this could be very nice for some applications but our method only allows a finite dimension for the fields, which is presumedly nearer to the physical reality.

3 Results and discussion

The programs are implemented on Sun workstations and on PC's with a good configuration (processor 80386 with coprocessor 80387, Weitek mW1167 accelerator , memory extension). Now, the parallelisation of the installation is completed and with T800 transputers bigger problems can be calculated much faster [3].

The illumination is always a horizontal plane wave with vertical polarisation. The length of our finite cylindrical bodies are $\lambda/2$. The relative magnetic susceptibility (μ_r) and electrical permittivity (ϵ_r) are both choosen to be one.

Figure 1 shows the error on the boundary for the elliptical cylinder. The left and the right pictures are the same representation of the error taken from two different points of view (3D–pictures). Only 1/8 of the cylinder is shown on the picture as symmetry considerations are used and only a part of the body needs to be discreticised.

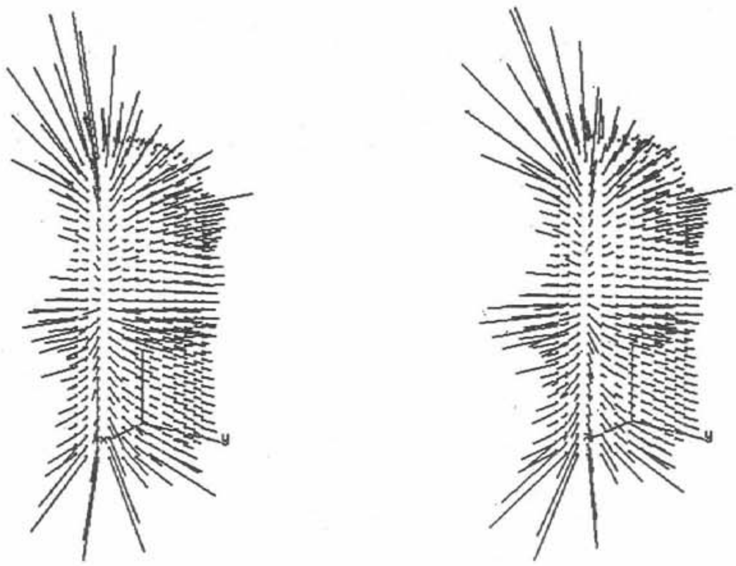

Figure 1 Error on the boundary, stereo figures

Figure 2 shows the electrical and magnetical field for the elliptical cylinder in three planes (xy–, xz– and yz–plane). The signification of the pictures: the length of the arrow is proportional to the projection of the vector field on the plane of representation. The radius of the circles is proportional to the perpendicular (to the plane of representation) projection of the field. The computation time on a Sun 3/260 workstation is approximatively 4100 sec (668 unknowns).

Figure 3 shows the results for the rod in three planes for the electrical and magnetical field. The error is bigger in the top plan and also at the corner. If the nearfield does look good the error (residius) are relatively big, as the multipoles can model a smooth shape, but have difficulties as soon as the geometry is getting a little wild.

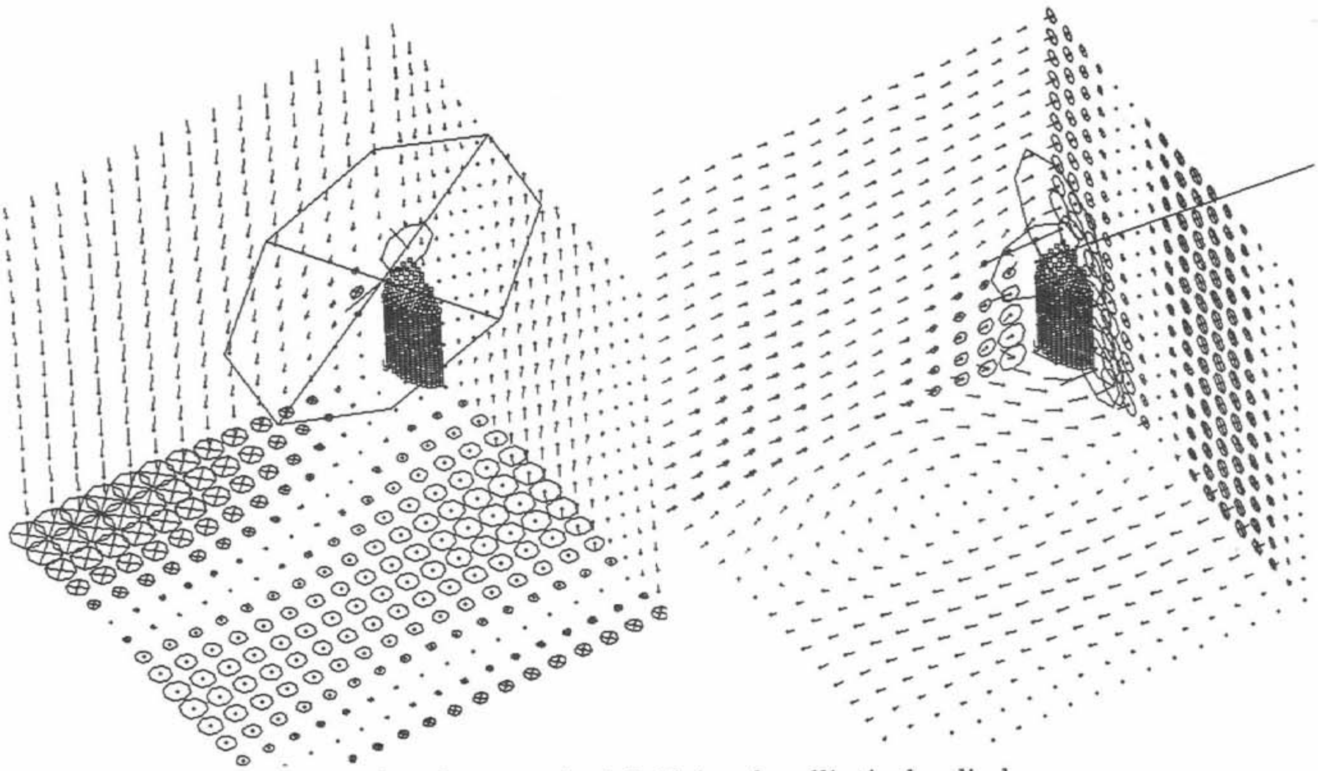

Figure 2 Electrical and magnetical field for the elliptical cylinder

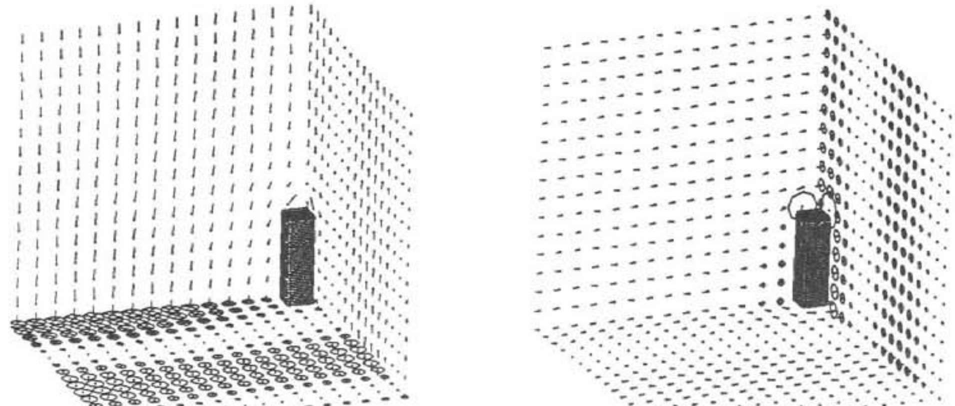

Figure 3 Electrical and magnetical field for the rod

References

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