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THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

Radiation Laboratory

SCATTERING OF ELECTROMAGNETIC WAVES BY MOVING BODIES

Final Report (15 April 1969 - 30 September 1970)

By
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Grant GK 10213

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Prepared for:

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Summary

For the period 15 April 1969 to 15 April 1970, most of the research under NSF Grant GK 10213 had been devoted to the following three problems.

(1) Dyadic Green's function pertaining to waveguides containing a moving isotropic medium.

(2) Scattering of electromagnetic waves by a moving conducting cone.

(3) Dyadic Green's function pertaining to a moving cylindrical dielectric column.

While problems relating to waveguides containing moving media have been discussed previously, the determination of the dyadic Green's function is a worthwhile addition because of the ease with which it can be applied to problems involving forced excitations due to currents or aperture fields.

To further broaden our knowledge of scattering by moving bodies it is useful to consider the solutions of problems involving less restrictive cases than have been previously considered (sphere, wedge, conducting cylinder).

The results of such a study will have increasingly important application in radar detection and communication with moving objects such as space vehicles.

Discussion of Research

The approach used in the solution of the above problems is based on the invariance of the laws of electrodynamics under uniform translation as postulated by the Special Theory of Relativity.

Problem (1)

This problem was solved using a reduced field defined by

$$\bar{F} = e^{-i\omega\Omega z} \overline{\overline{b}} \cdot \bar{F} \quad (b)$$

where the reduced field $\bar{F}^{(b)}$ represents either the $\bar{E}$ or $\bar{H}$ field, Ω is a constant proportional to the velocity of the medium and $\bar{\bar{b}}$ is a diagonalized dyad which is a function of the medium refractive index and its velocity. The Maxwell-Minkowski equations for the reduced field in the case of a moving medium take on a particularly simple form which is very similar to Maxwell's equations for a stationary medium. This formalism has been used to find the dyadic Green's function for the waveguide by the method of eigenfunction expansion.

Due to the particular form for the eigenfunctions it is found that a pole is introduced which must be excluded when performing the expansion of the delta function in terms of a series and contour integral involving the eigenfunctions. This phenomenon has never been observed in stationary medium Green's function problems. The work on this problem has been completed.

Problem (2)

The problem of scattering of electromagnetic radiation by an object moving with respect to an observer can be solved by using the Lorentz transformation to express the incident fields in a coordinate system which is stationary with respect to the object. The scattered fields are then determined using existing theory for scattering by stationary objects and these fields are then transformed back to the observer's frame of reference.

Expressions for the total fields have been obtained for this problem in terms of associated Legendre functions of non-integer degree. The interpretation of these results is not yet complete.

Problem (3)

To solve the problem of the moving dielectric cylinder it is first necesary to determine the dyadic Green's function for a stationary cylinder. During the period of this grant, the solution for the stationary cylinder has been obtained.

The dyadic Green's function has been available previously for the case of a perfectly conducting cylinder, but it has never been determined for the dielectric case. The function was constructed using the method of scattering superposition. The final expression exhibits a coupling between the TE and TM modes in contrast to a dielectric sphere which has no such coupling.

Extension of Time Period

Grant GK-10213 was planned to run for a period of approximately one year ending 15 April 1970. The completion date was extended to 30 September 1970 in accordance with the six-month grace period described in the NSF Brochure on Grants .

In March of this year, a proposal for an extension of funded study was submitted to NSF for an additional two years. We have now learned that the National Science Foundation has provided for a one year extension of the work under a new Grant.

Publications

A paper "Dyadic Green's Functions Pertaining to a Dielectric Cylinder," by Professor Chen-To Tai was given at the URSI Meeting in Washington , DC on April 16-19, 1970.

A paper "Dyadic Green's Functions for Waveguides with a Moving Isotropic Medium, "by C. F. Stubenrauch and C-T Tai was presented at the 1970 IEEE G-AP International Symposium held September 14-17, 1970 at Ohio State University, Columbus. It is expected that this talk will also be submitted later for publication.

Personnel

The NSF Grant GK-10213 was awarded to The University of Michigan Radiation Laboratory which is under the direction of Professor Ralph E. Hiatt. The Project Director is Professor Chen-To Tai whose assistants included a graduate student, Mr. Carl F. Stubenrauch.