AD-A106 982   SOUTH CAROLINA UNIV COLUMBIA DEPT OF MATHEMATICS AND--ETC F/G 20/3
STABILITY AND GROWTH ESTIMATES FOR ELECTRIC FIELDS IN NONCONDUC--ETC(U)
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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFOSR-TR- 81 -0706	2. GOVT ACCESSION NO: AD-A106982
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): STABILITY AND GROWTH ESTIMATES FOR ELECTRIC FIELDS IN NONCONDUCTING DIELECTRICS WITH MEMORY	5. TYPE OF REPORT & PERIOD COVERED: FINAL, 1 JUL 77 — 30 APR 81
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Frederick Bloom	8. CONTRACT OR GRANT NUMBER(s): AFOSR-77-3396
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Department of Mathematics and Statistics, University of South Carolina, Columbia SC 29208	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 61102F, 2304/A4
11. CONTROLLING OFFICE NAME AND ADDRESS: Mathematical & Information Sciences Directorate, Air Force Office of Scientific Research, Bolling AFB DC 20332	12. REPORT DATE: AUG 1981
	13. NUMBER OF PAGES: 4
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

DTIC ELECTE NOV 10 1981 D

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Stability; electromagnetic; dielectric; memory; nonlinear.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The report is of a mathematical study of electromagnetic phenomena associated with nonlinear dielectrics having memory. Definite details are available in the scientific papers produced and in the SIAM monograph, "Ill-posed Problems for Integrodifferential Equations in Mechanics and Electromagnetic Theory", SIAM Studies in Applied Mathematics, August 1981. The basic thrust of the work has been the derivation of stability and growth estimates (in suitable function space norms) for both electric fields and electric induction fields (CONT.)

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AFOSR-TR- 81-0706

August 1, 1981

FINAL REPORT

[redacted]
AFOSR-77-3346

Stability And Growth Estimates For Electric Fields In Nonconducting Dielectrics With Memory

7/1/77-4/30/81

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In the summer of 1977, this author initiated a program of study whose basic aim was to describe the qualitative behavior of rigid, nonconducting material dielectrics exhibiting memory effects. In effect, this program led to the study of specific evolution equations (systems of partial integro-differential equations) which result when the classical local forms of Maxwell's equations in a Lorentz reference frame are combined with the simple vector identity

$$\Delta E = \text{grad}(\text{div } E) - \text{curl curl } E$$

(where E is the electric field) and various constitutive hypotheses relating the electric field and the electric induction field D as well as the magnetic field B and the magnetic intensity H. Two basic types of constitutive relations were examined; the first of these was proposed by Maxwell in 1877 and subsequently used by Hopkinson in connection with his studies on the residual charge of the Leyden jar. The Maxwell-Hopkinson theory is governed by the constitutive relation

$$D(x,t) = \epsilon E(x,t) + \int_{-\infty}^{t} \phi(t-\tau) E(x,t)d\tau, H(x,t) = \mu^{-1}B(x,t)$$

where $\epsilon > 0$, $\mu > 0$, and $\phi(t)$, $t \geq 0$ is a continuous monotonically decreasing function of t. Implications of the Maxwell-Hopkinson theory have been derived in references [8] and [9] as well as in the recent SIAM monograph by this author ([1]). The second, and more interesting set of constitutive hypotheses, upon which a good deal of our work has been based, are those which incorporate the concepts of holohedral and hemihedral isotropic dielectric response as introduced by R.A. Toupin and R.S. Rivlin in 1960. Noting that the Maxwell-Hopkinson constitutive relations do not account for the observed absorbtion and dispersion of electro-magnetic waves in material non-conductors, Toupin and Rivlin effectively build into their constitutive relations both magnetic memory effects as well as the coupling of electric and magnetic influences. A simplified version of the Toupin-Rivlin hypotheses has been studied by this author in the papers [4], [5] and [10] and a complete presentation summarizing all of this work may be found in Chapter III of the SIAM monograph [1]; the Toupin-Rivlin models are of particular can stand as a guide for the laboratory measurement of constitutive constants which appear in both the Maxwell-Hopkinson and Toupin-Rivlin theories. Throughout the course of this work the basic tools have been certain differential inequality arguments (logarithmic convexity, concavity, or a combination thereof) which had earlier been proven sucessful in dealing with ill-posed problems for Linear partial differential equations. In almost every instance we have had to extend and modify these arguments (or invent new ones) to deal with the systems of partial-integrodifferential equations which were relevant to our studies.

The principal investigator began work on this project while an assistant professor in the Mathematics Department at the University of South Carolina; he is currently an associate professor in that same Department. During the year 1980-81 the principal investigator was a visiting associate professor in the School of Mathematics at the University of Minnesota. The principal investigator was invited by the AMS to organize a special session on ill-posed problems for integro-differential and partial differential equations at the annual meeting of that society in Atlanta in 1978. He also lectured for four weeks, by invitation, on the subject matter of the AFOSR Grant, in the Mathematics Department of the Technion, The Israel Institute of Technology, in December 1978 notes from that series of lectures resulted in the invitation from SIAM to produce the Monograph which is listed as reference [1] in the bibliography.

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