Project No: G-37-634 (R5979-0A0)

Project Director: E. P. Stephan

Sponsor: National Science Foundation

Type Agreement: Grant DMS-8501797

Award Period: From 7/1/85 To 12/31/86* (Performance) 3/31/87 (Reports)

Sponsor Amount:
- Estimated: $
- Funded: $

Cost Sharing Amount:
- Total to Date $17,000
- $6,244

Cost Sharing No: G-37-327

Title: Mathematical Sciences: Solution Procedures for Three Dimensional Crack Problems in Elasticity: Boundary Integral Equations and Boundary Elements

ADMINISTRATIVE DATA

OCA Contact: John Schonk x4820

1) Sponsor Technical Contact: Melvyn Ciment
   National Science Foundation
   MPS/DMS
   Washington, DC 20550

2) Sponsor Admin/Contractual Matters: Myra B. Galinn
   National Science Foundation
   DGC/MPS
   Washington, DC 20550

Defense Priority Rating: N/A

Military Security Classification: N/A

RESTRICTIONS

See Attached NSF Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT

COMMENTS:

*Includes 6 month flexibility period.

No funds may be expended after 12/31/86.
EOPGI \ INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 4-29-87

Project No. G-37-634 School/XXK Math

Includes Subproject No.(s) N/A

Project Director(s) E.P. Stephan GTRC /XIX

Sponsor National Science Foundation

Title Mathematical Sciences: Solution Procedures for Three Dimensional Crack Problems in Elasticity: Boundary Integral Equations and Boundary Elements

Effective Completion Date: 12/31/86 (Performance)3/31/87 (Reports)

Grant/Contract Closeout Actions Remaining:

[X] None

[ ] Final Invoice or Final Fiscal Report

[ ] Closing Documents

[ ] Final Report of Inventions

[ ] Govt. Property Inventory & Related Certificate

[ ] Classified Material Certificate

[ ] Other

Continues Project No. Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/GTRI Supply Services
Research Security Services
Library
GTRC

Project File

Other Duane H.

Angela Dubose
Russ Embry
Heyser

FORM OCA 69.285
MATHEMATICAL SCIENCES: SOLUTION PROCEDURES FOR THREE DIMENSIONAL CRACK PROBLEMS IN ELASTICITY: BOUNDARY INTEGRAL EQUATIONS AND BOUNDARY ELEMENTS

By

Ernst P. Stephan

Final Report for the Period July 1, 1985 through December 31, 1986

Prepared for

National Science Foundation
Washington, D.C. 20550

Under

NSI Award Number DMS-8501797

April 1987

GEORGIA INSTITUTE OF TECHNOLOGY
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF MATHEMATICS
ATLANTA, GEORGIA 30332
PART I—PROJECT IDENTIFICATION INFORMATION

1. Institution and Address
   Georgia Tech Research Corp
   Georgia Institute of Technology
   Atlanta, GA 30332

2. NSF Program
   Applied Mathematics

3. NSF Award Number
   DMS-8501797

4. Award Period
   From 7/1/85 to 12/31/86

5. Cumulative Award Amount
   $17,000

6. Project Title
   Mathematical Sciences: Solution Procedures for Three Dimensional Crack Problems in Elasticity: Boundary Integral Equations and Boundary Elements

PART II—SUMMARY OF COMPLETED PROJECT (FOR PUBLIC USE)

Research was carried out in numerical analysis, focusing mainly on problems involving boundary integral equations and boundary elements. The primary objectives were to determine: (i) existence, uniqueness and regularity of the solutions of the derived integral equations and the equivalence of the integral equations with the original boundary value problems; (ii) convergence of the approximation schemes used (Galerkin method and collocation); (iii) implementation of the discrete schemes to compute numerical approximations and numerical rates of convergence which underline the theoretical error analysis.

The project involved one faculty researcher over a one-year period with input from various collaborators and one graduate student; the work was both theoretical and applied and did also involve computers.

The primary findings included (i) new solution procedures for crack problems in linear elasticity based on first kind boundary integral equations on the crack surface, (ii) the explicit behavior of the displacement and traction fields near the crack front, (iii) the asymptotic convergence of improved Galerkin schemes with singular elements and of point collocation with graded meshes yielding quasi-optimal error estimates.

PART III—TECHNICAL INFORMATION (FOR PROGRAM MANAGEMENT USES)

1. ITEM (Check appropriate blocks)
   a. Abstracts of Theses X
   b. Publication Citations X
   c. Data on Scientific Collaborators X
   d. Information on Inventions X
   e. Technical Description of Project and Results
   f. Other (specify)

2. Principal Investigator/Project Director Name (Typed)
   Ernst P. Stephan

3. Principal Investigator/Project Director Signature

4. Date
   4-9-87
### PART IV - SUMMARY DATA ON PROJECT PERSONNEL

The data requested below will be used to develop a statistical profile on the personnel supported through NSF grants. The information on this part is solicited under the authority of the National Science Foundation Act of 1950, as amended. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. NSF requires that a single copy of this part be submitted with each Final Project Report (NSF Form 98A); however, submission of the requested information is not mandatory and is not a precondition of future awards. If you do not wish to submit this information, please check this box ☐.

Please enter the numbers of individuals supported under this NSF grant. Do not enter information for individuals working less than 40 hours in any calendar year.

<table>
<thead>
<tr>
<th>*U.S. Citizens/Permanent Visa</th>
<th>PI's/PD's</th>
<th>Post-doctorals</th>
<th>Graduate Students</th>
<th>Under-graduates</th>
<th>Precollege Teachers</th>
<th>Others</th>
</tr>
</thead>
</table>

**Total U.S. Citizens**

**Total U.S. & Non-U.S.**

**Number of individuals who have a handicap that limits a major life activity.**

*Use the category that best describes person's ethnic/racial status. (If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)*

**AMERICAN INDIAN OR ALASKAN NATIVE:** A person having origins in any of the original peoples of North America, and who maintains cultural identification through tribal affiliation or community recognition.

**ASIAN OR PACIFIC ISLANDER:** A person having origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands. This area includes, for example, China, India, Japan, Korea, the Philippine Islands and Samoa.

**BLACK, NOT OF HISPANIC ORIGIN:** A person having origins in any of the black racial groups of Africa.

**HISPANIC:** A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

**WHITE, NOT OF HISPANIC ORIGIN:** A person having origins in any of the original peoples of Europe, North Africa or the Middle East.

**THIS PART WILL BE PHYSICALLY SEPARATED FROM THE FINAL PROJECT REPORT AND USED AS A COMPUTER SOURCE DOCUMENT. DO NOT DUPLICATE IT ON THE REVERSE OF ANY OTHER PART OF THE FINAL REPORT.**
b. Publication Citations

List of papers by E. P. Stephan which were partially supported by NSF Grant DMS 8501797.


Publication Citations (continued)


c. Scientific Collaborators

The principal investigator, E. P. Stephan, was collaborating with Prof. Dr. W. L. Wendland, Universität Stuttgart; Dr. M. Costabel, Technische Hochschule Darmstadt; Prof. Dr. C. G. Hsiao, University of Delaware, Newark; Dr. M. Suri, University of Maryland, Baltimore County; Chr. Schwab, Department of Mathematics, University of Maryland, College Park; Prof. E. Meister, Technische Hochschule Darmstadt.
e. Technical Summary of Activities and Results

Results of research by E. P. Stephan which was supported in part by NSF Grant DMS 8501797 are summarized below. Abstracts of pertinent papers are given, followed by conferences, workshops, meetings, and universities at which talks were given and names of three researchers who were brought in for consultation.
Abstracts of papers of E. P. Stephan which were partially supported by NSF Grant DMS 8501797.


Abstract. This paper presents a solution procedure for three-dimensional crack problems via first kind boundary integral equations on the crack surface. The Dirichlet (Neumann) problem is reduced to a system of integral equations for the jump of the traction (of the field) across the crack surface. The calculus of pseudodifferential operators is used to derive existence and regularity of the solutions of the integral equations. With the concept of the principal symbol and the Wiener-Hopf technique we derive the explicit behavior of the densities of the integral equations near the edge of the crack surface. Based on the detailed regularity results we show how to improve the boundary element Galerkin method for our integral equations. Quasi-optimal asymptotic estimates for the Galerkin error are given.


Abstract. In this paper we analyze the solution of crack problems in three-dimensional linear elasticity by equivalent integral equations of the first kind on the crack surface. Besides existence and uniqueness we give sharp regularity results for the solution of these pseudodifferential equations. Two versions of Eskin's Wiener-Hopf technique are presented: the first one requires the factorization of matrix-valued symbols which is avoided in the second case. Based on these regularity results we show how to improve the boundary element Galerkin method for our integral equations by using special singular trial functions. We apply the approximation property and inverse assumption of these elements together with duality arguments and derive quasi-optimal asymptotic error estimates in a scale of Sobolev spaces.


Abstract. We prove convergence of the point collocation method for two basic integral equations of potential theory on plane polygons, namely the integral equation of the second kind with the double layer potential ("Neumann's integral equation") and the integral equation of the first kind with the single layer potential ("Symm's integral equation").

Abstract. We give for some special cases the singular forms (at corners and edges) of the solutions of 3D Laplacian problems. We incorporate such singular forms into a Galerkin procedure based on a regular partition of the 3D-domain and obtain optimal finite element error estimates.


Abstract. The boundary value problem is converted into a strongly elliptic system of boundary integral equations which can be used for numerical computations using Galerkin's procedure. The integral equations are analyzed using pseudodifferential operator calculus yielding existence and explicit regularity results.


Abstract. We formulate and prove Aubin-Nitsche-type duality estimates for the error of general projection methods. Examples of applications include collocation methods and augmented Galerkin methods for boundary integral equations on plane domains with corners and three-dimensional screen and crack problems. For some of these methods, we obtain higher order error estimates in negative norms in cases where previous formulations of the duality arguments were not applicable.


Abstract. This paper presents numerical experiments using the Galerkin and the collocation boundary element methods for first kind integral equations (with the single layer kernel) on an open surface in \( \mathbb{R}^3 \). Numerical results for the capacity are obtained.

Abstract. For three-dimensional transmission problems -- describing the scattering of elastic, time-harmonic waves by different, isotropic, linear elastic bodies -- we present a combined approach with finite elements and boundary elements. We show convergence and quasioptimality of the Galerkin scheme in the corresponding energy norm.


Abstract. We present numerical experiments for a modified collocation method with piecewise linear or quadratic trial functions according to the error analysis given in [3]. We find the experimental convergence in agreement with the theoretical results in [3].


Abstract. We solve the 3D conductor problem via an integral equation on a thin plate for the charge density. Based on the integral equation, the Galerkin procedure for 2D piecewise linear test and trial functions is implemented. The stiffness matrix is computed either by analytic integration or by suitably weighted Gaussian quadratures or combinations of both.


Abstract. We generalize to integral equations on pieces of curves the theoretical analysis of [3] and the numerical implementation of [9]. Especially the influence of graded meshes is studied.


Abstract. Consider a crack of finite length and arbitrary shape in a homogeneous isotropic ideal plane elastic field with given tractions on the crack faces. Then we derive a hypersingular integral equation for the displacements along the crack. The hypersingular integral equation can be analyzed for elastic fields of finite energy and provides for the corresponding stresses the same singular behaviour as for straight cracks. We obtain the validity of a singular expansion of the solution to the hypersingular equation by using the Mellin transform which also provides a modified boundary element method for the numerical treatment of the hypersingular equation.
Abstracts of papers (continued)


   Abstract. We analyze the p-version for the Galerkin procedure to solve the first kind integral equation governing the Neumann crack problem. We show the convergence rate for the Galerkin error is $O(p^{-1} \sqrt{\log p})$ in the energy norm where $p$ denotes the degree of the piecewise polynomials used as boundary elements. The standard $h$-version gives only $O(h^{3/2})$-convergence.


   Abstract. We derive quasioptimal error estimates of the Galerkin scheme with boundary elements solving an integral equation of the first kind with a hypersingular kernel.


Talks were presented at the following meetings, conferences, and universities by E. P. Stephan.

1. UAB International Conference on Differential Equations and Mathematical Physics (Birmingham, Alabama)  
   Mar 1986

2. 4th Inter. Symposium on Numerical Methods in Engineering (Atlanta)  
   Apr 1986

3. Technische Hochschule Darmstadt (Germany) (Colloquium)  
   Aug 1986

4. 1st World Congress in Computational Mechanics (Austin, TX)  
   Sept 1986

5. University of Arizona, Tempe (Colloquium)  
   Nov 1986

   Nov 1986

7. University of Delaware, Newark (Colloquium)  
   Nov 1986
The following researchers were brought to Georgia Tech for research consultations with E. P. Stephan.

1. Prof. W. L. Wendland, Mathematisches Institut A, Universität Stuttgart (April 1986)

2. Dr. M. Costabel, Fachbereich Mathematik, Technische Hochschule Darmstadt (September 1985, April 1986)

3. Chr. Schwab, Department of Mathematics, University of Maryland (November 1986)
ERNST P. STEPHAN
CURRICULUM VITAE
JANUARY, 1987

STEPHAN, ERNST P..........................Associate Professor
School of Mathematics
Georgia Institute of Technology
Atlanta, Georgia 30332

PERSONAL DATA:

Born: 5/18/47, Birkenau, Hessen, Germany Federal Republic

EDUCATIONAL BACKGROUND:

Dipl. 1970 Technical University, Darmstadt (GER) Mathematics & Physics
Ph.D. 1975 Technical University, Darmstadt (GER) Mathematics
Dr.habil. 1984 Technical University, Darmstadt (GER) Mathematics


EMPLOYMENT HISTORY:

Wissenschaftlicher Mitarbeiter, Technical University, Darmstadt
1970-1983
Visiting Mathematician, Ecole Polytechnique, Paris-Palaiseau (France) (2 months)
1978
Visiting Mathematician, Carnegie-Mellon University, Pittsburgh (6 months)
1981
Visiting Mathematician, Israel Institute of Technology, Haifa (1 month)
1982
Visiting Mathematician, Institute for Applied Mathematics, Sonderforschungsbereich 72, University Bonn (2 months)
1984
Associate Professor, School of Mathematics, Georgia Tech 1983-pres

CURRENT FIELDS OF INTEREST:

Numerical Analysis for problems arising in mathematical physics and in partial differential equations.
(i) Solution procedures for potential problems and time-harmonic scattering (Helmholtz, Maxwell) and problems in elasticity (crack problems) by means of pseudodifferential operators (boundary integral equations).

(ii) Error analysis for Galerkin, collocation and least squares methods; quadrature errors; finite elements, boundary elements.

(iii) Regularity of elliptic boundary value problems in domains with corners and edges.

(iv) Coupling of finite elements and boundary elements.

TEACHING EXPERIENCE (at Georgia Tech):

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter 1984</td>
<td>Math 2308</td>
<td>Calculus V</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Math 2308</td>
<td>Calculus V</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Math 4640</td>
<td>Scientific Computing I</td>
<td>36</td>
</tr>
<tr>
<td>Spring 1984</td>
<td>Math 2308</td>
<td>Calculus V</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Math 4641</td>
<td>Scientific Computing II</td>
<td>14</td>
</tr>
<tr>
<td>Fall 1984</td>
<td>Math 2307</td>
<td>Calculus IV</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Math 4347</td>
<td>Intro.: Partial Diff.</td>
<td>33</td>
</tr>
<tr>
<td>Winter 1985</td>
<td>Math 3308</td>
<td>Differential Eqns.</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Math 4582</td>
<td>Advanced Eng. Math.</td>
<td>36</td>
</tr>
<tr>
<td>Spring 1985</td>
<td>Math 4348</td>
<td>Intro.: Partial Diff.</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Math 6647</td>
<td>Theory of Numer. Methods for PDE's</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Math 4347</td>
<td>Intro. Part. Diff. Equa.</td>
<td>30</td>
</tr>
<tr>
<td>Winter 1986</td>
<td>Math 2308</td>
<td>Calculus V</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Math 4582</td>
<td>Advanced Eng. Math.</td>
<td>36</td>
</tr>
<tr>
<td>Spring 1986</td>
<td>Math 1308</td>
<td>Calculus II</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Math 4348</td>
<td>Intro.: Partial Diff.</td>
<td>20</td>
</tr>
<tr>
<td>Fall 1986</td>
<td>Math 4582</td>
<td>Advanced Eng. Math.</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Math 4640</td>
<td>Scientific Computing I</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Math 4641</td>
<td>Scientific Computing II</td>
<td>16</td>
</tr>
</tbody>
</table>
As one of the organizers of the seminar in Numerical Analysis I gave several series of lectures on the Foundations of Finite Elements and Boundary Elements from Winter Quarter 1984 through Fall Quarter 1986.

REFEREED PUBLICATIONS:

(a) Already published


23. Solution procedure for interface problems in acoustics and
electro-magnetics. CISM Courses and Lectures No. 277, ed. by P.

24. Zur Randintegralmethode fur das erste Fundamentalproblem der
ebenen Elastizitatstheorie auf Polygongebieten. (On the boundary
integral method for the first fundamental problem in elasticity on
polygonal domains). In: Recent Trends in Mathematics, Conference
in Reinhardtsbrunn October 1982, Teubner-Texte zur Mathematik 50,
56-68 (with M. Costabel and W. L. Wendland).

25. Theoretical and experimental asymptotic convergence of the
boundary integral method for a plane mixed boundary value problem,
Boundary Element Methods in Engineering, ed. C. A. Brebbia,
Wendland).

26. A simple layer potential method for three-dimensional eddy current
problems, in Ordinary and Partial Differential Equations, Dundee
(1982) (ed. by W. N. Everitt and B. D. Sleeman), Lecture Notes in
(with R. C. MacCamy).

27. Boundary Element Method for Membrane and Torsion Crack Problems.
Wendland).

28. The boundary integral method for a mixed boundary problem in a
polygonal domain. Advances in Computer Methods for Partial
Differential Equations-IV, IMACS, 300-304 (1981) (with M.
Costabel).

29. The boundary integral method for a plane mixed boundary value
problem. Advances in Computer Methods for Partial Differential
Equations-IV, IMACS, 223-229 (1981) (with U. Lamp,

30. Boundary integral methods for mixed boundary value problems. In:
ed. R. Shaw et. al. Innovative Numerical Analysis for the
Engineering Sciences, University Press of Virginia,
Charlottesville 1980, 543-554 (with W. L. Wendland).

31. Conform and Mixed Finite Element Schemes for the Dirichlet Problem
for the Bilaplacian in Plane Domains with Corners, Math. Meth. in

32. On the Integral Equation Method for the Plane Mixed Boundary Value
Problem of the Laplacian, Math. Meth. in the Appl. Sci. 1,

33. Zu: Approximation von Schalen mit hybriden Elementen, Computing
20, 75-94 (1978) (with V. Weissgerber).


(b) Accepted for Publication


(c) Submitted for Publication


46. An augmented Galerkin procedure for the boundary integral method applied to two-dimensional screen and crack problems - The Neumann case (with W. L. Wendland).

47. Some boundary integral operators of mathematical physics and their pseudodifferential operator properties (with T. Fischer and W. L. Wendland).


49. An improved boundary element Galerkin method for a thin, electrified, square plate in $\mathbb{R}^3$ (with S. Abou El-Seoud and V. J. Ervin).

50. On the convergence of collocation methods for boundary integral equations on open curves (with M. Costabel and V. J. Ervin).

51. Integral equations for transmission problems in linear elasticity (with M. Costabel).

52. Coupling of FEM and BEM for transmission problems in elasticity (with M. Costabel).

53. Coupling of FEM and BEM for time-dependent, inhomogeneous electromagnetic transmission problems (with M. Costabel).

54. Experimental asymptotic convergence for coupled 2D boundary element - finite element Galerkin schemes (with A. Kurdila).

BOOKS:

(a) Already Published


(c) In Preparation

Fundamentals of the Finite Element Method (with W. J. Layton).

RESEARCH GRANTS AND CONTRACTS:

(a) Accepted:

"Solution procedures for three-dimensional crack problems in elasticity: Boundary integral equations and boundary elements," N.S.F. for 1985-86, ($23,244.00).


(b) Submitted:

"Boundary element methods for integral equations of the first kind governing 3-D problems," NSF for 1987-89 ($148,739.00).

MEETING AND SYMPOSIA (List of scientific lectures of Ernst P. Stephan)

1977 Finite Elemente - Meeting Oberwolfach (Germany) (Invited)

1978 Ecole Polytechnique, Paris-Palaiseau (Colloquium) (Invited)

1979 Hochschule der Bundeswehr Munchen (Germany) (Colloquium) (Invited)

1980 Freie Universitat Berlin (Germany) (Colloquium) (Invited)

1980 Finite elements (Meeting) Oberwolfach (Germany) (Invited)

1980 Brunel University, Uxbridge/London (England) (Colloquium) (Invited)

1980 Meeting on integral equations, Universitat Pavia (Italy) (Invited)

1980 Universite Nice (France) (Colloquium) (Invited)

1980 Universite de Provence, Marseille (France) (Colloquium) (Invited)

1980 Integral equation methods in engineering (Meeting) (Oberwolfach) (Invited)

1981 Carnegie-Mellon University, Pittsburgh (USA) (Colloquium) (Invited)

1981 University of Delaware, Newark (USA) (Colloquium) (Invited)

1981 AMS Meeting, University of Pittsburgh, Pennsylvania (Contributed)
1982 Technion (Technical Univ.), Haifa (Israel) (Colloquium) (Invited)
1982 Brunel University, Uxbridge/London, England (Colloquium) (Invited)
1982 Conference on "Theoretical acoustic and numerical techniques," Undine (Italy) (Invited)
1982 Carnegie-Mellon University, Pittsburgh (USA) (Colloquium) (Invited)
1982 West Virginia University, Morgantown (USA) (Colloquium) (Invited)
1982 Virginia Tech (State Univ.), Blacksburgh (USA) (Colloquium)
1982 Georgia Tech (State Univ.), Atlanta (USA) (Colloquium) (Invited)
1983 Universitat Gottingen (Germany) (Colloquium) (Invited)
1983 Universitat Erlangen (Germany) (Colloquium) (Invited)
1983 Carnegie-Mellon University, Pittsburgh (Colloquium) (Invited)
1975 GAMM-Meeting Gottingen (Germany) (Contributed)
1976 DMV-Meeting Munchen (Germany) (Contributed)
1976 Ordinary and partial differential equations - Meeting (Dundee, Scotland) (Contributed)
1979 GAMM-Meeting Wiesbaden (Germany) (Contributed)
1981 Recent advances of boundary element methods - 3. Conference, Irvine (USA) (Contributed)
1981 4. IMACS Conference, Lehigh University, Bethlehem (USA) (Contributed)
1981 AMS Meeting, Univ. of Pittsburgh (USA) (Contributed)
1982 GAMM-Meeting, Budapest (Hungary) (Contributed)
1982 Ordinary and partial differential equations - meeting (Dundee, Scotland) (Contributed)
1983 GAMM-Meeting Hamburg (Germany) (Contributed)
1984 5. IMACS Conference, Lehigh University, Bethlehem (USA) (Contributed)

1984 University Bonn (Germany) (Colloquium) (Invited)

1984 Technische Hochschule Darmstadt (Germany) (Colloquium) (Invited)

1984 International Conference on Boundary Elements, Darmstadt, (Invited)

1984 Universitat Karlsruhe (Germany) (Colloquium) (Invited)

1984 Universitat Erlangen (Germany) (Colloquium) (Invited)

1985 Function theoretic methods in P.D.E.'s (Meeting) (Oberwolfach) (Invited)

1985 Southeastern-Atlantic Reg. Conf. on Differential Equations (Atlanta)

1986 4th Inter. Symposium on Numerical Methods in Engineering (Atlanta) (Invited)

1986 1st World Congress in Computational Mechanics (Austin, TX) (Invited)

1986 UAB International Conference on Differential Equations and Mathematical Physics (Birmingham, Alabama) (Invited)

1986 Technische Hochschule Darmstadt (Germany) (Colloquium) (Invited)

1986 University of Maryland, College Park (Num. Anal. Seminar) (Invited)

1986 University of Delaware, Newark (Colloquium) (Invited)

1986 University of Arizona, Tempe (Colloquium) (Invited)

1987 University of Zurich (Switzerland) (Colloquium) (Invited)

COMMITTEES:

Policy Committee (1984-85) - Georgia Tech
Graduate Committee (1986-83) - Georgia Tech

MEMBER IN PROFESSIONAL AND HONOR SOCIETIES:

GAMM - Gesellschaft fur Angewandte Mathematik und Mechanik
IMACS - International Association for Mathematics and Computers in Simulation
HONORS AND AWARDS:

Privatdozent, TH Darmstadt, 1984

ACADEMIC ADVISEMENTS:

Ph.D. Committee:

N. H. Patel (School of Industrial and Systems Engineering)
P. O. Donoghue (School of Civil Engineering)

Graduate Students Supervised:

Gave a series of lectures on the Mathematics underlying the finite element method jointly with W. J. Layton, Winter Quarter and Spring Quarter, 1984. In the Winter Quarter eight graduate students took it for two hours credit and 15-20 faculty sat in the course also. The same students and about 10-15 faculty attended the course in the Spring Quarter.

Gave a series of lectures on the boundary element method, Spring Quarter and Fall Quarter, 1986.

COOPERATION WITH OTHER DEPARTMENTS:

Joint research with J. C. Wu (Aerospace Engineering) on boundary elements for problems in fluid-flow.

PERMANENT RESEARCH CONTACTS WITH:

I. Babuska, University of Maryland, College Park
R. C. MacCamy, Carnegie-Mellon University, Pittsburgh
G. C. Hsiao, University of Delaware, Newark
W. L. Wendland, Technical University of Darmstadt
M. Costabel, Technical University of Darmstadt