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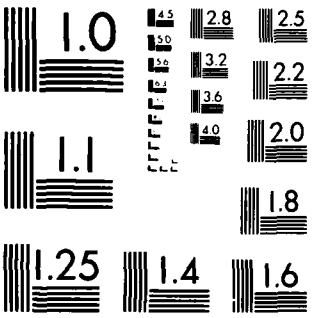


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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The original software development program has been extended in several directions: adaptive mesh generation, multigrid methods, singular perturbation problems. A crude code generator for very general two point boundary value problems has been activated. Extensions in all these directions are under way.

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# FINAL REPORT

on

# Mathematical Software for Hyperbolic Equations and Two Point Boundary Value Problems.

Grant No. AFOSR-82-0321

**Principal Investigators:**

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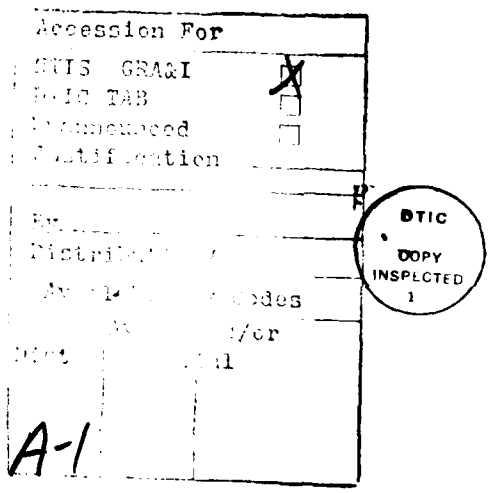


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# Mathematical Software Program: Summary of Results

In the brief period during which this program has been in effect we have accomplished quite a bit in the area of two point boundary value problems. We expected to just about have planned our codes but the work has gone much further.

A basic program for two point boundary value problems exists, runs on the IBM 4341, and is in the process of generating codes for a variety of problems. During the course of this work we have also experimented with the code AUTO, of E. Doedel, which is based on many of our early ideas in path following and bifurcation. His collocation scheme has some accuracy advantages over our present box scheme. Thus we plan to incorporate some of this work into the future development of our software. In particular we have arranged to have Doedel return to our group for two years starting in December 1984 or January 1985.

A host of new ideas have developed during this start up phase and we briefly indicate some of them here. The generated codes can be output in any of several languages for any of a variety of machines. The choice of machine and language will be just another set of decisions to be made by the user. This is currently a more versatile procedure than attempting to generate transportable code. We include of course personal computers in those that may be able to run our generated codes. We have also begun to examine extensions to array processors, concurrent processors and any other parallel types of architecture that may become practical.

Another new departure from our original program is the development of software for our multiple or overlapping grid techniques. These new methods have proven to be extremely powerful in the solution of numerous steady state and time dependent partial differential equation problems (mainly in fluid dynamics, oceanography, meteorology). Hopefully this work will benefit from

improved graphics facilities that we are currently investigating. In addition these ideas naturally relate to various multigrid techniques which we have also been developing and employing. Software for multigrid methods is frequently discussed but does not yet seem to exist. Of course multigrid fits in very well with some of the concurrent machines presently in operation and under development here at Caltech. Thus all of these ideas will be explored with such applications in mind.

A reduced effort in this area for the near future is expected. This is mainly due to the lack of availability of experienced people to extend our work. We hope to continue when we find or produce the proper researchers.

## Publications & Theses

During the period of this grant two PhD degrees were completed, two theses were written and a third is currently under way. All of the students worked on this project and one (Brown) was retained as a post-doc after the completion of his thesis. The completed theses are as follows:

1. J.M. Fier, PhD in Applied Mathematics, Caltech 1985
   Part I. Fold Continuation and the Flow Between Rotating Coaxial Disks.
   Part II. Equilibrium Chaos.
   Part III. A Mesh Selection Algorithm for Two-Point Boundary Value Problems.
2. D.L. Brown, PhD in Applied Mathematics, Caltech 1982.
   Solution Adaptive Mesh Procedures for the Numerical Solution of Singular Perturbation Problems.

Papers relating to this work are currently in preparation. In Fier's thesis Part III was done for this project and it briefly summarizes what he and Brown did in devising the code generator for two-point problems.

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Chief, Technical Information Division

The work on overlapping grids which grew out of this project is also currently being written up. It will appear in the thesis of Mr. G. Chesshire at Caltech in 1985. He has prepared software packages that are currently being tested at several national laboratories.

The multigird work stimulated by this project will result in two publications. One has already been submitted for publication and another is in preparation. They are as follows:

J.H. Bolstad and H.B. Keller, A Multigrid Continuation Method for Elliptic Problems and Turning Points, submitted to SIAM J. Sci. & Stat. Comp.

J.H. Bolstad and H.B. Keller, Computation of Anomalous Modes in the Taylor Experiment, in preparation.

Thus a total of at least five publications will result from this Grant.

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