09:58:42 OCA PAD INITIATION - PROJECT HEADER INFORMATION 12/14/88

Active

Project #: G-37-643 Cost share #: Rev #: 0
Center # : R6640-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: 881300 Mod #: Document : PO
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #:

Project unit: MATH Unit code: 02.010.144
Project director(s):
MEYER G H MATH (404)894-5367

Sponsor/division names: MCDONNELL DOUGLAS CORP / ST LOUIS, MO
Sponsor/division codes: 212 / 045

Award period: 880501 to 890430 (performance) 890430 (reports)

Sponsor amount	New this change	Total to date
Contract value	70,826.00	70,826.00
Funded	70,826.00	70,826.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: JOINT RESEARCH BETWEEN THE MCDONNELL DOUGLAS RES LAB & SCHOOL OF MATH/GIT

PROJECT ADMINISTRATION DATA

OCA contact: William F. Brown 894-4820

Sponsor technical contact

DR. W. W. DOWER/DEPT 222/BLDG 110
(314)233-2529
MCDONNELL DOUGLAS RESEARCH LABS.
8901 AIRPORT ROAD
BERKELEY, MO 63134

Sponsor issuing office

MS. KIMBERLY KELLY/DEPT. 760
(314)232-3253
MCDONNELL DOUGLAS CORP.
BOX 516 ST. LOUIS, MO 63166

Security class (U,C,S,TS) : U
Defense priority rating : NA
Equipment title vests with: Sponsor
NONE PROPOSED OR ANTICIPATED

ONR resident rep. is ACO (Y/N):
NA supplemental sheet
GIT X

Administrative comments -
INITIATION OF G-37-643. FIXED PRICE. PUBLICATION RESTRICTIONS-SEE ATTACH. 2, PARA. 7 AND ATTACH. 3.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 05/28/91

ect No. G-37-643 Center No. R6640-0A0

ect Director MEYER G H School/Lab MATH

sor MCDONNELL DOUGLAS CORP/ST LOUIS, MO

ract/Grant No. Z81200 Contract Entity GTRC

e Contract No. _____

e JOINT RESEARCH BETWEEN THE MCDONNELL DOUGLAS RES LAB & SCHOOL OF MATH/GIT

ctive Completion Date 900430 (Performance) 900430 (Reports)

eout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	_____
Final Report of Inventions and/or Subcontracts	N	_____
Government Property Inventory & Related Certificate	Y	_____
Classified Material Certificate	N	_____
Release and Assignment	N	_____
Other _____	N	_____

Comments_____

roject Under Main Project No. _____

tinues Project No. _____

tribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other _____	N
_____	N

A Proposal for Continued Joint Research Between the McDonnell Douglas Research Laboratories and the School of Mathematics of the Georgia Institute of Technology

Submitted by

Gunter H. Meyer
Professor of Mathematics
School of Mathematics
Georgia Institute of Technology
Atlanta, Georgia 30332
Tel: 404 894-5367/2700

Submitted to

McDonnell Douglas Research Laboratories
Saint Louis, Missouri

May 1989

I. Summary

I would like to request funding for a continuation of the joint research with MDRL which began in April 1985 and is currently funded until April 30, 1989. The current proposal is at the level of previous proposals and suggests an effort of four man-months at a total cost of $77,448. The recommended contract period is June 1, 1989 to May 31, 1990.

II. Current Status of Joint Research

Overview: Since the beginning of this joint research program research has been carried out in the three broad categories of

i) electro-magnetic signatures with Dr. Medgyesi-Mitschang and colleagues,

ii) control of transition to turbulence and receptivity in shear flows with Dr. Bower and colleagues, and

iii) time accurate integration of flow equations with Dr. Agarwal.

During the past contract period funding from MDRL has been used for release time from teaching in every quarter of the academic year and partial support during the summer of 1988. In addition, I have spent four weeks at various times during the year at MDRL to maintain personal contact with my colleagues.

A graduate student from the School of Mathematics of Georgia Tech was supported with contract funds during the summer 1988 in his MS thesis research. The remaining funds for a graduate assistant were not expended because of administrative difficulties in processing the previous proposal. These funds are on hand for the partial support of a student during the next contract period. A no-cost extension of the previous contract has been applied for to make residual funds of the 88/89 contract available during the coming year.

Research Results for 1988-1989

1) Electro-magnetic signatures: The Fock theory is an asymptotic theory for the electromagnetic fields near the shadow boundary of dielectric scatterers. It provides analytic expressions for surface fields which have been used routinely at MDRL to find the radar cross sections of lossy scatterers. The derivation of the Fock theory (as in [1]) is partly formal and partly based on physical arguments. The mathematical foundations and range of applicability of the Fock theory are still not completely understood and have been the subject of my research for the EM signatures group

since the beginning of this joint program. The most exciting development in this research is the recent derivation of the Fock equation and the appropriate Leontovich boundary conditions on the basis of singular perturbation and elementary boundary layer theory. When the EM fields are expanded in an asymptotic series of inverse powers of the square root of the wave number then the Fock equation and the correct boundary conditions fall out without the usual recourse to the ad-hoc order of magnitude assumptions employed in the original derivation of Fock [1]. We are currently examining the limits of applicability of the closed form solutions derived by Fock to clarify the role of geometry on the correct path integrals for the Airy functions which are ubiquitous in this theory.

In addition, we have developed an extension of the local coordinate approach of the RCS handbook [2] to a general three-dimensional convex scatterer. The idea is to express the EM field in a neighborhood of a reference geodesic on the scatterer which orginates on the shadow boundary with the direction of the incoming plane wave. The derivation of the Fock functions in this setting remains to be carried out but should be possible with the tools of boundary layer theory.

[1] V. A. Fock, Electromagnetic Diffraction and Propagation Problems, Pergamon, Oxford, 1965.

[2] G. T. Ruck, et al., Radar Cross Section Handbook, Plenum, New York, 1970.

2) Laminar flow control and receptivity: Work on laminar flow with W. W. Bower and A. Pal is drawing to a close. The case of suppression of a multi-frequency Tollmien-Schlichting instability wave by the dominant mode method and contour integration has been resolved. Similarly, the suppression of instability waves through thermal viscosity control is now understood. In all this work an accurate integration of eigenvalue and boundary value problems for the Orr-Sommerfeld and related equations is essential. The method of continuous orthonormalization analyzed and popularized through MDRL sponsored research remains the method of choice for these stiff problems.

Based on our understanding of laminar flow control we are now examining the question of receptivity. Many of the numerical techniques carry over toward the new formulation which still is based on the Fourier transformed equations for small perturbations. Our boundary value codes have been adapted to this setting. In addition, we have provided a least squares algorithm for the expansion of complex valued functions in terms of specially chosen complex basis functions.

Concurrently with this research Mr. M. Eidenschink carried out a comparative study of common boundary value codes from the IMSL Program Library and our continuous orthonormalization code to ascertain which algorithm is most competitive for stiff boundary value problems of Orr-Sommerfeld type. As presented in his MS Thesis, the algorithms used at MDRL in the flow control

and receptivity studies provide the versatility and robustness necessary for the manifold types of boundary and eigenvalue problems arising in this work.

3. Integration of the flow equations: We had speculated that the currently used Runge-Kutta methods were not the most suitable integrators for the 2-D Reynolds averaged Navier-Stokes equations. However, numerical experiments showed clearly that stiffness of the system to be integrated is not the issue in that the viscosity terms are meant to stabilize but not drive the solution. A change-over to implicit numerical methods of Gear type was checked but rejected because one cannot take the inviscid limit with this method. Runge-Kutta methods are indeed better suited for these equations.

Publications (in addition to work originating in the Laboratory)

G. H. Meyer, Continuous orthonormalization with application to Burgers' equation, Proceedings of Equadiff 1987, G. Ladas, et al., edts., Dekker, New York, 1989 (reprints not yet received).

M. Eidenschink, A comparison of numerical methods for the solution of two point boundary value problems, MS Thesis, Georgia Institute of Technology, 1988 (copy on hand at MDRL).

New Research

The research proposed for the period of June 1, 1989 to May 31, 1990 is a continuation of work in progress and is consistent with IRAD plans for 1989. The following topics are proposed:

1) Electromagnetic signatures: The consequences of the singular perturbation approach to the Fock theory need to be examined. There are several issues.

We now know that the zeroth and first order equations for fields near the shadow boundary are solvable in closed form by separation of variables in several geometries. We would like to derive the proper superposition formulas (based on complex contour integration) to provide solutions of the Fock equation which satisfy the Leontovich boundary conditions and the correct optical limit. The new geometries would be of interest because they do not require a constant radius of curvature in the direction of the incoming wave.

The singular perturbation approach is to be applied to the derivation of the solution of the Fock equation in two local coordinates. As demonstrated earlier in this research when Galerkin Ansatz functions were derived for the integral equations of EM fields on a body of revolution, numerous assumptions must be made in order to express the fields in terms of Airy functions of the local tangential and normal coordinates (see [2] above). The new approach should yield precise requirements on the geometry on the body so that the solutions remain valid to O(1/k) where k is the wave number of the incoming plane wave.