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FINAL REPORT: 1980 SUMMER RESEARCH FELLOWSHIP PROGRAM

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HAMPTON INSTITUTE
Hampton, Virginia 23668

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AND

HAMPTON INSTITUTE

FINAL REPORT

of the

1980 SUMMER RESEARCH FELLOWSHIP PROGRAM

Compiled by:

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LANGLEY RESEARCH CENTER
HAMPTON, VA 23665

1980 SRFP
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Rationale

Historically, the academic programs at traditionally black institutions have not fostered active involvement in basic scientific research. College teachers with scientific backgrounds spend a substantial amount of time engaged in other activities which do not utilize their research capabilities and skills. The NASA-Hampton Institute Summer Research Fellowship Program offers capable scientists and engineers at traditionally black instutions an opportunity to participate in research activities in an environment at the Langley Research Center where basic research is of primary importance.

The Summer Research Fellowship Program has been specifically designed to assist these faculty members in identifying areas of research which correlate positively with their individual interests and capabilities. It is also designed to help them to initiate viable research which increases their technical knowledge and expertise, and their knowledge about how research efforts at their institutions might be increased.

Programs similar to the Summer Research Fellowship Program also provide opportunities for university faculty members to engage in summer research activities, but these programs lack significant participation from faculty members representing predominately black institutions. This program actively solicits minority institutional involvement by providing fellowships which allow selected faculty members to become engaged in on-going research for ten-weeks during the summer at Langley Research Center. This experience should increase the quality and impact the quantity of research performed on these campuses, thus, giving more minority students the opportunity to participate in research activities. Through these activities, better research techniques will be developed by students and faculty members, therefore, a broader and more proficient base will be established from which capable scientists and engineers can be selected.

Objectives

The Summer Research Fellowship Program involves professors from predominately black colleges and universities in research activities at the Langley Research Center. The program is specifically designed to:

1) Provide faculty members from participating institutions the opportunity to identify active research areas appropriate to their interests and capabilities;

2) Impact the academic programs of participating institutions through modifications resulting from changing emphasis in an academic discipline due to research;

3) Promote more cooperative ventures between participating institutions and the Langley Research Center;

4) Increase the resource base which provides proficient scientists and engineers.

Eligible Institutions

All predominately black colleges and universities are eligible for inclusion in the program. Seven colleges and universities were represented in the 1980 Program.

Eligible Faculty

Faculty members in the areas of computer science, chemistry, engineering (aeronautical, architectural, civil, electrical and mechanical), mathematics, physics and electronic technology at eligible institutions are eligible to participate in this program. Chemistry, mathematics and physics were the represented disciplines this year.

Program Statistics

ITEM	PROGRAM YEARS				
	1967	1977	1978	1979	1980
Dollars Appropriated	42.5K	50K	43K	54K	62K
Dollars Spent	42.5K	47.2K	41.7K	56K	48K
Applicant Institutions	16	16	17	18	26
Fellow Institutions	8	9	8	9	7
Applicants	42	44	47	32	42
Females	(7)	(9)	(7)	(5)	(4)
Males	(35)	(35)	(40)	(27)	(38)
Fellows	9	11	8	11	7
Females	(1)	(2)	(2)	(2)	(0)
Males	(8)	(9)	(6)	(9)	(7)
Black	(4)	(4)	(6)	(4)	(3)
Caucasian	(5)	(5)	(1)	(5)	(3)
Asian	(0)	(2)	(1)	(2)	(1)
Fellow (Applicant) Disciplines					
Engineering	3(5)	0(3)	1(7)	1(4)	0(6)
Mathematics-Computer Science	5(28)	5(16)	5(21)	7(16)	3(18)
Chemistry-Physics	1(8)	5(13)	2(13)	2(10)	4(17)
Others	0(5)	1*(12)	0(6)	1**(2)	0(1)

*Biology
**Physical Science

During the first four years of the program faculty members from 25 of 26 participating institutions applied to the program and Fellows were chosen from 18 of the 26. Also, there were applicants from four institutions not included on the list and one Fellow was selected from among those applying. As of 1980, all predominately black colleges and universities were sent announcements of the program.

Program Management

The 1980 Summer Research Fellowship Program was the first to include all predominately black colleges and universities. The program was launched in October 1979 by writing the Academic Deans or Vice-Presidents for Academic Affairs of approximately seventy-five of the institutions to announce the program and request a list of eligible faculty members.

As the lists were received, letters and brochures were sent to the faculty members. The letter included information about the program and indicated how to obtain an application form and a list of the problems submitted by the Langley Research Center. Applications began arriving in late December and were accepted through January 1980, however, because of the schedules of some institutions, many faculty members did not collect their mail in time to submit an application. Also, some institutions did not submit lists so the brochures, application forms and list of problems were sent to department chairpersons at those institutions.

As the applications were received, they were reviewed by the program coordinator and most were taken to the Langley Research Center for distribution to the various research divisions. During the last week of February, Dr. John E. Duberg, Dr. Wayne D. Erickson, Dr. William H. Michael, Dr. Alvin F. Anderson, Mr. Franklin C. Owens (all at the Langley Research Center) and the program coordinator met to select ten participants and several alternates. These persons were notified of their selection by telephone and letter and were requested to notify the program coordinator of their decisions by March 15, 1980. Two persons declined the invitation so the alternates were contacted.

During April and May the Fellows were sent additional program information including, the name, address and telephone number of his respective Research Associate, the general research problem to be investigated, some housing information, and the time and place of the orientation meeting on June 2, 1980.

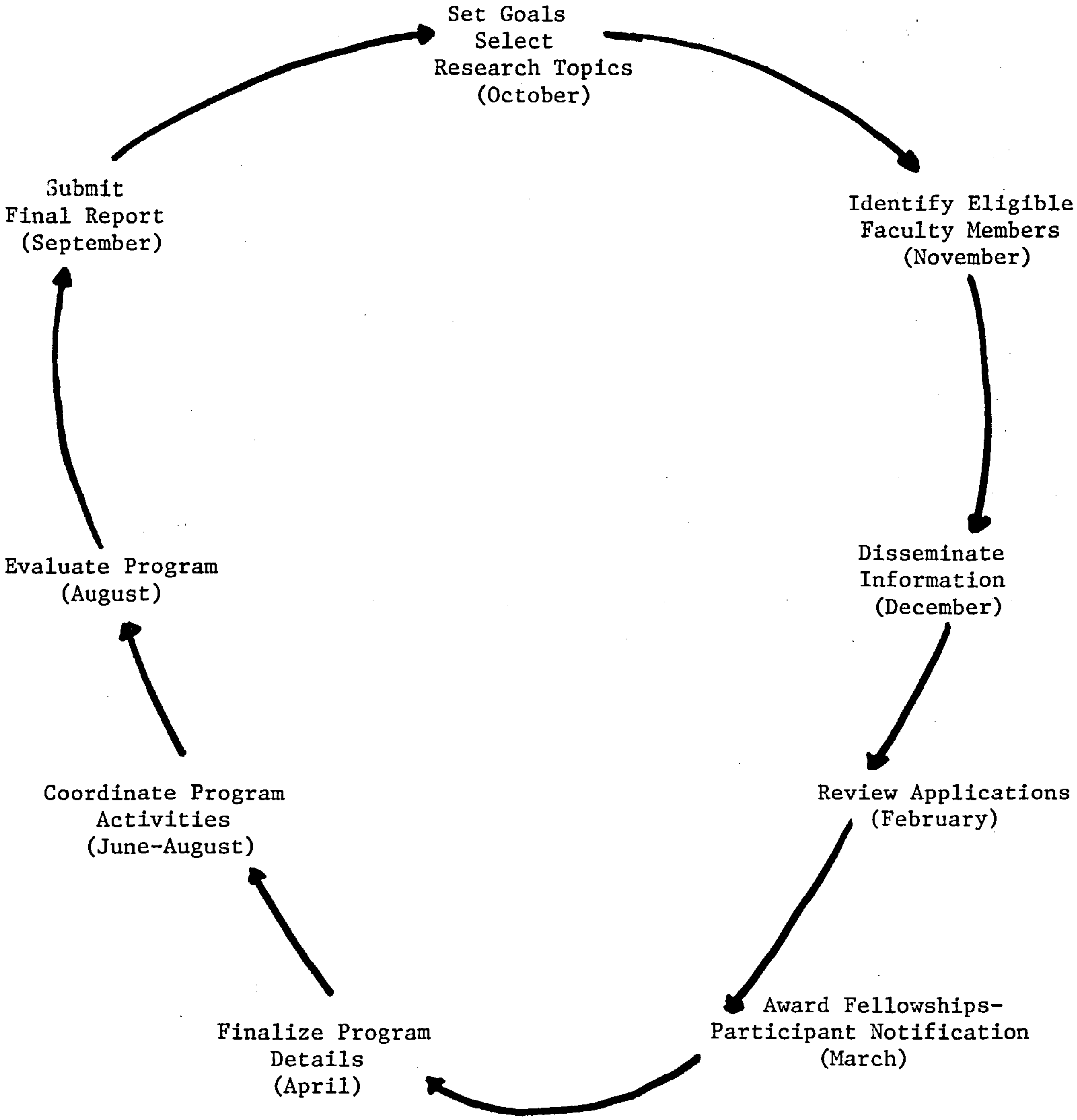
Prior to June 2, 1980, two Fellows resigned from the program, so the ten weeks were begun with eight Fellows. During the third week, one of the eight aggravated a back injury and eventually had to withdraw from the program.

Three of the Fellows attended conferences related to their research problems. Dr. John W. Bales visited the University of Virginia with some of his research colleagues to confer with professors at the university. Dr. Kailash Chandra attended a symposium on Molecular Spectroscopy at Ohio State University. Dr. Matthew E. Edwards attended the Eleventh International Quantum Electronics Conference in Boston, Massachusetts.

During the second week of the program the Fellows were invited to the home of the program coordinator to talk with some former participants in the program and to get acquainted with each other. During the summer the Fellows attended various programs and lectures at the Center. The program coordinator visited each Fellow twice during the ten-week period to discuss progress and concerns and to inform them about various persons and offices at the Center which they might visit for additional information of importance to their respective academic programs. The coordinator and Fellows lunched together each Wednesday. Fellows were urged to find out what research of interest to them is being conducted at the Center and to try to find some project they might possibly conduct on their own campuses.

Each Fellow submitted a written synopsis of his work on July 30, 1980, and gave an oral presentation on August 4, 1980. Also, a written evaluation was submitted and an oral evaluation was given on August 6, 1980.

Summer Research Fellowship Activities Cycle



1980 SRFP FELLOW INFORMATION

Name & Address	Age	Education	Area	Institution & Title	LaRC Division	LaRC Research Unit	LaRC Contact Extension (804)827-
Bales, John W. P. O. Box 361 Opelika, ALA 36801	36	B.A.-(1965) M.A.-(1967) University of Texas (Austin) Ph.D.-(1975) Auburn University	Mathematics Mathematics	Tuskegee Institute Assistant Professor	Flight Dynamics and Control Division	Flight Management Branch	L. K. Barker 3871
Chandra, Kailash S. 110 Paradise Drive Savannah, GA 31406	41	B.S.-(1956) M.S.-(1958) D.A.V. College Ph.D.-(1967) Gorakhpur University	Physics Physics Physics	Savannah State College Professor	Instrument Research Division	Laser & Spectros-copy Branch	J. M. Hoell, Jr. 2818
Coleman, David W. 6 Creighton Drive Wilmington, DEL 19810	36	B.S.-(1965) Knoxville College M.S.-(1967) Howard University	Chemistry Chemistry	Cheyney State College Assistant Professor	Space Systems Division	Space Technology Branch	C. E. Byvik 3781
Dyer, John A. 2529 Texas Street Baton Rouge, LA 70802	37	B.A.-(1963) Magdalen College Oxford Univer-sity Ph.D.-(1967) Indiana Univer-sity	Mathematics Mathematics	Southern University Associate Professor	Analysis and Computation Division	Computer Applications Branch	J. J. Lambiotte 4612

1980 SRFP FELLOW INFORMATION

Name & Address	Age	Education	Area	Institution & Title	LaRC Division	LaRC Research Unit	LaRC Contact Extension (804)827-
Edwards, Matthew E. 4307 Scott Avenue Pine Bluff, ARK 71603	33	B.S.-(1969) North Carolina A&T State University M.S.-(1975) Ph.D.-1977 Howard University	Engineering Physics Physics Physics	University of Arkansas at Pine Bluff Assistant Professor	Instrument Research Division	Aerosol Measurements Research Branch	J. H. Goad, Jr. 3029
Ghent, Robert C. Talladega College Talladega, ALA 35160	37	B.A.-(1964) University of Oregon A.M.-(1970) Harvard University	Mathematics Mathematics	Talladega College Assistant Professor	Analysis and Computation Division	Computer Applications Branch	J. N. Shoosmith 3466
Miles, Allen M. P. O. Box 518 Waskom, TX 75692	33	B.S.-(1970) Grambling College M.S.-(1977) Pennsylvania State University	Chemistry Chemistry	Wiley College Instructor	Space Systems Division	Space Technology Branch	C. E. Byvik 3781

Marking Parts To Aid Robot Vision

John W. Bales
NASA-HI 1980 Fellow
Flight Dynamics and
Control Division

The use of robots in industry has increased dramatically in the last several years, particularly in Japan, but also in this country. A robot is usually a programmable general purpose arm dedicated to specific tasks. For the most part, these arms are blind. That is, the software controlling most arms makes no use of visual input. How to incorporate visual input into such software is a problem of much current interest.

One of the most basic tasks of a robot vision system would be to locate and identify parts for handling. There are several problems which must be overcome in order to carry out such a task. First, <u>the part must be distinguished from the background</u>. Many sophisticated approaches exist for distinguishing the image of a sought object from its background. However, most approaches require too much computation to allow real-time operation. Furthermore, specially controlled lighting is usually necessary. Secondly, <u>the orientation of the part must be determined</u>. In a precisely controlled situation, the sought part may be pre-positioned in the correct orientation. But, software for determining the orientation of complex parts can involve excessive computation, slowing real-time operation. A third problem faced by a vision system is <u>the determination of the position of the part</u>. In many manufacturing situations this problem is simplified by the fact that the part is on a conveyer belt, the position of which is known. In this situation a single camera is adequate to provide the information needed to triangulate the position of the part. If the part is not on a conveyer belt, and is, in fact, randomly positioned and oriented then some other technique must provide the information necessary for triangulation. It is natural to consider using two cameras to provide the necessary information. Nevertheless, the extensive computation required for the correlation of two images severely handicaps any two-camera system because of the real-time requirement. Finally, <u>if the part is in motion, the visual system must be able to track the part</u>. The time required to perform the first three tasks restricts the rate at which the system can track a moving object.

The common thread running through each of these tasks is the requirement of real-time operation. This raises the question: what is real-time operation?

Any system can be said to operate in real-time if it permits the robot arm to operate at an adequate rate. An adequate rate for one situation or operation may be hopelessly slow for others. Since robots will be, for the immediate future, operating alongside human workers, any rate which slows down the workers would be inadequate.

This investigator has developed a system of special marks to be placed on parts to be located and identified by a robot vision system. These marks are easily distinguished from the background by an unsophisticated, but effective method. Because of the special geometry of the marks, the vision system is able to identify the part and deduce its position and orientation. Furthermore, this is accomplished in real-time using only one camera.

A NASA Technical Paper has been written describing this system in detail.

Tunable Diode Laser (TDL)
Spectra of Hydrogen Peroxide

Kailash Chandra
NASA-HI 1980 Fellow
Instrument Research
Division

The photochemistry of the stratosphere, particularly possible perturbations of the ozone layer of man's activities, is one of the major scientific problems which will be addressed by NASA's satellite programs in the next decade. The proceedings of the "Workshop on High Resolution Infrared Spectroscopy Techniques for Upper Atmospheric Measurements" held at Silverthorne, Colorado, July 31-August 2, 1979, stressed the need of the following measurements:

1. Molecules predicted to be present in lower stratosphere but never before (or almost never) measured (N_2O_5, $C\ell ONO_2$, HO_2NO_2, H_2O_2, HO_2 and OH, etc);

2. Molecules measured a few times by one or more instruments, but having interpretation problems ($C\ell O$, NO, HNO_3,H_2O, $HC\ell$, HF, OH, O, NO_3, and $C\ell$);

3. Well measured molecules, which are candidates for long-term monitoring for trends due to natural and/or man-made causes (O_3, N_2O, F-11, F-12, and CH_4).

These measurements are required to develop and to verify atmospheric models developed for the lower stratosphere by a number of persons.

Hydrogen peroxide (H_2O_2) is an important minor constituent in the troposphere and stratosphere. In order to use infrared techniques to obtain information concerning its distribution in the atmosphere, it is necessary to have laboratory spectral data (line positions, line strengths, etc.) with accuracies commensurate with the available resoultion of the present (and soon to be developed) instruments. Essentially no measurements have been published on line strengths, air broadening coefficients, line center pressure shifters, air broadening coefficients versus temperature, or line shape in "Voight" regime for the H_2O_2 molecule. Drs. J. J. Hillman and D. E. Jennings (NASA Goddard Space Flight Center, Greenbelt, Maryland), W. B. Olson (National Bureau of Standards, Washington, DC), and A. Goldman (University of Denver, Denver, Colorado) have recently measured: (1) Fourier transform-infrared spectra in the ν_6 region (1170 - 1350 cm^{-1}) at 0.02 cm^{-1} resolution, and (2) tunable diode laser spectra over selected regions in the 1240 - 1280 cm^{-1} spectral region of this molecule. However, more detailed information on line center positions, line strengths, and assignments for the ν_6 band is needed for the stratospheric measurements. It is planned: (1) to scan TDL spectra at 1266.8674, 1251.2524, 1244.0100 and 1239.4721 cm^{-1} lines which are free of interference effects from 10 - 50 km in the atmosphere; (2) to measure line positions and line strengths; (3) to measure pressure broadening and temperature dependence; and, (4) to complete quantum number assignments for the ν_6 band of the H_2O_2 molecule. The expected accuracy of these measurements is in the order of ± 0.0005 cm^{-1}.

Reasonable progress has been made during the ten-week period towards the completion of this project. The following accomplishments have been made.

1. The optical alinement of the tunable semiconductor laser spectrometer has been completed.

2. Hydrogen peroxide vapors above certain concentration limits readily explode on contact with a bit of catalytically-active material or with non-catalytic materials at slightly elevated temperatures. It is, therefore, usually shipped to customers at 50% or lower concentrations with the addition of small amounts of stabilizing compounds to inhibit catalytic decomposition and also with the addition of corrosion inhibitors to reduce attack on the containers. A special cell has been designed to purify H_2O_2 by the method of vacum distillation.

3. Preliminary scans of TDL spectra of H_2O_2 at 1239.4721, 1244.0100, and 1251.2524 cm^{-1} have been completed using SO_2, N_2O, and CH_4 gas as reference gases.

4. Preliminary studies on the pressure broadening of these lines at various pressures (0-115 mm of Hg) have been completed.

The work is still in progress.

The Photoelectrochemical (PED) Investigation of Selected Metal Thio-Hypodiphosphates

David W. Coleman
NASA-HI 1980 Fellow
Space Systems Division

The investigation of the photoelectrochemical properties of metal thio-hypodiphosphates was initiated because of the similarity in structure of these compounds to other "layered" type crystals that had been reported to possess photoanodic and photocathodic properties. As a result, several metal thio-hypodiphosphates having the empirical formula $Me_2P_2S_6$ (Me = Fe, $Ni_,$ S_n) were selected for characterization.

The compounds were synthesized according to a procedure described by R. Nitsche and P. Wild. In this procedure, stoichiometric amounts of the pure elements were sealed in a quartz ampoule and placed in an oven containing a horizontal temperature gradient. The quartz ampoule was placed in the oven so that the reaction proceeded at the higher temperature (T_2) and crystal growth, by iodine vapor transport, occurred at the lower temperature (T_1). Average growth times approximated 100 hours.

Ohmic contact to selected crystals was established with a silver epoxy and sealed in a glass tube. Current-voltage curves were obtained using a controlled potentiostat and an X-Y recorder. A 100 W Xenon Lamp was used as the light source. Measurements were made at atmospheric pressure and ambient room temperature in agueous solutions of varying acidity.

The results obtained from this investigation were not conclusive and suggest that further study is needed. Photocurrents were obtained from some crystals of the iron (II) and tin (II) compounds. However, no photocurrent could be obtained from the nickel (II) crystals investigated. This result is perplexing since one would assume that the nickel (II) thio-hypodiphosphate should possess chemical and physical properties similar to those of iron and nickel. The absence of photocurrent for the nickel compounds is perhaps related to the experimental conditions of crystal growth and electrode fabrication than to its semi-conductor properties. This assumption is warranted when one considers that on the average, only 40 percent of the crystals of the iron and nickel compounds examined, showed measurable conversion of white light to electrical energy. Nevertheless, current densities ranging from 5 to 8 Ma/cm^2 were obtained in some instances. Reproducibility was non-existent and most certainly related to either "passivation" or photo-corrosion of the electrode surface.

Further study of the photovoltai properties of the metal thio-hypodiphosphates could lead to their addition to the list of other compounds presently being evaluated for their ability to convert solar radiations into electrical energy and/or storageable fuels. However, any investigation should be preceded by an exhaustive study that would:
1. characterize and identify that part of the crystal growth possessing semi-conductor properties; and, 2. optimize the conditions for growing larger and more uniform crystals.

Implementation of the Lanczos Algorithm on the STAR Computer

John A. Dyer
NASA-HI 1980 Fellow
Analysis and Computation Division

The Lanczos approach to finding extreme eigenvalues of an N by N matrix A is to choose orthonormal vectors,

$$r_1, r_2, \ldots . r_M$$

and to compute the eigenvalues of the M by M matrix,

$$T_M = (t_{i,j}) = (r_i^T A r_j) .$$

It is possible to choose the vectors, r_i, in such a way that computation of the next vector, r_{i+1}, and the eigenvalues of T_i are very efficient, and that the largest and smallest eigenvalues of T_M are good approximations to those of A for values of M much less than N.

A package of subroutines, written in standard FORTRAN, to implement the Lanczos algorithm had already been obtained. These were combined with other subroutines and, after a few minor problems, were used to find approximations to the largest and smallest eigenvalues of a number of matrices. Some modifications were made to take advantage of the vector capabilities of the STAR.

It was found that the accuracy of the computed eigenvalues was not always as high as expected. An analysis of the convergence test in the program showed that in some circumstances it could fail. Test matrices were constructed to demonstrate an extreme disparity between the actual and computer errors. These tests also showed the failure of three other tests concerned with the recognition of multiple and clustered eigenvalues.

Additional coding was inserted in the original package to improve these tests. In the process, several programming errors were found and corrected. These corrections have resolved the original problem with accuracy. Multiplicities and clusters are now more frequently identified but still can be missed. More work is needed to resolve the remaining problems.

A Study of Rotational Raman Spectra of the Molecular Atmosphere

Matthew E. Edwards
NASA-HI 1980 Fellow
Instrument Research Division

Laser radar(Lidar) has become an effective method for investigating the constituents of the atmosphere, particularly those of the stratosphere. Along with other researchers, Joseph Goad, of NASA's Aerosol Measurements Branch, is utilizing it to investigate the shapes of the varied particles found in the atmosphere. His technique involves the detection of the depolarization of a backscattered laser pulse from an initially vertically projected polarized laser pulse. This backscattered depolarization intensity is compared with the backscattered polarized intensity to determine the depolarization ratio. These ratios, according to both experimentally and theoretically determined values, range from 0.008 for H_2 molecules to 0.04 for CO_2 molecules.

It has been known since 1928, that for initially monochromatic scattered radiation, the backscattered pulse contains, in addition to the emitted frequency, frequencies higher and lower than the emitted one. The lower and higher ones are referred to as stokes and anti-stokes frequencies, respectively. These frequencies are the direct resultant of transitions which have taken place in the scattering molecules.

Since the stokes and anti-stokes frequencies are observed in the backscattered radiation, it is desirable to know the intensity distribution of the separate parallel polarized and perpendicular polarized rotational Raman fine structure about the given Rayleigh line. We have considered this problem for N_2 and O_2, using a wavelength of 6943Å.

Basically, the considered problem involves, through the application of quantum electrodynamics, the determination of the differential scattering cross section, as a function of the wavelength. The desired backscattering intensities are directly proportional to these differential scattering cross sections. The mathematical development proceeds as follows:

A wavefunction $\bar{\Psi}$, which satisfies the wave equation

$$i\hbar \frac{\partial \bar{\Psi}}{\partial t} = H \bar{\Psi} \qquad (1)$$

describes the quantum mechanical behavior of the given system, where $\hbar$, is planck's constant over 2π and H is the total Hamiltonian. The latter quantity may be divided into the following parts:

$$H = H_r + H_m + \left(-\sum_k \frac{e_k}{m_k c^2} \left[\vec{p}_k \cdot \vec{A}(k) \right] + \sum_k \frac{e_k^2}{2m_k c^2} \vec{A}^2(k) \right) \qquad (2)$$

where H_r is the Hamiltonian of the radiation field, H_m is that of the molecule, and the term in parentheses is that of the interaction between the two components, field and molecule. From a series of mathematical operations with equations (1) and (2), we arrive at the desired results:

$$\frac{d\phi}{d\Omega} (\Omega, \Sigma, \omega, J) = \frac{\omega^4}{c^4} \frac{2B_o hc}{kT} \frac{g_J (2J+1) e^{-B_o J(J+1)hc/kT}}{g_J^+ + g_J^-} S \qquad (3)$$

where

$$S = \left[\sum_i \alpha_i \left\langle Y_J^{*m} (\Theta, \phi,) \mid \cos(i,\Sigma)\cos(i,\Omega) \mid Y_{J'}^{m'} (\Theta,\phi,) \right\rangle \right]^2 .$$

MACSYMA Applications

Robert C. Ghent
NASA-HI 1980 Fellow
Analysis and Computation
Division

For the past decade, Langley Research Center, (LaRC) has helped finance the development of MACSYMA, a mathematical symbolic manipulation system operating on a PDP-10 computer at the Massachusetts Institute of Technology (MIT). LaRC personnel are entitled to exploit this facility freely, from their interactive terminals via telephone lines. This summer, under the guidance of Dr. John Shoosmith, efforts were made to test the practicality of MACSYMA on mathematical analyses which arose in the context of research here at the Center. This investigation benefitted from the initial work of 1979 NASA-HI Fellow S. J. DeLoatch, who was also under Dr. Shoosmith's supervision.

Members of the Computer Applications Branch submitted three problems relating to radiation-sensing earth satellites. An aeronautical engineering group posed stability and control optimization questions about a mathematical model for the transonic wind tunnel under construction. Appropriate calculations, all theoretically within MACSYMA's repertoire, involved the algebraic decomposition and separation of variables of an integral kernel, closed form integration of trigonometric polynomials, Laplace transforms and their inverses, and the inversion of matrices with polynomial coefficients. In all cases, results were obtained and returned to the proposers, but many of the solutions were untidy enough to be of uncertain usefulness.

To give one example of MACSYMA's practical limitations, the string-manipulating subroutines proved quite adept at computing transfer functions and exact control parameter functions for textbook exercises involving integer constants; when confronted with high-dimensional matrices with real coefficients from the National Transonic Facility wind tunnel model, however, the computer's obsession with an exact solution prevented its completing the calculation within the available core storage space. In this case, a tabular numerical approximation had to be accepted in place of the analytic functions. Even transmitting the voluminous data from Hampton, VA to Cambridge, MASS was a problem. The MIT timesharing system expects characters to arrive not much faster than a human can type them.

MACSYMA's ability to imitate and surpass a mathematician's algebraic and analytic derivations surprised some LaRC researchers who formulated problems for this study. The system appears to have considerable potential, despite bounds imposed by storage size and increasingly heavy daytime use by their subscribers. MIT is building a new machine more specifically suited to MACSYMA which may alleviate some present limitations.

Allen M. Miles
NASA-HI 1980 Fellow
Space Systems Division

Preparation of Polycrystalline Semiconductor Electrodes of Tungsten and Molybdenum Dichalcogenides

Numerous photoelectrochemical cells based on semiconductor electrodes in aqueous media have been described in recent years. Presently, single crystal GaAS electrodes in a sulfide-polysulfide or selenide-polyselenide electrolyte exhibit the highest reported power conversion efficiency of 12%. However, the most expensive step in the production of these and other photochemical cells is the growth and preparation of single crystals. Therefore, it would be economically advantageous to construct cells using polycrystalline materials. Various preparation techniques have been successfully employed. Those such as pressure sintering, anodic polarization of metal substrates in an electrolyte of the corresponding anion (e.g., Cd in sulfide-polysulfide to form CdS), sputtering and chemical vapor deposition have been used to produce polycrystalline semiconductor electrodes. Photochemical cells constructed employing these electrodes retained power conversion efficiencies of 50 to 90 percent of their single crystal counterparts.

Another problem inherent in most semiconducting materials is their tendency toward gradual photodecomposition in aqueous solution. In some cases this problem has been circumvented by using specially formulated electrolyte solutions.

The possible use of layer compounds such as tungsten and molybdenum dichalcogenides (e.g., MoS_2 and WS_2) as semiconductor electrodes was recently suggested. One very desirable and promising characteristic of these substances is their resistance to photocorrosion in solution. In contrast to compounds such as CdS and CdSe, in which the generation of electrode-hole pairs result from $p \rightarrow s$ phototransitions causing chemical bond breakage, and thus corrosion, phototransitions in these layer materials are $d \rightarrow d$ transitions involving nonbonding transition metal orbitals.

Consequently, photoelectrochemical cells constructed using photoelectrodes of WS_2 and MoS_2 is desirable. But again, the manufacture and use of single crystals of these cheap and abundant compounds are expensive.

The major concern of the present investigation was to select and optimize possible preparation techniques for polycrystalline photoelectrodes of WS_2 and MoS_2. The various techniques examined were: (1) anodic polarization of W and

Mo substrates under constant current (5 - 30 mA/cm^2) or constant potential (0 - 0.1v vs NHE) conditions in sulfide solutions; (2) sputtering of MoS_2 and WS_2 onto Mo and W substrates, respectively, for times of 20, 60, and 90 minutes; (3) chemical formation of MoS_2 and WS_2 from their corresponding oxides (viz., MoO_3 and WO_3) at elevated temperatures (400 - 800°C) in an atmosphere of H_2 and sulfur vapor; and, (4) pressure sintering of WS_2 and MoS_2 powders at 5,000 to 10,000 psi with temperatures ranging between 500 and 1100°C. Following preparation, the semiconducting properties were ascertained from current-voltage curves recorded while electrodes were immersed in a solution of 0.1M NaI/0.5M Na_2SO_4 or 0.1M NaI/0.5M H_2SO_4. The radiant source was a 100W xenon lamp.

Thus far, the most encouraging technique has been that of pressure sintering. Pellets of WS_2 exhibited small photocurrent densities of 0.3 - 0.5 mA/cm^2 . These are expected to increase significantly with an improvement in the design of the pressure sintering apparatus which should facilitate the attainment of accurate and reproducible experimental parameters.

Some Significant Accomplishments, 1976-1980

The Summer Research Fellowship Program was initiated at the Langley Research Center during the summer of 1976. Since that time, some significant technical contributions have been made by Summer Research Fellows. Only one from each Program year is briefly discussed below.

1976 Plans for the future utilization of space indicate the necessity for the construction of large space structures. Since strong gravitational forces will be absent, these structures can be assembled using light-weight materials which are generally flexible.

Dr. Taft H. Broome, a Fellow from Howard University, investigated the feasibility of stiffening flexible large area space structures by means of cables. The scope of his analysis included cantilevered booms of constant cross-section. During that summer, Dr. Broome studied six different cable stiffening schemes which provided acceptable results, and upon returning to Howard University for the 1976-1977 academic year, continued this research by studying additional schemes.

1977 During the past several decades, the use of the computer to solve research problems has increased to a level which in some cases demands optimal efficiency in computer utilization. One case is the solution of partial differential equations in steady-state time dependent problems.

Dr. William H. Lee, a Fellow from North Carolina Central University, developed a finite-difference numerical method which reduced, by a factor of ten, the amount of computer time generally necessary to solve this class of problems.

1978 Currently, there is international concern about pollution of the natural environment. The Marine Environments Branch at the Langley Research Center is developing methods of determining various levels of pollution in water. Although some data is gathered using remote-sensing techniques, an effort is also being made to develop mathematical models that may be used to predict pollution levels in water.

Dr. Demetrius D. Venable, a Fellow from St. Paul's College, developed a computer model using the Monte Carlo technique to evaluate solar radiation scattered from water for a non-homogeneous pollutant profile. The use of this model will reduce the amount of data gathered by aircraft to determine the levels of water pollution and improve the accuracy of predicting pollution levels in water.

1979 Graphite, a material formed from carbon and which because of its properties of durable strength, light weight, resistance to high temperatures and corrosive chemicals, is being used in the manufacture of aircraft, automobiles and various consumer goods. The Materials Research Branch of the Materials Division at Langley Research Center has been performing uniaxial compression tests of high strength graphite-epoxy laminates and have results showing that Young's modulus and fracture stress depend upon the specimen dimensions. Dr. Robert Reiss, a Fellow from Howard University developed an analytical model that explained the experimental results. This model is relatively easy to automate, therefore, some predictions will be possible with the use of the computer.

1980 Today, the use of robots for industrial purposes is more prevalent than ever before. Since most robots presently used are "blind", it is necessary for the software controlling these robots to be developed so that when it is more feasible for the robot to see, it will be able to do so.

Dr. John W. Bales of Tuskegee Institute developed a system of special marks to be placed on parts to be located and identified by a robot vision system. As a result, he was asked to write a NASA Technical Paper and he has done so.

Survey Results

During the first four years of the program's existence 35 different faculty members served as Fellows in the program. Thirty-four (34) survey forms were mailed in June 1980 to past participants (one person is deceased). Two (2) survey forms were returned because they could not be forwarded and one person telephoned to respond to selected items of the survey. Eighteen (18) of the thirty-four returned completed forms, representing 52.9%. Partial summary results of the returned forms are in the table which follows.

The table indicates that 88.9% of those applying to NASA for funds were funded. At least one other former Fellow has been funded so that 26.5% of the SRFP Fellows have been funded. The reported range of the size of the grants is from $10K to $81K. Also, 77.8% of those applying to other agencies for funds have been funded with the reported range of such grants being $5K to $36K.

Only 16.7% of those reporting indicated that they have published as a result of the SRFP experience, two of which were through the NASA Langley Research Center. However, 38.9% have delivered papers or talks at meetings of such professional organizations as the National Technical Association, the Optical Society of America, the Society for Industrial and Applied Mathematics and the American Physical Society.

Several former Fellows indicated they had increased their professional contacts as a result of their SRFP experience. Contacts have been made with persons of such organizations as the National Bureau of Standards, the National Center for Atomospheric Research, the Bureau of Mines, the Army and Navy as well as some major universities.

Primary use of SRFP experience on respective campuses has been in advising thesis students, conducting seminars for students and faculty and directing student projects. Of those reporting, 83.3% indicated that they had used NASA materials or resources since their SRFP experience.

All of the respondents indicated that they think the program should be continued. Since their SRFP experience, some have spent a summer at one or more of the following agencies: Nuclear Regulatory Commission; University of North Carolina at Chapel Hill's Biostatistics Laboratory;

National Science Foundation; Langley Research Center; Wright-Patterson Air Force Base; and, the Air Force Summer Research Program.

Three recommendations for making the program more successful were made.

- During the ten-week period, scientists and engineers representing various research areas at the Langley Research Center should be invited to speak about what research is being done and what the projected areas of research are.

- NASA should be encouraged to give small starter grants so Fellows can work on projects similar to their summer projects, where possible, on their respective campuses and thus become more competitive when seeking larger grants.

- The program coordinator should write to former Fellows at the same time the Vice-President for Academic Affairs is contacted to assure that faculty members at those institutions hear about the program.

SURVEY STATISTICS *(%)

ITEM	YES	NO
At Academic Institution	88.9	11.1
Had Pre-SRFP NASA Grant	5.6	94.4
Had Pre-SRFP Non-NASA Grant	33.3	66.7
Post-SRFP Application for NASA Grant	50	50
Of Those Applying, Those Funded	88.9	11.1
Those With Present NASA Grants	77.8	22.2
Post-SRFP Application for Non-NASA Grant	50	50
Of Those Applying, Those Funded	77.8	11.1**
Post-SRFP Work on Grant Directed By Someone Else	22.2	77.8
Publications Resulting from SRFP Research	16.7	83.3
Papers or Talks to Professional Organizations Resulting from SRFP Research	38.9	61.1
Increased Professional Contacts	94.4	**
Post-SRFP Use of NASA Materials or Resources	83.3	16.7
SRFP Should Be Continued	100	

*18 responses of 34 mailed

**Some did not answer.

Evaluation

The 1980 Summer Research Fellowship Fellows, without exception, reported that their research assignments were both interesting and challenging, their Research Associates were very accessible and helpful and their office accommodations were quite adequate.

Most of the Fellows indicated they had discussed future ventures with their respective Research Associate and several indicated an interest in becoming involved in some project in the future. The Fellows indicated that the Summer Research Fellowship Program is "an excellent way to introduce faculty members to research opportunities" and "provides them the opportunity to engage in research activities that cannot be provided at ... home institutions."

There was a problem with the air conditioning where most of the Fellows lived, but eventually a token reduction in rent was made as an acknowledgment of the inconvenience. All others reported that living accommodations were satisfactory.

All reported the stipend to be adequate or more than adequate. There was a recommendation that in the future, the travel allowance should include meals and hotel rooms as well as an increase in the $0.12 per mile.

There is a problem, it seems, with the announcement of the program reaching individual faculty members. Either the announcement does not get from Chairpersons to the faculty members or faculty members do not always receive their individual announcements in time to submit applications.

Fellows indicated that information received after selection and prior to arrival at the Langley Research Center was generally satisfactory. However, it was suggested that telephone numbers of motels, hotels, and apartment rental agencies might be received earlier than presently received (April).

From the coordinator's point of view, this group of Fellows was very cooperative, conscientious and hard-working. They were a pleasure to work with.

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