11:37:11 OCA PAD INITIATION - PROJECT HEADER INFORMATION 01/23/89

Active

Project #: G-41-692 Cost share #: F6669-0A0 Rev #: 0
Center # : R6669-0A0 Center shr #: F6669-0A0 OCA file #:
Work type : RES
Contract#: PHY-8851560 Mod #: Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #:

Project unit: PHYSICS Unit code: 02.010.152
Project director(s):
BRADEN C H PHYSICS (404)894-5249

Sponsor/division names: NATL SCIENCE FOUNDATION / GENERAL
Sponsor/division codes: 107 / 000

Award period: 890101 to 900630 (performance) 900930 (reports)

| Sponsor amount | New this change | Total to date |
|---|---|---|
| Contract value | 37,263.00 | 37,263.00 |
| Funded | 37,263.00 | 37,263.00 |
| Cost sharing amount | | 37,264.00 |

Does subcontracting plan apply ?: N

Title: IMPROVEMENTS IN PHUSICS "ADVANCED LABORATORY" COURSES

PROJECT ADMINISTRATION DATA

OCA contact: David B. Bridges 894-4820

| Sponsor technical contact | Sponsor issuing office |
|---|---|
| ROBERT W. ELLSWORTH | DONNA C. JENNINGS |
| (202)357-9575 | (202)357-9602 |
| NATIONAL SCIENCE FOUNDATION | NATIONAL SCIENCE FOUNDATION |
| MPS/PHY | DGC/MPS |
| WASHINGTON, D.C. 20550 | WASHINGTON, D.C.__20550 |

Security class (U,C,S,TS) : U
Defense priority rating : N/A
Equipment title vests with: Sponsor

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

Administrative comments -
PROJECT INITIATION - FUNDS IAO $37263 FOR ADVANCE LAB COURSE IMPROVEMENT
GRANT IN ACCORDANCE W/ NSF 87-74.

JAN 1989
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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

# NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 07/19/90

Project No. G-41-531 Center No. P5068-0A0

Project Director BRADEN C H School/Lab PHYSICS

Sponsor NATL SCIENCE FOUNDATION/GENERAL

Contract/Grant No. PHY-8851560 Contract Entity GTRC

Prime Contract No.

Title IMPROVEMENTS IN PHUSICS "ADVANCED LABORATORY" COURSES

Effective Completion Date 900630 (Performance) 900930 (Reports)

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

Comments

Subproject Under Main Project No.

Continues Project No.

Distribution 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 |

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ATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

# FINAL PROJECT REPORT
NSF FORM 98A

*PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING*

## PART I—PROJECT IDENTIFICATION INFORMATION

| Institution and Address | 2. NSF Program | 3. NSF Award Number |
|---|---|---|
| Georgia Institute of Technology<br>Atlanta, Georgia 30332 | Instrumentation & Lab. Improvement Program | PHY-885-1560 |
| | 4. Award Period<br>From 1/1/89 To 6/30/90 | 5. Cumulative Award Amount<br>$37,263 |

Project Title

Improvements in Physics "Advanced Laboratory" Courses

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


The physics "advanced laboratory" courses at the Georgia Institute of Technology are taken mainly by junior and senior physics majors. Students choose experiments representative of diverse areas of physics. In addition to the laboratory experience, reports require independent study that often serves as an introduction to topics not covered in formal, lecture courses. Sixty-five students enrolled in the courses during the most recent four academic quarters.

With the aid of National Science Foundation matching funds, substantial improvements have been implemented. New laboratory work has been introduced, and some extant experiments have been improved through the introduction of more effective apparatus. The students derive benefit not only from improvements in the physics experiments but also from the opportunity to gain experience in the use of sophisticated, up-to-date instrumentation - an opportunity that is often lacking in undergraduate education.

Most areas of physics that have been affected by the improvements are also areas in which there is strong faculty and graduate research activity. One set of experiments includes laboratory observations and computer simulations of systems which exhibit deterministic chaos. A set of experiments in fiber optics and another set of microwave experiments provide complementary vehicles for the study of wave phenomena; a feature of both sets of experiments is utilization of the phenomenon of "frustrated internal reflection." Work in atomic physics has been supplemented by addition of a Zeeman effect experiment which permits observation of both the transverse and longitudinal effects. Other experiments that have been affected by the improvements include nuclear magnetic resonance, semi-conductor physics, the Pockels effect (useful in laser systems), and nuclear radiation measurements.


## PART III—TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

| 1. ITEM *(Check appropriate blocks)* | NONE | ATTACHED | PREVIOUSLY FURNISHED | TO BE FURNISHED SEPARATELY TO PROGRAM: Check (✓) | Approx. Date |
|---|---|---|---|---|---|
| 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 | | x | | | |
| f. Other *(specify)* | | | | | |

| 2. Principal Investigator/Project Director Name *(Typed)* | 3. Principal Investigator/Project Director Signature | 4. Date |
|---|---|---|
| C. H. Braden | | 7/12/90 |

NSF Form 98A (1-87) Supersedes All Previous Editions

Form Approved OMB No. 3145-0058

Award #PHY-885-1560
Georgia Institute of Technology
Principal Investigator: C. H. Braden

Part IIIe. Technical Report.

All of the experiments in the Advanced Laboratory courses that were slated for improvement in the original proposal have received attention. In addition, some improvements not contemplated in the proposal have been effected. In this narrative, the organization of Part B of the proposal is tracked, and comments are made pertaining to the specific improvements cited in the proposal; improvements not cited in the proposal are included at appropriate places. A list of major apparatus acquisitions made under the grant is appended to this part of the report, and references are made to apparatus relevant to each improvement, as, for example, (#4) indicates that item #4 on the apparatus list is utilized in the laboratory work being described.

Although some price increases were encountered between submission of the proprosal and acquisition of apparatus, several other considerations resulted in a net gain in what could be accomplished with the funding. In the interim between preparation of the proposal and award of the grant, local funds were utilized to obtain equipment that permitted reallocation of extant equipment. An analog oscilloscope similar to one listed in the proposal became available due to resignation of a faculty member and release of his experimental apparatus. Consultation with Professor Rajarshi Roy, who had examples of the apparatus in question in his research laboratory, led to the conclusion that a state-of-the-art LeCroy digital oscilloscope (#5) would not only combine functions of two items listed in the proposal but would be better for our purposes.

The signal averaging capabilities of the LeCroy digital oscilloscope (#5) are utilized in the NUCLEAR MAGNETIC RESONANCE experiment. Analysis of the "wiggles" that appear upon fast passage through resonance can now be made on the basis of a plot (#3) of the digital scope trace. The search for weak resonances is also facilitated.

With the use of departmental funds, the photoelectric effect laboratory was expanded to include an experiment with light emitting diodes, and modifications were made in the apparatus utilized for the classic stopping potential experiment. A result of these changes was the release of a low-current measuring instrument, which permitted expansion of the Franck-Hertz laboratory to include an experiment with helium, in addition to the classic experiment with mercury. Grant funds were then used to obtain a newly marketed ZEEMAN EFFECT apparatus (#8). A quantitative study of the normal Zeeman effect in cadmium is made. The structure of the magnet permits observations of both the transverse and longitudinal effects. It has also been found that a useful, albeit not very precise, study of the anomalous effect in mercury is possible.

A principal research area in the department is atomic physics, and an atomic physics "track" is being introduced into the undergraduate program. One of the faculty members who will be assuming supervision of the advanced laboratories upon the retirement of the PI is active in the area and wishes to provide strong laboratory support for the atomic physics program. In addition to the Zeeman effect and expanded Franck-Hertz experiments, she intends to introduce additional laboratory work (#7), including instrumentation associated with VACUUM SYSTEMS, as she assumes her responsibilities during the forthcoming academic year.

The oscilloscope with transistor curve tracer module needed to effect improvements in two semiconductor physics laboratories, viz. a laboratory involving experiments on various types of diodes and a laboratory which includes the study of the temperature dependence of p-n junction characteristics, was acquired from the laboratory of a faculty member who resigned. Reports on these experiments include photographs of the scope screens (#11).

A useful modification was made in another solid state experiment not cited in the proposal. A POCKELS EFFECT cell (#6) was acquired, and study of the Pockels effect has replaced previous study of the Kerr effect. This change is deemed advantageous on two counts. The Pockels cell is similar to devices employed in many laser systems and thus better supports the strong departmental program in optics. The Kerr cell experiment was always a cause of unease due to the need to employ a liquid with dangerous properties; the fumes were toxic to a degree and the liquid was highly inflammable.

An experiment on NUCLEAR COINCIDENCE SPECTROSCOPY has been introduced (#2, #12). Two sodium iodide detectors are used to study gamma radiation emitted in the decay of Bi-207. Presently, the apparatus is employed in a fast-slow coincidence configuration in which students investigate settings of two single-channel analyzer windows and the setting of an adjustable delay in order to secure time coincidence of signals in the two channels. This provides good experience with coincidence instrumentation. A Na-22 radioactive source has been obtained, and an experiment involving annihilation radiation may be introduced as a replacement or supplement to the present coincidence experiment. The apparatus also permits a configuration in which one radiation may be selected to gate coincidences with an entire spectrum. The apparatus may also be employed in a non-coincident mode as a multi-channel analyzer, a configuration appropriate to an older experiment using a Ge detector to study closely spaced gamma radiations in the decay of Ir-192 (produced locally in the Georgia Tech reactor).

The effectiveness of the laboratory observations on a driven (#9) diode-L-R circuit in the recently implemented DETERMINISTIC CHAOS laboratory has been dramatically improved by utilization of the LeCroy digital scope, with fast Fourier transform and signal averaging capabililties (#5). Records of the observations may be made with a plotter (#3) or with a camera (#11); the former proving most appropriate for the digital scope, and the latter being needed for observations made with an analog scope. A special triggering device was designed and constructed by our electronics technician, which has become an invaluable aid in the use of the digital scope. The first student to use the combination of the digital scope and triggering device discovered interesting patterns upon signal averaging of the diode circuit response when in a chaotic regime. The digital scope not only allows averaging of the circuit response but, by utilization of the capability to chain operations on accumulated data, also permits averaging of FFT data; both data treatments yield interesting studies.

The IBM computer system (#2) has been utilized to rework the computer simulation of a diode-L-R circuit, which is another part of the DETERMINISTIC CHAOS laboratory. The two programs needed by the students, one to search for interesting behavior and one to make a more detailed study of a response that has been identified as interesting, are made available on a disc that is compatible with the DOS operating system. A fairly fast computer is needed to make use of the search program practical. The students who have used the discs have enjoyed much more success in this part of the laboratory than had been the case in previous attempts to use programs placed on the Institute's central computer. In fact, student's had usually omitted this part and replaced it by extra work on another part. Now, all students do the simulation, which provides for a more complete laboratory experience. Although not anticipated at the time the proposal was prepared, the Institute seems determined to eliminate the main-frame computer, which makes the newly implemented procedure the only one that may be practical in the future.

In view of the considerable number of departmental faculty interested in the field of deterministic chaos and the student enthusiasm for work associated with the field, the improvements in this facet of the advanced laboratory courses are deemed to be a major improvement in the undergraduate program.

The MICROWAVES laboratory is now in operation (#4, #10, #13). In addition to the main experiment on frustrated internal reflection, a variety of other exercises (e.g., standing wave ratios, stub tuning, determination of approximate index of refraction of prism used in FIR experiment) are included to provide broader experience with microwave technology. Of particular value is the relationship of these microwave phenomena to similar wave phenomena in the optical regime, especially phenomena relevant to fiber optics technology.

The FIBER OPTICS laboratory (#1) has just been implemented. The laboratory comprises a variety of exercises, based mainly on parts of several of the experiments described in the Newport manual. In one experiment, a fiber coupler that utilizes the evanescent field is studied; this experiment is evidently complementary to part of the microwaves laboratory. In another experiment, a single mode coupler (also using the evanescent field) is a part of an interferometer. As in the microwave laboratory, an effort is made to include diverse phenomena, and experience is gained with a dry splice, the GRIN lens, a mode scrambler, the launching of lower versus higher order modes into the fiber, and polarization phenomena.

## APPENDIX

Major units of instrumentation acquired under the grant are listed here.

1. Fiber Optics Kit. Newport FKP-STD, F-ML1.

2. Computer System. IBM PS/2 Model 80, X24E, 8513/001.

3. Plotter. Hewlett-Packard 7440A.

4. Waveguide Terminations (2). Hewlett-Packard WR90.

5. Digital Oscilloscope. LeCroy 9400A, with AWP01 & AWP02.

6. Pockels Effect Cell. INRAD 111-200.

7. Atomic Physics and Vacuum System apparatus. Pressure measurement system, pump, gauges, time-to-amplitude converter module, 10 A power supply.

8. Zeeman Effect Apparatus. CENCO (Leybold) magnet, power supply, light source, optical system.

9. Function Generator. Hewlett-Packard 3314A.

10. Function Generator. Wavetek 182A.

11. Scope Camera. Tektronix C-4.

12. Pulse Analyzer Module for PC. EG&G Ortec NS917.

13. Microwave Frequency Counter. Hewlett-Packard 5350B.

## PART IV - SUMMARY DATA ON PROJECT PERSONNEL

NSF Division Office of College Science Instrumentation

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.

| *U.S. Citizens/ Permanent Visa | PI's/PD's | | Post-doctorals | | Graduate Students | | Under-graduates | | Precollege Teachers | | Others | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Fem. | Male | Fem. | Male | Fem. | Male | Fem. | Male | Fem. | Male | Fem. |
| American Indian or Alaskan Native .... | | | | | | | | | | | | |
| Asian or Pacific Islander .......... | | | | | | | | | | | | |
| Black, Not of Hispanic Origin ........... | | | | | | | | | | | | |
| Hispanic ........... | | | | | | | | | | | | |
| White, Not of Hispanic Origin ........... | 1 | | | | | | | | | | | |
| Total U.S. Citizens ..... | 1 | | | | | | | | | | | |
| Non U.S. Citizens ..... | 0 | | | | | | | | | | | |
| Total U.S. & Non-U.S. .. | 1 | | | | | | | | | | | |
| Number of individuals who have a handicap that limits a major life activity. | 0 | | | | | | | | | | | |

*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.

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