Annual Report of the Department of Physics

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From: Robert S. Cohen, Chairman, Department of Physics

This Annual Report may serve as a general survey of the affairs of this department, useful to my colleagues as much as to our deans and administrators. It is long, but yet incomplete for it merely mentions many problems without sufficient statement or analysis. It is intended to be informal, and I hope it will be found to be fair and judicious. We have had a good year, and this will be evident to the reader who persists on to the end. But while we tremble on the edge of becoming a noteworthy center of pure physics research and teaching, we have not yet become one. Our teaching facilities are embarrassing in several vital respects; our undergraduate students are mainly poor in motivation and in ability; our graduate students, while decidedly improving, are still often beset by fear of committing themselves wholeheartedly to the love of studying the nature of things; and our research still lags (however vigorously) because so much of it depends upon the generosity of neighboring institutions. If we can continue as we have been, we should be able to solve these problems during the next five years.

I hope I am not blamed in reporting these matters. It seems clear enough that the faculty at least are flourishing in their scientific lives, and much of this Report is a testimony to that, and to the improvement in the department's material support for them. Moreover it is also clear to me that the faculty are unanimously as devoted to teaching, and to careful thinking about the department's teaching obligations, as they are to Pure Physics. This seems to me to be the mark of health in any department in this University.

R. S. Cohen

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Contents

2 (a) Introductory and service courses

The scope of our general courses may be indicated by a table of registration figures.

Fall 1964

ASTRONOMY:

Course No.	Students Registered	Completing
AS101 (Section A)	228	229
(Section B)	158	167

PHYSICS:

PY101	230	219
PY101H	92	90
PY103	233	203
PY103H	74	72
PY104H	35	35
PY105	82	78
PY121	46	46
PY151	59	56
PY201H	23	21

Spring 1965

Course No.	Students Registered	Completing
ASTRONOMY:		
AS102 (Section A)	235	236
(Section B)	203	202
AS202	8	7
PHYSICS:		
PY102	207	160
PY102H	56	68
PY103H	48	43
PY104	196	165
PY104H	58	50
PY106	69	58
PY122	47	46
PY152	50	38
PY202H	16	8

2 (a) Continued

The offering of basic courses in Physics has been reorganized. We now offer a two year sequence in Principles of Physics, with two years of calculus concurrent, designed for physics majors, mathematics majors, and all engineering students. The first year of this sequence was initiated in 1964-65, by Professor Chapman, to a group of about 50 students. In 1965-66 this first year of the sequence will be offered to approximately 200 students, and the second year of the sequence will be offered to the now smaller initiating group of about 40 students by Professors Booth and Edmonds. This new course is being offered in this way because it is a new program, radically different from what we have done before, and we feel that it should be offered to a small group for one year while the course is being developed, then offered to the larger group after a year of development.

In other changes in the basic courses, the former General Physics course, PY103-104, has been discontinued. In its place we have two courses: a one-year course, Elementary Physics (PY 105-106) using no mathematics beyond that expected for entrance to CLA, and another one-year course, General Physics, (PY 111-112) which has a year of calculus as prerequisite. These two courses will provide a greater choice and more flexibility in advising and placing students in a one-year basic physics course. The course using calculus is designed for chemists and other science majors who can not spend two years in the program designed for physics majors and engineers. The course without the calculus is designed for non-science liberal arts students, and will be suitable for those majors in a non-physical science who do not study the differential calculus. Both courses will be new in 1965-66, and the development of these courses will be watched carefully by the department. We hope that most pre-medical students will elect PY 111-112.

Related to these developments is a problem of staffing. The greatest shortage in physicists is for those who are experienced in teaching basic courses, and interested in doing so. An experienced man can be obtained only at one of the higher ranks. In the present department faculty, Professor Cohen is experienced in teaching such courses of the type that do not have related laboratory work. Several years ago the only faculty members who were experienced and interested in teaching such courses with laboratory work were Professors Sidje and Hsu. Professor Hsu has moved to another institution,

2 (a) Continued

and we were very fortunate in obtaining Professor Snipes who is experienced and very interested in teaching such courses. But we are making progress on this problem by developing teachers of basic physics courses from within the department. Professor Rhoads is now experienced in teaching such courses. He wishes that he might use more mathematics than is normal for our lowest level course, and with his present experience he should do very well with the new General Physics (PY 111-112) course. Professor Hoy, who will join the department in September 1965, has a long-standing interest in teaching a basic physics course. Next year Professors Alston and Zimmerman will both teach evening sections of the Elementary Physics (PY 105-106), with some help and advice from Professor Snipes, who will be teaching the regular daytime course and who will coordinate the preparation of lecture demonstrations, laboratory plans, and course scheduling. We expect that after a year or so these two colleagues will be fully qualified teachers of our basic physics courses, and that they will be interested in continuing this type of teaching.

The other faculty problem is in Astronomy. This year the large basic astronomy course was in two lecture sections, with part-time visiting professor Guillotte teaching the second section. Next year the course will be still larger. We have added Professor Papagiannis to our staff, and surely will need still another man in astronomy. The increased interest in astronomy is not restricted to the basic course, for there is a sharp increase in interest in upper level and graduate courses in astronomy. A new faculty member brought in to help staff the large basic course should be expected to teach a high level course in his special field, and to engage in research. This means that we must plan for enlarging our own facilities for research in astronomy; it is generally true that we can not build a strong department with the faculty teaching here and doing all its research at neighboring institutions.

2 (b) Physics contribution in CLA: program and students

We now have an excellent series of required and elective courses for students who choose to concentrate in Physics, in Astronomy, or in Physics and Astronomy. Moreover we have sufficiently coordinated our program with that of the new EAS curriculum that students may, as late as their junior year, transfer from EAS to CLA Physics major, or the reverse, with little difficulty. It is also true that our series of 300 level courses provide our best students with the opportunity of preparing for graduate study at a level equal to those at the best of the larger university physics departments, although it is to be expected (and in my opinion encouraged) that our students will maintain a liberal arts emphasis equal to that in physics, and hence that at no time should we expect their preparation to be comparable to that of a physics major at a technical institute or other B.S.-granting university.

But our major undergraduate problem is the extraordinary lack of departmental majors. In the past eight years, we have developed a substantial graduate program and we cultivated many students by offering regular graduate courses through BUE. No such success was evident in the undergraduate program although the full B.A. major program in physics and mathematics was available through BUE. It is not necessary to add to Professor Gaosan's comments, quoted below, at 4(b), but it is necessary to underline the urgency of the problem. There are many able high school students who will not find their way to M.I.T., who should seek a physics education in a large urban liberal arts university environment, and who seem not to know of this department. It will be an expensive anomaly if Boston University has a fine physics program of service courses, a creative teaching and research faculty in physics, and yet has fewer liberal arts physics students of graduate study calibre than can be counted on the fingers on one hand. This is the principal concern of our Undergraduate Committee for the year or so just ahead.

2 (c) BUE Physics program.

Two problems related to the change in the basic physics courses are the questions of what courses to offer in the BUE evening program, and the question of which courses to offer in the BUE summer program. Our present feeling is that the Elementary Physics, PY 105-106 (without calculus), should

2 (c) Continued.

be offered in the evening, and we will do so both in the regular sequence and in the reverse sequence, in the evening schedule for 1965-66. However, there has been approved a joint CLA-DCE plan to offer a complete physics concentration program in the evening. If this is budgeted, then the new two-year sequence must be offered in the evening; but this will be very expensive unless there are more evening students in this course than we presently expect. A related question is the proposed plan of the College of Engineering to accept freshmen in the second semester of each year. Professor Shipe has suggested that if this is done, perhaps we can solve two problems by offering the two-year DCE sequence for physics majors and engineers in the late afternoon, starting in the second semester, with at least one evening laboratory section for the evening physics majors and at least one day laboratory section for the odd-semester entering engineering students. A department decision on this must await decisions by CLA, DCE and ENG concerning their programs.

The remainder of our DCE program has settled at a stable level. About one-fourth of our students in each graduate course are not degree candidates but rather are students with suitable prerequisites who come to B.U. for GRS physics for a variety of personal reasons. Perhaps five of these students apply for admission to GRS each year, and it is noteworthy that several of our outstanding Ph.D. dissertations have been written by such hard-working students. Nevertheless Professor Kenan's remarks, cited below, speak for all of us; there is no substitute for an abundance of time, an assurance of it, and an absence of competition for it. The doctorates of John Herrero in 1964, and of Paul Fougere and Thomas Skinner in 1965, were delayed and limited by their full-time efforts at substantial and responsible jobs elsewhere. Hence, although our reputation for difficult advanced courses in Physics is a good one, and one of the valuable and unique aspects of the B.U. contribution to Physics education in New England, I believe we must now look toward normalization of our demands upon students for their full-time, daily and weekly efforts, in the scientific and instructional life of the department. It is, after all has been said, only in the old-fashioned relation of master and apprentice that we will find it possible to bring our education of advanced students to a satisfactory state; and this can be brought about for part-time students only in the rarest of instances.

2 (c) Continued

Whether the full CLA physics concentration can attract a sufficient number of students from the metropolitan Boston area remains to be seen. It is an attractive educational prospect for there must be many high school students who must go to work after leaving school but who could undertake a scientific career with energy and ability and success if it were available in the evening. We do not know whether the Northeastern University or the new University of Massachusetts programs will drain off most of these students meanwhile, except for the question of the introductory courses, as noted above, there is no policy question of urgency. The major is now available, and it awaits a substantial University-CCE-Admissions effort in the high schools and in the community to give it a fair test. No such effort has yet been made, and I believe it will wait upon urging by CLA.

2 (d) Summer physics program.

For courses in the summer, we feel that the Elementary Physics (PY 105-106) should be offered as a service. But there has already been some evidence of a demand for the General Physics, PY 111-112 (with calculus prerequisite), in the summer for chemistry majors and premedical students. If it is sufficient, both courses may be offered in the summer of 1966.

In summer 1964, 69 students completed PY 103S and 77 completed PY 104S. Comparable numbers are registered in Summer 1965.

Summer offerings have been tried at the upperclass and graduate levels for three years. The registration for 1964 was as follows:

PY209S, Atomic and Nuclear Physics	24
PY305ES, Classical Mechanics	10
PY313ES, Advanced Laboratory	11
PY703ES, Advanced Mathematical Physics	13

In addition, some 15 graduate students continued in research projects during the summer, and a weekly summer seminar was held, concerned mainly with reports of research within our own department. In view of these figures, a slight expansion of the graduate courses has been given in summer 1965, with comparable registration. Cohen's advanced seminar in philosophical foundations of physics (PY 607S) has also been added, with 9 students registered; and Chasan is offering the junior course in Mechanics, with a substantial

2 (d) Continued

enrollment. It is noteworthy that the course in Atomic and Nuclear Physics, PY 20986, which Edmonds has made so successful, is entirely for non-physics students. The course was dropped from the CLA catalogue two years ago, and it continues merrily along in the SUM catalogue, as a late afternoon course, supported by undergraduate pre-med students, by outside scientific and medical workers, and by still others.

The summer courses are of no great importance to the University, (except for the introductory courses). But they make possible an easing of the pace of satisfying course requirements for our graduate students, and they help to reduce the calendar-time needed to complete the M.A. and Ph.D. degree requirements.

2 (c) NSF Instructional Equipment Grants

(c) We have been fortunate to obtain three grants for development of instructional laboratories in recent years, the first five years ago from the Atomic Energy Commission for a graduate nuclear physics laboratory, the second and third from the National Science Foundation for undergraduate laboratories.

(b) The second grant was for the purpose of improving undergraduate laboratory instruction at the junior-senior level as described in the proposal dated 12 September 1962. Approximately 75% of the funds have been used to provide laboratory equipment for new experiments, and to improve existing experiments, in a senior level Advanced Laboratory course. The remaining 25% of the funds have been used to provide equipment for an Electronics Laboratory course, PY205.

Instruction in the electronics laboratory has been improved by the addition of equipment of greater precision and better quality than we would have been able to afford without the aid of this grant. Most of the equipment purchased for this laboratory has been cathode ray oscilloscopes, regulated power supplies, and vacuum tube voltmeters. With this basic equipment, and standard components for vacuum tube and transistor circuitry, the course has been improved because the students have been able to contruct and test circuits, and make electrical measurements, that were impossible before we added this high quality equipment to the laboratory. This course has been under the direction of Professor Dean S. Edmonds. He is now writing a text for an electronics course for undergraduate majors in physics and related sciences, and this text is based on new laboratory instruction methods and procedures that he has developed during the term of this grant.

Instruction in the Advanced Laboratory course has improved far beyond our most optimistic expectations. This course is under the direction of Professor Wolfgang Franzen, assisted by other experimental physicists in the department, with Professor Bernard Chasan making major contributions to the improvement of the course. This course consists of a selection of experiments in modern physics, plus a few carefully selected experiments in classical physics. There is a wide variety of experimental subject matter, and there are experiments of several levels of difficulty. The schedule of experiments to be done is planned individually for each student to meet individual needs and interests, and to provide the student with a variety of laboratory experiences, familiarity with a variety of equipment, and a broad background for future experimental work.

A course of this type should include some experiments that are related to currently active research fields, and should include several experiments that are related to the experimental research interests of the department. It should include experiments that can be performed using commercially available equipment that can be operated according to manufacturer's instructions with a minimum of experimental difficulty. As a much more important feature, a course of this type should include experiments where the student is required to design, construct, and adjust the equipment to solve a laboratory problem, because this course is perhaps the student's first introduction to the problems of experimental research. The course should also provide the student with instruction in the use of vacuum systems, small current measurements, high voltage techniques, complex optical systems, and other standard laboratory procedures that are the basic skills of an experimental physicist. These statements about the course describe the philosophy that has been our guide in developing the Advanced Laboratory course.

2 (e) Continued

Changes in the program have been made without increasing the financial commitment stated in the original proposal. This has been accomplished by a combination of luck and hard work. The original proposal included approximately five thousand dollars for a large electromagnet and power supply to be used for an experiment on the Zeeman effect. An old electromagnet was available in the department, but this was not in satisfactory operating condition. With changes in the staffing of the course and consequent changes in the priorities assigned to the development of different experiments, the old electromagnet was attacked by staff and graduate students, and with imagination and hard work it was rehabilitated. The funds saved by this operation were applied to the purchase of equipment for several new experiments.

This Grant was for undergraduate instructional scientific equipment, but one important impact the project has had on the university is its effect on our graduate program. The course in Advanced Laboratory, PY313-314, is a senior level undergraduate course, required of undergraduate physics majors in the senior year. Properly, the course belongs in the borderline area described in college catalogs as "for seniors and first year graduate students" and the course is numbered so that it carries either undergraduate or graduate credit. We would like for all of our graduate students to have had a course of this type before they enter our graduate school, but one of the facts of academic life at Boston University is that we have graduate students whose undergraduate studies in physics were at small colleges with poorly equipped laboratories, and we have many graduate students from foreign countries where the instruction laboratories are very poorly equipped. We consider the Advanced Laboratory as an undergraduate course at the senior level. It is normally taken by most of our first year graduate students because they need a course of this type before entering higher level graduate courses.

Another important impact of this project has been on those graduate students who have a reasonably adequate background in experimental physics. These students have aided in the development of the Advanced Laboratory by designing and constructing much of the equipment used in the course. For example, the mass spectrometer, the laser, the experiment on optical pumping, and the experiment on angular correlation were assembled by graduate students. These experiments, placed in operating condition by graduate students, will be available to undergraduates next year. The graduate students have learned much about the assembly of vacuum systems, the construction of specialized electronic equipment, and the adjustment of complex experimental equipment. The undergraduates will have access to experiments that they would not ordinarily perform, or ever see. Both groups benefit as the result of this Grant.

(c). The third grant was awarded in Spring 1965 for improving our elementary course laboratories. It is in an amount of $22,400, which is to be matched by commitment of the greater part of our regular CLA budget for equipment and supplies during the next two years, supplemented by a small amount from the EMG budget. This award will enable us to carry the fundamental curricular revisions mentioned above, but at the cost of depriving normal teaching laboratories and other normal demands of what should be a fair operating budget. It will probably be mandatory for us to obtain a larger budget for supplies and equipment in 1966-67, the present budget having been unchanged for the third year.

2 (f) Problems of facilities.

The level of instructional equipment is the best we have had. The department is in a better position in terms of instructional and research electronic supplies and equipment than in any previous year. This is due, in large part, to the overall supervision of instructional laboratory supplies by Professor Stipe and of research supplies by Professor Edwards. It is also, in greatest measure, made possible by the unusually effective management and responsibility of Mr. Joseph DeSousa. Records and files of equipment, purchase orders, merchandise received, and payment of invoices are all in good order, and they have been so throughout the year. The separation of scientific equipment into those materials and apparatus which should be available for research and advanced laboratory instruction on the one hand and those for the general laboratories has been of enormous help to all, simple as it may be to state it.

A number of distinct problems may be described under this topic of facilities.

One problem, arising because of the change in basic physics courses, is that of instructional laboratory equipment. In recent years the registration for our various basic courses has increased greatly, and for the past three years only a very small portion of the departmental equipment budget has been used for these courses. During 1962-63, a large part of the equipment budget was used for upper level courses and for supplies for a new stockroom that supports the advanced laboratory and departmental research projects outside of foundation support. For the two following years the major part of the departmental budget was used to match the NSF grant for equipment for the upper level courses. During all three years there was difficulty in maintaining the elementary laboratories, and no funds for adding new experiments or improving old experiments. Now, with the new two-year course sequence for physics majors and engineers, this problem of the elementary laboratories has become acute.

A part of this problem is to be solved by the new NSF matching grant for laboratory equipment for the new two-year sequence. However, this grant must be matched by about $21,500 from the regular departmental budget, and this will take almost all of our budget for the next two years. This means that there will be two more years during which funds will not be available for improving the normal elementary physics laboratories and the astronomy course facilities. Thus there will have been a total of five years for which only small funds are available for these laboratories, and it will be extremely difficult to maintain a minimum satisfactory level of laboratory instruction in these courses.

The only solution of these problems seems to be a large increase in the departmental budget for laboratory equipment (or perhaps a special grant of university funds to be used for matching the NSF funds).

A second problem concerns rooms for laboratories and lectures. We moved into remodeled quarters at 700 Commonwealth Avenue only a few years ago, but we are already crowded for teaching laboratory space because of the increased student load in basic courses, both day and evening. This year we have taught several laboratory courses in the same room, with inconvenient schedules that made it impossible for some students to take the courses they should have taken, and with time-consuming shifts of equipment, several times each week, that were expensive in labor time. Plans were drawn for converting two classrooms into instructional laboratories beforeSeptember 1965, but this construction was voluntarily postponed for one year, due in part to the uncertainties of the DCE and ENG plans for offering the new two year sequence in the reverse semester sequence (see item 2c above), and in part due to the extreme shortage of classroom space that made it desirable to postpone the taking of any classrooms for one year.

3 (f) Continued

This construction converting classrooms at 700 Commonwealth Avenue into teaching laboratories, must be done before September 1966. The only question is whether we must convert two classrooms or three, and this depends on ECE and EMG. In the meantime, for 1965-66, we will again operate with a laboratory schedule that is inconvenient for students, and that requires shifting of heavy equipment three times each week. This is possible for 1965-66 because the second year of the new two-year sequence is offered for only a small number of students. This schedule will not be possible in 1966-67 when all sophomore engineers will be taking the second year of the two-year sequence.

The need for adequate facilities for demonstration lectures is desperate. Many years ago we used Room 50 for demonstration lectures. Ever since the Stone Science Building was remodeled for the Chemistry Department, and the Physics Department moved to 700 Commonwealth Avenue, this room has been inadequate for demonstration lectures in part because the Chemistry Department has used the preparation room for other purposes, in part because of distance and time factors. Our present facilities for demonstration lectures are far poorer than those of many high schools in this area, and are far below the normal standards of other good colleges, universities, vocational and technical institutes. The only demonstration experiments that can be used are those which can be set up in the seven minutes between courses, with two large classes of students, one leaving the room and the other entering the room, both using the single entrance door beside the lecture table (often 450 students). For many of the experiments equipment must be carried across the street, through traffic and bad weather.

For 1964-65 several of our larger courses met in Room 50, and very few demonstration experiments could be used for these courses. Other courses that should have had demonstration experiments, such as the physics course in the 6-year CLA-MED program, have met in other class rooms where it was impossible to do even the simplest demonstration experiments. This year the 6-year CLA-MED physics has met in a classroom with a level floor, and half of the class of 50 could not see more than the upper half of the chalkboard. These are honors students, coming to us from some of the best high school science courses, and we attempt to teach them physics with no demonstration experiments and inadequate visibility of the diagrams that are used instead of equipment.

Next year we will have the same problem of inadequate facilities for the large classes meeting in Room 50, and will also have two basic courses, the 6-year CLA-MED course (PY 121-122) and the General Physics with calculus prerequisite (PY 111-112) that are too small to meet in Room 50 and therefore will have to be taught in a room where no demonstration experiments, even the simplest, can be done with proper visibility and where the chalkboard visibility will be inadequate for a subject such as physics. Even if a priority could be assigned so that Room 50 could be used for these small classes, the room would still be unavailable because there are so many physics and astronomy lectures in Room 50 that nothing can be moved out without causing further problems.

We cannot give our students the quality of instruction that they deserve without having improved lecture room facilities. What is needed is a well designed large lecture room with adjoining preparation room used for no other purposes, and another smaller lecture room adjoining the same preparation room.

The university is now in the early stages of discussion and planning for a new science building. This is sorely needed, but planning, financing, detailed plans, and construction will take several years. The need for additional laboratory instructional space, and for lecture room facilities, can not wait. Some interim measures must receive a high priority.

2 (g) *Problems of staff: teaching fellows*

Professor Stipe writes as follows: "There are still many problems concerning teaching fellows, but we are making some progress here. If the proposals of the CIA-GRS Committee on Graduate Teaching Assistants are adopted and followed conscientiously many of these problems will be reduced. The most serious arises from a conflict within the department. Those members of the department who teach large basic courses requiring the assistance of many teaching fellows believe that the teaching fellow is a junior-level part-time faculty member, and that he should be awarded a fellowship on the basis of his competence in teaching and his willingness to make a serious effort to do the work assigned. Other members of the department, most of whom teach graduate level courses and have no responsibilities regarding the large basic courses, feel that teaching fellowships should in part be used for the support of graduate students, and should be awarded solely on the basis of the need for support. The department chairman is under pressure from both groups, and in several cases he has appointed teaching fellows who were not competent to teach sections. The results have been disastrous and have had a serious effect on the morale of the faculty members teaching the basic courses. In some instances teaching fellows who proved themselves to be incompetent as teachers and irresponsible in performing their duties have been removed from teaching sections and assigned paper grading duties, while other teaching fellows had to handle more sections to cover the load. This is interpreted, by some teaching fellows, as rewarding a man who does a poor job by giving him a lighter load, and penalizing a man who does a good job by giving him a heavier load. This has caused the morale of the good teaching fellows to become very low, and when one of the incompetent teaching fellows is reappointed for another year the effect on morale has been once again disastrous."

"We must give up the idea that all graduate students should be supported, and bring back the old fashioned idea that if a man receives pay for doing a job, he should do it, and do it well."

To this, the chairman can only say, mea culpa and amen.

2 (h) Graduate students.

The number of graduate students has only slowly risen and it seems likely to stabilize for a few years at about 70 regular degree candidates. The incoming students were selected from a group of applicants of about six times their number, and for the first time in some years only one or two came from Asia. This seems to be a fluctuation since there are four or five from India alone, and several others from other countries, among those admitted for Fall 1965. Stability may also be seen in the fact that the number of degrees awarded has now, (at last!) come to within range of the number of entering students. Indeed, after many years of awarding only one or two doctorates (going back to 1952 with the single exception of 1954 when three were awarded), the Physics department has come to awarding four doctorates in 1964 and again four in 1965; and it seems probable that six or more will be completed for award in 1966.

We need funds for fellowships, and we need greater support for research students as assistants to faculty; and, most urgently, we need to increase the stipends for our Teaching Fellows. This year, repeating what happened in each of the past three years, we admitted applicants with superb records only to have them go elsewhere, and in at least four cases the temptation elsewhere included a substantially higher stipend. Our present stipend of $2000 should be increased

2 (h) Continued

to $2400; a difference of $400 will make a substantial difference to applicants in my judgment, and will for the first time make our fellowships competitive in the present physics market. There seems to me to be no other way of obtaining competent CLA teaching assistants in competition with the vast range of NSF, NASA, NDEA and other fellowship opportunities. And at some universities, notably Princeton, the teaching fellowships are set at $200 higher than research assistantships and fellowships. We need have no thought of competing for Princeton's students to learn their lesson.

Thirteen of our students held special fellowships, as follows:

Summer 1964: Prakash Chand, fellowship to participate in the Brandeis University Summer School in Theoretical Physics

Paul Markowitz, NSF Graduate Fellowship for teaching fellows

Academic Year 1964-65:

John Browneon, NSF Cooperative Graduate Fellowship

Samuel T. Scott, NASA Fellowship

Wijit Senghaphan, Government of Thailand Fellowship

John Hegarty, NSF Faculty Fellowship (for Ph.D. study)

Benjamin Cogen, NSF Faculty Fellowship (for Ph.D. study)

Summer 1965: Paul Markowitz, NSF Summer Fellowship

Raymond Arnold, NSF Summer Fellowship

Chor Jin Koh, fellowship to participate in the University of Colorado Summer Institute in Theoretical Physics

2 (i) Graduate courses and curriculum

Once again, the department faculty has been wrestling with the problem of general examinations. Can a comprehensive examination fairly test a student's general knowledge of Physics? Can it predict his future in research? Is it possible to devise a new examination which will itself be a useful means of education in scientific thinking in one of our fields of research interest?

The general satisfaction with the improvement of standards in the written comprehensive examination has led us to consider a change in the oral qualifying examination, and this change, in the direction of a special problem studied in depth over several months, will be examined during 1965-66 by trying it with our new group of students who have passed the written examinations. But we will have also to meditate over the repeated concern that we test too much, that we do not know who among us could also satisfy his present colleagues, and indeed it is sobering to see Professor O'Neill's reiteration of this concern after his experience at Berkeley (see 4b below).

We will hope to introduce a course on Modern Optics as O'Neill returns from leave; and we will have a new course in Low Temperature Physics especially for students who will be working with Professor Zimmerman. The improvement in Advanced Laboratory is described above.

2 (1) Physics Colloquia

21 October 1964: Mendel Sachs (B.U.), The Masses of Elementary Particles from the Geometry of Space-Time

4 November 1964: R. A. Bernstein (University of Maryland), Low Energy Hyperon-Nucleon Scattering

2 December 1964: E. P. Gross (Brandeis University), Superfluidity

16 December 1964: C. Lanczos (Dublin Institute for Advanced Study), Relativity in Strongly Curved Riemannian Spaces

12 February 1965: William Yen (Stanford University), Optical Spectra of Ions in Crystals

24 February 1965: Peter Fershan (M.I.T.), NMR for Physicists: NMR Studies of Radiation Damage

4 March 1965: Barry Block (University of Maryland), Gravimeters and Gravity Waves

10 March 1965: Ernesto Corinaldesi (B.U.), Reformulation of the Heitler-London Theory

31 March 1965: B. Serin (Rutgers University), Type II Superconductivity - Intrinsic and Induced

7 April 1965: B. Ferretti (University of Bologna and M.I.T.), On the Possibility of a Neutrino Theory of Light

14 April 1965: Robert H. Kraichnan, Turbulence Dynamics

5 May 1965: Paul R. Zilsel (Western Reserve University and Princeton University), Pseudospin Model for Liquid He^4

12 May 1965: Eugene Guth (Oak Ridge National Laboratory), Brownian Motion and Quantum Theory

3. Research

3(a) Summary and anticipations

Although I am not aware of any serious external pressure toward research which has been felt by the faculty members, it is easy to observe that the research efforts of the department as a whole have led to a number of highly satisfactory results. The rough measure offered by rates of publication is itself startling since the number of published papers and books in 1964-65 is a little more than two times that of 1963-64. Such a 100% increase must be a fluctuation, but the work now in progress suggests that the pace has in fact increased substantially. That the quality is plausibly high may be seen, again in rough measure, by the professional recognitions and tasks which professors have received (as noted in 4c below), and I wish only to mention a few here. Professor Booth's work has been commended by E.P. Wigner; and Booth has been welcomed to work at the great nuclear laboratory in Copenhagen. Professor Franzen was invited to lecture at the International Conference on Atomic Spectra and Radiation Processes in Oxford in April; and he was elected a Fellow of the American Physical Society this past year. Professor Hawkins was nationally celebrated for his work on the interpretation of the Stonehenge monument in a CBS television hour during the Spring, and this show was noteworthy as much perhaps for its extraordinary combination of lucidity, articulation, and beauty as for its scientific and educational achievement; and Hawkins will during August 1965 be chairman and principal organizer of the major international symposium on meteor orbits and dust of recent years, to be held as 75th anniversary event of the Smithsonian Astrophysical Observatory. Professor O'Neill's research in statistical and quantum optics continues its success, and it seems likely that his "Berkeley Lectures" will be seen as a pedagogical achievement as well as a noted research treatise. Professor Braun works steadily at the highly competitive forefront of international research on fundamental particles of Nature, with a stream of professional invitations to attest to the respect and interest of his peers; and his noted treatise on elementary particles is soon to be

joined in print by his long-awaited book based on his lectures on Advanced Quantum Theory. Professor Sachs, working at that most difficult of tasks, a major re-formulation of the foundations of modern physical theory in terms of a philosophically subtle and original conception, has been invited to three centers of physical learning within the year: the Dublin Institute for Advanced Studies, P.A.M.Dirac's Cambridge University theoretical physics group, and the Aspen Institute for Humanistic Studies (Physics Division). Several aspects of Professor Siegel's work have reached a wide and appreciative audience, notably in the attention paid to his work in the recent standard review treatise in his general field of non-linear fluctuations and statistical mechanics. Professor Willis has seen his research become a flurry of creative achievement this past year, especially with his working out of the first exact solutions of certain vexing and basic problems of the interaction of radiation and matter; and he was invited to lecture on his work at the Puerto Rico international conference on quantum electronics during the end of June 1965.

Research in teaching has continued also, although in a less spectacular manner. Professor Edmonds has now approached the end of preparing his unusual text on electronics; and Professor Stipe is completing his promising textbook which will combine the general education goals of science education with the rigor of teaching general physics along with the calculus which is appropriate. Both books should appear in early Spring 1966.

We can anticipate that theoretical research will continue in much the same flourishing way as mentioned in this report. We can also anticipate that the work in Astronomy will expand considerably under the energetic efforts added by the appointment of Professor Papagiannis. Finally it now seems that we can foresee a mature and substantial activity in several well-equipped and sufficiently-staffed laboratories of experimental physics. This would appear to be the principal improvement in department culture to be looked for in the next year or two. And the group of experimentalists (Alston, Booth, Channon, Edmonds, Franzen, Loy, Zimmerman) have now

begun to have facilities available, students interested, and funds too. Our department is still marginal; and yet the very meaning of this word "marginal", which I have used repeatedly in the recent years of conversations, memoranda, and Annual Reports, has itself been changed to a higher demand for achievement of quality in research and in facilities to enable such efforts to be made.

3(b) Facilities and Research Services

The most important University contributions to research in Physics have been:

(1) the efficient improvement in both the administration and the material resources of the machine shop,

(2) the use of various special funds, mainly derived from NSF fellowships cost-of-education allowances and from the NSF and University general research allotments, for provision of a modest department research stockroom,

(3) substantial research grants for specific projects, research assistants, or instrumentation from the GRS research committee's budget.

Professor Edmonds reports on the Research Machine Shop as follows:

"During the past year the former Research Services machine shop has become a departmental establishment while remaining a general research shop open to all departments in the Graduate School. We have been most fortunate in securing the services of Mr. Alan O'Neill as superintendent of both the main machine shop and the student shop. He has reorganized both of these instal-

lations to facilitate operation, promote safety, and reduce tool loss and breakage to a minimum. In addition, he is a first-rate instrument maker, a former machine shop owner, and a man peculiarly suited to dealing with research people and the specialized problems they bring to a research as opposed to a commercial shop. His presence has been largely responsible for the present ability of the shop to satisfy research needs so that these need not be taken to outside contractors.

We have also been extremely pleased and encouraged by the reception of a $4,000 grant from the Graduate School for the purchase of a new miller and a new lathe. These were installed in the course of the past term and have greatly aided in increasing Mr. O'Neill's efficiency by giving him tools more on a par with his skill.

Finally, it should be noted that a new system for the purchase of metal stock and billing of Mr. O'Neill's time has been instituted in place of the very detailed procedure in effect when the shop was run as a (supposedly) self-supporting branch of Research Services. The new system is intended to reduce the burden of paper work while still producing some direct contributions to the machine shop budget so that it need not be entirely subsidized by the Graduate School. Although some day we would like to eliminate this kind of 'commercial shop' operation entirely, the present system seems at least to be a step in the right direction."

3(c) Grants and contracts

Thirteen grants and contracts now support the major part of the research of this department, two from private foundations, three from the National Science Foundation, and the remainder from the Army Research Office, the Air Force Office of

Scientific Research (Washington), or the Air Force Cambridge Research Laboratory (Bedford). It seems likely that four more may be received during the Fall or Winter ahead. In any case, while all regular faculty members are fully supported for their academic base salaries from the University budget (CLA), the research of the department depends overwhelmingly upon outside sources of funds of the order of $200,000 annually. This dependence is not unusual among physics departments today, from the smallest to the greatest. But we might look toward grants which would support a number of different research projects under one general rubric, and this would bring our research support more into line with that of the larger departments in the profession. Thus, as a first candidate, we may find it feasible to obtain a general nuclear physics grant for the four or five separately funded projects which will be underway in the coming year.

4 (a) Appointments, Leaves, and Promotions

Appointments, during 1964-65

During 1964-65, Ernesto Corinaldesi was Visiting Professor in the Spring semester, when he offered a course in Quantum Field Theory. Corinaldesi came from his post as Director of the Graduate School of Nuclear Studies of the Istituto Nazionale di Fisica Nucleare, Sezione di Pisa; and he left to join the Westinghouse Research Laboratories in Pittsburgh.

William Hellman came to B.U. as Assistant Research Professor to be associated with Paul Roman, after some years at the Naval Ordnance Laboratory; he will continue with us as Assistant Professor.

Krishna Raman came as Research Associate to Paul Roman from the Institute of Mathematical Sciences in Madras.

David Rosenbaum came as Assistant Professor to be associated with Mendel Sachs, from graduate studies at Brandeis University.

Michael Papagiannis, from the Harvard University physics department and Smithsonian Astrophysical Observatory, joined us as Lecturer in Astronomy for the Spring semester, and he will continue in the department as Assistant Professor of Astronomy.

Gerald Ouellette, formally in space research work at the Wolf Development Co., continued as Lecturer in Astronomy through the year.

During the late Spring, Gilbert Roy, of the Carnegie Institute of Technology, was appointed Assistant Professor, with special interests in solid state experimental physics.

Marcus Goodall of M.I.T. has come as Research Associate on a project concerned with extensions of quantum theory of measurement with R. S. Cohen, beginning July 1965.

Joseph Rosen, of the University of Tel Aviv, will come in the Fall 1965 to collaborate with Paul Roman, as Research Associate.

In collaboration with the Department of Philosophy, and the History of Science Course in the CLA-MED programs, the Physics Department will be joined by Joseph Agassi, a philosopher and historian of physics, who will collaborate with R. S. Cohen in the Physical Science course and the Seminar in Philosophical Foundations; Agassi comes from the University of London via posts in the Universities of Hong Kong and Illinois, and he will be Visiting Professor of Philosophy, beginning June 1965.

After five years of association with the Physical Science course, John Reed, of the B.U. School of Education, has terminated his work with the Physics Department in order to devote himself to writing and to graduate education in SED.

Stephen Hamilton will return full-time to the Division of General Education of CLA after some years of work as Instructor in Physics.

Leaves.

During 1964-65, Edward O'Neill has been on sabbatical leave, studying and lecturing in the Department of Physics of the University of California at Berkeley.

During the Spring 1965, Edward C. Booth has been on sabbatical leave, traveling and working in Europe, principally as Guest Scientist at the experimental facilities of the Universitetets Institut for Teoretisk Fysik in Copenhagen.

During 1965-66, it is expected that Arnaud Siegel will be on leave for work at the French scientific research center at Saclay, near Paris, and that Charles R. Willis will be on leave for work at the University of Utrecht.

Promotions.

Wolfgang Frentzen was promoted to Professor of Physics for 1965-66.

4 (b) Excerpts from faculty appraisals of the department, and its problems.

(Alston): "In the one-year course offered in the DCE program for sophomore physics majors, chemists and mathematicians this year I found an appalling admixture (greater than 50%) of incompetent and undisciplined part-time students together with students attempting to pass the course for transfer credit into another university. One half of the class received failing marks by withdrawing late in the semester or by not taking the final exam. The remaining half took the course in the second semester and performed satisfactorily.

A similar day course for freshmen majors in the same fields as above contained virtually no physics majors during the second semester (less than 10%). Most students were inarticulate, reticent and frequently absent in recitation sections. My teaching experience at two institutions of widely varying standards (Yale University and New Haven College) led me to expect far more in class participation (i.e., evidence of curiosity, vitality, spontaneity and humor) from beginning students.

At B.U. I have found a distressing percentage of students who conceive of themselves as being something other than what youngsters aged 18-22 in schools over this country must see themselves as: efficient student machines, equipped to do nothing else in life for 4 intense years but to seek education -- the process by which man becomes free--part of this unfortunate minority fancies that it is a working, loving, sociable, functioning part of this economic existence, and in addition and incidentally is also participating in student life. The other portion of this minority is a drab, pessimistic group, unaware of their potentialities and unfocussed--unmotivated and full of angst.

Occasionally one find pure gold in this latter sub-group. I would like to see a vigorous and dramatic campaign by B.U. to visit physics classes in high school in Massachusetts, giving vivid demonstrations to small groups and encouragement to those more mousey students early in their education. Why not send along undergraduate physics majors with a lecturer to assist in the demonstrations? It would require a full-time staff member (no present faculty member could spare the time) who is especially gifted and experienced in such magic? It would be useful to synchronize the demonstrations with the material being covered by the teacher that week, which would generate more invitations to visit."

(Booth): "No problems. Utopia. (Written from Copenhagen-NSC)"

"I heartily endorse the sabbatical leave concept which has put me in a modern nuclear research lab, Universitetets Institut for Teoretisk Fysik, for the first time, although of course I had passed through them before. A real eye opener, especially with the extremely close interest constantly displayed by the powerful theoretical contingent. I was lucky enough to land in the hottest experimental development here, the study of nuclear analogue states in heavy nuclei where isobaric spin turns out to be a very good quantum number after all. From point of view of papers published I should stay here and ride the surfboard for a year more, since we are just getting started now. It is also a dead end in Boston since there is no tandem in the area, but nevertheless I have learned a lot and it has been

exciting. Probably we should think more seriously about summers in National Laboratories or large University installations every two or three years. Incidentally, graduate students help very little here; one makes do with first rate technicians, machinists, etc. plus long range planning and good equipment.

(Chasman): "I. The experimental effort has been aided very greatly by: (1) the improved state of the machine shop, with emphasis on Mr. Alan O'Neill, and the new equipment. (2) The establishment of a research stock-room with a modest but very useful supply stock. (3) The availability of rather substantial research money from the B.U. Graduate School.

II. Teaching Fellows: The situation is not as good as it should be. Many fellows do well; I myself had Mr. Gene Ring as a fellow in the electronics course 3 years ago, and he was excellent. However there are always a few fellows who are spectacularly remiss in fulfilling their duties even mechanically, and I don't think that the average performance is good enough.

I realize that there are departmental plans for improving the entire teaching fellow situation, nonetheless, perhaps some suggestions are in order here. (1) Teaching fellow's office facilities should be improved. Each should have a good desk and a book-case as a minimum. In general this department seems a good shop for faculty and for staff, but a bad shop for graduate students, and the badness of the office facilities is part of this. (In suggesting that teaching fellows would do better if we gave them better office facilities I may sound like a right-winger's parody of a social worker, but I believe it anyway.) Incidentally, I think that the argument that teaching fellows are the highest paid (per hour) members of the department is without logical or polemical value. (2) I think that experienced and successful teaching fellows should get some small financial recognition in the form of increments. (3) It should be made clear to fellows that renewals depend on the adequate performance of teaching duties. (4) Those who supervise fellows should attempt to integrate them into the course, and allow them to participate (if they can) more intensely than on a simple piece-work basis. Some of this is done already by some instructors with some fellows; it should be extended. Weekly meetings with fellows should concern themselves with the course as an entirety, not just with techniques for doing particular laboratories and problems solutions. Attendance at lectures at least on an occasional basis should be required. Fellows should be asked to keep definite, announced office hours for students.

Note that my suggestions are decidly not in the direction of letting fellows off the hook. On the contrary, more time and effort should be required of them, but the whole enterprise should be on a more professional plane.

III. The Undergraduate Program: The present program seems like a sound one, both with respect to the courses offered and the general quality of instruction. It is troubling, therefore, to find so few students going through as physics majors. This year, only two students are going on to graduate school, and one of them is decidely marginal. (Of course the best physics student in the senior class decided to join the Peace Corps.) Next year there will be one very good physics senior, and no-one

4(b) Continued

else even close. Many of the students who do graduate in physics are transfer students or special cases. This lack of graduating majors seems to come not so much from attrition but from a small number of freshmen-sophomore prospects; my experience with PY151-152 taught me this. Unhappily, for all of its virtues the new two-year introductory sequence makes it harder for a student to go into the physics sequence late. This is a related problem.

The Undergraduate Committee is currently investigating this problem, in cooperation with the Admissions office. There are plausible reasons why we don't get more prospective physics majors. The geogrpphical competition is fierce, and we seem to have little to offer the qualified student that he can't get a a more prestigious university. The American Institute of Physics reports a levelling off and even a small drop in the nationwide number of physics majors. Nonetheless it doesn't seem utopian to expect 10-20 students out of a freshman class of about 900 to express a tentative professional interest in physics, and to expect half of these to graduate as physics majors four years later."

(Franzen): "I think we have reached a turning point of some sort. The volume of research activity in the Department is approaching critical size, graduate students have improved, and are working harder and more effectively, and we are beginning to turn out Ph.D. degrees in substantial numbers. But are we willing to consider ourselves a professional department, consisting of faculty members intellectually involved in physics and related subjects, or do we want to be amateurs, on the sidelines, interested only in special students, with special problems? There is a strong positive element in the warm, humane atmosphere that we maintain among ourselves; this we should not lose. But at the same time, we should realize that we are in the real world, where physics is constantly changing and evolving, and we cannot play ostrich, or use "the Administration" as an alibi for inactivity, or for a permanently ingrained sense of inferiority, which keeps us from pressing for those changes that a vital University Department must constantly press for:

1. Better academic standards
2. A better, more professional staff
3. Better facilities
4. Better students
5. More fellowships
6. A lecture room
7. A new building, or a renovation of our present one.

I believe that at this point our important problems are in ourselves, rather than in external limitations over which we have no control."

(Hawkins): "On the negative side astronomy is not being helped by being classified as one of the branches of Physics. In particular the basis of division of budgetary funds between the two disciplines in not clear. On the positive side the inclusion of Astrophysics in the Physics Comprehensive Exam is beneficial but it is doubtful whether the department faculty would be willing to include many other astonomical fields. The present Observatory is now overshadowed by the high-rise buildings and planning for removal or replacement should begin."

4 (b) Continued

(O'Neill): (Writing from Berkeley-RSC), "So far as students are concerned, I am not as optimistic as I am about research at B.U. I have had a good opportunity this year to compare our department with one of the best in the country. Two things stand out in my mind. First the degree of independence displayed by the good students is considerably greater than at B.U. The occasional meetings between a student and his advisor is truly an exchange of ideas. Like many large schools with complex and large pieces of equipment is appears that many good students "get off easier" so far as thesis requirements are concerned. This is particularly true of experimentalists and I am not sure that as a "small" department we may not over-compensate and scrutinize more than is necessary. The second point that comes to mind is simply the scholarly atmosphere that surrounds one here. There is simply an aura of work and quiet contemplation. Perhaps, located where we are, we can never hope to achieve this. Nevertheless it is one of the strongest impressions I have."

(Roman): After praising some students, associates and secretaries, Roman describes the difficulties: "too much pressure, too little money, too little freedom for leisurely contemplation and get-together with students and colleagues, too much rush."

(Sachs): "...salaries at B.U. at least should approach the faculty salaries that some of the higher quality Ph.D. - granting physics departments in the country are paying."

(Siegel): "This year I felt the full impact of the new size the Physics Department has attained, in terms of impersonality, difficulty of feeling a sense of common cause with all of my colleagues, and decreasing availability of the Chairman when little things turn up which need discussion. On the other hand, relative to its size, I think the department is a flourishing institution, with much more mutual communication and understanding than is usually found in equivalent bodies. I think the devotion and insight that have gone into its construction, and which continue to be expended on it, will bear a tidy crop of results in future years.

Complaint Dept.: I think my own evaluation of my work load is not given sufficient credence by the Chairman. In order to keep my head above water I have been compelled to abandon successively a number of practices--such as grading examination questions very carefully--which it is my impression most people have already abandoned, but which somebody ought to keep alive, as a working museum exhibit, so to speak. But maybe it is useless to fight the wave of the future."

(Stachel): "My general impression of the Department is very good. I like the high degree of internal democracy, which you somehow always manage to prevent from degenerating into anarchy, or at any rate regenerate into decisions. I think we have a number of gifted people in the department, and have the potential of evolving-with proper support-into a very excellent department indeed. The one criticism I have to raise, with no very definite

4 (b) Continued

suggestions to offer, I'm afraid, is on the question of inspiration of the students. A number seem to have very low morale. Whether this reflects their innate situation or some failure of communication which prevents faculty members from transmitting their enthusiasm to students, I'm not sure. I feel there is some defeatism about quality of students among faculty which may be justified; but which, by hampering the generation of interest among students, may be partially self-fulfilling. I think we need to challenge the students more to see what the best in them that we can bring out really is. I have no answers here, just questions.

(Stipe): (Much of this Annual Report derives from Professor Stipe's assistance. But his summary about current problems is given here --ESC)

"And we still need a large lecture room (300-400) and a small lecture room (75-100) both adjoining a demonstration preparation room that isn't used by anyone but the physics and astronomy staff, and we still need more space for teaching laboratories, and some money for the elementary laboratories that have been starved for three years and will be starved for at least two years more, and we need more and better teaching fellows, with better selection of them and better morale for the teaching fellows and the staff that teaches the big basic courses and uses the teaching fellows, and we need desk space for the teaching fellows, and we need more seed money for getting new ideas in experimental research started, and every year we seem to give out of ditto paper and stencils in February, with the money all gone....."

(Willis): "I am proud of the method of decision making in our department. Credit should go to the department as a whole and to Dr. R. S. Cohen as chairman. Special commendation should be given to Dr. Wolfgang Franzen for the work he has done as chairman of the Graduate Committee.

The one serious problem I would like to call to the attention of the administration is that the last two sizeable raises have been almost completely cancelled by the 3/9 to 2/9 reduction.

(Zimmerman): "...compliments on running the department.....I would like to be on some committees."

4 (c) Faculty Record

William J. Alston, III.

Research

Continuation of low energy nuclear physics program at B.U. has been based on research performed at the MIT 4Mev Van de Graaff generator (Resonance Fluorescence Scattering, Angular Correlations, etc.). We anticipate expansion of the above program, beginning in this summer of 1965, with an unusual number of graduate students (3) and receipt of two grants totalling around $30,000 for the next two years from the National Science Foundation and the Army Research Office.

A new building housing the Van de Graaff was completed in January at MIT with a separate experimental area for exclusive use by the Boston University nuclear physics group, making possible semi-permanent experimental geometries as well as better facilities for measurements.

Edward C. Booth,

Comments on courses and students

"I recall my comment that with little more than the means at our disposal we could mount a series of demonstration experiments in high voltage electricity and nuclear physics which would essentially duplicate those being included in the very ambitious proposal by the Museum of Science. In fact, I expect to do a considerable fraction of those experiments in the next year or so in the Electricity & Magnetism Course (PY 201). One might consider getting some money either from CEA or from NSF to fix up the old Van de Graaff next summer, which would make for some very impressive demonstrations. I had hoped the Physics Club would do it themselves, but apparently this is not likely at present."

Honors, and external appointments

Research Associate, MIT; Guest Physicist, Universitetets Institut for Teoretisk Fysik, Copenhagen, Denmark

B.U. Committees

Academic Standards Committee

Calendar of lectures and conferences

Spring 1965: Colloquia in Nuclear Physics at Universities of Darmstadt (Germany), Ljubljana (Yugoslavia), and Copenhagen (Denmark)

Bernard Chasan

Research

The main research effort of the year concerned the setting up of an angular correlation apparatus and the attempted measurement of a predicted, but as yet undetected correlation. This is the directional correlation between the inner-bremsstrahlung photon accompanying electron capture and a subsequent nuclear gamma ray. Preliminary experiments carried out at B.U. have thus far served only to underline certain experimental difficulties perhaps not sufficiently appreciated before. The experiment is not a simple one, but should be of value in determining certain nuclear beta decay matrix elements; an important goal in contemporary nuclear spectroscopy.

Our interest in the spectroscopy of electron-capture nuclei has led to a consideration of a possible directional correlation between the nuclear gamma ray and the x-ray accompanying the electron capture. This will be studied further in the near future.

A separate line of investigation not yet undertaken but under preliminary study is the measurement of the transverse polarization of internal conversion electrons in coincidence with beta electrons. These studies naturally extend the widely utilized beta-circularly polarized gamma studies, and should be more widely studied than at present. Solid state counters haven't been used for these studies as yet, and seem very natural.

B.U. Committees

a) Preston Lecture Committee of CLA
b) Chairman, Undergraduate Studies Committee, Physics Department

In this capacity Chasan was departmental representative to the (National) Commission on College Physics Minneapolis Conference on introductory physics for science and engineering students. (May 3-8, 1965)

Calendar of lectures and conferences

Dec. 5, 1964 "Resonance Fluorescence in Nuclei"
Joint Meeting, New England Sections: Amer. Assoc. Phys. Teachers; Association of Biology Teachers; and Assoc. of Chemistry Teachers.
April, 1965 "Angular Correlations" B.U. Physics Club.

Robert S. Cohen

Research

(1) Cohen continued to work on an annotated sourcebook of the history of concepts of time, in collaboration with Max Jammer. Further, he is continuing two related projects in the sociology of physical science, the first a critical reformulation of theories of the sociological origins of science (to appear in the Merezcus Festschrift, Winter 1966), and the second, a critical review of the pioneer work of Edgar Zilsel (to appear in Organon). He is also engaged in a longer study of empiricism and dialectics in the philosophy of science, particularly in Sartre's Critique de la raison dialectique.

(2) He has continued to serve as general editor of the Bollingen Foundation project for translation and publication of the posthumous manuscripts of the German philosopher Max Raphael, in collaboration with Claude Schaefer of the University of Montreal and Sir Herbert Read. The first volume should appear in Winter 1966.

(3) In collaboration with Marie Neurath of London, he has selected and edited a volume of untranslated, and in part unpublished, works by Otto Neurath, to be submitted for publication in Fall 1965.

(4) Cohen has undertaken to work at Harvard Project Physics on the development of a new high school physics course. This project, directed by Gerald Holton and Fletcher Watson of Harvard, seeks to bring historical and philosophical aspects of physical science into a high school course which is to be offered primarily to students who do not at that stage wish to concentrate in science or mathematics. Although substantial efforts have been made to develop such general education courses in science at the junior college, college and even adult education levels, it is apparently a new and serious problem to teach science to non-scientific students with these cultural goals in the secondary schools.

Comments on courses and students

Once again the large class in physical science had a substantial number of extraordinarily able students, mainly from SED. Almost without exception, these students entered the course with little motivation. And despite a poor textbook for this course (Orear's Fundamental Physics, chosen with the best of standards, I thought back in Spring 1964), it seemed to go well. The two teaching fellows were superb and deserve much gratitude. (Unfortunately both of them have left B.U., Bonnie Duboff to join her fiance in doctoral study at the University of Michigan, and Charles Norwood to seek a job in industry.)

Several of my graduate students also deserve mention. Michael Bradie came to B.U. from a physics major at M.I.T., and he has now completed his M.A. in philosophy of science with a lucid thesis on a difficult subject, Cassirer's philosophy of science. Caroline Snider, whose husband David is a graduate student in physics here, came to us from a philosophy major at Wellesley, and has now completed her M.A. thesis concerned with Whitehead's theories of space and time, again a

lucid essay on a controversial and difficult subject. Joan Bromberg has reached the stage of completing a doctoral dissertation on Maxwell under my supervision for submission to the Department of History of Science at the University of Wisconsin.

I served this year as adviser to a newly-reformed student group whose name is "B.U. Students for Peace". This group became active during the Winter and Spring 1965, held a number of faculty debates on foreign policy, organized a delegation to the national student's "March on Washington" concerned with the Vietnam problem, and as a principal effort, organized the B.U. Teach-In on Vietnam which was held all night May 5th-6th. They have been advised also by Rev. Joe Brown Love of the Protestant Ministry. It is difficult to judge whether this group will continue since so many of the students have graduated; but it is remarkable to see how devoted and fair-minded they were in organizing events concerned with issues on which they had such strong views themselves. In particular, I should mention a CLA English major, Edith Bobrick and her husband James Bobrick, a CLA classic major.

Honors and external appointments

Professor Cohen was appointed by the National Academy of Sciences to be a member of the U. S. National Committee for the International Union of the History and Philosophy of Science for a three year term, beginning January 1, 1966.

Cohen continued to serve as Chairman of the Boston Colloquium for the Philosophy of Science. He also continued on the Executive Committee of the New England Section of the American Physical Society. In addition to being staff consultant at Harvard Project Physics, as mentioned above, he continued as Visiting Professor at the American University Summer Institute in History and Philosophy of Science during one week each of summers 1964 and 1965. During Summer 1964, he spent four weeks on the planning staff of the AEC-NSF research institute on "Science and Contemporary Social Problems" at Oak Ridge, Tennessee in collaboration with N. R. Hanson of Yale University, R. C. Anderson of Brookhaven National Laboratory, and L. Nelson of Oak Ridge National Laboratory. During September 1964, Cohen was a member of the United States delegation to the conference on social problems in an age of science and technology which was held in Herceg-Novi, Yugoslavia under auspices of the U.S. Department of State and Atomic Energy Commission and the Yugoslav Federal Nuclear Energy Commission.

Cohen also was reelected as Chairman of the American Institute for Marxist Studies, and participated in several symposia of this Institute. He has undertaken to prepare a bibliography on "Marxism and Philosophy", which will attempt to be definitive on materials in English language, and to assist Dirk Struik of M.I.T. with a similar bibliography on Marxism and the history of science.

Cohen continued to serve on the American Institute of Physics Program of Visiting Scientists in Physics, and he visited the N.Y. Agricultural and Mechanical Institute of Delhi, N.Y., a two-year vocational school in the State University of New York, and Harpur College of the S.U.N.Y. system, a liberal arts university-in-gestation.

B.U. Committees

Member at Large, Senate Council
Member, Graduate Board (elected Spring 1965 from CLA)
Member, Committee on Science Development (as physics dept. chairman)

Calender of lectures and conferences:

June 15-July 15, 1964 Staff, Oak Ridge Institute on science and contemporary social problems
July 18, 1964 "Sociology of scientific knowledge", two lectures, B.U. medical school
July 20-24, 1964 Professor NSF Institute on history and philosophy of science, American University
Sept. 13-23, 1964 Member & Lecturer Delegation, US-Yugoslav conference, Herceg-Novi
Sept. 24, 1964 Lecture, Croatian Philosophy Society, Zagreb
Oct. 13, 1964 United Church of Christ, New England Annual Meeting, Portland, Maine: Dialogue with Professor Harvey Cox (Andover-Newton Theological School), "Does the Christian Mission Speak to the Man of Today?"
Oct. 24, 1964 Symposium on recent philosophical trends in Eastern Europe, RSC on philosophy of science in Hungary and Yugoslavia (sponsored in New York City by American Institute for Marxist Studies)
Oct. 26, 1964 Senior Seminar, University of Rhode Island, Kingston, "Political Consequences of the Rise of Science".
Nov. 30, 1964 Lexington Rotary Club and Lexington High School; "Humanistic Science"
Dec. 7, 1964 Merrimack College, Physics Dept. Lecture "What is Philosophy of Science?"
Dec. 7, eve: Commentator on Mendel Sachs at Boston Colloquium for the Philosophy of Science "On Elementarity of Measurement"
Dec. 29, 1964 Chairman, American Philosoph. Association session with BCPS on innate ideas (afternoon)
Chairman, American Philosophy Association session with BCPS on Soviet logic
Feb. 17, 1965 SED lecture, "Authority and the state" in Ph.D. candidates seminar (Prof. P. Nash)
March 10,1965 University of New Hampshire Colloquium Series on Philosophy of History: "What is a scientific theory of history?"
Mar. 11, 1965 Annual Meeting (at B.U.), Center for Liberal Education for Adults: The History of Science and the Science of History
Mar. 21, 1965 Jewish People's Forum (Boston): Jewish Life in Poland today
Mar. 22-25: Served for Visiting Scientist in Physics Program of American Institute of Physics at Delhi (N.Y.) Agricultural and Technical College (3 lectures) and at Harpur College (Binghamton, N.Y.) (2 lectures)
Apr. 13, 1965 AAUP panel at B.U. "Where is B.U. going?"
Apr. 20, 1965 School of Nursing Ph.D. panel "Research Methodology"
Apr. 28, 1965 U.S. Naval Weapons Laboratory, Dahlgren, Virginia: "What is Philosophy of Science? Observations East and West"
June 28-July 2: Professor, NSF Institute on history and philosophy of Science, American University

Community activities

Cohen continued on the Executive Committee of the Emergency Civil Liberties Committee of New York, and on the Executive Committee of the Boston Area Faculty Group on Public Issues. He preached at Jewish and Unitarian services on several occasions and participated in the annual New England meeting of the United Church of Christ.

Dean S. Edmonds, Jr.

Research

Edmonds pursued the rubidium cross-beam modulation experiment with Franzen this past year. See more detail in Franzen's report. Suffice it to note that the immediate aims of this experiment were accomplished and some very nice data obtained. Future plans include methods of observing a predicted double-frequency cross-beam modulation that should take place when a double-quantum transition is stimulated. The double frequency was not observed in our earlier experiments, and Franzen has obtained a theoretical explanation of why this should be so with our present experimental arrangement. Presently under consideration are new approaches that might make this frequency observable. Also under consideration is a light-chopping arrangement to allow observation of the RF transition with the pumping light switched off.

Edmond's principal effort for summer 1965 is microtron design study research, for which we hope to have a GRS grant. Peter Winter-steiner and he will attempt to come up with a suitable design for a short linac appropriate for a racetrack microtron, to make a model, and finally to test it first at low power and then at high. This will be a fundamental step in determining the feasibility of a CW microtron.

Honors, and external appointments

Edmonds continued as Vice President of Euclide Corporation, which has has now bought the assets of Alloyd General Corporation and proposes to carry on the manufacture of its own line of mass spectrometers and spectrographs plus an isotope separator and some of Alloyd's line of vacuum chambers, electron beam welding equipment and hollow cathode vacuum casting systems in Alloyd's former Medford plant. Edmond's own research projects there include an advanced RF mass spectrometer and a Paul-type quadrupole "mass filter".

B.U. Committees

Premedical Advisory Committee
Counselor in 6-year CLA-MED program
Physics Department Undergraduate Committee
Director, Physics Department Research Stockroom
Director, Machine Shop

Calendar of lectures and conferences

October 1964 (with D.R. Rothenberger), "A Small Radio-Frequency Mass Spectrometer", paper before the meeting of the American Vacuum Society in Chicago.

J. S. Kimonds, Jr. (continued)

Community activities

Judge at Massachusetts State Science Fair at M.I.T. Rockwell Cage, May 8, 1965.

Wolfgang Franzen

Research

(1) Continued an experimental study of optical-radio frequency coherence effects exhibited in the modulation of a beam of rubidium resonance radiation by a vapor of rubidium metal undergoing magnetic resonance. (In collaboration with D.S. Kimonds.)

(2) Supervised an experimental thesis project dealing with gamma-ray polarization effects exhibited in recoilless emission and absorption of gamma rays by iron-57. The experimental work is being carried by M. Alam in collaboration with S. Chandra. It is hoped that this project will be finished during summer 1965.

(3) Supervised a theoretical study of polarization effects to be expected in the scattering of low-energy electrons by neon, as a result of an interference between resonance and potential scattering. Much of this work was done by R. Gupta, who expects to begin a thesis investigation in this field this summer.

(4) Supervised a theoretical study of frequency shifts and circulation of coherence to be expected in optically pumped helium-3. This work was carried out by Bruce Mowell, who expects to start a thesis investigation in this field next fall.

Comments on courses and students

(1) Vibration and Waves. "I am sorry to say that the group of 12 students (mostly seniors) that took my Vibrations and Waves course was the worst group of students, in terms of work habits, motivation, rather than inherent ability, that I have ever taught in 10 years of teaching. Only two of the 12 were serious physics majors (Mercereau and Cimm). The others were amateurs, marginal loafers, etc. Nevertheless, they all liked the course (two wrote me very nice notes), and listened to my lectures with interest. But they were not motivated to study with any concentration, to attend regularly, or to hand in reasonably carefully worked-out homework problems. I have the impression that most are academic-credit collectors, not really interested in getting an education. I think this is a serious problem that should receive some attention.

(2) My major activity in teaching consisted of the effort devoted to the Advanced Laboratory which next year I think will be an excellent course, comparable with similar courses at the better universities. Details of the work accomplished in setting up this laboratory are described in Professor Stipe's report to the NSF."

Honors, and external appointments

(1) Professor Franzen was elected a Fellow of the American Physical Society by the Council of the Society on Jan. 26, 1965.

(2) Completed 3-year term on the Board of Editors of the Review of Scientific Instruments on Dec. 31, 1964.

(3) Elected in January 1965 to the Board of Editors of the (Swiss) Zeitschrift fuer Angewandte Mathematik und Physik.

(4) Consultant (one day a month) to Arthur D. Little, Inc., Cambridge, Mass., since January 1965.

(5) Member of the Regional Selection Committee of the Woodrow Wilson Fellowship Foundation, Winter 1964-65.

(6) Referee for the Physical Review.

(7) Member of Review Panel in Atomic and Molecular Physics for the Army Research Office.

(8) Referee for the National Science Foundation, Physics Division.

N.C.U. Committees

Chairman, Committee on Graduate Studies, Dept. of Physics
Member, Committee on Faculty and Committee Membership, ORS
Member, Admissions Committee, Dept. of Physics
Member, Comprehensive Examination Committee, Dept. of Physics
Nominee, Honors Committee, CLA
Acting Chairman, Dept. of Physics, Summer 1964.

Calender of lectures and conferences

April 12-14, 1965 Lecture at International Conference on Atomic Spectra and Radiation Processes (Oxford University, England).

Stephen G. Hamilton

Research

The calculation of e-p scattering cross-sections in the s-matrix limit on the new Sachs-Schweitzer theory of quantum electrodynamics is continuing. Evaluation of the cross-sections in the limits of zero and infinite momentum transfer (infinite and zero separation, respectively, between electron and proton) indicates agreement with experiment, viz.: the cross-sections go to the usual mott cross-section in the zero (small) momentum transfer limit and vanish in the infinite momentum transfer limit. Detailed calculations are currently in process. It is also planned to extend this work to include proton-proton scattering in the same approximation.

Computer activities

Elected member of executive board and chairman of education committee, South Middlesex Chapter, NAACP.
Co-chairman Joint Education Committee Temple Shalom (Arlington) NAACP.
Memorial Day Talk: The meaning of Memorial Day, for Relief Corps of the GAR. - West Sumner, Maine.
Moderator: Seminar on problems of the city, University Lutheran Church, Cambridge, Mass.

Gerald S. Hawkins

Research

M. Patra has continued work on the NASA Lunar Crater research with fair, but slow, success. His initial calculations of supersonic impact have been described in a research report now in process of duplication.

Undergraduate students (2 astronomy majors, and 1 Physics-Astronomy major) are currently doing routine measurements and data processing on this research.

A. Metz has made considerable progress on low frequency propagation measurements under the A.F.C.R.L. contract. This research will be helped considerably by the addition of Dr. Papagiannis to the Astronomy faculty. Research this year at B.U., as always, has been hampered by lack of adequate numbers of research oriented students. Next year the addition of two first year students may alleviate part of this constriction in the years to come.

J. Hegarty has begun background reading and study in preparation for research in the non-expanding cosmological models of the de Sitter-Hawkins type. He shows great promise.

The NASA traineeship program has been successful in the various departments and divisions of the Graduate School.

Honors, and external appointments

Professor Hawkins received the Boston University Faculty Merit Award (for research and publications concerning Stonehenge).

He has continued to administer the NASA Meteor Program at the Smithsonian Astrophysical Observatory.

B.U. Committees

Advisory Committee to the V.P. for Academic Affairs
University Affairs Council
Advisory Committee on Computer Education (CAS)
Editorial Board, B.U. Press
Committee on Admissions (CLA)
B.U. Graduate Journal, Editorial Board (GRS)
Interim Advisory Committee for Ph.D. Program in Geological Sciences (CAS)
Curriculum Advisory Committee, S.F.C.
Chairman, NASA Traineeship Committee (CAS)

Calendar of lectures and conferences

July 1964: The Gordon Conference, New Hampshire "The Physics and Chemistry of Space".

Aug. 1964: International Astronomical Union, Hamburg, West Germany, General Meeting.

Sept. 1964: B. U. College of Engineering, "The need for Engineers in Space Science".

Sept. 1964: Administration and Staff of B. U. Residence Halls, "The Status of Astronomy at Boston University".

Oct. 1964: Chelmsford School Teachers, "Science in Grade Schools".

Nov. 1964: International Station Staff, Smithsonian, "The Importance of Meteor Astronomy".

Nov. 1964: Archaeological Society of America, "Some evidence for prehistoric Scientific Thought".

Nov. 1964: Panel Discussion, Scientific Res. Society of America, "Creativity in Science".

Feb. 1965: Alumni, Greater Boston Club, "Recent Research at Stonehenge".

Apr. 1965: Author's Club, Boston, "Older than Books"

May 1965: Mass. Institute of Technology Joint Compass Seminar and Physics Colloquium, "Recent Astronomical Discoveries in Ancient Britain".

May 1965: B. U. College Business Administration, "The G.N.P. of Britain, circa 2000 B.C.".

May 1965: B. U. Alumniat of the Massachusetts General Court, "Political Organization in Prehistory".

June 1965: Oceanographic Institute of America, "Some Problems in Space Science".

Edward O'Neill

Research

"About my own research I am optimistic. Through almost an accident, we, in classical optics, have been able to come up with the right answers in the past. However, recent technological advances (lasers, non-linear effects, etc.) now indicate that one must understand these things at a deeper (quantum) and more detailed (atomic) level in order to make the right predictions. Having investigated at the atomic level the interaction of light with matter I believe I can see very clearly the direction the newer trends will take and why a quantum theoretic treatment is now necessary.

Honors, and external appointments

Chairman (1965) of the Optical Society of America Committee on Teaching and Research.

Calendar of lectures and conferences

a) Professor O'Neill was Lecturer-in-charge of the Holt-Bernack and Newman Inc., Program for Advanced Study: Industrial Lecture Series in Modern Optics and Random Processes.
Oct., Dec. and May in Boston; New York; Baltimore; and Los Angeles.

b) August 1964 "Three Lectures on Modern Optics", Utah State University Summer School (Physics and E.E. Departments)

Berkeley Lectures

Nov. 7, 1964	"The Feynman Path Approach to Quantum Theory" (Physics Department)
Nov. 9, 1964	"Principles of Holograms" (Spectroscopy Seminar)
Nov. 13, 1964	"Wave Theory of Aberrations" I (Phys. Dept.)
Nov. 20, 1964	"Wave Theory of Aberrations" II (Phys. Dept.)
Dec. 10, 1964	"The Question of Indistinguishability in Photon Correlation Experiments" (Phys. Dept.)
Feb. 1,3,5, 1965	"Three Lectures on Modern Optics" Guest Lecturer Physiological Optics Seminar
March 23,1965	"Is there more to Optics than meets the Eye?" Electrical Engineering Seminar
March-April 1965	"The Berkeley Lectures in Modern Optics" (Physics & E. E. Dept.)
May 10, 1965	"The Problem of Phase Retrieval", Linear Accelerator Seminar (Stanford)
May 21, 1965	"The Quantum Theory of Coherence" Lawrence Radiation Lab. (Livermore)

Michael A. Papagiannis

Research

Radio wave propagation in magneto-ionic media.
Cosmic radio-radiation near the ionospheric cut-off.
Magneto-bremsstrahlung.

Honors, and external appointments

Research Physicist, Harvard College Observatory
Visiting Lecturer in Nuclear Physics, Boston College (Fall semester)

Paul Penna

Research

"This year may be characterized as a significant break-through, insofar as the high-energy (elementary particle) physics group of our department came of age. Although the number of competent co-workers is still low (and there is only one senior among them), active and most productive work became possible. While many fields have been pursued with vigor and with results being obtained, our reputation was most remarkably increased by our work on the covariant SU(12) scheme. It appears that we were the first to have the idea, and, due to invaluable secretarial competence and cooperation, we even managed to publish our first paper in time, i.e., amongst the first three in this line. Thereafter, a rush started and by now there are about 120 papers in this field. From private contacts and from hearsay quotations I understand that our approach is recognized by many leading authorities as the best or at least the most interesting out of all other, partly equivalent, but "philosophically" different approaches. The interest can be gauged by the fact that for the 3 papers we have so far published in this line of work, I have received, so far, about 500 requests for pre- or reprints - whatever this implies. Another consequence was an abundance of invitations to give talks.

The most pleasant and constant co-worker is M. Heilman. His presence in the Department is one of my most cherished assets.

I have secured a presumably outstanding research associate (Joe Rosen) for next year; he was recommended by Y. Ne'eman. Incidentally, there were over 30 applications for research assistantship in our group."

List of papers and books in print or submitted

1.) On operator gauge transformations (submitted to Amer. Journ. of Phys. in April 1965) (with E. Corinaldesi).
2.) Some consequences of spin-isospin symmetry. Nuovo Cimento, in press (with K. Raman).
3.) Field theory of gravitation in a de Sitter world. (Submitted as an entry for the 1965 Gravity Research Foundation Contest, in April 1965.) (With J. J. Aghassi).
4.) On broken discrete symmetries. (Submitted to Phys. Rev. in May 1965) (With W.S. Heilman).

5.) D/F ratios and baryon magnetic moments in the SU(12) scheme. (Submitted to Nuovo Cimento, May 1965) (With J.J. Aghassi)
6.) Advanced Quantum Theory. Book, 730 pages, Addison-Wesley Publ. Co., in press.

Comments on courses and students

Concerning graduate students, Jack Aghassi turned out excellent: infact, without him, our work on SU(12) could not have been executed at all.

Koh made tremendous progress and gained a great deal of competence.

Yun, in his careful and thorough pursuit of preparation for research, has absorbed by now all relevant tools for successful and serious research. I must note also that his work in grading homeworks was not only impeccable, but a tremendous relieve of work for me.

Miscellenia

1) Student quality in Advanced Quantum Theory, PY 711-712, was remarkably better than in previous years. Cheers to Fred Ernst's teaching last year, I believe.

2) Difficulties with part-time grad. students still prevail, because appointments can be made only at late hours, and are often cancelled because of job-obligations.

Honors, and external appointments

Professor Roman won "Honorable Mention" at the 1965 Gravity Research Foundation Awards, with essay entitled "Field Theory of Gravitation in a de Sitter Space" (jointly with J.J. Aghassi).

Calendar of lectures and conferences

Dec. 1964 Colloquium and Theoretical Seminar at the Department of Physics, Louisiana State University, Baton Rouge.
Feb. 1965 Colloquium at the Dept. of Physics, Yale University, New Haven, Conn.
Feb. 1965 Seminar at the Dept. of Physics, University of Rochester, Rochester, N.Y.
Feb. 1965 Colloquium at Duke University (sponsored by the Army Research Office) at Durham, North-Carolina.
Apr. 1965 Talk at the April meeting of the Amer. Phys. Soc. in Washington, D.C.
May 11965 Six-hours seminar series on Quantum Electrodynamics, in the Advanced Study Program for Working Engineers and Scientists, given at Cambridge, Mass., New York City,
University of Maryland, College Park, and at Los Angeles, June 1965.
Jan. 1965 Second Coral Gables Conference on Symetries at High Energy, at the University of Miami.
(This by special invitation)

David Bohm

Research

"On 3/15/65 I submitted a paper to the Physical Review entitled, A Proof of the Impossibility of a Classical Action Principle for Magnetic Monopoles and Charges without Subsidiary Conditions. The paper was returned with a counter-example by the referee who claimed that the proof was therefore false. The counter-example was completely wrong in the most trivial way and since the referee obviously had not bothered to read the paper I returned it with an appropriate letter to Phys. Rev. The proof is true and the paper will no doubt be accepted.

On 4/15/65 I submitted a short paper to the American Journal of Physics entitled The Four Dimensional Divergence Theorem. I have as yet had no reply.

A long paper (already about 50 pages) is in preparation on canonical commutation relations in quantum mechanics. I hope it will be done soon."

Mendel Sachs

Research

"I have been very much encouraged during the past year by results that I have been obtaining from my investigations of a unified field theory of elementary interactions. The investigation has concentrated on the following three major aspects: a) mathematical formalism - structure and solutions, b) mathematical relation of results to those which are conventionally interpreted within the framework of the quantum theory (e.g., blackbody radiation, atomic spectra, high energy charged particle scattering) as well as predictions that go beyond the predictions of the quantum theory, c) Philosophy of Science. Analysis of the epistemological content of the present approach and its comparison with the approaches of the Copenhagen School and with the philosophies of Einstein and Mach. Particular emphasis in these studies has been given to the theory of measurement."

Comments on courses and students

Two graduate students are doing some preliminary research in order to get into some of this work. P. Markovitz has been studying the structure of the field equations in general relativity and possible directions for further generalization of the mathematical structure, within the logical framework of this approach. U. Ozguero has been preparing to do some calculations on atomic spectra in order to study possible differences that might appear in respect to the comparison of the present field theory and the usual quantum theory (in the limit of special relativity). A third, S. Hamilton, has been investigating the effect of the field equations on high energy e-p scattering and the comparison with the standard interpretation of the data in terms of nucleon form factors. He may finish this investigation this year and prepare it as his Ph.D. thesis.

Honors, and external appointments

Cambridge University, July 15 to September 10, 1964.
Aspen Institute for Humanistic Studies, Physics Division, Aspen, Colorado, June 14 to July 31, 1965.

Calendar of lectures and conferences

July 31, 1964 "A General Relativistic Approach to Elementary Particle Theory", Cambridge University, Department of Applied Mathematics and Theoretical Physics, Cambridge, England.

Sept. 7, 1964 "A Unified Elementary Interaction Theory in General Relativity", NORDITA, University of Copenhagen, Denmark.

Oct. 21, 1964 "The Masses of Elementary Particles from the Geometry of Space-Time", Physics Colloquium, Boston University.

Oct. 30, 1964 "The Masses of Elementary Particles from the Geometry of Space-Time", Third Eastern Theoretical Physics Conference, University of Maryland.

Dec. 7, 1964 "On Elementarity of Measurement in General Relativity: Toward a General Theory", Boston Colloquium for the Philosophy of Science.

Apr. 26, 1964 "Blackbody Radiation from Bound Electron-Positron Pairs", American Physical Society meeting, Washington, D.C.

Committees

Physics Department: Chairman, Comprehensive Examination Committee;
Librarian, Physics Library

Armand Siegel

Research

"It will be apparent from the list of publications that the last two years have been a period of fruition, in which ideas conceived in an earlier period have almost all at once reached completed and publishable form. I am sufficiently satisfied with these results to feel an urge to develop my comprehension of certain other areas of physics research in which I often feel myself lacking - in particular, quantum statistical mechanics. I intend to pay some attention to this problem during my coming sabbatical, which I will spend at the Saclay Laboratory in France."

In Chapter 5 of the review volume "Fluctuations in Nonlinear Systems", Academic Press 1965, the author of this chapter (N. G. van Kampen) devotes an entire section to Professor Siegel's expansion of the linear Boltzmann operator. (-ASC.)

Comments on courses and students

Mr. Ira Kohlberg is now finishing a thesis under my supervision. I have found him an extremely able and sturdy lieutenant in the development of my research ideas. He has been quite prolific with respect to implementation of such ideas, and indeed a very independent person once given an idea to start with. I am intrigued to find out if he will develop the ability to generate ideas as well once he finishes his doctoral research. I hope he will, but have misgivings.

Mr. Woo-kyung Kahng is now in the beginning stages of doctoral research under my supervision. He seems very promising, being well motivated and intelligent.

Mr. Jerome M. Freedman has been engaged in research not directed toward a thesis under my supervision during the past year. This was his first year as a graduate student in this department. Partly because I have no aptitude for this more casual level of research, and partly because of Mr. Freedman's shortcomings, this project was not particularly successful.

Honors, and external appointments

"I would like to make note of the following item, which is of a quasi-academic nature: A letter to the editor of the Notices of the American Mathematical Society 11, 40 (1964) in support of the present mode of operation of the very important abstracting journal Mathematical Reviews. There have recently been very strong pressures in the direction of a more conventional type of abstracting. This letter was solicited by the editor of Mathematical Reviews after he learned of my views on the subject. I continue to be a reviewer for Mathematical Reviews, and also to serve as referee for A.I.P. journals, this year for Physics of Fluids and J. Math. Phys."

Community activities

"Does Society need Scientists?" - Talk given before the M.I.T. Branch of the Society for Social Responsibility in Science, Oct. 20, 1964.

Dr. Siegel was one of the originating members of the committee of faculty members which arranged and financed the participation of Profs. Paul Doty and Banks McDowell in the April 8-9 lobby in Washington organized by the Universities Committee on the Problems of War and Peace. He was also one of the speakers in the Boston University Teach-In on Vietnam, May 5th.

John Bachel

Research

Continued work on monograph on "Cauchy Problem in General Relativity", extending earlier work on initial value for space-like hypersurfaces to null hypersurfaces.

Worked summer 1964 on Kandel Sachs's theory of elementary particles, on the generalization of Einstein's gravitational field equations using new invariants introduced by the spinor (or tetrad) formulation of the theory of general relativity.

Started a study of the problem of negative mass in general relativity. One of the biggest unsolved problems in general relativity is why negative mass solutions to the field equations can occur, while only positive masses seem to occur in nature. A possible topological criterion for the elimination of negative mass solutions is being investigated.

Invited by Prof. Peter Bayes of Temple University in Philadelphia to spend the month of June working with him on the problem of the formulation of the equations of motion of sources of the gravitational field in terms of Cauchy data for the fields.

B.U. Committees

Department Committees served on: 1964 Summer Colloquium Committee
Undergraduate Committee
Oral Revision Committee

Calendar of lectures and conferences

(1) Stevens Institute Relativity Conference

(2) Colloquium on "The Problem of Gravitational Radiation", Boston College, Spring 1965.

J. Gordon Stipe, Jr.

Research

The textbook that Professor Stipe is writing has been completed and sent by the publisher McGraw-Hill to reviewers. Two stated that if the book were in print they would use it in their courses, but the reviewers and the editor now wish to have it shortened by 15% to 20%. Cutting and revising are now in progress, but this will delay publication. There are tentative plans for a preliminary edition to be used next September, in multilith form.

Honors, and external appointments

Stipe has continued to serve as Secretary-Treasurer of the New England Section, American Association of Physics Teachers, and on a number of the Board of Directors of this organization. He was

also invited to attend all meetings of the Board of Directors of the New England Section, American Physical Society, to maintain liaison between these two organizations, although three professional meetings and five Director's Meetings in the past year.

Although he has made no new films for the Polaris Submarine physics courses handled by the Harvard Commission on Extension Courses, and did not teach an Extension Course at New London, based on these films, in the present year, Stipe attended several meetings with representatives from the Harvard Commission on Extension Courses, Television Station WGBH, and the Submarine School at New London. He also supervised the teaching of Extension Courses based on these films, by a graduate student in our department, (who made the trips to New London, while Stipe checked teaching details with him for each trip and for the examinations). Television Station WGBH expects to use the films that Stipe prepared some time ago for an Extension Course, under the auspices of Harvard Commission on Extension Courses, this course to be telecast on Channel 2 during the academic year 1965-66.

In September 1964 Stipe was invited to speak to the pre-orientation conference of the College of Engineering, at Osgood Hill, on the work of the Committee on Student Personnel Services ("Committee of Fifteen"). He was also the Physics Department representative at the College of Engineering Teaching Colloquy in March.

In January 1965 Stipe was an invited participant in a meeting of the A.I.P. Commission on College Physics, concerning Curriculum 8 and the writing of materials for this new curriculum. This meeting was held in New York City, in conjunction with the annual meetings of the American Physical Society and the American Association of Physics Teachers.

In October he represented Emory University at the Centennial Celebration of Worcester Polytechnic Institute.

B.U. Committees

(1) Committee on Student Personnel Services (this is commonly called the "Committee of Fifteen"), as one of the five faculty members on this committee, appointed by the University Senate. This committee has worked hard, under the direction of Dean Hemill, and done much useful work.

(2) CLA-GRS Committee on Graduate Teaching Assistants. The final report of this committee has been completed and submitted.

(3) CLA Committee on Premedical Advising.

(4) CLA-SAR Liaison Committee

(5) Physics Department Undergraduate Committee.

Stipe also served as Liaison Official for an NSF Matching Fund Grant for Improvement of Laboratory Teaching Equipment. This grant was for $11,825 from NSF, with matching funds supplied through the regular departmental budget over a two year period. This project was completed in February 1965.

Charles R. Willis

Research

Willis's work has been most successful recently. He has a manuscript not listed in the bibliography almost ready for submission to J. Math. Phys., and he has been invited to give a paper at the "Physics of Quantum Electronics Conference" at Puerto Rico June 28-30, 1965. In the near future he will submit two or three publications with his graduate students.

Comments on courses and students

Mr. Richard Calusdian obtained his Ph.D. degree this June. He is my first student who has received a Ph.D.

Mr. S. Scott and Mr. R. Picard will finish their doctoral dissertations late summer or early fall 1965. Both of these students have given public talks at national meetings of the American Physical Society. Both students will have two publications in major physics journals by the time they receive their degrees.

B. U. Committees

The Graduate Committee (Physics Department)
The Admissions Committee (Physics Department)
The Comprehensive Examinations Committee (Physics Department)

George O. Zimmerman

Research

Last summer the cryostat which was built by Zimmerman's students P. Zelder and R. Yee was used to measure the susceptibility of dilute chromium potassium alum by another student, S. Wolfson for a M.A. thesis. That experiment gave us practice in running the cryostat and also introduced us to the techniques of diluting paramagnetic salts. These techniques will be used in the magnetic susceptibility measurements of paramagnetic salts in a strong electric field (the thesis topic for R. Yee).

During March 1965, in a preliminary experiment, we have achieved a temperature of 0.08°K. This temperature was achieved by R. Yee and Zimmerman by means of adiabatic demagnetization. These tests were not intended to yield any publishable data and were intended to provide practice for future experiments.

On subsequent runs, also mainly for practice, we looked for superconductivity in a highly doped germanium gallium crystal and found nonedown to a temperature of 0.103°K.

Another set of runs, where the susceptibility of "Advance", a copper nickel alloy, was measured down to 0.100°K, has yielded publishable results, i.e., it is antiferromagnetic and the susceptibility becomes constant below 0.4°K. The results of those runs are still being analyzed.

Most of the above work was performed with assistance of R. Yee, with some help in building of the original apparatus by P. Zelder.

Yee has now installed a high voltage generator and should be ready to start his thesis experiment within a month. He is a good and hard worker, a good physicist.

P. Zeldes is now preparing to do his thesis experiments, on "The measurement of the velocity of sound in solid He^3 below 1°K". The equipment necessary is rather more formidable than that of Yee, requiering the building of ultrasonic propagation and detection apparatus, and a gas-handling and high pressure system capable of pressures up to 5000 atm. Zeldes is slower in his work but thorough. The things he has built till now have all worked the first time. This is quite a feat! It might be that the time he does "nothing" is well spent in understanding the instrument rather than building it first!

At this rate he should start his thesis experiment in the fall of 1965.

W. Senghaphan has a thesis project which will combine adiabatic demagnetization techniques, the ultrasonic sound propagation technique and the nuclear magnetic resonance technique in the investigation of spin-lattice relaxation times in He^3, i.e., the influence of sound, at the larmor precession frequency, on the spin-lattice relaxation time.

Comments on courses and students

Only one undergraduate student who shows some enthusiasm - D.A. Gim. I don't know why the others are in physics. Graduate students are good on the whole. As usual some are quite immature. Too many with insoluble personal problems.

Honors, and external appointments

During the summer of 1964 Zimmerman was employed as visiting scientist at the National Magnet Laboratory (M.I.T.) and continued to work there during the academic year.

The two projects are now about to yield results.

(a) Investigation of the density of He^3 near the critical point has yielded some data already (collaborator, C. Chase).

(b) Adiabatic demagnetization by means of a 100,000 gauss magnet is about to start working. Results are expected about mid-Summer 1965. (No collaborators).

Because of his association with M.M.L. Professor Zimmerman's research on adiabatic demagnetization was mentioned in the April 1965 issue of Scientific American. The article was "Intense Magnetic Fields" by H.H. Kolm and A.J. Freeman (on page 76).

William J. Alston (with Draper and Hilberg), "The Development and Operation of a Fast Proportional Counter", Bull. Am. Phys. Soc. II 10 1 (1965).

" (with Draper and Hilberg), "Photoproton Polarization from $C^{12}(\gamma, p)N^{12}$ and $Be^{9}(\gamma,p)Li^{8}$", Bull. Am. Phys. Soc. II 10 1 (1965).

" (with Draper), "A Simple Zero-Crossing Discriminator", Nucl. Instr. and Methods (in press).

" "The Measurement of the Photoproton Polarization from Carbon 12", Doctoral Dissertation, Yale University, 1965.

Edward C. Booth (with Chasan and Wright), "Nuclear Resonance Fluorescence from Light and Medium Weight Nuclei", Nuclear Physics 57 403 (1964).

" (with Chertok), "Nuclear Excitation by 1 Mev to 3 Mev Electrons", Nuclear Physics 66 230 (1965).

Bernard Chasan (see E. C. Booth).

Robert S. Cohen, "Interrogations of Paul Weiss" in Philosophical Investigations, ed. Sydney and Beatrice Rome (New York: Holt, Rinehart and Winston, 1964) pp. 261 ff and 291 ff.

" "Is the Philosophy of Science Germane to the History of Science? The Work of Meyerson and Needham" in Ithaca: Proceedings XIth International Congress for the History of Science, ed. M. Guerlac (Paris: Hermann, 1965) pp. 213-223.

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