ANNUAL REPORT DEPARTMENT OF PHYSICS - 1968 to 1969

To: Calvin B.T. Lee, Dean CLA
Philip E. Kubzansky, Dean GRS
Physics Faculty and Staff

Gilbert R. Hoy

From: Robert S. Cohen, Chairman Physics Department

No descriptive report was submitted for 1967-68 except for a list of publications. Hence this report covers faculty activities for both years. It was hardly noticed that no report was prepared. I understand this not as disinterest by our readers; rather this department seems to have presented no serious irritations nor failures of confidence. We have large problems which have been well known and thus far insoluable, and in the course of these years we have presented many proposals which have been carried out and many smaller problems which have been solved. The present report contains primarily an account of faculty activities in teaching and research, substantially drawn from the words of the individual professors. It does not contain an account of extra-curricular and other public activities although such activities in community and political life have increasingly occupied professors of physics at Boston University as much as at other institutions.

I shall introduce this report with some personal impressions of the state of affairs within the department.

Despite the serious revision of the undergraduate curricular structure by the CLA faculty, and the presence of a new President of the University and a new CLA Dean there has been a fairly steady and normal period of two years in the department of physics; a number of faculty changes have occurred but none of striking qualitative importance; thus we welcome Professors Gillespie and Hamilton as Assistant Professors of physics, and we note the promotion of Professors Chasen, Cerrualdesi, Edmonds, Hellman, Hoy, Stechel and Zimmerman to tenured positions. As noted later, research by faculty and graduate students has continued at a qualitatively superb level, and even the published output seems to be increasing. The number of graduate students continues a slow decline, under the triple pressures of the military draft, the declining

national interest in physics and the slowly increasing number of competent graduate physics departments; and nevertheless we are not yet without competitive pressures from graduate students for our small number of Fellowships and other financial aids. We continue to have quite good performance by graduate students on the difficult Ph.D. comprehensive examinations, although the number of genuinely excellent records on these exams is painfully small. Our output of Ph.D.'s has remained steady at about 1/2 dozen annually, but it seems likely that we will have 10/year beginning in 1970. We still have an unusually inadequate building, poor by every real estate criterion known to urban man (even rats appear in the psychology laboratories in the basement) and as has been usual for a decade, the university shows no inclination to solve this problem, confronted as it is by other priorities, Even the equipment within the building is of lesser quality and quantity than that of many dozens of physics departments with fewer faculty, few or so graduate students and far lower standards of teaching and scientific effort.

We have a poor library for physics research, and each positive increment in it - whether an addition of a new journal subscription, or of a technical service such as binding - requires unproductive efforts of persuasion and faculty or chairmanly time. We continue to have a department budget which is gravely inadequate and a staff for administrative, educational and research support which is minimal on all three counts.

Nevertheless, the human content of this poor building is generally excellent. Except for a serious matter of undergraduate labs (see remarks by Professors Chasen and Edmonds), physics teaching here is good, and at some points excellent. Research training of honors undergraduates and of graduate students is largely satisfactory, and in some cases both exciting and innovative, a genuine experience of collaboration between professors and students (see for example, Professor Papagiannis's notes below). Gerald Hawkins resigned to become Dean of Faculty at Dickenson College and Michael Papagiannis has now become Chairman of the CLA astronomy department. Two new Assistant Professors have joined the CLA

department and we anticipate that they will join the GRS physics faculty in due course; the unusually sound physics education of astronomy students has continued both within CLA and GRS, and indeed the close intellectual collaboration reflects the identity of approach and spirit of physics and astronomy which Papagiannis and his colleagues share with us. Also we have another unusual emphasis in the serious attention given to philosophical foundations of physics within this department and by a substantial portion of the philosophy department's faculty. Our current work towards the Ph. D. in physics and in the philosophy department shows nearly a dozen research students whose dissertations may fairly be described as philosophical analysis of physics, as large a number as any University in the western world, perhaps the largest. Our stress upon professional and detailed knowledge of physics and mathematics as a prerequisite for philosophical investigation seems to be successful thus far. Indeed, some of our most successful recruitment of students depends upon such unusual features of the department as these inter-disciplinary activities with astronomy and philosophy.

As we enter the summer of 1969, a number of housekeeping changes are worth noting. New secretaries, a new librarian, new laboratory equipment curators, an old laboratory room refurbishing for full use last spring, four new faculty offices. We still have inadequate space for graduate students and we will have to convert a teaching equipment room into an expansion of Professor Zimmerman's low temperature suite, and we still must find the means to equip a materials preparation room for which we have found some space - but for the moment, the smaller space problems are under control.

I cannot estimate how long this excellent faculty can continue with the larger problem of the inadequate building facility. Aside from our barely - competitive salary structure, there is no more important problem for this department.

Father Patrick Heelan (Fordham University) was Visiting Research Professor in Physics during the fall semester. Other post-doctoral Research Associates included Dr. T. Burke (England), Dr. R. Santilli (Italy), Dr. S. Naya (Japan) and Dr. K. P. Singh (India).

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I am most grateful to Deans Lee and Kubzansky and to Professor Siegel for so kindly allowing me to spend the spring quarter at the University of California, San Diego at La Jolla.

During the spring, Professor Siegel joined an informal interdepartmental Faculty study group which was organized by several members of the Government Department. It was concerned to examine "The Continuing Crisis in the Universities". Departmental "government" was a major topic and I have received Professor Siegel's permission to quote here his informal report to that study group about the operation of the physics department:

> Now to set down something about the method of "government" of the Physics Department. Our experience of 16 years seems useful as a working model for the department autonomy that this Study Conference wishes to propose in the College of Liberal Arts. I divide these remarks into two parts, the first describing the weekly meeting, and the second the division of powers between the department at large and the chairman.
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> I. The Weekly Meeting
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> Our weekly meeting takes place at lunch. The proceedings do not start immediately; the first fifteen minutes are taken up with relaxed conversation and chitchat, ordering food, and awaiting the arrival of laggards. This relaxed conversation provides a good introduction and setting for the meeting that follows. This meeting lasts about one hour. It opens with miscellaneous announcements on the part of the chairman, followed by reports by him or committee chairmen on essential aspects of departmental business. For example, at the departmental meeting which takes place immediately after the CLA department chairmen's meeting he gives a resume of the business that was conducted at the latter, at least insofar as it concerns the department. This is followed by any items of business that are known to be pending.
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> The agenda is usually determined by the chairman, but any faculty member may propose additional items or make an announcement. The procedure is informal, with essentially none of "Robert's Rules" but with a real attempt, monitored by the chairman and members, to finish one subject before starting another. In this way we have informality without generating the sense of frustration that comes from permitting anybody to change the subject at will, everybody's attention thereby hopping around so much that one loses the sense of having accomplished anything.
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> Questions are usually resolved not by vote but by "the sense of the meeting", as stated by the chairman at the close of the discussion of each item. The chairman thereby regards himself as instructed on the matter by the department. We may resort to formal motions and voting under certain conditions: If differences of opinion are very sharp; or if the chairman seems so committed to a minority point of view that nobody "trusts" him to carry out the will of the department without an explicit statement, for the record, of what that will is; or if the issue is unusually complicated or subtle.
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> II. Division of Authority within the Department
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> 1. Authority of the department as a whole: curricula, academic requirements educational and research policy in all aspects; down to every detail, if thought important, of management of department affairs. New faculty appointments, both in respect to area of specialization and selection of candidates.

2. Authority restricted to limited parts of the department: Each promotion of faculty members is decided by those in the rank above that of the promotion. This is to avoid the obvious dangers of corruption and logrolling that might arise if the faculty had to apportion these jobs among themselves.

3. Authority of the Chairman: We accept the principle that fairness and overall wisdom requires that the sharing of a common pool, whether of tasks or of desiderata, is not wisely carried out by processes of mutual bargaining among those involved. Thus the following are the province of the chairman (they may be questioned by the individual faculty member of the faculty members involved, but never, at least in practica , by the department as a whole): Committee assignments and chairmanships, teaching assignments, and salaries.

If this degree of autocracy is accepted by us it is only because we trust the chairman and his wisdom, or, at worst and in extreme cases, we feel that more would be lost than gained by challenging him. If the challenge ever did arise, one of two things would probably happen: The chairman would consent to be overruled and would change his policy, or if he felt this too repugnant, he would present his resignation to the Dean on the grounds that the department had lost confidence in him.

General remarks: It is evident that the department accepts some limitations to democratic procedure. In any plan for university reform I think it important to recognize this. One reason was given above: people can't negotiate with much wisdom over the apportionment of plums or tasks among one another. Another should also be given: Our responsibility is not to ourselves but to a wider constituency, our students and the community. Hence we don't entirely have the right to govern ourselves: Our fate is not just our own business. Under these conditions, we can either turn some power over to students and the community, or accept a degree of supervision which sees to the discharging of these responsibilities by putting some curb on possible selfish excesses.

Research

Research activities are mentioned in each of the several faculty notes. The serious and high quality is well represented by the caliber of the publications of the faculty and their students. Full lists for 1967-68 and 1968-69 are attached for the physics faculty, and a supplementary list for astronomy appears under "Graduate Astronomy" below.

The number of research publications means very little. In the two years reported here we see a fluctuation upward: the physics faculty published 32 articles and books during 1967-68, and 57 during 1968-69. It appears to be an increase of nearly 80% but the substantial basic research effort within the department has surely expanded by a far less impressive factor than that. The proper comment, it seems to me, is to note that the entire faculty is committed to scholarly investigations in physics and related fields, and their efforts are successful in very many cases. The department is increasingly known in this country and abroad for our faculty research contributions and we can look forward to continuation of this. The annual record of publications is of genuine interest but for content far more than for a total number, whether of a man or of the department.

Research support from outside agencies has continued but at a much reduced level. The Congressional and Executive restrictions upon NSF, NASA, AEC and even upon the Department of Defense have had severe effects nationally. Research in physics At BU has suffered mainly in two ways: reduced funds for support of research students and post-doctoral research associates, and a decided slowing down of our previous slow but steady expansion. We are barely keeping all our research efforts going, and only by quite marginal use of available money a number of excellent research proposals have not been funded. Here as elsewhere the support of new projects by younger investigators has suffered most. In our case this has meant a lack of support from outside agencies for Professors Alston, Chesan, Meyers and Corinaldesi.

In fact our present outside support is not negligible. Current research grants amount to about $600,000.; they are granted by NSF (5 grants), AEC

(1 grant). Our attempts to bring a good many of our research projects under one large general grant finally reached a new level of failure when the proposed and expanded cluster of projects on the interaction of radiation on matter to the Department of Defense under Project Themis. Although several questions were raised concerning the adequacy of our facilities and of our administrative support, the primary reason for DoD rejections seems to me to have been the 'pure' nature of our research proposal. Despite some descriptive statements by Project Themis administrators, the actual awards are predominantly mission-oriented and in politically preferred states.

Teaching

Aside from astronomy, the general teaching services by the physics faculty have continued without striking change. Some new courses have, of course, been offered, notably freshman and sophomore seminars by Professors Hamilton, Shuckstedts, Stuchal and Stipe, and a number of new graduate courses and seminars as well. Total registration continues fairly steady at about 1800. There are sizeable fluctuations in such numbers from year to year. Mainly they reflect curricular decisions by other faculties. Thus, when SED required physical science PY101-102 that course registered as many as 750 students, and recently its registration has been approximately 125. The size of the engineering school determines the size of our courses PY 151-152, PY 201-202. PY 121-122 is entirely dependent upon the six year medical program courses which primarily serve physics and astronomy majors, with some interest from students of chemistry, mathematics and geology, are characteristically registering 10 to 15 students per term. Graduate courses characteristically register 5 to 15 students. Physics in this University is, from a fiscal viewpoint, a service department of great importance and a profes-sional education department of great expense. It is necessary to recall that the quality of physics service courses depends upon the quality of those professors and graduate students who teach them; and their quality requires a professionally sound physics community of research and graduate teaching.

It remains the case that this physics department is still under-used at the undergraduate level. We have an excellent undergraduate major program and we could educate many dozens of physics majors but we have usually fewer than one dozen. As Professor Chasan remarks (see below) the national trend is a reduction of physics students so perhaps this is a poor time to recommend that the University's admissions effort should stress the availability of excellent science, including physics, for undergraduates here. Yet I feel such a stress should be made. An interest in natural science can be linked with other life perspectives and the effort to show this should be developed in the first instance through our influence upon high school advisors.

Graduate Astronomy

Professor Papagiannis has prepared a report on the years research and teaching in astronomy. This includes the program of air space science seminar, and a discussion of faculty activities as well as graduate students. It follows:

GRADUATE ASTRONOMY

In 1968/69 a Ph.D. in Physics-and-Astronomy was awarded to Terence Elkins.

John Hegarty submitted his thesis on Cosmology under the supervision of Prof. Hawkins and will proceed to his final oral examination. John Hegarty received Honorable Mention from the Gravity Research Foundation for his Essay on the Annihilation of the Gravitational Field when matter is transformed into electromagnetic radiation.

Dr. Hawkins participated as a Trustee of NEROC in the further developments of this large radio telescope. He gave several off-campus lectures and published a revised edition of Splendor in the Sky. He also published a Rebuttal of Coltin and Martin, Nature 221, March 15, 1969, pp. 1011-1012.

Four students passed their Ph.D. written qualifying exams. These students take their exams and are graded together with the Ph.D. candidates in Physics. Four of the eight parts of the exams are common to the two groups (e.g., Quantum Mechanics) while the other four are similar but different (e.g., Classical Mechanics for the Physicists, Celestial Mechanics for the Astronomers). It is worth mentioning that all four candidates in Physics-and-Astronomy passed the exams with distinction (Ph.D. level) and one of them (Mr. F. Strauss) ranked first among the thirteen physicists and astronomers who passed the exam.

Two students (Henry Mullaney and Michael Mendillo) passed their oral qualifying exams in Physics-and-Astronomy and both are working now full time on their Ph.D. theses. The scope of the oral is to introduce the students into a research project and to provide the opportunity for the faculty to judge the ability of the students in conducting research. Professor Papagiannis has placed on his graduate students the additional requirement that a paper co-authored by the student preparing for his orals must be accepted by a top-ranking journal in the field, before the student can take his orals with Professor Papagiannis as his adviser. This system not only raises the standards of the graduate program in Physics-and-Astronomy but also guides quickly and effectively the students in their Ph.D. thesis. This practice was started with the first two graduate students of Professor Papagiannis who took their orals (Mr. Elkins and Mr. Miller) and was continued this year with Mr. Mullaney and Mr. Mendillo. The papers which these students co-authored with Professor Papagiannis were:

"A world-wide investigation of the mid-latitude evening increase in foF2 in the Summer Hemisphere" by M. D. Papagiannis and H. Mullaney, J. Atm. Terr. Phys., 30, 1677, 1968, and

"A seasonal effect in the mid-latitude slab thickness variations during magnetic disturbances" by M. Mendillo, M. D. Papagiannis and J. A. Klobuchar, J. Atm. Terr. Phys., (in press).

Four M.A. degrees in Physics-andAstronomy will be awarded this August to the following students: Richard Hart, T. Charles Jones, Daniel Seeley and Federico Strauss.

Mr. Terence J. Elkins will receive the first Ph.D. in Physics-and-Astronomy to be awarded by Boston University. The title of his thesis, which he wrote under Professor Papagiannis, is: "Studies of Ionospheric Irregularity Using Radio Astronomical Techniques." The

final defence of the thesis took place on May 28, 1969. For accepting the Ph.D. thesis of his students Professor Papagiannis has again set a high standard requiring that a paper from the content of the thesis, and beyond the paper for the orals, be accepted by a prestigious journal in the field. In this way an essential part of the thesis is brought to the attention of the scientific community and is approved by other experts in the field, the referees of the journals. The paper in this case was sent to the Journal of Geophysical Research. A confirmation that it has been accepted for publication was received on April 24, 1969. The paper is entitled "Measurement and interpretation of power spectrums of ionospheric scintillation at a sub-auroral location" by T. J. Elkins and M. D. Papagiannis, J. Geophys. Res., (in press).

Four new graduate students have been admitted for next year in the graduate program in Physics-and-Astronomy. These are:

1. Stephen Keil, U. of California (Berkeley)
2. Michael Dalterio, Lowell Tech.
3. Joseph Kennedy, M.I.T.
4. Ching-Ling Paul Meng, Taiwan, The Republic of China

Of these, Mr. Meng will be a research assistant under the research contract of Professor Papagiannis, and the other three will be teaching fellows in Astronomy. Of the present two teaching fellows, Mr. Hart will be drafted during the summer and Mr. Seeley will now be a research assistant with Professor Berendzen, who has received an important research contract from N.S.F. to conduct research in the field of "Astronomy Education".

Three of our graduate students (Miller, Mullaney and Mendillo) travelled to Washington, D. C. for the annual meetings of the American Geophysical Union (AGU) and the International Union of Radio Scientists (URSI). Mr. Mendillo gave a paper at the AGU meeting "Seasonal effect in the Ionospheric Slab thickness during Magnetic Storms" by Mendillo, Papagiannis and Klobuchar, and he was a co-author in a paper presented at the URSI meeting entitled "Mid-latitude ionospheric effects associated with the Oct. - Nov. 1968 solar and magnetic events" by Klobuchar, Mendillo, Flaherty and Yeh.

The Space Science Seminar of Boston University, under the direction of Professor Papagiannis, has brought again to our university a series of distinguished speakers. The Seminar, besides the physicists and astronomers, attracts the interests of other disciplines of science and was also taken for credit by more than a dozen graduate students from the programs of Science Communication (School of Public Communication) and Science Education (School of Education). The speakers and their topics this year were:

Prof. John Stachel, Boston University. "General theory of relativity in astrophysics"

Prof. Edward Harrison, University of Massachusetts. "Galactic orbits"

Prof. George Contopoulos, University of Thessalonika and Harvard University. "Galactic orbits"

Prof. George Clark, MIT. "Discovery in space of high energy galactic gamma rays"

Prof. Oliver Schaeffer, Chairman, Dept. of Geology and Geophysics, SUNY at Stony Brook. "Ages of meteorites"

Dr. Robert Noyes, Smithsonian Astrophysical Observatory and Harvard University. "Solar ultraviolet observations from space vehicles"

Prof. Lynn Margulis, Boston University. "Evolution of photosynthesis in the primitive earth"

Dr. Michael Macrakis, NASA-Electronics Research Laboratories. "Research in plasmas"

Prof. Gerald Hawkins, Chairman, Dept. of Astronomy, Boston University. "Astroarchaeology"

Prof. Michael Papagiannis, Boston University. "Pulsars"

Prof. Allen Hynek, Chairman, Dept. of Astronomy, Northwestern University. "The scientific problems of the U.F.O phenomenon"

Prof. Roger Revelle, Director, Center for Population Studies, Harvard University. "The evolution of carbon dioxide in the terrestrial atmosphere"

Prof. Mohamed Gheith, Chairman, Dept. of Geology, Boston University. "Geochemistry of rock-forming minerals"

The Astronomy Research Library has continued to increase its holdings. It now contains 1,050 bound volumes. It subscribes to 31 scientific journals and six serials, has nearly 400 scientific textbooks and monograms, and 22 Astronomical Atlases. A small chart room has been prepared next to the library rooms to house the Atlases, the Ephemerides and the new large Palomar Atlas which is now on order by the Mugar Library for the Astronomy Library and will cost in excess of $1,000. However, in spite of all this progress and the essential role that this library plays in the research efforts of the five faculty members and over a dozen graduate students, the librarian continues to be paid from Professor Papagiannis' research contract.

Professor Papagiannis has been asked by the American Association for the Advancement of Science (AAAS) to chair, during the annual meeting of the Association next December in Boston, a symposium on pulsars and a symposium on Space Astronomy. Professor Papagiannis has accepted the invitation and is now in the process of selecting the speakers to be invited.

Professor Papagiannis signed a contract in December with W. H. Freeman and Company (the publishing company owned by the corporation which publishes the "Scientific American") to publish with them his forth-coming book "Space Physics and Astronomy". Three of the seven chapters of the book are now ready and he hopes to complete the other four by the end of the summer.

During the past year, Professor Papagiannis continued his research work in the areas of Space Physics and Radio Astronomy. Professor Papagiannis is conducting his research under a research contract with the AFCRL and had six graduate students working with him (Elkins, Miller, Mullaney, Mendillo, Strauss and Jones). The specific topics of their research during the past year is best reflected by the following list of his 1968-69 publications.

1. "A world-wide investigation of the mid-latitude evening increase in foF2 in the Summer Hemisphere" M. D. Papagiannis and H. Mullaney, J. Atm. Terr. Phys., 30, 1677, 1968.

2. "Correlation between solar radio bursts and sudden frequency deviation events" F. M. Strauss and M. D. Papagiannis, Astron. Contrib. of Boston Univ., Ser. II, No. 53, January 1969.

3. "Ray-tracing of the Z-mode in a tilted layer ionosphere" M. D. Papagiannis and D. L. Miller, J. Atm. Terr. Phys., 31, 155, 1969.

4. "Seasonal effect in the ionospheric slab thickness during magnetic storms" M. J. Mendillo, M. D. Papagiannis and J. A. Klobuchar, Transact. Am. Geophys. Union, 50, No. 4, 275, 1969.

5. "The relation of sudden frequency deviations to the spectrum and other characteristics of solar microwave bursts" F. M. Strauss, M. D. Papagiannis and J. Aarons, J. Atm. Terr. Phys., (in press).

6. "Measurements and interpretation of power spectrums of ionospheric scintillation at a sub-auroral location" T. Elkins and M. D. Papagiannis, J. Geophys. Res., (in press).

7. "A seasonal effect in the mid-latitude slab thickness variations during magnetic disturbances" M. Mendillo, M. D. Papagiannis and J. A. Klobuchar, J. Atm. Terr. Phys., (in press).

8. "Dispersive motions of ionospheric irregularities" M. D. Papagiannis and T. J. Elkins, J. Atm. Terr. Phys., (in press).

9. Discussion of some difficulties with the oblique rotator model for Pulsars" M. D. Papagiannis, Nature, (in press).

In Spring, 1969, Prof. Berendzen organized (and now serves as advisor for) a student organization called the B. U. Astronomical Society. This group, which is comprised of students interested in astronomy (including non-majors) from throughout the university and from M.I.T. and Harvard, has built displays for the cases in CLA 510 provided free tutoring for AS102 students and for local school child helped with repairs to the B. U. Observatory, and brought a guest speaker to B. U. from the Smithsonian Astrophysical Observatory. No fall, besides continuing these activities, they will lecture in the planetarium at the Natick High School and tutor in the public schools in Roxbury.

In Spring 1969, Prof. Berendzen proposed to the university th establishment of a laboratory course in astronomy, to be introduced in September 1970. This new course, AS103/104, will provide a labo

tory option in the basic astronomy program for non-science concentrators (AS101/102).

To implement the new lab course, the existing laboratory facilities of the Astronomy Department obviously must be made fully operative and some new materials must be obtained. At present, B. U.'s Observatory and telescopes are in disrepair and are unuseable. Prof. Berendzen and his students have inspected the old equipment of the Department in the Observatory (some of it dating from 1894) and have saved the useable items and have thrown out several dozen cubic yards of antiquated and broken crates, pipes, tools, lumber, etc. The Observatory is now cleaned and ready for painting, a Requisition for which was sent to Buildings and Grounds in October 1968. This summer, Prof. Berendzen and an undergraduate student will repair the salvageable equipment of the Department, draw detailed blueprints for a new darkroom to be located in CLA 507, which is currently part of the Astronomy Department (this idea has been unofficially sanctioned by Dean Blaustein); draw detailed blueprints for the installation of the 12-inch telescope in the present 6-inch telescope's dome; transfer the lens of the 6-inch telescope to the 7-inch telescope; compile a complete list with order numbers and specifications of new materials that must be purchased for the lab; and prepare a preliminary draft of the lab manual for the new course.

To accommodate the lab, the Astronomy Department proposed using a darkroom in CLA 507, the Observatory, CLA 519, and CLA 523. All of those areas are currently part of the Department except CLA 523. This room is vitally needed by the Department by September 1970 since it and CLA 519 will house the lab meetings themselves. Deans Blaustein and Lee have been apprised of these matters.

Also, due to the expansion of the Department (a secretary and two assistants on Prof. Berendzen's NSF grant, a Research Associate, a Lecturer, two Assistant Professors, and a Teaching Fellow), we requested that CLA 524 be allocated to the Astronomy Department, beginning September 1969. This request was sent on 25 April 1969 as a memo to Dean F. Erickson, who is in charge of room allocations for CLA.

Prof. Berendzen's principal research interests are in the history of science and in the development and improvement of astronomy education. He has analyzed the educational development of most of the astronomers in the U. S. and the educational offerings in astronomy of American universities. He is scheduled to present papers based on those studies at the next meetings of the following professional organizations: American Astronomical Society, American Personnel and Guidance Association, and the National Association for Research in Science Teaching.

Because of his active work on astronomy education, Prof. Berendze has been asked by the President of the Commission on Astronomy Education of the International Astronomical Union to compile a complete compendium of astronomical educational resources in the U. S. The list will be made available by the IAU, which is the international professional organization for distinguished astronomers, to astronomers and educators throughout the world. Prof. Berendzen has now largely fin-

ished this listing for the U. S. That compilation, plus the results from his Ph.D. thesis, are to be published in the Transactions of the IAU for the next meeting, which is to be in England in August 1970.

Also, he is actively engaged in research on the development of modern astronomy. He is co-authoring with Dr. M. A. Hoskin (Head of the Department of History and Philosophy of Science, University of Cambridge, England) a lengthy book on the controversies, c. 1900-1930, surrounding the scale of the universe.

As a put-together of Prof. Berendzen's interests in education and in history of astronomy, he submitted a proposal to the National Science Foundation for a project entitled "The Development of Case Studies on Modern Astronomy for Use in Undergraduate Instruction." NSF has recently written that they have approved this grant for $25,120, to run from 1 June 1969 to 1 September 1970. (Incidentally, through overhead and other arrangements, this project will put about $10,000 of Federal funds into B.U.) The project will support one graduate student full-time for a year and either another graduate student part-time or two undergraduates. At least one graduate student will begin his Ph.D. research on this project.

It has been made clear to NSF that proposals to continue and to expand this project will be forthcoming next year. We anticipate that when this grant terminates in September 1970, a renewal will be made by NSF.

Prof. Berendzen gave the following lectures:

University of Maryland, May 22, 1968, "Professional Astronomy Education"

University of Cambridge, England, July 16, 1968, "The Scale of the Universe"

American Astronomical Society, Professional meeting, August 13, 1969, "On the career Development and Education of Astronomers in the United States."

He was elected a Fellow of the American Association for the Advancement of Science on October 21, 1969 and a Member of Sigma Xi in June 1968.

Also, Prof. Berendzen has been appointed Editor of The Journal of College Science Teaching, which is a new publication of the National Science Teacher's Association, Washington, D. C.

His publications are as follows:

"On the Career Development and Education of Astronomy in the United States", Ph.D. thesis, Harvard University, June 1968.

THE SCALE OF THE UNIVERSE: Astronomy's "Great Debate", 1900-1930. (with M. Hoskin) History of Science Series of Oldbourne, American Elsevier, 1969.

Book Review of The Story of Jodrell Bank in "Isis", summer issue, 1969.

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ished this listing for the U. S. That compilation, plus the results from his Ph.D. thesis, are to be published in the Transactions of the IAU for the next meeting, which is to be in England in August 1970.

Also, he is actively engaged in research on the development of modern astronomy. He is co-authoring with Dr. M. A. Hoskin (Head of the Department of History and Philosophy of Science, University of Cambridge, England) a lengthy book on the controversies, c. 1900-1930, surrounding the scale of the universe.

As a put-together of Prof. Berendzen's interests in education and in history of astronomy, he submitted a proposal to the National Science Foundation for a project entitled "The Development of Case Studies on Modern Astronomy for Use in Undergraduate Instruction." NSF has recently written that they have approved this grant for $25,120, to run from 1 June 1969 to 1 September 1970. (Incidentally, through overhead and other arrangements, this project will put about $10,000 of Federal funds into B.U.) The project will support one graduate student full-time for a year and either another graduate student part-time or two undergraduates. At least one graduate student will begin his Ph.D. research on this project.

It has been made clear to NSF that proposals to continue and to expand this project will be forthcoming next year. We anticipate that when this grant terminates in September 1970, a renewal will be made by NSF.

Prof. Berendzen gave the following lectures:

University of Maryland, May 22, 1968, "Professional Astronomy Education"

University of Cambridge, England, July 16, 1968, "The Scale of the Universe"

American Astronomical Society, Professional meeting, August 13, 1969, "On the career Development and Education of Astronomers in the United States."

He was elected a Fellow of the American Association for the Advancement of Science on October 21, 1969 and a Member of Sigma Xi in June 1968.

Also, Prof. Berendzen has been appointed Editor of The Journal of College Science Teaching, which is a new publication of the National Science Teacher's Association, Washington, D. C.

His publications are as follows:

"On the Career Development and Education of Astronomy in the United States", Ph.D. thesis, Harvard University, June 1968.

THE SCALE OF THE UNIVERSE: Astronomy's "Great Debate", 1900-1930. (with M. Hoskin) History of Science Series of Oldbourne, American Elsevier, 1969.

Book Review of The Story of Jodrell Bank in "Isis", summer issue, 1969.

Professor Gerald A. Ouellette's work in the celestial geodesy area is continuing under NAS-12-598 at I.B.M. Under this effort, a new triaxial representation for the earth geoid has been developed using satellite ephemeris data to obtain even coefficients in the triaxial geopotential through order 4, degree 4. In addition, two new efforts have been initiated. The first to produce upper atmospheric density and composition models in collaboration with SAO personnel and the second, the application of the prismatic astrolabe for star catalog correction and geodetic position determination.

Gerald Ouellette has been coordinator for B. U.'s role in the summer institute to be held at M.I.T. and B.U. during the period June 16 to July 11. Gerald Hawkins will deliver a lecture on June 20 concerning Stonehenge and Gerald Ouellette will deliver a lecture on June 26 entitled "Historical Aspects of Dynamical Astronomy."

Various reports and presentation of results under the Celestial Geodesy contract have been delivered at NASA Headquarters, Washington, D. C., NASA-ERC at Cambridge, Massachusetts and NASA-Goddard, Greenbelt, Maryland.

Prof. Gerald Ouellette is on the planning and program committee for the annual AIAA-AAS Astrodynamics Conference to be held at Princeton in August 1969.

He is also continuing as an official representative of IBM to the American Astronomical Society.

In his research Dr. Hawkins visited the Peruvian Desert to continue the study of the ancient lines near Nasca.

Relativity Seminar

In addition to the relevant portions of the Boston Colloquium for the Philosophy of Science, the Physics Department Colloquium, and the Space Science seminar, we have had a continually impressive relativity seminar under the guidance of Professor Stachel. It has attracted much interest throughout metropolitan Boston and northern New England. The meetings were as follows: (note: 'Stevens Meeting' refers to the regular meeting of research workers in relativity theory at the Stevens Institute of Technology)

Sept. 16 - "Modern Cosmology" Prof. Edward R. Harrison, University of Massachusetts

Oct. 1 - "Einstein Tensor and G_3's with 2-Dimensional Orbits" Prof. Hubert Goenner, Temple University and Göttingen

Oct. 8 - Stevens Meeting

Oct. 15 - "Cauchy Problem in Generalized Electrodynamics and General Relativity" Prof. John Stachel, Boston University

Oct. 22 - Oct. 15th continued

Oct. 29 - "An Attempt at a Covariant Formulation of Radiation" Prof. Elliott Krefetz, Boston University

Nov. 5 - "The Bohm-Aharonov Effect and its Gravitational Analogue" Prof. John Stachel, Boston University

Nov. 12 - "Mach's Principle and Physically Determined Coordinate Systems" Fro. Solomon Schwebel, Boston College

Nov. 19 - "The Sagnac Effect" Dr. E. J. Post, Air Force Cambridge Research Laboratories

Nov. 26 - "Clairaut's Equation and Post-Newtonian Relativity" Prof. Elliott Krefetz, Boston University

Dec. 10 - Stevens Meeting

Jan. 14 - "Galaxy Formation from Statistical Fluctuations of the Early Universe" Mr. G. Gonzales-Martin, Boston University

Jan. 21 - "The Space-Time Code Prof. David Finkelstein, Yeshiva University

Jan. 28 - "Kinetic Cosmology" Dr. L. Bel, Institut Henri Poincare (Visiting Brown University)

Feb. 18 - "Collapsing Shells of Matter in General Relativity" Prof. K. Kuchar, Princeton University

Mar. 11 - "Approximately Relativistic Lagrangians and the Center of Mass Theorem" Prof. Peter Havas, Temple University

Mar. 20 - "Systems of Self-Gravitating Particles in General Relativity" Prof. Remo Ruffini, Princeton University

Mar. 25 - "Elementary Electrodynamics from an Advanced Viewpoint" Prof. Laszlo Tisza, Massachusetts Institute of Technology

Mar. 26 - "The Conformal Group" Prof. J. Rosen, Brown University

April 1 - Stevens Meeting

April 12 - "The Structure of Null Infinity" Dr. J. Winicour, Wright-Patterson AFB

Richard Oman Bell, B.S. in E.P.,M.S., A.M. Dissertation:"Ferroelectrics and the Mossbauer Effect."

John Stewart Brownson, B.A., M.S., A.M. Dissertation: "Electron and Photon Excitation of Nuclear Isomers."

Ramesh Chandra, B. Sc., M. Sc. Dissertation: "The Energy Levels in Pd^{105}."

Woo-Hyung Kahng, B.S., A.M. Dissertation: "The Cameron-Martin-Wiener ("Wiener-Hermite") Expansion in Turbulence and in the Burgers' Model."

Richard Henry Picard, A.B., A.M. Dissertation: "Mean-Field Kinetic Equations for a Laser."

Wijit Senghaphan, B.S., A.M. Dissertation: "An Investigation of Spin-Lattice Relaxation time of BCC Solid Helium-3."

Tahira Minhaj Servaes, B.Sc., M.Sc., M.Sc. Dissertation: "Anomalies in Chrome Alums."

Dennis W. Hamill, Dissertation:"Coincidence Mossbauer Effect."

Stephen Hamilton, Dissertation: "Electron-Proton Scattering by Potentials Suggested by a New Approach to Quantum Electrodynamics."

Philip B. Newell, Dissertation:"Simultaneous Hyperfine and Zeeman Resonances in Optically - pumped Rubidium-85."

Urbano Oseguera-Valladares, Dissertation:"Sum Rules in High Energy Electron-Proton Scattering."

K.P. Singh, Dissertation:"Magnetically Induced Quadrupole Interactions in Some Normal Spinel Iron Compounds."

Roy Yee, Dissertation:"An Investigation Into the Low Temperature Properties of Certain Magnetic Materials."

Machine Shop

Professor Edmonds has written about the operation of the Machine Shop as follows:

During the twelve-month period April 1, 1968 to March 31, 1969, the Machine Shop has put in a total of 1592 chargeable hours, which figures out to an average of 133 such hours per month. Of interest is the fact that the individual monthly records of chargeable hours do not deviate greatly from the average figure even though Mr. James Johnson, Mr. O'Neill's assistant, left us at the end of August. This means that after Mr. Johnson's departure, Mr. O'Neill had to do all the work himself with a consequent reduction in the time he could spend on non-chargeable work such as shop organization and consultation with faculty and students on the design of experimental equipment. His reduced availability for this latter function in particular is a distinct loss both to this department and to the other departments of Chemistry, Biology, Geology and Psychology as well as Physics in the College of Liberal Arts and in addition handled projects for Sargent College, SPC, Buildings and Grounds, and several Student Activities groups.

The budget under which the machine shop operated in the last fiscal year, revised as of Mr. Johnson's departure, is as follows:

	Total	Shop Account 38232 (To be recovered)	GRS (Not recoverable)
Salaries			
O'Neill	$ 8,403.	$ 3,400.	$ 5,003.
Johnson (2 mos.)	835.	300.	--
Supplies	300.	300.	--
TOTALS	$ 9,538.	$ 4,535.	$ 5,003.

This means that the total research machine shop budget for fiscal 1968 was under $10,000 and that of this, some $4,500 was to be recovered by charges for services. Billings for services do, in fact, produce a recovery rate of this order of magnitude, but this is largely because shop users tend to pay their shop bills last and therefore, if they are running close to the end of their grants, often not at all. Thus the number of shop hours at our going rate of $4.85 per hour implies a total billing of $7,721.20 for April, 1968, through March, 1969. As of this writing, however, only $3,327 have actually been recovered. The fact remains that a total subsidy support of only $5,000 for a machine shop which is supposed to serve all of the machining needs of a university the size of B.U. is nothing short of ludicrous. The result is that customers are driven away by our enforced insistence on billing, Mr. O'Neill dares not spend money for even small items of equipment, and both he and I are most unhappy about what appears to be a total absence of any policy concerning shop development. I hope these points will be considered.

(Please note that these Faculty Notes are presented in two sections. First material from 1967-68, and then from 1968-69 - R.S. Cohen)

1967-8

Faculty Notes

WILLIAM J. ALSTON

During July and August 1967, Professor Alston participated in the MIT Summer Study Program for Intermediate Nuclear Structure, together with Professors Booth and Chasan. During the period May 15 to July 15, 1968, he has been engaged in research at the Yale Linear Accelerator, measuring cross-sections for inelastic electron scattering, in conjunction with C. Bockelman and R. Eisenstein. The Graduate School has supported both of these summer research periods.

Professor Alston's research during the academic year has been measurement of lifetimes of odd-A nuclei at the MIT MeV Van de Graaff electron accelerator.

An honors laboratory was introduced in PY105-106 for outstanding biology and pre-medical majors.

EDWARD C. BOOTH

Professor Booth's research has continued as for some years using the Van de Graaff electron accelerator at MIT. Results continue to come in on resonance fluorescence (in collaboration with Professor Alston) and isomer excitation. Booth joined in the MIT Summer Study group in 1967, and partly as a result of that period of investigation, it seems likely that our nuclear experimentalists will be seeking support for work in a somewhat new field; namely, electron experiments at high energies. Perhaps in the next year the resonance fluorescence work can be continued and support for isomer work at higher energy may be initiated elsewhere than on the present MIT small accelerator.

Professor Booth gave an invited one-hour paper at the Small Accelerator Conference at the University of Maryland in June 1967. He also gave a research paper at the Washington Meeting of American Physics Society in April, 1968.

Professor Cohen serves as a member of the editorial boards of the following journals: Praxis, a philosophical journal (Zagreb, Yugoslavia); Soundings, a journal of interdisiplinary studies (Society for Religion in Higher Education, New Haven, Conn.); Journal of the History of Philosophy (University of California Press, Berkeley); Synthese, international journal for Epistemology, Methodology, and Philosophy of Science (D. Reidel, Dordrecht, Holland); International Dialog, Zeitschrift (Herder, Vienna and Freiburg); Philosophical Forum (Boston University); and as editor (with M.W. Wartofsky) of the Series Boston Studies in the Philosophy of Science (Humanities Press, New York and D. Reidel, Dordrecht, Holland). He also serves as referee for Science (AAAS, Washington) and the American Journal of Physics (American Association of Physics Teachers). Cohen served on the NSF Science Faculty Fellowship Advisor Committee in Physical Science; and is a member of the NSF Advisory Panel in History and Philosophy of Science.

Cohen's seminar in Philosophical Foundation in Physics was devoted during the first semester to interpretations of quantum theory. In this, he was joined by Professors Marlow, Fleischman, and Stachel. During the spring semester the seminar was devoted to interpretations of statistical mechanics. In this he was joined by Professors Siegel, Willis, and Professor Shimony (at that time at MIT).

A number of students in the Department of Physics, and others in the Department of Philosophy, have reached the stage of preliminary research on their dissertations in philosophical or historical foundations of physics: David Nartonis (Interpretations of the Quantum Theory), Michael Horne (Statistical Mechanics and Quantum Ergodic Theory), Mary Fehrs (Nature of Probability and its use in physics), Eror Hultgren (Historical Foundation of Quantum Theory), all in physics; and Sheldon Krimsky (The Mental Experiments), Franklin Axelrod (Minimal Principals), Patricia Hallen (Nature of Logical and Empirical Relations). These students form the first group to have come through regular graduate work with a special interest in phil-

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BERNARD CHASAN

Professor Chasan also participated in the MIT Summer Study Conference. His research continues on in-house low energy nuclear physics. His fine student, Ramesh Chandra, completed his dissertation in early 1968, and accepted a position as research physicist in bio physics at Massachusetts General Hospital. Two students are currently engaged in experimental work; Bhagwat Ahluwalia and Harrison Ransom have automated the angular correlation table and are carrying out a perturbed angular correlation study of internal fields and ordering in $CdCr_2Se_4$.

Chasan's preliminary measurement of angular collaboration involving inner bremsstrahlung made last year is still the only experiment in the field; it was mentioned in a review article on electron capture by Berenyi in the April 1968, Review of Modern Physics.

Professor Chasan served on the GRS Academic Programs Committee, the CLA Ad Hoc to study ROTC, as chairman of the CLA Library Committee, and as chairman of the Physics Department Committee on Undergraduate Affairs. In the latter position, he is principal advisor to physics majors.

ROBERT S. COHEN

Prof. Cohen served on the GRS Committee on Graduate Education in the Arts and Sciences. He is also a member of the Advisory Committee in the Selection of a Dean for Metropolitan College, and a member of the Advisory Committee on Selection of a Director of the University Libraries.

He is a member of the Executive Committee of the American Physical Society, New England Section; a member of the U.S. National Committee for the International Union of the History and Philosophy of Science; chairman of the Boston Colloquium of the Philosophy of Science; chairman of the American Institute for Marxist Studies; Trustee of Wesleyan University.

Professor Cohen serves as a member of the editorial boards of the following journals: Praxis, a philosophical journal (Zagreb, Yugoslavia); Soundings, a journal of interdisiplinary studies (Society for Religion in Higher Education, New Haven, Conn.); Journal of the History of Philosophy (University of California Press, Berkeley); Synthese, international journal for Epistemology, Methodology, and Philosophy of Science (D. Reidel, Dordrecht, Holland); International Dialog, Zeitschrift (Herder, Vienna and Freiburg); Philosophical Forum (Boston University); and as editor (with M.W. Wartofsky) of the Series Boston Studies in the Philosophy of Science (Humanities Press, New York and D. Reidel, Dordrecht, Holland). He also serves as referee for Science (AAAS, Washington) and the American Journal of Physics (American Association of Physics Teachers). Cohen served on the NSF Science Faculty Fellowship Advisor Committee in Physical Science; and is a member of the NSF Advisory Panel in History and Philosophy of Science.

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osophical aspects of science, since we initiated such a possibility in the physics and philosophy departments a few years ago. Also associated with one or another of these students are Professors Agassi (philosophy), Cohen (philosophy), Dauben (philosophy), and Shimony, Siegel, Stachel and Willis (in physics).

EMILIO CORINALDESI

Professor Corinaldesi served on the Physics Library Committee and on the Physics Department Committee on the Doctoral Comprehensive Examinations.

He taught Introductory Quantum Mechanics, PY307 and the year course in Advanced Mathematical Physics, PY703-704. One of his research students, Philip Huddleston, has joined Corinaldesi in special studies in group study with view to editing Professor Corinaldesi's lecture notes from the latter course. In addition, Corinaldesi offered discussion sections in the special physics courses for pre-medical students (PY121-122).

Professor Corinaldesi's graduate students, in addition to Huddleston, have been Mrs. Tahira Minhaj Servaes, who received her Ph.D. degree in Modified Schroedinger Equation Method. (Perhaps the chairman may be pardoned to note that Mrs. Servaes was the first graduate student he admitted when becoming acting chairman in 1958).

DEAN S. EDMONDS, JR.

Professor Edmonds has served as acting chairman of the CLA Pre-Medical Advisory Committee, an extraordinarily, time-consuming and responsible task. Since April, one hundred-five undergraduates have applied for admission to medical and applied professional graduate schools, normally in thrice-quintuplicate applications. And even larger numbers are anticipated for 1969. He also has served on the University Committee on Patents; as chairman of the committee on the physics course in the 6-year CLA-MED program; on the GRS Committee on Teacher Participation; on the Physics Department Committee on Language Examinations; the Physics Department Committee on Undergraduate Studies; and Edmonds has served as director of the machine shop and research services for the Physics Department and GRS.

Edmonds served again this year as judge of the Massachusetts State Science Fair, MIT April 27.

Professor Edmonds writes as follows concerning his course PY121-122, Physics for the 6-year Medical Program:

This experience was one of the most thrilling of my teaching career, as it brought me in contact with a class of really outstanding students. I believe that this group is superior even to the usual entering 6-year-medical freshman class, for which the selection process has, I think, been remarkably good. This year's freshmen seem to me to be the best the 6-year med program has had so far. In testimony thereof, I gave eight A's to a class of 40 (i.e. to 20% of the class), no D's, and only two F's. And FX121-122 is by no means an easy course. In lecturing to this group I was constantly aware that many of them were not only keeping right up to what I was doing but were jumping ahead to the next logical step before I had a chance to state it. Under such circumstances the lecturer is continually tempted to move along faster and/or treat the material in greater depth, and he must be always on the watch for that glaze whose descent over the faces of the students indicates that they are getting left behind. The lengths one can go before this happens to last year's 6-year med freshmen is amazing. And of course by the same token one can't get away with anything. Thus while discussing rotary motion, I mentioned the old-fashioned steam-engine governor and how the requirement of a centripetal force is used as a measure of angular velocity so that an automatic control of engine speed can be obtained. I made the mistake of saying that an equilibrium engine speed would be reached at which the governor would be turning at just the right angular velocity to hold the throttle at the corresponding degree of opening. One number of the class immediately asked why there had to be such an equilibrium rather than a velocity oscillation in which the engine ran first too fast causing the governor to open it. A short discussion revealed that this boy had on his own taken cognizance of the whole problem of servomechanism instability and was at that moment hopping ahead to a consideration of what the criteria were that determined whether a feed-back

system would be stable or unstable. It is quite a thrill to see a major section of electrical engineering reinvented before one's very eyes.

The only big problem was the extreme shortness of the second semester, aggravated by the closing of the university following the assassination of Dr. King. I have been no little disturbed by the attitude of the faculty towards this situation and have wondered if some of us (not in this department) believe that students could cover the material in their courses better if the faculty were not involved at all. As I happen not to share this view but rather to consider that my tuition-paying students were cheated out of a proper coverage of some of the more interesting aspects of modern physics, I have arranged an informal weekly seminar to which all members of the 1967-68 6-year-med freshman class are welcome and in which I propose to cover the points in question. This is not an official course, will include no tests, involve no grades, carries no credit, and is completely voluntary. Nevertheless, the 6-year med class being the way it is, I expect most of them will show up.

Two students, Michael Porter of SED and Michael Cohen of this department worked with Edmonds last term under the guise of registrants in PX398 Senior Seminar. Porter pursued a program in modern physics tailored to his needs as a secondary school teacher of physics and Cohen continued an experimental project directed towards developing a demountable vacuum tube in which a student can actually assemble a cathode, a grid, and a plate and after suitable evacuation, observe the characteristics of the triode thus formed. A demonstration in which amplification of a signal is accomplished by this plainly visible arrangement of wires and tubing is far more dramatic than any electronic performance by commercial tubes which, being hard to see into, are suspected of embodying some magic ingredient which the

instructor is careful not to tell the class about. Both Porter and Cohen earned two credits for their work. Miss Susan Nagel, who did not need the credits and was therefore not registered in PY398, also pursued her project of building a Rutherford scattering demonstration. She has constructed a successful vacuum system complete with an externally driven rotating arm and needs only an alpha particle source and a detector to complete the job.

Professor Edmonds' present research project may be entitled "Application of the Redhead-Varadi RF Mass Spectrometer to the Measurement of He^4 Impurity Abundances in He^3 Samples." This carries on the development work previsouly done with Mrs. Rosalyn Greenberger and has been supported by a GRS grant, awarded jointly to Professor Zimmerman and Edmonds. Marilyn Friolo has improved and adapted the earlier computer program for use on the new B.U. model 360 and has calculated the operating characseristics of the RF mass spectrometer under both voltage scanning and frequency scanning conditions. A paper reporting the development and measured characteristics of this instrument is presently in preparation, and a sample-handling system designed to introduce Professor Zimmerman's helium samples into the ionizing chamber is under construction. Miss Friolo will receive her MA degree in August 1968 with a master's thesis derived from this work.

OWEN FLEISCHMAN

Professor Fleischman delivered lectures at the Fourth (Boulder, Colorado) Conference on Particles and High Energy Physics in August, 1967 and at the Washington Meeting of the American Physics Society in April. He also gave two lectures to the B.U. Physics Journal group in March and April on Physical Intuitive Approach at Particle Symmetries.

He taught Electromagnetic Theory, PY309-310, adding to the standard material his own treatment of the Relativistic Formulation of Electrodynamic Radioactivity and the so-called Step-Ladder Approach to spherical harmonics. Fleischman also taught General Physics. PY111, together with the three discussion sections, and then in the spring he taught the sophomore honors discussion section of PY202.

Fleischmen served as a participant in Brookline PAX.

WOLFGANG FRANZEN

Professor Franzen lectured at the International Conference on Atomic Collisions, Academy of Sciences, Leningrad, U.S.S.R., July 18, 1967 on "Electron Polarization by Resonance Scattering from Rare Gas Atoms"; at the colloquium of the Physics Department of Clark University, October 1967 on "Electron Polarization by Resonance Scattering"; at New York University, October 1967 on "Electron Polarization by Resonance Scattering"; and at a B.U. Colloquium in February 1968 on "Light Beats at a Double Quantum Resonance."

Professor Franzen's principal teaching obligation, apart from research students, is the senior and first year graduate course, Advanced Laboratory, PY313-314. This year a new experiment on holography, using a helium-neon laser, was put together. Also the angular correlation of annihilation radiation experiment has been reconstructed. Improvements have been made in a number of other experiments. Most of the graduate students and the better undergraduate physics majors seem to find this course of substantial educational value. We have some difficulty with the weaker undergraduate majors, for whom the experiments are difficult and time-consuming, and who are often not sufficiently motivated to put in the necessary effort. John Porter, a second year graduate student, distinguished himself by assembling single-handedly a very neat holography experiment for the Advanced Laboratory. In addition, Franzen has instructed the honors section of PY152, Principles of Physics, for the better CLA science majors and engineering students.

Of Professor Franzen's research students, Bruce Newell has nearly completed his dissertation on "Simultaneous Hyperfine and Zeeman Resonances in Optically Pumped Rubidium Vapor." Rajendra Gupta, with the helpful collaboration of Phillip Hoeper, has nearly completed an experimental thesis on "Spin Polarization of Slow Electrons by Elastic Resonance Scattering from Neon."

Franzen completed an analysis of the Double Quantum Resonance light modulation experiment that Bruce Newell and he carried out in

He also served as president of the Boston University Chapter of Sigma Xi for 1967-68. A major advance was the adoption by the membership of a system of undergraduate prizes to go into effect next year.

He continues to serve on the Editorial Board of the Swiss Zeitschrift für Angewandte Mathematik und Physik.

In January 1968, at the invitation of the President of the National Academy of Sciences, he served on a panel of the National Research Council charged with selecting winners of National Science Foundation post-doctoral fellowships.

In addition, Professor Franzen has received an invitation to participate in an International Conference on Atomic Physics which has been organized by Vernon Hughes and that was held at N.Y.U. in June. He was invited to participate in the International Conference on Optical Pumping and Atomic Line Shape organized by the Institute of Physics of the Polish Academy of Sciences in Warsaw in June, but he could not attend. Franzen also received a personal invitation to attend the Arnold Sommerfeld Centennial Memorial Meeting and to contribute to an International Symposium on the Physics on One- and Two-Electron Atoms to be held at the University of Munich in September.

WILLIAM S. HELLMAN

Professor Hellman taught Advanced Quantum Mechanics and Mathematical Physics this year. In addition, his work with graduate research students has progressed; John Oliver, Gregory Hood, and at the MA level, William Serill.

Hellman served on the Physics Department Committee on Graduate Admission, as well as the Committee on Graduate Studies.

He also was an invited participant in the 1967 Eastern Theoretical Conference, and he reported on his research at the Physical Colloquium at the University of New Hampshire.

J. GORDON STIPE

Professor Stipe was on leave for the entire academic year 1967-68 -- on sabbatical leave for the first semester and on leave of absence for the second semester. He spent the first semester at the Lunar and Planetary Laboratory, University of Arizona, Tucson, with the rank of Visiting Professor, but no professorial duties other then study and research. This period was spent in study of the excellent collection of photographs of the lunar surface, studies of cratering and a comparison of the various mechanisms for cratering, and in discussing problems of the solid planets with staff members at the Laboratory. Much time was spent in the library of the Kitt Peak National Observatory, which is in a building on the University of Arizona campus. Most of the library work was a study of various models for planetary interiors, and on thermal problems of the moon and planets. Attending the many colloquia of the Lunar and Planetary Laboratory, the Kitt Peak National Observatory, the Astronomy Department of the University, the Geology Department and Physics Department of the University was an important part of the term spent at Arizona.

Professor Stipe adds the following comment:

> It was not all work, however, Mrs. Stipe was there, too, and we both enjoyed the wonderful square dances in Tucson. There were several trips in the desert and the nearby Mountains, some visits to Nogales, Mexico, and two trips to Flagstaff with visits to the Meteor Crater, the Grand Canyon, and some Indian ruins. Two visits were made to Sunset Crater, a volcano that erupted most recently in 1065 A.D.. We like the mariachi music but are not sold on Mexican food. The giant cacti in the desert surrounding (and in) Tucson made us feel as though we were living in a king-sized dish garden.

Stipe's second semester was spent mostly in and around Boston. Some computations to reduce extensive cratering data were made, using the B.U. computer. Some further analysis and writing based on the studies in Arizona were continued. From

March on, an average of almost two days each week were spent working with Professor E. C. Kemble of Harvard University.

In February, 1968, Professor Stipe made a brief trip to McMurdo Sound, Antarctica. This was to serve as an instructor in the physics course that is a part of the Navy PACE program. These are courses based on television tapes prepared in 1963 and 1964, with some live instruction at the beginning and end of each course. Professor Stipe made the television tapes for two of the physics courses in 1963. (Professor Sheid of the B.U. Mathematics Department was one of the four other persons on this trip.) Stipe comments as follows:

> We flew from Quonset, Rhode Island, to Honolulu, and flew non-stop from Honolulu to Christchurch, New Zealand. Flew again from there to McMurdo, which is 2400 miles due south of Christchurch and about halfway between the Antarctic Circle and the South Pole. In February there was continual daylight -- the sun just went round and round.
>
> A week was spent at McMurdo Base -- working on the course and talking with civilian scientists doing geophysical research there. (Some of the work most interesting to me was done at Scott Base, the New Zealand research station.) There were short sightseeing trips, courtesy of the Navy, in a helicopter and a snow cat, to see penguins and seals, and to go part way up the slope of Mount Erebus, an active volcano about 13,000 feet high and the cause of the island we were on. Went inside the huts of Scott at McMurdo and Cape Evans, and Shackleton's hut at Cape Royds. These are now New Zealand National Historical Monuments.
>
> Flew back to Christchurch, where it gets dark at night, and there for a visit of a little over 24 hours. Had a nice visit and dinner with some family friends there, and went out to see the new campus of the University of Canterbury. Dr. Seed showed me through the physics laboratories.
>
> The trip back from Christchurch, New Zealand, to Quonset,

Rhode Island, took only 23 hours! Stopped an hour in Pago Pago, another hour in Honolulu, then flew non-stop from Honolulu to Langley Field, Virginia, and on to Quonset.

Sabbaticals should be spent in studying new fields, and in beginning investigations in new areas -- this is a way to grow and progress. But a sabbatical can also include some interesting travel!

CHARLES R. WILLIS

Professor Willis lectured at the Worcester Polytechnic Institute in May on "Theory of Lasers"; at the B.U. Philosophy of Physics Seminar in March on "Irreversibility"; and also commented on Professor Siegel's talk at the Boston Colloquium for the Philosophy of Science in February.

His student Richard Picard received his Ph.D. this year with a dissertation on "Mean-Field Kinetic Equations for a Laser." During the year, Daniel Ostrowsky, John O'Brien and Herbert Fox continued their research. Professor Willis' research activities have been investigations of: many body theory of lasers; optical pumping; collision effects in gases; and quantum theory of radiation.

Willis served on the Physics Department Committee on Graduate Students, Physics Library Committee, and he also was jointly responsible for the Physics Colloquium with Professor Stachel.

During the year, Professor Willis organized an informal research seminar on "Problems of the Interaction of Radiation and Matter," attended by B.U. students and a number of scientists from outside Boston University.

His regular courses were Statistical Mechanics, PY 707-708, and the second half of Quantum Mechanics, PY 308.

GEORGE O. ZIMMERMAN

Professor Zimmerman lectured on "Spin Phonon Interaction in Solid He^3 " at the University of Minnesota Low Temperature Physics Colloquium, January 19, 1968. He later spoke at the Gordon Conference on Quantum Liquids and Solids during the late spring. In summer 1968 Professor Zimmerman delivered four papers at the 11th International Conference on Low Temperature Physics at the University of St. Andrews in Scotland. These were: "Equation of State of He^3 in the Critical Region" (with C. E. Chase); "Spin Lattice Relaxation and Phonon Absorption in Solid He^3 " (with W. Senghephan); "Specific Heat and Susceptibility of CuLa Compounds with the Addition of Er" (with Yee); and "Magnetic Properties of Cerium Magnesium Nitrate in the Millidegree Region" (with E. Maxwell, D. R. Kelland and D. J. Abeshouse).

Wijit Senghaphan, Professor Zimmerman's first doctoral student, received his Ph.D. degree and has returned to teaching in Thailand. Several other students are now fully in dissertation research, Roy Yee and Philip Zeldes; in another year David Abeshouse will be completing his research, collaborating with Zimmerman at the MIT National Magnet Laboratory. A fifth student, Frank Kearly, is just beginning to assist Professor Zimmerman.

Professor Zimmerman has taught Undergraduate Mechanics, PY 204, Advanced Solid State Physics, PY 716, and also Principles of Physics, PY 202.

Professor Zimmerman served as chairman of the Physics Department Graduate Admissions Committee and as a member of the Committee on the Comprehensive Exams. He also initiated a Student Journal Club and he writes as follows:

> I was appalled at the indifference of our graduate students. Faculty attendance was good. We had some good talks from Drs. Franzen, Hoy, Fleischman and Zimmerman. Will have to put a tighter control on student speakers. Will try to continue the club next year.

William J. Alston 1968 - 1969

Concerning his research, Professor Alston writes as follows:

> "Research over the last year has taken on two forms: Photon scattering at the 4 Mev High Voltage Laboratory MIT Van de Graaff Accelerator and electron scattering at the 70MeV Yale University Linear Electron Accelerator.
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> Working with us at the MIT facility was an undergraduate (H. Krakauer) from Rutgers University who came as an NSF Undergraduate Summer Research Participant. The research done doing the summer months yielded publishable results (see publications) and has continued through the school year. Recently an NSF grant was awarded, enabling us to extended our resonance fluorescence measurements into new regions of the periodic table with vastly improved detection systems as well as anticipating the upgrading of the Van de Graaff to 5 MeV. At the present time three graduate students, one undergraduate and two faculty members (E.C. Booth) are on this program.
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> Last summer GRS furnished living expenses for six weeks in New Haven, Conn. This summer it will supply travel expenses. The measurements performed over the past year at the LINAC stand at the present time as the only determination of odd-mass nuclear transition strengths using light particle scattering(see publications). This work is continuing into the region of even-mass nuclei at high excitations. Only one other accelerator (Darmstadt, Germany) is competing in these measurements. This experimenter is collaborating with two staff members at Yale University; we are regularly scheduled for one-quarter of the available beam time on the LINAC (180 hours/four weeks)."

Alston offered our old version of Modern Physics during the fall and the new version during the spring. The new CLA four-course program has obliterated both versions! However, Alston's comments are still of interest:

"The contrast between the "old" and the "new" approach to Introduction to Quantum Physics (PY 301) is evident in the performances of the Physics majors. The first semester course (now deleted) dealt with a group (5) of our majors who were seniors, and, though growing up with the recent four-semester introductory sequence, were weak intellectually and certainly of doubtful graduate school quality. (This suggests that in 1965-66 we were unsuccessful in attracting the good freshmen and sophomores.) Thus, the course got off to a slow start as a review of previous material and never got up to speed. On the other hand, the small (4) but excellent group of juniors in the second semester course did the best work seen in three years of teaching this course. Their performances answered the question as to whether Quantum Mechanics can be taught to our juniors. The

Another problem involves the quality and motivation of teaching fellows. Some are very good, but many are not, and they don't take their laboratory functions very seriously. More than one laboratory period this year has been demolished by a mis-informed teaching fellow. The undergraduate committee suggests that a serious attempt be made to assign new teaching fellows to their courses earlier than is now done, and to have these fellows available for work during the week before classes. Then an unhurried familiarization with experiments to be done that semester could be achieved.

It is difficult to sum up the peculiar feeling of frustration which those of us feel who have been associated with these laboratories. A series of small circumstances keeps us from getting full pedagogical value out of those experiments available in the department. As a result, a major part of the departmental teaching activity is carried out indifferently. And it is probably not necessary to add that innovation, even small in nature, is extremely difficult under these conditions.

But even if the laboratories were run smoothly there would still be problems. There is a general feeling on the part of both students and involved faculty that the laboratories are basically not satisfactory, in their format and content. This discontent is not limited to B.U., as a look at almost any issue of American Journal of Physics will show. But of course this fact makes it no less an issue for us locally.

There is surprisingly little consensus about the detailed aims and goals of the elementary laboratory. Some feel that its chief value is the illustration of physical principles learned in lecture, and that close coordination of lecture and laboratory should be maintained. Others feel that experience in making measurements is of major significance, together with the processing of data so obtained. Among the latter there is in our committee a small amount of sentiment for discontinuing the laboratory as a part of the lecture course. But this is a distinctly minority view.

For the relatively short range, I believe that there is agreement on some aspects of elementary laboratory. The Committee strongly recommends that fewer experiments be done per semester, the general sentiment being that more benefit could then be derived from those which are retained. Such a thinning out would automatically make it much easier for individual instructors to try new things.

My own feeling is that some further degree of "open-ended-ness" be introduced into all of our introductory course labs. As things stand now, there is no opportunity for students to design their own experiments, even to a modest degree. A

modest open-ended experiment in harmonic oscillations has been tried for a few years in the calculus level introductory courses, and has been successful. Most students consulted have been quite enthusiastic about it, perhaps in response to the sudden release from lock-step as much as to the intrinsic worth of the experience. The experimental "open-enced" laboratories run by Franzen for freshman honors majors and by Shuchatowitz for non-science students may be precursors of improved laboratories in all courses. No doubt there are problems in going from a small faculty-run seminar to a multi-sectional large course, but perhaps the time has come to see just how bad their problems are.

The small numbers and large variability in quality of physics majors at B.U. is well illustrated by our present student population. Four or five graduated as physics majors this year, but none seem ready for or motivated for further academic work in physics. Next year's senior class is equally small, but richer in achievement and potential. It is interesting that two of these students will spend the summer at Brookhaven. Catherine Olmer will work with the neutron chopper group, while Dean Howard will be associated with solid state work. Howard, incidentally, is one of two B.U. science majors who are going to Brookhaven under a special program worked out with Brookhaven by Professor Lichtin of the Chemistry Department. This program allows B.U. to designate one or two highly qualified science majors who are then automatically accepted by Brookhaven.

Three students will do senior honors projects next year; these are:

Catherine Olmer - Elastic Scattering of Gamma Rays (Alston)
Gerald Indorf - Isomer Excitation (Booth)
Dean Howard - Mössbauer Studies (Hoy)

The upcoming junior class of physics majors looks rather strong. Junior courses will be rather larger next term than they have for a few years, and many of the students are quite promising.

There is a clear need to improve recruitment procedures for science students at B.U. This may seem to be a rather empty and obsolete goal when we consider the national surplus of physicists and the well-known generation gap. Nonetheless our basic goal is still to teach and to do research. We can get introspective as hell about relevance, social responsibility, etc., and maybe get new insights. Who knows? Maybe a course in the thermodynamics of water pollution will be standard in two years. But whatever is standard in two years, the health of the program will depend in part on our ability to attract good students to B.U.