# Chapter Thirteen

# New High Energy Theory Center
# Allen Robbins (1979-1995)

**Rutgers University**

In the spring of 1982, President Bloustein appointed a new executive vice-president, T. Alexander Pond. This appointment was destined to have an enormous impact on the University as a whole, and the Physics Department in particular. Because of his background in physics, Pond was given a tenured appointment as Professor of Physics. He received his Ph.D. degree from Princeton in 1953 where he carried out positron experiments. Following his degree, Pond served for two years as Instructor at Princeton, and then went to Washington University, St. Louis for nine years. In 1962 he went to SUNY Stony Brook, where he was Chairman of the Department of Physics (1962-68) and played a major role in building the department there. He was then Executive Vice-President at Stony Brook (1968-80). At Rutgers he became Executive Vice President and Chief Academic Officer (1982-91).

A major thrust in the development of academic and scientific facilities in the State began shortly after the appointment of Alec Pond as Executive Vice-President in 1982. The result would be a significant enhancement of academic programs at Rutgers, especially in the sciences. In particular there would be a 50% increase in the size of the Physics Department, and the addition of distinguished faculty members who would dramatically enhance the reputation of the Department.

In 1982, Governor Thomas Kean established a Commission on Science and Technology for the State of New Jersey. President Bloustein was a member of that Commission. In December 1983, the Commission issued its report recognizing the vital role New Jersey had played and would continue to play in technological innovation. The report pointed out that no other state had more scientists and engineers per capita than New Jersey. In the fields such as pharmaceuticals and electronics, expenditures for research and development in New Jersey were the highest

in the nation. New Jersey's colleges and universities constituted a valuable resource. The Commission recommended investments in ideas, enterprise, and people in specific areas: biotechnology; hazardous and toxic substance management; materials science; food technology; and telematics, the convergence of computer and communications technologies.

In November 1983, President Bloustein convened a committee of 39 distinguished citizens to study the future financing of the University. The report, issued the following year, pointed out that Rutgers was poised on the threshold of a new level of national distinction. The report gave a list of public universities, ranked by the number of programs with high faculty quality ratings. In this list Rutgers ranked eleventh, behind Berkeley, UCLA, Illinois, Michigan, Wisconsin, Texas, Washington, Minnesota, UNC, and Indiana. The report suggested that Rutgers was in a position to make significant contributions to the economic, cultural, and social prosperity of New Jersey. It urged a broad-based partnership between New Jersey and the State University, and outlined the needs and strategies of the University in some detail.

In his 1984 Annual Message to the New Jersey State Legislature, Governor Kean announced that there should be a new partnership between the twin missions of higher education and economic development. In November 1986, he stated that he could not think of any better way to invest business dollars and bring back a return than in education, and that in education he couldn't think of a better investment than Rutgers University. Governor Kean spearheaded a movement for economic development in the State, and Rutgers was ready to take advantage of that movement.

In November 1984, the voters of New Jersey approved a $90 million Jobs, Science and Technology bond issue to provide funds for capital construction of research facilities at advanced technology centers around the State. This bond issue provided the stimulus for the development of a number of technology centers at Rutgers.

By December 1986, there had been substantial progress on the implementation of the University's Financial Strategy for Academic Distinction. The University had added to its faculty more than a dozen scholars of national and international reputation as part of a program to recruit world-class scholars. These new appointments included Herbert Freeman, an international authority on computer graphics and image

processing, Joachim Messing, a leading molecular geneticist, David Levering Lewis, a noted biographer of Martin Luther King, Jr., Aaron Shatkin, a cell biologist who was a member of the National Academy of Sciences, and George Sigel, Jr., former director of fiber optic related research for the Naval Research Laboratory. In addition, the Henry Rutgers Research Fellows program provided support for thirty-nine promising young scholars in launching their research projects at the beginning of their careers.

One of the recommendations of the Future Financing Committee was the bold proposal that the University use its bonding capacity for building academic facilities. Previously the University had only borrowed money to finance buildings such as dormitories and dining halls, which generated income that could be used to pay off the loans. The new financing strategy was approved by an act of the State Legislature in 1985-86. The first $10 million of general obligation bonds was issued in 1986 to finance Rutgers share of the construction costs of the New Jersey Center for Advanced Biotechnology and Medicine, a joint project with the University of Medicine an Dentistry of New Jersey and Robert Wood Johnson Medical School.

The University planned to issue $88 million in bonds in 1987 and another $62 million in 1988. This borrowing against future revenues, together with private giving and state appropriations, enabled Rutgers to embark on the largest building program in its history. In the fall of 1986 the University inaugurated a major capital campaign to raise $100 million from private sources. It eventually exceeded that goal. The Fund for Distinction that was created provided about $340 million for buildings and equipment by 1990. These projects included nine new science institutes such as the Center for Ceramics Research and the Center for Advanced Food Technology. The Fund for Distinction also provided for over forty-five other building or renovation projects, including $10 million for the new physics building and $2 million for physics laboratories.

President Bloustein died suddenly in December 1989, after serving as President for eighteen years. Francis Lawrence became the eighteenth president of Rutgers in 1990. Lawrence was a native of Woonsocket, Rhode Island, and received a bachelor's degree in French and Spanish from Saint Louis University in 1959. He earned a doctorate in French classical literature from Tulane in 1962. He became a faculty member at Tulane

and assumed a number of administrative positions there. He was Academic Vice-President and Provost, and Dean of the Graduate School at Tulane when he accepted the presidency at Rutgers.[1]

During the period between Bloustein's death and the appointment of the new President, Alexander Pond served the University as Acting President. He stayed on as Executive Vice President for a short time after Lawrence's arrival, but in 1991 decided to leave the position he had held at Rutgers for nine years. He and Bloustein had worked very well together in building the University. After leaving his administrative position in Old Queen's, Pond took up residence in the Physics Department in 1991. He had been given tenure in the Department when he came to Rutgers in 1982, and he was appointed University Professor when he stepped down as Vice-President.

When Francis Lawrence came to Rutgers he found a University that had seen major advances since it opened for instruction in 1771. By 1991 the University had awarded over 250,000 degrees, with nearly three-fourth of those degrees awarded in the previous twenty years. The University had 26 schools and colleges with nearly 100 major fields of study. Rutgers enrolled over 47,000 students and stood in the top five public universities of the 58-member Association of American Universities in minority enrollments. The University employed among the highest percentages of women and minority faculty of any of the AAU institutions. External research support at the University increased from $17 million in 1977 to $93 million in 1990. In its last private fund-raising campaign the University raised over $166 million, and higher education bond issues in 1984 and 1988 contributed to the massive $600 million building expansion program. These resources were instrumental in the growth of the University during the previous two decades. Rutgers University had become one of the great universities in the nation.

**Physics and Astronomy**

When Harold Zapolsky stepped down as Department Chairman after six years of service, the Department asked Allen Robbins to be its next Department Chairman. Robbins was familiar with the Department and the University, having come to the Department as an undergraduate

[1]"Presidents," *Journal of the Rutgers University Library*, v. 53, p. 37 , June 1991.

student in 1949, and as a faculty member in 1956. Robbins served as Department Chairman until 1995. During the first seven years (1979-86) there was no change in the size of the faculty, which had been at the level of about 40 full-time faculty members since 1971. Then, during the next seven years (1986-93) there was a major increase in the size of the faculty to about 60 full-time faculty members. In this latter period some outstanding faculty members joined the Department. The enhancement of the Department during this period could fairly be compared with the major developments of the Department at the end of the World War II and at the time of the Science Development Grant.

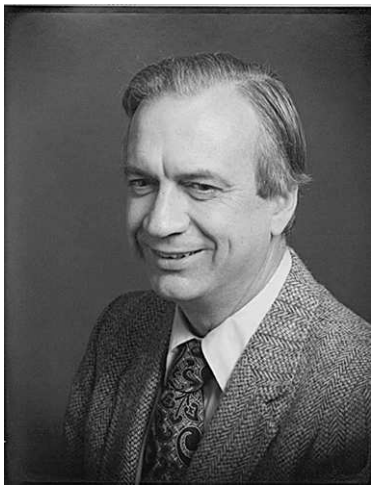

**Figure 44 Allen Robbins**

In the first seven-year period (1979-86), ten assistant professors and one associate professor joined the Department. These included: four nuclear physics experimentalists, Elliot Kanter, Paul Vincent, Yehuda Niv, and Ronald Ransome; two astronomers, Theodore Williams and Robert Schommer; two high-energy experimentalists, Gordon Thomson and Stephen Schnetzer; two high-energy theorists, Glennys Farrar and Herbert Neuberger; and a condensed matter/high-energy theorist, Natan Andrei. The appointments in nuclear physics were made in what turned out to be an unsuccessful effort to save the tandem Van de Graaff accelerator as a viable part of the Department's experimental research facilities. It also represented the first appointment of a faculty member, Ronald Ransome,

whose research efforts were directed to intermediate-energy nuclear physics, joining Charles Glashausser who had previously redirected his research interests to that area. The appointments in astronomy/astrophysics were made in support of the clear intent of the Department to build a viable program in that field.

The appointment of Natan Andrei was quite unique. Andrei's work in solving the Kondo problem had been widely acclaimed. The Kondo problem concerned a simple physical model of magnetic impurities in metals that required the most sophisticated of mathematical techniques for solution. Andrei executed a coup by exactly diagonalizing the Hamiltonian, which allowed a solution in closed form. Andrei was a postdoctoral fellow at New York University when he carried out this work. Because of the promise that this work indicated, the Department hired Andrei directly to a tenured associate professor position.

Of the ten assistant professors hired during this first seven-year period, seven received tenure in the Department: Farrar, Williams, Thomson, Schommer, Neuberger, Schnetzer, and Ransome. There continued to be faculty members leaving the Department. In 1980 Elliot Kanter left the Department for Argonne National Laboratory after one year, and Robert Stellingwerf went to Mission Research Corporation after three years in the Department. In 1981 Joseph Johnson moved to a full-professor's position at the City College of New York after nine years in the Department, and Peter Weiss retired to Maine after thirty-five years in the Department. In 1983 Andrew Cheng went to the Applied Physics Laboratory at Johns Hopkins University after five years in the Department, and Douglas Potter went to Carnegie Mellon University after six years in the Department. In 1983 Yehuda Niv returned to Israel after two years in the Department, and Paul Vincent went to Brookhaven National Laboratory after four years in the Department.

In 1979-80 the Department had 63 undergraduate physics majors, with 19 graduating seniors, 11 in the professional program and 8 in the general program. In pursuit of the development of its program in astronomy and astrophysics, 300- and 400- level courses were introduced, preparing students for graduate work in that field. The Department also added a course in modern instrumentation with the help of a grant from the Rutgers Council for Instructional Development. There were 76 graduate students, 60 full-time and 16 part-time, a decrease from the previous year.

## Allen Robbins (1979-1995)

In 1980 Arthur Gillman, a student of Harold Zapolsky, received the first Rutgers Ph.D. in astronomy for his work on a relativistic treatment of optically thick spherical accretion.

Also in 1980, Zapolsky brought to Rutgers the Eastern Theoretical Physics Conference, which was, arguably, the most successful of a long series of such conferences.

There were significant research accomplishments, and recognition of the faculty for these accomplishments. Elihu Abrahams and his collaborators made a major contribution to the understanding of disordered electronic systems. They predicted that thin metal films never exhibit true metallic conductivity. Abrahams was named President of the Aspen Center for Physics. Charles Glashausser began a program in intermediate-energy nuclear physics at Los Alamos National Laboratory, and Bell Telephone Laboratories extended its contract for the use of the tandem Van de Graaff accelerator.

The Department continued its unsuccessful efforts to bring an outstanding experimental condensed-matter physicist to the Department. It made an attractive offer to Allen Goldman at Minnesota, who turned down the offer, deciding to stay at Minnesota.

In 1980-81 the academic reorganization on the New Brunswick campus resulted in the establishment of the Faculty of Arts and Sciences with single academic departments, which served the students in the undergraduate liberal arts colleges, (Rutgers, Douglass, Livingston, and University College). Since the Physics Department was already a "singleton" department, teaching all the courses in physics and astronomy in New Brunswick, the Department faced a relatively minor adjustment. After the reorganization, the Chairman of the Physics Department reported to the Dean of the Faculty of Arts and Sciences rather than to the Dean of Rutgers College.

Total research grants in the Department had risen to the level of more than $2 million per year. The NSF provided major grants for a new helium liquefier and recovery system, and provided support to Daniel Murnick for laser experiments in nuclear and solid state physics. Murnick later became Chairman of the Physics Department in the College of Arts and Sciences at Rutgers-Newark. The large particle detectors, designed and built by Felix Sannes and his collaborators, were used at the electron storage ring accelerator in the discovery of the "bottom quark" at Cornell,

a major research accomplishment. Ted Kruse and Gergory Herzog of the Chemistry Department developed a method of detecting minute quantities of $^{10}$Be in meteorites, using the tandem accelerator as an ultra-fine mass spectrometer. This technique was used to obtain information about cosmic-ray interactions during the previous 10 million years. The Department acquired a 12-inch telescope for use in the undergraduate astronomy courses.

In June 1981, the Department formalized a proposal for a new physics building. The building proposal documented the need for 50,000 sq ft of new space for offices, instructional laboratories, research laboratories, and general support facilities. Prior to 1963 the Department was housed in Van Dyck Hall. In that year faculty, graduate students, and research moved to the Serin Laboratory and Nuclear Physics Laboratory on the Busch Campus. The instructional laboratories remained in Van Dyck Hall until 1970 when they moved temporarily to the former military structures (Physics Annex) on the Busch Campus. At that time, another major building of physics was high on the priority list for a forthcoming bond issue. Unfortunately the new building did not materialize for many years to come.

In April 1982, the Department had its second external review. The external review committee consisted of James Langer (UC, Santa Barbara), James Peebles (Princeton), John Schiffer (Argonne), and Frank Sciulli (Columbia). The committee found that the Rutgers Physics Department ranked between 15th and 25th nationally, and between 6th and 10th among state universities. The committee indicated that the overall program was well balanced, with most of the important areas of physics research being represented. They reported that some of the programs were visible nationally and that a few of the scientists were the top leaders in their fields.

The committee stated that the nuclear physics group at the tandem had made a number of important contributions to the progress of nuclear physics, but that the scientific focus of the field was shifting to physics for which other accelerators were more suitable. While the Rutgers group was seeking to make use of the tandem accelerator to explore other scientific areas, it appeared possible that the NSF might not be able to continue to support the tandem facilities at Rutgers.

The committee urged the continuation of efforts to strengthen the programs in experimental materials science and condensed-matter physics. It also commended the efforts to build a program in astronomy/astrophysics, urged the appointment of an experimental astrophysicist, and noted the lack of a highly visible leader at Rutgers in that field. The report specifically addressed the serious space problem.

Following the external review, the University Committee on Standards and Priorities in Academic Development evaluated the Department. The CSPAD committee gave the Department a ranking of 1a, its highest rating. While noting a CBARC study which rated the faculty quality at 55, or one-half standard deviation above the mean, the CSPAD committee supported the external review committee's report which found the Physics Department to have a large strong faculty with a few top leaders in their field. It recommended sympathetic support for the program, pointing out that given the high quality of the program and the mode of research in physics, the high level of faculty resources appeared justified. It recommended improvement of the physical facilities.

There follows here a brief outline of Departmental research in 1981. In astrophysics, Cheng studied the Jovian magnetosphere, Matilsky used the International Ultraviolet Explorer satellite to obtain information about the cores of metal-poor globular cluster, and Williams investigated the structure and dynamics of elliptical galaxies.

In condensed matter theory, Abrahams studied electrical conductance of a disordered electronic system as a function of size, Horton calculated the two-photon Raman scattering of light from solid Argon, and Langreth explored the ground-state properties and excitations of many-body systems. Leath studied the critical phenomena associated with the percolation threshold, Sak worked on the behavior of the critical point in various systems, and Stephen investigated the behavior of disordered magnetic or disordered conducting systems.

In elementary-particle theory, Bonzan studied the properties of the Abelian gauge field theory, Lovelace investigated the large N limit of SU(N) lattice gauge theories, Shapiro looked at QCD as a special case of a class of non-Abelian gauge theories, and Farrar examined the extent to which data from pp experiments could be used to test QCD.

In condensed matter experiment, Carr investigated liquid-vapor critical phenomena with NMR experiments, Croft characterized the fun-

damental modifications which occur as a Ce compound crosses from a "γ like" phase to an "α like" phase, and Glaberson investigated the dynamics of an array of vortex lines in rotating superfluid helium. Kojima determined that the function $\psi(\vec{r},t)$, which describes superfluid $^3$He, vanishes at the wall of the container, and Pifer used electron resonance experiments to find that as silicon is compressed the donor electrons overlap, and the silicon changes from a semi-conductor to a metal. Lindenfeld and McLean studied the properties of granular metals, finding that superconductivity may be possible in a system that in the normal state would be an insulator rather than a metal at absolute zero. Johnson discovered that molecular reaction rates can be distorted by turbulence, and that detonation waves can generate turbulent bursts.

In experimental high-energy physics, Devlin measured the polarization and magnetic moments of hyperons at Fermilab, Kalelkar and Plano examined multiparticle production reactions in bubble chamber experiments at Fermilab, and Potter measured the lifetimes and branching ratios for the weak decays of many hadrons. Sannes studied the properties of the B-meson at the Cornell Electron-Positron Storage Ring, Thomson continued his investigations of CP violation in very rare decays of the $K^o$ meson, and Watts studied jets formed in hadron collisions.

In experimental atomic and nuclear physics, Glashausser carried out experiments with the inelastic scattering of protons at the Los Alamos Meson Physics Facility (LAMPF) to try to determine whether nuclei are close to the density necessary for pion condensation. Koller used Mössbauer and conversion electron spectroscopies to obtain a microscopic description of the contributions to the hyperfine magnetic fields at nuclei embedded in or traversing magnetic materials. Kruse used the tandem accelerator to detect trace amounts of cosmic-ray produced radioactive beryllium from meteorites, and Murnick used dye and gas lasers for nuclear polarization spectroscopy of short-lived nuclear levels. Robbins examined a reported violation of time reversal invariance in a nuclear reaction at the tandem accelerator, and Temmer made measurements of lifetimes of highly excited nuclear states by determining the recoil distance at known velocity inside a crystal.

In theoretical nuclear physics, Harrington worked on the theory used to extract information about the wave functions of excited states of nuclei obtained from inelastic proton-nucleus scattering experiments at

energies near 1 GeV, and Kloet worked on the scattering dynamics of two protons at medium energies (500-1200 MeV). Mekjian studied the collision between two heavy ions of high energies, producing such phenomena as quark matter and pion condensation. Rockmore studied the pion nucleon interaction, and Zamick investigated spin mode giant resonances.

By 1983-84 the external research support in the Department had reached the level of $2.75 million per year. Continuing the pattern of an increasing number of faculty members carrying out their research at accelerators at other institutions, Stephen Schnetzer accepted the responsibility for the development of a large experimental facility at the new TRISTAN accelerator in Japan. Richard Plano joined a group developing the EHS detector at the CERN accelerator in Switzerland. Charles Glashausser carried out a nuclear physics program at Los Alamos Meson Physics Facility and at the Saturne II accelerator in France. Herman Carr received recognition when he was invited to write a commentary on the historical and personal circumstances related to the publication of a fundamental paper on nuclear magnetic resonance that he wrote in 1954 with E. M. Purcell. This paper was one of the most widely cited papers in the history of physics.

In July 1984, the University announced a five-year capital plan for FY1986 through FY1992. The plan listed 42 items with a total cost of $311 million. The 14th item on that list was a physics teaching and research building, to be located adjacent to the existing Physics Building. This new building was intended to accommodate the growth of physics research, and to consolidate those activities then located in the antiquated barracks buildings. The building was to have 42,000 net sq ft, with a total project cost of $14 million. The occupancy of the building was scheduled for FY1988. It appeared that the long-delayed needs of the Department for additional building space might finally be addressed. The Department had carefully documented those needs, and received support from the External Review Committee, the CSPAD Committee, the physicist Associate Provost (Leath), and the physicist Executive Vice-President (Pond).

In order to provide desperately needed accommodations for graduate students, a temporary office building was set up adjacent to the Serin Physics Laboratory in 1984. The building contained graduate student offices, a conference room, and a computer and terminal room.

This temporary building would remain a part of the Department's facilities for nearly fifteen years.

In 1985 a collaboration in surface physics was begun between physicists at Rutgers and physicists at Bell Communications Research (Bellcore), led by T. Venkatesan. Bellcore set up, on the first floor of the Serin Physics Laboratory, a laboratory that could well have been the finest university-based facility for surface physics in the United States. In excess of $2.5 million of Bellcore equipment was installed in the new laboratory. The equipment included a 1.7 MV ion accelerator for Rutherford back-scattering analysis (RBS), channeling analysis, particle induced x-ray emission (PIXE), and high-energy ion implantation.

In 1985 the University set about preparing master plans for each of its units and for the University as a whole. The Department of Physics and Astronomy prepared its master plan. In that plan the Department focused again on its efforts to build a research program in astronomy/astrophysics. It stated that in the following five years the Department would continue its efforts to strengthen its experimental program in condensed-matter physics, and would add a faculty member in surface physics. It would seek to strengthen intermediate-energy nuclear physics and nuclear physics at the tandem accelerator, and it would strengthen the experimental and theoretical elementary-particle physics research programs.

It was usual for members of the Department to be active on various national physics committees. Glennys Farrar was on the High Energy Advisory Committee of the Brookhaven National Laboratory, and Larry Zamick was on the Program Advisory Committee of the LAMPF. Georges Temmer was Editor of the *Chinese Physics Journal*, and Noémie Koller was Associate Editor of the *Hyperfine Interactions Journal*. Koller was on the Nuclear Physics Panel of the National Academy of Sciences and on the Executive Committee of the American Physical Society. Charles Glashausser was Chairman of the Board of Directors of the LAMPF Users Group and was Chairman of the Gordon Research Conference on Nuclear Structure. Thomas Devlin was on the Physics Advisory Committee at FNAL, and Theodore Williams was on the Advisory Committee at the Kitt Peak National Observatory.

There were a number of efforts to address the needs of the instructional program. In 1985-86 George Horton received a $179,000 grant from the New Jersey Department of Higher Education to set up a

Physics Learning Center. The Center provided an open laboratory for physics students, a series of videotapes with problem solutions, and teaching assistants who were on duty to assist the students. It provided valuable assistance to students taking physics courses.

**Figure 45 George Horton, Allen Robbins, Brian Holton, and Noémie Koller at Physics Learning Center**

Horton, and Brian Holton, who was hired as Director of the PLC, made an important contribution to the Department's instructional program. As an indication of the national reputation of this program, Holton was elected national president of the Physics Instruction Association. In 1987-88 the PLC was evaluated by an outside consultant and by the Department Undergraduate Studies Committee. The evaluations were positive and the Department voted to continue the PLC. In 1988 the Department changed the instruction in the large introductory course for engineers from the traditional lecture/recitation mode to a lecture with required PLC activities, which included a quiz, a one-half hour minilab, and tutorial instruction in groups of fifteen students. In 1990 the Department cooperated with the Faculty of Arts and Sciences in expanding the PLC into an interdisciplinary Math and Science Learning Center, with a Busch Campus

Center located in the Physics Annex and a Douglass Center located in the Douglass Chemistry Building. Holton was named Director of the MSLC.

Mark Croft provided a valuable service to the University and community by arranging telescope viewings of Halley's comet. These viewings drew about 500 people. Through the years, Croft frequently offered other telescope viewings of interest to the community. At times, David Maiullo, a member of the instructional staff, offered public demonstrations of various lecture demonstrations, and George Horton arranged for instructional seminars in physics, which have continued to this day, and have provided valuable information for the faculty about developments in teaching methods.

For several years the Department worked with the Rutgers Foundation to raise funds to enable the Rutgers astronomy/astrophysics group to join a consortium to construct and operate a 3.5-meter telescope with remote control and data collection facilities at Rutgers. Although this effort was not successful, the Department continued to explore the possibility of joining other telescope consortia in the years to come. It would be nearly fifteen years before the Department would be able to secure funding to enable the astronomy/astrophysics group to join a telescope consortium.

In April 1987, the Department had its next external review by a committee consisting of Curtis Callan (Princeton), Robert Dynes (AT&T Bell Laboratories), Stanley Hanna (Stanford), and Robert Kraft (Santa Cruz).

Although the Committee did not give an overall ranking for the Physics Department, its report indicated that the Department had become stronger since the previous review in 1982. It specifically indicated that the elementary particle theory group had improved significantly in the previous five years, giving it a ranking somewhere in the teens. It reported a substantial improvement in the health and productivity of the experimental condensed-matter group, and it noted that the theoretical condensed-matter group included individuals who were in a league with the very best in the world.

The Committee strongly supported the particle theory initiative that the Department was then proposing. It suggested that one of the few ways in which the Department could make a major leap forward was by hiring a “package” of stars. This approach would enable the Department to attract

faculty members that it could not attract by incremental hiring. The general impression of the experimental elementary-particle group was positive. The committee argued that no major university could afford to be without an astronomy program, that the Physics Department was an appropriate home for that program, and that additional faculty and equipment resources were required for a viable program.

The Committee addressed the experimental nuclear physics program at the tandem accelerator in some detail. It pointed out that during the 1960's and 1970's that program was among the most active and well known in the country, and that the work of that group had made an important contribution to the increased stature of the Department as a whole. However, with two of the experimental physics faculty members already pursuing research programs at other facilities, it seemed likely that the tandem would no longer receive adequate federal funding, and the Committee recommended that the Department should move in an orderly manner to close the nuclear physics program at the tandem.

In an effort to provide new leadership for the tandem Van de Graaff accelerator project, the Department had named Noémie Koller director of the Nuclear Physics Laboratory in 1985. Georges Temmer was named University Professor after having served as Director of the Nuclear Physics Laboratory since his appointment in 1963. The recommendation of the External Review Committee to close the tandem accelerator appeared to be a reasonable one. With Charles Glashausser and the newer appointments in nuclear physics (Ronald Ransome and Ronald Gilman) focusing their research at accelerators at other institutions, it was no longer realistic to maintain a vigorous nuclear physics research program at the Rutgers tandem.

An unsuccessful proposal was made to the NSF to utilize the accelerator as the National Ocean Sciences Accelerator Mass Spectrometer Facility. The tandem was finally closed down in April 1989 after twenty-five years of productive research in nuclear physics. The accelerator was sold to the Nuclear Science and Technology Laboratory in Australia for use as an accelerator mass-spectrometer facility. The Nuclear Physics Laboratory Building subsequently provided housing for the Laboratory for Surface Modification as well as for the nuclear physics researchers.

The major expansion of the Physics Department between 1986 and 1993 was a direct result of the special excellence fund established by

Governor Keane. This fund, which totaled about $25 million, provided money to spend in areas in which the University had an opportunity to attain world-class status. It was used to hire a number of outstanding scholars, and did, in fact, make a major impact in a number of areas. The Physics Department was fortunate to be able to take advantage of this unique opportunity. This opportunity resulted from a Governor with a vision for the development of technology in the state, and a number of leaders at the University who were aggressive in implementing that vision at the University. These leaders included University President Edward Bloustein, Executive Vice-President Alexander Pond, Vice-President for Research Felix Browder, and Provost Paul Leath.

As a result of the heightened level of State support for science and technology, the University recruited faculty members actively in several disciplines, hiring a number of outstanding junior and senior faculty members. The Physics Department moved aggressively to take advantage of the rather unique opportunity with a number of hiring initiatives. The largest of these initiatives was the elementary-particle theory, or "string-theory", initiative. There was a major condensed-matter theory initiative as well, and a significant development of the program in surface physics. There were also enhancements of the programs in astrophysics, experimental nuclear physics, elementary-particle physics, and condensed-matter physics.

While the size of the Physics Department had remained approximately constant between 1971 and 1986, these initiatives resulted in a dramatic increase in the size of the physics faculty between 1986 and 1993. During this period the number of full-time physics faculty members increased by roughly 50% from approximately 40 to about 60. During this period the Department hired twenty-three new faculty members. Nine of these appointments were at the assistant professor level, and fourteen were tenured appointments at the associate professor or professor level. Six of the new faculty members were in elementary-particle (string) theory, five in condensed-matter theory, four in surface physics, three in astronomy/ astrophysics, two in nuclear physics experiment, two in elementary-particle experiment, and one in condensed matter experiment.

Also during this period, Alec Pond came to the Department in 1991, after nine years as Executive Vice President and Chief Academic

Officer, and Paul Leath returned to full-time service in the Department in 1992 after fourteen years of service as Associate Provost and Provost.

During this period, seven faculty members left the Department. Herman Carr retired in 1987 after 35 years in the Department, Richard Weidner retired in 1988 after 41 years, and Georges Temmer retired in 1990 after 28 years of service. In addition, William Glaberson left for a permanent position at Hebrew University in Israel in 1988 after 21 years in the Department, and Robert Schommer left for a position at the Cerro Tollo Observatory in Chile in 1990 after nine years in the Department. The Department was saddened by the tragic death of two of its faculty members. William McLean passed away in 1990 at the age of 57, after twenty-nine years of service in the Department, and Felix Sannes retired in poor health in 1992 after twenty-two years of service. He passed away two years later at the age of 53.

The first major development in this period of expansion (1986-93) was the hiring of a number of faculty members in surface science to build the Rutgers Laboratory for Surface Modification. T. Venkatesan of Bell-core had started this effort in 1985. David Langreth of the Physics Department had worked in the area of surface physics for a number of years and supported the development of this Rutgers program. This center became one of the state-supported centers of science and technology, and was a member of a New Jersey research consortium organized under the aegis of Sematech.

The first faculty member to be hired in the Department in Surface Science was Robert Bartynski, who was appointed Assistant Professor in 1986, following the completion of his Ph.D. degree at the University of Pennsylvania. In 1987 Torgny Gustafsson, also from the University of Pennsylvania, was appointed Professor. His appointment was featured in a *Time* magazine article on corporate raiding.[2] The effort of Rutgers to build its Physics Department received considerable publicity, mostly positive, but some skeptical.

In 1988 Theodore Madey joined the Physics Department as State of New Jersey Professor of Surface Science and Director of the Laboratory for Surface Modification. He replaced Venkatesan, who had served as Acting Director of the Laboratory since 1985. Madey came to the

[2]*Physics Today*, June 1989, p. 63.

Department from the National Institute of Science and Technology (NIST) (formerly the Bureau of Standards) where he had been Deputy Chief of the Surface Science Division. He had received his Ph.D. from Notre Dame in 1963, and had held a number of positions at NIST before coming to Rutgers.

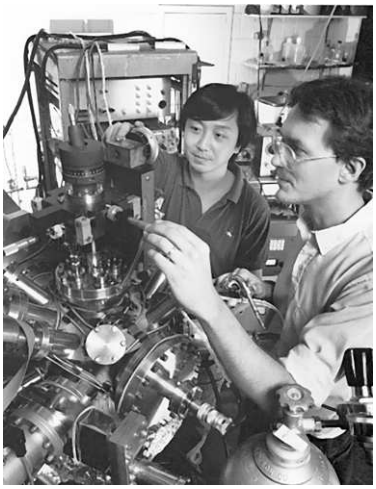

**Figure 46 Robert Bartynski and Student in Surface Science Laboratory**

At Rutgers, Madey continued the development of the inter-disciplinary program in surface science that became recognized as one of the best in the country. Madey's appointment was featured in a *Physics Today* article describing central Jersey's strengthening of its position as a pole of U.S. physics.[3] Following Madey's appointment, David Vanderbilt, a theorist, joined the surface physics group in 1990. Vanderbilt had received his Ph.D. degree from MIT in 1981, was a Sloan Fellow, and was Associate Professor of physics at Harvard when he came to Rutgers.

The largest of the initiatives in the Physics Department in this period was the program in high-energy theoretical physics. The initiative began with an offer to Leo Kadanoff, an outstanding senior physicist from the University of Chicago. He was given an opportunity to bring other physicists, and to put together an attractive program at Rutgers. After

[3]*Physics Today*, June 1989, p. 62.

consideration, Kadanoff decided to stay at Chicago. At that point the Department developed the idea that it might be possible to attract a "package" of outstanding young people who could not be enticed to come to Rutgers individually. The University's fund to attract world-class scholars made such a bold proposal possible. This approach was successful in bringing to Rutgers packages of outstanding physicists in elementary-particle theory and in condensed-matter theory.

The elementary-particle theory package was put together by Daniel Friedan, also from the University of Chicago. Friedan had received his Ph.D. degree from Berkeley in 1980 and became Professor of Physics at Chicago in 1987. Joining the initial group were Thomas Banks, Nathan Seiberg, and Steven Shenker. Banks received his Ph.D. degree from MIT in 1973, and spent thirteen years at Tel-Aviv University and three years at University of California, Santa Cruz, before coming to Rutgers. Seiberg received his Ph.D. degree from the Weizmann Institute in 1982, and spent seven years at the Weizmann Institute and the Institute for Advanced Study before coming to Rutgers. Shenker received his Ph.D. degree from Cornell in 1980 and had become Professor of Physics at Chicago in 1987. Friedan and Shenker had received the prestigious MacArthur and Sloan Foundation awards.

Because all four of these physicists had made contributions to the development of string theory, they became known as the string theory group or the "string quartet." Friedan, Shenker and Martinec had solved the long-standing problem of the fermion vertex operator, Banks and Peskin had made an important contribution to string field theory, and Seiberg and Moore had advanced the understanding of rational conformal field theory. In the theory of superstrings, the fundamental building blocks of nature are strings rather than point particles. It is an elegant theory that seems likely to include gravity in a singly unified theory of nature. Sheldon Glashow, who had been critical of superstring theory, was reported to have said, "it was strange that half the world's theoretical physicists–*and the better half at that*–were doing string theory.[4] The Department brought these four string theorists to Rutgers in 1989 because they were working in one of the hottest fields of physics, but also because they were very bright physicists who could work in other fields as well.

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[4]*Physics Today*, June 1989, p. 63..

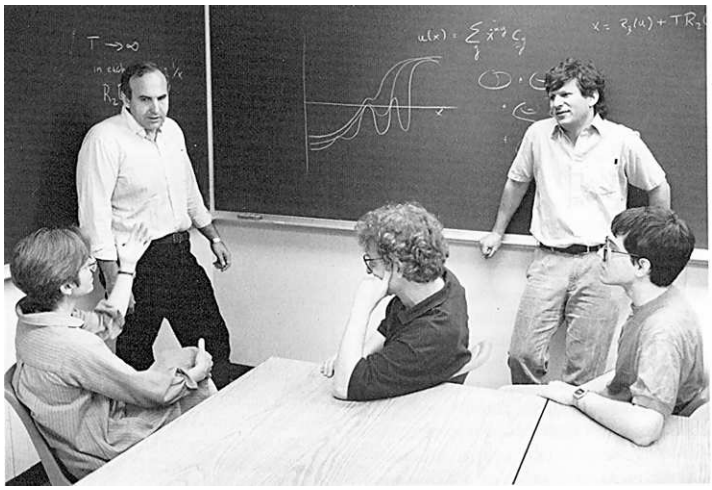

**Figure 47 Glennys Farrar, Tom Banks, Dan Friedan, Steve Shenker, and Student Discussing String Theory**

Following the appointment of the first four string theorists in 1989, there were two more appointments in 1990: Alexander Zamolodchikov, one of the world's most distinguished mathematical physicists from the Landau Institute for Physics in Moscow; and Michael Douglas, who had received his Ph.D. degree from Cal Tech in 1988.

The string theory initiative also received publicity, mostly favorable. A *Physics Today* article described Rutgers efforts to build its programs in particle theory, surface science and computation.[5] The article reported that during the previous two years, Rutgers had taken everybody by surprise by enormously strengthening its physics department and related programs. It predicted that Rutgers would soon rank among the world's most prestigious universities in physics and mathematics. A somewhat more critical article appeared in *Newsweek*, entitled "Lets Buy a Physicist or Two."[6] This article suggested that when Rutgers wanted to build up its physics department, it went out and "bought" one, much like the New York Yankees baseball team might go out to purchase an outfield. As might be expected, the *Rutgers Magazine* published an

[5]*Physics Today*, June 1989, p.62.
[6]*Newsweek*, February 12, 1990, p. 60.

extensive and favorable review of the string theory initiative, entitled "The Smallest Frontier."[7] The article reported that Rutgers had become one of the two or three top centers in the world for superstrings.

As part of the effort to recruit the string theory group, Rutgers offered attractive salaries, a research support budget, reduced teaching loads, and a separate theoretical physics center for the group. In addition to agreeing to hire the initial six faculty members, the University agreed that three additional faculty lines could be used either for permanent faculty members or for visitors. The University also agreed to provide support for postdoctoral fellows and for administrative staff. Initially the group was housed in the temporary office building adjacent to the Serin Physics Laboratory.

When the new physics building was finished, the entire third floor of the original Serin Physics Laboratory was completely rebuilt for the string theory group. The group was able to move into attractive facilities which included large offices, general meeting rooms, and computer rooms. The special treatment of the string theory group was a source of some notice both within the Department and outside. Although there was minor resentment of the special treatment, the group was generally well accepted by the Department, which respected the addition being made to the Department. The undesirable effects of such a large recruiting effort were even mentioned in a letter of recommendation by an outside referee, who insisted that his criticism be brought to the attention of the Board of Governors. It is reported that in later years he changed his mind about this criticism.

Although on a more modest scale, the same philosophy of attracting several people together was used in putting together an outstanding package of young condensed-matter theorists. These theorists were working on the modern many-body problem, which dealt with electronic systems characterized by strong correlations.

Piers Coleman joined the Department in 1987, Gabriel Kotliar and Andrei Ruckenstein in 1988, and Lev Ioffe in 1990. Coleman received his Ph.D. degree from Princeton in 1984, and spent two years at the Institute for Theoretical Physics at Santa Barbara before coming to Rutgers. Kotliar received his Ph.D. degree from Princeton in 1983, and spent two

[7] *Rutgers Magazine*, Fall 1991, p. 16.

years at Santa Barbara and three years on the faculty at MIT before coming to Rutgers. Ruckenstein received his Ph.D. degree from Cornell in 1984, and then spent a year at AT&T Bell Laboratories and three years as a faculty member at the University of California, San Diego, before coming to Rutgers. Ioffe received his Ph.D. degree from the Landau Institute for Theoretical Physics in Moscow in 1985, and spent four years at the Landau Institute and one year at Illinois before coming to Rutgers.

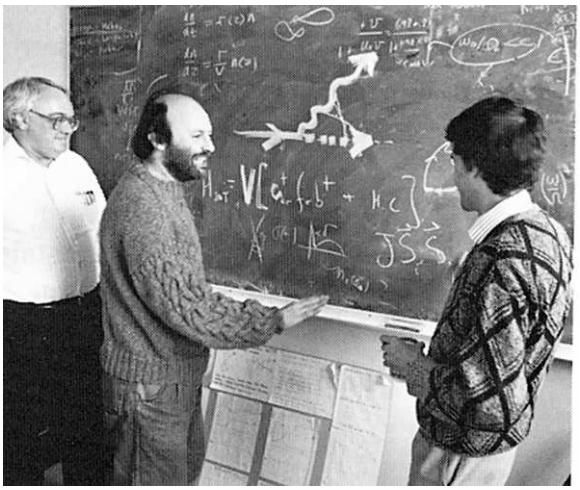

**Figure 48 David Langreth, Gabriel Kotliar, and Piers Coleman Discussing Problem in Condensed Matter Theory**

The addition of these four young condensed matter theorists had an enormous impact on the reputation of theoretical condensed-matter physics at Rutgers. Such a major addition to an area that was already strong could not have been envisioned before the advent of the excellence movement at Rutgers.

Although not a part of this original condensed matter initiative, another significant condensed-matter theory appointment was made with the hiring of Shirley Jackson in 1991. Jackson received her Ph.D. degree in elementary particle theory from MIT in 1973. As a black woman she was truly a pioneer in physics. After receiving her Ph.D., Jackson spent time at the Fermi National Accelerator Laboratory, the European Organization for Nuclear Research, and AT&T Bell Laboratories. She worked in a number of different areas of theoretical physics and served on

a number of Boards of Trustees. After fifteen years as a term member, she was elected a life member of the MIT Board of Trustees.

At Rutgers Jackson became a member of the Board of Trustees in 1986 and the Board of Governors in 1990, serving on those Boards until she joined the faculty in 1991. She received a number of awards in recognition of her service. After a few years of teaching and research at Rutgers, she was appointed by President Clinton to head the Nuclear Regulatory Commission, the first woman and the first African-American to chair the U.S. Nuclear Regulatory Commission. She served with distinction in that position for several years. In 1999 she became President of Rensselaer Polytechnic Institute, the first African-American to head a major research university.[8]

While taking advantage of the opportunities to add World Class Scholars to the faculty in the period 1986-93, the Department also moved ahead with its objective to strengthen its program in astronomy/ astrophysics. Three faculty members were added in that area: Carlton Pryor and David Merritt in 1988, and Jerry Sellwood in 1991. Pryor received his Ph.D. degree from Harvard in 1982 and came to Rutgers after service at Michigan, Victoria, and Vanderbilt. Merritt, a theoretician, received his Ph.D. degree from Princeton in 1982, and came to Rutgers after service at Berkeley and at the Canadian Institute for Theoretical Astrophysics (Toronto). Sellwood received his Ph.D. degree from Manchester (England), in 1977 and came to Rutgers after extensive service at the Stockholm Observatory, the European Southern Observatory, the Institute of Astronomy (Cambridge, England), Groningen, and the Space Telescope Science Institute (Baltimore). The appointment of Sellwood brought the total number of astronomer/astrophysicists in the Department to six (Matilsky, Merritt, Pryor, Sellwood, Williams, Zapolsky).

In addition to the appointments in surface physics, string theory, condensed-matter theory, and astronomy/astrophysics in the period 1986-93, there were also five other appointments in experimental physics. In condensed-matter physics, Eva Andrei was appointed in 1986. She had received her Ph.D. degree from Rutgers in 1981 and spent time at AT&T Bell Laboratories and Saclay (France). In nuclear physics, Jolie Cizewski was appointed in 1986 and Ronald Gilman in 1989. Cizewski received her

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[8] *Rutgers Magazine*, Fall 2000, p.31.

Ph.D. degree from SUNY Stony Brook in 1978, spent two years at Los Alamos and six years on the faculty at Yale before coming to Rutgers. Gilman received his Ph.D. degree from Pennsylvania in 1985 and spent seven years at Argonne National Laboratory before coming to Rutgers. Finally, in elementary-particle physics John Conway and Sunil Somalwar joined the faculty in the spring of 1993. Conway had received his Ph.D. degree from Chicago in 1987 and spent five years as a research associate at Wisconsin. Somalwar received his Ph.D. degree from Chicago in 1988 and spent four years as a research associate at Chicago.

These new faculty appointments "made the headlines" in a somewhat different way. *Physics Today* reported in 1994 that the Physics Department at Rutgers had the largest number of women (5) on its tenure-track faculty of any physics department in the country.[9] These women were Eva Andrei, Jolie Cizewski, Glennys Ferrar, Shirley Jackson, and Noémie Koller.

The construction of the new physics building became a part of the new five-year Capital Plan for the University, FY1990 through FY1996. The capital construction was to be carried out under the Fund for Distinction Program. In that Program, the highest priority was to be given to the improvement of physical facilities for those academic programs which had already attained national distinction or which had the potential to do so with enhanced facilities. The new physics building was project No. 11 in that plan, and provided for 62,140 net sq. ft. of new space for physics.

In December 1986, the Board of Governors approved the concept document for a new physics building, which would meet approximately half of the needs of the Department for additional space. The total project budget was $14,062,000 and the construction budget was $11,762,000. The firm of Hellmuth, Obata & Kassabaum was selected as the architect to begin the design of the building, which was to be located adjacent to the Serin Physics Laboratory. The design was begun in October 1987 and completed in June 1988. The construction contract was awarded to Epic Construction Co. in August 1988. Construction began by the summer of 1989, and the building was ready for occupancy by the summer of 1990. In May 1990, the Department moved into the new building, and the

[9] *Physics Today*, September 1994, p. 86.

University began renovating the second and third floors of the old physics building for the condensed-matter theory and string-theory groups. At the same time, the introductory and advanced instructional laboratories moved from their temporary accommodation in the Physics Annex to the new physics building. By January 1992 the renovations on the old physics building were completed and the theory groups were able to move into the refurbished space.

**Figure 49 New Physics Building (Serin West)**

Members of the Department continued to receive recognition. The most significant recognition of a member of the Department came in 1986-87 when Elihu Abrahams was elected to the National Academy of Sciences for his work in condensed matter theory. He and Joel Lebowitz, who held a joint appointment in the Departments of Mathematics and Physics, were the only members of the Department to be so honored. Heinrich Rohrer, a former postdoctoral fellow with Peter Lindenfeld in the Department's low-temperature physics group, received the Nobel Prize in physics for his work in developing the scanning tunneling microscope, and returned to Rutgers to receive an honorary degree. William Glaberson

went to the NSF to serve as Program Officer in low-temperature physics, and Richard Plano served for two years with the DOE in the Division of High Energy Physics. George Horton received the Rutgers Presidential Award for outstanding public service for his work in starting the Rutgers Community Health Plan. In 1988 Peter Lindenfeld received the Warren I. Sussman Award for Excellence in Teaching, and a year later he received the Robert Millikan Medal from the American Association of Physics Teachers for notable and creative contributions to the teaching of Physics. In 1989 George Horton received the Warren I. Sussman Award for outstanding teaching, bringing continuing recognition to the Department for its excellent teaching.

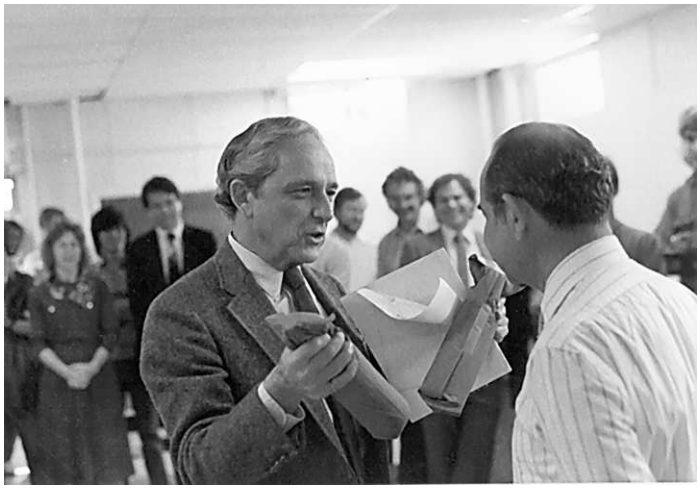

**Figure 50 President Bloustein Congratulating Peter Lindenfeld on the Award of the Robert Millikan Medal**

There were a number of other significant awards to the physics faculty. In 1991 Eva Andrei received the Prize of Physics, awarded by the French Commission of Atomic Energy for her work on the Wigner Crystal, and Jolie Cizewski received the NSF Award for Women in Science and Engineering. In 1992 Theodore Madey was elected President of the International Union of Vacuum Science, Technique and Applications. Joe Pifer received the 1992 FAS Award for Distinguished Contributions to Undergraduate Education. It was notable, as well, that one of the new string theorists, Stephen Shenker, received the Undergraduate Teaching Award from the Rutgers Society of Physics

Students. Joel Lebowitz received the Boltzman Medal in 1992 for his outstanding contributions to statistical physics, and the Planck Research Award. Thomas Devlin received the Panofsky Prize from the American Physical Society for his strange-baryon experiments at Fermilab. In 1993 Shirley Jackson received the Governor's Thomas Alva Edison Award, and the Henry Hill Achievement award of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers. David Vanderbilt received the NSF Creativity Award for his research program. Among the younger faculty members, Michael Douglas and Piers Coleman both received Sloan Foundation Fellowships and NSF Presidential Young Investigator Awards, and Sunil Somalwar received the NSF Presidential Young Investigator Award.

There were other evidences of the attention given by the Department to its instructional programs. In 1986-87 Joe Pifer, the undergraduate coordinator, received an NSF grant for a summer research program for undergraduate physics majors from northeastern universities and colleges, and in 1992-93 he placed first in the annual national apparatus competition of the American Association of Physics Teachers. Also, Peter Lindenfeld and George Pallrand from the Graduate School of Education organized, for several years, four-week summer institutes for New Jersey high-school physics teachers.

In 1987 George Horton organized the Gateway Program for under-prepared students planning to take the introductory physics course for engineers. It consisted of problem solving and minilab sessions. Initially a one-semester course, it was eventually extended to two semesters. In 1993 Suzanne Brahmia joined the Department as Director of the Gateway Program and its Extended Analytical Physics course. In 1993 George Horton and Brian Holton received $600,000 in grants from NSF, FIPSE, and GE to establish sections of the Extended General Physics course on the Douglass Campus. In 1994 the Gateway Program on the Busch Campus was moved from the MSLC to the Serin Laboratory with equipment purchased with money from the Equipment Leasing Fund. The Gateway and extended introductory physics courses were extremely successful in improving the rate of successful completion of the physics courses by poorly prepared students, as well as by women and minorities.

In an effort to further develop its laboratory instruction, Michael Molnar was hired in 1990 as Laboratory Manager, with responsibility for

running and upgrading the instructional laboratories. Molnar was trained as an astronomer and had extensive collegiate teaching experience. In an effort to provide a physics major program better designed for students seeking industrial jobs, an applied physics option was introduced in 1990 to supplement the general and professional options available to physics majors. In 1992 the Department hosted a conference on Teaching Introductory Physics and Chemistry, sponsored by the New Jersey Institute for College Teaching and Learning. Some 130 New Jersey college teachers attended the conference. In 1993 Joe Pifer, Gregory Herzog (Chemistry), and Emmet Dennis (Biological Sciences) received an NSF grant to develop a new interdisciplinary course, The Greenhouse Effect, for first-year liberal arts majors. As a service to the national physics community Peter Lindenfeld edited an educational newsletter for the College-High School Interaction Committee of the APS and AAPT.

**Figure 51 Students in Physics Learning Center**

As an indication of the rising stature of the Graduate Program, the average graduate record examination advance physics test score for incoming graduate students rose from 47% in 1983 to 72% in 1987. The number of applicants more than doubled in that period, although much of the increase was a result of a substantial increase in the number of foreign applications. These increases in the quality and quantity of graduate applications were a reflection of intensive recruiting efforts and of the

spreading reputation of the Department worldwide. In 1990, in recognition of the enhanced role of astronomy in the Department, the Graduate Program in Physics was changed to the Graduate Program in Physics and Astronomy. The Department added new graduate courses in astronomy, and an astronomy option was made available to physics graduate students, with slightly different course requirements designed to speed the preparation of students for research in astronomy.

In response to a somewhat pervasive discontent among physics graduate students at Rutgers, the Ad-Hoc Committee on Graduate Student Life was appointed in spring 1992, charged to look into the concerns of the graduate students and make recommendations to the faculty for rapid improvement. In the spring of 1993 the committee made several recommendations relating to concerns about graduate student life, the graduate program, graduate student job assignments, and about the possibility of providing more information about job opportunities. The Department moved quickly to respond to most of those concerns.

There was a special honor for the Rutgers Graduate Program when Karl Gebhardt received the 1995 Northeastern Association of Graduate Schools Dissertation Award for his thesis, “Dynamics of Globular Clusters.”

There were a number of significant research accomplishments. In 1987-88 Devlin and Watts completed work on their part of the $50 million detector for Fermilab, designed to detect the particles resulting from 2-TeV proton-antiproton annihilations. In 1993-94 Devlin, Watts and Conway were part of a 440-person group that announced that it had found evidence for the existence of the top quark, one of the elementary constituents of matter. In 1987-88 Sannes and Schnetzer completed the construction of the electromagnetic shower detector, which was installed at TRISTAN accelerator in Japan. Schommer and Williams completed the design and construction of an imaging Fabry-Perot interferometer, which was installed at the Cerro Tololo Observatory in Chile. In 1990-91 Plano supervised the construction and installation of a complex component of the $65 million SLD detector at SLAC, which subsequently made the most precise measurement of the weak mixing angle, fundamental to the Standard Model. In 1988-89 members of the LSM were successful in securing NSF funding for a Materials Research Group, which would focus on “Oxide Surfaces and Their Interaction with Metal Overlayers.”

In 1992-93 Thomas Banks outlined a new scenario for black hole evaporation, which resolved the long-standing problems of information loss identified by Steven Hawking. Banks' work was reported in a long article in the *New York Times*, and Banks received a Gravity Foundation Award for an essay in the field. In 1993-94 Banks published a paper on the cosmological implications of superstring theories, which appears to provide a unique chance to confront string theory with experiment.

Also in 1993-94, Nathan Seiberg produced exact solutions of the four-dimensional sypersymmetric gauge equations, which describe the elementary forces of nature. This achievement was a major breakthrough, which has revolutionized that branch of mathematics and pointed the most promising way in decades to get a unified theory of elementary forces of nature. This work, which was done in collaboration with Edward Witten at the Institute of Advanced Study, has had an enormous impact on the field and brought great credit to Seiberg and to the Department.

As part of the planning process for the University, each unit was asked to draw up a strategic plan for the unit. In April 1993, the Department of Physics and Astronomy adopted its Strategic Plan. The Department committed itself to honor previous commitments made for three remaining faculty lines for the string theory initiative, for the faculty line that had been committed at the time Professor Madey was hired, and for the faculty line that had been committed to counter an outside offer to Professor Farrar. The New High Energy Theory Group agreed to donate one of their remaining faculty lines, which, together with the line promised to Farrar, would be used to build a strong group in particle phenomenology. It was expected that the remaining two NHET lines would be used for visitors for some time.

Further Departmental goals included continuing the efforts to build an outstanding program of instruction, strengthening the experimental condensed-matter physics program, and continuing the development of the program in astrophysics. The Department planned to hire, in the following decade, five new faculty members in condensed-matter physics and five in astronomy. With the death, departure and retirement of McLean, Glaberson, Carr and Weidner, there remained four experimental condensed-matter physics faculty members (E. Andrei, Croft, Kojima, and Lindenfeld), in addition to the experimental LSM faculty members (Madey, Gustafsson, and Bartynski). There were also six astrophysics

faculty members, three theorists (Merritt, Sellwood, Zapolsky), and three observers (Matilsky, Pryor, Williams).

The Strategic Plan spelled out the needs for additional building space. The Plan pointed out that by the end of the 1990's, the growth of the instructional program would make necessary construction of a new building, devoted entirely to department instructional activity. It was estimated that 42,000 sq ft of space would be needed for the instruction building, with an estimated cost of $6.3 million. The Department emphasized the importance of honoring the commitment to renovate the Nuclear Physics Laboratory for the LSM, with an estimated cost of $1 million. Short-term renovation needs for the Physics Building and Lecture Hall required an estimated $200,000, and long-term reconfiguration of the Serin west wing, after the instruction programs moved into the new building, would cost another $500,000. The total cost of additional space for the Department was estimated to require $8 million.

In November 1994, the Department had its fourth external review, by a committee consisting of Icko Iben (Illinois), Patrick Lee (MIT), John Rowe (AT&T Bell Laboratories), John Schwarz (Cal Tech), and George Walker (Indiana). Their report recognized the significant advancement of the physics program at Rutgers since the previous external review in 1987, and concluded that the University resources had been well spent in the three major areas of expansion, the Laboratory for Surface Modification, the New High Energy Theory Group, and the Condensed Matter Theory Initiative.

In terms of productivity, the External Review Committee concluded that the NHET group ranked second in the world only to the two Princeton groups combined (at Princeton University and the Institute for Advanced Study), that the LSM ranked with the best two or three such centers in the country, and that the CMT group ranked fifth in the country in overall quality and breadth of coverage. The Committee reported that the Department as a whole ranked among the top 10-15 physics departments in the nation. It was particularly noteworthy that the Committee found that faculty morale in the Department was high, and that there was little friction between the newer superstars, with high budgets and low teaching assignments, and the older members of the Department.

The Committee suggested that the graduate student quality in condensed-matter theory lagged behind the programs at such prestigious

places as Princeton and Stanford, whose research programs in some areas were not assessed as highly. They pointed out that a stronger program in experimental condensed-matter physics was essential to maintain the excellence of the strong theory effort. The Committee strongly supported the Department's strategic plan, indicating that it should position the Department among the very best physics departments in the country.

The Department took a number of actions in response to the recommendations of the External Review Committee. In the spring of 1995 the Department hired a surface scientist, Frank Zimmermann, on the line committed to Madey in the LSM, and hired a condensed-matter experimentalist, Michael Gershenson, utilizing funds for the start-up package that became available from a special State program. The Department reaffirmed its priority areas for future hiring (experimental condensed-matter physics and astrophysics), and agreed to make available space for these new faculty members. The Department also agreed to expand course offerings in astrophysics, and to apply for membership in the Association of Universities for Research in Astronomy at the earliest opportunity.

The Department agreed to give higher priority to excellence in teaching in salary increment and promotion actions. In the area of graduate student life, the Department moved to improve the advisement of graduate students, to involve graduate students in decisions about which graduate courses to teach each year, to create a first-year seminar course, to start a daily Department coffee hour, and to explore ways to reduce the teaching loads of the teaching assistants.

In 1995, Allen Robbins ended sixteen years as chairman of the Department. In 1995 there were 63 faculty members in the Department, including Lebowitz and Kupiainen who held joint appointments with the Department of Mathematics, and Gershenson and Zimmermann who were hired in the spring of 1995 and joined the Department in the fall. With the inclusion of Lebowitz, Kupiainen, Gershenson, Zimmerman, and the NHET and LSM faculty members, the breakdown of the faculty members by research area was: astronomy (6), theoretical condensed matter physics (15), experimental condensed matter physics (10), theoretical elementary particle physics (11), experimental elementary particle physics (8), theoretical nuclear physics (5), and experimental nuclear physics (8). With

a small number of exceptions these faculty members were all active in research.

In addition to the faculty members, there were about 100 full-time and several part-time graduate students, 33 postdoctoral research associates, and approximately 40 full-time supporting staff. In the previous five years, the Department had awarded 51 doctoral degrees and 26 masters' degrees in physics.

The Department had acquired substantial, although not yet adequate facilities. The Serin Physics Laboratory provided about 100,000 sq ft of office, laboratory, and classroom space, in addition to the Nuclear Physics Laboratory and Physics Lecture Hall. In-house equipment for the LSM included a 400 keV ion accelerator, a 1.7 Mev tandetron accelerator, and several tunneling microscopes. Low temperature equipment included three mk-range dilution refrigerators and two ten-Tesla superconducting magnets. Whereas, all of the physics research was carried out on the Rutgers campus in 1945, much of the physics research was carried out at other institutions in 1995. Surface physics studies were carried out at the synchrotron radiation facilities at the Brookhaven National Laboratory. Nuclear physics experiments were carried out using accelerators at Argonne and Lawrence Berkeley National Laboratories, Yale University, New Port News (Virginia), Mainz (Germany), and Saclay (France). Elementary-particle physics experiments were carried out at the Fermi National Accelerator Laboratory and at the Stanford Linear Accelerator Center. Astrophysics observers used facilities at Kitt Peak, Cerro-Tololo, Mauna Kea, and the VLA. The mode of physics research had changed significantly in fifty years.

The last of the group of physicists who started this research program at the end of World War II had left the Department some years earlier. A large group of outstanding new physicists were carrying on the tradition that had been started fifty years earlier. There were new areas of research, greater emphasis on undergraduate and graduate teaching programs, and many programs that reached out to the community. The group that came from the MIT Radiation Laboratory would be pleased with what they saw today.