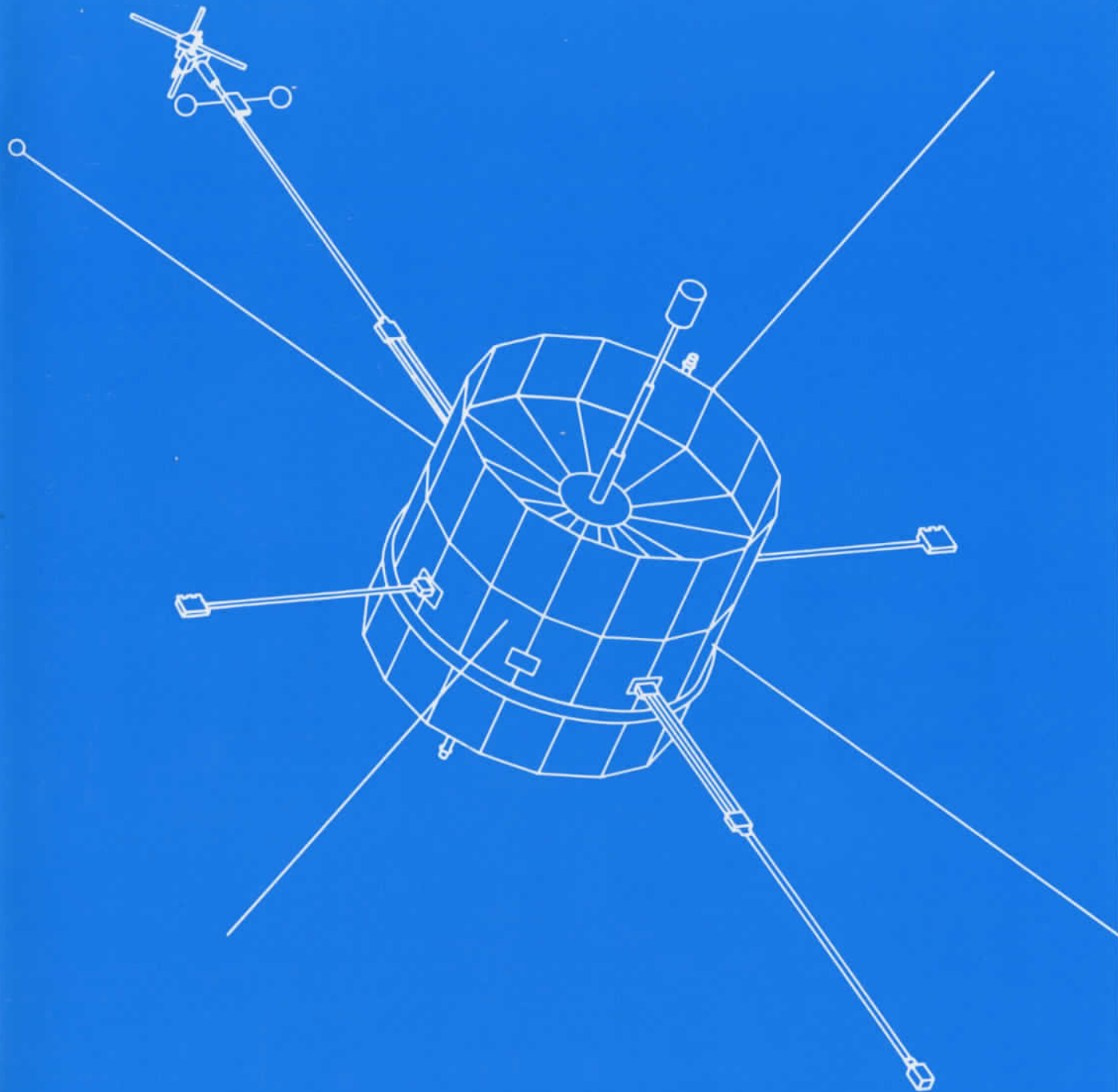


THE UNIVERSITY OF IOWA
Iowa City, Iowa



GRADUATE STUDY IN PHYSICS AND ASTRONOMY

INTRODUCTION

The Department of Physics and Astronomy at The University of Iowa is a major national and international institution devoted to teaching and research. In the spring of 1990, 29 faculty members, 3 adjunct professors, 2 emeritus professors, 16 Ph.D. research scientists, 81 graduate students, and 102 undergraduate majors were active in research, teaching, and study of physics and astronomy.

Over the years, the department has achieved particular distinction in space physics. The experimental study of charged particles and electromagnetic fields in space began here, and remains a vital area at Iowa today. The Department of Physics and Astronomy has two experiments aboard the Galileo spacecraft to Jupiter and will have experiments on other missions planned for the coming decade. The acquisition and interpretation of data from these missions will insure continued prominence for the department.

In addition to continued vitality in its traditional areas of strength—such as space physics, plasma physics, theoretical nuclear physics, and astronomy—the department has recently established vigorous expansion groups in other areas. There are now seven faculty members in experimental and theoretical high energy physics, and departmental researchers participate in experiments at laboratories throughout the world. The department also has established a state-of-the-art laboratory in atomic and molecular physics.

As a result, the department features research in a wide variety of areas in theoretical and experimental physics and astronomy. Van Allen Hall, the department's home, has a number of research laboratories, and faculty members and students also conduct experiments and observations at national and international laboratories and observatories, such as Fermilab and the Very Large Array radio telescope.

This vigorous research environment benefits the department's teaching mission. Graduate students participate in all aspects of research, and the department prides itself on a tradition of including undergraduate students in research programs. It is felt that this research experience, together with sound academic training, has enabled physics and astronomy undergraduate students to go on to graduate study at the most prestigious institutions in the country.

Finally, the department succeeds admirably in attracting external support for its research programs. Departmental faculty and research scientists obtain \$10 million each year from NASA, the National Science Foundation, the Department of Energy, and various private sources. In addition to the other ways in which this aid supports research, it permits support of many graduate students on research assistantships and the hiring of undergraduate students for work on scientific projects.



Dwight R. Nicholson, department chair

DEGREES GRANTED

INTRODUCTION

The University of Iowa offers two advanced degrees in physics: the Master of Science, with thesis or critical essay; and the Doctor of Philosophy, with research dissertation. One advanced degree is offered in astronomy—the Master of Science, with thesis or critical essay. Students who wish to pursue a program in astronomy beyond the Master of Science level may qualify for a Doctor of Philosophy degree in physics with specialization and dissertation in astronomy or astrophysics. An interdepartmental Ph.D. program is offered in applied mathematical science.

Each graduate student has an individual faculty adviser who oversees the student's academic work and thesis or dissertation research. A typical Ph.D. program requires five years of graduate work.

The University also offers Bachelor of Science and Bachelor of Arts degrees in both physics and astronomy. Undergraduate students may pursue double majors in these disciplines, and selected juniors and seniors may receive degrees with honors in recognition of research work they have done with faculty members.



Instruction in the undergraduate physics laboratory

DESCRIPTIONS OF RESEARCH GROUPS

Atomic, Molecular, and Laser Physics

High-vacuum atomic and molecular beam systems are used to study collision dynamics in simple molecular systems. Conventional and laser high-resolution spectroscopic studies that complement these collision dynamics studies are being carried out simultaneously. In several instances, these molecular systems include either actual or potential laser transitions of considerable promise.

Theoretical work in atomic and molecular physics is concerned primarily with determining atomic and molecular interactions, especially potential energy curves of diatomic molecules. Also of interest are radiative transition probabilities and lifetimes, elastic and inelastic scattering cross sections, corrections to the Born-Oppenheimer separation of electronic and nuclear motion, and the dependence of atomic cluster properties on atomic size.

Lasers are used to probe atomic and molecular processes through high-resolution spectroscopy and various laser pump-probe techniques. Primary emphasis is on the study of excited-state collision dynamics; in many cases these excited-state interactions are important to the development of new laser sources. Similar laser pump-probe techniques are being applied to the study of the kinetics and dynamics of cluster or particulate nucleation and condensation.

Intense laser fields can appreciably modify the dynamics of atomic and molecular interactions. Detailed studies of nonlinear phenomena in this important strong radiation, field-atom coupling limit are also currently under way.

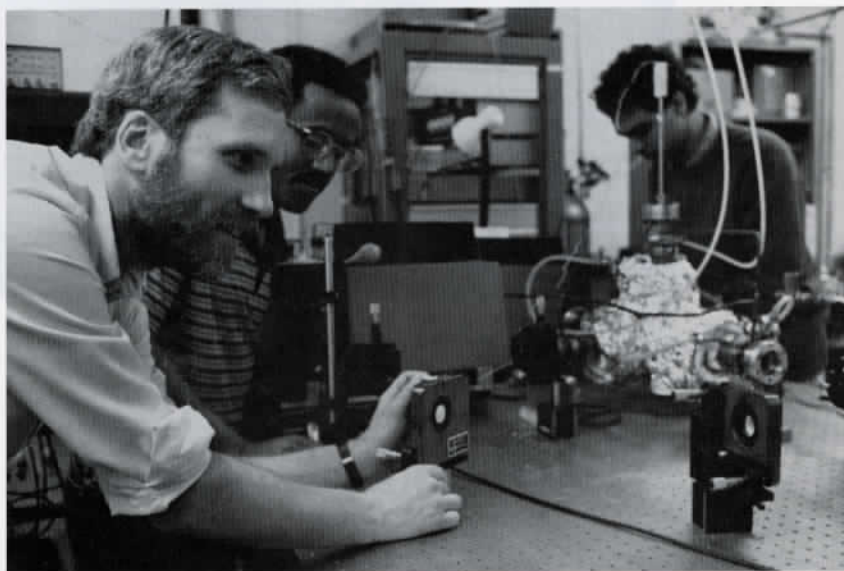
Recent Publications in Atomic, Molecular, and Laser Physics

"Reactive Collision Dynamics by Far Wing Laser Scattering: $\text{Mg} + \text{H}_2$," P.D. Kleiber, A.M. Lyyra, K.M. Sando, V. Zafirooulos, and W.C. Stwalley, *Journal of Chemical Physics*, 85, 5493, 1986.

"Energy Dependent Photodissociation Dynamics Probed by Fluorescence Polarization," V. Zafirooulos, P.D. Kleiber, K.M. Sando, Z. Zeng, A.M. Lyyra, and W.C. Stwalley, *Physical Review Letters*, 61, 1485, 1988.

"Alignment Effects in Ca-He ($5^1P_1 - 5^3P_2$) Energy Transfer Half Collisions," S. Ananthamurthy, P.D. Kleiber, W.C. Stwalley, and K.C. Lin, *Journal of Chemical Physics*, 90, 7605, 1989.

"Stimulated Emission in Laser Pumped Magnesium Vapor," P.D. Kleiber, A.M. Lyyra, S.P. Heneghan, and W.C. Stwalley, *Journal Optical Society America B*, 2, 522, 1985.



Professor Paul Kleiber and students adjust an experiment for study of atomic collisions.

Astronomy and Astrophysics

Research programs in optical and infrared astronomy are carried out at The University of Iowa Observatory near Riverside and at several national observatories. The Riverside observatory is equipped for polarimetric, photometric, and spectrophotometric observations. Current research programs include spectrophotometry of comets, novae, binary stars, and stars with unusual energy distributions. Work on surface photometry of comets and emission nebulae also is in progress.

A survey of interstellar polarization is being conducted to map out the small scale structure of the galactic magnetic field. Work carried out at national facilities includes photometry, spatial interferometry, and spectroscopy of cool stars.

The department has a strong tradition of research in radio astronomy, particularly in investigations using radio interferometry. For many years, the astronomy group operated the North Liberty Radio Observatory, part of the U.S. Very Long Baseline Interferometry (VLBI) network. This radio telescope has been replaced by a superior one on the North Liberty site, operated by the National Radio Astronomy Observatory. Departmental commitment to the VLBI technique remains strong, with several ongoing projects using global VLBI networks (with both Mark II and Mark III recording techniques) as well as the new Very Long Baseline Array (VLBA), which is currently under construction.

To maintain its strength in training graduate students in the instrumental aspects of radio astronomy, the department is planning for construction of an instructional radio observatory. Several graduate students are involved in research projects using data from VLBI arrays or the Very Large Array interferometer radio telescope.

Radio astronomy research involves the imaging of extragalactic and stellar radio sources, polarimetry of radio sources, spectroscopy, and observations of molecular clouds and star formation regions. Infrared, optical, and X-ray studies complement radio observations of stellar radio sources. Studies also are made of radio wave propagation through the plasma turbulence in the interstellar medium, interplanetary medium, and solar corona.

Theoretical astrophysics research includes study of gas and dust in the circumstellar envelopes of evolved stars. Current topics include computer simulations of radiative transfer in circumstellar mass flows, scattering properties of circumstellar dust shells, and models of OH masers near cool stars. Radio wave propagation properties of the interstellar medium and magnetospheric models of cool stars also are of considerable interest.

The Department of Physics and Astronomy at The University of Iowa, with its strengths in space physics and plasma physics, is particularly well-suited for studies in plasma astrophysics. The proximity of the space and plasma physics groups facilitates study of processes that might be important in astrophysical settings and that can be studied in detail in the solar wind and the magnetospheres of the Earth and other planets. Current investigations in plasma astrophysics are heating of the interstellar medium by dissipation of plasma turbulence, and nonlinear generation of radio waves from electrostatic plasma waves.

Recent Publications in Astronomy and Astrophysics

"Bolometric Albedos of Titan, Uranus, and Neptune," J.S. Neff, T.A. Ellis, J. Apt, and J.T. Bergstrahl, *Icarus*, 62, 425, 1985.

"The Structure of Circumstellar Shells," J.D. Fix and M.L. Cobb, *Astrophysical Journal*, 329, 290, 1988.

"Interstellar Scattering Towards Cygnus X-3: Measurements of Anisotropy and of the Inner Scale," L.A. Molnar, R.L. Mutel, M.J. Reid, and K.J. Johnston, *Astrophysical Journal*, (in press), 1990.

"Interstellar Scattering of the Compact Radio Source 2005 + 403," R.L. Mutel and J.F. Lestrade, *Astrophysical Journal (Letters)*, 349, L47, 1990.



Faculty members in the astronomy group: John Neff, John Fix, Robert Mutel, Steven Spangler, and Lawrence Molnar

High Energy and Elementary Particle Physics

EXPERIMENTAL WORK

Research in high energy experimental physics currently is being carried out at Fermi National Accelerator Laboratory (FNAL), Deutsches Elektronen-Synchrotron (DESY), Stanford Linear Collider (SLAC), and the Center for European Nuclear Research (CERN). At present, four professors in the department are involved with a large array of national and international institutions.

Research at Fermilab

An experiment to study the nonleptonic radiative decay modes of hyperons (particles with strangeness) is in progress. This will answer important questions about the weak interactions. A major component of the hardware for this experiment is a state-of-the-art silicon microstrip detection system designed and built at The University of Iowa. A new proposal to study the production and decay of strange charmed particles using a hyperon beam is under way. (Recent experiments indicate that this is an efficient way to produce and study charmed strange particles.)

Two closely related experiments deal with direct and critical tests of quantum chromodynamics (QCD). The first studies the g - p interaction to provide information on the QCD Compton effect and quark-gluon fusion. It will extract information on the gluon structure function of the proton. The second experiment will study proton and antiproton spin physics at the highest energies to date. QCD predictions already have been seriously challenged by measurements of spin effects, and it is possible that this experiment will provide decisive tests of QCD.

Research at CERN

Two experiments are presently under way at CERN. The first—the JETSET experiment—will search for gluonic matter and other exotic phenomena. The discovery of glueballs and exotics is essential for the survival of QCD-inspired models as well as for a clear understanding of the confinement mechanism in QCD. The apparatus planned will provide a compact, large-acceptance detector using advanced technology as a model detector for the giant supercollider. A second experiment (spin-splitter) will provide proof of principle for a method of creating high-intensity polarized antiproton beams.

Research at DESY

The world's first electron-proton colliding beam machine, HERA, will be operational in 1991 in Hamburg, West Germany. This machine will increase the available phase space in deep inelastic scattering by a factor of one thousand. HERA will provide electron or positron beams with 80 percent polarization, enabling sensitive tests of the standard model and probing new physics. ZEUS is a hermetic detector built with state-of-the-art technology—in particular, the fully compensated Uranium-scintillator calorimeter. Aside from answering questions of structure functions (quarks, gluons, photons), it will be an excellent place to explore physics signatures outside the standard model (right-handed currents, leptoquarks, and so forth).

Research at SLAC

At SLAC, physics analysis of the data from the "Charm factory," MARK III, is continuing in both weak and strong interactions; data gathering for this experiment is complete.

THEORETICAL WORK

The three members of the theoretical particle physics group work on a variety of problems. They use phenomenology to study particle production at facilities such as FNAL, CERN, SLAC, and SSC (the Superconducting Super Collider) as well as the phenomenology of quantum chromodynamics, the standard model, and string theoretic models. They are also engaged in studies of early cosmology, topological solitons, instantons, and supersymmetry.

The group is pursuing string theory and string-related topics, such as conformal field theory, infinite dimensional groups and algebras, p-adic field theory, and strings in four dimensions. Hopefully, these theoretical studies will lay the groundwork for a consistent quantum theory of gravity and better understanding of existing theories such as QCD.

Recent Publications in High Energy Physics

"Measurement of the Branching Fractions for $D^0 \rightarrow \pi^+ e^- \nu_e$ and $D^0 \rightarrow K^+ e^- \nu_e$ and Determination of $(V_{cd}/V_{cs})^2$," U. Mallik and others, *Physical Review Letters*, 62, 1821, 1989.

"High-Precision Measurements of Polarized Σ Beta Decay," E. McCliment, C. Newsom, and others, *Physical Review D*, 38, 2056, 1988.

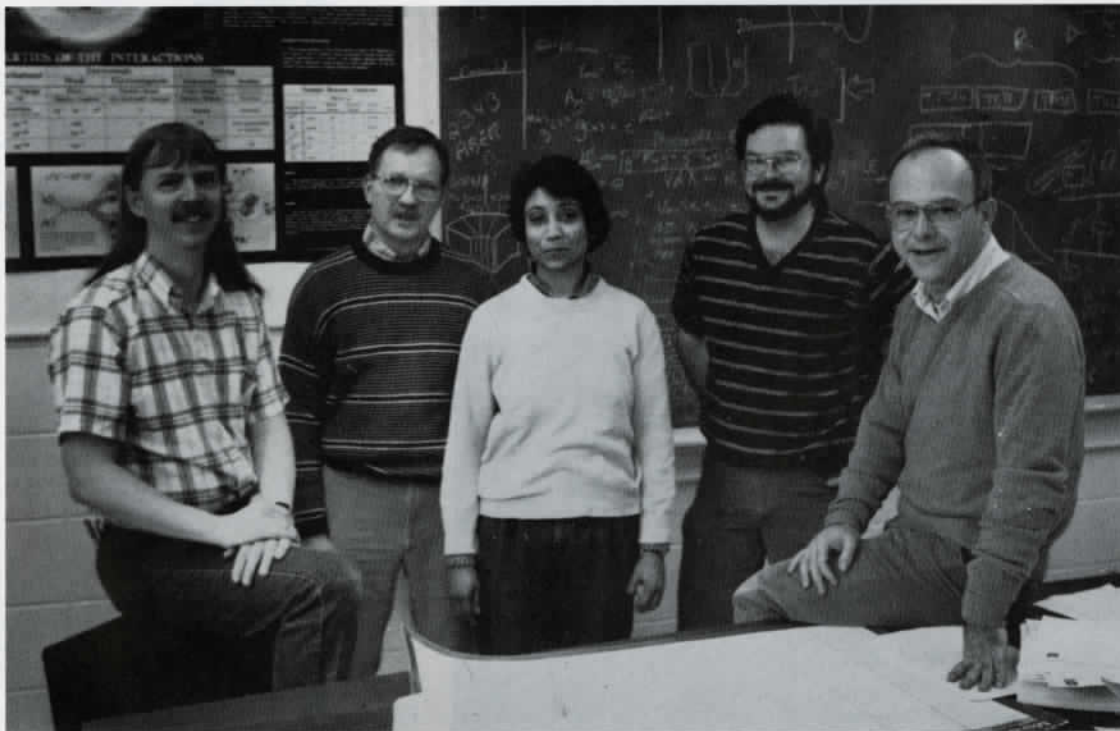
"New Measurement of the Production Polarization and Magnetic Moment of the Ξ Hyperon," L.H. Trost, E. McCliment, C. Newsom, and others, *Physical Review D*, 40, 1703, 1989.

"Elastic $p \uparrow p \uparrow$ Scattering Between 240 and 470 MeV," Y. Onel and others, *Physical Review D*, 40, 35, 1989.

"Quantum Mechanics with p-Adic Numbers," Y. Meurice, *International Journal of Modern Physics A*, 4, 5133, 1989.

"High P(t) W and Z Production at the Tevatron," P. Arnold, R.K. Ellis, M.H. Reno, *Physics Review D*, 40, 912, 1989.

"From Coadjoint Orbits to Scale Invariant WZNW Type Actions and 2-D Quantum Gravity Action," B. Rai and V.G.J. Rodgers, *Nuclear Physics B*, (in press) 1990.



The high energy physics group: Charles Newson, Edward McCliment, Usha Mallik, James McPherson (graduate student), and Yasar Onel

Nuclear Physics

A versatile 6-MV Van de Graaff accelerator is used to study nuclear reactions induced by all stable isotopes of hydrogen, helium, lithium, and beryllium. A unique design allows energies up to 14 MeV for triply charged ions. Special emphasis is given to lithium-ion reactions where three or more particles are produced. Ion beams are also used for measuring the chemical and physical structure of semiconductor materials. Nuclear physics experiments using higher-energy beams are carried out at national accelerator facilities.

Theoretical research in nuclear and intermediate energy physics is directed at understanding the interactions between the elementary constituents of the nucleus. Current research areas include relativistic quark models of the nucleus, few-nucleon models of the nucleus, lepton-nuclear interactions, and symmetry properties of scattering amplitudes. The numerical calculations for this research are done either on the departmental VAX or on supercomputers located at the national laboratories. The department is engaged in research collaborations with scientists at both Argonne National Laboratory and Los Alamos National Laboratory.

Recent Publications in Theoretical Physics

"Energy Dependence of Direct Effects in the ${}^6\text{Li} + {}^6\text{Li} \rightarrow 3\alpha$ Reaction Around the Coulomb Barrier," M. Lattuada, F. Riggi, D. Vinciguerra, C. Spitaleri, G. Vourvopoulos, D. Miljanic, and E. Norbeck, *Z. Physics A—Atomic Nuclei*, 330, 183, 1988.

"(p, $\rho\alpha$) Cluster Knockout Reaction on ${}^9\text{Be}$ at 200 MeV," A. Nadasen, P.G. Roos, N.S. Chant, C.C. Chang, G. Ciangaru, H.F. Breuer, J. Wesick, and E. Norbeck, *Physical Review C*, 40, 1130, 1989.

"Low Energy Nucleon-Deuteron Scattering," C.R. Chen, G.L. Payne, J.L. Friar, and B.F. Gibson, *Physical Review C*, 39, 1262, 1989.

"Constraints on Hadronic Current Operators in Relativistic Quantum Mechanical Models," W.N. Polyzou, *Physical Review D*, 32, 1216, 1985.

"The Structure of Poincaré Covariant Tensor Operators in Quantum Mechanical Models," W.N. Polyzou and W.H. Klink, *Annals of Physics*, 185, 369, 1988.



Professor Edwin Norbeck, Lawrence Schroeder (engineer), and Jian-Xin Zhang (graduate student) in the nuclear physics laboratory

Solid State Physics

Experiments on electrical and magnetic properties of materials are included in the solid state program, with current studies focused on preparation and characterization of sulfide and nitride analogues of the high-temperature oxide superconductors.

Theoretical work in solid state physics is concerned with application of many-body approaches to the theory of electronic and magnetic properties of condensed matter. Current interests include valence instabilities in rare-earth compounds and related narrow-band phenomena, and nonlinear effects in quasi-one-dimensional models of condensed matter.

Recent Publications in Solid State Physics

"Superconductivity in Yttrium-Terbium-Barium-Copper Oxide," J.E. Kasper, L.S. Martinson, W.R. Savage, N.G. Baenziger, and J.W. Schweitzer, *Solid State Communications*, 68, 57, 1988.

"Calculation of the Lifetime of a Davydov Soliton at Finite Temperature," J.P. Cottingham and J.W. Schweitzer, *Physical Review Letters*, 62, 1792, 1989.



Professor John Goree (right) and associates work on a laser used for measurements of ion distribution functions in plasmas.

Plasma Physics

Research in plasma physics includes the study of basic plasma properties and the applications of basic plasma phenomena to thermonuclear fusion plasmas, space plasmas, astrophysical plasmas, and plasmas for materials processing.

One class of experiments carried out in the department is designed to simulate, in the laboratory, various plasma processes that occur in the ionosphere; this work is funded by the Office of Naval Research. Topics under investigation include electrostatic ion cyclotron waves and their relation to ion beam and conic formation in the auroral zone, double layers, and ionospheric instabilities. Several plasma devices are available for these studies, including a Q-machine, a coaxial double plasma device, and several multidipole plasma devices. In addition, devices are available for studying plasma phenomena associated with cusp confinement.

Experimental study of the properties of solitons is funded through the National Science Foundation. Experimental research on high-power radio waves in ionospheric plasma is performed at the National Astronomy and Ionosphere Center near Arecibo, Puerto Rico. Other space-related experiments include dusty plasma studies designed to simulate the pre-solar nebula and spacecraft interactions with the plasma environment.

Another experimental area is concerned with applied plasma processing. Investigations are being made of plasmas used for thin film deposition and etching. Magnetron and radio frequency discharge experiments are conducted in a computer-automated laboratory. Tunable dye lasers are employed for laser-induced fluorescence diagnostics of plasmas, and numerical simulations are carried out to test theoretical models of these discharges.

Theoretical plasma physics uses a combination of analytic and numerical techniques. Two kinds of numerical techniques are used. Nonlinear partial differential fluid equations, which describe a plasma, are integrated numerically; and Newton's laws of motion, together with Maxwell's equations, are solved for systems of one thousand to one million particles. This work concentrates on the study of plasma equilibrium, stability, solitons, nonlinear waves, stochasticity, chaos, and turbulence in laboratory plasmas, fusion plasmas, ionospheric plasmas, magnetospheric plasmas, space plasmas, and astrophysical plasmas. The numerical work is performed on campus computers and on supercomputers in Colorado and Illinois via telephone link.

Turbulence The

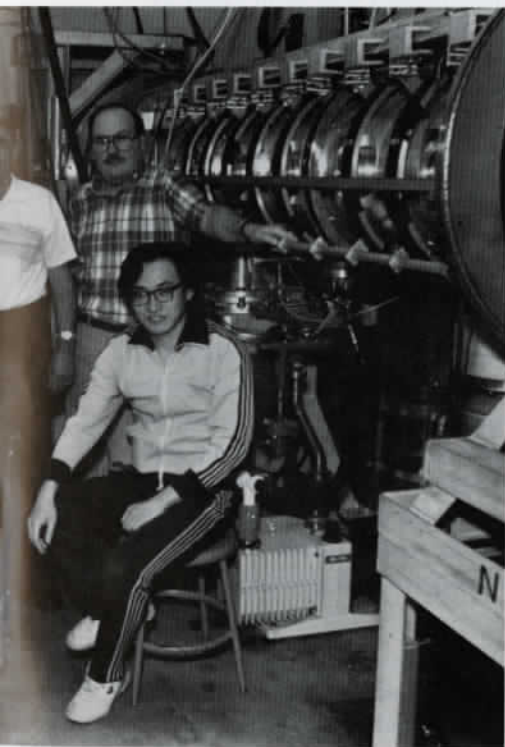
A research area akin to plasma physics is the study of turbulence, which is among the most important and interesting problems in classical physics. Turbulence has resisted attempts at a general understanding for the past century, and current studies are devoted to the behavior of a plasma in a magnetic field, transition to turbulence in Couette flow, and the transfer of turbulent energy from large to small scales. A problem of current interest in the department is the study of chaos in turbulence, in which the flow is sometimes ordered, sometimes chaotic. Problems in turbulence are being addressed with both analytical and numerical means, and the connection between deterministic chaos and



The Q-machine plasma laboratory: (back) James Johnson (graduate student), Professor Albert Scheller (senior machinist), Professor Robert Merlino; (front) Paul Lovekamp and (graduate students)

Turbulence Theory

A research area akin to plasma physics is the study of turbulence. Turbulence is among the most important and outstanding problems in classical physics and has resisted attempts at a basic understanding for the past century. Previous and current studies at Iowa include behavior of a plasma in a strong magnetic field, transition to turbulence in Couette flow, and cascade of turbulent energy from large to small scales. A problem of particular interest in the department is "self organization" in turbulence, in which large-scale, sometimes ordered, structures form. Problems in turbulence theory are addressed with both analytic and numerical means, and developments from the mathematical theory of deterministic chaos are used.



son (graduate student), Professor Nicola D'Angelo, Merlini; (front) Paul Lovekamp and Bin Song

Recent Publications in Plasma Physics

"Numerical Tests of Weak Turbulence Theory," G.L. Payne, D.R. Nicholson, and M.-M. Shen, *Physics of Fluids*, B1, 1797, 1989.

"Asymptotic State of the Finite Larmor Radius Guiding Center Plasma," G. Knorr and H.L. Pécseli, *Journal of Plasma Physics*, 41, 157, 1989.

"Model of Energetic Electron Transport in Magnetron Discharges," T.E. Sheridan, M.J. Goeckner, and J. Goree, *Journal of Vacuum Science and Technology*, A8, 30, 1990.

"An Experimental Study of Electrostatic Ion-Cyclotron Waves in a Two-Ion Component Plasma," D.M. Suszcynsky, N. D'Angelo, and R.L. Merlino, *Journal of Geophysical Research*, 94, 8966, 1989.

"The Current-Voltage Characteristics and Potential Oscillations of a Double Layer in a Triple Plasma Device," R.T. Carpenter and S. Torvén, *IEEE Transactions in Plasma Science*, 15, 434, 1987.

"Modulation of the Plasma Flow in Plasma Wake Experiments," J. Tao, J. Cooney, W.B. Lim, M.S. Ghaemi, and K.E. Lonngren, *Journal of Applied Physics*, 67, 1246, 1990.

"Kinetic Effects on Alfvén Wave Nonlinearity II. The Modified Nonlinear Wave Equation," S.R. Spangler, *Physics of Fluids B*, 2, 407, 1990.

Space Physics

The department conducts a major program of experimental and theoretical space physics. Extensive facilities and an engineering and technical staff are available to design, construct, and test equipment for flight in rockets, spacecraft, and the space shuttle, as well as to perform computerized decoding and analysis of data. Emphasis is on comprehensive observational and theoretical study of the magnetospheres of Earth, Jupiter, Saturn, Uranus, and Neptune; the interplanetary medium, including the propagation of energetic particles therein; and the galactic cosmic radiation.

The space physics group currently has active instruments on IMP-8; Pioneers 10 and 11, now at over 48 AU and 30 AU, respectively, from the sun; International Cometary Explorer (ISEE 3); Dynamics Explorer 1; and Voyagers 1 and 2, now at 41 AU and 32 AU, respectively, from the sun. The Plasma Diagnostics Package (PDP), a comprehensive set of plasma wave and particle

detectors, has flown twice on the space shuttle. Two instruments are also on the Galileo spacecraft to Jupiter, launched in October 1989. Four instruments are being developed for the International Solar Terrestrial Physics Program.

Space plasma physics deals mainly with the magnetohydrodynamics, wave-particle interactions, transport, heating, and acceleration of charged particles in planetary magnetospheres and the solar wind. In situ measurements by the instruments described above enable research teams to use planetary magnetospheres as natural laboratories for plasma physics.

A major focal point of the department's space physics theory group is a thematically coordinated program of analytical and numerical investigation of diffusion, heating, and acceleration processes in the thin, highly structured boundary layers that provide transitions between large-scale regions with qualitatively different regimes of the characteristic plasma parameters. Among the many examples of such transition regions is the one that separates the magnetospheric cavity from the solar wind.

This research is funded by NASA under the prestigious, highly competitive Space Physics Theory Program. It benefits from close association with the experimental space physics group and the extensive, high-quality database it has assembled through participation in most of the major satellite missions of magnetospheric and planetary exploration.

Other topics under investigation by the theory group include theory and numerical simulation of the critical ionization velocity mechanism in the interaction of plasmas with neutral gases; the physics of dusty plasmas, which contain charged macroscopic grains as well as free ions and electrons; and the theory and modeling of magne-



Members of the space plasma wave group discuss diagrams of an experiment: Iver Cairns, Roger Anderson, and William Kurth (research scientists); and Professor Donald Gurnett.

ospheric regions with internal plasma sources, such as the plasma torus surrounding Jupiter's moon Io.

In addition to traditional analytic methods, the space physics theory group employs advanced numerical simulation codes based on both magnetohydrodynamic and particle-in-cell models. These codes are run extensively at NSF supercomputer centers in Illinois and California.

Recent Space Physics Publications

"The Thermal Catastrophe Model of Substorms," C.K. Goertz and R.A. Smith, *Journal of Geophysical Research*, 94, 6581, 1989.

"Ion Beam Generation at the Plasma Sheet Boundary Layer by Kinetic Alfvén Waves," E. Moghaddam-Taaheri, C.K. Goertz, and R.A. Smith, *Journal of Geophysical Research*, 94, 10047, 1989.

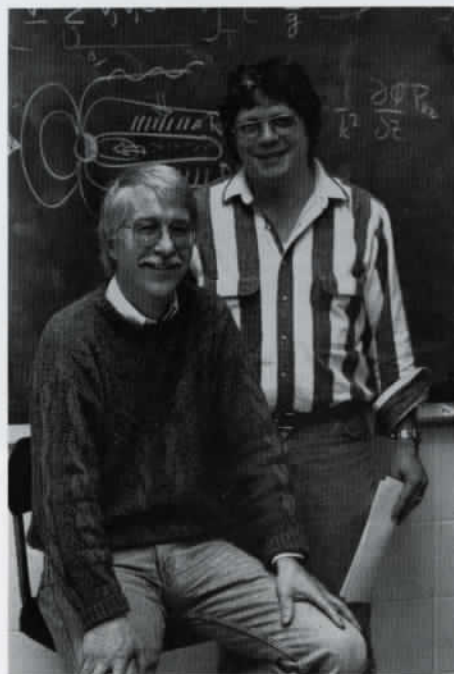
"Dynamics of the Near-Earth Magnetotail—Recent Observations," L.A. Frank, *American Geophysical Union Monograph*, 44, 262, 1988.

"Plasma Wave Observations with the Dynamics Explorer 1 Spacecraft," D.A. Gurnett and U.S. Inan, *Reviews of Geophysics*, 26, 285, 1988.

"Relativistic Electrons in Saturn's Inner Magnetosphere and an Estimate of Their Synchrotron Emission," J.A. Van Allen and C.L. Grosskreutz, *Journal of Geophysical Research*, 94, 8731, 1989.



Professor Louis Frank (center) discusses data from the Dynamics Explorer satellite with John Craven (left) and John Sigwarth (research scientists).



Professors Christoph Goertz and Robert Smith lead the space physics theory group.

FACULTY

Carlson, Richard R., professor; Ph.D., Chicago, 1951. Experimental low energy nuclear physics.

Carpenter, Raymon T., professor; Ph.D., Northwestern, 1962. Experimental plasma physics.

D'Angelo, Nicola, professor; Dr., Rome, Italy, 1953. Experimental plasma physics, experimental space physics.

Fix, John D., professor and associate chair for astronomy; Ph.D., Indiana, 1969. Observational stellar astronomy, theoretical astrophysics.

Frank, Louis A., professor; Ph.D., Iowa, 1964. Experimental space physics.

Goertz, Christoph K., professor; Ph.D., Rhodes, South Africa, 1972. Theoretical space physics.

Goree, John A., assistant professor; Ph.D., Princeton, 1985. Experimental plasma physics.

Gurnett, Donald A., professor; Ph.D., Iowa, 1965. Experimental space physics.

Kleiber, Paul D., associate professor; Ph.D., Colorado, 1981. Atomic, molecular, and laser physics.

Klink, William H., professor; Ph.D., Johns Hopkins, 1964. Elementary particle physics, mathematical physics.

Knorr, Georg E., professor; Ph.D., Munich, Germany, 1963. Theoretical plasma physics.

Lonngren, Karl E., professor (joint appointment, electrical and computer engineering); Ph.D., Wisconsin, 1964. Experimental plasma physics.

Mallik, Usha, associate professor; Ph.D., City College, CUNY, 1978. Experimental elementary particle physics.

McCliment, Edward R., professor; Ph.D., Illinois, 1962. Elementary particle physics.

Merlino, Robert L., associate professor; Ph.D., Maryland, 1980. Experimental plasma physics.

Meurice, Yannick, assistant professor; Ph.D., UCL Louvain-la-Neuve, Belgium, 1985. Theoretical elementary particle physics.

Molnar, Lawrence A., assistant professor; Ph.D., Harvard, 1985. Radio astronomy.

Mutel, Robert L., professor; Ph.D., Colorado, 1975. Radio astronomy.

Neff, John S., professor; Ph.D., Wisconsin, 1961. Observational optical astronomy.

Nelson, Edward B., professor emeritus; Ph.D., Columbia, 1949.

Newsom, Charles R., associate professor; Ph.D., Texas—Austin, 1980. Experimental elementary particle physics.

Nicholson, Dwight R., professor and chair; Ph.D., California—Berkeley, 1975. Theoretical plasma physics.

Norbeck, Edwin, professor; Ph.D., Chicago, 1956. Experimental nuclear physics.

Onel, Yasar, associate professor; Ph.D., London, England, 1975. Experimental elementary particle physics.

Payne, Gerald L., professor and associate chair for physics; Ph.D., California—San Diego, 1967. Theoretical nuclear physics, theoretical plasma physics.

Polyzou, Wayne N., associate professor; Ph.D., Maryland, 1979. Theoretical nuclear physics.

Reno, Mary H., assistant professor; Ph.D., Stanford, 1985. Theoretical elementary particle physics.

Rodgers, Vincent G. J., assistant professor; Ph.D., Syracuse, 1985. Theoretical elementary particle physics.

Schweitzer, John W., professor; Ph.D., Cincinnati, 1966. Theoretical solid-state physics.

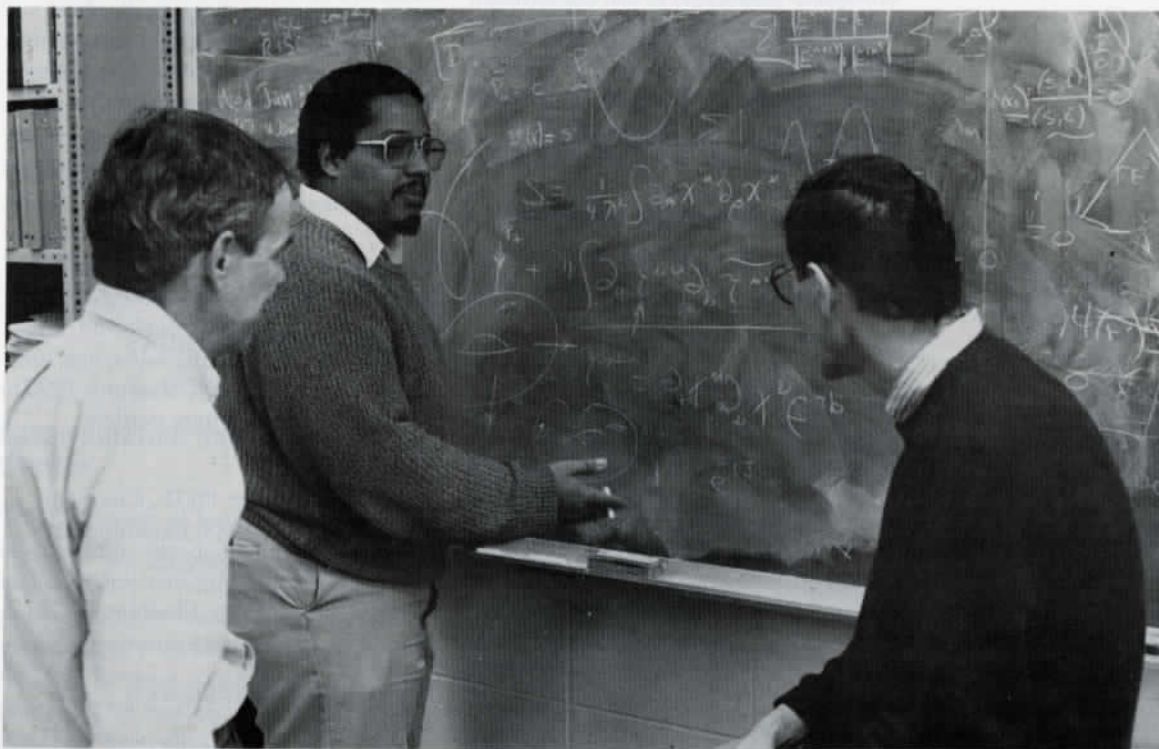
Smirl, Arthur L., professor (joint appointment, electrical and computer engineering); Ph.D., Arizona, 1975. Quantum optics, atomic and molecular physics, laser physics.

Smith, Robert A., associate professor; Ph.D., Maryland, 1973. Theoretical space physics.

Spangler, Steven R., professor; Ph.D., Iowa, 1975. Radio astronomy, plasma astrophysics, space plasma physics.

Stwalley, William C., professor (joint appointment, chemistry); Ph.D., Harvard, 1969. Quantum optics, low-temperature physics, atomic and molecular physics, laser physics.

Van Allen, James A., professor emeritus; Ph.D., Iowa, 1939. Experimental space physics, astrophysics.



A discussion in theoretical physics by Professors Gerald Payne, Vincent Rodgers, and William Klink

RESEARCH STAFF

Research Scientists

Ackerson, Kent L.; Ph.D., Iowa, 1972. Space plasma physics.

Anderson, Roger R.; Ph.D., Iowa, 1976. Interplanetary and magnetospheric plasma waves.

Calvert, Wynne; Ph.D., Colorado, 1962. Space plasma physics.

Craven, John D.; Ph.D., Iowa, 1969. Auroral and magnetospheric physics.

Grabbe, Crockett L.; Ph.D., California Institute of Technology, 1977. Theoretical plasma physics.

Kurth, William S.; Ph.D., Iowa, 1979. Interplanetary and magnetospheric plasma waves.

Associate Research Scientists

Berman, David; Ph.D., Wisconsin, 1976. Optics.

Cairns, Iver H.; Ph.D., Sydney, Australia, 1986. Theoretical astrophysics.

Huang, Cheryl Y.; Ph.D., Iowa, 1981. Space physics.

Macek, Wieslaw; Ph.D., Warsaw, Poland, 1976. Space physics.

Nishikawa, Ken-Ichi; Ph.D., Nagoya, Japan, 1981. Theoretical space plasma physics.

Randall, Bruce A.; Ph.D., Iowa, 1972. Magnetospheric physics.

Assistant Research Scientists

Bohns, John T.; Ph.D., Iowa, 1983. Laser spectroscopy.

Hansen, Paul J.; Ph.D., Iowa, 1983. Theoretical plasma physics.

Lyrra, Marjatta; Ph.D., Stockholm, Sweden, 1979. Laser spectroscopy.

Sheridan, Terrence E.; Ph.D., Dartmouth, 1987. Experimental plasma physics.

Sigwarth, John B.; Ph.D., Iowa, 1989. Experimental space physics.

Research Investigators

Bienz, Timothy; Ph.D., Stanford, 1990. Experimental elementary particle physics.

Hamri, Abdelkader; Ph.D., Clermont-Ferrand, France, 1988. Experimental elementary particle physics.

Moghaddam-Taaheri, Ebrahim; Ph.D., Maryland, 1986. Space plasma physics.

Postdoctoral Research Associates

Allan, Graham A.; Ph.D., Heriot-Watt, Scotland, 1985. Laser physics.

McCallum, David S.; Ph.D., Imperial College of Science and Technology, London, 1987. Laser physics.

Schroeder, W. A. (Andreas); Ph.D., University of London, 1987. Laser physics.

Swoboda, Hans-Erik; Ph.D., University of Kaiserslautern, West Germany, 1989. Laser physics.



Work with test equipment in the radioastronomy laboratory

ASSOCIATED RESEARCH PROGRAMS AT THE UNIVERSITY OF IOWA

In addition to the research programs carried out in the Department of Physics and Astronomy, other research and academic programs at The University of Iowa are of interest to physicists. These draw the participation of faculty members in the department and offer physics and astronomy graduate students the prospect of research and interdisciplinary study.

Iowa Institute of Hydraulic Research

This internationally-recognized institute is a leader in research in numerous areas of hydraulic engineering and fluid mechanics, which are of interest to many physicists and astronomers. The institute occupies its own laboratory building with five modern laboratories. Areas of particular interest to students in physics and astronomy are the institute's research in computational fluid dynamics, studies of boundary layers, turbulence and turbulent shear flow, and active involvement in global climate issues.

Laser Science and Engineering Center

The University of Iowa is in the process of expanding its education, research, and outreach activities in the rapidly growing area of laser science and engineering. A major new laboratory building is under construction, and plans call for participation by 24 faculty members from physics, chemistry, and engineering in the activities of the center.

Center for Global and Regional Environmental Research

Perhaps the science issue most relevant to society in the next decade will be modification of Earth's climate by human activity, such as release of carbon dioxide and other "greenhouse gases" into the atmosphere, destruction of the ozone layer, and so forth. Study

of this complicated area involves sophisticated problems in physics, chemistry, and engineering as well as interdisciplinary synthesis. In recognition of the importance of this topic, The University of Iowa recently established the Center for Global and Regional Environmental Research. Thirty-one faculty members from the College of Liberal Arts and the College of Engineering participate.

Center-related research in the Department of Physics and Astronomy includes the use of millimeter wavelength radio measurements for precise measurement of the stratospheric ozone layer. Work by other faculty members in the center consists of measurements of tropospheric ozone and other urban air pollutants, mathematical modeling of atmospheric chemistry, remote sensing of the Earth's surface, and hydrometeorology.



Researchers in experimental high energy physics

RESEARCH FACILITIES

Facilities for graduate study and research in physics and astronomy are located in Van Allen Hall. The 195,000-square-foot, completely air-conditioned building houses an excellent library, machine shops, well-equipped laboratories, offices, storerooms, auditoria, darkrooms, classrooms, lecture halls, and seminar rooms. A desk and private study area are provided for each graduate student.

The central machine shop is staffed with skilled instrument makers and machinists, and several electronic and machine shops are available for use by advanced students and research staff.

The department has an extensive, VAX-based computer network. All major computers in the department are networked and can access SPAN and HEPNET. More than 20 terminals and auxiliary apparatus are provided for student use, and additional computing facilities are available at the University's Weeg Computing Center.

Several networks permit access to supercomputers at the National Magnetic Fusion Energy Computing Center, Livermore, California; the National Center for Atmospheric Research, Boulder, Colorado; the National Center for Supercomputing Applications, Champaign, Illinois; and the Los Alamos National Laboratory, Los Alamos, New Mexico. A direct link to the Stanford Linear Accelerator Center (SLAC) IBM 3081 is available to the particle physics group.

Major research facilities in the department are:

- a comprehensive array of low-energy particle accelerators, electronic test equipment, and environmental test chambers and clean rooms; an optics laboratory for the development, calibration, and proof testing of instruments for space flight;
- a computer-assisted design (CAD) facility;
- a 6-MV Van de Graaff accelerator in a nuclear physics laboratory adjoining Van Allen Hall;
- a fully equipped high-energy physics laboratory for design, construction, and testing of detectors used in experiments at Fermilab and other large facilities around the world;
- twenty-four-inch and 12-inch Cassegrain telescopes at the Riverside Astronomical Observatory, ten miles south of Iowa City;
- a solid-state laboratory with facilities for magnetic susceptibility, resistivity, Hall effect, and specific heat measurements at low temperatures; facilities for the preparation of experimental materials;
- several plasma physics laboratories, including a 6-kG Q-machine facility; a variety of multidipole plasma devices and associated computer-based diagnostic equipment used for basic plasma physics research, laboratory simulation of space plasma physics phenomena, and applications to plasma processing of materials;
- the Iowa Laser Facility, located in the Chemistry-Botany Building, which houses a wide variety of modern laser instrumentation and related equipment, including several monochromators, with lengths up to 3.4 meters; high-vacuum molecular beam systems; and low-temperature equipment, including a 110-kG superconducting magnet and a helium dilution refrigerator capable of operation at 0.012 K.

Advanced astronomy students also conduct research at the National Astronomy and Ionosphere Center, Arecibo, Puerto Rico; the Very Large Array radio telescope, near Socorro, New Mexico; the Very Long Baseline Interferometry Network; the Very Long Baseline Array; Haystack Observatory, Westford, Massachusetts; Kitt Peak National Observatory, near Tucson, Arizona; the Infrared Telescope Facility, Mauna Kea, Hawaii; and the International Ultraviolet Explorer, Goddard Space Flight Center, Greenbelt, Maryland.

Students can arrange to do physics research at the following facilities:

- in nuclear physics at the Argonne National Laboratory, Argonne, Illinois;
- in elementary particle physics at the Fermi National Accelerator Laboratory, Batavia, Illinois; the Los Alamos Meson Physics Facility, Los Alamos, New Mexico; the Stanford Linear Accelerator Center, Palo Alto, California; and the Center for European Nuclear Research, Geneva, Switzerland;
- in space plasma physics at the Los Alamos National Laboratory, Los Alamos, New Mexico;
- in ionospheric plasma physics at the National Astronomy and Ionosphere Center, near Arecibo, Puerto Rico.



Analysis of images from the Dynamics Explorer satellite

Advanced astronomy students also conduct research at the National Astronomy and Ionosphere Center, Arecibo, Puerto Rico; the Very Large Array radio telescope, near Socorro, New Mexico; the Very Long Baseline Interferometry Network; the Very Long Baseline Array; Haystack Observatory, Westford, Massachusetts; Kitt Peak National Observatory, near Tucson, Arizona; the Infrared Telescope Facility, Mauna Kea, Hawaii; and the International Ultraviolet Explorer, Goddard Space Flight Center, Greenbelt, Maryland.

Students can arrange to do physics research at the following facilities:

- in nuclear physics at the Argonne National Laboratory, Argonne, Illinois;
- in elementary particle physics at the Fermi National Accelerator Laboratory, Batavia, Illinois; the Los Alamos Meson Physics Facility, Los Alamos, New Mexico; the Stanford Linear Accelerator Center, Palo Alto, California; and the Center for European Nuclear Research, Geneva, Switzerland;
- in space plasma physics at the Los Alamos National Laboratory, Los Alamos, New Mexico;
- in ionospheric plasma physics at the National Astronomy and Ionosphere Center, near Arecibo, Puerto Rico.



Analysis of images from the Dynamics Explorer satellite

GRADUATE APPOINTMENTS AND AWARDS

Nearly all students admitted to graduate study in physics and astronomy are offered assistantships. Any student who progresses satisfactorily can expect to receive continuing financial support until he or she completes the M.S. or Ph.D. degree, as appropriate. Primary sources of support are teaching assistantships and research assistantships.

Teaching Assistantships

The usual initial appointment for a graduate student is a half-time teaching assistantship, which entails instructing three sections of elementary laboratory under the supervision of the professor in charge of the course. Teaching assistants also serve as tutors and proctors and grade examination papers. Duties are arranged so that the student can take a full load of course work—up to 12 semester hours—concurrently with the assistantship.

Stipends for the 1990-91 academic year are \$11,200 for first-year graduate students and others who have not yet passed the departmental qualifying examination, and \$11,800 for more advanced students.

All graduate assistants are eligible for resident tuition rates. The maximum tuition for 1990-91 is \$1,113 per semester for 9 or more semester hours. A few teaching assistantships are available during the summer session.

Research Assistantships

Half-time research assistantships usually are available for all students engaged in Ph.D. dissertation research. The duties consist primarily of work on the student's own thesis and other work contributing to competence in research. Many students are associated with and supported by research groups even before beginning Ph.D. thesis research. Early research experience is desirable if the student is to make an informed choice of a thesis problem.

The department tries to place new students in a research position during the summer following the first year of graduate study and occasionally can offer research assistantships starting in June to new graduate students who have accepted teaching assistantships for the following academic year. Applicants who wish to be considered for research assistantships should indicate the particular field in which, and/or the professor with whom, they wish to work.

Stipends are similar to those for teaching assistantships, and research assistants are also eligible for resident tuition rates.

Scholarships

The department has been awarded a substantial grant from the U.S. Department of Education to provide full fellowship support of \$18,000 per 12 months to a few excellent candidates. In other cases, scholarships may be awarded to cover part or all of tuition and fees.

Prospective graduate students are encouraged to apply for other scholarships and financial assistance as well.

PLACEMENT OF RECENT PH.D. GRADUATES

1985

Chia-Rong Chen, George Washington University, Washington, D.C.; "Effects of the Three-Nucleon Forces on the Trinucleon System"

Michael L. Cobb, Naval Research Laboratory, Washington, D.C.; "Infrared Photometry and High-Resolution Imaging of OH/IR Stars"

Ralph A. Gaume, Naval Research Laboratory, Washington, D.C.; "Study of the Ground State Hydroxyl Maser Emissions Associated with Eleven Regions of Star Formation"

Richard L. Rairden, Lockheed, Palo Alto, California; "Geocoronal Imaging with Dynamics Explorer"

1986

Mark M. Baumbach, Naval Research Laboratory, Washington, D.C.; "Properties of Auroral Kilometric Radiation from an Interferometer Analysis of the ISEE-1 and -2 Plasma Wave Data"

Robert A. Bosch, KMS Fusion, Ann Arbor, Michigan; "Plasma Confinement in a Spindle Cusp Magnetic Field"

Steven L. Cartier, McDonnell-Douglas, St. Louis, Missouri; "Properties of Electrostatic Ion-Cyclotron Waves in a Nonuniform Magnetic Field and Their Association with Strong, Magnetized Double Layers"

Hong-Young Chang, Korea Institute of Technology, Korea; "On the Excitation and Propagation of Ion Acoustic Solitons in Non-Ideal Plasmas"

Ti-Ze Ma, Utah State University, Logan, Utah; "Electrostatic Waves Generated by Gases Interacting with Flowing Plasmas"

Mei-Mei Shen, Seagull Technology, Inc., Sunnyvale, California; "Numerical Studies of Strong Langmuir Turbulence Models"

1987

Ping-Lin Chung, Argonne National Laboratory, Argonne, Illinois; "Relativistic Calculations of Deuteron Form Factors"

William M. Farrell, Goddard Space Flight Center, Greenbelt, Maryland; "An Analysis of the Whistler-Mode Radiation from the Spacelab-2 Electron Beam"

1988

Dirk Morris, The University of Iowa, Iowa City, Iowa; "Radio Emission from RS CVn Binaries and Similar Systems"

John T. Steinberg, M.I.T., Cambridge, Massachusetts; "Quasi-Static Electric Field Measurements Made with the Plasma Diagnostics Package in Free Flight During Spacelab-2"

Alan C. Tribble, Rockwell International, Seal Beach, California; "The Large-Scale Wake Structure of the Shuttle Orbiter: Plasma Density, Temperature, and Turbulence"

Robert E. Johnson, Tri-State University, Angola, Indiana; "Point Contact Spectroscopy Measurement on Ceramic Superconductors"

Scott A. Boardsen, Marshall Space Flight Center, Huntsville, Alabama; "Dynamics Explorer-1 Satellite Study of Electrostatic Ion Cyclotron Waves"

1989

James P. Cottingham, Coe College, Cedar Rapids, Iowa; "Calculation of the Lifetime of a Davydov Soliton at Finite Temperature"

David M. Suszcynsky, Los Alamos National Laboratory, Los Alamos, New Mexico; "An Experimental Study of Current-Driven Electrostatic Ion Cyclotron Waves in a Two-Ion Component Plasma"

Alan L. Fey, Naval Research Laboratory, Washington, D.C.; "VLA and VLBI Angular Broadening Measurements: The Distribution of Interstellar Scattering at Low Galactic Latitudes"

John B. Sigwarth, The University of Iowa, Iowa City, Iowa; "A Search for Small Comets in Consecutive Images Acquired with a Ground-Based Telescope"

THE UNIVERSITY OF IOWA

The University of Iowa is a major public research university with a long-standing commitment to teaching, research, and service. Founded in 1847 as Iowa's first public institution of higher learning, the University has long been a national leader in such areas as creative writing, space physics, educational testing, and health sciences. Today the University enrolls 29,000 students in undergraduate, graduate, and professional degree programs. The University's 1,639 faculty members are teachers and researchers in ten colleges: Business Administration, Dentistry, Education, Engineering, Graduate, Law, Liberal Arts, Medicine, Nursing, and Pharmacy.

The University of Iowa does not discriminate in its programs, policies, and employment practices on the basis of race, national origin, color, religion, sex, age, or disability. The University also affirms its commitment to providing equal opportunities and equal access to University facilities without reference to affectional or associational preference. For additional information on nondiscrimination policies, please contact the Coordinator of Title IX and Section 504 in the Office of Affirmative Action, 202 Jessup Hall, The University of Iowa, Iowa City, Iowa 52242; phone 319-335-0705.

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Van Allen Hall, home of the Department of Physics and Astronomy