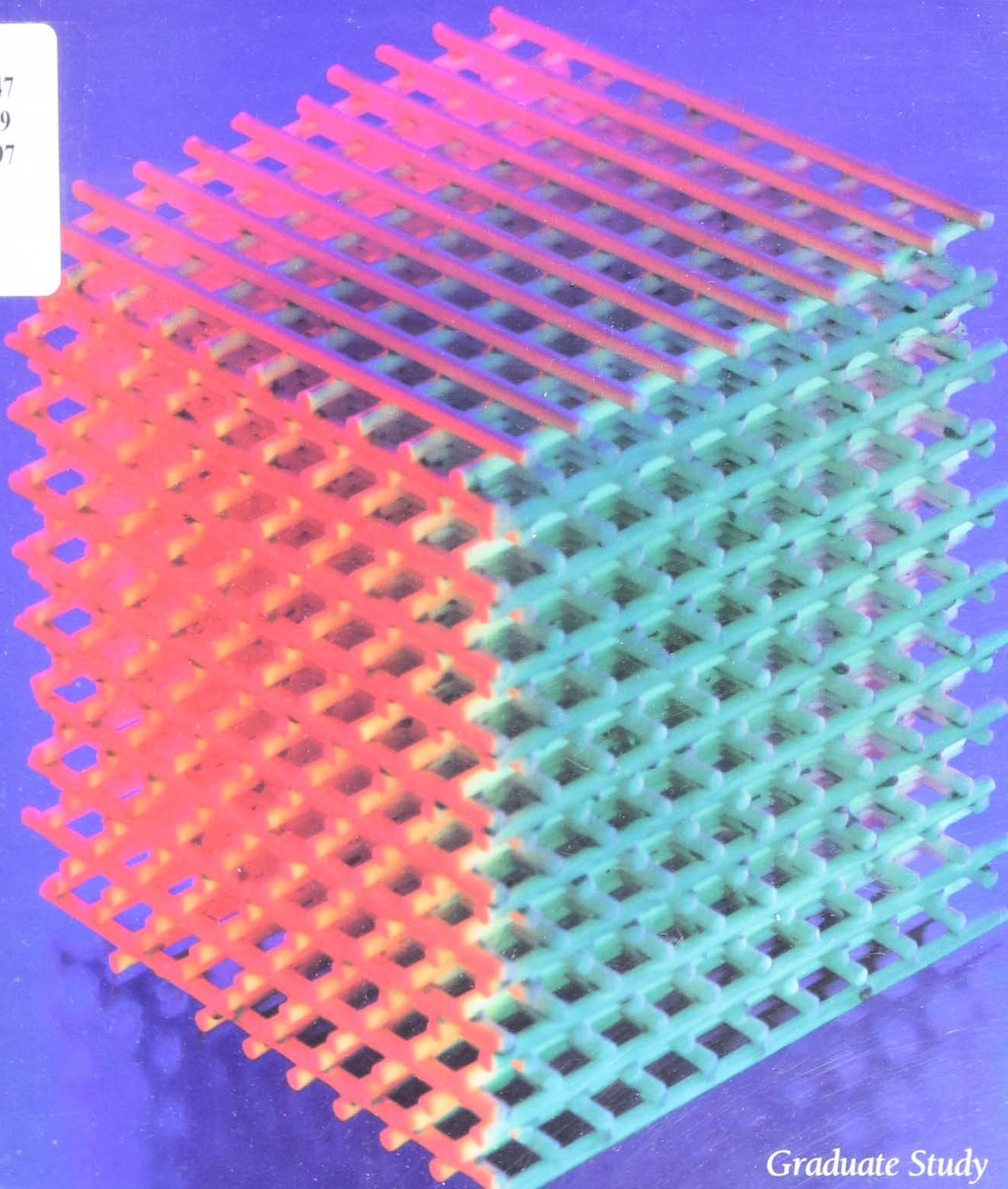
IOWA STATE UNIVERSITY

Physics and Astronomy



Graduate Study

Physics and Astronomy

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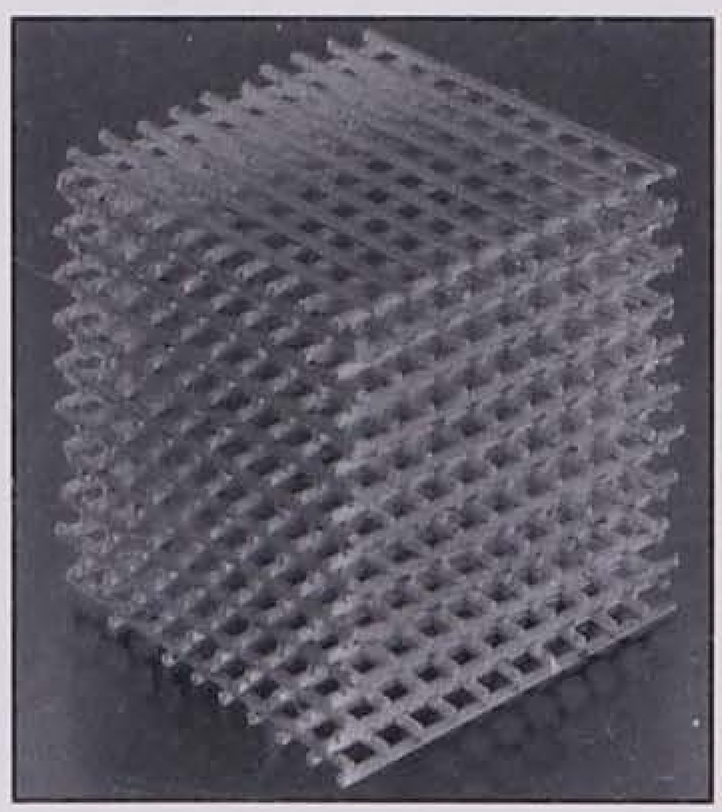


IOWA STATE UNIVERSITY

Contents

Cover: Photonic Band Gap material composed of a periodic array of dielectrics. Photons of specified energies will not propagate in this medium, just as electrons of specified energies will not propagate in a semiconductor.

Department of Physics and Astronomy

The Department of Physics and Astronomy is engaged in internationally recognized forefront research and takes pride in providing outstanding teaching and training for all levels of students at Iowa State University. Superior research attracts faculty and graduate students, while providing an atmosphere of mutual learning. Superior teaching imparts relevant knowledge and shares with the students the excitement of the scientific culture and its motivations. An important aspect of the Department's activities is the education of students from other disciplines and the improvement of teaching methods, outreach efforts, and cooperative programs with other sections of the University. This booklet outlines some of the activities of the Department and tries to give the flavor of our objectives. For additional information, see our Web page on internet: http://www.public.iastate.edu/~physics

The Department of Physics and Astronomy at Iowa State University consists of 46 faculty, approximately 110 graduate students, and about 60 undergraduate majors, as well as a large number of permanent staff, postdoctorals, and visitors. The largest research group is in condensed matter physics with 15 faculty. Within this group there are strong efforts in X-ray and neutron scattering, photoemission spectroscopy, magnetic resonance spectroscopy, surface physics, semiconductor physics, superconductivity, and magnetism. There is a long tradition of materials research with strong collaborations with chemistry, metallurgy, and ceramics through the Ames Laboratory of the U.S. Department of Energy. There are 9 faculty in high energy physics with a major effort at the Large Electron-Positron (LEP) Collider at CERN in Geneva, Switzerland. The main scientific thrust here is to use Z-zero production to look for deviations from the standard model. A second HEP effort is at the proton-antiproton collider at Fermi National Accelerator Laboratory in Batavia, Illinois where effort has been centered around the discovery of the top quark and related experiments.

There are 5 faculty in nuclear physics focussed on the use of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory to look for a quark-gluon plasma in the massive collisions of hadrons. There are 7 faculty in Astronomy or Astrophysics with significant programs in both optical and gamma-ray astronomy. Colliding galaxies, mass loss from stars, the equation of state for small-mass stars, and the discovery of gamma-ray sources are important topics under study.

Physics building addition

Graduate Degree Requirements

The department offers the M.S. degree, both with and without the thesis, and the Ph.D degree. The requirements for M.S. degree with thesis include one year of graduate course work and typically another year of thesis research. Most students do not take an M.S. on the way to the Ph.D. Ph. D. candidates generally take from two to three years of graduate coursework and then do original research for the dissertation. They must also pass a qualifying examination on undergraduate and first-year graduate material, usually at the beginning of the second year, and then preliminary (general), and final (thesis defense) oral examinations. The total time to attain a Ph.D. is from four to six years. There is no language requirement for either degree. Students are encouraged to establish early contact with research programs, although a "firm" decision as to a thesis area and major professor is normally not made until the end of a student's second year.

University-wide regulations that affect graduate students are described in the Graduate Student Handbook. Graduate students participate in departmental decisions through an elected Graduate Status Committee representative.

Graduate Student Support

Teaching assistantships The primary source of financial aid for most beginning graduate students is a teaching assistantship for teaching assistantships recitations and laboratories for the 100- and 200-level courses. These range in pay from $1175 to $1350 a month.

Research assistantships Beyond the second year, most graduate students do research toward their dissertation and are paid $1250 to $1350 a month.

PACE Awards Outstanding applicants are nominated by our department for Premium for Academic Excellence (PACE) awards which are granted by the Graduate College usually for a period of twelve months. Exceptionally qualified students may receive a two-year award.

GAANN Fellowships A Department of Education Grant has been available to provide fellowships which pay about $1530 per month to U.S. or permanent resident students who plan a career in teaching or research and who need financial aid.

Additional benefits Students on assistantships receive free health insurance, fees assessed at resident rates, and Graduate College Scholarships covering a portion of the resident fees if they are in good academic standing.

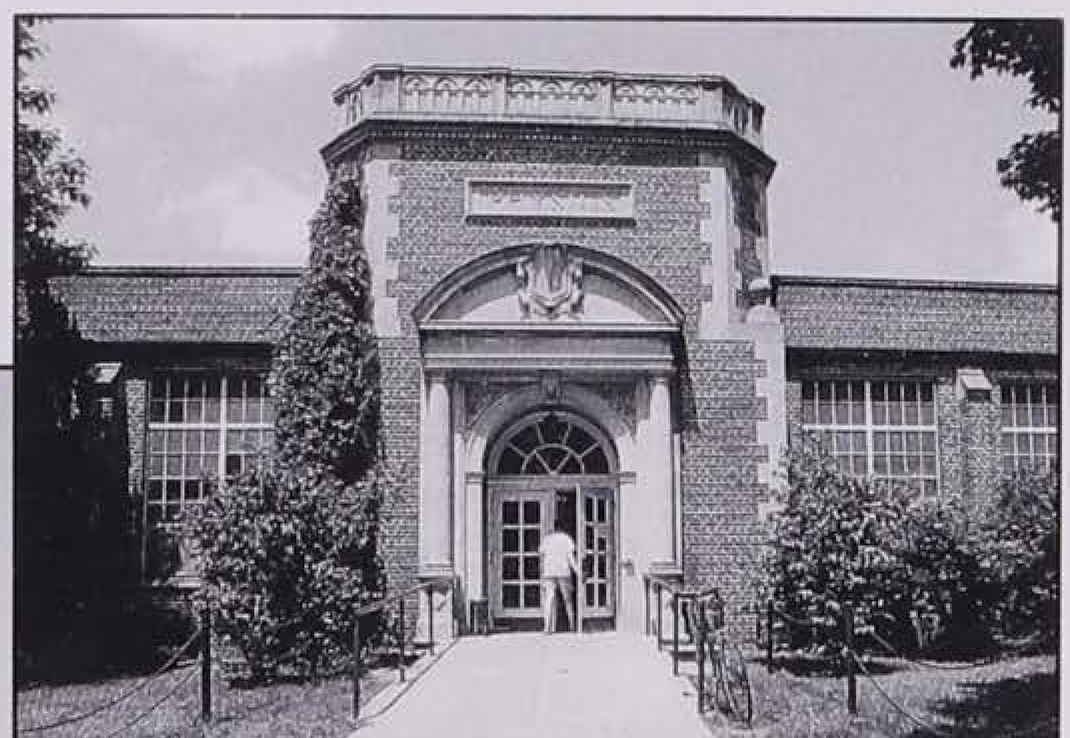
Facilities

Iowa State University is the birthplace of the electronic digital computer–the Atanasoff-Berry Computer–which was designed and built in the late 1930's by mathematics and physics professor John Vincent Atanasoff and graduate student Clifford E. Berry. Project Vincent, a powerful on-campus work station network that has brought a new era of academic computing to ISU, was named in honor of John Vincent Atanasoff. Through more than 750 RISC-type workstations it provides ISU faculty, administrative staff and students with all the advantages of the most powerful workstations developed to date, and is particularly useful for physics and astronomy researchers who require extensive computations and graphical analysis. Off-campus resources such as the National Science Foundation Supercomputers are easily reached from the workstations and terminals, and access to international electronic mail networks facilitates world-wide collaborative research.

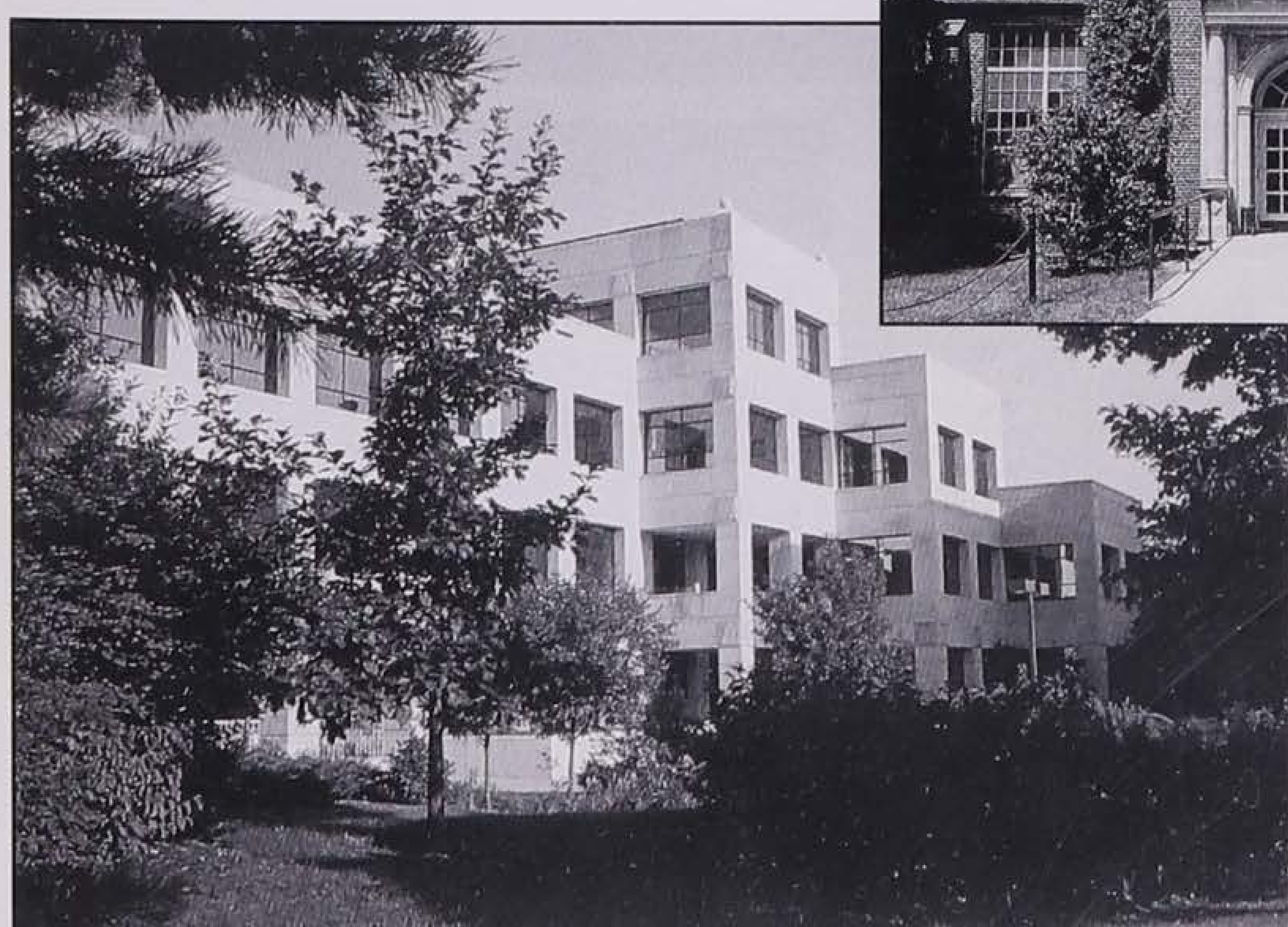
Computer Facilities

The high-performance capabilities of Project Vincent allows researchers to quickly get answers to complex research questions and problems. System users can exchange text and graphics to other workstations and computers across campus and access computational resources world-wide. Project Vincent is fast becoming a model for other major research institutions interested in developing large, sophisticated, computer networks.

The Parks Library at ISU has a collection that totals more than 4 million items, including books and bound serials, microforms, maps and extensive holdings of manuscripts, films, archival photographs, and audio-video materials. The library is nationally recognized for its collections in the basic and applied fields of the biological and physical sciences and has major strengths in agriculture, design arts, statistics, and veterinary medicine.



Physics building

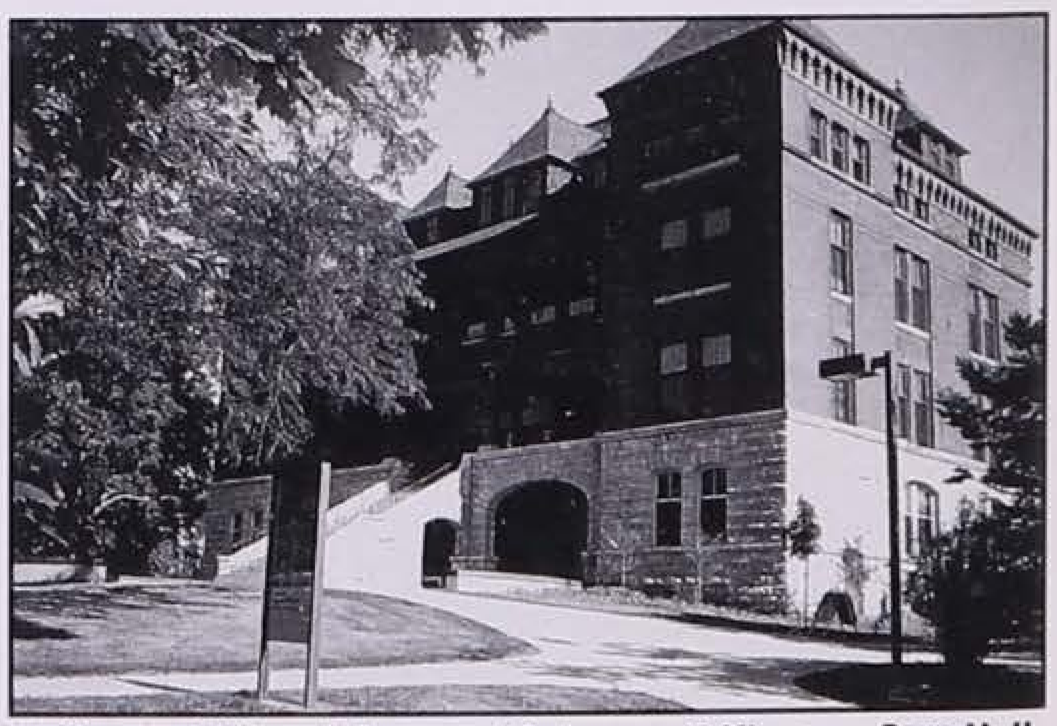


Durham Center

Library Facilities

Over 20,000 journals and other serial publications are currently received, providing invaluable resource materials for the various university programs. Additional subject collections outside the Parks Library are provided in the physical sciences, economics, sociology, design, and mathematics reading rooms and the Library of the College of Veterinary Medicine. The Library's Media and Microform Centers provide state-of-the-art facilities. The Department of Special Collections houses a rich resource of rare works and archival documents. The ISU library system is on the cutting edge of utilizing computers for information storage and retrieval.

Parks Library



College of Liberal Arts and Sciences Offices — Catt Hall

Graduate Courses

Courses in Astronomy and Astrophysics

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

505. Astrophysics. Physics of stars, galaxies, and the universe. Stellar spectra, structure and evolution. Origin of the elements. Black holes, neutron stars and white dwarfs. Large scale structure of the universe, dark matter, Big Bang Cosmology.

510. Observational Astrophysics. Techniques in optical and near-IR astronomy, including spectroscopy and photometry with both single channel and 2-dimensional array detectors. Emphasis on projects involving proficiency in the use of small telescopes and modern instrumentation. Project topics range from spectroscopic and photometric studies of pulsating and binary star systems to deep photographic and CCD imaging of faint nebulae and galaxies.

518. Radio Astronomy and Astrophysics. Radio astronomy fundamentals; wave polarization and measurement; radio telescope receivers and antennae; wave propagation in plasmas; synchrotron emission; continuum and line spectra; physical conditions in radio sources.

575. Radiative Transfer, Stellar Atmospheres, and Spectroscopy. Radiative transfer with applications to stellar interiors, atmospheres, and the interstellar medium. Interaction of radiation and matter; line and continuum processes. Statistical equilibrium. Line profiles. Interpretation of stellar spectra; temperature, pressure, and abundance determinations. Dynamic and extended atmospheres, chromospheres, coronae, and stellar winds.

Fick Observatory

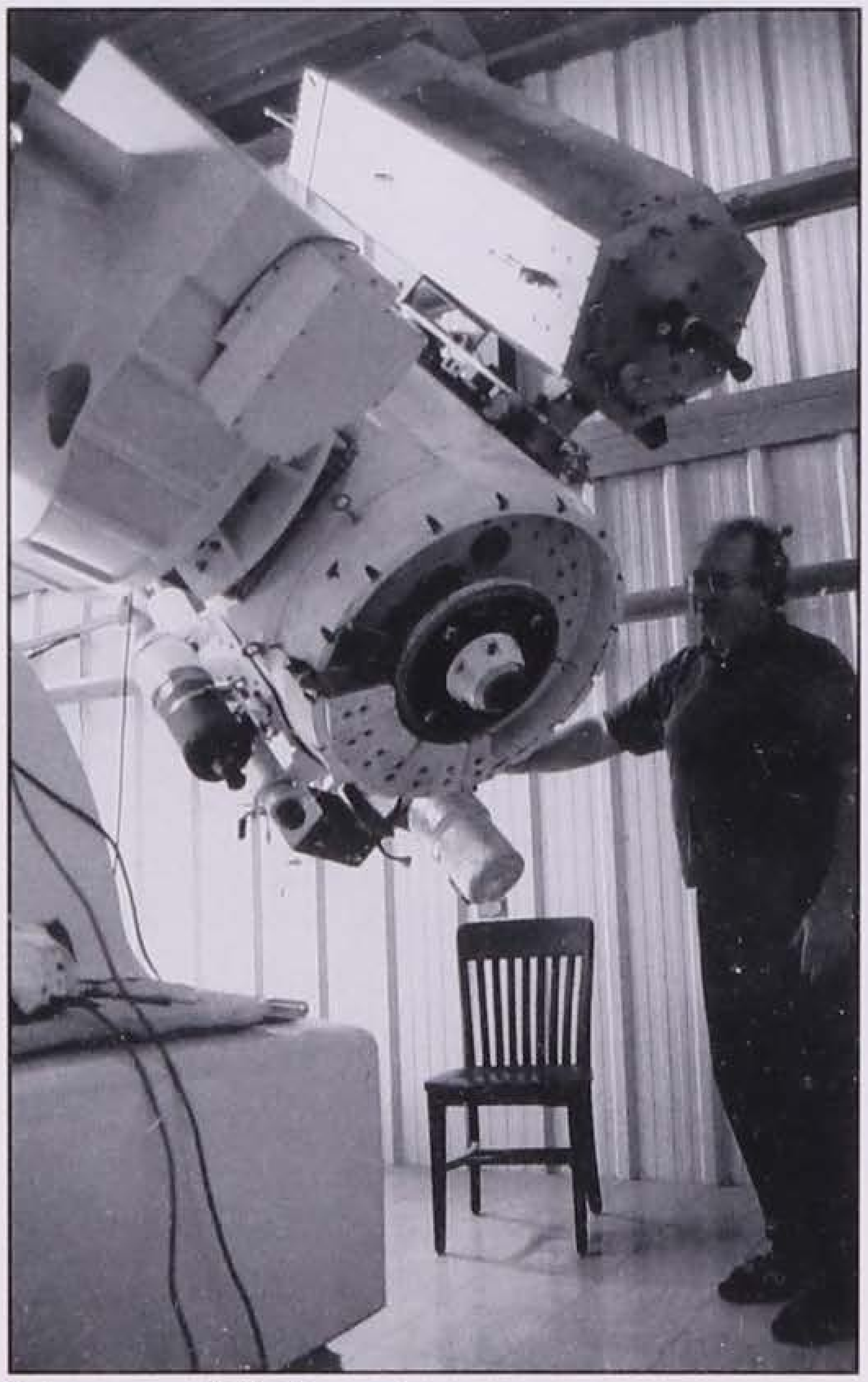
580. Stellar Structure and Evolution. Stellar structure equations and constitutive relations: energy generation, energy transport by radiation and convection; equation of state. Solutions to the equations; general theorems, analytic approximations, numerical techniques, and results. Stellar evolution from formation to final phases. Nucleosynthesis; recycling of material to the interstellar medium. Evolution in interacting binaries. Variable stars.

590. Special Topics

599. Creative Component. Individually directed study of research-level problems for students electing the nonthesis M.S. option in astronomy.

Courses for Graduate Students, major or minor

615. Galactic and Extragalactic Astronomy. The interstellar medium, galactic structure, dynamics of external galaxies, evolution and classification of galaxies, extragalactic radio sources, quasars, cosmological models.



Telescope at Fick Observatory

650. Advanced Seminar. Topics of current interest in astronomy and astrophysics. Offered on a satisfactory-fail basis only.

660. Advanced Topics in Astronomy and Astrophysics. Topics in stellar, galactic, and extragalactic astronomy, including stellar evolution, solar physics, variable stars, compact objects, the interstellar medium, active galaxies and quasars, formation and evolution of galaxies, cosmology, high energy astrophysics, advanced observational techniques, and astrophysical applications of hydrodynamics.

699. Research.

Courses in Physics

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Introductory Research Seminar. Discussion by research staff of their research areas, expected thesis research work, and opportunities in the field. For graduate physics majors only. Offered on a satisfactory-fail basis only.

501. Oral Communication of Physics Seminar. Practice in communication of physics and astronomy in typical college classroom settings and professional meetings. Skills emphasized include selection of physical examples and analogies, presentation styles of topics, scientific dialogue, organization of physics topics, and classroom technique. The teaching proficiency of each student is evaluated in detail. For graduate physics majors only. Offered on a satisfactory-fail basis only.

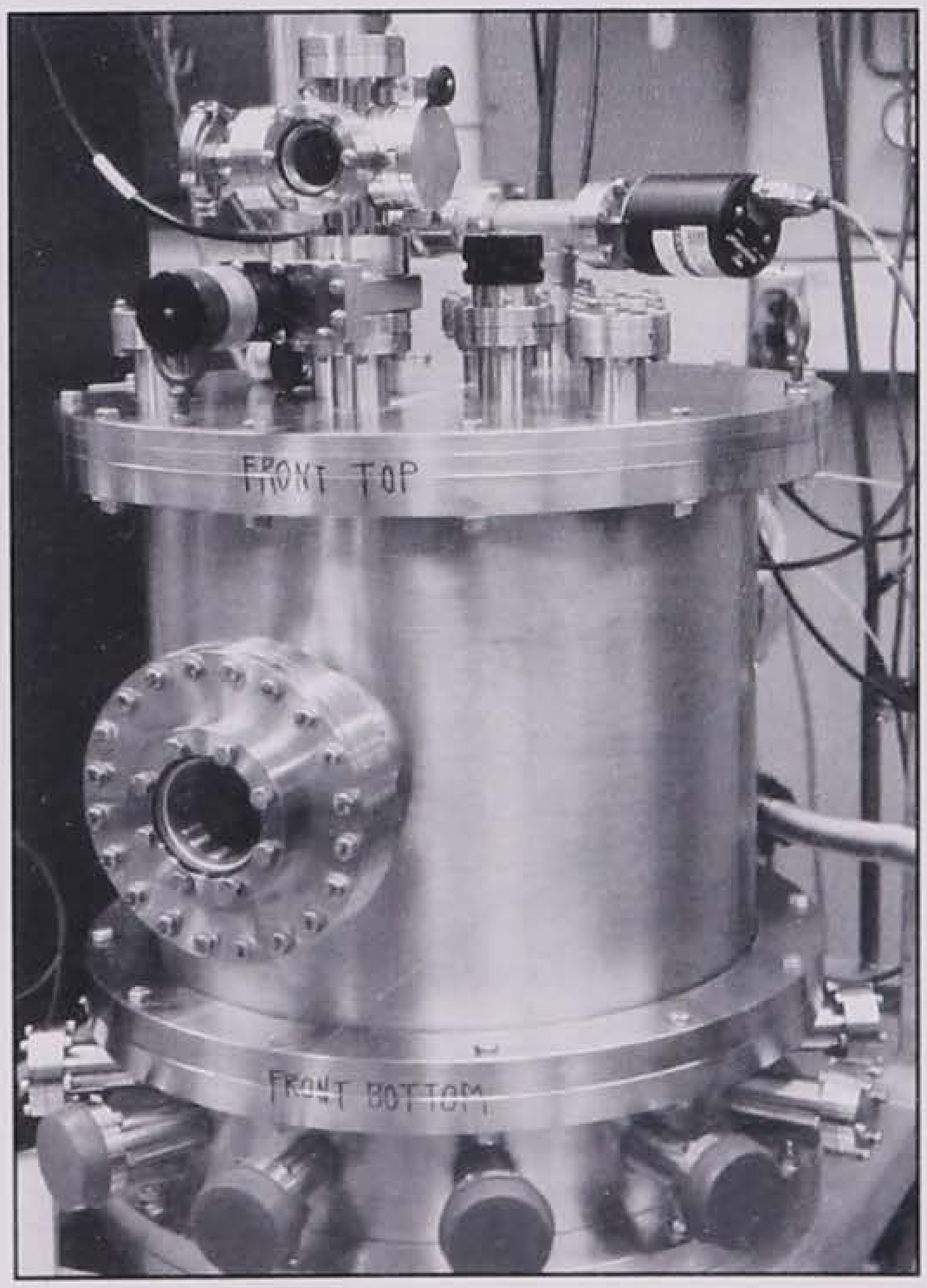
511, 512. Solid State Physics. Free electron model; crystal symmetry; band theory of solids; transport properties; Fermi surface; phonons; semiconductors; crystal surfaces; magnetism; superconductivity.

515. Physical Processes in Plasma. Ionization and breakdown phenomena. Description of plasma and basic concepts. Collision theory and Debye shielding. The Liouville theorem and the Boltzmann equation. Macroscopic properties of a Graduate Courses weakly ionized gas. Diffusion and mobility. Particle ballistics in a plasma. Solution of the Boltzmann equation. Plasma diagnostics, plasma oscillation. Thermionic and plasma diodes. The magnetohydrodynamic (MHD) generator. The gas discharge and the gas laser.

524. Nuclear Physics. Basic properties and structure of atomic nuclei, introduction to nuclear models, nuclear reactions, decay and stability; accelerators; nuclear astrophysics and nuclear physics at the quark-gluon level.

528. Atmospheric Physics. Physics of fluids as applied to the atmosphere: equations of motion, conservation laws; atmospheric waves, small to planetary scale; remote sensing by satellites.

531. Statistical Mechanics. Thermodynamic properties of systems of many particles obeying Boltzmann, Fermi-Dirac, and Bose-Einstein statistics; microcanonical, canonical, and grand canonical ensembles and their application to physical problems; density matrices, introduction to phase transitions; renormalization group theory; kinetic theory and fluctuations.



High vacuum system

535. Semiconductor Device Theory and Technology I. Basic elements of quantum theory, Fermi statistics, motion of electrons in periodic structures, crystal structure, energy bands, equilibrium carrier concentration and doping, excess carriers and recombination, carrier transport at low and high fields, phonons, optical properties, amorphous semiconductors, heterostructures, and surface effects.

536. Semiconductor Device Theory and Technology II. P-n junctions, band-bending theory, tunneling phenomena, Schottky barriers, heterojunctions, bipolar transistors, field-effect transistors, negative-resistance devices, LEDs and semiconductor lasers, solar cells, detectors.

537. High Energy Physics. Survey of particle physics; covariant kinematics and Lagrangians; the Standard Model and the Higgs mechanism, $W^{\pm}$ and Z^{0} production and decay; hadron spectroscopy, structure functions; running coupling constants; the CKM matrix; selected topics beyond the Standard Model such as supersymmetry and grand unification.

541. General Relativity. Tensor analysis and differential geometry developed and used to formulate Einstein field equations. Schwarzschild and Kerr solutions. Other advanced topics may include gravitational radiation, particle production by gravitational fields, alternate gravitational theories, attempts at unified field theories, cosmology.

551. Computational Physics. Use of modern computational techniques to analyze topics in classical and modern physics.

564. Advanced Classical Mechanics. Variational principles, Lagrange's equations, Hamilton's canonical equations, canonical transformations, Hamilton-Jacobi theory, infinitesimal transformations, classical field theory.

571, 572. Advanced Electricity and Magnetism.
571: Electrostatics, magnetostatics, boundary value problems, Maxwell's equations, wave phenomena in macroscopic media, wave guides.
572: Special theory of relativity; least action and motion of charged particles in electromagnetic fields, radiation, collisions between charged particles, multipole fields, radiation damping.

590. Special Topics. Topics of current interest. (A) Nuclear Physics. (B) Condensed Matter Physics. (C) High Energy Physics. (D) Physics. (E) Applied Physics.

591, 592. Quantum Physics. Time-dependent and time-independent Schrödinger equations for one, two and three-dimensional systems; bound systems; methods of quantum scattering; linear vector spaces; angular momentum theory and intrinsic spin; perturbation methods; identical particles and exchange effects; symmetries; applications in physics and chemistry.

599. Creative Component. Individually directed study of research-level problems for students electing the nonthesis M.S. degree option. Courses for Graduate Students, major or minor

Courses for Graduate Students, major or minor

611. Quantum Theory of Condensed Matter. Quasiparticles in condensed matter: phonons, magnons, photons, electrons. Quantum theory of interacting many body systems: Green's functions and diagrammatic techniques.

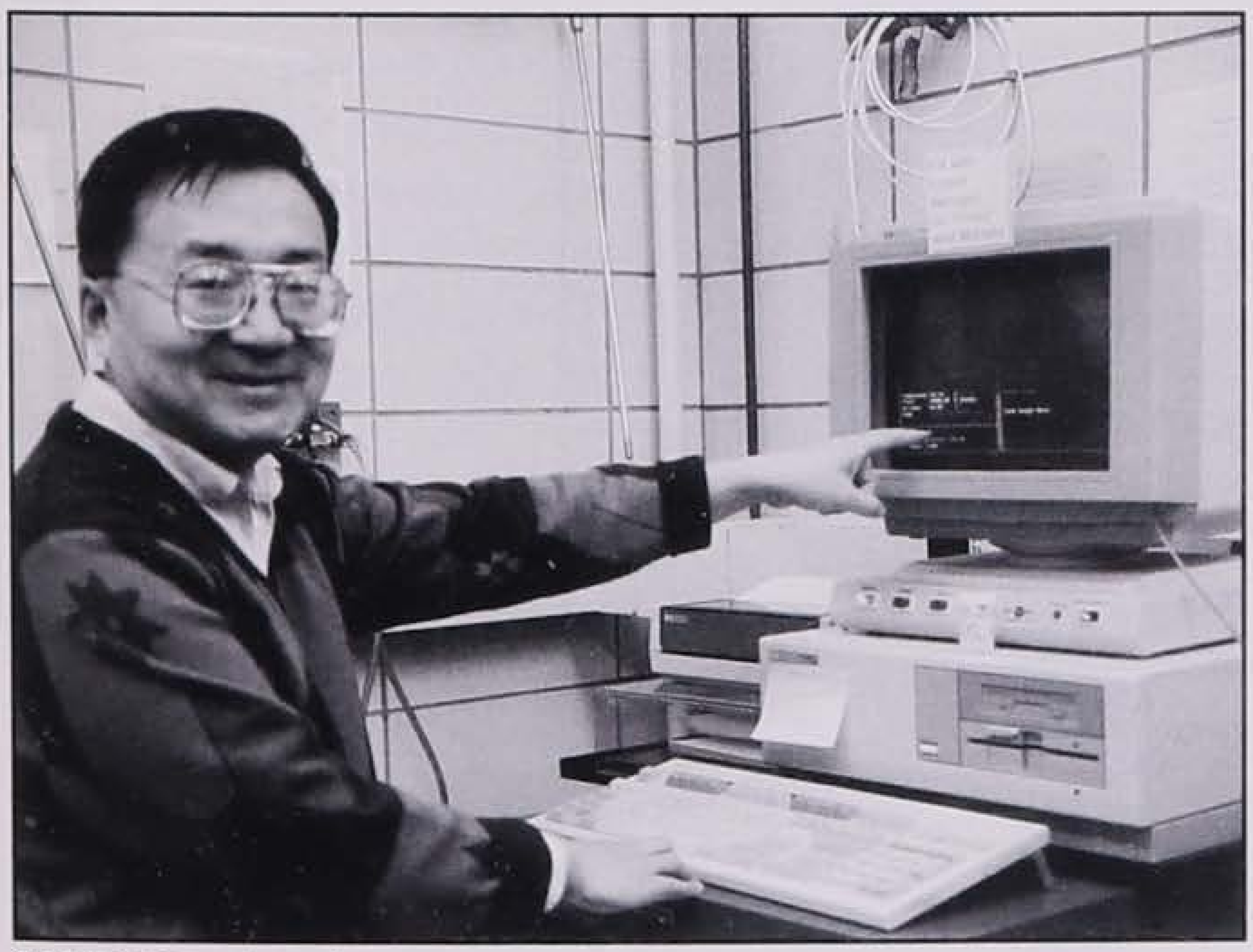
624. Advanced Nuclear Physics I. Microscopic fw-body and many-body theory; theory of effective Hamiltonians; relativistic nuclear physics; high-energy hadron-nucleus, lepton-nucleus, and nucleus-nucleus reactions.

625. Advanced Nuclear Physics II. Quantum field theory applied to nuclear structure and reactions; tests of the standard model in nuclei; phase transitions in hot and dense hadronic matter; quark-gluon plasma.

632. Semiconductor Physics. Band structure; statistical mechanics of electrons and holes; galvanomagnetic effects; magnetoresistivity, cyclotron resonance; transport properties; principles of junctions and heterostructures; optical properties; amorphous semiconductors; quantum well structures.

637, 638. Elementary Particle Physics. Properties of leptons, bosons, and quarks and their interactions; quantum chromodynamics, Glashow-Weinberg-Salam model, grand unification theories, supersymmetry, and superstring theory; modern theoretical techniques.

650. Advanced Seminar. Topics of current interest. Offered on a satisfactory-fail basis only. (A) Nuclear Physics. (B) Condensed Matter Physics. (C) High Energy Physics. (D) Physics. (E) Applied Physics.



SQUID magnetometer

660. Advanced Topics in Physics. Courses on advanced topics and recent developments. (A) Nuclear Physics. (B) Condensed Matter Physics. (C) High Energy Physics. (D) Physics. (E) Applied Physics.

674. Applications of Group Theory to Physics: Condensed Matter Physics. Theory of groups and group representations; point, space, and rotation groups; applications to molecular and crystal structures, crystal field and spin-orbit interactions, energy bands and phonon dispersion relations. Applications to modern materials.

675. Applications of Group Theory to Physics: Nuclear and High Energy Physics. Theory of Lie groups, Lie algebras, and their representations. Survey of the Lorentz group, Poincaré group, SU(3), and other Lie groups of physical importance. Applications to nuclear and elementary particle physics.

681. Advanced Quantum Mechanics. Relativistic quantum mechanics, second quantization; introduction to quantum electrodynamics.

682. Quantum Field Theory. Field quantization, functional integrals, Feynman rules and renormalization methods. Abelian and non-Abelian gauge theories.

699. Research.

Department of Physics and Astronomy

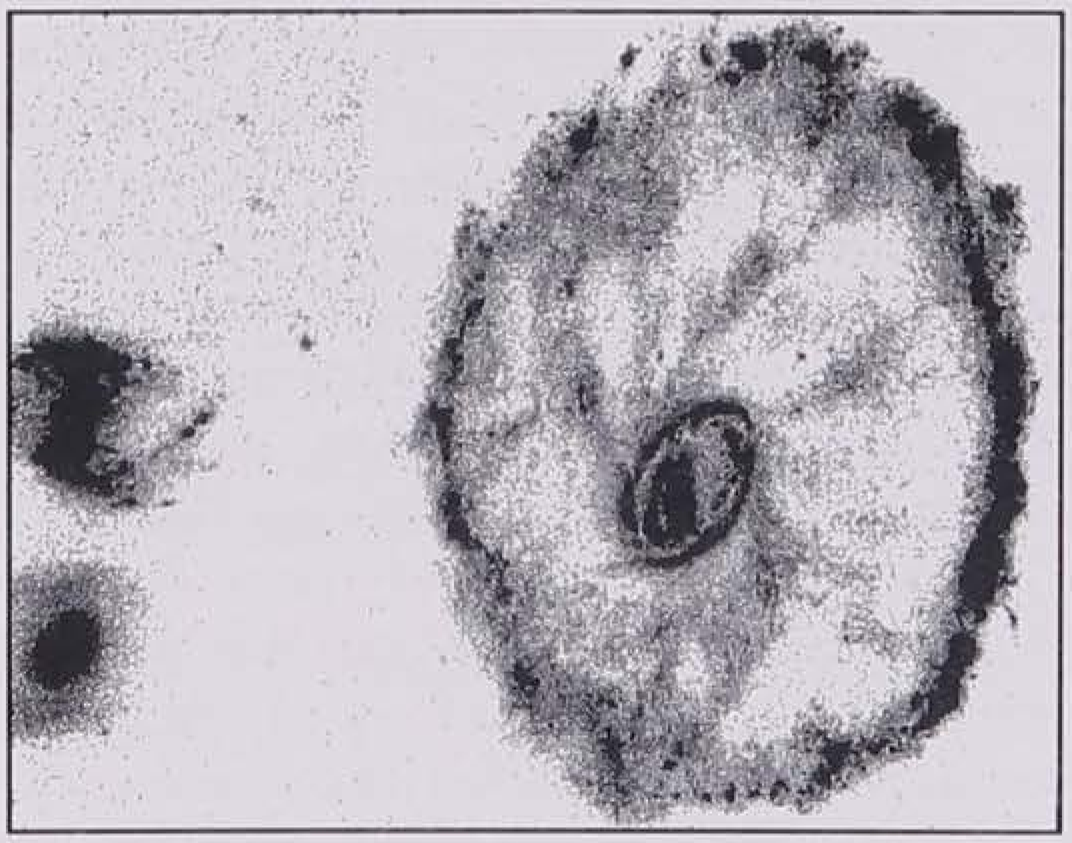
Astronomy and Astrophysics

Research programs in frontier topics in astronomy and astrophysics are carried out by six faculty members and one emeritus professor, with graduate and undergraduate student participation. Current research topics in theoretical astrophysics include stellar evolution, asteroseismology, variable star interiors and atmospheres, including atmospheric shock waves, mass loss processes, and the evolutionary consequences of mass loss; modeling of processes in galaxy formation and evolution; studies of galaxies in collision and of processes of star formation. Observational projects include observation and interpretation of gamma-ray sources, including supernova remnants and x-ray binary pulsars; observation and interpretation of colliding galaxies; young, distant galaxies; infrared and optical image processing methods; globally networked photometric observations of pulsating variable stars; and stellar radial velocity measurements for the study of binary systems.

ISU's Erwin W. Fick Observatory, 18 miles from campus, houses a 61-cm Cassegrain coude reflecting telescope with a unique high dispersion spectrometer. This instrument is used regularly for rapid high precision photoelectric radial velocity measurements for stars brighter than ninth magnitude. New instrumentation for the Fick Observatory includes an extremely sensitive CCD camera, similar to the one used on the Hubble Space Telescope. The CCD camera is used to make deep images of the universe, allowing studies to be made of extremely faint objects.

Iowa State faculty members have ongoing collaborations with colleagues at a number of other institutions. For example, our graduate students have recently used facilities at the Kitt Peak National Observatory in Arizona, the McDonald Observatory in Texas, observatories on Mauna Kea, Hawaii, the Very Large Array in New Mexico, as well as optical and radio telescopes in Australia. Gamma-ray observations are routinely made at the Whipple Observatory in Arizona. Data have also been obtained for the Hubble Space Telescope, the Infrared Space Observatory, and ROSAT X-ray telescope. Iowa State is a member of the Associated Universities for Research in Astronomy (AURA), which operates many of the national observatories.

A sequence of graduate astrophysics courses supplement the core physics curriculum for students who specialize in astronomy and astrophysics. Many of the students in the astronomy and astrophysics program are able to start research work early. All graduate students assist in the undergraduate teaching program, gaining valuable experience in the classroom and in the planetarium.



Hubble Space Telescope observations of the "Cartwheel" ring galaxy obtained by Drs. Appleton and Struck (and collaborators) are helping astronomers understand how galaxy collisions can influence galaxy evolution. The star-forming rings and spokes in the Cartwheel are probably formed as a consequence of a "bulls-eye" hit between one of the companion galaxies and the original Cartwheel disk.


Philip N. Appleton

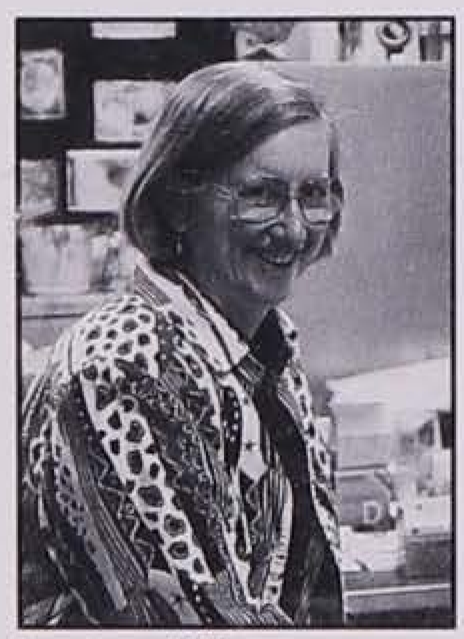
Philip N. Appleton, Associate Professor

B.S. Leicester, U.K. 1976, Ph.D. Manchester, U.K. 1980. "Samples of nearby galaxies selected as having high infrared luminosities contain large numbers of colliding, merging or interacting galaxies and are amongst the most luminous objects in the universe. Such systems often contain centrally concentrated 'starburst' nuclei or in some cases an Active Galactic Nuclei (AGN). At higher redshifts, quasars are being discovered embedded in host galaxies with collisional morphologies again suggesting that interactions and collisions may play a significant role in causing their nuclear activity. My research is directed at using radio, IR and optical observations of colliding and interacting galaxies to explore the physical consequences of gravitational interaction on their structure and star formation properties. This may well ultimately lead to a clearer understanding of the relations between starbursts and AGN's and the evolution of galaxies at high redshift as well as helping us to understand star formation mechanisms. In addition to local facilities at the ISU Fick Observatory, considerable use is made of national facilities and available spaceborne observatories and databases."

"The Neutral Hydrogen Disk of Arp 10: A Non-Equilibrium Disk Associated with a Galaxy with Rings and Ripples", *Astrophys. J.* 460, 686 (1996).

"The Head-on Collision between Two Gas-rich Galaxies: Neutral Hydrogen Debris from the Centrally Smooth Ring Galaxy VIIZw466", *Astrophys. J.* in press 1996.

"Kiloparsec Scale Bow-Shock Structures in the "Hub" of the Cartwheel Ring Galaxy", *Astron. J.*, in press 1996.


Lee Anne Willson

Lee Anne Willson, University Professor

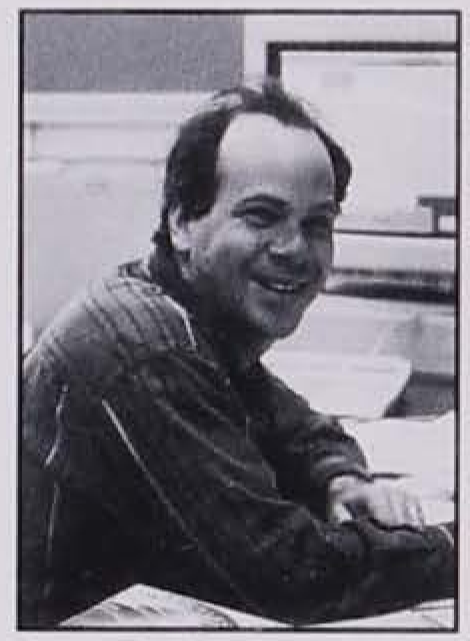
A.B. Harvard 1968, Ph.D. Michigan 1973. "Most of the light that astronomers gather comes from stars. Stars are the factories in which the most of the chemical elements are built. If we don't understand how stars evolve then we will misinterpret observations of the colors and chemical composition of galaxies, for example. My emphasis has been on trying to understand processes that drive mass loss, the effects of the resulting episodes of mass loss on stellar evolution, and the implications for the interpretation of observations. One very important episode of mass loss for a star like the Sun takes place near the end of its nuclear evolution: The star becomes a mass-losing Mira variable star and loses all but the "dead" core of carbon and oxygen at its center. G. Bowen (Prof. Emeritus), C. Struck and I have been able to demonstrate that this mass loss process depends on pulsation; that the effects of pulsation are augmented by formation of dust or by thermal pressure; and that most people have been grossly misinterpreting the observations of mass loss from these stars." Selected relevant papers:

"From Wind to Superwind: The Evolution of Mass Loss Rates for Mira Models", *Apl J.* 375, L53-56, 1991.

"Winds from Pulsating Stars", in *Cosmic Winds*, University of Arizona Press, Sonnett and Giampapa, eds., 1996.

"The metallicity dependence of terminal AGB luminosity", in *From Stars to Galaxies*, PASP Conference Series, Leitherer, ed., 1996.

Steven D. Kawaler, Associate Professor



Steven D. Kawaler

B.A. Cornell 1980, Ph.D. Texas 1986. "My principal research interests concern stellar evolution. In the effort to understand the properties of stars, pulsating stars frequently provide important probes of stellar structure, and give insight into their past and future evolution. In some cases, standard techniques for observational study of stars run up against physical limitations, and the pulsators lay a crucial role in filling out the evolutionary picture. My research therefore includes the application of stellar pulsation theory to problems in stellar evolution. Using data on stellar variations obtained using global networks of telescopes, we can detect and study many normal modes of oscillation in a certain stars. These "asteroseismological" studies allow us to probe stellar interiors in the same way that earthquakes have revealed the internal structure of the Earth. Through this new field of asteroseismology, we are learning about the inner workings of a wide variety of stars. Though my current research concentrates on the seismology of white dwarf stars, which represent the final evolutionary stage for stars like our Sun, I am also involved in seismic analysis of normal main sequence stars including the Sun itself."

"White Dwarf Stars", in *The 1995 Saas Fee Advanced Course in Astrophysics: Stellar Remnants,* ed. G. Meynet (Berlin, Springer—Verlag) (1996).

"Whole Earth Telescope Observations and Seismological Analysis of the Pre—White Dwarf PG 2131+066," *Astrophys. J.* 450, 350 (1995).

"Thick to Thin: The Evolutionary Connection Between PG 1159 Stars and the Thin Helium—Enveloped Pulsating White Dwarf GD 358," *Astrophys. J.*, (Letters) 445, L141 (1995).

"Precision Asteroseismology of Pulsating PG 1159 Stars," *Astrophys. J.*, 427, 415 (1994).

Curtis Struck, Associate Professor

Curtis Struck

B.S. Minnesota 1976, M. Phil. Yale 1978, Ph.D. 1981. "Observational studies show that colliding and interacting galaxies can form stars at a much higher rate than normal galaxies (so-called starbursts). They also suffer major dislocations and rearrangements of their dynamical components, and are more likely to experience nuclear (quasar) activity. Thus, interactions are a very important process in galaxy evolution. In collaboration with Phil Appleton and colleagues at other institutions, I am working on theoretical modeling and computer simulation of many aspects of the interaction phenomenon. This work includes N-body type modeling of the stellar dynamics, and numerical hydrodynamical modeling of the galactic gas dynamics. This work is also one expression of my more general interest in nonlinear dynamical systems, and specifically, the question of how the modern theories of bifurcations, chaos and singularities apply to star and galaxy evolution."

"Hydrodynamic Models of the Cartwheel Ring Galaxy", *Astrophys. J.* 411, 108 (1993).

"Observations and Models of the Sacred Mushroom: AM1724-622", *Astrophys. J.* 433, 631 (1994).

"Collisional Ring Galaxies", Fundamentals of Cosmic Physics, 16, 111 (1996).


Russell J. Lavery

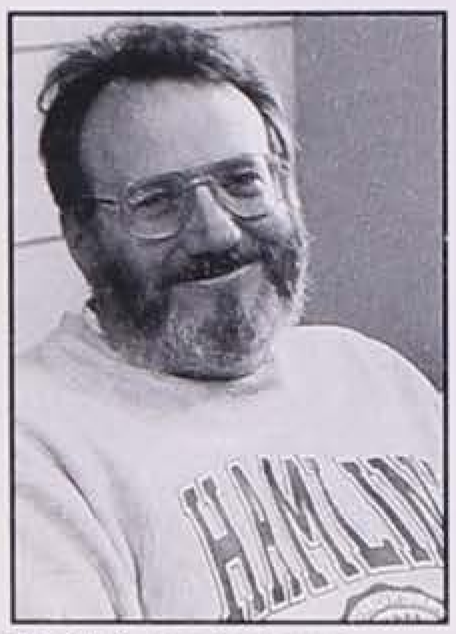
Russell J. Lavery, Assistant Professor

B.S. Massachusetts 1977, M.S. Hawaii 1983, Ph.D. Hawaii 1988. "Presently, clusters of galaxies provide the best means for the study of the cosmological evolution of galaxies. These clusters, which contain large numbers of luminous galaxies, are identifiable at great distances and are, therefore, observed when the universe was younger. My main research is the study of these cluster galaxies, through both photometric and spectroscopic observations, in order to understand the mechanisms which determine the rate of star formation in and the morphological appearance of these galaxies. The spectra reveal information about the star formation history of these galaxies and the imaging observations are used to determine their morphology. My most recent work has shown that a large fraction of the enhanced star-forming galaxies in distant clusters are members of interacting and merging systems of galaxies, suggesting these galaxy collisions are the cause of the observed star formation and that such collisions are much more prevalent in these clusters than previously believed. These interactions and mergers also play an important role in shaping the final morphology of these galaxies. In addition to studying the evolution of these cluster galaxies, I am involved in studying the gravitational lensing of much more distant galaxies behind these clusters, which produce curved images called arcs and arclets. This lensing provides a method for studying the total mass distribution in the cluster and can be compared with mass distributions determined from both the dynamics of the galaxies in the cluster and the structure of the hot x-ray gas associated with rich clusters."

"Observations of a High Surface Brightness Arclet in the Cluster of Galaxies GHO 2154+0508", *Astrophys. J.* 418, 43 (1993).

"Imaging of 'Butcher-Oemler' Blue Galaxies at a Redshift of 0.2", *Astrophys. J.* 426, 524 (1994).

"Distant Ring Galaxies as Evidence for a Steeply Increasing Galaxy Interaction Rate with Redshift", submitted to *Astrophys. J. Letters* (1995).


David A. Carter-Lewis

David A. Carter-Lewis, Professor

B.S. Michigan 1969, Ph.D. Michigan 1974. "My research is in ground-based very high energy gamma-ray astronomy. Observations are made using the atmospheric Cherenkov technique with a unique imaging telescope at Whipple Observatory in Southern Arizona. We study supernova remnants, highly magnetized, spinning neutron stars and active galactic nuclei."

"Outburst of TeV Photons from Markarian 421", *ApJ.* 438, L59 (1995).

"An Upper Limit to the IR Background from Observations of TeV Gamma-Rays", *ApJ.* 445, 227 (1995).

"Very High Energy Gamma-ray Emission from the Blazar Markarian 421", *ApJ.* in press. (1996).

"Detection of Gamma Rays with E>300 GeV from Markarian 501", *Ap.J (Letters)*, in press. (1996).

Department of Physics and Astronomy

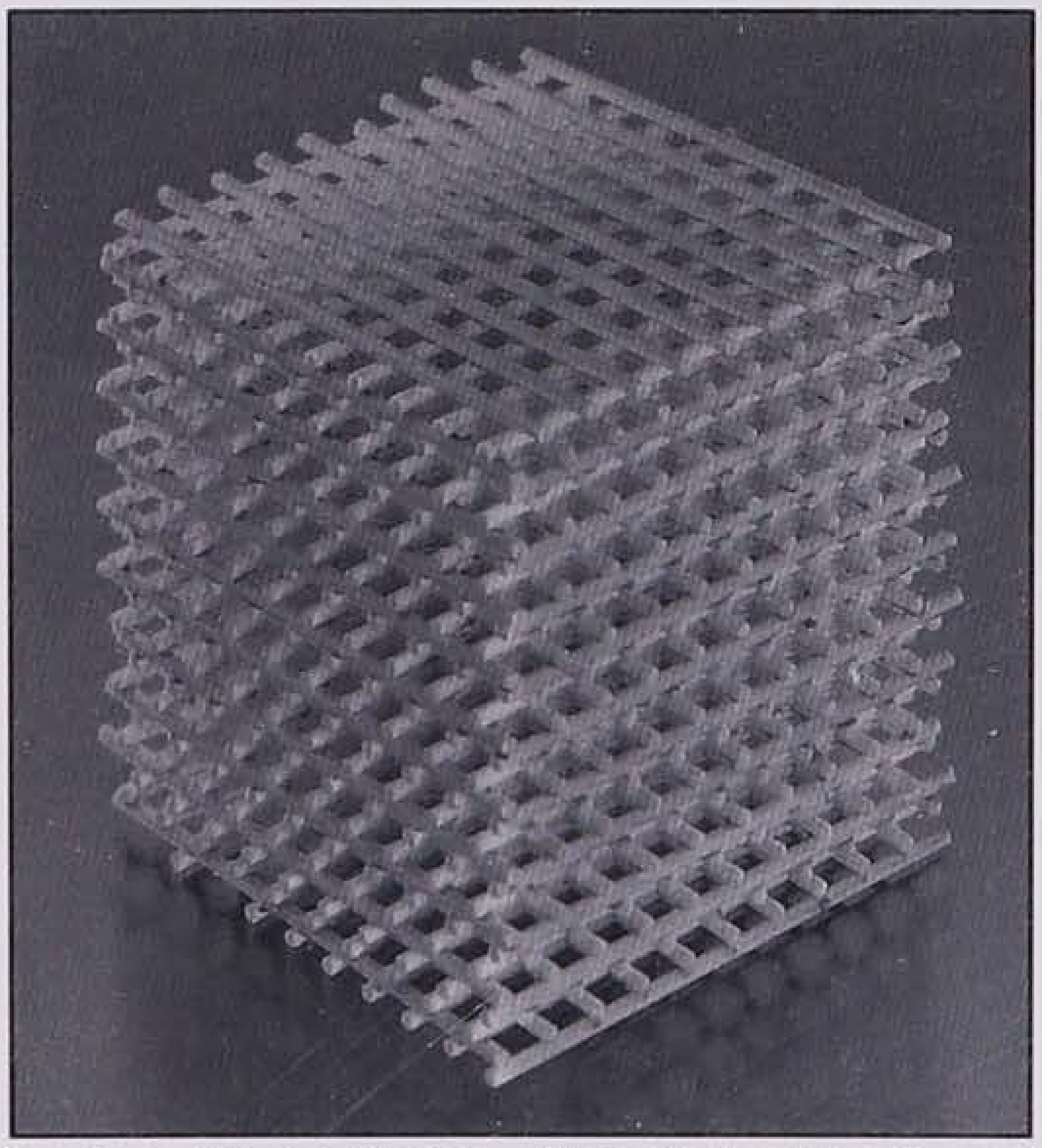
Condensed Matter Physics

The Condensed Matter Physics (CMP) group currently consists of 15 faculty (ten experimentalists and five theorists), along with nine permanent senior scientists, seven postdocs, about 40 graduate students, and many long- and short-term visitors. Most faculty members of the Condensed Matter Physics group also have appointments with the Ames Laboratory.

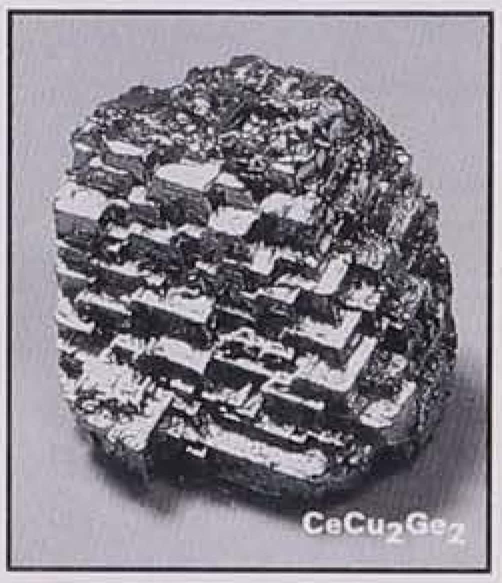
The facilities for CMP in the Physics building are outstanding, as might be expected for a research department with such an intimate involvement with the Ames Laboratory, an on campus federal facility owned by the United States Department of Energy and operated by the University. In addition to two rotating anode x-ray generators, there are five Quantum Design SQUID magnetometers in the department (the highest concentration in the world outside the company). There are numerous facilities for the synthesis of new materials and instruments to characterize their properties. Ultra high vacuum chambers and spectrometers are used for surface physics, lasers are used to probe ultra fast phenomena, and NMR is used to study phase transitions, electronic properties and ionic conduction. Superconductivity, magnetism, polymers, magneto-optical materials, superlattices, glasses, and quasicrystals are all topics of current interest.

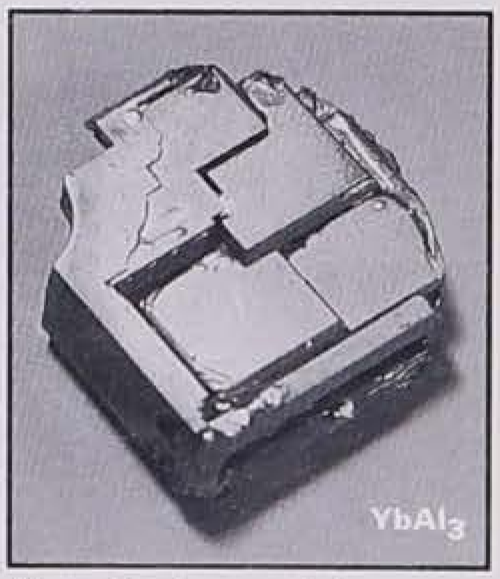
Many CMP faculty are active users of major national and international facilities. These include reactors for neutron scattering experiments, synchrotrons for extremely high intensity x-ray and ultraviolet probes of materials, and laboratories for high magnetic fields. Supercomputing centers with CRAY machines and massively parallel computers are routinely accessed by the theoretical groups who also have local smaller parallel computers and high performance workstations.

In competition with much larger National Laboratories during the last five years, CMP scientists have won a number of prestigious Department of Energy national awards. In 1989 John Clem won the award for Sustained Research for his work on superconductivity, in 1990 Ames Lab scientist Cliff Olson won the award for Outstanding Research for photoemission experiments on high Tc superconductors, in 1991 Doug Finnemore won the award for Research Related to Energy Technologies. Costas Soukoulis, Che Ting Chan and Kai Ming Ho won the 1992 award for Outstanding Research for their development of photonic bandgap materials, and in 1995 a team of eleven CMP scientists again won the Outstanding Research award, this time for studies of the simultaneous magnetic and superconducting properties of rare earth nickel boro-carbide compounds. In this same year another team of Ames Lab scientists led by Alan Goldman won the Sustained Research award for investigations of quasicrystals.

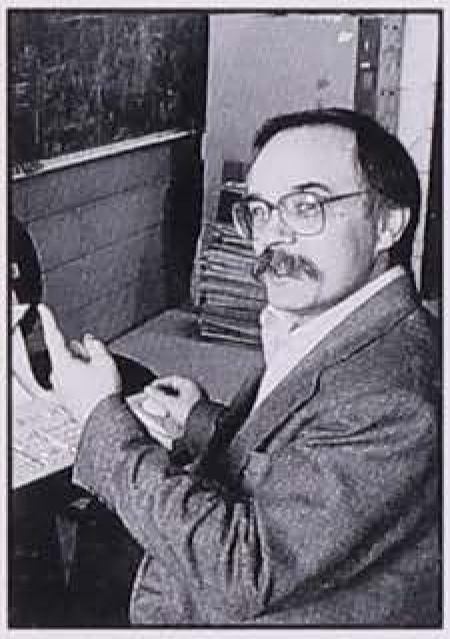


Condensed Matter Physics — Photonic Band Gap Crystal





Two single crystals



Bruce N. Harmon

Bruce N. Harmon, Distinguished Professor (AL)
Deputy Director, Ames Laboratory

B.Sc. I.I.T. 1968, Ph.D. Northwestern U. 1973. "My research is concerned with the superconducting, optical, magnetic and lattice dynamic properties of metals and alloys. Remarkable and continuing advances in computing power have made possible complete quantum mechanical calculations of materials properties. We are now able to understand and model at the atomistic level materials with properties desirable for industrial applications."

"Spin Dynamics in Magnets I. Equations of Motion and Finite Temperature Effects," *Phys. Rev.* B 54, 1019 (1996); and short version in *Phys. Rev. Lett.* 75, 729 (1995).

"Electronic Structure and Magneto-Optical Effects in Gd," *J. Phys. Chem. Solids* 56, 1521 (1995).

"Generalized Susceptibility and Magnetic Ordering in Rare Earth Nickel Boride Carbides," *Phys. Rev. B* 51, 15585 (1995).

John R. Clem

John R. Clem, Distinguished Professor (AL)

B.S. Illinois 1960, Ph.D. Illinois 1965. "The primary objective of my research program is to develop the theory for the electrodynamic behavior of current-carrying superconductors subjected to magnetic fields. At present I am studying the following properties of the high-temperature copper-oxide superconductors: anisotropy, vortex dynamics, flux pinning, critical currents, flux flow, ac losses, and Josephson- junction behavior."

"Correlation of Vortex Motion in High-Tc Superconductors," *Phys. Rev. Lett.* 74, 2796 (1995).

"Local Time-dependent Magnetization of Superconducting Films in the Presence of a Transport Current," *Phys. Rev. B* 51, 9111 (1995).

"Measurement of the True ac Power Loss of Bi-2223 Composite Tapes Using the Transport Technique," *Appl. Phys. Lett.* 67, 3189 (1995).

"Instability of a Tilted Vortex Line in Magnetically Coupled Layered Superconductors," *Phys. Rev. B* 53, 438 (1996).

Ferdinando Borsa

Ferdinando Borsa, Professor (AL)

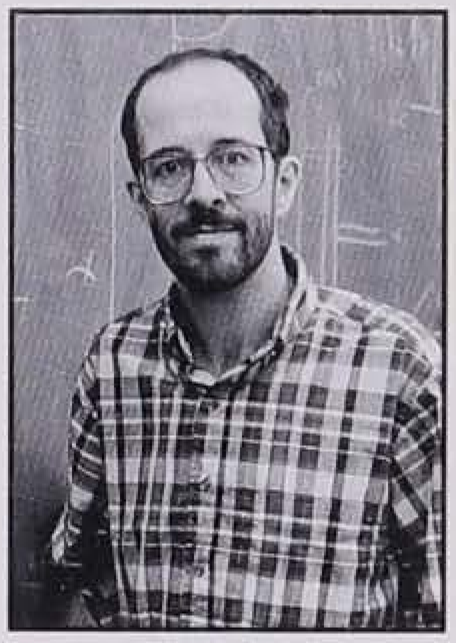
Laurea (M.S.) Pavia 1961, Libera Docenza (Ph.D.) Pavia 1969. "My main research interests are in the general domain of static and dynamic collective effects and phase transitions in condensed matter investigated by means of Nuclear Magnetic and Nuclear Quadrupole Resonance and Relaxation. The areas of research in which I have been involved recently include: (a) Electronic and magnetic properties of High-Tc superconductors and related materials; (b) Ionic dynamics i fast ions conductors; (c) Martensitic phase transitions and quasicrystals; (d) Magnetism, in low dimensional systems."

"Spin Correlations and Magnetic Field Effects in the Weakly Anisotropic Square-Lattice Antiferromagnet $Sr_2CuO_2Cl_2$", *Phys. Rev. Letters* 75, 2212 (1995).

"NMR and NQR Study of the Electronic and Structural Properties of Al-Cu-Fe and Al-Cu-Ru Quasicrystals", *Phys. Rev. B* 50, 15651 (1994).

"Fluxon Thermal Motion Detected by Nuclear Spin Echo Decay Measurements: 89Y NMR in $YBa_2Cu_3O_7$", *Phys. Rev. Letters* 71, 3011 (1993).

Paul C. Canfield, Assistant Professor (AL)



Paul C. Canfield

B.S. University of Virginia 1983, Ph.D. University of California, Los Angeles 1990.

"My general interests are in the low temperature magnetic and electronic ground states of new and exotic materials. This includes superconductivity, metal-to-insulator transitions, ferro- and antiferromagnetic transitions, Kondo lattices and heavy fermion materials. I pursue these general interests by i) the design, growth and discovery of new materials, primarily in single crystal form, and ii) measuring the anisotropic, magnetic field and temperature dependent magnetization and electro-transport properties. To state it simply: I grow single crystals of intermetallic and oxide compounds and measure the magnetic susceptibility and electrical resistivity of them as a function of temperature. I currently have active research efforts in magnetic superconductors, heavy fermion and mixed valent compounds, potential hard ferromagnetic materials, and the study of meta-magnetic transitions. In general students working in my group learn both crystal growth and measurement techniques."

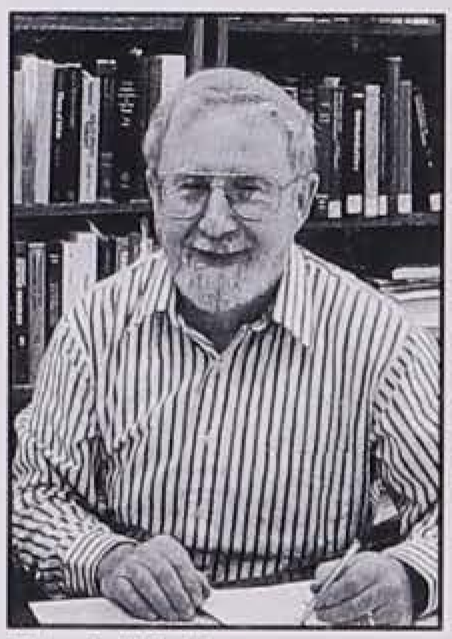
"Breakdown of de Gennes Scaling in $(R_{1-x}R'_x)$ Ni_2B_2C Compounds", *Phys. Rev. Lett.* 77, 163 (1996).

"Possible co-existence of superconductivity and weak ferromagnetism in $ErNi_2B_2C$", *Physica C* 262, 249 (1996).

"Onset of Superconductivity in the Antiferromagnetically Ordered State of Single Crystal $DyNi_2B_2C$", *Phys. Rev. B* 52, R3844 (1995).

"Growth of Single Crystals from Metallic Fluxes", *Philosophical Magazine B* 65, 1117 (1992).

Marshall Luban, Professor (AL)



Marshall Luban

B.A. Yeshiva 1957, M.S., Ph.D. Chicago 1962.

"My research interests are primarily in theoretical condensed matter physics. At present I am devoting major emphasis to the theoretical modeling of quantum nanostructures using both analytical and computational methods. Specifically, this research deals with the equilibrium properties as well as the dynamical characteristics of ultra-compact (spatial dimensions of several hundred Angstroms) and ultra-fast (pico-second switching times) on/off semiconductor heterostructures which operate according to the laws of quantum mechanics. There is a rapidly growing interest world-wide in quantum nanostructures because their extremely small size and fast switching characteristics makes them, at least in principle, ideally suited as the building blocks of a new generation of ultra-small and ultra-fast computers. To successfully model these novel systems requires the application of a broad spectrum of methods of quantum mechanics and quantum statistical mechanics."

"Bloch Oscillations and other Dynamical Phenomena of Electrons in Semiconductor Superlattices", *Phys. Rev. B* 52, 5105 (1995).

"Massive Interminiband Transitions Triggered by Strong Static Electric Fields in Superlattices", in Hot Carriers in Semiconductors, edited by K. Hess, J-P Leburton, and U. Ravaiolli (Plenum, New York, 1996).

"Semiconductor Superlattices as Terahertz Generators", *Phys. Rev. B* 47, 6815 (1993).

David Johnston

David Johnston, Professor (AL)

B.A. University of California-Santa Barbara 1969, Ph.D. University of California-San Diego 1975. "Our research encompasses three general interrelated areas: (1) Synthesis of new materials systems using various ceramic and metallurgical techniques; (2) Characterization and physical measurements of these using x-ray diffraction, thermal analysis, magnetic susceptibility, heat capacity, and electronic transport measurements; and (3) Modeling the data and comparing with behavior predicted by theory. Our current emphasis is in the area of high Tc oxide superconductivity, where we are synthesizing new materials and attempting to understand the basic mechanism for the phenomenally high Tc's. The correct mechanism will ultimately be determined by comparison of theoretical predictions with such experimental data."

"Phase Separation and Finite Size Scaling in $La_{2-x}Sr_xCuO_{4+y}$ $[0 \leq (x,y) \leq 0.03]$," *Phys. Rev. Lett.* 70, 222 (1993).

"Antiferromagnetic Ordering and Paramagnetic Behavior of Ferromagnetic Cu_6 and Cu_{18} Clusters in $BaCuO_{2+x}$," *Science* 264, 402 (1994).

"Onset of Superconductivity in the Antiferromagnetically Ordered State of Single Crystal $DyNi_2B_2C$," *Phys. Rev. B* (Rapid Commun.) 52, R3844 (1995).

"Antiferromagnetic Exchange in Two-Leg Spin-1/2 Ladders," *Phys. Rev. B* (submitted).

Douglas K. Finnemore

Douglas K. Finnemore, Distinguished Professor (AL), Chair

B.S. Penn State 1956, Ph.D. Illinois 1962. "My research interests are primarily in superconductivity. Typical problems include a study of the new high transition temperature superconductors, studies of the superconducting wave function near a superconductor-normal metal boundary, studies of the motion of quantized vortices relevant to superconducting devices. Recently, there has been an emphasis on "in-situ" high temperature x-ray studies of high transition temperature materials."

"Thermal Depinning of a Single Superconducting Vortex in Nb", *Phys. Rev. B* 50, 12,770 (1994).

"Reversible Magnetization, Critical Fields, and Vortex Structure of Grain Aligned $YBa_2Cu_4O_8$", *Phys. Rev. B* 51, 6035 (1995).

"Stability of Pb-Doped $Bi_2Sr_2Ca_1Cu_2O_8$", *Appl. Phys. Lett.* 66, 3359 (1995).

Costas M. Soukoulis, Professor (AL)


Costas M. Soukoulis

B.S. Athens, Greece 1974, Ph.D. Chicago 1978.
"My present research interest is to develop a theoretical understanding of the properties of disordered systems with emphasis on electron and photon localization, photonic band gaps, random magnetic systems (spin glasses and random fields), effects of disorder on nonlinear problems and amorphous semiconductors. In the localization area we study the conditions under which localization or propagation of waves in disordered systems take place in either one, two, or three dimensions; this is a fundamental problem that is directly related to transport properties of amorphous solids. In the areas of spin glasses and random fields the emphasis is to understand the properties of these rather unique systems in which both glassy (metastable) and phase transitions phenomena are simultaneously present. Finally, our group is involved in studies of the phonon and electronic density of states of computer-generated models of amorphous semiconductors."

"Propagation of Classical Waves in Random Media," *Phys. Rev. B* 49, 3800 (1994).

"Photonic Band Gaps in 3D: New Layer-by-Layer Periodic Structures," *Sol. State Comm.* 89, 413 (1994).

"Electron-Phonon Interaction, Localization and Polaron Formation in 1D Systems," *Phys. Rev. B* 51, 15038 (1995).

"Transport Properties of Random Media: A New Effective Medium Theory," *Phys. Rev. Lett.* 75, 3442 (1995).

David W. Lynch, Distinguished Professor (AL)
Director of Microelectronics Research Center


David W. Lynch

B.S. Renesselaer 1954, Ph.D., Illinois 1958.
"Our work deals with the optical properties of solids and with photoelectron spectroscopy of solids and surfaces, the latter being the larger part of the effort. For all of the latter we use synchrotron radiation from an electron storage ring, with photons in the energy range 5-800 eV. Materials of current interest are high Tc superconductors, Ce-based compounds, and heavy Fermion systems, the latter two manifesting the problem of how best to describe the nature of the 4f or 5f state-localized or delocalized. In these and in all other studies, the goal is to understand the electronic structure of solids over a wide energy range."

"A New Mestastable Nonmetallic Phase of Europium," *Phys. Rev. Letters* 74, 992 (1995).

"Electronic Band Dispersion and Pseudogap in Quasicrystals: Angle-resolved Photoemission Studies in Icosahedral $Al_{70}Pd_{21.5}Mn_{8.5}$", *Phys. Rev. Lett.* 75, 4540 (1995).

"Valence Band Dispersion in Angle-Resolved Resonant Photoemission from LaSb", *Phys. Rev. Letters* (submitted).

Kai-Ming Ho

Kai-Ming Ho, Professor (AL)

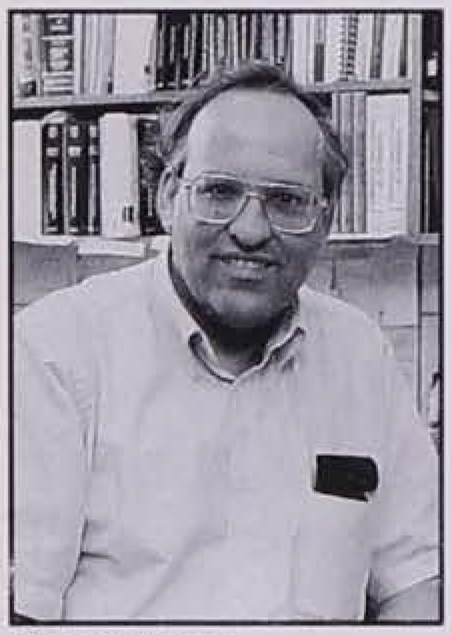
B.S. University of Hong Kong 1973, Ph.D. University of California-Berkeley 1978. "Our group is active in the following areas in computational condensed matter physics: (1) Properties of clean and adsorbate-covered crystal surfaces in vacuum and electrolyte; (2) Materials with strong covalent bonding, e.g. carbon fullerenes, amorphous carbon, graphite; (3) Problems in material science, e.g. point defects and impurities in crystals, displacive phase transitions; (4) Propagation of electromagnetic waves in periodic dielectric structures, design and fabrication of materials with photonic band gaps."

"Calculating accurate free energies of solids directly from simulations", *Phys. Rev. Lett.* 74, 940 (1995).

"Defect structures in a layer-by-layer photonic band gap crystal", *Phys. Rev. B* 51, 13961 (1995).

"Anomalous Phonon Behavior and Phase Fluctuations in bcc Zr", *Phys. Rev. Lett.* 74, 1375 (1995).

"Molecular geometry optimization using a genetic algorithm", *Phys. Rev. Lett.* 75, 288 (1995).



Joseph Shinar

Joseph Shinar, Professor (AL)

B.Sc. 1972, M.Sc. 1974, Ph.D. 1980, Hebrew University, Jerusalem, Israel. "My research involves fabrication, processing, and characterization of thin films and devices of hydrogenated amorphous Si and related materials, porous Si, thin diamond films, „-conjugated polymers, and fullerenes. Fabrication techniques include rf sputtering, chemical vapor deposition, e-beam, and thermal evaporation, and spin coating. Characterization techniques include UV-Vis-NIR-IR absorption spectroscopies, conductivity, photoconductivity, photoluminescence, electroluminescence, electron spin resonance, and optically detected magnetic resonance. They address fundamental issues in the photophysics of the thin films, photovotaic cells, and light-emitting diodes made from these materials, which directly impact their performance."

"Microvoid, Si, H, and Al Dynamics in a-Si:H/Al_2O_3 /Al Structures: A Small-Angle X-Ray-Scattering and Infrared-Absorption Study," *Phys. Rev. B* 50, 7358 (1994).

"Photoluminescence and Auger Spectroscopy of Porous Si: Solvent, Reactive Ion Etching, Annealing, and Substrate Boron Level Effects", *J. Appl. Phys.* 77, 3403 (1995).

"A Comprehensive Photoluminescence Detected Magnetic Resonance Study of C_{60} and C_{70} Glasses and Films", *Phys. Rev. B* 51, 10028 (1995).

"Symmetric Light Emitting Diodes from Poly (p-diethynylene phenylene)(p-dephenylene vinylene) (PDEPDPV) Derivatives", *Appl. Phys. Lett.* 67, 3960 (1995).

"Optically Detected Magnetic Resonance Study of Efficient Two-Layer Conjugated Polymer Light Emitting Diodes", *Phys. Rev. B* 53, 13528 (1996).

Alan Goldman, Professor (AL)

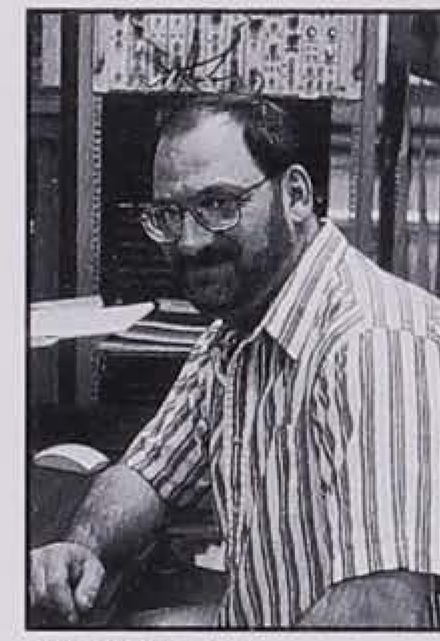
B.S. SUNY, Stony Brook 1979, Ph.D., SUNY, Stony Brook, 1984. "My research involves the use of x-ray and neutron scattering techniques to study the structure and dynamics of interesting materials. My most recent research interests include magnetic x-ray scattering measurements of magnetic phase transitions, circular magnetic x-ray dichroism (CMXD), the structure of, and disorder in, icosahedral phase alloys, and the interplay between magnetism and superconductivity in the magnetic superconductors."

"Quasicrystals and Crystalline Approximants", *Rev. Mod. Phys.* 65, 213 (1993).

"Confirmation of quadrupolar transitions in circular magnetic x-ray dichroism of the dysprosium L_3-edge," *Phys. Rev. Lett.* 74, 4935 (1995).

"Magnetic Pair Breaking in $HoNi_2B_2C$", *Phys. Rev. B* 50, 9668 (1994).

"The Magnetic Structure of $GdNi_2B_2C$ by Resonant and Nonresonant X-ray Scattering," *Phys. Rev. B* (in press).



Alan Goldman

Constantine Stassis, Professor (AL)

B.S. Lausanne, Switzerland 1960, Ph.D MIT 1970. "My research is directed toward an understanding, on the microscopic level, of the magnetic and dynamical properties of solids using neutron scattering techniques. Recent neutron scattering investigations include studies on the electron-phonon interaction in superconducting solids, the magnetic properties of high-temperature superconductors, the temperature properties of metals, in particular of the heavy-fermion and mixed valence systems. The neutron scattering research is conducted using neutron scattering facilities at the High Flux Isotope Reactor (HFBR), Oak Ridge National Laboratory, and the Intense Pulsed Neutron Source (IPNS) at Argonne National Laboratory."

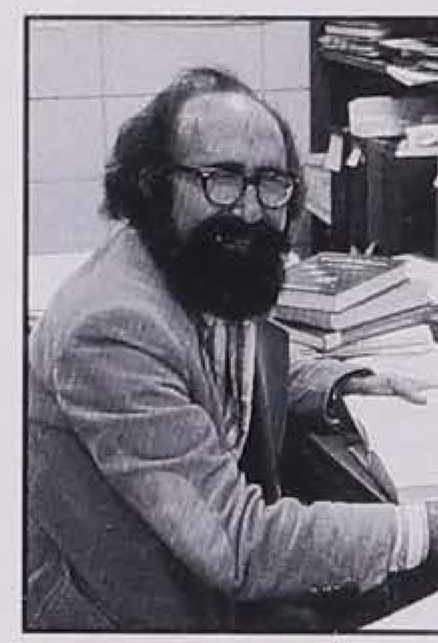
"Soft Phonons in Superconducting $LuNi_2B_2C$," *Phys. Rev. B* 52, 9839 (1995).

"Observation of Oscillatory Magnetic Order in the Antiferromagnetic Superconductor $HoNi_2B_2C$," *Phys. Rev. Lett.* 75, 2628 (1995).

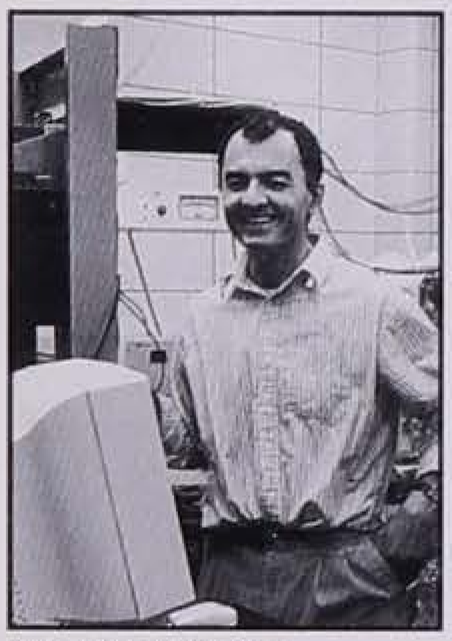
"Magnetic Structure of $DyNi_2B_2C$," *Physica B* 212, 1 (1995).

"Magnetic Structure of $ErNi_2B_2C$," *Phys. Rev.* 51, 678 (1995).

"Incommensurate Antiferromagnetism in the Intermetallic Superconductor $HoNi_2B_2C$," *Phys. Rev. B* 53, 3487 (1996).



Constantine Stassis



Michael Tringides

Michael Tringides, Associate Professor (AL)

B.A. Yale 1977, Ph.D. Chicago 1984. "My interests involve the study of growth phenomena at the atomic scale on clean surfaces, to control the fabrication of nanostructures. The characterization of the structures is obtained with quantitative diffraction (high resolution-LEED, RHEED) and scanning tunneling microscopy (STM). Time-dependent measurements of the evolution of the grown structures provide important parameters controlling the growth, like surface diffusion coefficients. Our goal is to understand how layer-by-layer growth is obtained during epitaxy so defect-free films are produced. We also attempt to correlate the film morphology with its 2-d conductivity to understand electron transport in low-dimensional systems."

"Flux Dependence of the Ag/Si(111) Growth", *Europhys. Letters* 23, 257 (1993).

"Low Temperature Growth Mechanism of RHEED Oscillations", *Phys. Rev. B* 50, 10932 (1994).

"Flux Dependence of in-site Transport in Ag/Si(111)", *Jour. of Vac. Sci & Tech.A* 13 (2) 462 (1995).

"Surface Diffusion Measurements from STM Tunnelling Current Fluctuations", *Europhys. Letters* 30 (x) 537 (1995).

Stefan Zollner

Stefan Zollner, Assistant Professor (AL)

B.S. 1983 Universität Regensburg, Germany; M.S. 1987, Ph.D. 1991, Universität Stuttgart, Germany. "The macroscopic speed of an electronic or electro-optic device (say, a transistor, a semiconductor laser, or a magneto-optic disk) is ultimately limited by microscopic scattering time of two elementary excitations (electrons, holes, phonons, magnons, etc.) We study the dynamics of such ultrafast processes with pump-probe spectroscopy using a femtosecond titanium-sapphire laser and compare the experimental data with microscopic theoretical calculations. Most recently, we determined the fundamental physical constants for intervalley transfer limiting high-field electronic transport in germanium. We are also interested in the steady-state optical properties (dielectric function, band structure, Kerr angle) of novel materials (for example $Si_{1-x-y}Ge_xC_y$ alloys or new transition metal compounds for magneto-optics). For this purpose, we are use a spectroscopic ellipsometer, a magneto-optic Kerr effect (MOKE) setup, and a superconducting 8 Tesla-magnet."

"Short-range deformation-potential interaction and its application to ultrafast processes in semiconductors", *Semicond. Sci. Technol.* 7, B137 (1992).

"Conduction-band states and surface core excitations in InSb(110) and other III-V compounds", *Phys. Rev. B* 50, 7384 (1994).

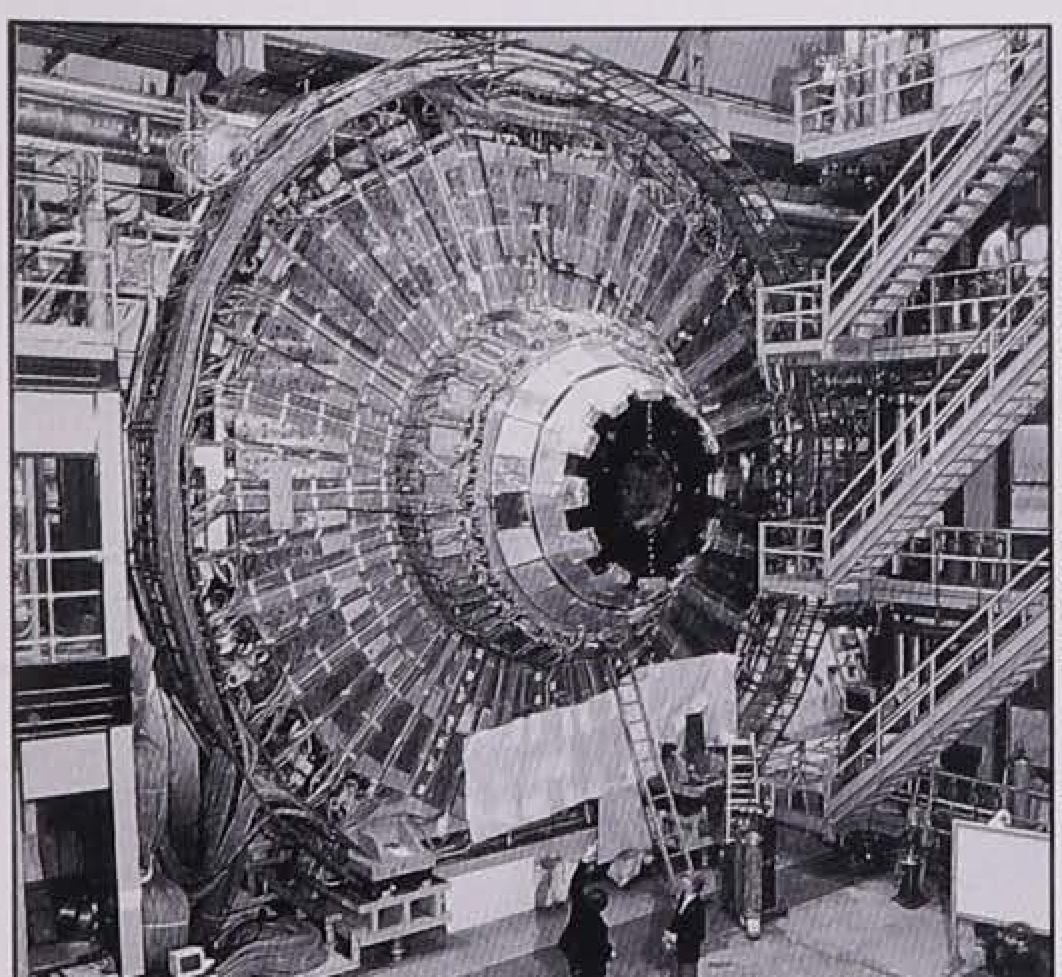
"Theory of optical interband transitions in strained $Si_{1-y}C_y$ alloys grown pseudomorphically on Si(001)", *J. Appl. Phys.* 78, 5209 (1995).

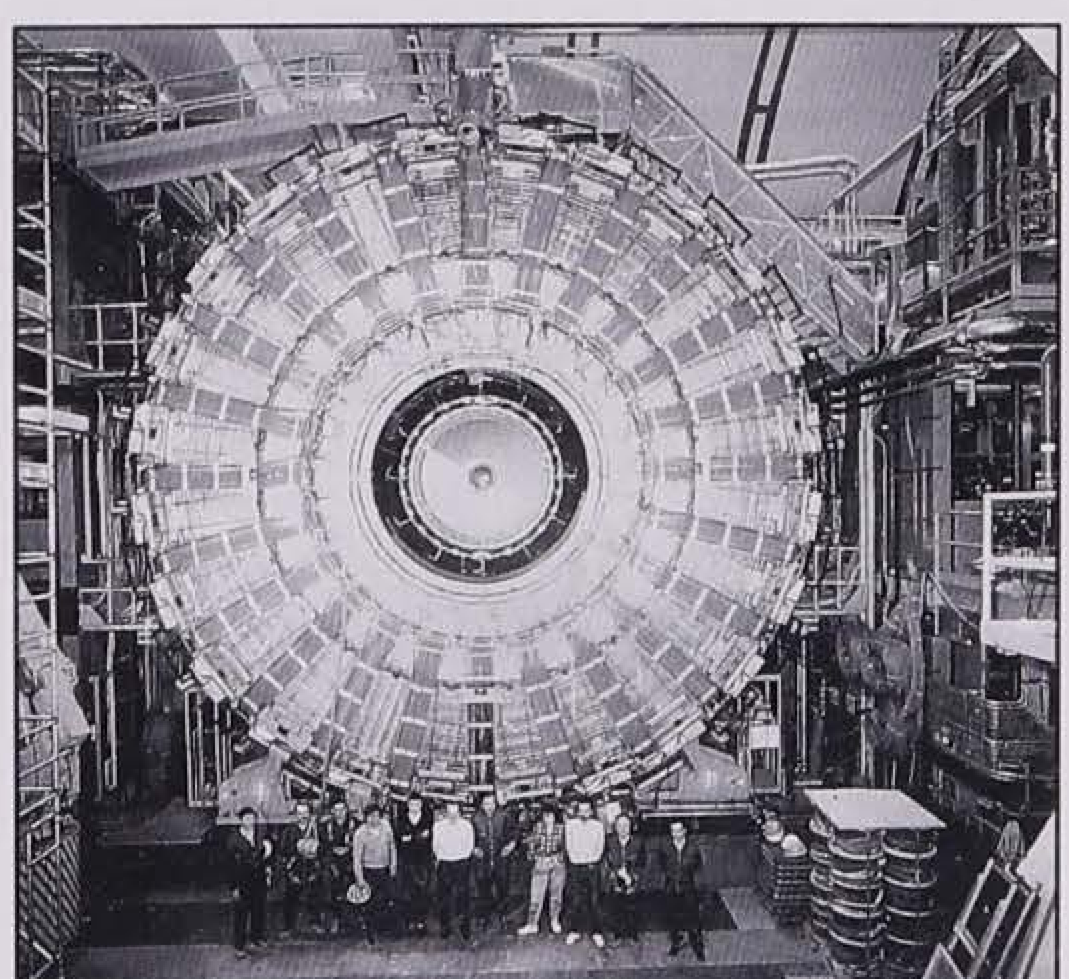
Department of Physics and Astronomy

High Energy Physics

The research program in High Energy Physics includes major efforts in both experimental and theoretical particle physics. The experimental program is composed of two groups, Alpha & Ames, emphasizing studies at collider beam accelerators. Experiments focus not only on the so-called "standard model" and the quark structure of hadronic matter, but also investigate the existence of new phenomena. The theoretical program includes studies of electroweak interactions, neutrino physics, extensions to the Standard Model (including supersymmetry and technicolor models), and Quantum Chromodynamics (QCD).

On July 14, 1989, the Large Electron-Positron (LEP) collider located at the European Laboratory for Particle Physics (CERN) was commissioned and one month later produced its first e^+e^- collisions. Within 24 hours of these first collisions, the DELPHI experiment detected its first neutral intermediate vector boson, the Z particle. This was the culmination of over six years work by the Ames experimental group. The physics goals include studies of the vector bosons (Z and W), massive spontaneous symmetry-breaking bosons (Higgs particles), heavy leptons, new quarks, as well as studies of how the fundamental partons (quarks and gluons) materialize as hadrons. Early results have shown that the number of light neutrinos is three and have extended the lower bounds on the masses of new particles. The maximum energy of the LEP collider has been increased making it the world's highest energy e^+e^- collider. By the end of 1996, DELPHI will collect data on $e^+e^- \longrightarrow W^+W^-$. For the DELPHI experiment, the Ames group has designed and constructed readout electronics for the High-Density Projection Chamber (HPC) barrel electromagnetic calorimeter component of the DELPHI detector. The HPC is a novel device which records electron drift times in a gaseous medium interspersed with a lead radiator to measure a complete three-dimensional energy profile of an electromagnetic shower. The readout required the construction of 20,000 channels of state-of-the-art waveform digitizers.





Two views of the DELPHI detector currently collecting data at the large Electron-Positron (LEP) Collider located at the European Laboratory for Particle Physics (CERN) in Geneva, Switzerland. On the left a view of one of the end-cap detectors; on the right the barrel or central region of the detector. In both pictures, the moveable counting rooms which house the readout electronics for the detector are visible. Iowa State University is the only U.S. Member of the DELPHI collaboration. Iowa State physicists designed and built 20,000 channels of state-of-the-art readout electronics for this experiment.

The Alpha group is presently working at the Fermilab Tevatron Collider, which provides the world's highest energy proton-antiproton collisions. In the D-zero experiment, this group has measured the mass of the top quark. D-zero is currently being upgraded to accept the higher event rates that will be available in 1999. To study proton-proton collisions at the highest possible energies, the Alpha group is collaborating on the CMS experiment for the CERN Large Hadron Collider (LHC). The Ames group is also a member of the BABAR collaboration at the SLAC asymmetric B-factory. The primary goal of this experiment is a study of the origins of CP-violations.

The theoretical program features research in both basic theoretical formalisms and phenomenology, with an emphasis on the latter. Current theoretical research consists of the following areas: (1) E6 electroweak phenomenology, including new gauge bosons and exotic fermions; (2) ideas beyond the Standard Model, including technicolor, compositeness and non-standard unification groups; (3) the Standard Model and extensions, including fourth generation and multi-Higgs models; (4) radiative corrections and new physics; (5) Quantum Chromodynamics and strong interaction phenomenology; and (6) dynamic symmetry breaking and the chiral quark model. The more formal investigations include a study of the high energy behavior of supersymmetric field theories.


Alexander Firestone

Alexander Firestone, Professor

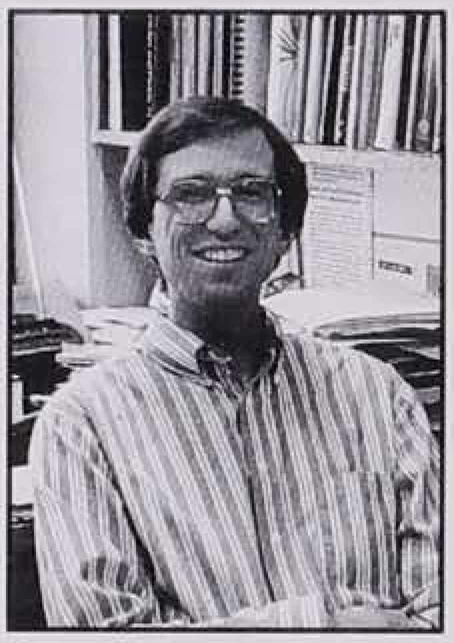
B. S. Columbia 1962, Ph.D. Yale 1966. "I am interested in studying the standard model of strong and electroweak interactions, and also in trying to discover what exists beyond the standard model. To that end, I am currently working on a major study of e^+e^- annihilations at the highest available energies using the DELPHI detector at the LEP collider at the CERN Laboratory in Geneva, Switzerland. Of foremost importance are studies of the Z^- boson, searches for Higgs particles, heavy leptons, new quarks, supersymmetric particles and other phenomena beyond the standard model. Since LEP turn-on in late 1989, DELPHI has collected more than 4.5 million Z° decays. We have measured the mass, width, and decay branching fractions of the Z°, and have shown that there are exactly three generations of quarks and leptons. We have also set stringent limits on new phenomena beyond the standard model, as listed above. I am in charge of the DELPHI analysis of single photon events and of hadronic Z decays in which there is an isolated energetic photon. The single photon events measure the number of light neutrino generations and are used to search for new phenomena beyond the standard model. The hadronic events with isolated photons are used (a) to measure the electroweak coupling constants of u- and down-type quarks, (b) as a sensitive probe of QCD quark and gluon fragmentation, and (c) to search for new phenomena such as Higgs bosons, excited quarks, and new vector bosons. The Higgs case would be a sign of a composite Z° boson."

"Study of Final State Photons in Hadronic Z^- Decay and Limits on New Phenomena," *Zeitschr. Phys. C* 53 (1992) 555.

"Study of Prompt Photon Production in Hadronic Z^- Decays," *Zeitschr. Phys. C* 69 (1995) 1.

"A Measurement of the Photon Structure Function F_2^γ at an Average Q^2 of 12 $GeV^2/c4$," *Zeitschr. Phys.* C69 (1995) 223.

Kerry Whisnant, Associate Professor



Kerry Whisnant

B.S. Missouri-Rolla 1976, Ph.D. Wisconsin 1982.

"My research interest is in the general area of electroweak physics - the study of weak and electromagnetic interactions. Although the standard electroweak model of Glashow, Weinberg and Salam is consistent with current experimental data, many alterative theories have been proposed that roughly agree with the standard model at currently observable energies but which have a richer structure at higher energy. These differences can appear in the interactions of matter (quarks and leptons), the gauge particles that carry the electroweak forces (the photon and the W and Z bosons), and/or the elusive Higgs bosons that are thought to be related to the symmetry breaking in the theory. One of my research topics has been to find limits on electroweak theories from current data and determine how they might be distinguished from the standard model in future experiments, especially in searches for Higgs bosons at high energy colliders. Another area of interest in neutrino physics. It is still not known whether or not neutrinos have mass; my research includes an examination of the properties and consequences of neutrino mass, including the phenomenon of neutrino oscillations and the solar neutrino puzzle."

"Unitarity and Anamolous Top Quark Yukawa Couplings," *Phys. Rev. D* 52, 3115 (1995).

"Long Wavelength Oscillations and the Gallex Solar Neutrino Signal," *Phys. Rev. Lett.* 69, 3135 (1992).

Kenneth Lassila, Professor

Kenneth E. Lassila

B.S. Wyoming 1956, Ph.D. Yale 1961.

"Theoretical studies of the interactions of the constituents of protons and neutrons, the quarks and gluons, are proceeding vigorously. Interactions that violently perturb these constituent quarks or gluons produce very energetic jets of conventional particles. These jets contain information on the mechanism binding these constituents in protons. Thorough theoretical studies are showing how to relate these jets to the fundamental quantum chromodynamics theory of the interactions of quarks and gluons."

"Experiments and Theoretical Results for Weak Charge Current Backward Proton Production," FERMILAB preprint to appear in Physical Review D, 1996.

"The EMC Effect in Extraction of Neutron Asymmetries from Polarized M non-Polarized D Neutron Scattering," in Yale Symposium on the Internal Spin Structure of the Nucleon, Ed. V. W. Hughes and C. Cavata (World Scientific, Singapore 1995) p. 204.

"Neutrinos to Probe and Compare Six Quark with Two Nucleon States," *Physics Letters B* 317, 205 (1993).

"Probing Multiquark Fragmentation with the Weak Current," in Puzzles on the Electroweak Scale, XIV International Warsaw Meeting; Eds. Ajduk, Pokorski and Wr¢blewski, (World Scientific, 1992) p.579.


H. Bert Crawley

H. Bert Crawley, Professor

B.S. Louisiana Polytech 1962, Ph.D. Iowa State 1966. "Most of my research activities during the past five years have been related to the Ames experimental high energy physics group's participation to the DELPHI collaboration at the Large Electron-Positron Collider (LEP) at CERN, which is located near Geneva, Switzerland. The ISU group designed, built and installed the readout electronics for the central region electromagnetic calorimeter. This readout system involves almost 600 FASTBUS modules, each of which digitizes 32 input waveforms (from charge deposited in the calorimeter) at a sampling rate of 15 MHz. The LEP experiments are able to record information from large numbers of events where the colliding e^+ and e^- form a Z°, the neutral intermediate vector boson, which subsequently decays to a pair of leptons or quarks. The quarks materialize as a "jet" of ordinary hadrons (pions, kaons, protons, etc.). These data allow one to make high-precision tests of the predictions of the Standard Model, the theory which combines the weak and electromagnetic forces, as well as searching for new phenomena.

A small fraction of my time is spent on a project which involves testing analog to digital converters (ADCs) which can operate in the 100 megasample per second range, and helping develop the standards for testing these devices."

"Electroweak Parameters of the Z° Resonance and the Standard Model," *Phys. Lett. B* 276, 247 (1991).

"Performance of Flash ADC's in the 100 MHz Range II. Results from 8 Bit Devices," *IEEE Trans. Nucl. Sci.* NS-39 780 (1992).


Germán E. Valencia

Germán E. Valencia, Assistant Professor

Ph.D. University of Massachusetts 1988. "My research interest is centered around the phenomenology of the electroweak interactions. This involves finding ways to test our current understanding of particle physics (the standard model) and its possible extensions. Recent work has included: study of rare kaon decays for precise measurements of standard model parameters; study of CP violation within the standard model and beyond in non-leptonic hyperon decays and in W production; constraints on physics beyond the standard model from precision electroweak measurements and implications for future colliders."

$K_L \longrightarrow \pi^+\pi^- \nu\, \bar{\nu}$ within the Standard Model," submitted to *Phys. Rev. Lett* (Jan. 96).

"CP Violation in $\Lambda \longrightarrow p\pi^-$ beyond the Standard Model," *Phys. Rev. D*. 52 (1995) 5257.

"Bounds on anomalous gauge boson couplings from partial Z widths at LEP," *Nucl. Phys. B* 439 (1995).

Eli I. Rosenberg, Professor


Eli I. Rosenberg

B.S. CCNY 1964, Ph.D. Illinois 1971. "My research concentrates on using electron-positron interactions at high energies to study the structure of the elementary particles and their interactions. This research is conducted at the European Laboratory for Particle Physics (CERN) and the Stanford Linear Accelerator Center (SLAC).

At CERN, we are using the DELPHI detector at the Large Electron-positron Collider (LEP) to make a detailed study of the electroweak structure of the Standard Model, first at the Z resonance and then at the highest possible energies. We have already demonstrated that the number of particle families with a light neutrino is three, we have set new limits on new particle production and performed many precision tests of the Standard Model.

At SLAC, we are designing a new detector BABAR to investigate the origins of CP (Charge conjunction-parity) violation by making detailed measurements of systems containing the b-quark.

For these experiments, my group designs and builds electronics to be used in the detectors and then participates in the data collection and analysis."

"Improved Measurements of Cross-Sections and Asymmetries at the Z Resonance," *Nuclear Physics B* 418, 403 (1994).

"B* Production in Z Decays," *Zeitschrift für Physik C* 68, 353 (1995).

"BABAR Technical Design Report," (SLAC-R-95-457).

"Recent Results from Tests of Fast Analog-to-Digital Converters," *IEEE Transactions on Nuclear Science NS-41*, 1181 (1994).

Bing-Lin Young, Professor

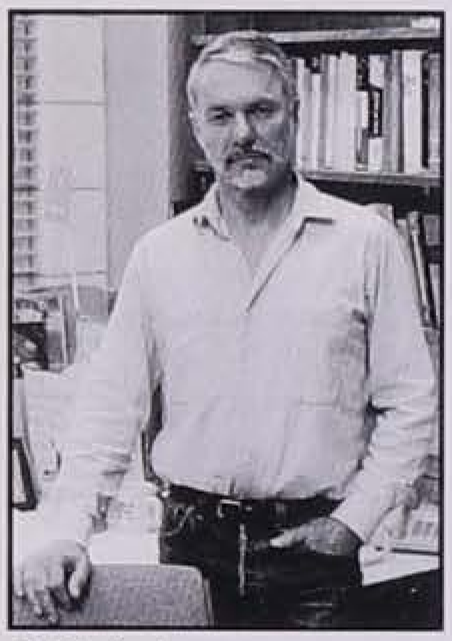

Bing-Lin Young

B.S. Taiwan 1959, Ph.D. Minnesota 1966.
"I am interested in the standard model, top quark physics, effective Lagrangian, electroweak baryogenesis, and application of quantum field theory".

"'Phenomenology of a Non-Standard Top Quark Yukawa Coupling", *Phys. Rev. D* 50 (1994), 7042.

"Electroweak Sphaleron for Effective Theory in the Large Higgs Boson Mass Limit", *Phys. Rev. D* 51 (1995), 5327.

"Non-Universal Correction to $Z^{\circ} \to b\bar{b}$ and Flavor Changing Neutral Currents", *Phys. Rev. D* 51 (1995) 6584.



E. W. Anderson

E. Walter Anderson, Professor

A.B. Harvard 1959, Ph.D. Columbia 1965.

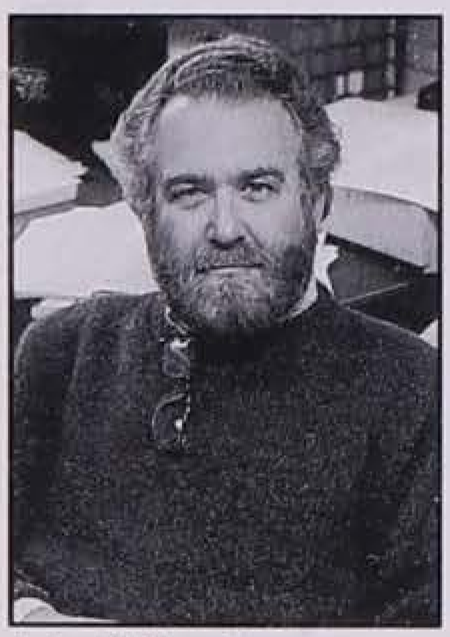
"I am a member of the Alpha High Energy Physics Group. My research in experimental particle physics has predominantly been at the Fermi National Accelerator Laboratory in Illinois, where the present experiment is installed at the Fermilab Tevatron Collider (Experiment E-740 and the D0 intersection point).

E-740 is one of two detectors at the Collider currently taking data from proton-antiproton collisions at 1.8 TeV, which is the highest available energy for the study of fundamental interactions. The Alpha group is also involved in the upgrade of E-740 in preparation for the increased beam luminosity and enhanced physics program resulting from the newer vertex detectors and central magnetic field. Data from E-740, as well as monte carlo simulations are analyzed at Iowa State on the university's RISC processor network. At present 10,000 MIPS of computing capacity are available, which we access during low-load hours using our BATRUN (Batch After Twilight Running) scheduler. Our most notable recent achievement has been our participation in the discovery of the top-quark.

The Alpha group is also involved in the research and development program of the Compact Muon Solenoid (CMS) detector being prepared for the Large Hadron Collider (LHC) at CERN. We are focusing our efforts on the hadron calorimeter subsystem within the CMS US Collaboration. While the Fermilab Tevatron Collider is presently the highest energy hadron collider in the world, this distinction will pass to the LHC when it goes on-line in 2004."

Recent publications:

1. D0 Collaboration, S. Abachi et. al., "Observation of the Top Quark", *Phys. Rev. Lett.* 74, 2632 (1995).
2. D0 Collaboration, S. Abachi et. al., "W and Z Boson Production in pp Collisions at $\sqrt{s}$ = 1.8 TeV", *Phys. Rev. Lett.* 75, 1456 (1995).
3. D0 Collaboration, S. Abachi et. al., "Measurement of WW Gauge Boson Couplings in pp Collisions at $\sqrt{s}$ = 1.8 TeV", *Phys. Rev. Lett.* 75, 1034 (1995).



John M. Hauptman

John M. Hauptman, Professor

B.A. U.C. Berkeley 1968, Ph.D. Berkeley 1974.

"We work in several areas of high energy physics in the Alpha high energy group. On the Tevatron Collider at Fermilab, we are working on the D-zero detector. The Tevatron is the highest energy machine in the world, colliding protons and anti-protons at 1.8 TeV in the center of mass. D-zero is a major detector in the U.S. program, encompassing excellent calorimetry and a high-precision vertex chamber with which we at ISU are primarily involved. We discovered the top quark in D , along with the CDF detector in March 1995. Search for new phenomena and an exploration of mass generating mechanisms are the highest priorities of this experiment.

We also collaborate on the Compact Muon Solenoid experiment (CMS) at the Large Hadron Collider (LHC) at CERN. Specifically, we will be working with the experimental group at the University of Iowa and with Fermilab on the hadronic calorimeter for CMS.

Prof. Walter Anderson has configured the 850-plus Project Vincent workstations at ISU into a massively-parallel machine that we use in D0 and CMS detector simulation work."

"In addition, we collaborate on DUMAND, a deep underwater detector off the coast of Hawaii. We are calculating trigger backgrounds and supernova signatures for this novel astrophysical neutrino telescope."

"Observation of the Top Quark," *Phys. Rev. Letts.* 74 (1995) 2632.

"Search for Squarks and Gluinos in $p\bar{p}$ Collisions at $\sqrt{s}$= 1.8 TeV," *Phys. Rev. Letts.* 75 (1995) 618.

"Search for Heavy W Bosons in $p\bar{p}$ Collisions at $\sqrt{s}$= 1.8 TeV," *Phys. Letts. B* 358 (1995) 405.

Department of Physics and Astronomy

Nuclear Physics

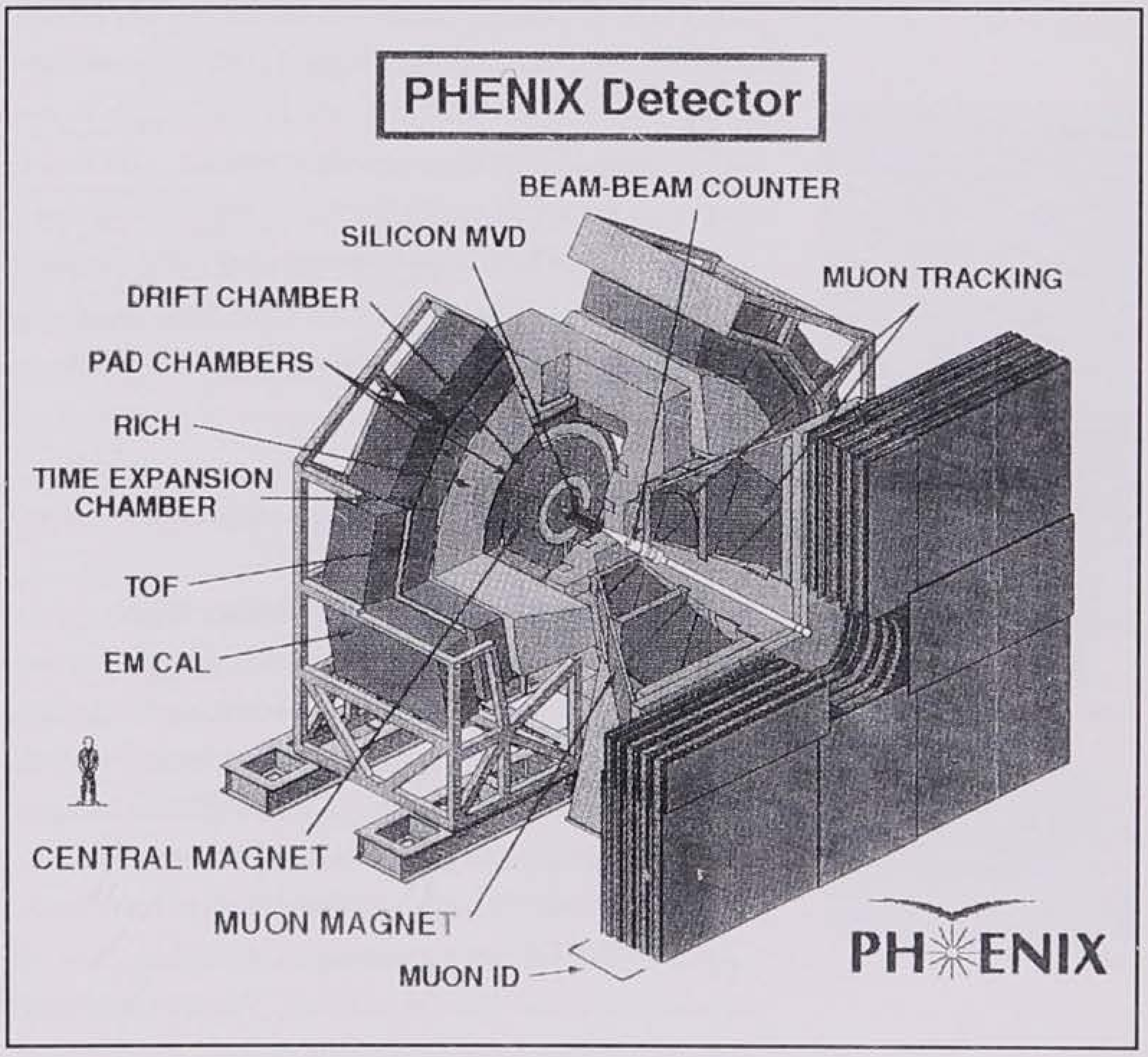
The nuclear physics group consists of six faculty (three theorists, three experimentalists), four post-doctoral associates, and graduate students.

The nuclear theory group consists of three faculty members, two postdoctoral associates and from two to four graduate students. Intense efforts are focused on four areas: (1) Perturbative QCD and its applications-especially Relativistic Heavy Ion Collisions. (2) Quantum field theory and applications to nuclear phenomena. (3) Theory of high energy lepton-hadron and lepton-nucleus reactions. (4) Quantum statistical mechanics of small systems. The theory group interacts strongly with the experimental group and with the high energy physics groups.

The nuclear experimental group, with three faculty, two postdoctoral associates, and three graduate students, is actively doing research in three areas. The major effort involves a search for and studies of the quark-gluon plasma and hot hadronic matter, which may be produced by collisions of 100 GeV/nucleon gold nuclei at the Relativistic Heavy Ion Collider now under construction at Brookhaven National Laboratory. The ISU group is in charge of designing the first-level trigger for the large PHENIX detector system. It will emphasize using the heavy vector meson resonances as probes of properties of the quark-gluon plasma.

In addition we study the response of heavy nuclei to very intense electromagnetic fields. This phenomena (electromagnetic dissociation) is studied using relativistic heavy ions at the AGS accelerator and the SPS accelerator at CERN, near Geneva, Switzerland. Nuclear excitations leading to giant resonance formation are being studied. Faculty and students will spend appreciable time at these international centers as they carry out research.

A third effort involves the search for strangelets produced by collisions of relativistic gold ions from the Brookhaven AGS accelerator with lead targets. The ISU group designed and built the late energy trigger that allows one to separate events where heavy exotic matter is formed. We will emphasize the search for neutral strangelets.



Department of Physics and Astronomy CONTINUED


Fred K. Wohn

Fred K. Wohn, Professor

B.S. Louisiana State 1962, Ph.D. Indiana 1967.
"My research interests in high-energy nuclear physics are to use relativistic heavy ion (RHI) beams to study nuclear matter under extreme conditions. The Department of Energy (DOE) supports the research of our experimental nuclear physics group (Hill, Wohn, postdocs, students). Our RHI research has two components: (1) studying "quark matter" at the RHIC (RHI Collider) facility at Brookhaven National Laboratory (BNL) and (2) searching for "strange matter" at BNL's Alternating Gradient Synchrotron (AGS) with RHI beams.

The PHENIX Collaboration, of which we are charter members, is building a large $100M detector at RHIC whose main goal is to study the "quark matter" regime of hot, dense nuclear matter. The main goal is to establish the existence of the state of matter called Quark Gluon Plasma (QGP) and deduce its properties. I am spokesman for a team of physicists and engineers who are building the Level-1 Trigger for PHENIX. I also serve on the PHENIX Detector Council that oversees the construction of the detector.

The E864 Collaboration uses relativistic gold beams from the AGS on stationary heavy (Au or Pb) targets to produce "strange matter" or "stranglets". Such as yet undiscovered states with multiple strangeness are expected to be produced in such collisions. The E864 Late Energy Trigger, built by our group, was used successfully in Fall 1995 to produce data that is currently being analyzed."

"PHENIX: Conceptual Design Report Update," (approved by RHIC Technical Advisory Committee in April, 1994).

"Calorimeter/Absorber Optimization for a RHIC Dimuon Experiment," *Nucl. Instrum. Meth.* A350, 150 (1994).

"Implementation of PHENIX Level-1 Trigger Algorithms on Massively Parallel Computers," *Computers in Physics* 9, 438 (1995).


John C. Hill

John C. Hill, Professor

B.S. Davidson, 1957, Ph.D. Purdue 1966.
"The major emphasis of my research program is the study of nuclear matter under extreme conditions and the search for the quark-gluon plasma (state of the universe at the moment of its birth) produced in collisions of ultrarelativistic gold nuclei. The studies will take place at the Relativistic Heavy Ion Collider (RHIC) now under construction at Brookhaven National Laboratory. We are designing and constructing the Level-One Trigger for the large PHENIX detector which will study lepton pairs produced at RHIC. Our studies will emphasize the behavior of the and J/ mesons in hot nuclear matter. A second main project is the search for strangdeto produced in collisions of relativistic gold ions with lead targets at the AGS. We have built the late energy trigger to sort out possible strangdeto among the other reactor particles. A program is also underway to study the role of Coulomb effects in reactions of heavy ions which have been accelerated to relativistic energies as the AGS and CERN-SPS accelerators. For the heaviest projectiles and highest energies the Coulomb effects dominate the reaction."

"Observation of Very Large Electromagnetic Dissociation Cross Sections," *Phys. Lett. B* 273, 371 (1991).

"Two Neutron Emission from Electromagnetic Dissociation of ^{59}Co and ^{197}Au Targets by Relativistic Heavy Ions," *Phys. Rev. C* 39, 524 (1989).

"Electromagnetic Dissociation for High-Z Projectiles and at Ultrarelativistic Energies," *Phys. Rev. Lett.* 60, 999 (1988).

Jianwei Qiu, Associate Professor

Ph.D. Columbia University, N.Y. 1987. "I am interested in the precision test of the standard model and new physics beyond the standard model. Currently, my research involves two directions. One is to study the role of QCD perturbation theory in scattering processes at very high energy. Understanding QCD effect in these processes is important for the precision tests of QCD as a theory for strong interactions, and is critical for identifying new physics beyond the standard model. The other is to study QCD effects in scattering processes at very high density, such as relativistic heavy ion collisions. Such processes can form not only a new testing ground for QCD, but also a new domain for studying QCD vacuum and formation of hadrons from quarks and gluons."

"Breakdown of Conventional Factorization for Isolated Photon Cross Sections", *Phys. Rev. Lett.* 76, 2234 (1996).

"Inclusive Prompt Photon Production in Hadronic Final States of e^+e^- Annihilation", *Phys. Rev. D* 53, 1124 (1996).

"Effects of QCD Resummation on Distributions of Leptons from the Decay of Electroweak Vector Bosons", *Phys. Lett. B* 355, 548 (1995).

Jianwei Qiu

James P. Vary, Professor

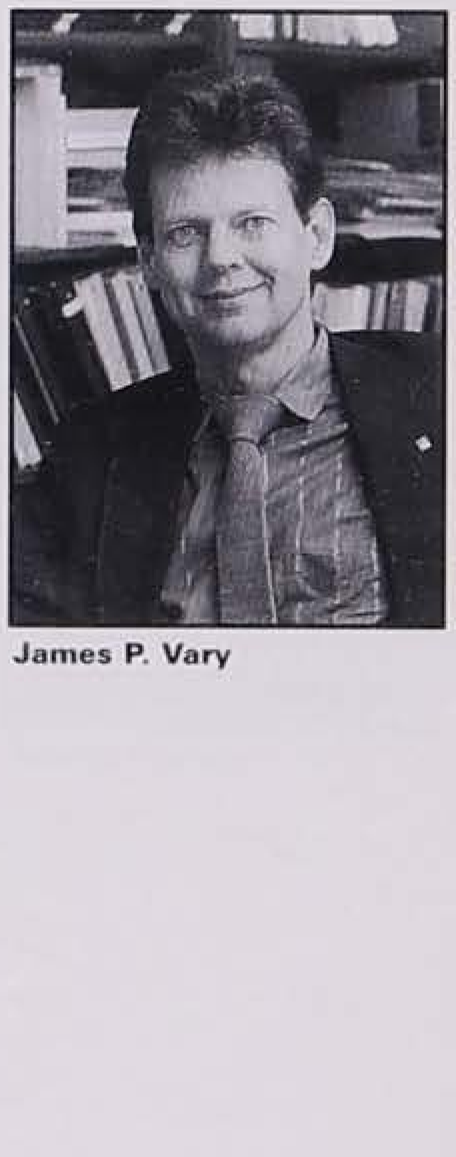
B.S. Boston College 1965, Ph.D. Yale 1970. "Theoretical nuclear physics has been moving toward intermediate and high energies in order to more clearly resolve the richness of nuclear phenomena at the microscopic level. We have recently been successful in building a quark model for nucleons interacting at short distances in nuclei. We have extracted important information on the nature of this short distance interaction from high energy interactions of electrons with nuclei. This has opened an exciting new frontier of research for us, and we are involved with extending the model to other nuclear phenomena. Our nuclear theory group is also actively developing a new field this physics of non-perturbative phenomena arising in quantum field theory. I also maintain a continuing effort devoted to the development of nuclear many-body theory via the use of renormalization procedures such as those of Brueckner and Bethe. We have been successful in conquering some of the unsolved problems in this very difficult area of nuclear theory."

"Large-Space Shell Model Calculations for Light Nuclei," *Physical Review C* 50, 2841(1994).

"Relativistic Meson Spectroscopy and In-Medium Effects," *Physics Letters B* 348, 277(1995).

"Massive Schwinger Model for Small Fermion Mass, in Theory of Hadrons and Light-Front QCD," edited by St. D. Glazek (World Scientific, Singapore) 122(1995).

"Variational Tamm-Dancoff Treatment of Quantum Chromodynamics: The Heavy Mesons in the Valence Quark Approximation," *Phys. Rev. C* 52, 1668(1995).



James P. Vary

William H. Kelly

William H. Kelly, Professor

B.S.E. (Phys.) Michigan 1950, Ph.D. Michigan 1955. "The primary focus of my physics research is the study of a new state of nuclear matter called superdeformation that occurs in certain nuclei when they are given very large values of angular momentum. These and other more "normal high-spin" states are created in nuclear reactions using heavy ions from the 88-inch cyclotron coupled with the new high energy resolution gamma-ray detector array (Gammasphere) at the Lawrence Berkeley Laboratory. The mechanisms by which the nuclei relax as they decay to more normal angular momentum states are being studied. I also have strong interests in the quality of teaching physics at all levels, from K through 16, and work closely with teachers nationally and regionally. Here we are examining the different ways that students learn to use different physics concepts and how to deal with their misconceptions."

"Ml Transitions Between Superdeformed States in ^{195}Tl: the Fingerprint of the $i_{13/2}$ Proton Intruder Orbital", *Physics Letters B* 341, 64 (1994).

"Neutron Blocking and Delayed Proton Pair Alignment in Superdeformed ^{195}Pb", *Phys. Rev. C* 51, 2288 (1995).

"Superdeformation in the Bismuth Nuclei", *Phys. Rev. C* 53, 117 (1996).

Stanley A. Williams

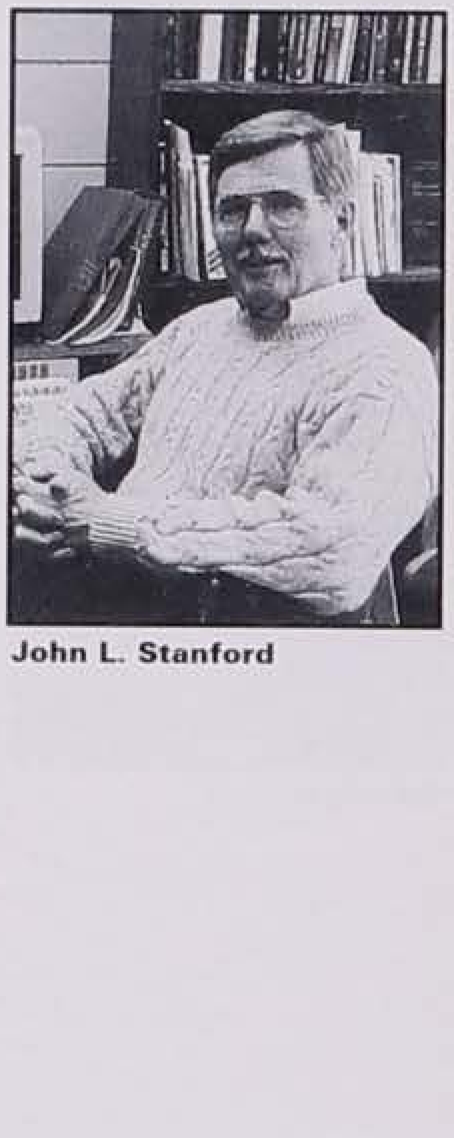
Stanley A. Williams, Professor

A.B. Nebraska Wesleyan 1954, Ph.D. Rensselaer 1962. "My formal research interest remains the application to very light nuclei of the nucleon-nucleon interaction derived from the interactions of the constituent quarks. Typical problems include prediction of binding energies and the electron scattering form factor.

Atmospheric Physics

The atmospheric physics program is particularly well integrated into global problems and has great potential for impact outside the university. Satellites such as the Upper Atmosphere Research Satellite and the Total Ozone Mapping Spectrometer Satellite have revolutionized the field and provides the ISU group with data for the dynamical analyses of the stratosphere and for studies of ozone depletion. The group is funded by NASA grants. Current projects include collaborations with the University of Oxford; Instituto de Astrofisica de Andalucia, Spain; Goddard Space Flight Center, Greenbelt, Maryland; Jet Propulsion Laboratory, Pasadena, California; and Argonne National Laboratory, Illinois. In addition the national supercomputer facilities at the National Center for Atmospheric Research, Colorado, are being used to study carbon dioxide circulation in the atmosphere, crucial to understanding long range climate and global warming. See WEB page which contains details of current research activities, publications, students and former students (http://www.public.iastate.edu/~atmos/homepage.html).

John L. Stanford, Professor


John L. Stanford

B.S. Texas 1960, Ph.D. Maryland 1965. "My students and I are involved in investigations of the dynamics of the middle atmosphere. We analyze satellite derived observations of atmospheric temperature, ozone, and other trace constituents for analysis and modeling studies."

STATISTICAL METHODS FOR PHYSICAL SCIENCE, (Volume 28 in the series METHODS OF EXPERIMENTAL PHYSICS, Academic Press, 1994), 542 pp. (J. L. Stanford and S. B. Vardeman, Eds.)

Field (Map) Statistics. Chapter 16 of STATISTICAL METHODS FOR PHYSICAL SCIENCE, Academic Press (1994).

"The Quasi-biennial Oscillation and Tropical Waves in Total Ozone," *J. Geophys. Res.* 99, 23041-23056 (1994).

"Space-time integrity of Improved Strato-spheric And Mesospheric Sounder and Microwave Limb Sounder temperature fields at Kelvin wave scales," *J. Geophys. Res.* 100, 14089-14096 (1995).

"Middle Atmosphere Dynamics", *McGraw-Hill Encyclopedia of Science and Technology,* 8th Edition, in press.

"The 4-Day Wave as Observed from the Upper Atmosphere Research Satellite Microwave Limb," *J. Atmos. Sci.* to appear, 1996.

Mathematical Physics

Theoretical physicists in the mathematical physics group have interests in many areas of the quantum theory, in model independent data analyses including interpretation of sparse data, and in the structure of space-time. The quantum theory studies include a geometrical approach to the foundations of quantum mechanics, an investigation of new classes of bound states caused by coherent reflection from oscillatory potentials, examination of resonances by studying zeroes in the momentum plane, explorations of isospectral hamiltonians, and the development of a form of the quantum mechanics that parallels classical Hamilton-Jacobi theory. The theory of sparse data analysis has been applied to gamma-ray curves from Cygnus X-1. Work on the structure of space-time includes classical and quantum gravity as well as geometrical and topological aspects of gauge theories.

The members of the mathematical physics group collaborate with physicists at other schools, with other areas of the department, and with each other. Although the activities of the group cover a broad spectrum of physical problems, a common thread which links all members of the group is a strong interest in the fundamental aspects of physical theory.

Dennis K. Ross

Dennis K. Ross, Professor

B.S. Cal Tech. 1964, Ph.D. Stanford 1968

"I have worked extensively in general relativity and in fiber bundle models of gauge theories. Work in this area has included papers on supergravity, on charge quantization, on the origin of Planck's constant, and on calculating fundamental gauge constants. I am very interested in the fundamental structure of space-time. More recently, I have collaborated on work related to quantum gravity and to fundamental aspects of quantum mechanics."

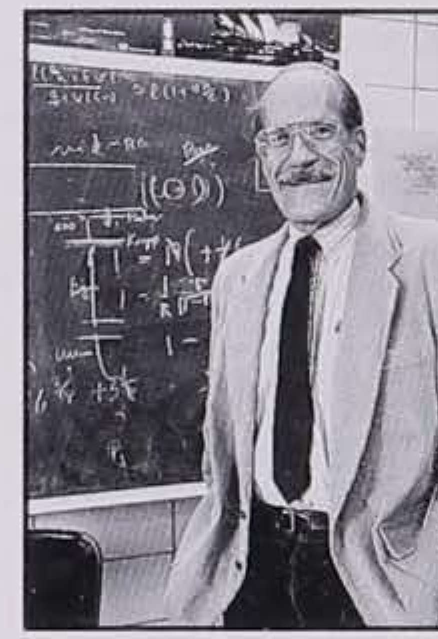
"Topological Origin of Planck's Constant", *Il Nuovo Cimento* 107B, 777 (1994).

"Stochastic Gravity", General Relativity and Gravitation, 845 (1995).

"Torsion in Fiber Bundle Models of Gauge Theories", *Il Nuovo Cimento* A 109, 185 (1996).

"Renormalizable Conformally Invariant Model for the Gravitational Field", Classical and Quantum Gravity, 1996.

Thomas A. Weber, Professor



Thomas A. Weber

B.S. DePaul 1956, Ph.D. Notre Dame 1961.

"My interests are in scattering theory, relativistic astrophysics, and the mathematics of ill-posed problems. My most recent work has been on the relationship between scattering resonances and bound states with energy embedded in the continuous spectrum."

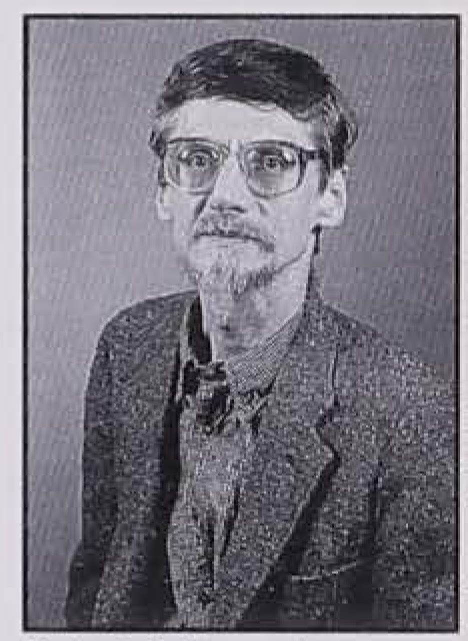
"Bound States With No Classical Turning Points in Semiconductor Heterostructures," *Solid State Communications*, 90, 713 (1994).

"Simple Local Potential for Spectrum of e^+e^- Coincidence Peaks Found in Heavy-Ion Collisions," *Nuovo Cimento* 107, 2767 (1994).

"An extended Gel'fard-Levitan method leading to exactly solvable Schridinger equations with generalized Bargmann potentials," *Phys. Rev. A* 52, 3923 (1995).

"Scattering from a shifted von-Neumann-Wigner potential," *Phys. Rev. A* 52, 3932 (1995).

Robert A. Leacock, Professor



Robert A. Leacock

B.S. Michigan 1957, Ph.D. Michigan 1963.

"Motivated by the spectrum of resonances found in hadronic physics, my students and I have constructed a formulation of the quantum theory which is the quantum analog of classical Hamilton-Jacobi theory. Results to date include (1) definition of a quantum action variable which permits determination of the bound states without solving an equation of motion, (2) construction of an action-variable perturbation theory, (3) formulation of the theory for relativistic particles, and (4) definition of an extended action variable to allow unified descriptions of bound states and resonances. Parts of this last project are complete, and other parts are in progress."

"Evidence for f_2 (1270) production in the reaction pomeron-pomeron —> $\pi^+\pi^-\pi^+\pi^-$," *Zeit. Phys. C*, to be published.

"The reaction pomeron-pomeron —> $\pi^+\pi^-$ and an unusual production mechanism for the f_2 (1270)," *Zeit. Phys. C* 48, 569 (1990).

"Action-variable Theory of Angular Momentum," *Phys. Rev. A* 33, 1 (1986).

"Hamilton-Jacobi/Action-angle Quantum Mechanics," *Phys. Rev. D* 28, 2491 (1983).


Francis C. Peterson

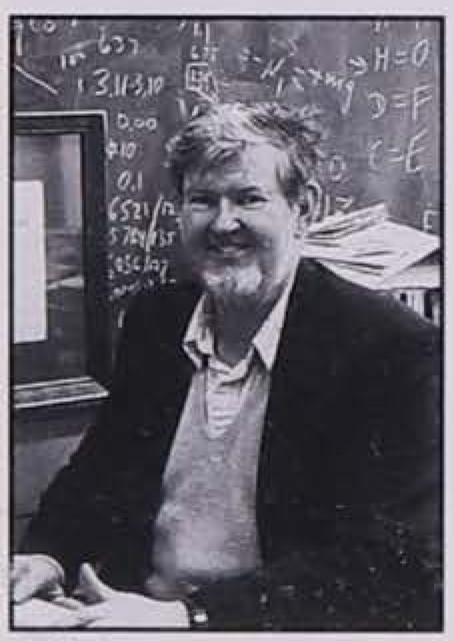
Francis C. Peterson, Professor

B.E.E. Rensselaer 1964, Ph.D. Cornell 1968.
"I am a high energy experimental physicist by training and am active in educational development at the undergraduate level. My work includes the design of suitable laboratory equipment and courses for undergraduates, and the administration of the laboratory programs for the large enrollment introductory courses. Specific topics of interest to me are the inclusion of modern instrumentation and computers in the experience of undergraduates, the classroom performance of teaching assistants, and the development of instrumentation appropriate to the instructional laboratory."

"Recent Efforts to Upgrade the Use of Computers in Introductory Physics Labs," *AAPT Announcer* Vol 25, #4, 93 (1995).

"Characteristics of the Classroom Style of Physics Teachers Who are Highly Rated by Iowa State Students", F. C. Peterson, *AAPT Announcer* Vol 24, #2, 85 (1994).

"Operating Characteristics of the Common Braun Electroscope", F. C. Peterson, *AAPT Announcer* Vol 24, #4, 26 (1994).


L. Hodges

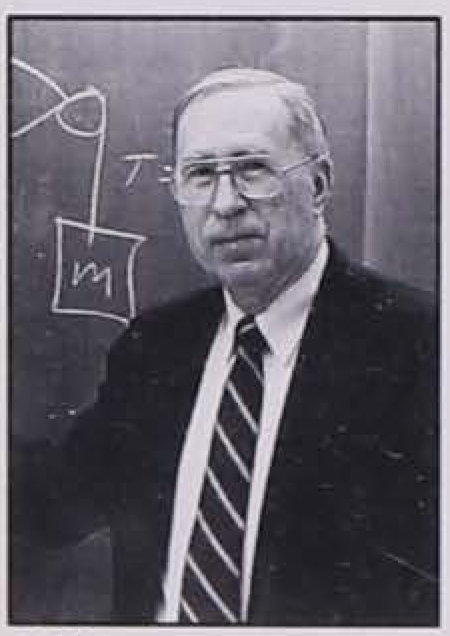
Laurent Hodges, Professor, Asst. Chair

A.B. Harvard 1960, Ph.D. Harvard 1966.
"Originally a condensed-matter physicist, my interests over the past 20 years have been largely in energy and environmental physics, particularly solar energy for use in homes. Our home is a passive solar home that has functioned well since it was completed in 1979. In recent years my interests have shifted to reforming and improving our introductory physics courses, using new ideas from physics education research and introducing electronic materials to help students learn physics."

"Computer Problems for Large Classes", *The Physics Teacher* 32:16-17 (1994).

"Common Univariate Distributions", Chapter 2 of *Methods of Experimental Physics, Volume 28: Statistical Methods for Physical Science,* edited by Steve Vardeman and John Stanford. (Academic Press, 1994).

"A lesser-known Goldbach conjecture", *Mathematics Magazine* 66:45-57 (1993).


Ed Dixon

Ed Dixon, Assistant Professor

A.B. Wm. Jewell, 1956. "My primary areas of interest are the introductory physics courses, the science preparation of primary and secondary school teachers, musical acoustics, and academic advising."

Applied Physics

Ph.D. and Master's degree programs in applied physics are approved for thesis research that has implications in some area of technology as well as advancing basic knowledge. Several members of the physics faculty carry out applied physics research as a natural extension of their basic research. Examples include experimental solid state work in thin films and thin-film devices; applied theoretical and experimental superconductivity research relating to superconducting wire and research on Josephson tunnel junction devices similar to those used in ultra-fast electronics and as low level sensors for magnetic fields, voltage, and current. Much of the surface physics carried out in the department also has implications for technologically important processes including catalysis, corrosion, and surface passivation. Many other examples can be found, especially in the extensive research on materials with useful properties.

In addition, other faculty members are expert and active in atmospheric physics, in applied mathematical physics, and in energy conservation and environmental physics.

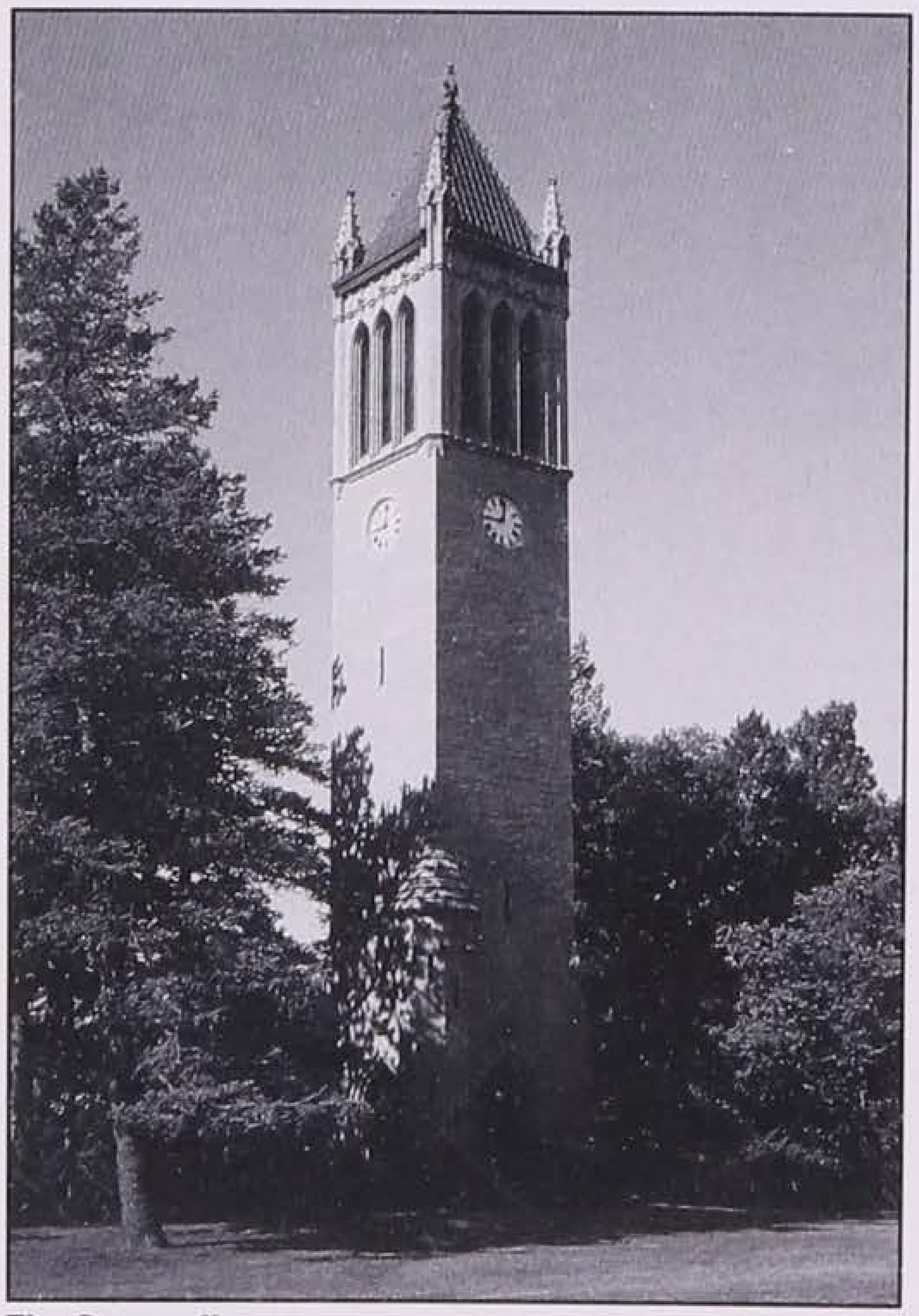
An applied physics degree can also be obtained by a student who takes the bulk of coursework in physics but performs thesis research in one of several research groups outside the department. Particularly noteworthy is the Microelectronics Research Center near campus at the Applied Science Center. Here, thin-film deposition research is aimed at improving the quality and utility of amorphous semiconductors for photovoltaic applications. There are also projects using modern lithography methods to create "photonic band gap" devices (similar to semiconductors with electronic band gaps but for light). In addition, a strong applied nondestructive evaluation (NDE) research program utilizes ultrasound and other techniques to detect internal flaws as may occur in key industrial components. These methods are sophisticated both in the experimental aspects (ultrasonic, eddycurrents, and x-rays) and in interpretation based on classical scattering theory. This well-equipped, physics-related program is sponsored by NSF, the Department of Defense, and many industrial affiliates and offers opportunities for applied physics thesis research.

If a student elects to do research in a group outside the Department of Physics and Astronomy, it is necessary to have a graduate faculty member of that group serve as co-chair (with a collaborating physics faculty member) of the student's Program of Study Committee.

University Environment

The Iowa State University of Science and Technology was founded in 1858 as the land-grant institution for the State of Iowa - the first in the United States. It is a member of the Association of American Universities, a prestigious organization of 53 major research universities in the United States and Canada. On a campus encompassing over 405 hectares Iowa State offers outstanding facilities for study and research. More than 120 curricula and numerous professional programs are offered by a faculty of more than 2000. Of the more than 25,000 students just over 10% are international students, representing more than 100 foreign countries.

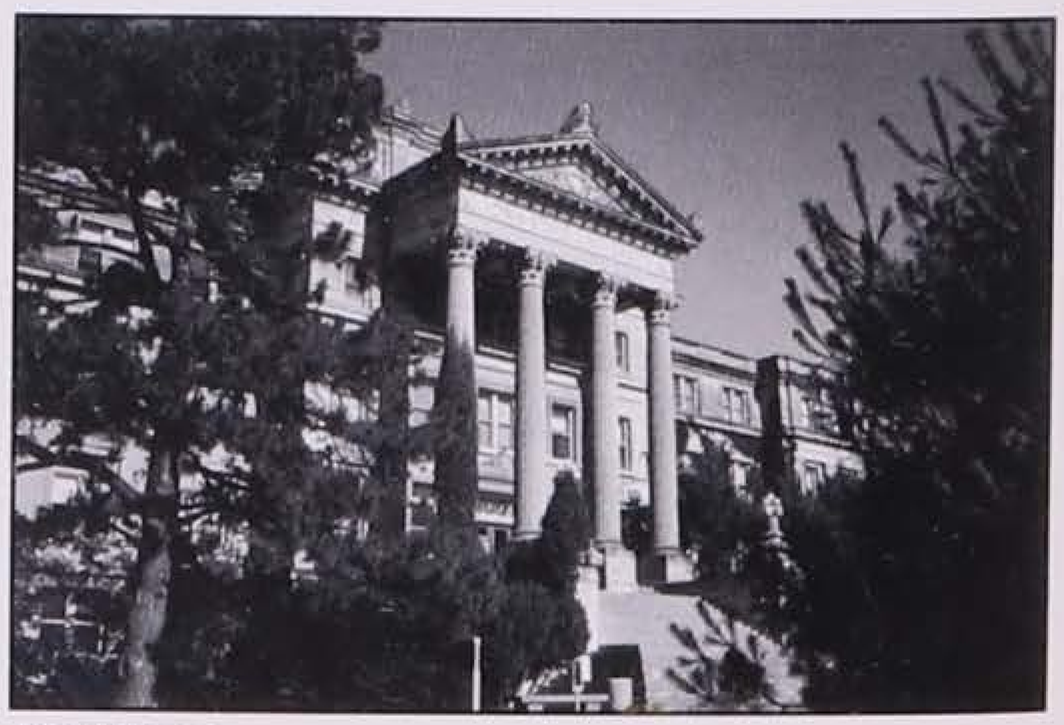
Iowa State University has great strengths in science and engineering and the city of Ames adds its cultural diversity. More generally, the central Iowa area, including the state capitol, Des Moines, represents a very attractive and cost-effective environment. Ames and Des Moines lie near the geographical center of Iowa and are separated by about 56 km. Minneapolis is only 349 km. away, Chicago 515 km., Kansas City 363 km., St. Louis 576 km., and Omaha 269 km.



The Campanile

Within Ames, the Cy-Ride Bus System provides multiple transportation services to nearly 2.5 million passengers every year. It runs into the late evening hours and links the city with the campus, shopping malls, restaurants, and hotels. Services include a fixed route, an Iowa State University parking shuttle, and a Friday and Saturday late night service. The Dial-A-Ride door to door service is available to all residents of Ames, including elderly, disabled, and the general public. Cy-Ride won the coveted All-America City Award in 1982-83 and has served as a model for new transit systems in other cities.

The satellite uplink and downlink capabilities of Iowa State University enable users to link Ames with places throughout the nation and world for conferences and instructional programs. Ames is also served by community and university newspapers, radio stations, and public access cable television. The Des Moines Register, the state's major daily newspaper, ranks seventh in the nation in total number of Pulitzer prizes awarded.



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Recreation and Culture

The City of Ames maintains over 700 acres of parkland. County parks, Iowa State University's horticultural gardens and arboretum, and a preserved natural prairie within the city Recreation limits are additional recreational sites. Recreation facilities include ballfields, an ice-skating center, tennis courts, bicycle paths, golf courses, swimming pools, and nature trails. Summer concerts are held in the Municipal Bandshell Park. The Parks and Recreation Department offers a year-round schedule of activities ranging from instruction to organized sports. The Ames and ISU communities sponsor several annual events, including the Midnight Madness Road (Running) Races, the Iowa Games, and the Iowa Masters Golf Tournament. Within a half hour drive from Ames are state parks like the Ledges State Park on the Des Moines River, with popular camping and picnicking areas. Saylorville and Big Creek lakes are located about 20 miles south of Ames. These lakes form a very large fresh water recreational area with beaches, a boat marina, and many nature and water sports activities.

The Iowa State Center, with the 2,800-seat C.Y. Stephens Auditorium, the 450-seat Fisher Theater, and the Scheman Continuing Education (Conference) Center, provides a focus for the arts at ISU. Local participation includes Department of Music concerts and recitals, the ISU Players, and exhibits of art and sculpture in Brunnier Gallery and at the Ames Society for the Arts, the Octagon, where classes are also held. The Central Iowa Symphony Orchestra, based in Ames, is composed of talented amateur musicians, and it offers four public concerts annually. The Des Moines Symphony Orchestra offers several subscription concert series and youth concerts. This ensemble is rapidly acquiring recognition and praise throughout the Midwest. A number of lecture, concert, and other series bring first-rate individuals and groups to Ames. The highlight of each year is provided by the Ames International Orchestra Festival Association, which sponsors orchestras of international rank at the Stephens Auditorium. Recent concert series have included the Royal Philharmonic, Cleveland, Philadelphia, the New York Philharmonic, St. Petersburg (Leningrad) Orchestra, Dresden Staatskapelle-Chicago Symphony, St. Paul Chamber, Norweigan Chamber, and the Baltimore orchestras. Iowa State has also drawn several well-known rock bands. Groups performing in recent years include the Rolling Stones, Paul McCartney, Genesis, U2, Boyz II Men, Hootie & the Blow Fish, Ozzie Osborn, and Billy Joel, to name a few.

Varsity Sports

Iowa State is a member of the Big Twelve (formerly Big Eight) Conference. The football team plays in a 43,000 seat stadium. Basketball and wrestling take place in the modern 14,000-seat Hilton Coliseum. Hockey and ice-skating facilities are also available. In recent years, basketball, wrestling and track teams have reached national prominence.

Housing

Single graduate students may apply for housing in the graduate dormitory, Buchanan Hall, with meals taken in residence halls or in local restaurants. Married students are eligible for three different university-operated housing areas that provide a wide range of facilities and costs that usually are less than those of other apartments. Many different types of rooms and apartments are available in Ames, either through agencies or directly from owners. The choice is wide, at least for early applicants.

Employment for Spouses

The unemployment rate in Ames has been low. Employment opportunities exist within the University, several large state and federal facilities, the local business community, and a substantial medical community.

Atanasoff-Berry Computer

Origin of the Modern Computer

It is well known that advances in physics have played a crucial role in the development of the modern computer. Not so well known, however, is that a physicist at Iowa State University played a key role in the invention of the first digital computer, and that his motivation was the desire to solve calculational problems in physics.

The story begins in 1934 when a young professor of mathematics and physics at Iowa State University (then College) began to think seriously about machines to do numerical computation. The professor, John V. Atanasoff, had completed his doctoral thesis in 1930 at the University of Wisconsin on the dielectric constant of helium. In the course of this work and during his teaching and research at Iowa State, Atanasoff became aware of the need for computing devices. Most of the calculations for his thesis were done on a Monroe desk calculator; in Atanasoff's words, "such calculations required many weeks of hard work." At that time quantum mechanics was relatively new and was being applied to many physical phenomena. Atanasoff wanted the ability to solve partial differential equations. He was "impressed that the process of approximating solution of partial differential equations required a great many calculations, a fact that ultimately motivated my work in automatic computing."

Many of the conceptual foundations of the modern digital computer were constructed by Atanasoff between 1934 and the winter of 1937. He had to consider whether the machine would be mechanical or electrical, what type of number system and computational method to use, and how to store information. His thinking was clarified one winter evening after a long drive from Ames to the Mississippi River: "During that evening in the Illinois roadhouse, I made four decisions for my computer project. I would use electricity and electronics as the media for the computer. In spite of custom, I would use base-two numbers (binary) for my computer. I would use condensers for memory, but 'regenerate' to avoid lapse. I would compute by direct logical action, not by enumeration." After these four concepts were in place, Atanasoff spent the next year experimenting with memory and logic circuits. He soon realized he would need assistance. In the fall of 1939, he was joined by his graduate student, Clifford Berry. Together they began construction of a prototype digital computer.

Atanasoff and Berry decided to use capacitors and vacuum tubes, since these elements had enough voltage to actuate each other. The computer memory consisted of a set of capacitors that were periodically recharged. By working hard through the fall, Atanasoff and Berry had the prototype completed and functioning by November, 1939. Atanasoff describes the machine and how he felt about it: "The prototype was, of course, a very crude device. It would just add and subtract the binary equivalents of decimal numbers having up to eight places. Nevertheless, Clifford Berry and I regarded this machine as a great success. It settled many doubts about how an electronic computer should be built: the device was digital, not analog like the differential analyzer. While the clock system was mechanical, all computing was electronic. For the first time, vacuum tubes were used in computing. The very advantageous base-two number system was first used. Logic systems were first employed in computing. All computation was done in a serial manner. Capacitors (or condensers) were used as memory elements. A rotating drum memory contained the capacitors. What I called jogging (which others call regeneration or refreshing) was first used in computation. While the prototype did not shift or detect sign, the changes needed for these processes were obvious and could be immediately applied, thus providing the essentials for multiplication and dividion. Clifford E. Berry and I were very pleased to have access to a method of computing with such power. Once our prototype had proved successful, we both knew that we could build a machine that could do almost anything in the way of computation." This prototype, functioning in late 1939, was the forerunner of the modern electronic digital computer.

Atanasoff and Berry intended to continue their work on the prototype. In the spring and summer of 1940, Atanasoff made application to various foundations for support; he received a grant from the Research Corporation for $5,330 to complete the prototype. While some further work was done, the project came to an end in 1941 with the start of World War II. Clifford Berry joined an engineering firm in California to work on the war effort, and John Atanasoff became head of acoustical testing of naval mines at the Naval Ordnance Laboratory in Maryland. With the exception of a short period of several months at the Ordnance Laboratory, Atanasoff never returned to computing.

As Atanasoff and Berry did not write or talk much about their design and construction of an electronic digital computer, their contribution to the origins of the modern computer might have become lost. However, in the late 1960's litigation began between several corporations concerning patent rights on various aspects of digital computing devices. After years of deposition of evidence, trials took place in Federal Court in Minneapolis beginning in June 1971 and concluding with Judge Earl R. Larson's decision on October 19, 1973. Among his reasons for his decisions about patent rights, Judge Larson states: "Between 1937 and 1942 Atanasoff, then a professor of physics and mathematics at Iowa State College, Ames, Iowa developed and built an automatic electronic digital computer for solving large systems of simultaneous linear algebraic equations." As a result of the litigation, the contribution to the development of modern computer of physicists John V. Atanasoff and Clifford E. Berry became known.


Clifford Berry


John Vincent Atanasoff

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