September 2011

Volume 6

Physics Matters

at Syracuse University

Ezra (Ted) Newman

APS EINSTEIN PRIZE 2011

For outstanding contributions to theoretical relativity, including the Newman-Penrose formalism, Kerr-Newman solution, Heaven, and null foliation theory. For his intellectual passion, generosity and honesty, which have inspired and represented a model for generations of relativists.

Ezra (Ted) Newman graduated from Bronx High School of Science in 1947 and received his BA from New York University in 1951. He then came to Syracuse University and as a first year graduate student began to interact scientifically and socially with the students working with Peter Bergmann on problems related to the then new field of quantum gravity. His dissertation was on a perturbation approach to quantum gravity. After receiving the PhD degree in 1959, Ted was appointed Assistant Professor at the University of Pittsburgh. He rose through the ranks, becoming Professor in 1966 and Professor Emeritus in 1996. Since "retirement", Ted has continued to have a rich research career and has visited colleagues in Britain, Germany, and Poland as well as at home in the United States.

Photo credit: R. Schulte-Ladbeck

Ted Newman in discussion

One of the first papers Ted wrote after completing his dissertation was on the use of the geodesic deviation of light rays in general relativity for the definition of distance in astrophysical observations. This set the stage for his future research. Almost all of his research has used the properties of light rays, real and complex, to understand the properties of space-time and the movement of matter in that space-time. Together with Roger Penrose, he developed the Newman-Penrose formalism - a description of geometry using a set of basis vectors adapted to null rays. In this formalism, the Einstein equations become a set of first order equations which have a physical or geometrical meaning. He used this formalism to examine asymptotically flat space-times, generalizing work by Hermann Bondi describing gravitational radiation. The N-P formalism has led to an explosion to known number of solutions of the Einstein equations. He narrowly missed constructing the solution for a rotating mass, the Kerr solution, but as a class project, he constructed the solution for a charged rotating mass using a complex transformation.

The above represents only the beginning of Ted's use of null rays to study general relativity and the structure of space-time. With the definition of null infinity by Penrose, Ted began an intensive study of what can be learned from null rays which terminate on null infinity. This work has been collected in an article in Living Reviews in Relativity. Included is work on complexification of space-time which led to the idea that the imaginary part of the radius of a complex time-like world line represents the magnetic moment of a particle in a real space-time. This satisfies the Dirac gyromagnetic ratio for the electron. The study of wave fronts led to an understanding of the caustics associated with the singularities that occur when null rays converge or intersect. Much of the above work was done with students, postdocs, or collaborators, but all carry the imprint of Ted's way of thinking about and way of presenting a problem.

Ted enjoys having people around him. He wants to talk with them to explain what he is doing. He wants to draw people into his work and to make them part of it. His whole manner is very exciting and stimulating. Students are impelled to work and colleagues are challenged. During a six week stay at Syracuse, he drew together five people from different areas to produce a short paper on an aspect of spin weighted spherical functions. This work is currently important in the development of wave forms in the search for gravitational radiation. His appeal and energy has allowed him to guide 23 students through their dissertations and to host 16 postdocs and visitors.

His research activities is just one side of him as a professional. On at least one occasion he was chosen by students to be the best teacher at Pittsburgh. That is a distinction that can be won only by teaching large classes. He also developed new courses both for graduate students and the general student in Liberal Arts, most enjoyably, a course in the physics of music. The latter is an outcome of his broad interest in music and literature. In addition, he has a passionate interest in the out-of-doors – he enjoys hiking and camping.

Finally, Ted has been a significant contributor to the general relativity community and to physics. From 1980-89 he served on the board of the International Committee on General Relativity and Gravitation, as president from 1986-89. He served on the organizing committee of several of the triennial meetings of the organization. In two stints, three years as Associate Editor (1971-73) and eleven years as Board Member, he served on the editorial board of the Journal of Mathematical Physics.

The range of his activities and the depth of his work make Ted Newman worthy of the APS Einstein Prize for 2011. Syracuse University and, especially the Department of Physics, is proud of his accomplishments.

Patricia E. Ford

Almost every day around noon, one can find Patricia Ford in shorts and running shoes. Patti is a devoted runner who averages 35 miles a week. She started running seriously in 1979 when she decided she needed an activity to help her stop smoking. Characteristically, she took up running and became a champion. In 1993, she won a Gold Medal in the Empire Games 10,000 meter run; in 2000, she set records in the 3,000 meter, one mile, and 800 meter for the age 40 and above in USA Track and field Masters Championship in Boston. In 2001, she set the World Record for Women 45-49 in the Hartshorne Masters Elite Invitational Mile at Cornell University; and in 2004, she was the Champion for Women 45-49 in the USA National Masters 5 km Cross Country Championship Run. During this time, Patti was initially a "Stay At Home Mom", but came to work at Syracuse University in 2001 in various positions. In 2006 she settled down in the Department of Physics, first as an Administrative Assistant, but she quickly rose to Budget and Office Manager. Patti had previously worked as Secretary and Administrator in the Mathematics Department from 1977-94. She then took a year's leave to have her daughter and decided she wanted to extend that time to care for the child. Patti grew up on a dairy farm in Paris Hill, NY and went to a small school in Madison, NY. When she graduated, she wanted to become a large animal veterinarian, but was dissuaded because it was *not for women* as well as for financial reasons. She then got a job at SUNY Morrisville where she earned an Associate Degree, Science and Mathematics, in 1977. When Patti came to work at Syracuse University, she began taking courses with the goal of a degree in computer science. Somehow, her interests shifted to philosophy and linguistics. In 1994, she finally was awarded a BA in Linguistics, Summa Cum Laude. In the Mathematics Department, she met Terry McConnell. They married in 1993 and now live on a farm in Pompey where they raised chickens until the coyote got them and now keep horses. Patti is a delight to have in the Office. She greets everyone with a smile, a grin, or a chuckle.

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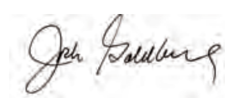
From the Editor

When I began planning for this issue, I thought that it would be nice to tell about the role that William R. Fredrickson had in forming the Physics Department and setting the tone for the relations between faculty and students. However, for me, this issue has become one of reminiscence. First, Ted Newman, who came to Syracuse as a graduate student and became my close friend in 1951, was awarded the Einstein prize for 2011 by the American Physical Society. Then in close order, two former members of the faculty, Herbert Berry and Arthur Komar, died.

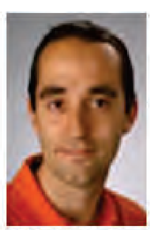
Herb was here as a faculty member when I arrived as a graduate student and retired during the time that I was Chair. Artie was a close colleague in relativity theory and I arrived here to replace him when he left to go to Yeshiva University. So, preparing this issue has been somewhat of a nostalgia trip, reminding me of my student days as well as the pleasures of studying physics together with my colleagues. I am grateful to the Physics Department for the opportunity to be in this role where I can share some of these thoughts with you.

Apart from my nostalgia, this issue is filled with the activities of the Department and the individual achievements of its faculty. Soft condensed matter is represented by an interesting article on percolation by Jennifer Schwarz. Cristina Marchetti left being Chair to devote herself to research and other professional activities. Liviu Movileanu is building research links with scientists in Japan and China. Jay Hubisz is working on theoretical problems related to the search for the Higgs particle and to cosmology, while Sheldon Stone is working at CERN to discover new physics. There is much more going on in the Department and all members of the faculty are busy. Look for that in the pages that follow.

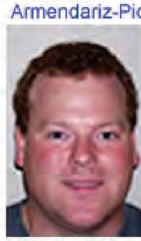
However, there is one thing missing. Undergraduate majors, what have you done with your lives? Graduates, where are you? Are you in industry, academia, or …? You all have stories to tell. Tell us.



TENURE AWARDS

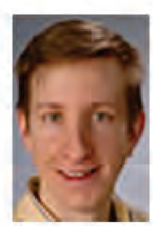


Cristian Armendariz-Picon



Duncan Brown

Jen Schwarz



Britton Plourde

This has been a windfall year for tenure awards in the department. That results from the fact that over the past 10 or 11 years the Physics Department has been able to hire 13 young faculty members, including Lisa Manning who arrived this year. This has been strong growth as well as a rejuvenation of the faculty. As a result the research effort has also seen strong growth. As a further result, four young faculty members came up for evaluation this year and have been granted tenure in recognition of their achievements in teaching, service, and research. The four and their research areas: Cristian Armendariz-Picon, cosmology and astro-particle physics; Duncan Brown, gravitational radiation; Britton Plourde, low temperature physics and quantum computing; and Jennifer Schwarz, soft condensed matter.

We've had an exciting year in the Physics Department, and are looking forward to another one. Among the highlights are:

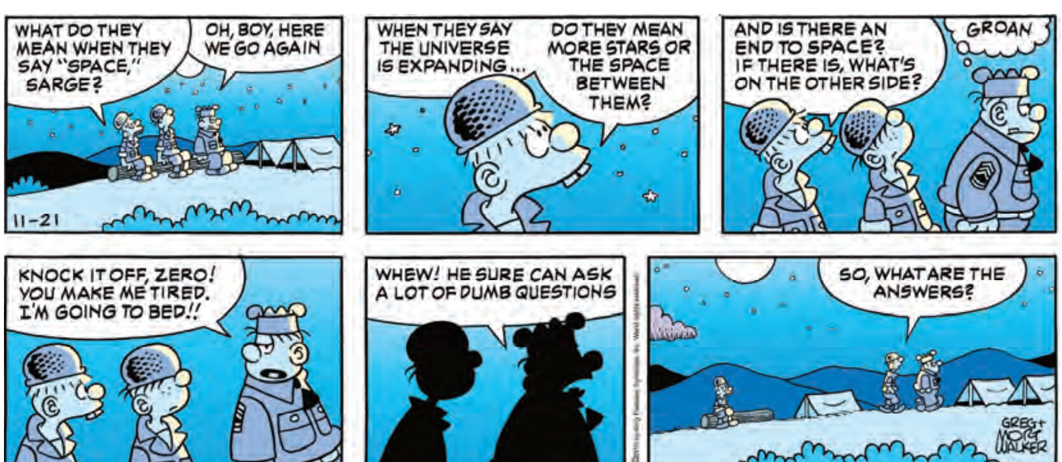
- We were successful in all four of our tenure cases this past year: Cristian Armendariz-Picon, Duncan Brown, Britton Plourde, and Jen Schwarz.
- The members of our Department set a new record total of $5.8M in sponsored research expenditures during the just-closed fiscal year. This represents growth of about a factor of two over a few years ago, and makes us the most successful (by this measure) department in the College of Arts and Sciences.
- Former Department Chair and former Associate Dean Eric Schiff received the Chancellor's Citation for Excellence.
- Associate Chair Alan Middleton was elected a Fellow of the American Physical Society.
- Assistant Professors Martin Forstner and Matt LaHaye were each successful in winning prestigious NSF CAREER awards.
- Profs. Duncan Brown and Tomasz Skwarnicki were awarded a large Major Research Instrumentation grant to build a new supercomputer cluster at the University's Green Data Center at Skytop. That cluster is now up and running.
- Prof. Sheldon Stone and his group produced two papers on the first observations of the decays of Bs mesons from the LHCb experiments. These are among the very first scientific results to come out of the LHC.
- We succeeded in attracting to our faculty Dr. Lisa Manning, who comes to us from the Princeton Center for Theoretical Science. Lisa is an expert on modeling of structure, deformation, and flow

Lisa Manning arrived at the Syracuse Physics department after an appointment as a Postdoctoral Fellow at the Princeton Center for Theoretical Science at Princeton University. Lisa received undergraduate degrees in Mathematics and Physics from the University of Virginia in 2002. In 2008, she earned her Ph. D. in Soft Condensed Matter Physics working with Jean Carlson and James Langer at the University of California Santa Barbara. Her thesis, *Effective temperature and strain localization in amorphous solids,* developed a continuum models for flow in disordered materials, showed that the model quantitatively matched shear banding in simulations, and explained the implications of these models for friction on earthquake faults. As a postdoc, she continued to study disordered solids by using computer simulations to identify the structural defects, analogous to dislocations in crystals, that control flow in these materials. She also studied how the properties of biological tissues arise from interactions between individual cells; in close collaboration with experimental colleagues, she developed and verified a theory to explain how the collective property of tissue surface tension arises from properties of individual cells in developing embryonic tissues. At Syracuse, she plans to develop new collaborations in the physics, engineering, and biology departments, to further her investigation into the collective mechanical properties of both biological and non-biological disordered, non-equilibrium materials. Some directions of future research include using a random matrix ensemble to understand localization at low frequencies and the boson peak in disordered solids, as well as developing a model for biological tissues that overlays biochemical signaling on top of mechanical interactions to understand emergent pattern formation in developing embryos.

Reflecting on these major successes, and on the everyday achievements that are the stuff of life in a thriving department such as ours, I've drawn strength from my connection to an outstanding academic leader, Martin A. Pomerantz '37. Martin's distinguished career led him from his initial successes as a Physics major at Syracuse to the Bartol Research Foundation, where he served as Director for several decades. A renowned cosmic ray physicist, Martin is perhaps best known for having discovered the potential of the South Pole as a site for astronomical observation, and for having not let up until the rest of the world caught up with his insight. The Martin A. Pomerantz Observatory there was named to express the community's gratitude for his vision. (See Physics Matters Vol.2 for more on Martin.) I only got to know Martin late in his life, when we brought him to the Department for a symposium in his honor on the occasion of his receiving an honorary doctorate from Syracuse. He was an inspiring figure in every way, radiating enthusiasm for life as a scientist. As the Martin A. Pomerantz '37 Professor of Physics and Chair, I'm dedicated to living up to Martin's example by maintaining and building the climate of mutual support that makes this Department so special.

Peter R. Saulson

Martin A. Pomerantz '37 Professor of Physics and Department Chair



Physics in the Era of the Large Hadron Collider

Jay Hubisz

For decades we have been exploring a fundamental theory of microscopic physics known as the Standard Model. This beautiful structure, based on symmetries, has the ingredients to describe all non-gravitational forces: electromagnetism which binds electrons to nuclei to make up atoms, the weak force which allows for radioactive decays, and a strong force which binds together protons and neutrons in atomic nuclei.

The standard model is a fantastically successful theory, it correctly predicts the magnetic moment of the muon to one part in one billion. All other precision tests of the Standard Model are in harmony with experimental results. However, for this grand structure to hold together, it must explain why the weak force governing radioactive decay is so weak. For this to work, the particles responsible for this force must be massive, outweighing the proton or neutron by about a factor of 100, so that there is a large energy requirement for the interaction. This puts the symmetry principles that hold together the Standard Model in grave danger, as such masses would break the symmetries that form the core of the theory. The Standard Model would then predict nonsensical results. The keystone of the Standard Model which must resolve this issue is as yet undiscovered. The mechanism by which the carriers of the weak force become massive may involve the elusive Higgs particle, or perhaps something completely different.

The Large Hadron Collider at CERN is designed to uncover this keystone ingredient which holds together the mathematical consistency of our understanding of fundamental forces. By pushing particles to their limits, colliding them at unprecedented energies and at phenomenal rates, the detritus of the resulting mini-explosions should arrange themselves in patterns that reveal the underlying mechanism of mass generation. Despite an initial setback when the machine was first turned on, the Large Hadron Collider is now performing well beyond expectation. It is the world leading machine in terms of the energy associated with each particle collision, and will soon surpass the U.S. based Tevatron in terms of the number of such collisions accumulated. The level of excitement in the particle physics community is palpable. In the last year, overly-premature “results" have been leaked to the blogosphere, only to be swatted down by more careful analysis. It is still too early to be seeing the simplest form of Higgs boson, but many exciting extensions of the Standard Model, which aim to solve other technical issues with this successful theory, are being pushed aside as their predictions come to terms with the null results at this new collider.

Looking along the beam in the LHC

Aside from the issue of the primary keystone issue of mass generation, many other puzzles arise when one takes a broad view of the Standard Model. Of its 19 free parameters, those which play a role in the masses of particles are spread across a vast hierarchy of numbers. If there is a Higgs particle, the electron interacts with it one-million times weaker than the top quark, the most massive particle we have discovered so far. Extraordinary hierarchies like this cry out for a dynamical explanation, akin to the realization that tidal forces damp the ellipticity of planetary orbits over time, explaining why they are almost circular. Also, the Standard Model contains no particle that can explain the abundance of so-called dark matter in our universe. Such matter dominates our galaxy, yet we have no idea what it is.

I and other theoretical physicists posit solutions to such problems, invoking the existence of new symmetries and particles beyond those predicted by the Standard Model that the LHC could discover. One of the most studied extensions of the Standard Model involves the addition of a special type of symmetry called supersymmetry. In a supersymmetric world, every particle has a doppelganger, identical in all respects but spin. Supersymmetry may hold the key to the question of why the masses of the particles we see are so small (or equivalently, why gravity is so weak. It also could explain the dark matter. However, the Standard Model doppelgangers are so far suspiciously absent from LHC observations. On the other hand, we already have at our disposal a test case which dynamically generates hierarchies naturally. As it turns out, the strong force itself generates masses for the particles responsible for the weak force, although at a scale too low to be consistent with observations. Many theorists believe that a similar principle may be at work at the high energies that will be probed at the LHC. Models with extra dimensions share many features with these strongly coupled theories, and are another important arena to explore.

An immense international collaboration of experimentalists and theorists in high energy physics, in which Syracuse University is playing a vital role, will be putting the pieces together in the coming years, giving us a more complete picture of our universe.

William Russell Fredrickson
June 28, 1903-January 9, 1983

William R. Fredrickson (Bill or Freddy) came to Syracuse University as Instructor in the Department of Physics in September 1928 and was appointed Chairman of the Department of Physics in October, 1939.

Freddy was born in Chicago, IL on June 28, 1903. His grade school education was in Chicago and he attended the Univ. of Chicago, receiving his B.S. in 1924 with a major in physics and mathematics. He remained at the university to receive his M.S. in 1926 and Ph.D. in 1928. His dissertation was on band spectra under the guidance of W.W. Watson.

At the time of his appointment, the Department consisted of a faculty of four with Professor Royal A. Porter as Chairman. The Department was housed in Steele Hall along with three other departments. It wasn't until the war years that the Physics Department took over all of Steele Hall. In fact, in carrying out training for the Army during the war, the Department expanded into space all over the campus.

When he arrived on campus, Bill Fredrickson found that astronomy was being taught in the Chemistry Department. This lasted until 1937 when Chemistry found it could not hire a suitable person to teach the course. Freddy was asked to take over the course and Holden Observatory was turned over to the Physics Department for teaching. Since he had been away from astronomy for 9 years, Fredrickson asked for a stipend so that he could go to Yerkes Observatory (Williams Bay, WI) to refresh his knowledge of what was current. Chancellor Graham approved a grant of $100 with which he spent 4 weeks at the Yerkes Observatory. From then until he retired in 1971, Freddy taught the astronomy course.

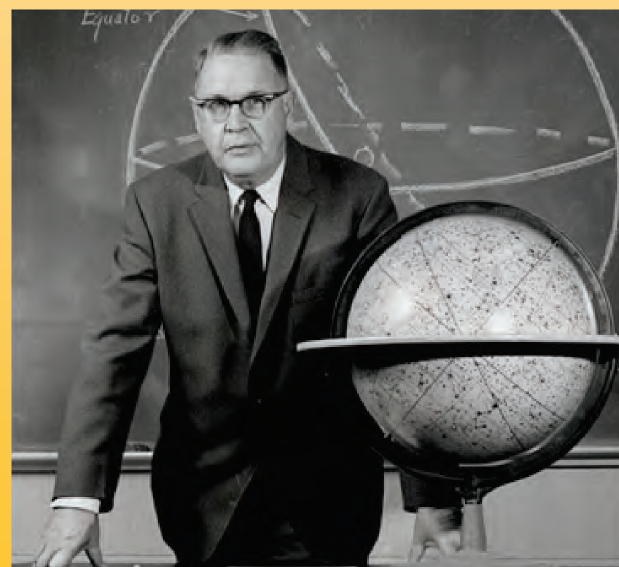
He advanced through the ranks and was appointed Professor in 1937 and Chairman in 1939. Thus, he was the Chairman during World War II and was responsible for the education and training of the soldiers the Army sent to Syracuse. This required finding the space on campus for the needed classes and, what was even more difficult, finding the people who were capable of doing the teaching. In this he was successful, but he was also planning for the Department after the war. He prepared a request to the New York State Department of Education for the right to grant the Ph.D. degree in Physics. That approval came in 1946 and the first Ph.D. graduated in 1950.

However, State approval may grant permission, but does not create a Ph.D. program. Fredrickson sought a faculty that would be engaged in research, but would also pay attention to the education of the undergraduates. His first choices included, Charlie Bachman working in electronics, Henry Levinstein in infrared devices, Nathan Ginsburg in spectroscopy, Herbert Berry with atomic physics, Melvin Lax in nuclear physics and quantum field theory, Johanna Brunnings who had worked with H. Casimer, and Peter Bergmann who had worked on general relativity with Albert Einstein. These, with five from earlier times, made up the Department of Physics in 1947. The following year John Trischka, with an interest in atomic beams, and Kurt Sitte, cosmic rays, joined the Department. At the time he stepped down in 1965 there were 24 faculty members and most were actively engaged in research. All were involved with teaching both undergraduates and graduates. And in the previous 20 years, over 100 students had completed their Ph.D .dissertations.

As the Department grew, Steele Hall could not contain the graduate students and the additional faculty. Prefabricated buildings, left over from the war training period, were used to house graduate students and some faculty. In time, more space was needed and houses in the University's neighborhood were commandeered. By the '60s people were scattered around the campus and communication became difficult. With the help of Nathan Ginsburg, Freddy prepared an NSF proposal to support construction of a new building for the Physics Department. The grant was approved and, in 1967, the Department moved into a new building with sufficient research space, class rooms, teaching laboratories, and offices for the faculty and graduate students.

Syracuse University recognized his accomplishments by naming William R. Fredrickson the *Joel Dorman Steele Professor of Physics* in 1952 and in 1967 he became the first *William R. Keenan, Jr. Professor of Physics*. After stepping down as chairman, Fredrickson continued to teach Astronomy to undergraduates and returned to research in spectroscopy with Nathan Ginsburg. Even after retirement Freddy came to colloquia to sit in what appeared to be a reserved seat and to smoke a cigarette as he listened to the speaker.

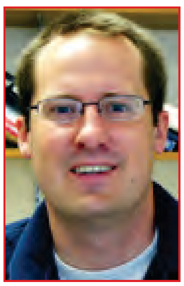
His accomplishment in building a Department of Physics which is active in research and engaged in teaching both undergraduate and graduate students is not the reason he is still so admired by all those who knew him. Freddy's qualities as a human being set a tone and a standard by which this Department still lives. Arguments could be conducted and concluded without fracturing the Department. Decisions could be made without bitterness. He understood the importance of teaching; he understood the importance of research; and he understood the role of the Department as a part of SU. The students who passed through SU undergraduate or graduate, felt the warmth of Bill Fredrickson whether or not they came into direct contact with him. It is the sense of respect and consideration of students and faculty alike which most people remember about him.



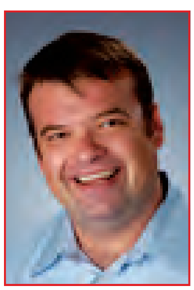
Faculty News

This has been a ***Chandrasekhar Year*** for **Kameshwar Wali**. He was co-organizer of an International Symposium (October 15-17) at the University of Chicago to celebrate the centenary of S. Chandrasekhar's birth and in December he spoke on The Legacy of S. Chandrasekhar (1910-1995) at a similar International Symposium in Bangalore, India as well as at several other institutions in India. For Physics Today, he wrote "A Biographical Portrait of S. Chandrasekhar" and he edited *A Scientific Autobiography S Chandrasekhar* which appeared this spring.

Peter Saulson, in addition to being department chair and principal investigator in the LIGO program, gave 10 lectures on gravitational wave detectors at an NSF-sponsored summer school run by the University of Texas – Brownsville, South Padre Island, TX. June.



The NSF granted **Matt LaHaye** a $600,000 five year NSF Career Award for the topic "Probing Quantum Behavior in Coupled Nanomechanical Systems". This is a study to look at measurements in the quantum-classical limit. He was invited to talk on this subject at the "Workshop on Nano-Opto-Electro-Mechanical Systems: Approaching the Quantum Regime" at the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy.



Martin B. Forstner: received an NSF CAREER award. The Project "Non-equilibrium Physics of Biological Interfaces" has been funded through the Physics of Living Systems program with $794,000 for 5 years. Martin presented colloquia on his recent work at the Departments of Physics in the University of Rochester and the University of Pennsylvania.

An article by **Mark Bowick** with his former student **Luca Giomi**, "Two-dimensional matter: order, curvature and defects", Adv. Phys. 58 (2009), was listed by Physics Reviews in the top most downloaded articles in 2010. March and April, Mark gave two lectures at Laboratoire de Physique Theorique, Ecole Normale Superieure, Paris on shape and structure in soft condensed matter materials. Mark also had time to captain the Drumlins A interclub tennis team to victory over Liverpool and Auburn in the seasonal playoffs.

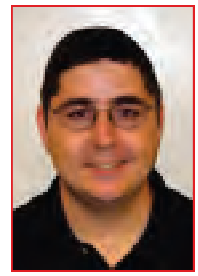
Scott Watson had a very busy year talking about his research on inflation, cosmic acceleration, and dark matter. Scott was invited to give colloquia on his work at several institutions. He also co-organized and participated in six workshops on various aspects of cosmology. In particular, he was invited to a workshop honoring Stephen Hawking sponsored by Cambridge University.

Britton Plourde's research on qubits for quantum computing has been widely recognized. In August he was a participant and speaker in the *ARO/NSA/IARPA Quantum Computing, Quantum Algorithms & Multi-Qubit Coherent Operations Program Review* in Cincinnati, OH and he spoke at three IARP review meetings in October, January, and June. In addition to giving several colloquia lectures, Britton appeared on a BBC program discussing the status of quantum computing.

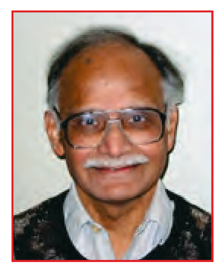
Alan Middleton was on leave in the spring semester and was invited to spend three weeks at a workshop in the Kavli Institute in Beijing, China and to give a colloquium in Hefei as well as lectures at Rutgers and Washington Universities in the US. Alan was elected to Fellowship in the APS *"For his innovative numerical studies of the dynamical and static properties of disordered condensed matter systems, including charge density waves, spin glasses and disorderd elastic media."*

From January to March, **Simon Catterall,** was a visitor in CERN; then at the University of Southern Denmark until June. In both places he gave lectures on lattice gauge theory. He also visited the Bohr Institute in Copenhagen, spent a week at the University of Regensberg, Germany and visited the University of Edinburgh lecturing and discussing his research.

Mitchell Soderberg is engaged in experiments with neutrinos at Fermilab. These experiments study the oscillations of the electron, mu, and tau neutrinos which determine the mass difference squared with the object of determining the individual masses. Mitchell was called upon to give nine talks on his work as well as, in June, being co-convenor of the Neutrino Detector session at the *2011 Technology and Instrumentation in Particle Physics (TIPP)* conference in Chicago.



Bal's research on applications of non-commutative geometry continues to draw interest. In the past year, the Institute of Physics, Bhubaneswar and the University of Hyderabad, Hyderabad in India and the University of Brasilia and the International Institute of Physics, Natal in Brazil invited him to lecture about Hopf algebras and non-commutative geometry. Bal also participated in two workshops in Italy on *Folding and Unfolding: Interactions from Geometry* and *Current Problems in Differential Calculus over Commutative Algebras, Secondary Calculus, and Solution Singularities of Nonlinear PDE*. In addition, he was an invited speaker at the centennial celebration of Subrahmanyan Chandrasekhar at the University



Percolation

Jennifer Schwarz

Fig.1: The orange-colored structure is the spanning structure of aluminum on the square lattice at the percolation transition. White denotes holes. The boundary conditions are periodic.

Consider the following experiment. Take a sheet of aluminum and measure the electrical conduction across it. Then, randomly punch a few, small holes in the sheet and, again, measure its electrical conduction. Repeat this procedure until the conduction drops to zero. Why would the conduction drop to zero? For a small density of holes, there still exists a spanning path, a path connecting one side of the sheet to other. This spanning path allows for current to flow. As the density of holes increases, pieces of the sheet fall to ground and, eventually, a spanning path no longer exists such that the conduction drops to zero. In other words, the system undergoes a phase transition from conducting to non-conducting due to a phase change in the underlying geometry as the density of holes increases beyond a critical density. The phase change in the geometry is from the existence of spanning structures to the absence of spanning structures. Figure 1 depicts a spanning structure at the transition for holes cut out on a square lattice.

Percolation is the study of connected structures, i.e. paths, in random geometries and how these connected structures undergo a phase transition from spanning to not-spanning as the geometry is modified. This geometric phase transition is the simplest phase transition in existence in a system with randomness and much is known about it. For example, the percolation transition is a continuous phase transition. In particular, at the transition, the dimension of the spanning structure is fractal such that the fraction of material participating in the spanning structure is zero (in the infinite system limit). As the density of holes is decreased beyond a critical density, the fraction of material participating in the spanning structure becomes non-zero in a *continuous* way. See Fig. 2.

Applications of percolation are numerous. In addition to electrical flow in granular metals, we also consider fluid flow through granular sea ice. Due to the existence of spanning fluid channels between the ice “grains” at temperatures larger than -5 degrees C, brine carrying heat and nutrients can flow through the sea ice, but not below -5 degrees C, where there are no spanning fluid channels. For those interested in a purely entertaining aspect of percolation, the game of Hex is based on percolation. I leave you to google “Hexy”, download it, and play a game.

Consider another granular system: sand. At low densities, sand flows like a liquid. However, at high enough densities, sand acts as a solid, i.e. it can support structures sticking out of it. To understand this liquid-to-random solid phase transition, properties such as gravity and friction are ignored and only two-body forces due to the deformation of grains in contact are considered---a simplified model. Physicists then numerically study minimal energy configurations of the simplified model. At small densities, the minimal energy configuration consists of sand grains that do not come into contact with one another. Beyond some critical density, there are many minimal energy configurations where grains can no longer avoid each other, deform, and transmit forces. It turns out that the liquid-to-random solid transition occurs at the same density at which there exists a spanning structure of grains in contact. However, unlike ordinary percolation, the fraction of grains participating in the spanning structure is finite at the transition. In other words, the geometric phase transition here is *discontinuous.*

Why the discontinuity? Mechanical properties affect the connectedness of the contacts between grains. For example, for each grain in the packing to be locally mechanically stable, a minimum number of contacts is required. In three-dimensions, at least four contacts are needed. One can encode this local constraint into a percolation model to arrive at k-core percolation, one of the simplest examples of constraint percolation, which requires that each grain have at least k neighboring grains (k=4 in three-dimensions). In certain geometries, k-core percolation also exhibits a discontinuous phase transition (Fig. 2) and shares several other properties with the liquid-to-random solid transition. One can go beyond k-core to include additional constraints in order to identifying the underlying ingredients driving the liquid-to-random solid phase transition.

In sum, percolation, constraint percolation, and other percolation models, provide for much insight into how disorder in the geometry/connectivity of a system can radically alter the system's properties---be it conductivity, permeability, or the ability to transmit of forces, etc. In fact, one could argue that percolation is a theory of everything disordered.

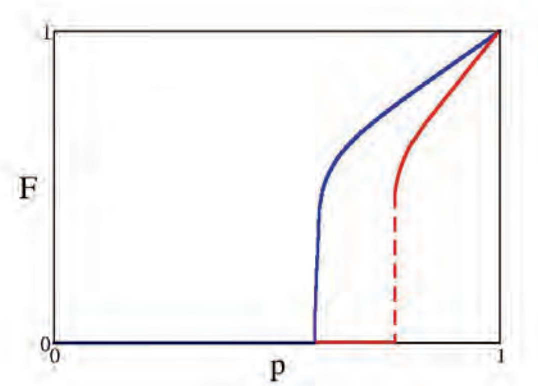


Fig. 2: Blue curve denotes ordinary percolation. It is a sketch of the fraction of material in the spanning structure, F, as a function of the probability p of not having a hole. The red curve represents k=3-core percolation. The dotted red line shows that the transition is discontinuous in contrast to the blue curve where there is no dotted line and the transition is continuous. Stability set in suddenly, all at once. There is no slow growth of the stable state as there is for the growth of conductivity as one adds material.

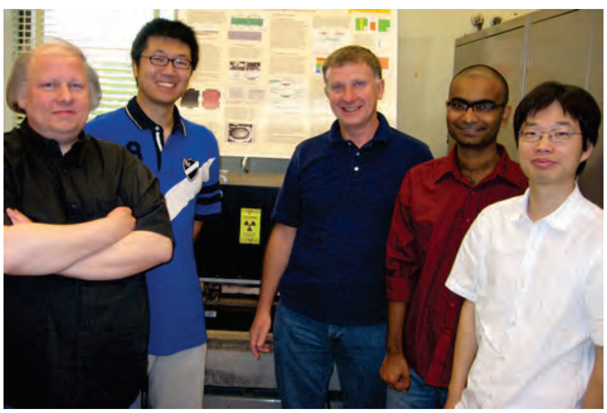
Dark Matter Workshop
Richard Schnee

In January, the Syracuse physics department hosted a two-day workshop of the DEAP/CLEAN collaboration, which is in the process of building two experiments aimed at detecting the ***dark matter*** in the Universe. This dark matter must be in the form of elementary particles that have not yet been detected, except through their gravitational tug on astrophysical objects. The DEAP/CLEAN detectors will consist of large spheres of liquid argon or neon viewed by light detectors.

Twenty-three participants, consisting of faculty, post-docs, and graduate students from Penn, MIT, Yale, Queen's, Boston University, the University of South Dakota, and the University of New Mexico, and staff scientists and engineers from Los Alamos National Lab and NIST, attended in person, while additional collaborators joined by videoconference.

This workshop focused on issues related to construction of the assemblies to house the detectors of light from interactions involving dark Matter (*Physics Matters V. 4*). The key challenge is how to maximize light collection while simultaneously shielding the liquid spheres from the relatively small but still problematic radioactivity in the light detectors themselves. Participants shared results of measurements or simulations illustrating trade-offs as well as highlighting other issues important for the assembly construction. SU graduate student Boqian Wang, post-doctoral research associate Mark Kos, and assistant professor Richard Schnee all made presentations. In the end, the group worked out a plan for construction of an initial prototype assembly that will be tested further before going into full construction. The detectors are scheduled to be installed deep underground in Fall 2011.

LHCb: FIRST RESULTS



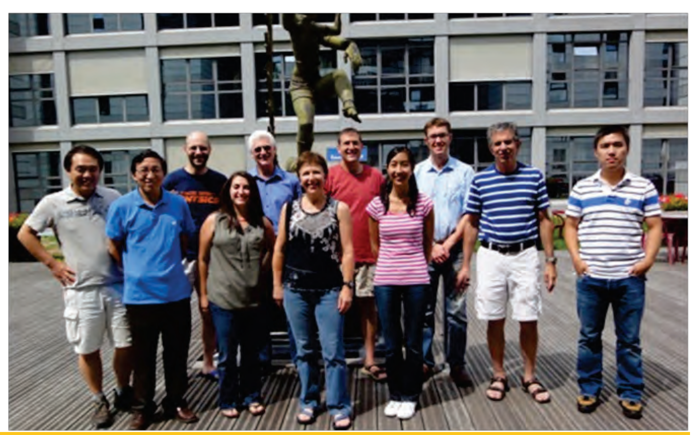
← Syracuse

The High Energy Particle Physics group, led by Sheldon Stone, has an important role in studying B meson physics with the LHCb experiment on the Large Hadron Collider (LHC). The first collisions of protons with protons at 7 TeV center-of-mass energy (7 trillion electron volts) occurred last Spring.

The expectation had been that LHCb would accumulate 1000 pb^{-1} in the first year of operation, but little thought had been given as to how to use a very small amount of data effectively. So the Syracuse group invented new methods to measure the yield of particles containing b-quarks. Results were obtained using 15 nb^{-1} of data and the 300 μb cross-section was reported by Sheldon at the 35th International Conference of High Energy Physics in Paris. Subsequently this became the first LHCb publication on the 7 TeV data.

Attention then turned to the B_s mesons which are composed of a b-quark and an anti-strange-quark. Extending the new methods to look specifically at B_s meson decays, they saw a new decay of the B_s into an excited charm meson a lepton and a neutrino. Furthermore, in 2008, Stone and Zhang (Postdoctoral Research Fellow) had predicted that there was a yet unseen decay mode of the B_s meson, $B_s \rightarrow J/\psi f_0(980)$, that could be useful for measurements of CP (particle-antiparticle symmetry) violation. After an intensive effort, put in over the Christmas break, LHCb found this final state with 40 pb^{-1} of data. "First observation of $B_s \rightarrow J/\psi f_0(980)$ decays" was submitted for publication on Feb. 2, 2011. Shortly thereafter, the Belle Collaboration, KEK in Japan, submitted a corroborating result. It is interesting to note that the first three LHCb papers on the 7 TeV data were written by members of the Syracuse group.

CERN →



Cooperation with Tohoku University, Sendai, Japan

Liviu Movileanu had a whirlwind 2010-11. He began with lectures at the *The 5th Summer School of Biophysics*: "Biosensing with channels 2010: Heading for faster, smaller, smarter biosensors", Ile de Berder, Rennes, France in August and at *The 2nd International Conference on Research and Higher Education in Romania*, Institute of Physics and Nuclear Engineering, Bucharest-Magurele, Romania in September.

On the other side of the world, before giving the keynote lecture at *The 7th International Conference on Flow Dynamics, Molecular and Nanoscale Phenomena in Fluids and Interfaces* in Sendai, Japan, he gave an invited talk, Sendai International Center, Tohoku University. Liviu has established a collaborative program with the Institute of Fluid Dynamics, Tohoku University, Japan. The program is funded by the Institute of Fluid Dynamics and includes bilateral exchange visits between the US and Japanese groups. In the Spring semester, he was host to Dr. Noriko Tomita, Senior Research Associate from Tohoku University in Sendai. In June, Liviu visited Shanghai to give two invited talks and chair a symposium session at the *2011 In Vitro Diagnostics Technology and Industry Development Summit, Biochips and Biosensors Based Molecular Diagnostics*, Ever Bright Convention & Exhibition Center. While there, he also discussed forming a program for joint research. Based on work in his laboratory, he has filed a Provisional Patent, "**Engineered Nanopores for Molecular Sensing & Detection".**

Syracuse University physicist named 2010 Cottrell Scholar

Duncan Brown was named a 2010 Cottrell Scholar by Research Corporation for Science Advancement. The prestigious award recognizes outstanding scientist-educators in leading U.S. research universities and comes with a $75,000 grant to further the recipient's teaching and research. Brown is among 11 early-career scientists nationwide to receive the 2010 award.

Duncan analyzes data from the National Science Foundation (NSF)-funded Laser Interferometer Gravitational-Wave Observatory (LIGO) in Hanford, Washington, and Livingston, Louisiana. LIGO was built to detect and study gravitational waves. Brown will use his award to support student research in gravitational-wave astrophysics and to enhance the experiences of undergraduate students taking Astronomy 101. Specifically, Brown proposes to recruit and mentor undergraduate students on multi-year research projects in gravitational-wave astronomy, with the goal that each student's research will lead to a scientific publication upon graduation. The Cottrell Award will also support Brown's efforts to implement student-centered teaching and peer instruction in AST101. These teaching methods incorporate small-group learning into large-lecture courses and have been shown to produce substantial gains in student learning. Brown has been using lecture tutorials developed by the Conceptual Astronomy and Physics Education Research (CAPER) team in his AST 101 class. 15-minute exercises are completed during class and promote critical thinking about concepts in astronomy. Duncan also proposes to develop new lecture tutorials and laboratory exercises for AST 101. This will be done in collaboration with Sharon Dotger, assistant professor of science education in The College of Arts and Sciences and in the Teaching and Leadership Program in SU's School of Education, and Steven Stewart, a science teaching graduate student.

Chancellor's Citation for Excellence: Eric Schiff

Prof. Eric Schiff has been awarded a Chancellor's Citation for Excellence. This very high honor carries this particular citation:

"Your distinguished career as an experimental physicist has included innovative and influential work with important implications for addressing current and future energy needs at national and global levels. With an extensive publication record and productive collaboration with tech industries, you embody the spirit of Scholarship in Action. Beyond your scholarly work, you have served Syracuse University in leadership roles as an administrator and curriculum innovator and as an inspiring teacher and mentor."

Eric served as Chair of the Physics Department for 6 years, 2001-2007. As chair, he encouraged students to earn the BA degree as a useful step to other fields. The following three years, he served as an Assistant to the Dean for Science. His research has been on amorphous material science with emphasis on solar cells.

Gordon Conference and Travel

Cristina Marchetti and Heinrich Jaeger of the University of Chicago were awarded $15,000 from ONR and $12,000 from NSF for proposals to support the 2011 Soft Condensed Matter Gordon Research Conference: Soft Matter Far from Equilibrium, August 14-19, 2011, at Colby-Sawyer College, New London, NH. Then, together with Mark Bowick and Jennifer Schwarz of SU and Abe Stroock (Cornell) and George Thurston (RIT), she organized the *11th New York Complex Matter Workshop*, held at the Syracuse Biomaterials Institute on June 10.

Following her three year stint as Chair, Cristina was on research leave in the fall semester. In this time she traveled abroad where she visited and lectured on soft biological material at various institutions - the Institute Curie in Paris, at an international workshop in Dresden, at the ICTP, Trieste, Italy, University of Stellenbosch, SA. Cristina was also invited to visit several US universities. She gave an invited talk at the Aspen Winter Conference *Materials and the Imagination*, was the keynote speaker at the *5th Southeast Meeting on Soft Materials*, Georgia Tech, and delivered four lectures at the *University of Massachusetts Summer School of Soft Solids and Complex Fluids*, Amherst, MA. In June she returned to Amherst to speak at the*47th New England Complex Fluids Workshop*, University of Massachusetts, Amherst, MA, and to the Lorenz Center in The Netherlands for a *Workshop on Fluctuations and Response in Active Materials: From Driven Granular Systems to Swarming Bacteria.* In addition to continuing her research program, Cristina also found time to serve as a member of a Reverse Site Visit panel for the NSF-EPSCoR (Experimental Program to Stimulate Competitive Research) Program on Sept 13-15, 2010, at the NSF headquarters in Arlington, VA.

Passing Thoughts...

Arthur Komar: March 26, 1931 - June 3, 2011

Courtesy of Richard Replin

Arthur Komar came to Syracuse University in 1957 as a postdoc with Peter Bergmann to do research on quantum gravity. He stayed on as Assistant Professor and Associate Professor until 1963 when he left to join the Physics Department at Yeshiva University in New York City. There he had a distinguished career, becoming Dean of the Graduate School of Science for a 10 year period, 1968-78. Artie then served as Chairman of the Physics Department until 1982 and from 1983-86 as Chairman of the Division of Natural Science. He remained at Yeshiva as Professor of Physics until his retirement in 1997. A year later, he returned to Syracuse to live with his long time companion, Alice Honig.

Artie received his AB from Princeton University with a thesis reviewing the classical electron. His PhD dissertation, supervised by John Wheeler, was on “Some Consequences of Mach’s Principle for General Relativity”. As a graduate student, he also worked on the problem of invariants in general relativistic space-times. This became the search for observables in general relativity which occupied much of the years of collaboration with Peter Bergmann. As long as his mental capacity remained, Arthur continued to wrestle with the problem of observation in general relativity and in quantum theory. But, his interests ranged over many issues including conserved quantities, time and space, and thermodynamics.

Close friends knew Artie as a renaissance man. He read widely about politics, history, archaeology, and plants. And he remembered what he read and was happy to share that knowledge and appreciation with whomever would listen.

While associated with Yeshiva, Artie took leave on three occasions to work with the National Science Foundation. During 1982-83 and 1986-87, he served as Program Director for Gravitational Physics. During 1991-92, he served as a consultant with specific responsibility for the LIGO project to observe and analyze gravitational radiation. Arthur Komar made a significant contribution to physics as an educator, as a research scientist, and as an administrator.

Herbert W. Berry, December 13, 1917-December 25. 2010

Prof. Herbert W. Berry of physics (Jack Orton/Photo center)

Herbert W. Berry came to Syracuse University as Assistant Professor of Physics in 1946. In 1942, he had taught briefly at Case Institute of Technology in Cleveland, OH and he spent the next three years on the Manhattan Project at the University of California at Berkley and at Oak Ridge, TN. Before coming to Syracuse after the war, he taught for a year at the University of Oklahoma in Norman. At Syracuse, his teaching was mainly in the second year of general physics as well as graduate courses in atomic and molecular physics. Undergraduate students thought his course was outstanding. His research was in scattering of neutral atoms and molecules and was supported with grants from the Navy and Army.

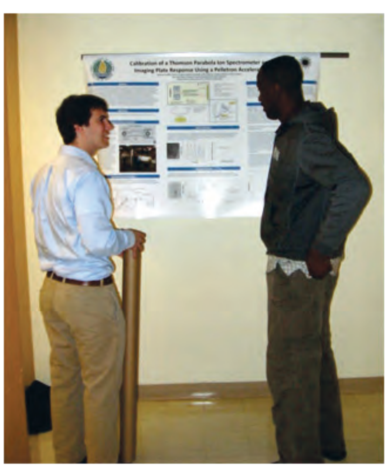
Upon retirement in 1979, he was able to devote his time to his avocation of repairing antique furniture and especially grandfather clocks. He traveled with his wife Myra to look for clocks and other interesting antique objects which she could sell in her small shop. After her death, he remained in his home on E. Genesee Street until his son David moved him to Scottsdale, AZ where he died in a nursing home.

Herb received his BS and MS from Syracuse University in 1937 and 1939, respectively. He then went to Washington University in St. Louis where he received the PhD in 1942. He was a gentle and very private person.

The family has started The Professor Herbert W. Berry Endowed Scholarship Fund at Syracuse University awards scholarships to physics students in his honor.

Undergraduate Research

Matt LaHaye



This was the fifth year that the Physics Department has hosted URD, which is geared towards physics majors at schools within a few hours driving distance from Syracuse, and provides them with a forum to present their research and meet other physics undergraduates, as well as introduce them to the Syracuse Physics program. Prof. Carolina Ilie, from the Department of Physics at SUNY Oswego, delivered the day’s opening talk, discussing career opportunities for physics majors and providing valuable insight on the decisions that physics majors face upon moving into the next phase of their career. Throughout the day, the 25 students participated enthusiastically in a series of seminar sessions and a poster session, during which they were able to showcase the results of their research projects. Six Syracuse Physics faculty contributed by leading lab tours and delivering four 45 minute lectures, which served to outline the diversity of research topics and graduate research opportunities in the Syracuse Physics Department. These faculty members participated throughout the event to talk with students during the poster session, coffee breaks and dinner.

Degrees Granted—2011

Doctor of Philosophy:

- Steluta Dinca, Condensed Matter Experiment
- Suphatra Adulrattananuwat, Biophysics
- Eric West, Astrophysics/Cosmology
- Russell Kincaid, Jr., Biophysics

Undergraduate Commencement Awards—2011

Neil F. Beardsley Prize—Matt Voelker
Paul M. Gelling Scholarship—Eva Bodman
Award for Academic Excellence—Thuc Mai, Sam MacAvoy, Chao Jie Zhen

Bachelors Degrees:

- Eva Bodman
- Diamon Breland
- Scott Collison
- Ben Forry
- Charles Graf
- Brandon Joyce
- Timothy Kelly
- Cynthia Lam
- Sam MacAvoy
- Thuc Mai
- Colin Murray
- Pat O'Connor
- Matt Voelker

Contributions can be made to the following:

_____Henry Levinstein Fellowship Fund—this **graduate** fellowship is to foster graduate student research with members of the Physics faculty, based on academic excellence of the nominee and promise of excellence in research.

Henry Levinstein (1919-1986) came to Syracuse University in 1947 and established a laboratory to study the properties of various lead salts sensitive to the infrared spectrum. He introduced a once a week lecture course on the Physics of Toys which was oversubscribed and overfilled Stolkin Auditorium. Much loved by his students, the Henry Levinstein Fellowship Fund was established by them.

_____ William Fredrickson Fund— this **undergraduate** fund was established to provide a partial tuition scholarship for an incoming freshman who indicates an interest in physics.

William R. Fredrickson came to Syracuse University in 1928 and was Chairman of the Physics Department from 1939-65. With the end of World War II, he began to build the department by choosing a faculty with strong interests in research. He was admired for his warmth and consideration of both the students and faculty. For his 75th birthday, former students, faculty, and university colleagues contributed funds for the William R. Fredrickson Scholarship Fund.

_____Niel F. Beardsley Prize—an award to an **undergraduate** physics major, based on outstanding academic achievement and contributions to the department.

Niel F. Beardsley was not a student at Syracuse University. He was both the monitor at Wright Patterson Air Force Base of some of the research carried out in Henry Levinstein's laboratory and a contributor to that research. When he died in 1962, friends and colleagues raised the funds to establish the Neil F. Beardsley Memorial Award whose undergraduate awardee would be selected by the Syracuse University Physics faculty.

_____Paul M. Gelling Fellowship Fund—a memorial scholarship fund made to an outstanding **undergraduate** physics major based on outstanding achievement.

Paul Gelling was a long time jack-of-all-trades in the department from 1949-84. He set up the demonstrations, printed laboratory manuals, constructed laboratory space, and generally took care of the building. When he died in 1984, his children, Paul D. and Susan Gelling and Mary Gelling Merritt, recognized Paul's identification with and devotion to the department by establishing the Paul M. GellingFellowship.

_____General Department Gift Fund: At the discretion of the Chair, funds are used to support teaching, research, travel and other general departmental needs.

Checks should be made out to *Syracuse University* with an indication of the selected fund, and sent to:
Chair, Department of Physics, Syracuse University, 201 Physics Building, Syracuse, NY 13244-1130.

Syracuse University

Department of Physics
201 Physics Building
Syracuse, NY 13244-1130

Physics Matters

Physics Matters is published by the Department of Physics of Syracuse University for its students, alumni and friends to inform them about the department and to serve as a channel of communication. Readers with comments or questions are urged to send them to Department of Physics, Syracuse University, 201 Physics Building, Syracuse, NY 13244-1130. Fax to 315-443-9103. Email to physmatt@phy.syr.edu. The Web address is http://www.phy.syr.edu/.

Steele Hall circa 1950