INTER ACTIONS

DEPARTMENT OF PHYSICS 2014

Physics

Carnegie Mellon University

Early Research in Magnetism and Solid State Physics in Pittsburgh

Luc Berger

Introduction

THIS ARTICLE IS BASED PARTLY ON A TALK I GAVE IN THE PHYSICS DEPARTMENT IN NOVEMBER 2012. IT IS A PERSONAL VIEW OF THE SITUATION, WHICH EMPHASIZES CERTAIN PERSONS AT THE EXPENSE OF MANY OTHERS. BY NECESSITY, IT IS SUBJECTIVE AND VERY INCOMPLETE. ITS COVERAGE IS LIMITED MOSTLY TO THE PERIOD BEFORE 1965.

Carnegie Tech Physics Department

Clinton J. Davisson was a faculty member from 1911 to 1917. At that time, teaching loads were heavy and research opportunities few. He moved to the Engineering Department of Western Electric Company (later the Bell Telephone Laboratories), where he performed with Lester H. Germer an experiment involving scattering of electron waves by a nickel crystal. An early confirmation of the validity of wave mechanics, this 1927 work was the basis of Davisson's 1937 physics Nobel Prize, which he shared with George P. Thomson who had done similar work.

Otto Stern escaped from Nazi Germany, and came to Pittsburgh in 1934. He was soon joined by his former collaborator, Immanuel Estermann. Carnegie Tech President Baker built for them one of the first research laboratories in the Physics Department. They continued the work with atomic beams done earlier at the University of Hamburg. For example, I found a paper by I. Estermann, O.C. Simpson and O. Stern in Phys. Rev., vol. 52, p.535 (1937), about a measurement of the magnetic moment of the proton. This is a difficult experiment since this moment is three orders of magnitude smaller than the moment of the electron. See also O. Stern, Phys. Rev. vol. 51, p. 852 (1937), which proposes a new method to measure the electron moment.

During World War II, Stern and Estermann worked on radar technology. Also, like other Carnegie Tech professors, they became advisers on metallurgical problems connected with the development of the atom bomb. While at Carnegie Tech, Stern received the 1943 Nobel Prize in physics. After Stern's retirement in 1945, Estermann started the tradition of low-temperature magnetism work continued later by Simeon A. Friedberg.

While I was a doctoral student in Lausanne, Switzerland, during 1955-1960, I noticed an interesting body of publications on magnetism and the solid state originating in Pittsburgh. Roman Smoluchowski and Jack Goldman were in the Physics Department of Carnegie Tech. Also Fred Seitz, who wrote the well-known 1940 textbook "The Modern Theory of Solids" and the 1943 book "Physics of Metals." Later in life, he became president of Rockefeller University and of the National Academy of Sciences. In the Metallurgy Department, Professor Mehl had founded the Metals Research Laboratory in the early thirties. This institution involved the physics professors just mentioned, as well as Westinghouse Research personnel.

A long-time Physics Department member, Emerson M. Pugh was interested in the Hall effect of ferromagnets, an anomalously large and mysterious phenomenon. During World War II, he worked on explosive shaped charges and high-velocity projectiles. After funding became available from the Office of Naval Research after the war, a series of his doctoral students measured the Hall effect in such alloys as nickel-copper, nickel-

Early Research in Magnetism and Solid State Physics in Pittsburgh

cobalt, etc. This systematic work clarified considerably the nature of current-carrying electrons in magnetic metals, showing that they have a marked 4s character.

Solid-state theorist Walter S.C. Kohn was present during the fifties. The so-called Kohn anomalies, discovered by him in 1959, affect the speed of sound waves propagating in metals. They are caused by the electron-phonon interaction. He also developed the ideas leading to the Kohn-Korringa-Rostoker method of calculating electron states in solids, based on Green's functions. After leaving Pittsburgh, he invented the density functional approximation, an improved way to account for electron interactions in solids. Because this method also works for molecules, he received the 1998 Nobel Prize in chemistry, shared with John Pople.

The first Annual Conference on Magnetism and Magnetic Materials took place at the William Penn Hotel in 1955. That fact is symbolic of the importance of Pittsburgh in the development of that field.

Carnegie Tech Electrical Engineering Department

Considerable research on semiconductors took place in that department in the fifties and sixties. But I am somewhat more familiar with the activities of Leo Finzi and Chang who started a tradition of work on Applied Magnetism. This tradition was continued by Joseph O. Artman with experiments of ferromagnetic resonance and also by Stanley Charap. With the foundation of the Data Storage System Center by Mark Kryder around 1980, this tradition continues to this day.

Westinghouse Research Laboratories

In 1931, Francis Bitter published a short note in Phys. Rev. vol. 38, 1903 (1931), on the first observation of magnetic domain walls, by means of magnetic nanoparticles deposited on the surface of iron-silicon and nickel crystals. The pictures he obtained are now called Bitter patterns. At that time, the laboratories were located on Ardmore Boulevard near Forest Hills.

When I arrived In Pittsburgh in 1960, the Westinghouse Research Laboratories were the best equipped and best funded physics institution in Pittsburgh. They were in new buildings located in Monroeville, and Clarence Zener was director of science. For example, noted theorists such as Alex A. Maradudin and Ted Holstein were studying lattice vibrations and the electron-phonon interaction. An important project attempted to develop kitchen refrigerators without moving parts, based on the thermoelectric Peltier effect in semiconductors. Although it encountered technical difficulties, it resulted in the publication in 1961 of the book "Thermoelectricity: Science and Engineering" by Robert R. Heikes and Roland W. Ure.

A large number of physicists and engineers worked on superconductivity and its applications, under the direction of John K. Hulm.

Because of transformers and electric motors, research on soft magnetic alloys was always of importance to the Westinghouse Electric Corporation. I am most familiar with the work of Fred Werner and his collaborators. In addition, ferrites and garnets were used in microwave magnetic devices for radar applications. W. Jim Carr worked on the theory of both ferromagnets and superconductors. A long time ago, he gave me a copy of the article on Secondary Effects in Ferromagnetism that he wrote for volume 18 of the Encyclopedia of Physics, edited by S. Flugge.

University Of Pittsburgh

In the Physics Department, Fred Keffer worked on theoretical magnetism. In 1965, he was the author of a book-length article on Spin Waves for volume 18 of the Encyclopedia of Physics, edited by S. Flugge.

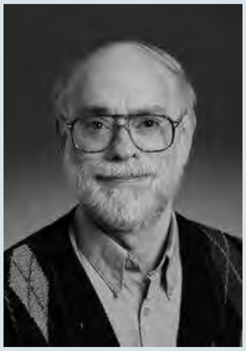
Edward Wallace was head of the Chemistry Department, as well as a respected expert on the physical and magnetic properties of rare-earth elements. Now they are used to make powerful permanent magnets and for hydrogen storage.

U.S. Steel and Gulf Research Laboratories

In the sixties, the U.S. Steel Research Laboratory was located in Monroeville. One notable asset was the most powerful transmission electron microscope in the world, with an accelerating voltage of one million volts. In that laboratory, D.A. Oliver had obtained very pure samples of iron through a technique called zone refining. After he retired, I was graciously given a piece of this iron by Fred C. Schwerer of the same laboratory. My doctoral student Alak Majumdar measured the Hall effect of that sample at very low temperature and in very high fields, as part of his thesis.

The Gulf Research Laboratory was in Harmarville. Most of the work was probably of a chemical nature. Nevertheless, an important magnetic device was invented there. Born in Russia in 1907, Victor Vacquier was educated in electrical engineering and physics. In 1937, he invented the fluxgate magnetometer, a very sensitive detector of magnetic fields. During World War II, after moving to Columbia University, Vacquier applied the fluxgate to the detection of submarines. Later, at the Scripps Institution of Oceanography, he demonstrated with it the validity of the theory of plate tectonics in geology.

From the Department Head



Steve Garoff

It has been two years since we last published our Interactions Newsletter and so there is a lot of catching up to do. While we were remiss in failing to publish last year, it was not for lack of news. More to the point, we have been very busy with many exciting developments.

Since 2012, the department has continued to grow, with the addition of new faculty including Matt Walker and Tina Kahniashvili in cosmology, Raphael Flauger in astroparticle physics, and Di Xiao and Ben Hunt in solid state physics. In the past decade, we have hired eleven new faculty! Beyond their scientific talents, these people have brought new perspectives and energy to moving our department forward.

We have also seen retirements over the past two years, including Richard Griffiths, Robert Griffiths and John Nagle. Sadly, last fall we lost our great colleague, Hugh Young, who had been retired for a number of years. We had a chance to celebrate his life and contributions with a program this spring that attracted almost two hundred friends, former students and colleagues.

This past June after sixty-six years, Lincoln Wolfenstein, who had remained a fixture in our department doing research and giving lectures even after he retired in 2000, left Pittsburgh to live closer to family. Lincoln was a pillar of our department and a source of pride for our university.

In the past two years, faculty members have won prestigious awards. Luc Berger won the 2012 American Physical Society Buckley Condensed Matter Physics Prize, and Bob Swendsen won the 2014 American Physical Society Rahman Prize for Computational Physics. Our department has marked both occasions with well-attended special colloquia by distinguished scientists, celebrating the achievements of our colleagues. We also had faculty members recognized for outstanding educational contributions. Gregg Franklin won the 2013 Richard Moore Award for sustained contributions to the educational mission of the Mellon College of Science, and Bob Swendsen won the Julius Ashkin Award for unusual devotion and effectiveness in teaching undergraduate students in the Mellon College of Science (quite a year for Bob!).

Our graduate and undergraduate programs continue to flourish. Under the direction of Kunal Ghosh, our assistant head for Undergraduate Affairs, our undergraduate program continues to successfully mix a vibrant program of activities with research opportunities for our students and a rigorous curriculum. Each year we are proud to see how this leads to our students moving on to great jobs and future studies at top-ranking institutions. In the past three graduations, we have seen over one hundred physics majors receive their bachelor's degrees. Under the direction of Manfred Paulini, our graduate program also continues to expand and thrive. Thirty-three students have received their Ph.D.s and forty-one their master's degrees since our last newsletter.

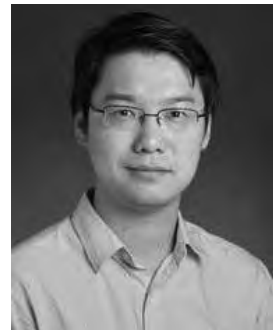
I especially want to thank Gregg Franklin for his leadership over five years as department head. His dedicated service brought much success to our department. I became head in September 2013, and I hope I can do as much over the rest of my term as department head.

Finally, I want to invite all of you to renew and strengthen your ties to our department. Whatever your affiliation, we value you as part of our community. We would like to hear from you, telling us what you are doing and commenting on how the department helped in your careers and life. We also welcome suggestions on how we can improve.

Please write me at physics@andrew.cmu.edu. If you are ever in Pittsburgh and can stop by the department, let me know when you will be here and I will be happy to host you.

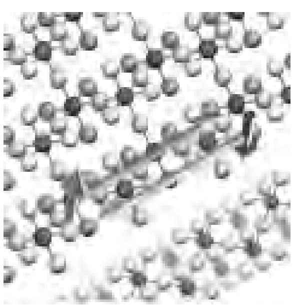
Quasiparticles:
A Tale of Many Electrons

DI XIAO



Condensed matter physics is perhaps the largest and most diverse branch of physics. It deals with the physical properties of condensed phases of matter, which appear whenever the number of particles in a system is extremely large and the interactions between the particles are strong. The most familiar examples of condensed phases are solids and liquids, which arise from the electromagnetic forces between atoms. In condensed matter physics we study questions such as why are metals shiny and conductive, why is glass transparent, why is iron magnetic, and why is rubber soft and stretchy. In fact, almost every question we might ask about the world around us, short of asking about the sun or stars, is probably related to condensed matter physics in some way.

Given such diversity of condensed matter phenomena, you might be surprised to learn that they are the result of only two "elementary" particles, the ions and electrons. Then, where does this diversity come from? It turns out that because of their interactions, particles in a condensed phase behave collectively as quasiparticles, quantum entities with very different properties from individual particles. For example, in semiconductors — ubiquitous in modern electronics — the electric currents are sometimes carried by quasiparticles that act like they have negative mass. These are known as "holes," and rather than think of them as negative charges with negative mass, we treat them as positive charges with positive mass. There are more exotic quasiparticles under extreme conditions. At low temperatures, the electrons can pair up and move in concert, just like a single particle. The result is electric current that flows without resistance. This is the phenomenon of superconductivity. Under a strong magnetic field, the electrons must tightly grab magnetic flux lines to lower the total energy of the system, resulting in quasiparticles with fractional electric charge — something impossible for free particles, since electrons are indivisible. It is exactly this diversity of quasiparticles that makes condensed matter physics so interesting!



Network of oxygen (yellow spheres) and transition-metal (red spheres) ions realized in a (111) bilayer of transition-metal oxides. Along the edge of such a structure, electrons with opposite spins flow in opposite directions without dissipation.

My current research interest is focused on a new type of quasiparticle that can be described by the relativistic Dirac equation. Typically, the electrons moving in a solid are regarded as non-relativistic. However, it has been discovered that in graphene, a monolayer of carbon atoms packed into a honeycomb lattice, the quasiparticles behave like pseudo-relativistic Dirac fermions without mass. Many extraordinary properties of graphene, such as its high mobility, can be traced back to the behavior of massless Dirac fermions. Another place where one can find massless Dirac fermions is at the surface of topological insulators, a newly discovered quantum matter. In these remarkable materials, the spin-orbit interaction allows a non-trivial topology of the electron bands, resulting in protected "helical" edge and surface states in two and three-dimensional systems. Many interesting phenomena, including quantum number fractionalization and magneto-electric effects have been predicted to occur in these systems, and are the subjects of a growing experimental effort. In my group, we use both analytical and computational tools to predict what type of materials possess these quasiparticles, and study how they respond to external perturbations. For example, we have predicted that certain 2-D heterostructure made of transition metal oxides can be topological insulators, which could be useful for low-power oxide electronics.

Sometimes the Dirac fermions can also acquire a mass. We recently found that in monolayers of molybdenum disulfide, a layered compound best known as a lubricant, the quasiparticles can be described by a pair of massive Dirac fermions with opposite mass. This is due to the interaction between electrons and ions, which in this material, are arranged in a way that breaks inversion symmetry. The two species of Dirac fermions have different response to electric, optical and magnetic fields, thus can be used for information encoding and processing. Our hope is that it may lead to new types of electronic devices. Currently we are trying to understand the role of electron interactions in the behavior of these quasiparticles.

My research is only part of the condensed matter program at Carnegie Mellon. Looking ahead, there are ample opportunities for new discoveries in condensed matter physics, particularly at the interface between traditionally different branches in our field. I'm looking forward to starting a new scientific journey with my colleagues, perhaps making a few friends with some exotic quasiparticles along the way.

RACHEL MANDELBAUM

Visualizing the Invisible

Modern cosmology is a field with a problem: only 4% of the energy density of the Universe today can be accounted for by ordinary matter such as stars and planets. Based on a variety of observations, we have been forced to posit the existence of dark matter (which we detect through its gravitational attraction) and dark energy (which causes the expansion of the Universe to accelerate, a discovery that led to the 2011 Nobel Prize in physics). While we know that these dark components exist, that is not the same thing as knowing what they are. Indeed, much of modern observational cosmology is focused on studying dark matter and dark energy in great detail, to try to determine their properties and thereby determine what they are from a theoretical standpoint.

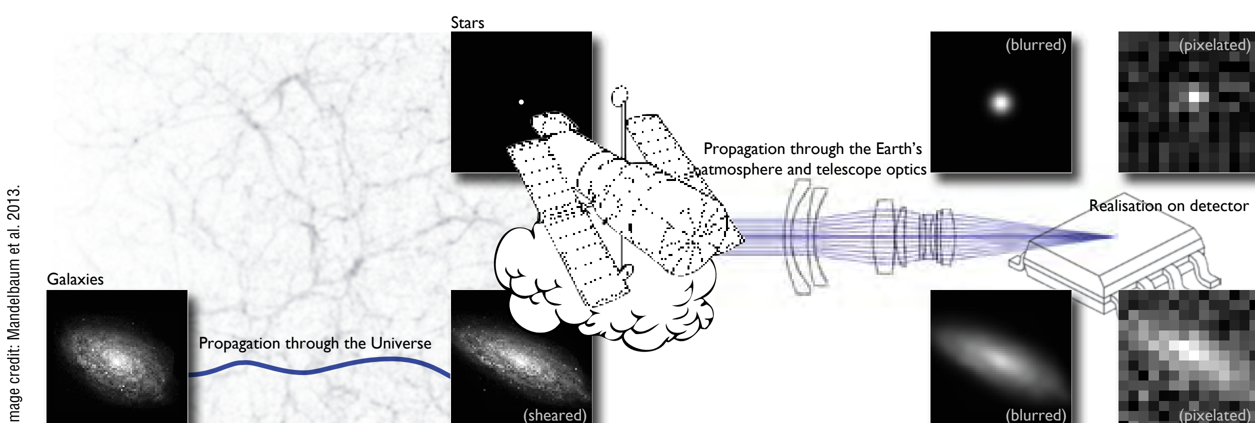
My work in observational cosmology involves the use of one of the most promising observational methods for studying both dark matter and dark energy. Gravitational lensing, the deflection of light by mass, is an important cosmological measurement technique because the deflections of light coming from distant galaxies are caused by both ordinary matter and dark matter. It is thus one of the most direct ways to “see” dark matter. But that is not all: the accelerated expansion of the Universe that is caused by dark energy also affects the growth of massive cosmological structures like groups and clusters of galaxies. By using gravitational lensing to measure how cosmological structure is changing with time, we can indirectly infer the effects of dark energy.

Weak lensing

While gravitational lensing can cause dramatic changes in the appearances of galaxies, or even the appearance of multiple images (an effect known as “strong lensing”), my research is on so-called weak lensing, which is what happens when the light deflections due to gravitational lensing are so small that they only cause tiny distortions in the shapes of galaxies. The advantage of studying weak lensing is that it occurs practically everywhere in the Universe, but the disadvantage is that we have to measure tiny (<1%) distortions in galaxy shapes, in a Universe where typical galaxies have rather large ellipticities. We also have to distinguish between galaxy shape distortions due to gravitational lensing, versus those that come from nuisances like the earth’s atmosphere, our telescope optics or imperfections in detectors. The combination of these factors makes weak lensing a challenging measurement, and a great deal of the effort of people in the field in the past decade (including my own work) has gone into making sure that we avoid “systematic errors” that might bias our measurements.

Measuring mass in galaxies

Many of the weak lensing measurements that I have made used data from the Sloan Digital Sky Survey (SDSS), which measured the images of tens of millions of galaxies over one-fourth of the sky. Using SDSS data, I have studied the relationship between the amount of light coming from galaxies and the amount of dark matter in extended halos around these galaxies. My measurements showed that for typical galaxies, the ratio of mass in stars to total mass in dark matter is around 4%. This is only 25% of what we expect based on the total amount of ordinary matter in the Universe, and implies that galaxies are not very efficient at forming stars: some of the mass in ordinary matter gets expelled instead of forming stars, or stays in the galaxy as hot gas. My weak lensing measurements in the SDSS provided some of the first concrete evidence for this



The physical processes contributing to a weak gravitational lensing measurement: Light from a galaxy (bottom row) is lensed by matter in the Universe, blurred by the atmosphere and telescope optics, and then appears on a pixelated and noisy image on the detectors. Stars (top row) are also blurred by atmosphere and telescope optics, so we can use them to learn about the blurring and remove it from the galaxy images.

finding, which was later confirmed by several groups using other datasets as well.

But this is not all that we can do with measurements of mass around galaxies. Using a sample of massive galaxies called Luminous Red Galaxies (LRGs), I measured the associated mass in dark matter out to distances of more than 100 million light years, many times farther than the average distance between the galaxies. By measuring the associated mass to such large distances, we can learn about the way cosmological structures have grown on extremely large scales in the past ~2 billion years, which teaches us about the amount and nature of dark energy.

What's next?

As a result of the success of multiple groups at measuring weak lensing and using it to learn about dark matter and dark energy, the research program in the field of observational cosmology has a heavy emphasis on gravitational lensing in the next two decades. Four large sky surveys have recently begun or will start soon to make measurements of weak lensing over large areas of sky; several more will take place in the next decade. I am a member of one of the surveys that started in early 2014, called the Hyper Suprime-Cam (HSC) survey, which will take place at the Subaru telescope on Mauna Kea, Hawaii. Looking even further ahead, I am working on preparations for the Large Synoptic Sky Telescope (LSST) survey, a ground-based U.S. project for which the actual telescope will be located in Chile, and on preparations for the Euclid Survey, a project being led by the European Space Agency (ESA) with involvement by a limited number of U.S. scientists through an agreement with NASA. We have every reason for optimism that weak gravitational lensing and the other measurements that are being planned with these surveys will finally allow us to unravel the nature of the mysterious dark matter and dark energy that dominate our Universe.

MATTHEW G. WALKER

Using galactic dynamics

At present, dark matter is detected exclusively via gravitational interaction as inferred from astronomical observations. Information about the particle nature of dark matter awaits detection of non-gravitational interactions, perhaps also as inferred from astronomical observations (e.g., in the case of indirect detection via self-annihilation). Plausible particle candidates span tens of orders of magnitude in mass and even more in cross-section for interaction with standard-model particles.

Given these rather loose constraints, the favored dark matter model must be one that gives the simplest rules for reproducing the visible structure of galaxies in a cosmological context.

I am working to infer the nature of dark matter from galactic dynamics. Ultimately I aim to help identify the simplest rules for reproducing the visible structure of galaxies in a cosmological context. The standard 'cold' dark matter (CDM) hypothesis uses an extremely simple recipe: negligible thermal velocities and negligible self-interactions let CDM particles clump gravitationally on all scales, enabling hierarchical clustering that begins with 'microhalos' of less than Earth's mass.

Alternatively, viable 'warm' or 'self-interacting,' etc., particle models invoke greater complexity: thermal streaming and/or scattering mechanisms can suppress formation of the smallest halos without affecting large-scale structure. Therefore the clustering of dark matter at small scales reflects basic information about its nature. I study small galaxies in order to get a sense of how much complexity the dark matter model requires.

The Milky Way's dwarf spheroidal (dSph) satellites are the smallest objects associated empirically with dark matter. They are also the darkest, with luminosities ranging from mere hundreds to millions of suns and dynamical mass-to-light ratios between ten and thousands of times that of the Sun. Their extreme central densities correspond to the mean density of the Universe when it was just a small fraction of its current age. These properties put dSphs at the intersection of dynamics, galaxy formation, cosmology and particle physics. Over the past decade, wide-field imaging and spectroscopic surveys of dSphs have sparked data-driven upheavals in all of these fields.

For example, deep/wide imaging surveys such as the Sloan Digital Sky Survey have revealed ~ 2 dozen 'ultrafaint' satellites around both the Milky Way and M31. Not only have these discoveries doubled the census of Local Group galaxies, they have also stretched the concept of 'galaxy' to such low luminosities that some galaxies are intrinsically fainter than some stars! The ultrafaints extend well-known galactic scaling relations — involving size, velocity dispersion and surface density — by three orders of magnitude in luminosity. Evidently, galaxies form according to rules that hold over baryon-dominated and extremely DM-dominated regimes.

Meanwhile, I have worked on spectroscopic surveys of the Milky Way's eight 'classical' dSph satellites, increasing samples of individual stellar velocities and metallicities in these objects by two orders of magnitude, from tens per galaxy to thousands. The flat velocity dispersion profiles that we measure for all of these objects (Figure 1) constitute the strongest available evidence that dark matter dominates dSph internal dynamics at all radii. The quality and quantity of these data are now attracting dynamicists and statisticians into the field.

My own published analysis of these data reveals the presence of large (~ 1000 light years) central 'cores' of constant dark matter density in at least two dSphs (Figure 2). This result requires that collisionless

CDM halos must have absorbed ≳10^{54} erg of energy from baryon-physical processes in order to unbind the dense central 'cusps' that otherwise characterize CDM halo structure.

However, my collaborators and I have shown that the amount of baryon-generated energy that is available for core formation is limited fundamentally by the low star-formation efficiencies that CDM models must simultaneously invoke in order to explain the low luminosities of dSphs. The viability of the CDM model now depends on its ability to escape this tension.

Thus it is beginning to seem that dark matter may have more complexity than is prescribed by the simplest cosmological/particle models. This circumstance would imply that at least one of the following — sorted in order of increasing consequence for the nature of dark matter — is true:

1) baryons efficiently alter the central structure of galactic dark matter halos;
2) the dark matter is collisional (i.e., self-interacting), which may require further complexity in the form of a velocity-dependent scattering cross section;
3) the dark matter is not cold (i.e., its thermal velocity is sufficient to suppress cosmic structure formation below a characteristic scale); 4) the dark matter is composed of more than one type of particle; 5) the dark matter is not composed of particles (i.e., modified gravity).

Armed with new instrumentation and techniques for data reduction and statistical analysis — and in collaboration with CMU statisticians! — I am now planning new observations and analyses that can distinguish among the possibilities listed above. Specifically, I will use the 6.5-meter Magellan Telescope at Las Campanas Observatory, at an altitude of 8,000 feet, in the Chilean Andes.

Attached to the telescope is a new spectrograph that is fed by 256 optical fibers and is thus capable of acquiring spectra for thousands of targets per night. The instrument performed spectacularly during its first science run, which took place during mid-November, 2013, and is poised to increase available sample sizes by another order of magnitude. Such large data sets will then enable more sophisticated statistical analyses, particularly allowing non-parametric methods that directly operate on the structure that is present in the data, ultimately telling us not only how much dark matter resides in the smallest galaxies, but also how it is distributed spatially.

Galactic dynamics has long been used to infer that dark matter exists. I now intend to use galactic dynamics to figure out what the dark matter is.

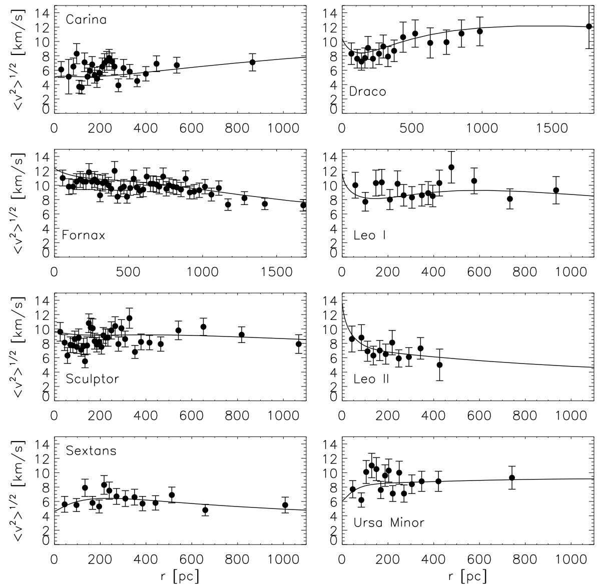


Fig. 1. — Velocity dispersion profiles that I measure for the Milky Way's 8 'classical' dwarf spheroidal satellites, including velocity measurements for 7 104 individual stars. Overplotted lines show best-fit models, which generally require that dark matter dominates the internal kinematics at all radii, with mass-to-light ratios & 10 solar units even at the centers.

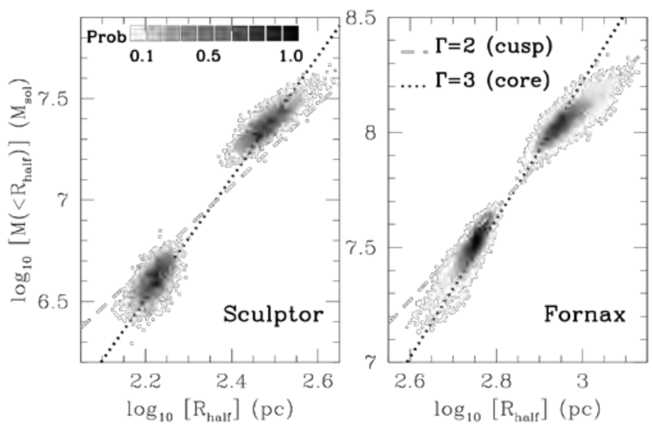


Fig. 2. — Left, center: Model-independent constraints on halflight radii and masses enclosed therein, for two chemo-dynamically independent stellar subcomponents in the Fornax and Sculptor dSphs. These measurements are consistent with the presence of large (7 1000 light years) 'cores' of constant central density, suggesting a limit to the ability of dark matter to from clumps at small scales. This result implies either that baryons alter CDM halo structure even in the least luminous galaxies, or that the dark matter is something other than standard CDM.

Kathryn McKeough

When we look at images from telescopes, there are many galaxies scattered across the field of sight. A galaxy cluster is a group of galaxies drawn together by strong gravitational forces. Astronomers are interested in clusters because they are the most massive gravitationally bound objects in the Universe. Counting them gives us the ability to constrain parameters of cosmological models. However, it is a challenging three-dimensional problem to determine which sets of galaxies are close enough to be considered clusters. Not only are we looking at the locations of grouped galaxies in the sky, but we must also take into account how far they are from each other. The task at hand is to create a numerical method to determine which clusters are statistically significant and which appear to be because of a cluttered sky. Elisa Chisari from the Astrophysical Sciences Department at Princeton University is working on this problem. Elisa has chosen to use the G statistic in her analysis, which is not often used in the context of astronomy. My goal is to test the G statistic in comparison to maximum likelihood and chi squared statistics, to discover which is the best tool for determining the significance of galaxy clusters.

My advisors for this project are Peter Freeman, Ph.D., (Statistics) and Rachel Mandelbaum, Ph.D., (Physics). I am working on this project through the Carnegie Mellon Department of Statistics as part of the ‘Astrostatistics’ group. Astrostatistics is a field in which advanced statistical modeling and analysis is applied to data with astrophysical goals. As a double major in Physics and Statistics, Astrostatistics work was a natural fit for me. Since starting research in the fall of 2012, I have been involved in several projects at CMU including galaxy morphology detection and interpolating telescope point spread functions. I have also done research in this field through an REU program at the Harvard-Smithsonian Center for Astrophysics.

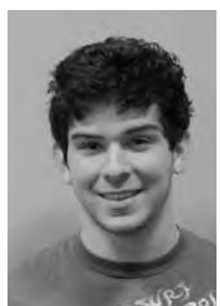
With the large amounts of astronomical data being gathered almost every day, statistical methods have become essential in performing low-cost, comprehensive analyses. For me, it is an exciting and active field in which to combine my passion for both physics and statistics.

Michael Darcy

My research is about different kinds of waves on liquid interfaces. The ultimate goal of the research is to inform and optimize aerosolized drug delivery for people with respiratory illness. I did this work in Professor Garoff’s lab on campus over the summer and will continue it over the academic year. I was referred to Professor Garoff’s lab by Dr. Ghosh last spring, and luckily Professor Garoff was willing to take me on.

After setting up a laser inclinometer to measure the inclination of liquid surfaces, I set out to examine what kinds of waves occur when surfactant is deposited on the surface. As it turns out, there are two separate waves! One is an everyday wave like those found when raindrops hit puddles, or wind waves on the ocean before they have broken on the shore. The second wave is caused by a surface tension gradient, this second wave is also known as a Marangoni wave. The functional groups in surfactants cause them to self-assemble into layers at interfaces, and their presence typically lowers the surface tension of that interface. Because surfactants alter the surface tension at the interface in this way, a Marangoni wave is generated. The Marangoni wave is very important to my research because it is the wave that will be directly responsible for transporting the aerosolized drugs in a lung.

In addition to the laser inclinometer, I also used a surface tension measuring device called a Wilhemy pin. With both instruments together, we were able to see, for the first time, both a change in the surface tension (indicating the presence of surfactant) and a distortion of the surface (using the laser inclinometer). Over the course of the next few months before I graduate, I hope to use my instrument and technique to examine these waves in unprecented detail. Already, we have been able to say definitively many things about the waves which were unknown before, so I have high hopes for my project.

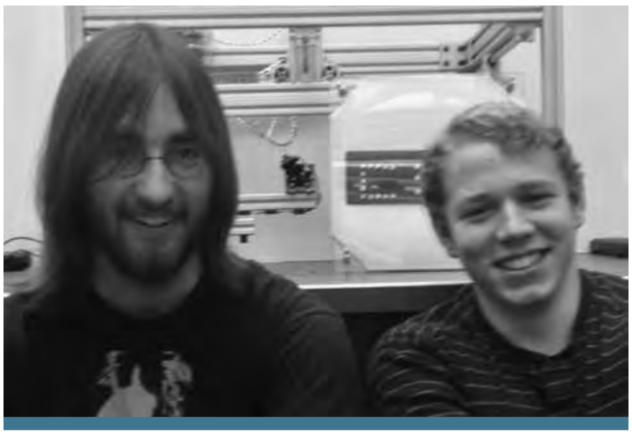


Robert Macedo

Over the summer, I worked at the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, on creating an Interatomic Potentials Repository. The research was funded by the government Student Undergraduate Research Fellowship (SURF) program. I heard about this research by an email from my adviser, Dr. Ghosh.

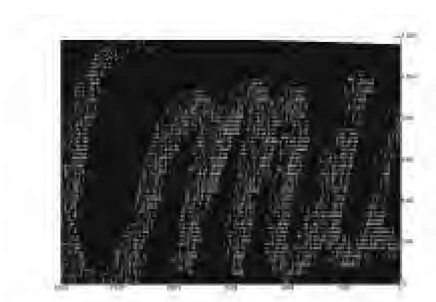
Development of new materials is essential to our advancement of a society from a technological standpoint. If a company can use a trustworthy computer model to understand the properties of a new material without having to physically test the material, the company has the ability to save enormously on development costs. One popular method of simulating materials is molecular dynamics (MD). MD involves simulating a material on the nanoscale (~10^-9 meters) level. From molecular dynamics, one can predict material properties such as melting temperature and elasticity. However, every molecular dynamics simulation is dictated by an interatomic potential. An interatomic potential is a mathematical relationship between the distance one atom is from another, and the energy of the atoms. However, there have been many interatomic potentials developed for every element, and each interatomic potential succeeds and fails in different ways. For example, if a company wished to simulate aluminum to measure the element’s melting temperature, said company would have to choose an interatomic potential that gave an accurate representation of aluminum's melting temperature. Unfortunately, information about interatomic potentials is not available in any one place, and instead companies are struggling to choose interatomic potentials in an efficient manner.

The goal of my research over the summer was to create an infrastructure of programs that would take a list of interatomic potentials as an input, run molecular dynamics simulations on said material, and publish a website with helpful data corresponding to each interatomic potential. Ideally, my infrastructure would allow easy publication of interatomic potentials data in one location, thereby increasing the attractiveness and utility of molecular dynamics simulations. When finished, the user of my infrastructure can simply input a list of interatomic potentials, and my infrastructure would publish a website with all the relevant information pertaining to the potentials. The intention of my infrastructure is for it to be distributed freely online so that any group wishing to test and publish data about an interatomic potential can easily do so. I completed the infrastructure by the end of the summer, and gained an abundance of scientific, programming and writing skills in the process.

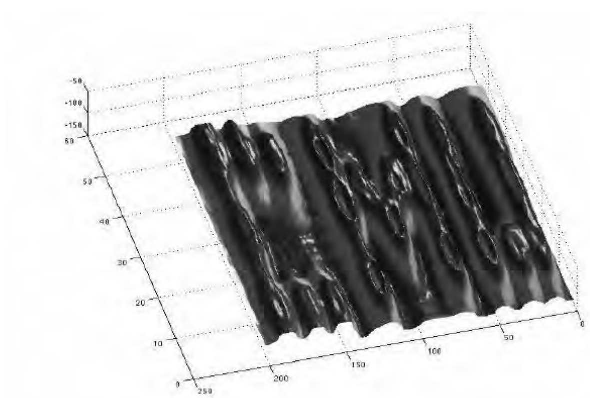


Michael Matty & Kevin Tkacz

Scanning probe microscopes are important tools for nanoscale measurements of surfaces to determine their height contours, their local magnetization or the local electrical conductivity. In magnetic force microscopy, a magnetic cantilever is rastered across the scan area and is subject to the magnetic interactions between the scanned material and its own magnet. This interaction causes the cantilever to tilt. Using a laser and photodiodes, this tilt can be related to the magnetic properties of the scanned material and a map of the magnetic forces felt by the tip can be created. Because the working components of the microscope are so small, it is often difficult to "see" how a scanning probe microscope works. In this project, we developed a model scanning probe system that works the same way but has much larger parts. Our model Magnetic Force Microscope (MFM) helps others visualize the important components and understand how they work together in order to reveal the local magnetic properties of a surface. Our model is able to scan over either an array of permanent magnets to demonstrate MFM or a piece of copper clad board that the user can draw on with sharpie to demonstrate Conductive Atomic Force Microscopy (CAFM). CAFM is another type of scanning probe microscopy meant to examine the local electrical properties of a surface. Results of both are pictured below. We have been able to demonstrate our device to both groups of students and professors, and hope to continue demonstrations at places like the Carnegie Science Center.



CAFM Results. Sharpie CMU on copper



MFM Results. Magnet CMU sample

Degrees Granted in 2012

Doctor of Philosophy in Physics

Bora Akgun

Biplab Dey

Eric Evarts

Megan Lynn Friend

Chang-You Lin

Benjamin Adair Sauerwine

Prabhanshu Shekhar

Siddharth Subhash Shenoy

Nishtha Srivastava

James Charles Thome

Chik Him Ricky Wong

Li Yu

Master of Science in Physics

Onur Albayrak

Benjamin Taylor Carlson

Patrick Michael Diggins IV

Marilia Cabral Ramos Do Rego Barros

Brendan Michael Fahy

Fan Gao

Michael Stephen Jablin

Samuel D. Oberdick

Melih Ozbek

Stephan K. Piotrowski

Katherine Elizabeth Robbins

Nikhil Sivadas

Daniel Lee Stahlke

Venkatasatya Ananth Tenneti

Varun Pradeep Vaidya

Undergraduate Honors

Conroy P. Baltzell
College Honors

Anthony L. Bartolotta
University Honors
Phi Kappa Phi

Sarah D. Benjamin
University Honors

Luke A. Ceurvorst
University Honors

Jennifer Y. Chu
University Honors
College Honors
Phi Beta Kappa
Phi Kappa Phi

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University Honors
Phi Kappa Phi

Alexander O. Edelman
University Honors
College Honors
Phi Beta Kappa
Phi Kappa Phi

Emily Gehrels
University Honors
College Honors
Phi Beta Kappa
Phi Kappa Phi

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College Honors

Dara J. Krute
University Honors
College Honors

Alisa A. Rachubo
University Honors

Svetlana L. Romanova
University Honors

Charles P. Swanson
University Honors
Phi Beta Kappa

Joseph J. Vukovich
University Honors
College Honors

Nanfei Yan
College Honors

Brian M. Zakrzewski
University Honors

Undergraduate Degrees

Bachelor of Science Double Degree in Physics and Computer Science

Michael Jordan Alexovich

Bachelor of Science in Physics, Astrophysics Track with a Minor in Philosophy

Dimitry Ayzenberg

Bachelor of Science Double Degree in Physics and Mathematical Sciences

Conroy Baltzell

Bachelor of Science Double Degree in Physics and Mathematical Sciences

Anthony Leo Bartlotta

Bachelor of Science in Physics with a Minor in Business Administration

Brian Austin Beck

Bachelor of Science in Physics, Astrophysics Track with a Minor In Economics

Sarah Denise Benjamin

Bachelor of Science Double Degree in Physics and Mathematical Sciences with a Minor in Computer Science

Luke Anthony Ceurvorst

Bachelor of Science in Physics

Jennifer Yuenjane Chu

Bachelor of Science Double Degree in Physics and Computer Science

Matthew Jacob Dailey

Bachelor of Science in Physics

Alexander Orson Edelman

Bachelor of Science in Physics

Emily Williams Gehrels

Bachelor of Science in Physics, Astrophysics Track with a Minor in Philosophy

Yelena Goryunova

Bachelor of Science in Physics, Computational Physics Track with a Minor in Computational Finance

Peter William Krengel

Bachelor of Science in Physics
Graduated in December 2011

Dara Jennifer Krute

Bachelor of Science Double Degree in Physics, Astrophysics Track (May 2012) and Computer Science (December 2012)

Andrew David McKinnie

Bachelor of Arts in Physics

Lauren E. Mcquaide

Bachelor of Science in Physics

Jonathan Andrew Michel

Bachelor of Science in Computer Science with an Additional Major in Physics

Natalie Ann Morris

Bachelor of Science in Physics, Astrophysics Track with a Minor in Russian Studies

Alisa A. Rachubo

Bachelor of Science in Physics with a Minor In Computer Science

Svetlana Romanova

Bachelor of Science in Physics, Computational Physics Track

Edward R. Sharick

Bachelor of Science in Mathematical Sciences with an Additional Major in Physics

Nicholas James Steele

Bachelor of Science in Physics
Graduated in December 2011

Charles Pendleton Stuntz Swanson

Bachelor of Science in Physics

Joseph John Vukovich

Bachelor of Science in Physics, Astrophysics Track with an Additional Major in Japanese Studies

Nanfei Yan

Bachelor of Science in Physics

Brian Matthew Zakrzewski

Minors in Physics

Caroline Buckey

Keshav Budwal

Pablo Chavez

Kapil Easwar

Patrick Kane

Andrew Keeton

Jesse Lawrence

Rafee Memon

Amanbir Singh

Dhruv Swaroop

Winny Tan

Degrees Granted in 2013

Doctor of Philosophy in Physics

Ryan Anderson Booth
Chien-Yi Chen
Colin Joseph Degraf
Haw Zan Goh
Christopher M. Hefferan
Weihua Hu
Chang-You Lin
Yueh-Feng Liu
Duff Neill
Cem Yolcu

Master of Science in Physics

Sergio Cristian De La Barrera Noyes
Arun Kannawadi Jayaraman
Bai-Cian Ke
Paul La Plante
Ian Laflotte
David Benjamin Menasche
Amy Stetten
Tereza Vardanyan
Xin Wang

Undergraduate Honors

Christopher L. Baldwin
University Honors
Phi Beta Kappa

William K. Balunas
University Honors
Phi Beta Kappa

Lauren E. Beck
University Honors
College Honors

Samuel Carp
University Honors

Eric M. Chandler
University Honors
College Honors

Vivian L. Chang
University Honors

Nidhi P. Doshi
University Honors

Nicholas C. Eminizer
University Honors
College Honors
Phi Beta Kappa

David T. Fraebel
University Honors

Neil F. Goeckner-Wald
University Honors
College Honors

James E. Komianos
University Honors
College Honors

Linus V. Marchetti
University Honors

Amrit K. Narasimhan
University Honors
College Honors

Tyler S. Nighswander
University Honors

Nicolas Pabon
University Honors

Jason W. Rocks
University Honors
College Honors
Phi Beta Kappa
Phi Kappa Phi

Graham L. Spicer
University Honors

Rebecca L. Stabile
University Honors

Colleen E. Treacy
College Honors

Corinne E. Vassallo
College Honors

Evan L. Walden
University Honors
Phi Kappa Phi

John Wu
College Honors

Undergraduate Degrees

Bachelor of Science in Physics, Biological Physics Track with a Minor in Mathematical Sciences
Christopher L. Baldwin

Bachelor of Science in Physics
William K. Balunas

Bachelor of Science in Physics with a Minor in Computer Science
George Bargoud

Bachelor of Science in Physics with a Minor in Biomedical Engineering
Lauren E. Beck

Bachelor of Science in Physics
Zachary R. Benamram

Bachelor of Science in Physics
Gregory J. Bernero

Bachelor of Science in Physics, Biological Phyics Track
Alexander Lee Boscia

Bachelor of Science in Physics
Albert N. Brown

Bachelor of Science Double Degree in Physics and Mathematical Sciences
Samuel Carp

Bachelor of Science in Physics with a Minor in Professional Writing
Eric M. Chandler

Bachelor of Science in Physics and Bachelor of Arts in Hispanic Studies with a Minor in Enviromental Science
Vivian Liang Chang

Bachelor of Science and Arts in Physics and Art
Caroline M. Colombo

Bachelor of Science in Electrical and Computer Engineering with an Additional Major In Physics
Nidhi P. Doshi

Bachelor of Science in Physics with a Minor in Chinese Studies
Nicholas C. Eminizer

Bachelor of Science in Physics, Biological Physics Track
David T. Fraebel

Bachelor of Science Double Degree in Physics and Electrical and Computer Engineering
Neil F. Goeckner-Wald

Bachelor of Science in Physics, Computational Physics Track
Shayanta Hasnat

Bachelor of Science in Physics
Young June Jhe

Bachelor of Science In Physics
Daniel John Kirby

Bachelor of Science in Physics, Applied Physics Track With A Minor In Engineering Studies
Russell Logan Kirmayer

Bachelor of Science in Physics
James E. Komianos

Bachelor of Science in Physics
Sean Parker Macgahan

Bachelor of Science in Physics, Applied Physics Track
Linus V. Marchetti

Bachelor of Science in Physics
Graduated August 2012
Taylor Ryan Merritt

Bachelor of Science Double Degree in Physics (May 2013) and Materials Science and Engineering (May 2013) with a Master of Science in Materials Science and Engineering (May 2014)
Amrit K. Narisimhan

Bachelor of Science Double Degree in Physics and Computer Science
Tyler S. Nighswander

Bachelor of Science in Physics
Nicolas A. Pabon

Bachelor of Science in Physics with a Minor in Mathematical Studies
Tyson I. Price

Bachelor of Science in Physics, Computational Physics Track
Jason W. Rocks

Bachelor of Science In Physics
Scott O. Shepard

Bachelor Of Science In Physics
Rebecca L. Stabile

Bachelor of Science in Physics
Graduated in December 2012
Ruben Tarziu

Bachelor of Science in Physics, Chemical Physics Track
Colleen Elizabeth Treacy

Bachelor of Science in Physics with a Bachelor of Fine Arts in Music Performance (Clarinet)
Corinne E. Vassallo

Bachelor of Science in Physics
Graduated in December 2012
Edward Thompson Von Bevern

Bachelor of Science, Double Degree in Physics (May 2013) and Mechanical Engineering (May 2013) with a Master of Science in Mechanical Engineering (December 2013)
Evan Walden

Bachelor of Science in Physics, Astrophysics Track
John Wu

Minors in Physics

John T. Bresson
Eric R. Chang
Eric Gottlieb
Elizabeth A. Keller
James T. Kiraly
Alejandro A. Martinez
Jesse R. Post
Thomas M. Prag
Lucas T. Ray
Johanne A. Rokholt
Yevgeniya Solyanik
Minghui Zhang

Degrees Granted in 2014

Doctor of Philosophy in Physics

Krishna Chowdary

Qi Fu

Mingyang Hu

William Paul Huhn

You-Cyan Jhang

David W. Lenkner

Jonathan Lind

Daniel Lee Stahlke

Xi Tan

Zhen Tang

Brian James Vernarsky

Master of Science in Physics

Shadab Alam

Rulin Chen

Matthew William Daniels

Krista Gabrielle Freeman

Brian Josey

Jun Li

Mao Sheng Liu

Xianglin Liu

Zachary Allen McDargh

William Edmund McGinley

Chasen Ranger

Sukhdeep Singh

Michael Staib

Menglei Sun

Nora Swisher

Bradley Treece

Sanxi Yao

Undergraduate Honors

Joseph C. Albert
University Honors
College Honors
Phi Kappa Phi
Phi Beta Kappa

Leslie E. Bartsch
College Honors

Noah M. Baum
University Honors
College Honors

Jarrett B. Brown
College Honors

Steven W. Casper
University Honors
College Honors

Aditya Das
University Honors
College Honors

Samuel M. Greess
University Honors
Phi Kappa Phi
Phi Beta Kappa

Kelsey M. Hallinen
University Honors
College Honors
Phi Kappa Phi
Phi Beta Kappa

Richard J. Lyons
University Honors
College Honors

Philip E. Mansfiel
University Honors

Ahmed Osman
University Honors

David J. Papale
University Honors

Graham L. Spicer
University Honors

Kevin P. Tkacz
University Honors
College Honors

Han Wang
University Honors

Undergraduate Degrees

Bachelor of Science Double Degree in Chemistry and Physics
Devin Schaefer

Bachelor of Science in Physics
Joseph C. Albert

Bachelor of Science in Physics, Astrophysics Track
Leslie E. Bartsch

Bachelor of Fine Arts in Music With an Additional Major in Physics
Noah M. Baum

Bachelor of Science in Physics
Ryan N. Black

Bachelor of Science in Physics
Andrew P. Borowski

Bachelor of Science in Physics
Jarrett B. Brown

Bachelor of Science Double Degree in Physics and Mathematics With a Minor in Computational Finance
Steven W. Casper

Bachelor of Science in Physics
Michael A. Darcy

Bachelor of Science in Physics, Biological Physics Track With a Double Minor in Biological Sciences and Chemistry
Aditya Das

Bachelor of Science in Physics, Astrophysics Track With a Minor in Russian Studies
Karl J. Destefano

Bachelor Of Science Double Degree in Computer Science and Physics
Mackenzie P. Devlin

Bachelor of Science in Physics
Ashley Ann Disbrow

Bachelor of Science in Physics With a Minor in French and Francophone Studies
Samuel M. Greess

Bachelor of Science in Physics, Astrophysics Track With a Minor in Music Performance
Colin Grossman-Cross

Bachelor of Science in Physics With a Minor in History
Kelsey M. Hallinen

Bachelor of Science in Physics
Donald R. Hood

Bachelor of Science in Physics
Edward O. Kahn

Bachelor of Science in Physics, Applied Physics Track
Samarth Kakria

Bachelor of Science in Physics, Astrophysics Track
Richard J. Lyons

Bachelor of Science in Physics
Philip E. Mansfield

Bachelor of Science in Physics With a Minor in Mathematics
Peter D. Marchetti

Bachelor of Science in Physics
Michael C. Martin

Bachelor of Science in Physics, Applied Physics Track
Madalyn A. Mckay

Bachelor of Science in Physics
Richard H. Mebane

Bachelor of Science in Physics, Applied Physics Track
Giri R. Mehta

Bachelor of Science and Arts in Physics And Art
Anna L. Mohr

Bachelor of Arts in English With an Additional Major in Physics
Ahmed Osman

Bachelor of Science in Physics
David J. Papale

Bachelor of Science in Physics, Applied Physics Track
Hugo Ponte

Bachelor of Science in Physics
Aleksander Popstefanija

Bachelor of Science Double Degree in Physics and Applied Mathematics and a Minor in Logic and Computation
Alonso Sanchez

Bachelor of Science Double Degree in Chemistry and Physics
Devin Schaefer

Bachelor of Science in Physics
Karpur Shukla

Bachelor of Science Double Degree in Physics and Chemical Engineering *Graduated in August 2013*
Graham L. Spicer

Bachelor of Science in Physics
Kevin P. Tkacz

Bachelor of Science in Materials Science and Engineering and an Additional Major in Physics
Han Wang

Bachelor of Science in Physics
Graduated in December 2013
Brendan White

Minors in Physics

Wyatt Bridgeman

Maddison M. Brumbaugh

Jason M. Chow

Joseph Chu

Emily N. Furnish

Benjamin J. Karp

Stephanie S. Luck

Andrew B. Maurer

Craig W. Schwarz

Ryan Sit

George K. Tian

Yang Wen

Andrew R. Willig

Tom Z. Xu

William A. Zorn

FACULTY APPOINTMENTS & RECOGNITION

New Appointments

Frank Heinrich, Research Assistant Professor

Rachel Mandelbaum, Assistant Professor

Di Xiao, Assistant Professor

David Anderson, Assistant Teaching Professor

Raphael Flauger, Assistant Professor

Tina Kahniashvili, Associate Research Professor

Matthew Walker, Assistant Professor

Benjamin Hunt, Assistant Professor

Faculty Recognition

Luc Berger | 2012 American Physical Society Buckley Award

Rupert Croft | The Leverhume Trust Visiting Professorship, Oxford University Member, SDSS Advisory Councils

Gregg Franklin | 2013 Richard Moore Education Award

Stephen Garoff | Fellow, Center for Smart Interface, Darmstadt Technical University

Fred Gilman | Member, Association of Universities for Research in Astronomy (AURA) Board of Directors
Chair, AURA Management Council for LSST
Member, Executive Board of the LSST Corporation

Tina Kahniashvili | Outstanding American Physical Society Referee

Mathias Lösche | Fellow, American Physical Society

Barry Luokkala | Director, Pennsylvania Governor's School for the Sciences

Sara Majetich | Invited co-editor of Special Edition of Materials Research Society Bulletin on Magnetic Nanoparticles

Rachel Mandelbaum | Annie Jump Cannon Prize, American Astronomical Society
2012 Department of Energy Early Career Research Award
2013 Sloan Research Fellowship in Physics
Falco DeBenedetti Career Development Professorship in Physics
Co-Chair, GREAT3 Weak Lensing Data Challenge

Curtis Meyer | Spokesperson, GlueX Collaboration

Manfred Paulini | 2013 CMS Fellow at LHC Physics Center, Fermilab

Robert Swendsen | 2014 American Physical Society Award for Computational Physics
2014 Julius Ashkin Teaching Award

Diane Turnshek | Crew member at Mars Desert Research Station, Utah

Matthew Walker | Presented the pH Endowed Lecture at the Harvard Smithsonian Center for Astrophysics
Block Award for Promising Young Physicist, Aspen Center for Physics

New Books by Faculty

Leonard Kisslinger | *Astrophysics and the Evolution of the Universe* (World Scientific Publishing Company, 2014)

Barry Luokkala | *Exploring Science Through Science Fiction* (Springer, 2014)

Robert Swendsen | *An Introduction to Statistical Mechanics and Thermodynamics* (Oxford University Press, 2012)

Tell us about yourself!

Mail this form to:

Department of Physics
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213-3890
or email us at physics@andrew.cmu.edu

Name: ____________________ Class Year: ____________

Email Address: ____________________

News Brief: *(News briefs may be chosen for printing in our next issue of INTERACTIONS.)* ____________________

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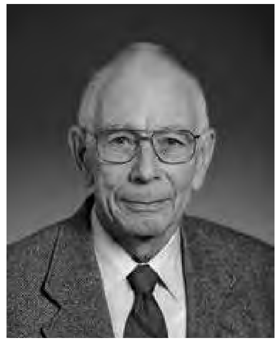

IN MEMORIAM

Hugh D. Young

We mourn the passing of our esteemed colleague and one of the world's great physics educators, Hugh D. Young, who died on August 20, 2013. Hugh was a member of the Carnegie Mellon community for more than 60 years. He came to Carnegie Mellon (then Carnegie Tech) in 1948, earned four degrees here (S'52, '53, '59; A'72), and was a member of the physics faculty for 52 years. During his career he taught over 18,000 students, and influenced countless others through the publication of numerous textbooks on physics, including Addison-Wesley's University Physics, one of the most widely used introductory textbooks in the world. A celebration of Hugh Young's life and legacy was held in the Kresge Theatre, in the College of Fine Arts, over the weekend of Spring Carnival in April 2014.

Tell us about yourself! (additional space)

News Brief: *(News briefs may be chosen for printing in our next issue of INTERACTIONS.)* ____________________

Pennsylvania Governor's School for the Sciences returns to Carnegie Mellon University

2013 saw the successful restart of the Pennsylvania Governor's School for the Sciences (PGSS) at Carnegie Mellon University.

The 5-week summer residential program for talented high school students was one of eight Governor's Schools of Excellence, each with a different area of specialty, hosted on various college campuses throughout the commonwealth of Pennsylvania. The School for the Sciences was hosted by the Mellon College of Science at Carnegie Mellon every summer for 27 years (1982 – 2008), until the global financial crisis of 2009 resulted in the termination of all eight programs in Pennsylvania. Thanks to the determination of alumni of the program, who found it to be a life-changing experience, and with the help of Barry Luokkala, teaching professor of physics and third director of PGSS, who wrote the successful grant proposal, the PGSS program reopened with 60 rising high school seniors in the summer of 2013. The PGSS students are chosen by competitive application from all over the state, and attend the program free of charge.

The overall shape of the new PGSS program is similar to previous years, but with a very different funding model. The students take college-level courses in biology, chemistry, physics, mathematics and computer science, choose from an array of laboratory courses and elective courses, and participate in a team research project. They also benefit from guest lectures on a variety of special topics in science and technology. In addition to the academic program, the students have social activities in the dormitory every evening, which are equally important, and help to transform them from a collection of scientifically-minded individuals into a cooperative community of active learners, where they discover common interests and develop lifelong friendships.

For the first 27 years the PGSS program was fully funded by a grant from the Pennsylvania Department of Education. The new funding model is a public-private partnership, proposed by Governor Corbett, whereby half of the cost of the program is now covered by the PGSS alumni, through private donations and corporate sponsorships. According to professor Luokkala, the PGSS program as it is today simply could not exist without the dedication and determination of the PGSS alumni, who worked so hard to raise the private funds in order to match the $150K annual grant from the Department of Education. The program is currently in its second year of the initial 2-year grant. Funding for 2015 was recently secured through the Team Pennsylvania Foundation, and we are hopeful that many new groups of young scientists will be inspired to pursue careers in the STEM fields by participation in the program in years to come.

Carnegie Mellon University
Physics

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Hugh Young photos:

By Jim Feldman (S'57, '58, '60)
Courtesy of Alice Young

Produced by the Communications Design and Photography Group and the Physics Department, August 2014, 15-032.