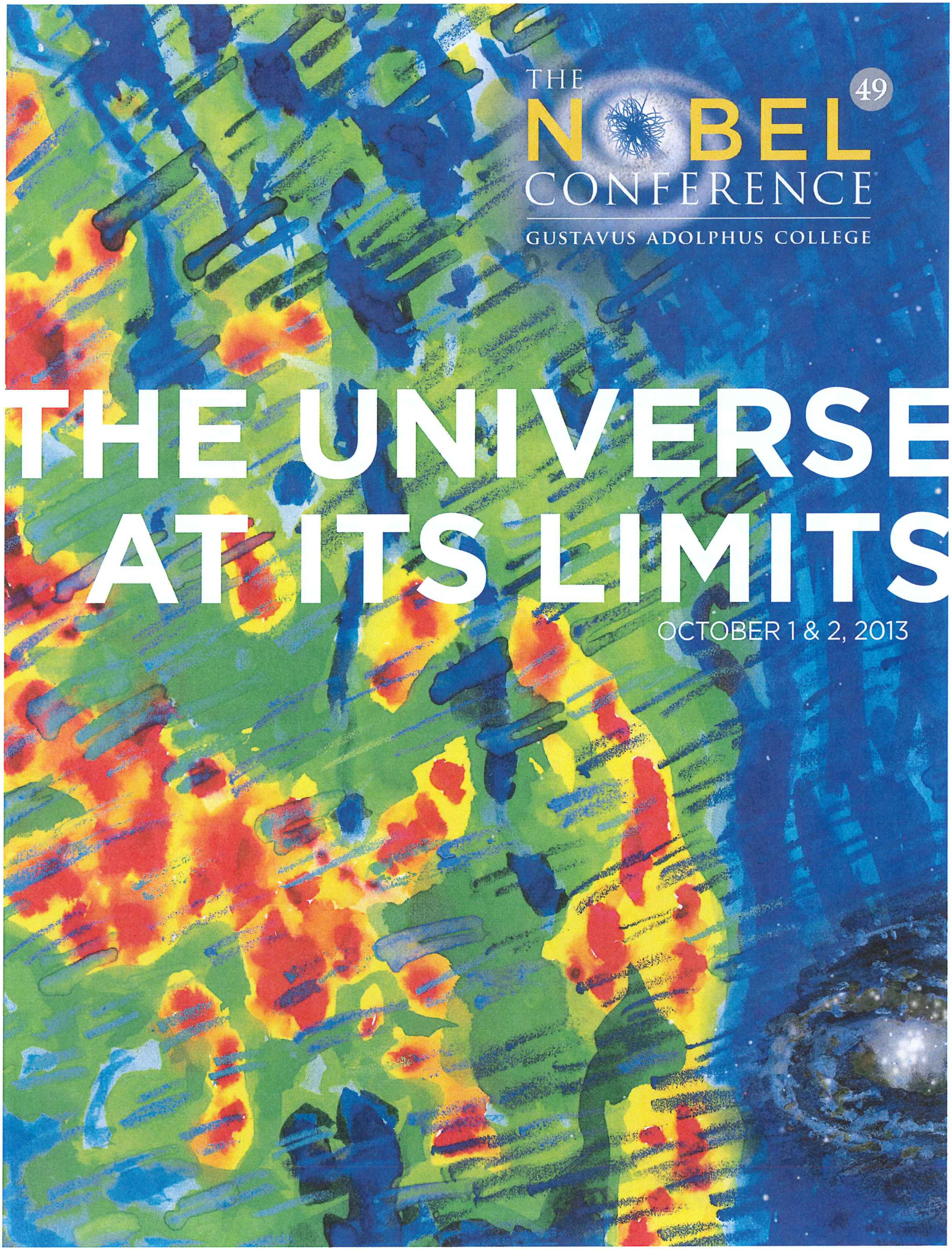

THE NOBEL CONFERENCE 49

GUSTAVUS ADOLPHUS COLLEGE

THE UNIVERSE AT ITS LIMITS

OCTOBER 1 & 2, 2013

THE
NOBEL CONFERENCE®
GUSTAVUS ADOLPHUS COLLEGE

Established in 1862 by Swedish Lutheran immigrants, Gustavus Adolphus College is a private, liberal arts college that provides an undergraduate education of recognized excellence. The Alfred Nobel Hall of Science at the College was named as a memorial to the great Swedish inventor and philanthropist. Following its dedication in 1963—which was attended by Nobel Foundation officials and 26 Nobel laureates—the College sought endorsement from the Nobel Foundation for an annual science conference. Permission was granted and the conference, now in its sixth decade, continues to set a standard for timeliness, intellectual inquiry, and free debate of contemporary issues related to the natural and social sciences.

NOBEL CONFERENCE® 49 COMMITTEE

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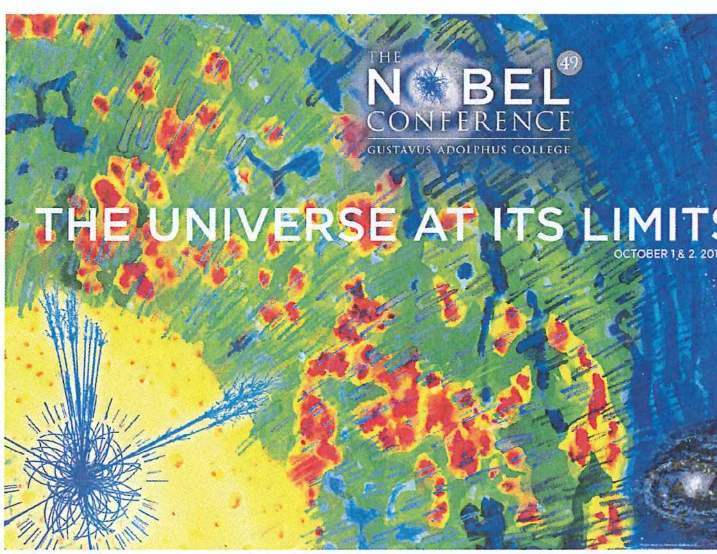

ABOUT THE ARTIST

The poster and graphic images were designed by Sharon Stevenson, a graphic designer and illustrator based in Corvallis, Oregon. The illustration on the poster represents the progression of the universe from opaque plasma at the Big Bang to the our everyday experience of it in its current transparent state. A representation of anisotropic temperature distribution is included behind the thick soup of virtual particles paired with antiparticles. The simulated Higgs event rendering is used courtesy CERN © 2008. Stevenson designs for clients in higher education and non-profit and commercial enterprises. For more information, visit StevensonCreative.com.

NOBEL CONFERENCE® 49 OCTOBER 1 & 2, 2013

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Order Nobel lecture and meal tickets and pre-order merchandise online at **gustavustickets.com** or by phone at **507-933-7520** (mail orders no longer accepted).

Seating in Lund Center Arena is limited to 3,000. Overflow seating will be available in Lund Center Forum, a video-equipped site. Tickets are non-refundable. Please note that a separate ticket is required for the Nobel Conference Banquet on Wednesday evening.

Ticket prices: Reserved-$115; General Admission-$70; Student Delegation (block of 10)-$50.

For more information, contact the Office of Marketing and Communication at 507-933-7520 or e-mail marketing@gustavus.edu.

NOBEL CONFERENCE **SCHEDULE**

All lectures are held in Lund Center Arena unless indicated otherwise.

TUESDAY, OCTOBER 1

9:30 a.m. **ACADEMIC PROCESSION and OPENING CEREMONY**

9:45 a.m. **CONFERRAL OF HONORARY DEGREES UPON NOBEL LAUREATES**
George Smoot, Samuel Ting, and Frank Wilczek

10 a.m. **FIRST LECTURE: Frank Wilczek, PhD,** Massachusetts Institute of Technology, Cambridge; 2004 Nobel laureate in physics

1 p.m. **SECOND LECTURE: Tara Shears, PhD,** University of Liverpool, United Kingdom

3 p.m. **THIRD LECTURE: Alexei Filippenko, PhD,** University of California, Berkeley

6 p.m. **ART EXHIBITION OPENING**
Hillstrom Museum of Art, Jackson Campus Center

6:30 p.m. **FOURTH LECTURE: Samuel Ting, PhD,** Massachusetts Institute of Technology, Cambridge; 1976 Nobel laureate in physics

8:15 p.m. **THE NOBEL CONFERENCE CONCERT**
Christ Chapel

WEDNESDAY, OCTOBER 2

9:30 a.m. **OPENING MUSIC and WELCOME**

10 a.m. **FIFTH LECTURE: George Smoot III, PhD,** University of California, Berkeley, Berkeley National Laboratory, and Paris Diderot University, France; 2006 Nobel laureate in physics

1 p.m. **SIXTH LECTURE: Lawrence Krauss, PhD,** Arizona State University, Tempe

3 p.m. **SEVENTH LECTURE: The Rev. George Coyne, SJ, PhD,** Le Moyne College, Syracuse, N.Y., and director emeritus of the Vatican Observatory, Tucson, Ariz.

6:30 p.m. **THE NOBEL CONFERENCE BANQUET**
Evelyn Young Dining Room, Jackson Campus Center

7:30 p.m. **CLOSING LECTURE: S. James Gates Jr., PhD,** University of Maryland, College Park
Evelyn Young Dining Room
For those not attending the banquet, the lecture will be simulcast in *Alumni Hall, Johnson Student Union.*

WHAT LIES AT THE LIMITS OF OUR UNIVERSE

Steve Mellema
Professor of Physics and
Chair of Nobel Conference 49

What is the Universe like, and how does it behave, at the very smallest, microscopic scales? What lies beneath the level of the atoms that make up the ordinary matter that the Universe contains? What, exactly, is "in there"?

What does the Universe look like, and how does it behave, at the very largest, astronomical distances? What lies beyond our solar system, beyond our galaxy? What, exactly, is "out there"?

If we look back in time, where did it all come from? And, as for the future, where is it all going?

Throughout most of the history of Western science, these seemingly disparate lines of inquiry have been carried out independently of one another—studying the natures of the big and of the small, seeking to understand the history of the Universe's past and trying to make predictions about its future. Along the way, philosophers and theologians have also been involved in the dialogue. Is there a role for God in the creation and evolution of the Universe? Is the existence of intelligent life unique to Earth?

The surprising directions that science took in the 20th century have shown us that all of these questions and studies are, in fact, interconnected. If the Universe began in some explosive Big Bang 14 billion years ago and has been expanding ever since, we seek to understand its origins both by looking "out there" with our most powerful telescopes, and by looking "in there" using particle detectors at accelerator laboratories that seek to recreate the conditions of that early Universe. And, if the ultimate constituents of our Universe include entities that we have not yet discovered or understood, we now seek them, both in the particle collisions that we carry out at places like the Large Hadron Collider and by measuring the cosmic rays that arrive here from the farthest reaches of space and are captured in a detector at the International Space Station.

Nobel Conference 49: "The Universe at Its Limits" will bring together leading scholars to discuss these questions and, especially, their interconnectedness. In the end, we may ask questions not only about the limits of the Universe but also about the limits to human knowledge.

In ancient Greece, Democritus first proposed the idea of an atom as the smallest, indivisible piece of any type of matter, and Aristotle proposed a model of the heavens in which the Earth was at the center and all the other visible objects orbited in perfect circles. Ptolemy refined that model and gave it exquisite precision; his theory's ability to predict the positions of astronomical objects in the sky at any particular time made it perhaps the longest-lived theory in the history of science, lasting almost 1500 years.

In the two millennia since they began, these investigations of the very big and the very small have continued, and much has been learned. The natural philosophers' ideas and theories have been challenged and refined by the experimenters' instruments and measurements. Clever inventors made microscopes to look "inside" and then telescopes to look "out there." Centuries of refinements that have given us instruments like the Hubble Space Telescope and the Large Hadron Collider have made possible measurements on both the largest and smallest scales that would have been inconceivable not so very long ago.

But what are the fundamental discoveries of the 20th century that have inextricably connected the studies of these two limits—the very large and very small? And how do we now approach the answers to the big questions about the origin, evolution, and future of the Universe?

At the limit of the very small, the atomic theorized by Democritus went in and out of favor over the two millennia after it was first proposed. Even after John Dalton used atomic theory in the mid-19th century to explain the constant ratios of weights observed in every chemical reaction, the very existence of atoms was questioned by competing theories. When J.J. Thomson discovered the electron in the late 19th century, it became clear that atoms are not indivisible, that they have smaller, constituent parts. The 20th-century discoveries of the proton and neutron as the other constituent parts of the atom, followed by the discovery of a whole "zoo" of fundamental particles, led to the development of what is called the Standard Model—to explain the collections of and interconnections between the tiniest particles that are the ultimate constituents of our Universe.

At accelerator laboratories of increasing energy, size, and cost, scientists have sought to create and investigate these particles and the forces that govern their behavior. Albert Einstein's famous equation, E=mc2, which tells us that energy can be converted into mass and vice versa, explains the need for higher and higher energy particle accelerators. As we seek to study more exotic particles with higher masses, from the top quark discovery of the 1990s to the Higgs boson just this year, we need higher energies to create (and observe) them.

At the limit of the very large, the late astronomer Carl Sagan used the phrase "We are made of star stuff." What he meant was that every atom that exists in your body, at this instant, once lived inside a star. We human beings not only study the cosmological evolution of the Universe, but our very essence, the matter of which we are composed, is a part of that evolution. The stars we see in the sky seem to appear, faithfully, in the same relative positions, night after night. The ancients thought of them as eternal entities, fixed to a celestial sphere that rotated forever around the Earth. But we now know that stars are born and die, in a grand cycle of cosmic evolution. Our own Sun and the component parts of its solar system were born out of the remnants of previous stars. The elements that make up our planet (and us) have been built up over billions of years, in the many generations of stars that have gone through their life cycles.

Telescopes are time machines. Once we realized that light, although very fast, travels at a finite speed, we realized that whenever we use our telescopes to look "out there" in space we are also looking back in time. The farther away we look at astronomical objects, the longer ago the light reaching us was emitted, and so the older is the picture that we see.

Edwin Hubble was the first to observe that, as we look deep into outer space at distant galaxies, every galaxy is moving away from every other galaxy, and that the farther apart the galaxies are, the faster they recede from one another. What at first seemed like a conundrum had a simple solution: the Universe itself, the very space which we are studying, is expanding. Like the raisins in a cake that is rising as it bakes in an oven, they get farther and farther apart as the cake itself gets bigger. Playing this story of the Universe in reverse, of course, means that it all began from a single point, a so-called "singularity," which we call the Big Bang.

What we know about gravity and energy tells us that, as the Universe has expanded against the pull of gravity, its temperature has fallen. This means that the farther back we look in time, the smaller, denser, and hotter the Universe. The conditions of the very early Universe, right after the Big Bang, were so hot that matter as we know it—nuclei and electrons bound together inside atoms, even protons and neutrons—could not exist.

What did exist? Only those fundamental constituent particles and forces that other scientists have been seeking at the limits of the very small. And so, if we want to understand the origin and evolution of this vast Universe of ever-receding galaxies and ever-expanding space, we must understand the relationships and interactions of its tiniest constituent parts.

Frank A. Wilczek, PhD, Herman Feshbach Professor of Physics, Massachusetts Institute of Technology; 2004 Nobel laureate in physics

What do you do after you win the Nobel Prize for your PhD thesis work? You study anything you want. So, Frank Wilczek picks problems that he finds interesting, which helps keep the excitement of discovery in his work. Some problems in physics bother him because nobody has studied them or they haven't been well-studied. Those are the ones he likes to go after. Sometimes they are very esoteric, but not totally without regard for usefulness, like his work on the nature of the universe. Even as he continues that work, as experiments catch up to the theory providing challenges and tweaks, he is moving on in new areas. He approaches these with a "more mature attitude," he says, looking for problems that are more practical and useful, like exotic electronics.

As a small child, Frank Wilczek was interested in puzzles and mathematics. He was born in Mineola, New York, on Long Island, and was educated in the public schools of Queens. He says that he was born to do theoretical work, and was very fortunate to have been educated by excellent teachers. When he was in high school, his parents realized that he was exceptional and encouraged him to pursue his dream of solving mathematical puzzles. He received his bachelor of science degree in mathematics at the University of Chicago in 1970, a master of arts in mathematics at Princeton University in 1972, and a PhD in physics at Princeton University in 1974. In 1973 Wilczek, working with his adviser, David Gross, at Princeton University, discovered asymptotic freedom. This theory holds that "the closer quarks are to each other, the less the strong interaction between them." When quarks are in extreme proximity, the nuclear force between them is so weak that they behave almost as free particles. Asymptotic freedom, which was independently discovered by David Politzer, was important for the development of quantum chromodynamics and earned Gross, Politzer, and Wiczek the 2004 Nobel Prize in physics.

Early in his career, Professor Wilczek's research was focused on one of the basic interactions of nature, the strong nuclear force. He says that at that time nuclear forces were very mysterious, partly because their domain was limited to the size of the nucleus of an atom. Scientists had rules of thumb but no real equations and despaired that they would ever find any. It turns out that the strong force has much simpler forms in extreme cases, like those found shortly after the Big Bang. Wilczek and Gross were able to develop a mathematically coherent model and essentially identified a new kind of particle (gluons) to make equations consistant, which were subsequently discovered. Wiczek says that the mathematical symmetry that they discovered enabled them to dream up a model for unification of all four forces in nature, work that is still being tested today at CERN.

In the last 20 years or so, Professor Wiczek has turned to using some of the same mathematical ideas to describe matter in other extreme conditions—at low temperatures. At low temperatures quantum mechanics comes into its own and gives good descriptions of the exotic behavior of many materials. Applying the concepts of field theory developed for the realm of nuclear physics to semiconducting materials at low temperatures has given rise to one approach to quantum computers. Frank is also beginning to explore research in other areas of engineering and applied physics, making use of mathematics that he developed for condensed matter and nuclear physics.

Wilczek says of his work that although it doesn't have practical implications like curing cancer or ending hunger, it allows us to better appreciate our world. It doesn't give us any insight into god or religion, but the more that it gets disseminated, the more it enriches peoples' lives. Like music and art, it has potential cultural value.

Frank Wiczek would like folks to know that he is just a regular guy. He and has wife, Betsy Devine, have two daughters of whom they are very proud. He has many interests, including music. In August of 2006, he had his operatic singing debut in *Atom & Eve*, which was performed in Alpbach, Austria, getting favorable reviews in the *New York Times*. He also plays the piano and is currently working on a mystery novel. And, Frank still loves doing puzzles.

Tara Shears, PhD, professor of physics and Royal Society University Research Fellow working with CERN's Large Hadron Collider (LHC) project, University of Liverpool, United Kingdom

CERN, the European center for particle physics, is "a place where magic is explained," actor Tom Hanks said when interviewed about his movie *Angels and Demons.* That makes Tara Shears something of a magician. But she describes science as an adventure, a voyage of discovery in which she is armed only with the barest of tools. So, maybe she is more like an explorer, trying to find the underlying principles that link the outcomes of her experiments and then connecting those same principles to the behavior of stars, weather systems, and fundamental particles. She describes it as amazing and humbling. For an instant science gives her a glimpse of something deep and profound running through the universe.

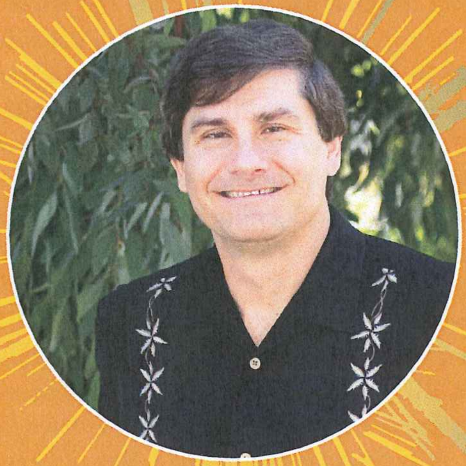
As an undergraduate at Imperial College London, Tara Shears was interested in the big questions, like why are there stars and planets in the sky. She knew that she had to study physics, and when the university first offered a course in particle physics, she had to take it. As she puts it, "Things at CERN were getting very interesting." She decided that she wanted to get her doctorate and do her own experiments in particle physics and subsequently went on to earn her PhD from Cambridge University. She started her experimental career investigating the behavior of fundamental particles and forces at the OPAL experiment at CERN. In 2000, she was awarded a Royal Society University Research Fellowship with the University of Liverpool to continue her research at the Fermilab particle physics facility in the United States. And in 2004 Tara joined the LHCb experiment at CERN's Large Hadron Collider, an experiment designed to investigate where all the antimatter in the universe has gone. Data collection started in earnest in 2010 and she is working with her collaborators analyzing the data and hoping to find some answers.

Dr. Shears finds her work incredibly exciting. She has the opportunity to look at a facet of universe that is completely unexplored, to study the very small pieces that nobody has looked at yet. She describes the basic theory as quite simple, but we need to construct huge experiments to explore it. The only guide book for this scientific adventure is the scientific process itself, and it is important to her that science is a process carried out in the most objective way possible. Scientific laws are not subject to spin or reinterpretation, unless they're wrong. Scientists must be rigorous about separating any personal bias from their results. The view of the universe this gives us is the clearest it can be.

Shears quotes Robert Wilson who, when asked what value particle physics research had in defending the United States, said, "None, except to make it worth defending." She believes that statement encapsulates why science is so important. Great science, like great art, enriches our lives and gives us a way to make sense of the world. But this isn't just philosophy. The most arcane areas of scientific research can yield surprisingly useful spin-offs. We probably can't imagine life without electricity. Or electronics of all kinds. Without semiconductors and their use in all aspects of computing and telecommunication, we wouldn't have smart phones. If not for the need of scientists at CERN to share large amounts of data with collaborators around the world, we wouldn't have the World Wide Web. Science shapes our culture and pushes our civilization forward—that's why it's so important.

But large scientific enterprises like CERN also provide examples of international cooperation, as scientists from around the world and from all political systems work together in an attempt to find answers to the most fundamental questions. Explicitly stated in its founding documents, CERN was set up so that anyone could study fundamental physics and the results would be shared with everyone around the world, enabling people from all places to work together after World War Two.

Tara shears enjoys hiking in the mountains and cross country skiing when she has the time. She also enjoys going out to eat, going to the opera, and listening to jazz. Her interest in jazz stems from her time at Fermilab, when she would go to the Jazz Showcase in Chicago, where she heard all the great jazz musicians.



Alexei V. Filippenko, PhD, professor of physics and Richard and Rhoda Goldman Distinguished Professor in the Physical Sciences, Department of Astronomy, University of California, Berkeley

Alexei Vladimir Filippenko (Alex) says that he was interested in science for as long as he can remember, back to the first grade when he played with magnets and iron filings in the sandbox. He was a budding chemist from ages 10 through 17, but astronomy became a growing hobby in high school, after he "discovered" Saturn on his own at age 14 with a small telescope given to him by his parents. Graduating from Dos Pueblos High School in Goleta, California, he went on to the University of California, Santa Barbara, where he took a wonderful astronomy course that showed him the deep connection between the physics of the very small and the very large. Realizing that he could "have it all" as an astrophysicist, he switched his major from chemistry to physics at the end of his first year. After earning his bachelor's degree, he went on to the California Institute of Technology as a Hertz Foundation Fellow to earn his PhD in astronomy. He was a Miller Fellow at the University of the University of California, Berkeley, and was subsequently appointed to a faculty position at the same institution.

Filippenko is involved primarily in observational studies at optical, ultraviolet, and near-infrared wavelengths, mainly using data from the Keck 10-meter telescopes, the Lick 3-meter reflector, and the Hubble Space Telescope. In addition, his group has developed the 0.8-meter Katzman Automatic Imaging Telescope (KAIT), Lick Observatory, which obtains data robomatically, every clear night, without human intervention. With KAIT, they have conducted one of the world's most successful searches for nearby supernovae, having found about 1,000 of them since 1998. Alex's group has spectroscopically classified hundreds of objects, providing a rich database for individual and statistical studies. For example, their work shows that there are small physically distinct subclasses of H-poor (Type 1) supenovae.

One of his group's major activities is to use supernovae as cosmological distance indicators, and to improve their utility through detailed studies of nearby supernovae. In 1998, Alex was a member of two separate teams that announced that high-redshift Type Ia supernovae seem to be dimmer (and hence farther away) than expected. This led to the conclusion that the expansion of the Universe is now accelerating, perhaps due to the cosmic "antigravity" effect of a nonzero vacuum energy density or some other type of "dark energy," findings that were deemed the "Top Science Breakthrough of 1998" by *Science* magazine. Completely independent studies using different techniques and conducted by other researchers confirmed the cosmic acceleration, leading to the recognition of this discovery with the 2011 Nobel Prize in Physics to the teams' leaders.

Alex has long been interested in determining the physical properties of quasars and active galactic nuclei. He was a member of the team that used the Hubble Space Telescope to investigate supermassive black holes in the nuclei of nearby galaxies and determined the relationship between the central black hole's mass and the stellar velocity dispersion. His group has also found strong evidence for stellar-mass black holes in several binary star systems.

Filippenko is a professor of astronomy and the Richard & Rhoda Goldman Distinguished Professor in the Physical Sciences at UC Berkeley. His research accomplishments, documented in more than 700 published papers, have been recognized with several major prizes including a Guggenheim Fellowship, and he is one of the world's most highly cited astronomers. In 2009 he was elected to the National Academy of Sciences, and he shared part of the Gruber Cosmology Prize in 2007 for the discovery of the accelerating expansion of the Universe.

Alex has won the top teaching awards at UC Berkeley and has been voted the "Best Professor" on campus a record nine times. In 2006 he was selected as the Carnegie/CASE National Professor of the Year among doctoral and research institutions, and in 2010 he won the Astronomical Society of the Pacific's Emmons Award for undergraduate teaching. He has delivered more than 700 public lectures to a wide range of audiences, produced five richly illustrated astronomy video courses with *The Great Courses*, coauthored an award-winning college astronomy textbook, and appears in numerous TV science documentaries including about 40 episodes of *The Universe* series. In 2004, he was awarded the Carl Sagan Prize for Science Popularization. An avid tennis player, hiker, skier, snorkeler, and world traveler, he enjoys spending time with his family and is addicted to observing total solar eclipses (12 so far).

Samuel C.C. Ting, **PhD, Thomas Dolby Cabot Institute Professor of Physics, Massachusetts Institute of Technology, Cambridge; 1976 Nobel laureate in physics**

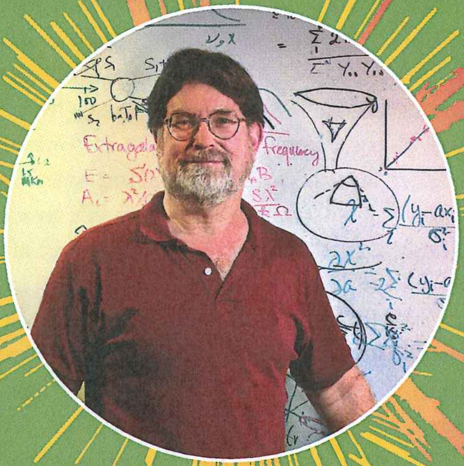
Samuel C.C. Ting grew up in an academic family. He was born in Ann Arbor, Michigan, where his parents met as graduate students. His parents had hoped that he would be born in China, but he was born prematurely while they were visiting the United States. And, by accident of birth, he became an American citizen. Two months after his birth his family returned to China where, due mainly to the Japanese invasion of China, Samuel was largely home-schooled by his parents until age twelve. After the war, his parents became professors of engineering and psychology at National Taiwan University in Taipei, Taiwan, and Samuel attended the prestigious Provincial Chien-Kuo High School in Taipei.

Because his parents were always associated with universities Samuel had the opportunity to meet many accomplished scholars, and he developed the desire to be associated with university life. After high school he studied at National Cheng Kung University, Tainan City, before returning to the United States and Ann Arbor to finish degrees in both mathematics and physics from the University of Michigan. He stayed with the family of his parents' friend, who was the dean of the School of Engineering, and worked his way through college in only three years, maintaining high grades in order to keep his scholarships. He continued his education, earning his PhD in physics in three more years before becoming a Ford Foundation Fellow at the European Organization for Nuclear Research, which would later become CERN. Samuel says that he had the good fortune of working with Giuseppe Cocconi at the Proton Synchrotron, who taught him a lot of physics. He says of Cocconi that he always had a simple way of viewing complicated problems and did his experiments with great care.

In his second year at Columbia University, Dr. Ting became aware of an experiment at Cambridge on electron-positron pair production that seemed to show a violation of quantum electrodynamics. He studied the experiment, decided to duplicate it, and was invited to do so at the Deutsches Elektronen Synchrotron (DESY) in Frankfurt, Germany. As a result, he began his efforts to study the physics of electron and muon pairs, which involved searching for new particles that could decay into them. In the search for new particles at higher mass, now at Brookhaven National Laboratory in 1974, his group found evidence of a new, totally unpredicted, heavy particle—the J particle. Subsequently, a whole family of new particles was found. It was for this work that Ting shared the 1976 Nobel Prize in physics with Burton Richter.

In 1995, not long after the cancellation of the Superconducting Super Collider project had severely reduced the possibilities for experimental high-energy physics on Earth, Ting proposed the Alpha Magnetic Spectrometer, a space-borne cosmic-ray detector. The proposal was accepted and he became the principal investigator of this massive $1.5 billion undertaking involving 500 scientists from 56 institutions and 16 countries. A prototype was flown and tested on the Space Shuttle in 1998, but Ting was forced to lobby the United States Congress and the public to secure an additional Shuttle flight dedicated to this project after NASA announced that the Shuttle was to be retired in 2010. The AMS, successfully installed on the International Space Station in May of 2011, is a particle physics experiment module designed to measure antimatter in cosmic rays and search for evidence of dark matter. In March 2013, at a seminar at CERN, Professor Samuel Ting reported that AMS had observed over 400,000 positrons, with the positron-to-electron fraction increasing from 10 GeV to 250 GeV but showing a slower rate of increase at higher energies. There was "no significant variation over time, or any preferred incoming direction. These results are consistent with the positrons originating from the annihilation of dark matter particles in space, but not yet sufficiently conclusive to rule out other explanations." Additional data is still being collected and analyzed to improve experimental statistics, especially at higher energies where the answers are expected to lie.

In 1985, Samuel Ting married Dr. Susan Carol Marks, who gave up her career as a psychologist to take charge of all management affairs in Ting's group. They have one son, Christopher, who is currently a third-year law student at the University of Michigan Law School. Ting also has two daughters from a previous marriage: Jeanne Ting Chowning, who is the director of education at the Northwest Association for Biomedical Research, and Amy Ting, who is an artist.



George F. Smoot III, PhD, professor of physics, University of California, Berkeley; senior scientist, Lawrence Berkeley National Laboratory; professor of physics, Paris Diderot University, France; 2006 Nobel laureate in physics

Does winning a Nobel Prize in physics make one a nerd? In George Smoot's case, maybe not a nerd, but a member of the establishment. Prior to winning the prize, George Smoot stayed on the fringes of being a nerd, playing football in high school, volunteering as a sound tech for Jerry Garcia, and trekking in Nepal. But after winning, he felt as though he was thrust into the position of role model. He says, "When I first came to Berkeley and met Nobel Prize winners, I found out that they were regular people." So, an appearance on the game show *Are You Smarter than a Fifth Grader?* seemed a good way to show his students and others that he was human. If he failed, others, who thought that they weren't up to the task, might be encouraged to try. Getting help from a 10-year old on the question of whether a porcupine was a rodent was also a good example to students of all ages. That wasn't Smoot's only TV appearance, though. He appeared on *The Big Bang Theory* because he appreciates that the scientists are portrayed as heroes. Playing himself as the keynote speaker at a conference attended by the main characters, ultra nerdy scientists, he delivers the classic line, "With all due respect, Dr. Cooper, are you on crack?"

George Smoot was born in Yukon, Florida, but grew up in a suburb of Columbus, Ohio. As a child, he was a curious and interested in many things. He enjoyed reading science fiction, engineering, and science books and, as he says, "science courses drew him in." His father was a hydrologist and his mother a science teacher who instilled in George a respect for learning and an interest in science and math. He began his studies at MIT leaning toward premed, but soon changed to mathematics and physics. He earned his bachelor's degrees in mathematics and physics with a senior thesis on the subatomic remnants of collisions of deuterium nuclei. Smoot continued to study the decay of subatomic particles for his doctoral thesis and received his PhD in physics from MIT in 1970. At that time particle physics was being done by large teams, and Smoot, wanting more impact, jumped to the less crowded discipline of cosmology while a research physicist at MIT. The switch to cosmology was a natural transition, because subatomic particles were instrumental in the birth of the universe in the Big Bang and he was still studying the fundamental nature of the universe.

Professor Smoot won the Nobel Prize in physics in 2006 for his work on the Cosmic Background Explorer with John C. Mather that led to the measurement "of the black body form and anisotropy of the cosmic microwave background radiation." He continues to study the universe and how it came into being. In the last two decades humans have made great strides in this area as we have realized that the radiation left over from the Big Bang is providing a wealth of data about the early universe. The spectrum gives us the temperature, but the details are in the anisotropy, providing information about the geometry of space-time as well as the distribution of matter in the early universe. In essence we are studying the seeds of the galaxies, and comparison to galaxy surveys also provides information about the distribution of dark matter.

With the Planck space observatory, we now have lots of data to analyze, but the last great advance was over ten years ago. Smoot is concerned that we are reaching a plateau in our understanding and is looking for something to point us in the direction of the next big step forward. He donated a substantial portion of the money that he received for winning the Nobel Prize to UC Berkeley to establish the Berkeley Center for Cosmological Physics. Dr. Smoot envisioned the center as a place where young postdoctoral researchers could explore and dream up lofty projects just as he did when he studied cosmic microwave background radiation.

When asked what the future will bring, Professor Smoot indicates that he expects new large scale surveys of galaxies and continued study of the cosmic microwave background radiation with a new satellite to probe the polarization of the radiation. Although we will have an incredibly rich set of data, he guesses that the existing models will fit the data very well and we will be left looking for new directions in other places. One of those places will likely be in the area of extrasolar planets, studying their properties to better understand solar system formation, but also looking for evidence of life on those planets.

George Smoot likes to travel. He likes being outdoors, gardening, and taking hikes and is often lucky enough to be able to hike in the Alps. He has enjoyed learning more about the Middle Ages by listening to courses on his IPod. Because he has appointments at both Berkeley and at Paris Diderot University, he doesn't have a lot of free time.

Lawrence M. Krauss, **PhD, Foundation Professor of the School of Earth and Space Exploration, Department of Physics, and director of the Origins Project, Arizona State University, Tempe**

Many mothers want their children to grow up to be doctors. But Lawrence Krauss's mom was still holding out hope when, immediately after he earned his Ph.D., he was named Junior Fellow in the Physics Department at Harvard. She suggested that he was still young and had time to go back to medical school.

But Krauss followed his passion, one that he had acquired when just a young teenager reading books about physicists like Einstein, Feynman, and Gammow. He wanted to be a scientist. He wanted to understand the universe and humans' place in it. He had other interests, too—philosophy and history, which fueled his interest in the connections between science and society and culminated in his being named the director of the Origins Project at Arizona State University, a transdisciplinary initiative that nurtures research, energizes teaching, and builds partnerships, offering new possibilities for exploring the most fundamental of questions: Who are we? and Where did we come from?

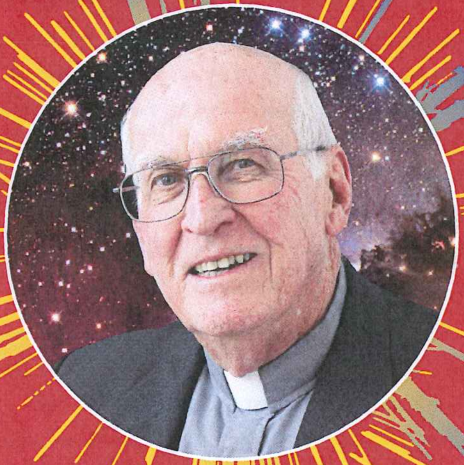
Professor Krauss believes that people should be driven by what interests them and, since early in his life, his interests have been dominated by the mysterious. He studied mathematics and physics at Carleton University in Ottawa, not far from his home in Toronto. He continued his formal education at MIT, earning the PhD in physics in 1982 before beginning his stint at Harvard. He taught in both the Physics and Astronomy departments at Yale for a number of years while collaborating as a visiting scientist at Boston University, the Smithsonian Astrophysical Observatory, and the Harvard-Smithsonian Center for Astrophysics. In 1993, he became the Ambrose Swasey Professor of Physics and Professor of Astronomy at Case Western Reserve University, where he served as chair of physics, director of the Office of Science, Public Policy, and Bio-Entrepreneurship in Case Western's School of Medicine, and director of the Center for Education and Research in Cosmology and Astrophysics. In August 2008 Krauss joined the faculty at Arizona State University as Foundation Professor in the School of Earth and Space Exploration and the Department of Physics, also assuming responsibilities as director of a university initiative, the Origins Project.

Although his primary research is in cosmology and particle physics, he has worked in a very broad range of the sciences. He sees the universe as one big experiment in which to test our theories and continues to be surprised that we can understand the Universe and that occasionally an idea that he comes up with late at night might explain some aspect of it. Krauss was one of the first physicists to suggest that most of the mass and energy of the Universe resides in empty space, an idea now widely known as "dark energy." He has authored several best-selling books, including *The Physics of Star Trek* and *A Universe from Nothing: Why There Is Something Rather than Nothing*. He has been recognized for his contributions to public education in science, most recently in 2012 when he was awarded the National Science Board's Public Service Medal.

When asked about the practical significance of his work, Lawrence says that it doesn't have any. But he quickly points out that like art, literature, and music, it has cultural significance, connecting us to the cosmos and, in a profound way, helping us understand our origins. Even as it appears that humans have less significance in the universe, what we do becomes more significant.

Krauss's broad ranging interests and diverse career path have provided him with opportunities to cross the chasm between science and popular culture. For example, he has performed solo with the Cleveland Orchestra, narrating Gustav Holst's *The Planets* at the Blossom Music Center in the most highly attended concert at that venue, and was nominated for a Grammy Award for his liner notes accompanying a Telarc CD of music from *Star Trek*. In 2005 he also served as a jury member at the Sundance Film Festival, and most recently he has produced and starred in a full-length film, *The Unbelievers*, which premiered this spring. In it, Krauss and Richard Dawkins cross the globe as they speak publicly about the importance of science and reason in the modern world.

In his spare time, Lawrence Krauss enjoys mountain biking, fly fishing, and meeting new people. But he really enjoys his work, having time to think about things and writing. He says of his work with the Origins Project at Arizona State University that it is "like being a kid in a candy shop."



The Rev. George V. Coyne, SJ,

PhD, McDevitt Chair of Religious Philosophy, Le Moyne College, Syracuse, N.Y.; director emeritus of the Vatican Observatory, and former head of the observatory's research group based at the University of Arizona, Tucson

The Jesuit order is well known for being intellectual, so when George Coyne joined at age 18, he knew what to expect. However, he didn't know where his interests would take him. If not for his Greek professor, an amateur astronomer, he might not have discovered the wonders of astronomy and their relationship to religious belief. Coyne completed his bachelor's degree in mathematics and his licentiate in philosophy at Fordham University in 1958. As the study of science and his religious faith became an intimate part of his thinking, he was asked by his superiors to go on to study for his PhD in astronomy. He carried out a spectrophotometric study of the lunar surface for the completion of his doctorate in astronomy at Georgetown University in 1962. He continued to do research and teach in astronomy while continuing his theological studies and was ordained a Roman Catholic priest in 1965.

Coyne believes that the universe participates in the mystery of the god who created it. Although he began his astronomical research in the solar system and went on to the University of Arizona to continue his lunar research, he quickly became interested in the evolution of stars and the complexities of evolution in close binary systems. In nearly 40 years of active research in the subject Father Coyne has published more than 50 scientific papers on interstellar space, binary systems, variable stars, and the tools astronomers use to study them. He even spent some time doing research on Seyfert galaxies, a class of galaxy characterized by extremely bright nuclei with spectra containing very bright emission lines of hydrogen, helium, nitrogen, and oxygen. With his assignment as director of the Vatican Observatory in 1978 came more administrative responsibilities, but he continued his research in close binary systems. He retired as director of the Vatican Observatory in 2006 and from the observatory itself in 2011. He in now McDevitt Chair of Religious Philosophy at Le Moyne College in Syracuse, New York, where he teaches astronomy and science and religion courses. Coyne was granted an honorary doctorate by Le Moyne in recognition of "his tireless effort to promote an open dialogue between philosophy, theology, and the sciences," as part of his work "to bridge the gap between faith and science."

While at the Vatican Observatory, Coyne began a number of new educational and research initiatives in his efforts to urge the Catholic Church to use good science in their decision-making. The Vatican Observatory wasn't involved in any issues related to human life, and there are no direct implications of his research, but his work does indirectly affect science and science education. For close to ten years, Coyne has been a vocal opponent of intelligent design. He was quoted as saying, "Intelligent design isn't science even though it pretends to be." In an interview for the BBC documentary "A War on Science," he criticized intelligent design as being unscientific and suggested that the Archbishop of Vienna was pressured by the Discovery Institute to publish an article in the *New York Times* critical of evolution. Father Coyne is concerned that fundamentalist religious beliefs might continue to influence the role of science in the modern decision-making process.

To some it appeared that Father Coyne's retirement from the Vatican Observatory was controversial. Some even suggested that he was replaced due to his criticism of intelligent design and its supporters, particularly the Archbishop. However, Coyne denies this. He does indicate that his appointment as director may have been unsettling to some in the Catholic Church. He was appointed to the position by Pope John Paul I shortly after he was elected pope and only a short time before he died of an apparent heart attack. Father Coyne continues to wonder if he may have contributed to the stress that caused his heart attack.

Father George Coyne enjoys biking, hiking, and snowshoeing when he isn't teaching or debating science and religion with the likes of Richard Dawkins.

S. James Gates Jr, PhD, University System of Maryland Regents Professor, the John S. Toll Professor of Physics, and director, Center for String and Particle Theory, University of Maryland, College Park

Most of us can remember receiving a toy for a birthday or Christmas that, despite the initial excitement and all of the hype, disappointed us by becoming boring in a few days. Maybe it is because we didn't understand what the toy was about, or maybe it was really not that interesting. That isn't a problem for Dr. Sylvester James Gates, who thinks of physics as the toy that never gets boring. He has had the toy since he was in high school, and it still brings him so much excitement that it seems it will never end. Jim recalls his mother taking him to see a movie about rockets and space travel called *Spaceway* when he was four years old and how he attempted to explain it all to his father that evening when he got home. His dad remembered Jim's interests and when he was eight got him four books by Willy Ley that kept his curiosity about space alive. Like many young people of that time, Jim also found inspiration thumbing through the encyclopedia, where he found Schroedinger's equation and wondered if he would ever be able to understand it. Well, Professor Gates not only understands Schroedinger's equation better than almost anyone, he makes significant use of it in his work.

After taking a high school course in physics, Jim was hooked on math and physics, but where to go to college to study it was actually inspired by an episode of *Make Room for Daddy* in which a nephew comes to visit the family. When Gates learned that the genius nephew went to a school where you only have to study the "good stuff" like math, physics, and engineering, he knew that the Massachusetts Institute of Technology was the place for him. Jim Gates received his bachelor's degree in 1973 and his PhD in 1977. His doctoral thesis was the first at MIT on supersymmetry. With M. T. Grisaru, M. Rocek, and W. Siegel, Gates coauthored *Superspace, or One Thousand and One Lessons in Supersymmetry* in 1984, the first comprehensive book on supersymmetry. His postgraduate studies started as a Junior Fellow of the Harvard Society of Fellows and, after an appointment at Caltech, he received a faculty appointment at MIT and in 1984 at the University of Maryland at College Park, where he is currently the John S. Toll Professor of Physics. He was the first African American to hold an endowed chair in physics at a major research university in the United States.

When asked about his work, Gates replies, "I sit and wonder about the nature of the universe, of the nature of symmetry and super symmetry, and I do calculations with a pencil on paper." He says that sometimes the answers come to him "out of the blue," like the time he sent two graduate students off to solve a problem and two weeks later the answer just "appeared" in his head. Professor Gates has authored or co-authored more than 120 research papers in the areas of the mathematical and theoretical physics of supersymmetric particles, fields, and strings, covering topics such as the physics of quarks, leptons, gravity, super and heterotic strings, and unified field theories.

Gates was excited to see the announcement from CERN concerning the discovery of the Higgs Boson, but is still wondering if the ambiguity in the announcements leaves open the possibility of discovering more Higgs particles. If supersymmetry theory is correct, there should be five Higgs particles. He is also wondering when the discovery of superpartners or "sparticles," hypothetical elementary particles predicted by the supersymmetry theory, will come. The fact that no superpartners have yet been found may indicate that supersymmetry is incorrect, or it may also be the result of the fact that supersymmetry is not an exact, unbroken symmetry of nature.

Those who attended Nobel Conference 41, "The Legacy of Einstein," will recall that Jim Gates is a real advocate for the importance of science. He often refers to the biblical passage stating "if the leaders have no vision the people fail" as he argues that humans' only defense against a changing and potentially hostile world will be our technology. The reason that species became extinct—here he uses the example of dinosaurs—is that they didn't have scientists with vision to develop the technology that would allow them to survive.

Jim Gates is very proud of his family: his wife, Dianna, who is a pediatrician and head of a county health agency, and his twin daughter and son, who are juniors at the University of Maryland, both pursuing double majors in the sciences and math. He enjoys traveling and talking about science and math and the relationship to his faith. For years he has been mistaken for Morgan Freemam, so he is excited that Freeman will be narrating some footage on chemistry that Gates shot for PBS.

Lucinda Mason (1974–2007), *String Theory*, 2007, oil on canvas, 77 ⅝ x 83 inches, private collection.

THE NOBEL CONFERENCE **CONCERT**

DARK ENERGY

Tuesday, October 1 | Christ Chapel | 8:15 p.m.
Open to the public; no ticket required

The 49th Nobel Concert will bring you to the "inner universe" with music by Dmitri Shostakovich (1906–1975) and Johannes Brahms (1833–1897). The program will feature two contrasting piano trios that share a powerful dark energy.

Shostakovich wrote the Piano Trio in E Minor in 1944 during World War II, mourning the death of his close friend. A sense of suffering pervades the piece, from the eerie sound of the opening cello to the final sounds of a Jewish prayer.

The Piano Trio in C Minor (1886) by Brahms will awaken the audience from the meditative state with a powerful opening movement. The entire piece is full of the passion and energy of the late Romantic period.

Thomas Hart Benton (1889–1975), *I Got a Gal on Sourwood Mountain*, 1938, lithograph on paper, 12 ½ x 9 ⅛ inches, Collection of the Springfield Museum of Art, gift of Susan Wayne and Leslie Wayne Loftus.

ART AT THE NOBEL CONFERENCE

STRING THEORY, AND THE SUPERCONDUCTING SUPER COLLIDER SERIES: Paintings by Lucinda Mason; **AMERICAN ASSOCIATED ARTISTS:** Art by Subscription; and **RECENT ACQUISITIONS AND DEBUTS OF THE HILLSTROM MUSEUM OF ART**

Nobel Conference Reception | Tuesday, October 1 | 6–8 p.m.
September 9–November 10 | Hillstrom Museum of Art
Open to the public; no ticket required

The late Lucinda Mason (1974–2007), an artist and art critic who received her MFA from Concordia University, Montreal, began a series of paintings shortly before her sudden death in which she sought to explore the micro and macro elements of the world, asking, "What does the space look like inside the nucleus of an atom?," "Can one paint the essential make-up of energy?," and "Can one paint the immeasurable space?" Mason's large-scale oil paintings in *String Theory, and the Superconducting Super Collider Series* use abstract patterns that employ dots and lines of paint that coalesce to resemble the cosmos and its motion and energy.

American Associated Artists: Art by Subscription features 75 prints, the majority of them dating from the 1930s and 1940s, made by prominent American artists such as Thomas Hart Benton (1889–1975), Peggy Bacon (1895–1987), and Reginald Marsh (1898–1954) for American Associated Artists (AAA). That company, begun by entrepreneur Reeves Lewenthal in 1934, sought to bring affordable art to middle-class America through relatively inexpensive prints that were marketed through department stores and the U. S. Postal Service, a successful venture made all the more remarkable given its inception during the Great Depression. The exhibition was organized by and drawn from the collection of the Springfield Museum of Art in Ohio.

Henry Varnum Poor (1887–1970), *Hudson Freighter*, probably 1940s, oil on Masonite, 20 x 24 inches, Hillstrom Museum of Art, Gift of Peter Poor.

The Hillstrom Museum of Art Collection includes a number of AAA prints, one of which, by Grant Wood (1891–1942), is included in *Recent Acquisitions and Debuts of the Hillstrom Museum of Art*. Several works—recently acquired by donation or, in a few instances, purchased with funds resulting from donation—are being shown for the first time. The exhibition includes paintings, prints, and photography, with landscapes, cityscapes, genre scenes, and portraits amongst them.

CONTRIBUTORS TO NOBEL CONFERENCE® 49

The Nobel Conference at Gustavus Adolphus College, the first educational conference of its kind in the United States, is made possible through income generated by a Nobel Conference endowment and the support of annual conference contributors. The Nobel Conference Endowment Fund was created in July 1978 and is permanently secured as a result of the generous support of the Rev. Drell and Adeline Bernhardson. Other gifts to the fund have been made by Russell and Rhoda Lund; the Mardag Foundation, in memory of Edgar B. Ober; and the UnitedHealth Group. Contributors to the 2013 conference include the Katherine B. Andersen Fund of the Saint Paul Foundation, Cambria, Heroic Productions, and the Robert E. and Susan T. Rydell Distinguished Visiting Professor Fund.

HHMI-SUPPORTED PROGRAM USES NOBEL CONFERENCE TO ENHANCE HIGH SCHOOL SCIENCE TEACHING

In 2008, Gustavus Adolphus College received a $1 million science education grant from the Howard Hughes Medical Institute (HHMI) of Chevy Chase, Md. It has supported a variety of programs that seek to transform the first-year student experience in the STEM disciplines (science and math)—particularly through collaboration between the Departments of Biology and Chemistry.

In addition, the grant supports an innovative year-long outreach program that utilizes the topic of the College's annual two-day Nobel Conference to enhance high school science education and to better prepare participating teachers and their students to attend the conference. A central component of the program is the role of selected high school teachers in developing specially designed lesson plans that are integrated into their teaching. The grant also supports the approximately 400 participating students who attend the conference by contributing to all program costs, including those related to conference tickets and transportation.

THE RYDELL PROFESSORSHIP AT GUSTAVUS

The Drs. Robert E. and Susan T. Rydell Professorship at Gustavus Adolphus College is a scholar-in-residence program designed to bring Nobel laureates, Nobel conference presenters, and similarly distinguished scholars and researchers to campus as catalysts for enhancing learning and teaching. It was established in 1993 by the late Dr. Robert Rydell '46 and his wife, Dr. Susan Rydell, of Minnetonka, Minn., "to give students the opportunity to learn from and interact with leading scholars." To date, fifteen scholars and scientists have been in residence at Gustavus through the auspices of this professorship.

After participating as one of the invited presenters at the 2005 Nobel Conference, "The Legacy of Einstein," Sylvester James Gates Jr., PhD, University System of Maryland Regents Professor, the John S. Toll Professor of Physics, and director, Center for String and Particle Theory, University of Maryland, College Park, returned to Gustavus during the spring of 2007 as the College's tenth Rydell Professor, team-teaching an upper-division physics course and presenting a public lecture.

Professor Gates is back again this year as one of eight invited presenters at the College's 49th Nobel Conference, "The Universe at Its Limits," and likewise, he has accepted a second appointment as Gustavus's Rydell Professor. Among his Rydell-related activities, Gates will headline a 2013 Nobel Conference Preview Event on campus on September 20 (2:30 p.m., Alumni Hall), will visit two of the high schools participating in the HHMI outreach program (above), and will deliver a conference preview lecture at the Science Museum of Minnesota in St. Paul on Sunday, September 29 (7:30 p.m., Omnitheater). The events are open to the public without charge, but reservations are requested for the Science Museum lecture due to limited space. (Visit gustavustickets.com to make reservations.)