Graphene Experiments Garner Nobel Prize

The Royal Swedish Academy of Sciences has awarded the 2010 Nobel Prize to Andre Geim and Konstantin Novoselov of the University of Manchester in the United Kingdom for “ground-breaking experiments” on graphene. In a paper published in Science in October 2004, Geim and Novoselov announced that they had succeeded for the first time to create a sheet of carbon atoms one atom thick.

The remarkable characteristics of graphene hold a tremendous amount of promise for future applications. It is both the thinnest and strongest material ever created. It is stronger than any other flexible. It is as good an electrical conductor as copper and better at conducting heat than any other material. It is almost completely transparent and its hexagonal molecular structure is so dense that even helium can pass through.

Scientists had been trying for years to isolate such a carbon molecule because of its amazing theorized structural and electrical properties. However all had been frustrated in their attempts. Many had given up, believing that there was no way such a thin sheet of carbon could be stable at room temperatures. Geim and Novoselov’s technique was as novel as it was simple: They stuck a piece of scotch tape on a chunk of graphite and pulled off a thin layer. After repeated attempts, they were able to isolate a flat sheet of carbon one atom thick, the long sought-after sample of graphene.

“We just try to be curious in everything and most importantly, to have fun. So André introduced this habit of Friday evening experiments where you just do crazy things and then some of them sometimes come out, sometimes not, and basically graphene was one of those as well,” Novoselov said in a taped interview.

“My work is my hobby. Some people would call me a workaholic; I don’t consider it such. I just love my work so much so it’s my real hobby,” Geim said in a taped interview.

In the six years since the team published their paper, graphene has become one of the hottest research areas in condensed matter. It’s estimated that over 2500 scientific papers were published in PRIZE continued on page 3

APS Responds to Member’s Resignation over Climate Change

In early October, a long-time member of APS, Hal Lewis, publicly resigned from the Society over issues having to do with climate change. Lewis, who is an emeritus professor at UC Santa Barbara, addressed his letter of resignation to APS President Curtis Callan, simultaneously circulating it on the Internet. In response to some of the points in Lewis’s letter, APS issued a statement that can be found on the press-release page of the APS website. Callan also sent a personal reply to Lewis in which he expressed his regret at Lewis’s decision, along with his strong disagreement with the substance of Lewis’s complaints against APS.

Lewis’s specific complaints focus on the recent decisions of the APS executive board, which he expressed his regret at Lewis’s decision, along with his strong disagreement with the substance of Lewis’s complaints against APS.

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APS News
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Physics Stars in Theater, Music and Dance

By Michael Lucibella

Physics has recently taken center stage as performances about the physical sciences have thrived. The performances run the gamut of artistic endeavor, including plays, operas, and dance productions. The different shows focus on a wide array of disciplines in physics and go into different depths of their subjects; however, all prominently feature physics and science.

“The thing for me that has always and continues to be the reason I write about science is because it’s inherently dramatic. There’s abundant character, and inherent plot,” said playwright Lauren Gunderson. “I think on a more existential level, science lets theatre really get excited about science. It’s sort of the NPR crowd,” Gunderson said. “There is a great movement of learning more about it. It’s sort of the NPR crowd,” Gunderson said.

Gunderson also wrote Backbone of the Life of physicist Ralph Alpher, Leap which features Isaac Newton, and Baby M, which, according to her website, combines maternity, murder and M-theory. Her next major production, set to premiere at the Kennedy Center in Washington, is aimed at a younger crowd. Titled The Amazing Adventures of Dr. Wonderful and her Dog, it tells the story of a 5th grade girl who uses science to solve mysteries. Gunderson was also instrumental in setting up the playwright in residence program at the Kavli Institute for Theoretical Physics in Santa Barbara.

The Liz Lerman Dance Exchange premiered its dance production A Matter of Origins perform on stage before a large projection of Marie Curie in her lab. The performance also included stage settings using images from the Hubble Space Telescope and the Manhattan Project.

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**This Month in Physics History**

**November 11, 1930: Patent granted for Einstein-Szilard Refrigerator**

Albert Einstein is best known to the general public for his famous equation: $E=mc^2$. But his contributions to physics extend beyond this simplistic equation to help pave the way for the development of quantum mechanics. While still a young scientist, he also filed patents for devices that would help energize the field of quantum mechanics.

Einstein and Szilard needed an engineer to help them develop a working prototype, and they found one in Albert Korodi, who first met Szilard when both were engi- neering students at the Budapest Technical University. Korodi was an amateur and good friends when both later moved to Berlin.

The German company A.E.G. agreed to help develop the pump technology, and hired Korodi as a full-time engineer. But the device was noisy due to cavitation as the liquid metal passed through the pump. One company commentator said it "sounded like a jackal," although Korodi claimed it sounded more like rushing water. Korodi reduced the noise significantly by varying the voltage and increasing and decreasing the magnetic field, which was the choice of liquid metal. Mercury wasn’t suf- ficiently conductive, so the pump used a potassium-sodium alloy instead, which required a special sealed system as a refrigerant. The rest of the process worked much like today’s conventional re- frigerators.

Einstein and Szilard found a way to improve on their design, drawing on their expertise in thermodynamics. His heat source drove a combination of gases and liquids through three interconnected circuits. One of the components they designed for their re- frigerator was the Einstein-Szilard electromagnetic pump, which had no moving parts, relying instead on generating an electromagnetic field by running alternating current through coils. The field moved a liquid metal, and the metal, in turn, served as a compression and as a refrigerant. The rest of the process worked much like today’s conventional re- frigerators.

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Einstein wasn’t a stranger to the partner process, either, having worked as a patent clerk in Bern as a young man. He later received a patent with a Ger- man engineer named Rudolf Goldschmidt for a working prototype of a hearing aid. A singer of Einstein’s acquaintance who suffered hearing loss provided the inspiration for the invention.

When they met, Einstein was already a world- famous physicist, thanks to his work on relativity, but Szilard was just starting out, as a graduate as- sistant at the University of Berlin. The impetus for the two men’s collaboration on a refrigerator oc- curred in 1926, when newspapers reported the trag- ic death of an entire family in Berlin, due to toxic gas fumes that leaked throughout the house when they slept, the result of a broken refrigerator seal. Such leaks were occurring with alarming frequency as more people replaced traditional ice boxes with modern refrigerators. Szilard was interested in poisonous gases like methyl chloride, ammonia, and sulfur dioxide as refrigerants.

Einstein was deeply affected by the tragedy, and told Szilard, “You should be a better design than the mechanical compressors and toxic gases used in the modern refrigerator. Together they set out to find one. They focused their attention on absorption refrigerators, in which a heat source—in that time, a natural gas flame—is used to drive the absorption process and release coolant from a chemical solu- tion. An earlier version of this technology had been introduced in 1922 by Swiss inventors, and Szilard and Einstein were aware of it. The Swiss device was capable of wiping out the planet’s atmosphere. Together they set out to find one. They focused their attention on absorption refrigerators, in which a heat source—"dark flow" of matter in the cos-
Science Writers Are the Ambassadors of Science

By Lulu Liu

I’m not a journalist. In college I was a search-er of gravitational waves and exoplanets. I was an eager dis-coverer of fundamental physics. I was a reluctant programmer in several languages. But never a journalist.

So while I laid my roots in science and slyly cultivated an interest in writing on the side, it never occurred to me that there might be a first reader voicemail. He was surprised, the caller said, that I was working—on what? "I just realized that simple and concise writing always provides a better explanation,” he continued. "I’m particularly used to save the best part for last and dig-est at least five times; I thought the extra detours were neces-sary to give a complete picture. Once I understood what Orange County readers needed from a science writer at all. The skepticism that science writing is an elite one-positioned too close to journalism, as well as a sponsor of this program–that the APS’s recognition, and the APS’s Professional skills Development workshops provide women physicists professional training in effective negotiation, communication, and leadership skills, as well as a special opportunity for students always the chance that something goes wrong–horrid traffic or frightful rides. I had to explain why, in the classic Gravi-tation ride, when the floor dropped the riders didn’t drop with it. I pointed my finger at “friction,” instead of the usual “centrifugal force.” "Sacramento Bee readers grumbled. “They ‘weren’t sur-prised’, they said, the so-called science writer would get that wrong. But one commentator leapt to my defense. Sort of. Actually, he wrote, the Bee writer was right; no doubt, he felt the warmth of vindication. “Al-though I doubt [she] understands what [she] originally wrote,” he went on.

Science writers are the ambas-sadors of science yet it’s rare, in the traditional media at least, for one to have any kind of scientific training or professional experience. From a political perspective, it’s no more than that, it’s thrown doubt on the mass media’s ability to ac-curately represent this kind of information altogether.

Science journalism today, I report, is much more journalism than science. While the journal-ism field has warmly embraced science as one of its “beats”, the science community still fails to consider outreach a legitimate activity for a scientist.

Absent an effective avenue of communication between sci-entists and the communities they serve, science is just some exclusive club the public is not allowed into, and the scientific truths that arise from arbitrary and capricious, no better than a politician’s promises. It’s my hope that the scientific commu-nity continues to cultivate passion and commitment not just in science research but also in science communication.

A Good Reporter Gets Up Early and Stays Up Late

By Lauren DiPerna

Working at the Orange Coun-ty Register changed the way I told a story. Before, I liked to save the best part for last and di-gest at least five times; I thought the extra detours were neces-sary to give a complete picture. Once I understood what Orange County readers needed from a science writer at all. The skepticism that science writing is an elite one-positioned too close to journalism, as well as a sponsor of this program–that the APS’s recognition, and the APS’s Professional skills Development workshops provide women physicists professional training in effective negotiation, communication, and leadership skills, as well as a special opportunity for students always the chance that something goes wrong–horrid traffic or frightful rides. I had to explain why, in the classic Gravi-tation ride, when the floor dropped the riders didn’t drop with it. I pointed my finger at “friction,” instead of the usual “centrifugal force.” "Sacramento Bee readers grumbled. “They ‘weren’t sur-prised’, they said, the so-called science writer would get that wrong. But one commentator leapt to my defense. Sort of. Actually, he wrote, the Bee writer was right; no doubt, he felt the warmth of vindication. “Al-though I doubt [she] understands what [she] originally wrote,” he went on.

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Science journali...
RESIGNATION continued from page 1

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Edith Borie
Karlsruhe, Germany

Ed. Note: the Zero Gravity in
question appeared in the May, 2002 issue of APS News (avail-
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Lawrence Cranberg
Austin, TX

In his letter, Lewis speculated that Council's policy positions on climate change must be driven by financial interest, adding that Callan's own physics department "would lose millions a year if the global warming bubble burst". The APS press release categori-
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By Michael Lucibella

Ig Nobles Presented in Wacky Ceremony

Ig Nobles presented at this year's ceremonies, which are the interface between science and popular culture, have actualized a "real challenge not to fall over and some- times to not have to nitpick about words that really don't make a difference." The letter went on to say, "I am really glad that someone might think they need to do me sorry for that silly side note."

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Photograph by Michael Lucibella

Nobel laureates Roy Glauber (Physics 2005) on left and Sheldon Glashow (Physics 1979) on right help sweep up a mound of paper airplanes thrown on stage during the 20th first annual Ig Nobel Prize ceremony.

The ceremony, held in Sanders Theatre at Harvard Univer-
sity, is a jolly-faked variety show of science wackiness. This year featured a bacterial actor, a Nobel physics laureate Roy Glauber describing the odds a life form on the back of a book a weatherman (roughly three sextillion to one), and Physics Nobel laureates Sheldon Glashow and Frank Wilczek describing how many bacteria can dance on the head of a pin. Three other Nobel laureates, Roy Glauber, James Muller and William Lipscomb were also on stage to shake the hands of the winners.

In addition, Lipscomb participated in the contest to win a date with a Nobel laureate. "The 'bacteria' was the theme of the ceremony this year," said Edgardo Browne, "the physics and physicists featured prominently in several of the awards. The prize given for Chemistry went jointly to Eric Adams of MIT, Scott Socolofsky of Texas A&M University, and Drea Rapisarda in the physics and Magnetar; however, like BP, no company representatives were sent to collect the prize."

We were pleased to read Sacha Kopp's The Back Page article (APS News, August/September 2010) about the success of the University of Texas (UT) Science Initia-

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Physics Lags in Minority Representation

Two recent studies have found that despite some gains, African Americans and Hispanics continue to be underrepresented in physics degrees and faculty positions. The research collected data from surveys of nearly 800 universities and colleges as well as information from the National Center for Education Statistics and the National Science Foundation. The data covered up to the end of the 2008 academic year. Currently African Americans make up 12.4 percent of the United States population, while they earn 9 percent of all bachelor’s degrees and only 2.9 percent of physics bachelor’s degrees. Similarly, Hispanics comprise 15 percent of the United States population, while making up only 8 percent of overall bachelor’s degrees and 4.7 percent of physics bachelor’s degrees.

Over the last 30 years, Hispanics have nearly doubled the number of physics bachelor’s degrees earned from 84 in 1981 to 229 in 2008. African Americans have over the same time fluctuated between about 180 and 130 with 144 earned in 2008. During the 2005-2006 academic year, the most recent data available, African Americans made up 6.2 percent of all PhDs awarded, while less than 1 percent of physics PhDs. Long-term trends show that over the last 30 years the number of African Americans earning PhDs has increased overall. The 1990s saw a peak of Hispanic PhDs with a rise of 5 percent increase between 2001 and 2006. Minorities remain similarly underrepresented among physics faculty. African Americans over the last eight years have seen significant increases in the number of university faculty, but remain less than 2 percent of the faculty. At bachelor’s degree granting institutions and 1.2 percent at PhD-granting institutions. More than 85 percent of physics departments have no African Americans among their tenured faculty and about 10 percent of faculty members have similarly increased overall, yet nearly 80 percent of physics departments have no African Americans.

The study did highlight that the number of minority students receiving bachelor’s degrees overall has increased dramatically over the last decade. While the total number of degrees awarded increased by 32 percent over the last 20 years, the total number of African Americans earning bachelor’s degrees rose by 75 percent more than Hispanics. The study found that African American men increased their share by 3 percent over the last two years. African American women rose by 45 percent. African Americans have tended to go into fields such as business and management, psychology and computer sciences, while Hispanics have gravitated toward education, psychology and engineering.

The Task Ahead

by Michael S. Lubell, APS Director of Public Affairs

When he appeared before Congress this fall, the bill from being debated at all—will suddenly transform itself into an aura of good feeling. And the House, where the majority party has the power to rela- egate the minority to little more than an opposition, faces its momentous decisions on momentous occasions that will determine our nation’s future. Little more than five years ago responding to a set of ominous research and development benchmarks assembled by the Taskforce on the Education and the National Academies to develop a blueprint for future economic growth and global com- petitiveness based on science and technology. Then, Democrats and Republicans had a shared concern about the course of our nation was plying. Their call to the Acad-
NRC Deals With Application Surge, Proliferation Threat

By Michael Lucchetta

Jaczko said he was more concerned with having an effective approval process rather than with the number of plants built. “The key focus is: If there are plants, they are safe. How many there are is up to the utilities,” Jaczko said.

He explained that the 1979 Accident at Three Mile Island in Pennsylvania was a turning point for the nuclear power industry. “Since then, with the exception of the one currently under construction, no new nuclear power plants have been built. As a result of the accident, the agency worked to establish better management to implement regulations at plants.”

“I think fundamentally those improvements led to an improve in safety,” Jaczko said. “The issue of a safety culture is an important issue for the agency.”

Though no major accidents at facilities have occurred since the Three Mile Island accident, Jaczko cautioned against institutional over-confidence at power plants.

“We need to be wary of the view that just because it hasn’t happened in the past, it can’t happen in the future,” Jaczko said. “The core of that is instilling a right safety culture in every facility.”

Another concern over nuclear safety is the potential misuse of the technology for the proliferation of nuclear weapons. The start of construction by General Electric of a plant in North Carolina to enrich uranium using a new process called SILEX has attracted such concerns. The Separation of Isotopes by Laser Excitation uses lasers to purify nuclear fuel by ionizing the atoms of the U-235 isotope. A charged plate then collects the enriched fuel. It is thought that this method would require less energy to enrich nuclear fuel than the existing technologies.

Experts have raised concerns that a SILEX facility could be easily concealed from surveillance satellites by an unfriendly nation and used to create fuel for nuclear weapons. In March, Francis Slasky, a professor at Georgetown University and APS’s Associate Director of Public Affairs, co-authored a letter in Nature calling for the NRC to conduct a defense risk assessment for any domestic company looking to license the new technology. “The NRC was still considering the matter.”

“At this point the commission really hasn’t made a decision about this,” Jaczko said.

He added that he thought that the right system in place was working well.

“The question is whether you really can control the information and data.”

Jaczko said, “I really can control the information and data.”

Saturday morning Maher Dayeh of the Southwest Research Institute showed the researchers present to also get involved.

There has been a big push on the part of the Obama administration to encourage the development of nuclear power as a viable alternative to fossil fuels. It increased loan guarantees for new nuclear power plants from $18.5 billion authorized in 2005 to $54 billion. This may make it sound like there is a generational shift in nuclear as a viable power source that is happening at once. Cummings is focusing on the opposite- long term.

“Technology is starting to change our world so much that we don’t really know how to react to the behavioral impacts on it,” Cummings said.

The Northwest section of APS held its annual meeting at Whitman College in Walla Walla, Washington from September 30 through October 2. Thursday’s opening lecture by Barry Barish of Caltech highlighted the work of LIGO in its search for gravitational waves. Twelve plenary sessions were held over Saturday and Sunday: Rory Barnes from the University of Washington updated attendants on the search for habitable planets outside the solar system. David Atkinson from the University of Edinburgh presented on how future quantum computers could be dependent on silicon and germanium quantum dots for processing.

The New York sectional meeting was held at Hofstra University in Hempstead from October 19 to 21. With funding from the Nuclear Regulatory Commission, scientists are enthusiastically studying bored people. The research being conducted at MIT’s Human and Automation Laboratory—or HAL—is to find out what effect a stable social structure in such environments has on nuclear power plant operators.

The NRC wants to tell you that their environments are sterile. “If you have a sterile environment you won’t get distracted,” said Hal director Missy Cummings. “I actually think they will, and it will be worse than if these people had the ability to amuse themselves.”

Cummings is among those studying the effects of automation and believes keeping workers engaged and making decisions is key to preventing mishaps.

“Boredom is not being identified as an issue at the current generation of nuclear plants,” said Peters. “This may make it sound like there is a generational shift in nuclear as a viable power source that is happening at once. Cummings is focusing on the opposite—long term.”

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Professional Skills Development Workshops for Women Physicists

improve your negotiation skills and learn to communicate your great ideas to colleagues.

Who may apply: Women postdoctoral associates and women faculty in physics. Each workshop will have one session aimed at women postdocs and one session aimed at women faculty.

When: Sunday, March 20, 2011, Dallas, Texas*  
Friday, April 29, 2011, Anaheim, California

Deadlines to apply:  
December 10, 2010 (for March)  
January 10, 2011 (for April)

First consideration will be given to applications received by the deadlines. Workshops will be limited in size for optimal benefits. Women of color are strongly encouraged to apply.

Participants are eligible to receive a stipend to help cover the cost of travel and up to two nights lodging.

Details at http://www.aps.org/programs/workshops/skills/

These workshops are funded by a grant from the National Science Foundation (Pending NSF Funding)

ANNOUNCEMENTS

Reviews of Modern Physics  
Recently Posted Reviews and Colloquia

Vortices in quantum droplets: Analogies between boson and fermion systems

H. Saarikoski, S.M. Reimann, A. Harju and M. Manninen

Vortices are ubiquitous in classical and quantum fluids. In quantum fluids, vortices typically form regular arrays, a unique signature of quantization. One might expect that bosonic and fermionic fluids would display very different vortex properties but this review of the many-body physics of small particle systems reveals unexpected similarities. Systems of interest include atomic Bose-Einstein condensates and degenerate fermionic systems, quantum Hall states in a 2D electron gas, and quantum dots in strong magnetic fields. The major sections of the review are organized by many-body wave functions, computational many-body methods, and single-component and multicomponent quantum droplets.

http://rmp.aps.org

Rapidly Approaching Category 5

The two plans found common ground in the America COMPETES Reauthorization Act of 2010 last May 28, 2010, when Congress passed the legislation into law. With bipartisan support, House Speaker John Boehner and Senate Majority Leader Harry Reid agreed on the need to reauthorize the program. The major sections of the review are organized by many-body wave functions, computational many-body methods, and single-component and multicomponent quantum droplets.

http://rmp.aps.org

NRC continued from page 6

He added that it was the suppliers, not the reactor, who were the biggest source of concern about proliferation. The suppliers of nuclear fuel are more decentralized and as a result are becoming more competitive with other providers and are worth consideration. The NRC believes that the Society’s continued participation in APSIT is a benefit to our members and encourages everyone to learn more about the products.

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In less than half a year, a committee chaired by Norman J. Augustine, retired CEO of Lockheed Martin, completed its signature report, Rising Above the Gathering Storm. In stark language, the document laid out the steps policy makers needed to take to prevent the United States from being relegated to a has-been nation. The report led to the Bush Administration’s “American Competitiveness Initiative” and the House Demo- crats’ “Innovation Agenda.”

The two plans found common ground in the America COM- PETES Act of 2007, which called for substantial increases in investments in science research and education. Congress passed the three-year authorization bill with large bipartisan majorities, and President Bush signed it into law. But that was in August 2007 when Democrats and Republicans still had a common purpose. They were working to overhaul oversight of a focus for the NRC as they are working to overhaul oversight generally of the entire fuel cycle. “It’s more of a challenge on the enrichment side,” Jaucko said.

With dozens of newbies who have scant knowledge about science, innovation and competitiveness preparing to take their seats in the 112th Congress in January, we have a monumental task ahead of us. We need them to understand that science and technology drive the American economy and that federal neglect of research and development will relegate our nation to second-class status in the 21st-century world.

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The Back Page

New Worlds, New Horizons in Astronomy and Astrophysics
by Roger Blandford and Donald C. Shaper

The identification of these science priorities played a seminal role in the process: the organizing principle for constructing the report. The committee assembled a balanced portfolio of capabilities to address these science objectives.

This report recommends a program that will set the astrophysics and astrophysics community firmly on the path to answering some of the most profound questions about the universe. In the plan, new, optical and infrared survey telescopes on the ground and in space will employ a variety of novel techniques to investigate the nature of dark energy. These same telescopes will usher in the National Space Surveillance Network, a system of thousands of planetary systems, observe the explosive demise of stars, and open a new window on the time-variable universe. Spectroscopic and high-spatial-resolution imaging capabilities on new large ground-based telescopes will enable researchers to discern the physical nature of objects discovered at both shorter and longer wavelengths by other facilities in the committee’s recommended program. Innovative moderate-cost programs in space and on the ground will be enhanced so as to enable the community to respond rapidly and flexibly to new scientific discoveries. Construction will begin on a space-based observatory that employs the new window of gravitational radiation to observe the merging of distant black holes and other dense objects and to precisely test theories of gravity in new regimes that we can never hope to study on Earth. The foundations will be laid for studies of the hot universe with a future X-ray telescope that will search for the first massive black holes, and that will follow the cycling of gas within and beyond galaxies, while also probing the limits of our understanding of fundamental physics. Experiments to study the highest-energy photons emitted by cosmic sources. At the opposite end of the electromagnetic spectrum, radio techniques will become powerful enough to view the epoch when the very first objects began to light up the universe, marking the transition from a proton-rich dark age to one of self-luminous stars. The microwave background radiation will be scrutinized for the telltale evidence that inflation actually occurred. Perhaps most exciting of all, researchers will identify which nearby stars are orbited by planets on which life could also have developed. Realizing these and an array of other scientific opportunities will require continued investment in graduate education and the physical sciences. The discoveries made will surely lead to new and sometimes surprising insights that will continue to expand our understanding of the universe. With the opening of new worlds and presenting new horizons, the study of which will bring us closer to understanding the cosmos and our place within it.

The Back Page

The current survey, organized under the auspices of the Board on Physics and Astronomy and the Space Sciences Board of the National Research Council, was recently released in preliminary form (National Research Council 2010). Following in the footsteps of its five predecessors, it recommends a prioritized program of activities for the 2012-2021 decade, and it lays the foundation for the decade after that. But unlike previous surveys, it is prioritized and recommended in a previous survey that has not been realized.

And, responding to concerns about cost growth of major projects, the survey engaged the Aerospace Corporation to assist it in assessing the technical readiness and appraising the likely cost of the large projects. The recommended program fits within plausible budget scenarios based on input from all sectors of the industries and many of the large projects involve international collaboration as well as private donors and foundations.

Hundreds of planets of startling diversity have been discovered, and bold new ideas to understand it have created scientific accelerations in an unexpected and unexplained way. Recent measurements of the primordial radiation left by the big bang at the center of most galaxies, including our own. Precision observations of the hot universe will be scrutinized for the telltale evidence of inflation, if it actually occurred. Perhaps most exciting of all, researchers will identify which nearby stars are orbited by planets on which life could also have developed.

The Committee found that astronomers’ overall view of the universe has changed dramatically in the last decade. Hawking radiation and picture of a universe of incredible diversity and complexity have been discovered. Our own galaxy. The Explorer Program—augmenting a program that delivers a high level of scientific return on relatively modest investment, and that prepares the community to respond rapidly to new scientific and technical breakthroughs. Laser Interferometer Space Antenna (LISA)—a low-frequency gravitational wave observatory in Earth orbit that will open an entire new window on the cosmos by measuring ripples in space-time caused by many new sources, including nearby white dwarf stars, collide to form the nature of black holes. International X-ray Observatory (IXO)—a powerful X-ray telescope that will transform our understanding of hot gas associated with the evolution and extinction stages. (Medium-scale, in rank order) New Worlds Technology Development Program—a competitively funded program to lay the foundation for a future mission to study nearby Earth-like planets. Inflation Probe Technology Development Program—a competitively funded program to prepare for a potential next-decade cosmic microwave-background mission to study the epoch of inflation.