O R I O N

Newsletter of the
Friends of Astronomy
Cornell University

Greetings

The semester is almost over. Our students are preparing for final exams and looking forward to the Holidays. Exciting discoveries are being made almost daily as data from Spitzer, Cassini and the Mars Exploration Rovers continue to flood in. Our astronomers continue to receive prestigious awards. Jean-Luc Margot won this year's Urey Prize awarded by the Division for Planetary Sciences of the American Astronomical Society (AAS) to an outstanding young planetary scientist. Steve Squyres received the Carl Sagan Memorial Award from the AAS this fall for "demonstrated leadership in research and policies advancing the exploration of the cosmos". And Yervant Terzian was honored with a Distinguished Alumni Award from his Alma Mater, the American University in Cairo.

Work on the Atacama Project is progressing well. Tom Sebring, an engineer who has overseen the construction of several large telescopes has joined us as Study Manager. We are working with our colleagues at Caltech and JPL to complete the Preliminary Study for the project by the end of December 2005. Cornell and Caltech have each committed $1M dollars to this effort.

With help from the Friends and the College of Arts and Sciences we have undertaken to markedly improve the facilities for teaching

Continued p. 6

If confirmed as a remnant of a gamma-ray burst, W49B would be the nearest known example of one of nature's most violent explosions. It would give scientists an excellent opportunity to study their aftermath. NASA/CXC/SSC/J. Keohane et al.

Dear Friends,

We wish you Happy Holidays and a Great Year 2005. Lots of good things happened in 2004 including having two Mars Rovers explore the planet Mars, a project of which our Department is very proud. We also had a very successful 'Special Symposium on The New Cosmology' early in the summer at Cornell that was attended by more than 75 Friends. I am also happy to tell you that during the year more than 40 undergraduate students worked in various Astronomy related research projects under the supervision of the faculty. However, we were also sad because Thomas Gold, the founder of our Department as we know it, passed away in late June.

In addition to remembering Tommy, this issue features an article about the Arecibo Observatory by Professor Robert Brown, and an extended answer to the 'Barbara Asks' column by Professor Ira Wasserman on the complex

Continued p. 6

Winter 2004

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Contents

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Exploring the Universe with Telescopes Big and Small

Brian Kent is a graduate student at the Department of Astronomy and an astrophotographer

The number of objects in the Universe is astounding. For centuries astronomers have tallied their observations, recording positions and new insightful details about the objects they see. From the early catalogs of Charles Messier to the Palomar Sky Survey, to today's enormous databases of stars and galaxies, *sky surveys* have played an important role in exploring the Universe. Astronomers cover broad areas of the sky probing for specific types of objects in our galaxy or attempting to understand the large-scale structure of the Universe. Today astronomical surveys are carried out across the entire electromagnetic spectrum to study different types of stars, molecular clouds in our galaxy, other galaxies and quasars beyond our own, and the cosmic microwave background radiation.

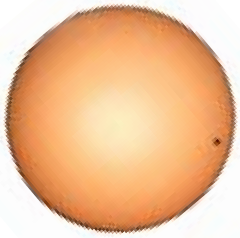
As a graduate student in the Department of Astronomy at Cornell, I am part of a large consortium of astronomers taking part in surveys to be completed at the Arecibo Observatory in Puerto Rico <http://www.naic.edu/>. With its 1000-foot dish, Arecibo is home to the largest single dish radio telescope on Earth. Arecibo observes the sky with receivers on a moving platform suspended 420 feet above the dish. The radio telescope is now making use of a new instrument for radio surveys, the ALFA receiver – the **A**recibo **L**-band **F**eed **A**rray <http://alfa.naic.edu/>. The L-band frequency range is especially important in astronomy as it is home to the 21-centimeter energy emission of neutral hydrogen that astronomers use to study the Milky Way Galaxy and galaxies beyond our own. Most of the time, receivers on radio telescopes have a single pixel, or *beam* looking at the sky. With ALFA, seven beams will observe simultaneously, allowing scientists using the system to survey the sky at a faster rate. Coupled with the sensitivity of Arecibo's large dish, ALFA will be a powerful scientific tool for studies of our galaxy, the Milky Way, other galaxies and pulsars.

ALFA will present new challenges in observing strategies and data analysis. I have spent my first year at Cornell working with Professor Riccardo Giovanelli in Cornell's Extragalactic Group <http://www.astro.cornell.edu/Galaxy/egg.html>, developing computer procedures to analyze data from extragalactic surveys. What will astronomers gain from surveys with ALFA? One of the objectives is to resolve the discrepancy in the number density of low mass neutral hidrogen sources. ALFA will allow observers to detect these faint objects in the local Universe, and we will begin to understand what simulations predict.

Making sure that the astronomical community is able to use the products of any astronomical survey is of crucial importance to its success. I am interested in storing the data from extragalactic ALFA surveys in databases so that astronomers can access the data for future scientific studies. Astronomical databases will be accessed through the protocols of the International Virtual Observatory Alliance <http://www.ivoa.net/>, a standard that allows all astronomical data to be shared and accessed in an efficient manner.

Backyard astronomy is fun too! I have always enjoyed observing through small telescopes and photographing astronomical phenomena (pending clear weather in Ithaca!) Visit <http://www. astro. cornell. edu/ ~bkent/> to see some of the astronomical images of eclipses, aurorae and other recent events I have taken. Whether studying distant galaxies with radio telescope surveys or stargazing from Ithaca, astronomy is one of the most fascinating of all the sciences.

-Brian Kent '08



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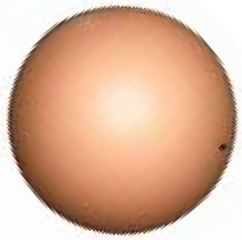

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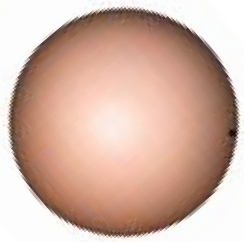

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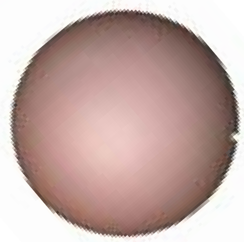

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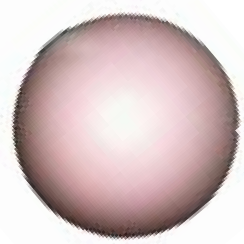

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Venus transiting across the face of the Sun on June 8, 2004 as seen from the roof of the Space Sciences Building at Cornell in Ithaca, N.Y. Venus is the small black (white in the last two photos) dot in the lower right hand quadrant of the Sun. The Sun's changing color is to to its rising. Photo: Brian Kent.

Thomas Gold

Thomas Gold, Professor Emeritus of Astronomy at Cornell University, died on June 22, 2004, in Ithaca, New York from complications from a heart attack. He was one of the most prolific thinkers of his time. He questioned many fundamental physics assumptions with no hesitation and with a lot of confidence. He was an 'idea' man of enormous breadth, who many times succeeded in finding the right solutions to prominent problems like the real nature of pulsars and the mechanism of hearing.

On October 13, 2004 a Memorial Service was held at Cornell where many speakers attended from around the world, including Sir Hermann Bondi, Harry Messel, and Freeman Dyson. This essay contains most of what I said at this Memorial.

It is not possible to ever forget Tommy. We shall always remember his superior intellect, his penetrating mind, his brilliance, his humanity, his sportsmanship and his love of life.

Tommy was born in Vienna, Austria, on May 22, 1920. When he was 13, he moved with his family to Berlin and then to London. Tommy attended a boarding school in Switzerland, and in 1938 he became a mechanical engineering student at Cambridge University. Being an Austrian citizen, he was sent to a camp in Canada as an enemy alien. Soon he was returned to England and was appointed to the British Admiralty Signals Establishment, where he designed radar detection systems during World War II, partly in collaboration with Hermann Bondi and Fred Hoyle. He received his B.A. degree in 1942, and his M.A. degree in 1946 (and in 1969 he was awarded a D.Sc. degree from Cambridge University.)

Soon after the war, at Cambridge, Tommy developed a model of a positive feedback mechanism in the inner ear to explain the theory of hearing. This work was disregarded for many decades, but modern theories of hearing incorporate much of it. During this period Tommy again worked with Hermann Bondi and Fred Hoyle and developed the controversial cosmological theory called the Steady State Theory. In this theory the universe maintained a constant appearance, in spite of its expansion, by creating new matter. The theory had no adjustable constants and was beautiful, even though observations have disproved it.

In 1957 Tommy accepted a professorship at Harvard University, and in 1959 moved to Cornell University to build a modern department of astronomy from an almost non-existing one. He fostered interdisciplinary research and became the first Director of Cornell's Center for Radiophysics and Space Research, a post that he held for 20 years. The Arecibo Observatory was built in Puerto Rico as part of this program. Initially designed for ionospheric backscatter, Tommy guided its use for radio astronomy. He was the John L. Wetherill Professor of Astronomy at Cornell until his retirement in 1987.

Tommy had a fertile mind that led him into many fascinating areas of research, such as the alignment of galactic dust, the instability of the earth's axis of rotation, the dusty lunar surface, cosmic rays from the sun, plasmas and magnetic fields in the solar system, the origin of solar flares, the nature of time, molecules and masers in the interstellar medium, rotating neutron stars and the nature of pulsars, terrestrial sources of hydrocarbons, and the deep earth biosphere. He was a central figure with NASA during the Apollo Moon missions, but also disagreed with NASA on several topics, and voiced opposition to the excessive use of humans in space. As early as 1955 he pointed out that the lunar surface could not be pristine rock and estimated the thickness of Moon dust. It was a slight overestimate, but a good antidote to those who ignored a loose surface entirely.

Perhaps his greatest contribution came when pulsars were discovered and he explained them as magnetized rotating neutron stars, an explanation that has proven correct. Joseph Taylor of Princeton University once wrote in honor of Tommy:

Pulsars, when found, were intriguing
But not quick to be understood.
Many efforts were made to explain them:
One wondered when somebody would.
The process which keeps the things ticking
Was the question most often addressed.
Pulsations? Or orbits? Or spinning?
How to put each of these to the test?
From Ithaca came the solution,
From a man who ne'er shrinks to be bold.
"They're magnetic neutron stars spinning!"
Boomed the voice of Professor T. Gold.

Some of Tommy's ideas that have not yet been accepted, are at least stimulating and thought provoking. One example is his work on the Arrow of Time, which he claimed is controlled by the direction of the expansion of the universe. Once he wrote, "The universe is what it is, because it was what it was." He believed in the Laws of Physics. He suggested that if the Universe was closed, when the expanding Universe stops expanding and begins to collapse, the entropy of the universe will be reversed! The Universe will play back, like a movie in reverse. A broken glass on the floor will be seen to assemble itself and reconstruct the glass on the table as time moves backwards. In this sense, in a closed universe, all of us, and Tommy, will come back again tens of billions of years from now. It is a long time, but it is worth the wait.

Continued p. 6

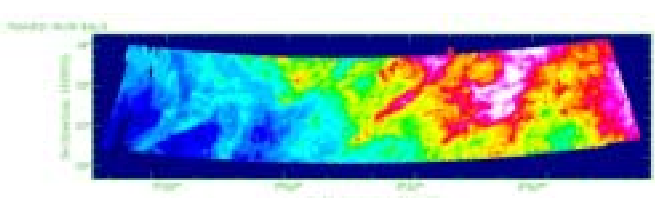
New Science and New Ways of Doing Science at the Arecibo Observatory

It may well be true, as the old saying goes, that necessity is the mother of invention. But if so, then invention's father is technology. Think of Galileo with his first telescope. Throughout antiquity and the middle ages, scientists surely had a *need* to see the things Galileo first saw such as the satellites of Jupiter and lunar craters. But that need did not lead to the invention of the telescope. Rather, technology developed for another application, microscopy, was adapted to astronomical studies with truly transformational results. The application of new technology for the benefit of research is a story that has repeated itself frequently over the centuries in astronomy. One current beneficiary is the research program at the Arecibo Observatory.

In radio astronomy the 21-centimeter (1420 MHz) spectral line of neutral atomic hydrogen is a key diagnostic tracer. It is important not only because hydrogen is the most abundant element in the universe, and hence all gaseous astronomical objects will be hydrogen-rich and will emit this line, but also because the natural width of the 21-cm line is very narrow. The narrow line width means that even subtle movements of the hydrogen gas due to rotation or motion toward or away from us can be very reliably measured. Observations of atomic hydrogen being made at Arecibo tell us about the temperature, gas mass, and kinematics of a wide variety of objects from isolated interstellar clouds to individual galaxies and enormous clusters containing many thousands of galaxies.

Because hydrogen is so ubiquitous in the cosmos, astronomers are challenged to select the "best" objects or parts of the sky to study. For a given amount of observing time choices have to be made, and depending on these choices, discoveries may be made or missed. Clearly, the way to maximize the chance for success is to maximize the area on the sky to be observed. And here's where new technology comes in: recently installed on the Arecibo telescope is the Arecibo L-Band Feed Array (ALFA) pictured below. Instead of using a single receiver pointed to a single position on the sky, ALFA generates 7 telescope beams simultaneously all of which observe slightly different positions on the sky. Sweeping the ALFA beams across the sky speeds up the mapping speed of the Arecibo telescope by a factor of seven. Comparing the signals in the various beams second-by-second gives the astronomer a way to separate real astronomical signals from radio frequency interference (RFI) in a way that cannot be done with a single-beam receiver. The same technique will make for an effective way to separate RFI from potential artificial signals from beyond the solar system. Either way—or perhaps both ways—ALFA will lead to transformational science.

The 7-beam ALFA receiver installed in the Gregorian dome of the Arecibo telescope.



Neutral atomic hydrogen emission from part of the Milky Way galaxy.

To the left is one of the early maps made at Arecibo with ALFA. This map, made in ALFA tests, is an image of the neutral atomic hydrogen filling the interstellar space in a particular region of the Milky Way.

Extensive searches of the cosmos using ALFA are planned in three key science areas: (1) studies of the gas in the Milky Way; (2) studies of galaxies and the cosmic distribution of galaxies out to redshifts of 0.2; and (3) searches for pulsars with an emphasis on "exotic" pulsar binary systems. Each of these are major surveys that will require thousands of hours of observations and each will produce an archival dataset that will be important to the research of students and scholars for decades to come. The magnitude of the effort involved in acquiring, reducing, calibrating and archiving such enormous datasets is far beyond what any individual or research group can undertake. For this reason, the key science survey programs are being organized around consortia of interested researchers and students each of whom brings special talents and interests to the consortia. This is a new research model for astronomy, one brought about by the scale of the task and the interest of so many people to become involved.

Each of the ALFA consortia involves NAIC staff members working collaboratively with university-based academic researchers and students. The three consortia are self-organized. Each has developed its own rules and organizational structure. The manner in which data are to be shared, and the scientific observations published, is being decided by the consortia. The scale of this organizational problem is also large: each of

Continued p. 8

Barbara Asks!

On our understanding of the origins of the Universe

Q. With its unknown origin, unknown matter and energy, may the Big Bang be the prevailing scientific myth of our time?

A. Before I get to the heart of the question, let me begin by saying that our late colleague Tommy Gold would probably have shouted a resounding "Yes!" in answer to this question. For many years, I had the pleasure of arguing with Tommy about cosmology, and while he and I never agreed on the nature of the Universe, my understanding was sharpened by our discussions, which I shall miss.

Observations of the cosmic microwave background radiation (the remnant energy of the hot Big Bang), the large scale structure of the Universe, and tracers of the geometry of spacetime, such as Type Ia supernovae, have converged on an accurate, but surprising picture of the Universe: about 5% of it is in ordinary matter made of protons, neutrons and electrons, which cosmologists call "baryonic," about 25% is in "non-baryonic" dark matter, whose constitution is still unknown, and about 70% is in the form of dark energy, a ubiquitous background that pervades all of space but whose origin confounds physicists and astronomers. There are also traces of radiation—the cosmic microwave background itself, for example, is about 1 part in 20,000 of the energy density today—that play little role today, but dominated for the first 10,000 years or so of the expansion of the Universe.

Many cosmologists now tout the dawn of an age of "precision cosmology" in which we "understand" the Universe with exquisite accuracy. However, while astrophysicists now know the gross composition of the Universe extremely well, we hardly "understand" how this particular recipe came to be. One should say that we now know the precise question posed by cosmology, but, as yet, we do not know how to answer it.

Does this mean that Big Bang cosmology is a "scientific myth" (much less the prevalent one)? To address this, we must first separate the general idea of the Big Bang from the larger question of why the Universe is dominated by one form of energy or another.

For modern cosmologists, the Big Bang is an almost inevitable outcome of the laws of physics combined with Einstein's classical general relativity. What we know is that if the Universe is made up of "ordinary" matter—which includes baryonic and nonbaryonic particles and radiation—then general relativity says that at some finite time in the past the density of the Universe was infinite. Nobody believes that this classical description extends back to truly infinite density; presumably, at some tremendously high density, the physics associated with superstring theory or some other form of quantum gravity intervenes to explain the start of the Big Bang era.

Dark matter is needed to explain the motions of the visible matter in spiral galaxies such as NGC 1232 or our own Milky Way. Photo: FORS1, 8.2-meter VLT Antu, ESO.

Before I comment on each beast in the "mythology," let me say that, to me, there is no reason to suppose that we already know everything we need to understand the nature of the Universe. Indeed, at any stage in the history of scientific discovery, we might have labelled any emerging, but incompletely understood, picture of the Universe as myth. One need only go back 100 years to a time when we were just discovering galaxies.

Dark Matter: The idea of dark matter is very old. I can date it at least to 1937, when the cantankerous Caltech astronomer Fritz Zwicky noted that the mass required to keep the Coma cluster of galaxies from flying apart was much greater than the mass associated with the visible material of galaxies in the cluster. Later on, it was found that considerable amounts of dark matter were needed to explain the rotation of the galaxies. Up until about 1980, most astronomers would have said that the dark matter was either baryonic—dark planets, faded brown or white dwarf stars, old neutron stars were candidates—or "retired baryons" in the form of black holes. Today, we know that none of these can really work, because the density of baryonic matter (plus retired baryons, in the form of black holes) is just too small. An observable consequence would be fluctuations on the sky of the temperature of the cosmic microwave background radiation at least a factor of ten larger than we see. This was already becoming appreciated 25 years ago.

Coincidentally, at about the same time, an experiment that proved wrong—one that claimed to measure an interestingly large mass of the electron neutrino—opened our minds to the idea of nonbaryonic dark matter. Before this wrong experiment most of us reflexively took neutrinos to be massless, but after everyone realized there was no real reason to do so. The experiment proved to be wrong, and the cosmology of massive neutrinos turned out to be unacceptable, but the idea that there might be subatomic particles as yet unknown which could be abundant in the Universe remained.

Nowadays, there is no shortage of candidates for dark matter particles, the most promising being the neutralinos associated with supersymmetric theories of particle physics. These might even be discovered in the next generation of accelerators—and searches for neutralinos in the halo of our galaxy are ongoing.

Continued p. 7

Thomas Gold

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His most recent ideas discussed that fuel in the form of methane and other hydrocarbons originates deep within the Earth, as remnants of material included in the formation of the earth. He authored two books on this subject; 'Power from the Earth', and 'The Deep Hot-Biosphere'. The second book discusses micro-biology in deep cracks in the earth amongst other topics. Many geologists disagree with the ideas in these two books, but the concept of "life in cracks" seems to be fairly well accepted.

In 1980 we celebrated Tommy's sixtieth birthday at Cornell with an important symposium. Peter Goldreich, professor of Astronomy and Planetary Sciences at the California Institute of Technology and Tommy's first graduate student at Cornell, spoke on "Resonances in the Solar System." Sir Hermann Bondi, then chief scientist for Great Britain's Department of Energy, spoke on "The Theory of Gravitation." The late Dennis Sciama, then at Oxford, talked about "Black Hole Explosions." And the late Sir Fred Hoyle talked about "The Steady State Theory Revisited."

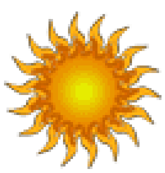
Among many honors, Tommy was a member of the US National Academy of Sciences, the American Philosophical Society, and was a Fellow of the Royal Society. He received the Gold Medal of the Royal Astronomical society in 1985. In his honor Cornell University established the prestigious Thomas Gold Annual Lectureship that brings to campus some of the most outstanding astrophysicists from around the world.

Whatever he undertook, he always did with enthusiasm and confidence. In his leisure time Tommy was a competitive skier, both on snow and water. He was also a master carpenter.

Tommy married twice, to Merle Tuber in 1947, by whom he had three daughters; and to Carvel Beyer in 1972, by whom he had one daughter.

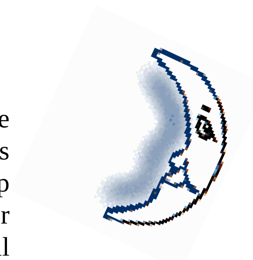
Throughout his life, Tommy explored new territories and discovered problems unseen by others. With his open mind and deep scientific intuition, he challenged established dogma and he won many times. It was a very great honor to have known Tommy.

-Yervant Terzian



Thanks to the Friends

Many thanks to all the Friends who have contributed towards the publication of this newsletter. We appreciate your help enormously and will continue doing our best to bring you all the news of Cornell Astronomy and the FoA!



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Dear Friends

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realities of the state of the Big Bang cosmological model.

On April 13, 14, and 15, 2005, Sir Martin Rees, The Astronomer Royal of the UK will be the Messenger Lecturer at Cornell. He is an outstanding speaker and will present talks for the public on topics such as 'The Universe from Start to Finish' and 'A Perspective of Earth's Future'. I hope you will be interested in attending. If so, let me know for details at <yt28@cornell.edu>.

These are exciting times for our Department.

All our best wishes,

-Yervant Terzian

Greetings

(cont.)

undergraduate astronomy at Cornell. During 2005 we plan to refurbish both the Hewitt Laboratory and the facilities used for teaching Astronomy 410—an observational/laboratory course designed for our seniors. The installation of the new Josephine Lawrence Hopkins Foundation Teaching Radio Telescope was a major first step in Astro 410 improvements. We are also working with the College on a longer term plan to replace the Fuertes observatory with a modern facility appropriate for teaching astronomy in the 21st century.

2005 promises to be another great year for Astronomy at Cornell. I hope that it is also a great one for each and every one of you.

-Joe Veverka

Inflation: Inflation was invented in 1980 to cure the horizon and flatness problems of Big Bang cosmology. The horizon problem is one of causality. We observe the microwave background to be nearly the same in temperature in different patches of the sky—to about a part in a thousand. How did it homogenize? In Big Bang cosmology, the age of the Universe is finite, and in relativity (special or general) no physical process can transfer information faster than the speed of light, so we are now observing patches of the sky with almost exactly identical temperatures that have never been in contact with one another. (Moreover, inhomogeneities amplify as the Universe ages, so the small temperature differences we detect must have their origins in even smaller ones at early times.) The flatness problem is fundamentally geometrical. Suppose that observations were to show—as was thought likely until recently—that the Universe is spatially curved with a present "curvature" scale comparable to the size of the observable Universe. This would be an extraordinary coincidence in Big Bang models, because the ratio of the size of the observable Universe to the curvature scale changes with time. Very early, this ratio was small, tending to zero at the instant of the Big Bang. To get a ratio like, say, a half today would require tuning its value at some early time to unprecedented accuracy—something like 60 digits at the so-called Planck time.

Inflation, a period of rapid expansion of the Universe at early times, can solve both problems at the same time. According to this idea, the Universe was homogeneous in very small, causally-connected regions that expanded in size enormously over a short time. Since these small regions grew so huge, our entire observable Universe can fit into just one such region with plenty of room to spare. This solves the horizon problem almost by fiat, but it also solves the flatness problem for even if the small region is really curved, it grows so large during inflation that the small fraction we can observe seems extremely flat, just as Earth seems flat to us locally even though it is a sphere.

If the Universe inflated, then it is overwhelmingly likely that we observe it to be flat today—and we do. Physicists have constructed models for inflation based on a new type of field, the inflaton, that stores an enormous amount of "latent heat" that drives the rapid expansion. The inflaton itself evolves relatively slowly during inflation, until at the end it releases its latent heat into ordinary elementary particles (creation of matter). Superposed on this more or less classical evolution is a jitter due entirely to quantum mechanics. These quantum fluctuations produce gravitational fields that become frozen during inflation—and much later on seed the formation of large scale structure, in a manner that is in remarkable agreement with observations.

There are different ideas on how inflation might have happened, and some have been discarded. The most promising ideas today are that inflation is a consequence of the collision of three dimensional membranes, called 3-branes, that occur in the 10 dimensional space of superstring theory. We shall see.

Dark Energy: Dark energy was invented by Einstein in 1917 in the form of what he called the cosmological constant. He invented it because he thought the Universe should be static, and he could show that this was impossible if the Universe was only made of normal matter in the form of stars. Once the expansion of the Universe became established in the mid-1920s, Einstein famously abandoned the cosmological constant, calling it his greatest blunder.

Once the standard model of particle physics began to emerge in the 1970s and 1980s (leading to many Nobel prizes, including the one given this year), and certainly after the advent of inflationary cosmology, the cosmological constant reappeared as a sort of "latent heat" of empty space. If you estimate how large this ought to be in particle physics, simple dimensional arguments give values too large by huge factors, ranging from 50 to 122 orders of magnitude. Indeed, inflation is driven by such a latent heat, but also requires it to disappear to high accuracy once at the end. One possibility is that some fundamental principle requires the cosmological constant to vanish exactly at the end of inflation—but we now now that it is not zero. One might complain that inflation replaced a couple of fine tunings with a still more severe one: to 100 digit accuracy, the cosmological constant disappeared at the end of inflation, but the tiny smidgeon that remained was just large enough to dominate the expansion of the Universe today!

There are many ideas about why the cosmological constant is 50-100 orders of magnitude smaller than its "natural" value in particle physics, but not precisely zero. In these theories, the net contribution to the cosmological constant from the inflaton and other conventional, particle physics sources really is zero for fundamental reasons (such as something called supersymmetry). Then, the dark energy must have a different origin, only tenuously related to the standard model of particle physics, if at all. Perhaps it is a ghostly manifestation of the presence of the curved spacetime of the additional dimensions of

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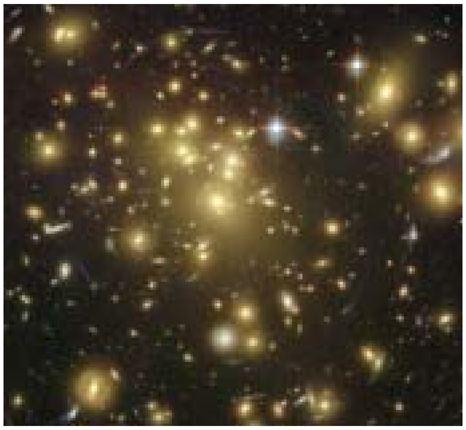

Galaxy cluster Abell 1689 warps space as predicted by Einstein's theory of gravity. The visible matter accounts for about one percent of the gravitational mass needed to warp space enough to explain cosmic scale lensing. The rest is in the form of still mysterious dark matter. Photo: N. Benitez (JHU) et al., ESA, NASA.

Books in Science and the Universe

A Universe of Consciousness by Gerald Edelman and Giulio Tononi. Published by Basic Books, 2000.

The subject of consciousness remains mostly a mystery, despite all the scientific and technical advances of the last few centuries. Some philosophers have suggested that consciousness is beyond the realm of scientific explanation. However, Edelman, the 1972 Nobel Laureate for Medicine, and Tononi try to describe what happens in our heads when we have a thought by developing a scientific theory based on modern neuroscience. The book is very readable and among other topics includes: building a picture of the brain, distributed neural activity, perception and memory, complexity and discrimination, language and the self, and the process of thinking. Consciousness, according to the authors, is indeed grounded in the evolution of the brain.

-Yervant Terzian

New Science

(cont.)

the ALFA key program consortia has 40-70 participating members; keeping all of these people working productively in a manner that proves satisfying to all involved is a significant social challenge. So far all is very encouraging.

I am not at all sure that Galileo would very readily recognize astronomical research as done at radio wavelengths by large teams of collaborating researchers, but I am quite sure he would be fascinated to see how new technology is continuing to lead to new scientific insight. With some good fortune, the ALFA consortia will produce images at Arecibo as startling to the public, and as scientifically meaningful, as Galileo did using his new technology.

-Robert Brown

Another of Brian Kent's beautiful astronomy pictures. Northern Lights on November 9, 2004 from the Hartung-Boothroyd Observatory in Ithaca, NY.

Barbara Asks!

(cont.)

string theory. Perhaps it is a refinement to general relativity—the relativistic theory of gravitation—that we do not understand yet. Conceivably, there will be a new breakthrough—like the conception of inflation—that will change our way of thinking about this problem. The dark energy is the biggest problem confronting cosmology and physics today.

Does this mean that our understanding of Big Bang cosmology is merely myth? I don't think so. Although I disagreed with Tommy Gold on many aspects of cosmology, I agreed with him that science is an adventure in discovery. New observations lead to new ideas, and even to puzzles we may be unable to unravel for a long time. It would be presumptuous of us to demand that, at any particular stage in the process of discovery, we ought to be able to explain every phenomenon via ineluctable logical deduction. Not only that, it wouldn't be fun if we could.

-Barbara Burger (for the question)
-Ira Wasserman (for the answer)

Yervant's Critical Thinking Corner

- Once someone told me that it would be impossible to have a Planetarium in Ithaca because it is always very cloudy.
- A tv weatherman informed the viewers that there was a 50% chance of snow for Saturday and a 50% chance of snow for Sunday. He concluded that there was a 100% chance of snow that weekend.
- I was explaining to a small group of people that a solar eclipse occurs when the Moon passes just in front of the sun, and that it gets dark during the day, and animals get scared and confused, and so do some people. Someone in the group suddenly was disturbed and asked me "Why do scientists do such bad things?"
- A Persian philosopher was once asked which was more important, the Sun or the Moon. After some thought he said, "It must be the Moon because at night when it is dark everywhere the Moon at least gives some light, but in the day when there is light everywhere, who needs the Sun?"
- A newly hired coach in his inaugural speech said "I'll turn this team around 360 degrees."