SkyWAAtch

Jellyfish Nebula

WAA'ers Tyler Cohen and Doug Baum captured this image of the Jellyfish Nebula (IC 433), a supernova remnant in Gemini. To take this black and white H-alpha image, they used Doug's Takahashi FSQ106 refractor with a QSI532 CCD camera on a Takahashi EM200 mount at Doug's home observatory (a 15-minute exposure through an 5nm Astro Don H-alpha filter). Tyler did the image acquisition while Doug did some post-processing in CCDstack.

The Jellyfish lies at a distance of about 5,000 light years. Although its age is uncertain, 30,000 years is a recent estimate.

In This Issue . . .

Events for April

WAA April Lecture

"A Tale of Two Meteorites: An Untold Tale of Apollo and the Stardust Revolution"
Friday April 1st, 7:30pm
Leinhard Lecture Hall,
Pace University, Pleasantville, NY

Mr. Alan Witzgall will discuss the histories of two very special rocks from space and how in the past 45 years they have reshaped our thinking about the origins of the stars, the planets, and even life itself. Alan will have specimens of the stones at the talk, so you can get up close and personal with these messengers from an ancient Red Giant Star.

Mr. Witzgall holds a Bachelor's degree in Earth Sciences from Kean University. He is an active long-term member of the Amateur Astronomers, Inc. of Cranford, NJ, and is a past president of that organization. He is also active at the New Jersey Astronomical Association in High Bridge, NJ, serving there as its Vice-president. He is currently a Senior optician for ESCO Optics of Oak Ridge, NJ. His career in optics started with building telescopes in his basement during his high school years. In 1977, one of them, a 10-inch reflector, took First Award at Stellafane. Free and open to the public. Directions.

Upcoming Lectures

Pace University, Pleasantville, NY

Our speaker on May 6th will be Dr. Daniel Wolf Savin from the Astrophysics Laboratory at Columbia University. His presentation is entitled "A Brief History of Chemistry in the Cosmos." Free and open to the public.

Starway to Heaven

Saturday April 2nd, Dusk.
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for April, weather permitting. Free and open to the public. The rain/cloud date is April 9th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Kenneth and Michael Masiello - Ardsley
David Weiser - Brewster
Moniko Monov - Hastings-on-Hudson

Renewing Members. . .

Rick Bria - Greenwich
Theresa C. Kratschmer - Yorktown Heights
Lawrence C Bassett - Thornwood
Neil Roth - Somers
Jim Cobb - Tarrytown
Joseph Depietro - Mamaroneck
Lori Wood -Yonkers
David Butler - Mohegan Lake
Emily Dean - Pelham
Beth Gelles - Scarsdale
John Benfatti - Bronx

Join WAA at NEAF, April 9-10th Rockland Community College, Suffern, NY

WAA will have a booth at the Northeast Astronomy Forum, to be held at Rockland Community College on Saturday, April 9th and Sunday, April 10th. This is the nation's premier astronomy show, with a vast diversity of exhibitors, vendors, equipment, lectures by leading astronomy figures and, weather permitting, the famous Solar Star Party.

We need volunteers to staff our booth. It's an opportunity to meet and chat with fellow club members and other astronomy enthusiasts, and to help recruit new members to the club. It also is a place where you can store your swag while attending lectures or other events. Last year 20 club members participated, we recruited new members and we made many new friends. Put NEAF in your calendar now.

WAA Apparel

Charlie Gibson will be bringing WAA apparel for sale to WAA meetings. Items include:

- Hat ($15)
- Polos ($15)
- Tee shirts ($12)

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don't forget to visit the WAA website.

Almanac
For April 2016 by Bob Kelly

Apr 7 Apr 13 Apr 22 Apr 29

It's all about Jupiter this month. Well, not really. Saturn hangs like an ornament next to Mars in the morning. Even by the end of the month, Saturn and Mars don't rise until 10pm and are highest in the sky at 3 or 4 in the morning. Mars is the largest we've seen in a decade. But that's almost like saying April is the latest month in the year so far. Mars will be even larger at the late May opposition and even closer at our next oppositions in 2018 and 2020.

Saturn obligingly tips its rings wide open for spectacular viewing in a telescope. Mars' north pole is tipped a bit toward Earth, but the northern hemisphere Summer is well underway and likely to have shrunk the polar cap.

Mercury has its best evening apparition of 2016. Now that means something. Its greatest distance out from the Sun is on the 18th, setting 1¾ hours after the Sun. Mercury is best and brightest the first two-thirds of the month and dims quickly after the 20th.

In other "_____ of the year" awards, we have the closest new Moon of the year at 8am EDT on the 7th. You can't see it, but you'll know it's there when higher-than-normal tide ranges occur then and a few days afterwards. The Canadian Almanac says this new Moon induces extreme tides on the peak of an 18.6-year cycle on the 9th. Since what goes around comes around, on the other side of the lunar month we have the smallest-looking full Moon of the year on the night of the 22nd.

Venus may have surprised some people who found this bright object in March when they had a clear sky and a clear view of the eastern horizon. In April, it rises only an hour before the Sun at the start of the month and decreases from there.

Jupiter exceeds magnitude minus 2 in April and stands out even without optical aid. It's a wonderful scene of bright moons and distinct cloud belts for all observers using telescopes. Double shadow transits are common earlier in the month, less so later; but none in the nighttime for the eastern United States. *Sky and Telescope* notes a 5th magnitude star in Leo sits in with Galileo's band of moons around the 8th.

Speaking of bands, Antares hangs with Mars and Saturn in the southern sky. A blazingly bright Moon jams with them on the morning of the 25th.

There are no meteor showers of note in April, since the weak Lyrids have to contend with a full Moon when they peak on the 21st/22nd.

Remember how hard it was to find Venus when Venus was occulted by the Moon in daylight? Aldebaran slips behind the Moon on the 10th and will be even harder to find, but the red spark of a star could be a fine sight in the telescope. The pair will be in the western sky, with the Sun low in the west late in the afternoon, which may make it easier to shade the telescope from the Sun. Aldebaran disappears behind the shadowed part of the Moon about 6:15pm ET and reappears at sunset about 7:30pm.

The International Space Station makes a few brief evening appearances early in the month but has an extended run in the morning sky starting on the 22nd.

Religious festivals based on lunar calendars occur at the end of March and the end of April. Easter and Passover are separated by a lunar month this year, despite usually occurring near the first full Moon after the Spring Equinox.

The February 2016 leap day brought the Equinox early on the 20th (the 19th in some parts of the world) this year and the Roman Catholic calculation of Easter assumes the Equinox is always on the 21st. The Jewish calendar adds a leap month seven times in a nineteen year cycle to keep Passover from coming before the new growth of Spring is apparent. This year these adjustments make Easter very early and Passover later.

Westchester Amateur Astronomers

Big Science: Progress in Astronomy and Physics

Larry Faltz

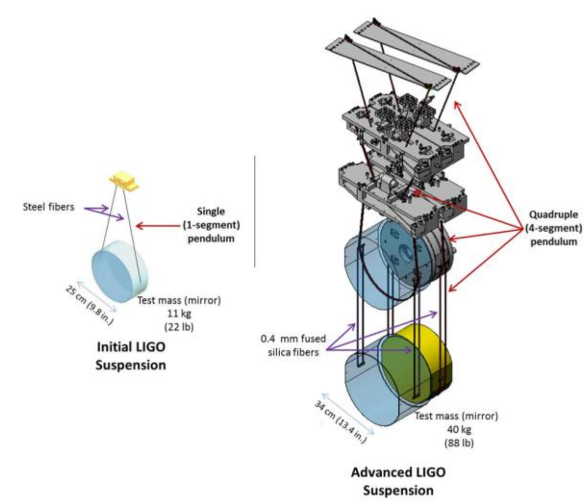
The LIGO instruments in Washington (top) and Louisiana (bottom).

The first direct detection of gravitational waves by LIGO (the Laser Interferometer Gravitational-Wave Observatory), announced in February, was a resounding triumph for both theoretical and experimental physics and another demonstration of the capabilities of the advanced technology that characterizes modern scientific instrumentation. The newly upgraded Advanced LIGO devices were just beginning to collect data in a shake-out period in advance of their first formal operational run when an eddy in space-time originating from the collision of two black holes 1.3 billion light years distant washed over the detectors 0.007 seconds apart. That's the time that light takes to go from Hanford, Washington, to Livingston, Louisiana, where each of the instruments is located. The delay is proof that the signals were moving at light speed, as gravitational waves are predicted to do.

LIGO utilizes a combination of Michelson and Fabry-Perot interferometers. Laser beams are directed down two evacuated 4 kilometer tubes, bouncing off of optically flat mirrors multiple times (that's the Fabry-Perot device, just like a hydrogen alpha telescope's étalon), then combined at the junction of the tubes (the Michelson device). The waves are in exactly opposite phase when space is calm, canceling each other out completely, but when a gravitational wave comes by it changes the length of the tubes, creating a slight phase difference between the laser beams. This permits a signal to pass into the detector. The experiment revealed that space-time had warped by 1/1,000 the width of a proton. Considering that protons are about 10^{-17} cm in diameter, we're talking about a distance of 10^{-20} cm. If you can't make a mental picture of something this small, join the club.

Considering the thermal and surface imperfections of the device (it can't be cooled to absolute zero, the vacuum isn't perfect, you can't make a mirror optically flat to a tolerance of 10^{-20} cm, low-level seismic activity is frequent, there's "photon shot noise" that confuses the detectors) even imagining that the LIGO device could ever detect a change this small seems insane. Yet work it did, and in a sense it worked right out of the box.

The original LIGOs were not as sophisticated or sensitive and could not detect waves generated very far out in space (that is, they needed very strong signals). Advanced LIGO, with its higher technology and sensitivity, can detect waves that originate 1 billion light years or more from Earth. Recall that the waves, as they spread out from their source, lose energy by a factor of $1/r^2$. They have substantial amplitude when they are created but by the time they reach us, space-time is barely jiggling.



Mirror suspension systems showing the progress in technology in Advanced LIGO

No one doubted that gravitational waves exist. They come right out of Einstein's General Theory of Relativity. It was published in 1915 and the detection is a kind of 100th birthday present for the theory, the latest in an unbroken string of confirmations. In 1974, Russell Hulse and Joseph Taylor used the Arecibo radio telescope to study signals from the pulsar PSR1913+16. They found that the pulsar was a component of a binary neutron star system in orbit around a common center of mass, and that the periastron (the closest distance between the two stars) was slowly decreasing. They realized that this could only occur if the system was emitting gravitational waves. Their calculations showed that each orbit, which takes 7.75 hours, brings the stars 3.1 mm closer. In 300 million years, they will collide. The only explanation for the orbital decay consistent with the laws of physics was that the system was losing energy by radiating gravitational waves. This is indirect evidence, and that's just not good enough, even if it did win the Nobel for the two astronomers. We have to actually touch the waves, somehow.

If the waves were macroscopic, we'd be feeling them all the time. That would pose a problem for doing anything in the actual world, as physical dimensions of spacetime change every time a wave passes through. So everything would shake and clocks would go nuts. It would be like living in a constant earthquake. Fortunately for our lives the waves are ultramicroscopic, but this means that the technology needed to find them must be ultra-sophisticated, which also means ultra-expensive.

The $1 billion Advanced LIGO is the most recently successful example of something that has come to be known as Big Science: the investigation of important physics and astronomy problems (and gravitational waves are of course both physics and astronomy phenomena) using large, complex and expensive experiments. Governments, universities and foundations must be willing to provide substantial funds for these projects. The origin of Big Science as we know it today has been attributed to one man and one device: Ernest O. Lawrence and the cyclotron. It's the subject of a very fine book, *Big Science: Ernest Lawrence and the Invention that Launched the Military-Industrial Complex*, by Michael Hiltzik (Simon & Schuster, 2015). Hiltzik is a business journalist with the Los Angeles Times. He won a Pulitzer Prize in 1999 for his reporting about corruption in the music industry. His journalistic skill makes the highly detailed material and strong personalities come alive.

The first Big Science projects might very well have been the 1761 Transit of Venus expeditions mounted by a number of European states and scientific societies, but they were relatively modest (the Royal Society, with support of the Exchequer, allocated about £2,000 for British voyages to two remote islands) and didn't require the new technology that we've come to associate with Big Science. Early astronomical observatories were often the gifts of royalty or other nobility. William Herschel wheedled funds from George III for his 20- and 40-foot reflectors. The modern era of Big Science in astronomy probably had its start with the funding of the 40-inch Yerkes refractor, which was commissioned in 1897. George Ellery Hale, newly appointed as Professor of Astrophysics at the University of Chicago, got wind that a pair of 42-inch glass lens blanks was available. He convinced Charles T. Yerkes, a Chicago businessman who had made a fortune with the Chicago electric transportation system, to fund the purchase and figuring of the optics. He had to work Yerkes to keep him interested in the project. In 1897 the observatory opened, boasting the largest refracting telescope in the world. It surpassed the 36-inch refractor at Lick Observatory, which opened in 1888, but the Lick story differs in that the telescope was funded by a general bequest of $700,000 to build an observatory by James Lick, who died in 1876. It was money looking for a project, not a goal-directed project created by scientists looking for funding. It's the latter that characterizes Big Science.

Hale was responsible for the next great telescope, the 100-inch reflector on Mount Wilson. This instrument was funded by the Rockefeller Foundation, which was established in 1913 with capital from the immensely rich John D. Rockefeller, founder of Standard Oil. The Rockefeller Foundation has been a leader in underwriting worthy science institutions, of which the Rockefeller University in Manhattan is but one.

Faraday in his laboratory, painting by Harriet Moore

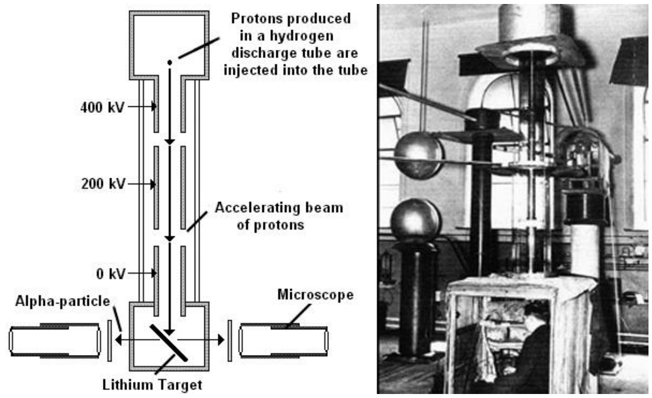
Until Lawrence, experimental physics research was room-sized, not counting Galileo's dropping iron balls from the Leaning Tower of Pisa (probably apocryphal anyway). If you're in London, you can visit the Royal Institution, on Albemarle Street just off Piccadilly. In the basement you will see the great Michael Faraday's actual laboratory with his original chemical and physics equipment, including the world's first electromagnet, just 8 inches in diameter.

Faraday's electromagnet (LF)

After the discovery of radioactivity in 1896, the desire to probe the atom meant, inevitably, the search for higher energies. Between 1908 and 1913 Hans Geiger and Ernest Marsden, in Ernest Rutherford's laboratory at the University of Manchester, probed the nucleus. Their tabletop device consisted of some radium at the end of a small tube with an opening through which alpha particles (helium nuclei) were emitted by natural radioactive decay. They were aimed at gold foil, and were detected at different angles by counting scintillations on a fluorescent screen in a darkened room. They were able to show that the nucleus was very small and dense relative to the overall size of the atom. Rutherford later showed that it was positively charged. This disproved the "plum pudding" model of Lord Kelvin and J.J. Thomson, which had the nucleus as a mélange of protons and electrons.

Hans Geiger (L) and Ernest Rutherford (R)

The first devices to achieve higher-than-natural energies were linear accelerators, such as the Cockcroft-Walton device that in 1932 achieved the first artificial nuclear disintegration at the Cavendish Laboratory at the University of Cambridge, where Rutherford had been appointed director in 1919.

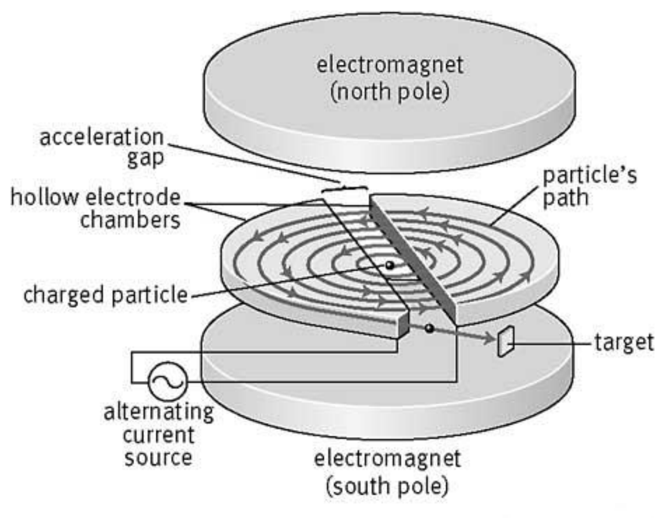


Cockcroft-Walton linear accelerator

A beam of protons is accelerated by high voltages onto a target. Cockcroft and Walton bombarded lithium nuclei and detected alpha particles, the reaction being:

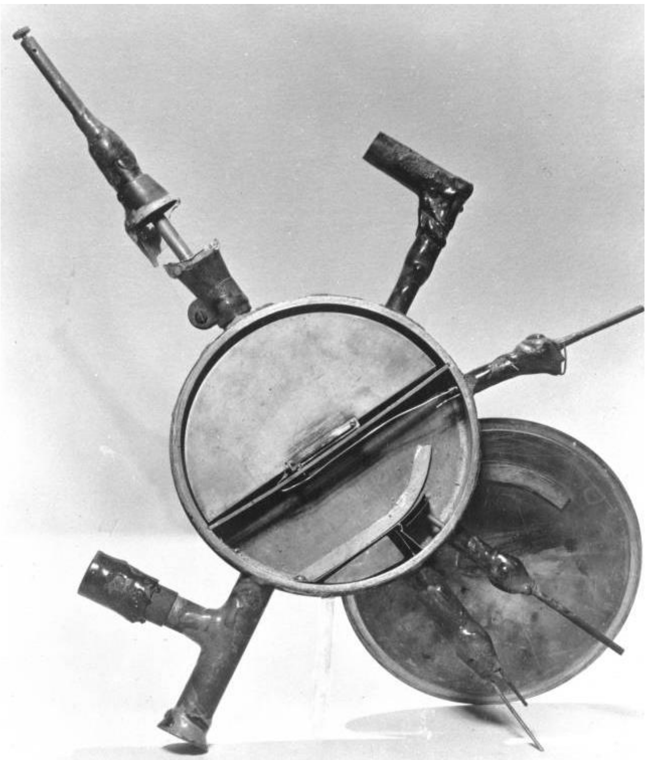
$$^{7}_{3}Li + \, ^{1}_{1}H \rightarrow \, ^{4}_{2}He + \, ^{4}_{2}He + Energy$$

Cockcroft-Walton devices grew ever larger but reached limits of about 1 million electron volts (eV) because of electrical issues. Television cathode-ray tubes and bug zappers are fundamentally Cockcroft-Walton generators, although they accelerate electrons rather than protons and don't reach energies that result in nuclear disintegrations. The largest linear accelerator, a more sophisticated design using radiofrequency pulses, is the Stanford Linear Accelerator (SLAC), which is 2 miles in length. It can reach almost 50 billion eV. It's worth a visit if you're in the Bay area.



Schematic of the cyclotron

Lawrence had a better idea, based on a paper he read in a relatively obscure German physics journal in 1929. Why not raise the energy of the beam by having it spiral outwards from the center multiple times in a magnetic field, accelerated by alternating the polarity of the accelerating electrodes? The beam would travel inside of two hollowed out plates, called "dees" because they resembled the letter D. The evacuated plates would alternate between being positive and negative and the path of the charged particles would be controlled by an external magnet.

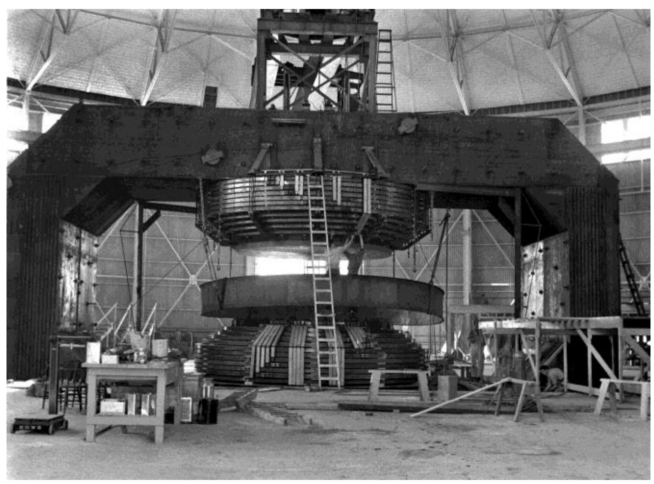


Lawrence's first cyclotron

The first proof-of-concept cyclotron, built in 1930, was only 4 inches in diameter. The vacuum was sealed with wax. It was able to accelerate protons to 80,000 eV. As soon as it was operational, Lawrence began to dream of higher energies, which meant larger devices. He was able to cadge $700 from the University of California at Berkeley, where his Radiation Laboratory was located, for a larger electromagnet that would boost energies towards one million eV. Lawrence realized that a purely theoretical argument for the research would not necessarily open up the monetary floodgates that he knew he would need for larger devices, and his research was directed towards creating novel radioactive isotopes for biomedical research and cancer treatment, as well as directly irradiating patients with the ion beam. He was aided in this effort by this brother, John Lawrence, who was a Harvard-trained physician with an interest in what we now call radiation oncology.

Ernest O. Lawrence

Lawrence's cyclotrons got ever bigger and more powerful: a device 9 inches in diameter, then 11 inches, then 27 inches, then 37 inches, then 60 inches, and finally, just after the end of World War II, a monster cyclotron 184 inches in diameter. It was this last device that directly spawned a new generation of accelerators, called "synchrotrons", which improved the acceleration (and thus the energy) by dynamically varying the voltage around the beam track. To fund each of these projects, Lawrence exploited contacts with business, charitable organizations and the government. The 60-inch, first operational in 1939, was known as the "Crocker Cracker" because it was substantially funded by William Crocker, a railway and banking magnate and financial backer of UC Berkeley.

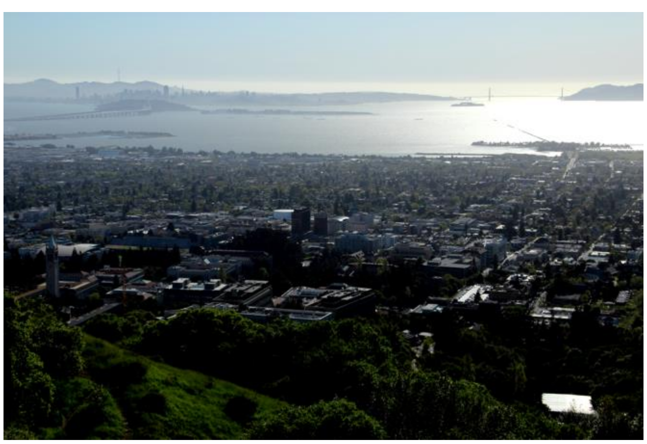


The 184-inch cyclotron under construction. The magnet weighs 4,000 tons.

World War II changed the dimensions of scientific equipment as well as the source of science funding. High technology science was needed for war aims, primarily to beat the Nazis to the atomic bomb. Lawrence, recognized as the pre-eminent experimental physicist of the era, realized that the cyclotron concept could be used to separate the two important isotopes of uranium. U^{238}, the most abundant isotope, can be used as fuel for controlled fission reactors, but only U^{235} is fissile enough for a weapon. The cyclotron could be made to function as a mass spectrometer, separating the two isotopes because they would take slightly different paths around the device based on their mass. At Oak Ridge in Tennessee, Lawrence oversaw the installation and operation of devices he called "calutrons," which purified the U^{235} for the "Little Boy" atomic bomb dropped on Hiroshima.

The "alpha racetrack" calutrons at Oak Ridge

By the time World War II ended, the government had taken over as the prime funder of basic science research, including high-technology physics projects, many of which were still tied to the national nuclear weapons program. Los Alamos, where basic research on nuclear weapons started, was eventually joined by other labs, and there are now 17 Department of Energy national laboratories, primarily dedicated to physics, technology, engineering and energy research. The Radiation Laboratory, Lawrence's research station on the Berkeley campus, became the Lawrence Berkeley National Laboratory. It's on a hill with a magnificent view of Berkeley and San Francisco Bay. Livermore was renamed the Lawrence Livermore Laboratory in 1989 in his honor.



The afternoon view from the Lawrence Berkeley National Laboratory (LF)

The problems of physics and astronomy can no longer be answered by a scientist cloistered in a small, personal laboratory or with a modest instrument. To probe the outer reaches of the universe or the inner sanctum of the atom, one needs size and energy. The growth in size and power means a growth in money. Small grants and even major support from scientifically-focused charitable organizations or individuals will rarely cut it. For example, the W.M. Keck Observatory on Hawaii was started with capital grants totaling $138 million from the Keck Foundation, but its annual $27 million operating budget now comes from a variety of government (NASA), university and private sources, and of course you are invited to send them a few bucks if you wish. Ever larger telescopes obviously cost a lot of money, and have the added expense of requiring assembly and operations in distant, difficult to reach places like the Atacama Desert in Chile or outer space. As an example, the Giant Magellan Telescope being constructed in Chile will cost over $1 billion. It's funded by a consortium of governments and universities. But it still tries to develop a private funding stream, a legacy of Lawrence's approach. I wrote about a fund-raising event for this worthy project in the December 2014 newsletter. The Hubble Telescope will have cost well over $12 billion by the time it ends its mission, including repair missions and ground operations. Surely the results from this magnificent instrument justify the cost, and the same can be said for the other space probes we've launched and physics projects we've undertaken.

But that may not be obvious to everyone. Two days before results from LIGO were released, the U.S. House of Representatives passed (by a vote along strict party lines) HR-3293, sponsored by Rep. Lamar Smith (R-Tex). This bill is "An act to provide for greater accountability in Federal funding for scientific research, to promote the progress of science in the United States that serves that national interest." What does this mean? The National Science Foundation would be required to attest in writing that the sponsored research meets the following criteria:

> (1) is worthy of Federal funding;
> (2) is consistent with established and widely accepted scientific methods applicable to the field of study of exploration;
> (3) is consistent with the definition of basic research as it applies to the purpose and field of study; and
> (4) is in the national interest, as indicated by having the potential to achieve—
>> (A) increased economic competitiveness in the United States;

(B) advancement of the health and welfare of the American public;
(C) development of an American STEM workforce, including computer science and information technology sectors, that is globally competitive;
(D) increased public scientific literacy and public engagement with science and technology in the United States;
(E) increased partnerships between academia and industry in the United States;
(F) support for the national defense of the United States; or
(G) promotion of the progress of science for the United States.

It sounds well and good, but like many happy-sounding legislative proposals, the real goal of this legislation is encoded: it will introduce a political test into the NSF funding process. The NSF works by independent peer-review, and this legislation would open up that mechanism to political influence. In particular, the bill's sponsor objected to a variety of grant awards in the areas of climate change, social science and anthropology, and claims his legislation would prevent those from being funded. We recall the sad parade of "Golden Fleece Awards" given by Senator William Proxmire (D-Wisconsin 1957-1989) to research projects that sounded silly. His goal was to ridicule unnecessary government spending. Proxmire's awards were based primarily on project titles, and not on the real content or value of the studies. HR 3292 would extend that form of grandstanding in a more onerous way. If the Senate passes the bill, and it might in this hot-house election year, President Obama has promised a veto.

The physically and fiscally biggest Big Science project ever attempted (not counting the Apollo program, which was not purely a research project) was the Superconducting Supercollider, which would have built a 40 TeV accelerator (compared with 14 TeV for the Large Hadron Collider at CERN) with a 53 mile circumference south of Dallas. Originally proposed for $4.4 billion, the estimates grew to $12 billion, much of which was attributed to mismanagement, and the project was cancelled by Congress in 1993 after $2 billion was spent. Although the main reason was economic, there was a good deal of science bashing (of the "what value could it possibly have?" variety) in the run-up to the Congressional vote.

The James Webb Telescope nearly faced a similar execution. Originally to cost $1.6 billion and to launch in 2011, cost overruns and technology delays caused about $3 billion to be spent by 2011. The House of Representatives voted to terminate funding. A compromise with the Senate restored it, but there is a cap at $8 billion. Launch is set for 2018, but this is by no means certain if costs continue to rise. Undoubtedly the remarkable and widely shown results from Hubble impel a good deal of popular support for the Webb, and its goals are tangible: examining exoplanet atmospheres for signs of life is a bit more understandable to the average person than finding the Higgs boson. One disappointment is that it is only scheduled to operate for 5 years, and that's assuming that it achieves stable orbit at the Earth-Sun L2 point, a million miles from Earth, unfolds itself properly and all of its technology works according to plan. There's no possibility of repairs for the Webb. It's all or nothing.

Another risk for Big Science is a form of "NIMBY" (not in my back yard) that we can see in the resistance to the 30-meter telescope on Mauna Kea. The opposition claims the project is an insult to native religion. The challenge is also the political expression of pent-up anti-establishment frustrations among some native Hawaiians. Opponents of the project claim they are protecting Hawaii's natural and cultural resources, asserting that traditional Hawaiian religious practices depend on the purity of these resources and the landscape. Their protests have halted the project. The Hawaiian religion has been dormant since the early 19th century, and whether it was rightly or wrongly suppressed when the United States took control of the islands, the claim that the top of Mauna Kea has to be isolated for purposes of a resurgent religion practiced by a small group of locals makes the presumption that the Hawaiian deities don't want the telescopes there. But how do those practicing the Hawaiian religion know that? Maybe the gods actually *do* want the telescope there! Maybe they feel it would honor them. Who can say? What audacity and self-righteousness to claim to know otherwise! There's just no proof that the top of Mauna Kea needs to be purified of modern technology, as the opponents of the project claim. Anyway, if you've ever been there, you know that the area is vast and barren and can easily accommodate both telescopes and religious ceremonies. The protests are a way of asserting power and control via a form of politico-religious correctness. I have less of a problem with the objections that were offered to the construction of the Large Binocular Telescope on Mt. Graham in Arizona 25 years ago. In the case of that instrument, the concern was about the possible extinction of a ground squirrel unique to the site. I can accept argument that it might not be virtuous to build the telescope if the cost is the disappearance of a unique species of animal. That's an argument with ethical and intellectual integrity: we shouldn't destroy a harmless species. The Hawaiian religion is hardly threatened by the 30-meter telescope. You can practice it anywhere. The claim that the top of Mauna Kea must be kept in a primitive state because of a small group's tradition or the primacy of their religion is an archaic orthodoxy resurrected by someone seeking power. Ask them why, if they're so dedicated to the purity of their faith, they haven't insisted on resurrecting the other defining aspects of pre-1820 Hawaiian religion: extensive and bizarre taboos, suppression of women, violent punishments and ritual human sacrifices.

Astronomers have been trying to broker peace with the anti-telescope activists, but this has not helped move the project forward. In an article in the July 2015 *Scientific American*, Astronomer Michael West, sought to mollify the objectors. He spoke favorably about the importance of the project, but also wrote "In the eagerness to build bigger telescopes, [astronomers] forgot that science is not the only way of understanding the world." This is a servile, cowardly statement. Science is the *only* way of understanding the world, if actual understanding is your goal. Everything else is a deception, a hallucination, or at best, as in art, a metaphor. As physicist Lee Smolin recently wrote, "The progress of science has been marked by the dismissal of illusions." The only true *understanding* of the world is through reason and its language, science. If the 30-meter telescope fails to be built, our comprehension of the universe will be diminished. Illusions have to be dismissed for man to progress. In this modern world, why should science yield to religion? Moral and ethical progress from the Renaissance onward has been about the secular transcendence of human thought and values. Science is the great democratizer. No one has ownership of its laws. $E=mc^2$ applies to all of us. Stop the nonsense and build the 30-meter telescope!

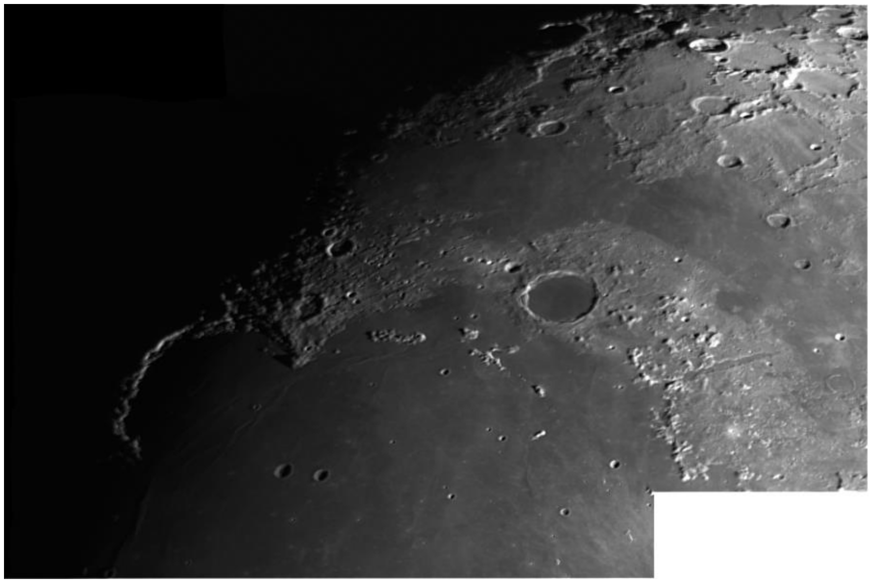
The 30-meter telescope

Unlike physics, in the world of biological sciences things are getting smaller and cheaper. Protein analysis used to require a sample of at least several grams injected into a room-sized device with tubes, columns and reaction chambers under the constant attention from trained operators over the course of days, but now, a microwave-size unit will do your analysis in a few hours. And a company in the United Kingdom is producing a palm-sized analyzer powered from a USB port that can provide the sequence of 150 thousand base pairs of DNA (and can also do RNA and protein sequencing) on less than a microgram of material in just a couple of hours, for a cost of less than $1,000.

The MinION DNA sequencer

Science, big or small, faces competition for dollars with all of the other things that society values. Our commitment to entitlements has resulted in a reduction in the proportion of the Federal budget available for "discretionary spending," everything other than Medicare, Medicaid, Social Security, defense, government worker and military pensions and interest on the national debt. Only 17% of the budget is left for everything else. In 2016, Medicare will spend almost 15% of the Federal budget, about $600 billion. I like to compare costs to the amount of time it would take Medicare to spend the same amount of money. For the $8 billion Webb telescope project, it's about 4.9 days, which is a lot of health care. On the other hand, the $700 million New Horizons mission came in for 10 hours of Medicare spending. The interferometer at Keck, mothballed for lack of funding, would be covered by Medicare in one minute. Society has to make its choice, of course, and for most people having their operation is more important than whether there's ozone in an exoplanet atmosphere many light years away. There will always be a fight about spending for basic research. Lawrence figured out early in his career that linking his work to medical care was a way to get the attention of funders. Most physics and astronomy research can't make that appeal, and that puts it at a disadvantage. For me, it is enough to want to know how the world really works. ■

Astrophotos



Larry Faltz took this two frame mosaic of the northern edge of the Mare Imbrium, with dawn breaking on the cliffs of the Sinus Iridium. The large flat crater is Plato and the Alpine Valley is to the east. 9-day moon on 3/18/16. Celestron CPC800, QHY-5-II monochrome camera, from Larchmont. Seeing 3/10, transparency 8/10, some wind.

Tyler Cohen and Doug Baum took this picture of the Flaming Star Nebula (IC 405) in Auriga, which shows the Nebula's tadpoles (single 4-minute exposure binned 3x3, otherwise using the same equipment as Tyler and Doug's image of the Jellyfish Nebula on page 1). The Flaming Star Nebula is an emission/reflection nebula and lies at a distance of about 1500 light years.

Northern Lights

Scott Nammacher and his wife Bonnie spent 4 nights in Churchill Manitoba on a Natural Habitat Photographic Tour to photograph the Northern Lights. Three of the four nights were clear and one of them was especially spectacular. The above images were taken with a rented Canon 5D Mark III with a 17-35mm F2.8 canon wide angle lens. These were exposures generally in the 5 to 15 second time frame at ISO of 1000 to 3200 at F2.8 or 3.2. The brighter the lights, the lower the time frame. Both were shot in the -25 to -30 degree night air in Churchill.