SIRIUS ASTRONOMER

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The Newsletter of the Orange County Astronomers

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This month's cover photo is provided by OCA Member Greg Pyros. Greg's image of the Leo Triplet was taken using a Meade 1616XT CCD camera mounted to a William Optics Fluorite refractor. The Leo Triplet is a wonderful galaxy group in the winter sky. The three galaxies shown are known as M65, M66 and NGC 3628. The cluster of spirals is located at a distance of 35 million light years. More information on this group is available at http://www.seds.org/messier/more/m065-066_more.html. For those who are unfamiliar with the SEDS site, it is a wonderful database of information on nearly any celestial object in the sky. You will definately want to bookmark this site. Once again, Greg, great shot!

OCA CLUB MEETING

The free and open club meeting will be held Friday, March 14th at 7:30 PM in the Science Hall of Chapman University in Orange. the featured speaker will be John Hoot . John has presented several topics to the club in the time I have been a member and his talks are always fascinating. This time, John will present "Amateur/ Professional Collaborations In Astronomy."

STAR PARTIES

The Star Party this month, is on March 29th and is also the annual MESSIER MARATHON! Can you find all 110 Messier objects in one night? Come out and find out! Certificates of completion will be awarded to participating individuals. The annual Messier Marathon is really a lot of fun! The Black Star Canyon site will be open this month on March 22nd. Members are encouraged to check the website calendar, for the latest updates on star parties and other events. Also, please use the Anza Webcam before driving out to Anza to potentially save you some driving time.

COMING UP

Beginners class will be held on Friday March 7th, at the Discovery Science Museum located at 3101 West Harvard Street in Santa Ana. The Astrophysics SIG will be meeting on March 21st. The Astro-Imagers' SIG will meet March 18th. The EOA SIG will meet March 19th. Please check the website calendar for the many outreach events this month! Volunteers are always welcome!

President's Message

by Barbera Toy

In remembrance:

This last month has seen some sad changes in the astronomical world. Nationally, the disintegration of the Columbia as it reentered the atmosphere and the deaths of its crew have had a devastating impact on the space program as well as on the families, friends and colleagues of the astronauts. Our deepest sympathy goes out to the families and all those who knew the crew members for their loss. We can only hope that the cause of the disaster will be found quickly, and that the remaining shuttles will made safer as a result.

We had a sad loss closer to home, with the death of Bill Kuhn, who designed and built the Kuhn telescope with the help of other club members. Though I never met him in person, I've heard stories about him ever since joining the club, and I heard even more on the day of his funeral. He was an inventor, and, among other things, developed a field shunt in World War II to hold veins and arteries together when they were severed, which saved many lives and even more limbs. He was an avid amateur astronomer who insisted on showing his children the delights of the night skies, whether they wanted to see them or not (they are now glad he did), and who used his hand-built telescope to show the sky and its treasures to a multitude of young people over the years. He loved to solve problems and he loved to build things, and we in the club have certainly benefited from his skills. We hoped that he would recover from the stroke he suffered a few months ago, and could join us in celebrating the refurbishment of the Kuhn telescope. That's no longer possible, but we look forward to hosting members of his family at Anza and letting them see the telescope that bears his name in action.

Looking to the future – a call to action:

With these and other reminders of how limited our time might be, it seems to me that there is no better time to launch a campaign in an area that we all, at some level, agree is important, but that we have not yet done much about – light pollution. The "other reminders" include the massive development going forward right now in Telaga Ranch, the proposal to build 25,000 homes in Rancho Mission Viejo, and the continuing development of the Temecula area. If we do nothing, the comparatively dark skies over the Santa Ana Mountains, including our Black Star Canyon site and Caspers Wilderness Park, will be about as bright as they are in urban Orange County, and we will see growing light domes and increasing local lights encroaching on our Anza site.

What can we do?

1. Developers: We can talk to their design people before they've made commitments on specific light fixtures, show them good lighting alternatives. It often won't cost any more to put in full or partial cut-off lights if they make that decision early, and it would allow them to advertise the development as energy-efficient and environmentally friendly. Developers also establish the basic CC&R's for their developments, and could include provisions controlling outside lighting for the entire development – Coto de Caza has a very strict provision, and has much darker skies than neighboring communities as a result. So, we need people to identify and work with developers in Orange County and the Temecula area to improve the outside lights they are going to install and to get limits on excessive outside lights included in the CC&R's for new developments.

2. Local governments: We have members in every city and in unincorporated areas of Orange County, and some in the Temecula area, as well. We need to find out what ordinances each local government has relating to outside lighting (many have none). We need to identify which people in each local government could be allies in getting helpful ordinances passed, and start work to get them passed. Where ordinances have been enacted, we need to find out what's happening with enforcement. Cities replace streetlights regularly, and we can pressure them to replace them with full cut-off alternatives. We could also pressure them not to approve streetlights in new developments that are not full cut-off, and not to approve excessive numbers of streetlights. We need people to do the legwork in their own cities and start to work with their own local governments in these areas.

3 Liaisons with other groups: We're mainly concerned about light pollution because it gets in the way of our seeing the sky and what's in it. There are other good reasons to be concerned, though, such as the effects on migratory birds and nocturnal animals, undue destruction of certain insects causing problems for bats and other insectivores, and even human health concerns. The wider impact of light pollution means that there are groups, such as the Audubon Society, the Sierra Club and the Nature Conservancy, that could be our allies on lighting issues. There are also other astronomy clubs in Orange County and in the Temecula/Elsinore area who could be our allies in this campaign. We need people to start building bridges to these groups.

4 Shields and adaptors for existing light fixtures: The IDA website (http://www.darksky.org/~ida/) is a treasure-trove of information, and has links to several different types of shields that can be added to some of the most common types of outside fixtures to improve them. However, there are no commercially available shields for most styles of outside lights, nor any designs for do-it-yourself types. We have a lot of people in the club with skills that could be turned to designing and building shields for many other types of lights, to give people who like the style of their current fixtures an option to entirely replacing them. We could also build a fund to get commercially available shields and provide them free to people in sensitive areas who would agree to use them (and we could do the installation, to ensure they actually did use them) – it would be really nice to get them installed on a lot of the properties in the area of our Anza site. We need people who could design, build, and/or install shields, people who could convince folks with bad outside lights to get shields or to allow us to install shields on their fixtures (or even to replace their lights with better models), or who could help raise funds for a shield-installation program.

You may be thinking that all of this is too ambitious. It's certainly more than one person can do alone, and more than a small group of people could do unless they did it full-time. But we have over 800 members in our club, with the majority in Orange County. If every one of you in Orange County or the Temecula/ Elsinore area spends just a couple of hours per month on one of these projects, we would make tremendous progress.

So, what do I want you to do? Contact me about which one of these areas you want to work in, and what particular activities you want to do most, and let's get started. The easiest way for me is by email, to btoy@cox.net. You could also send me a note by snail mail, to Orange County Astronomers, P.O. Box 1762, Costa Mesa, CA 92628. You could call or talk to me when you see me, but, unfortunately, memories are less reliable than something in writing. My intent is to get people who want to work on the same aspects of the problem together and to help get them going on their particular projects, helping in whatever way I can, and coordinating activities between groups.

We *can* have darker skies, with your help. I look forward to hearing from you.

Desert Sunset Star Party - May 1-4, 2003

EARLY REGISTRATION ends March 15. The Desert Sunset Star Party will be held at Kartchner Caverns State Park May 1-4, 2003. In addition to scheduled tours for Friday and Saturday, there are many places to visit in southern Arizona, many within a 1-hour drive. Vendors will be on hand in the afternoons along with several demonstrations. Dinner will be catered in for those who order it, followed by speakers, door prizes, and some great star gazing. Get your registrations in soon to take advantage of the early registration rates. And don't forget to order your T-shirts. Information and registration materials are available on the web at: http://chartmarker.tripod.com/sunset.html.

A Tiny Galaxy is Born

Michael Corbin
Space Telescope Science Institute,
Baltimore, MD

New detailed images from NASA's Hubble Space Telescope show a "late-blooming" galaxy, a small, distorted system of gas and stars that still appears to be in the process of development, even though most of its galactic cousins are believed to have started forming billions of years ago.

Evidence of the galaxy's youthfulness can be seen in the burst of newborn stars and its disturbed shape. This evidence indicates that the galaxy, called POX 186, formed when two smaller clumps of gas and stars collided less than 100 million years ago (a relatively recent event in the universe's 13-billion-year history), triggering more star formation. Most large galaxies, such as our Milky Way, are thought to have formed the bulk of their stars billions of years ago.

The Hubble images of POX 186 support theories that all galaxies originally formed through the assembly of smaller "building blocks" of gas and stars. These galactic building blocks formed shortly after the Big Bang, the event that created the universe. Astronomers Michael Corbin of the Space Telescope Science Institute in Baltimore, Md., and William Vacca of the Max-Planck Institute for Extraterrestrial Physics in Garching, Germany, used the telescope's Wide Field and Planetary Camera 2 to study POX 186 in March and June 2000. Their results will appear in the Dec. 20 issue of the Astrophysical Journal.

"This is a surprising find," Corbin says. "We didn't expect to see any galaxies forming in the nearby universe. POX 186 lies only about 68 million light-years away, which means that it is relatively close to us in both space and time."

Adds Vacca: "POX 186 may be giving us a glimpse of the early stages of the formation process of all galaxies."

POX 186 is a member of a class of galaxies called blue compact dwarfs because of its small size and its collection of hot blue stars. [The term "POX" is derived from the French "prism objectif," or objective prism, a device that astronomers place in front of a telescope to photograph spectra of all objects in its field of view.] POX 186 was discovered 20 years ago, but ground-based telescopes resolved few details of the galaxy's structure because it is so tiny. To probe the galaxy's complex structure, astronomers used the sharp vision of the Hubble telescope. The Hubble pictures reveal that the system is puny by galaxy standards, measuring only about 900 light-years across, and containing just 10 million stars. By contrast, our Milky Way is about 100,000 light-years across and contains more than 100 billion stars.

So why did POX 186 lag behind its larger galactic cousins in forming? Corbin and Vacca find that the young system sits in a region of comparatively empty space known as a void. Its closest galactic neighbors are about 30 million light-years away. The two small clumps of gas and stars that are merging to form POX 186 would have taken longer to be drawn together by gravity than similar clumps in denser regions of space. The Hubble data don't reveal the ages of the stars in the clumps. Corbin, however, suspects that the oldest stars may be about 1 billion years old, which is young on the cosmic time scale.

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The youthful galaxy's puny size may support a recent theory of galaxy formation known as "downsizing," which proposes that the least massive galaxies in the universe are the last to form. In clear contrast to POX 186, the most massive galaxies in the universe, known as giant ellipticals, have a generally spherical structure with few or no young stars, indicating that they formed many billions of years in the past. To actually see the formation process of stars in such large galaxies, astronomers are awaiting the deployment of Hubble's successor, the James Webb Space Telescope. This telescope is designed, in part, to study faint objects whose light left them early in the 13-billion-year history of the universe.

Although the POX 186 results are tantalizing, Corbin and Vacca realize that one galaxy is not enough evidence to support the idea that galaxy formation is an ongoing process. They are proposing to use Hubble to study nine other blue compact dwarfs for similar evidence of recent formation.

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Contact:
Donna Weaver
Space Telescope Science Institute, Baltimore, MD
(Phone: 410/338-4493; E-mail: dweaver@stsci.edu)
Michael Corbin
Space Telescope Science Institute, Baltimore, MD
(Phone: 410/338-5001; E-mail: corbin@stsci.edu)

Astrollaneous

Free to good home!

A friend of mine has a blank for a 12 inch mirror for a reflecting telescope that his brother bought a long time ago, but never ground. He'd like to give it away (free, no strings attached), preferrably to a younger astronomy enthusiast who would grind it and turn into a telescope. For details contact Mike Bertin at MCB1@aol.com or call (949) 786-9450.

AstroImagers training a success!

Several members of the AstroImagers SIG met at the Black Star Canyon Site on February 22nd for a training period on polar alignment. One of the most often overlooked problems in taking quality astrophotographs is achieving a good polar alignment. AstroImagers chairman, Greg Pyros met with several interested members of the group to provide some "hands-on" practice in polar aligning your telescope. If you are interested in learing this, or any other aspects of astrophotography, contact Greg a 714-708-3400 (extension 12) OR attend our meetings held on the third Tuesday of each month.

Wanted, your article!

Each month, your fellow club members are anxious to hear about your recent experience. Please share them with the club! Sirius Astronomer is the vehicle we can use to share our expertise, experiences and interests. While I do get many interesting articles from club members, I can always use more! If you would like to see your article in Sirius Astronomer, feel free to send it to siriusastronomer@ocastronomers.org.
Darren Thibodeau

NASA's Space Place

Seven Strangers

by Dr. Tony Phillips

At the dawn of the space age some 40 years ago, we always knew who was orbiting Earth or flying to the Moon. Neil Armstrong, Yuri Gagarin, and John Glenn were household names—everywhere.

Lately, it's different. Space flight has become more routine. Another flight of the shuttle. Another visit to the space station. Who's on board this time? Unless you're a NASA employee or a serious space enthusiast, you might not know.

Dave Brown, Rick Husband, Laurel Clark, Kalpana Chawla, Michael Anderson, William McCool, and Ilan Ramon.

Now we know. Those are the names of the seven astronauts who were tragically lost on Saturday, Feb. 1st, when the space shuttle Columbia (STS-107) broke apart over Texas.

Before the accident, perhaps, they were strangers to you. But if that's so, why did you have a knot in your gut when you heard the news? What were those tears all about? Why do you feel so deep-down sad for seven strangers?

Astronauts have an unaccountable hold on us. They are explorers. Curious, humorous, serious, daring, careful. Where they go, they go in peace. Every kid wants to be one. Astronauts are the essence of humanity.

They are not strangers, they are us.

While still in orbit Dave Brown asked, jokingly, "do we really have to come back?" No, but we wish you had.

Please see the NASA Home Page (http://www.nasa.gov) for more information on the Columbia Investigation.

This article was provided by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

AstroSpace Update

Gathered by Don Lynn from NASA and other sources

To find out more on these topics, or those of past months' columns, through the World Wide Web, send your Web browser to our OCA Web site (http://www.ocastronomers.org), select Space Update Online, and the topics are there to click on.

Wilkinson MAP - has been taking measurements of the Cosmic Microwave Background (CMB) since soon after its launch in June 2001, from its orbit about 1 million miles from Earth. Recently it was named for David Wilkinson, a MAP team member who died last year. MAP is able to measure the CMB with 40 times the resolution of the COBE spacecraft, which made the first measurements of temperature variation patterns in the CMB in 1992. The first results from analyzing the MAP data have been released: the Universe is 13.7 billion years old, with precision of 1%; the first stars began shining 200 million years after the Big Bang, a much shorter time than previously believed; the Universe is flat, that is, parallel light rays remain parallel rather than bending gravitationally together, as would be true in a more dense universe; 73% of the contribution toward this flatness comes from something that is not mass, which has been termed "dark energy"; of the remaining 27% contributed by mass, it is split 4% ordinary matter (neutrons and protons) and 23% some other (but unknown) types of particles. The CMB is the heat energy of the Big Bang, released 380,000 years after the Big Bang, when the Universe cooled by expansion enough to allow hydrogen to become transparent.

First galaxies - Astronomers have found the first direct evidence that galaxies as large as the Milky Way had formed in less than a billion years after the Big Bang. Quasars are the extremely bright active centers of galaxies, containing very massive black holes. Spectra taken of 2 quasars so distant that light left them only a billion years after the Big Bang showed that the speed of material falling into the quasar indicated a total mass for the galaxies of about that of the Milky Way. Because of their distance, the galaxies themselves were too dim to directly measure, so this method using the much brighter light of the quasar within the galaxy had to be used. Previous evidence showed that most early galaxies were tiny, and took billions of years to merge and grow. The early large galaxies apparently grew into the few extremely large elliptical galaxies found today, typically in the centers of large clusters of galaxies.

Origin of neutron star - Astronomers have traced the orbit through our Milky Way Galaxy of the neutron star Scorpius X-1, along with the companion star that it is devouring, and conclude that the pair joined more than 30 million years ago and probably were thrown out of a globular star cluster far from the galaxy's center. The action of a neutron star consuming its companion forms an accretion disk of material falling in, which heats to millions of degrees and glows in X-rays, and forms jets of material thrown out, probably along magnetic field lines. This behavior mimics that of the active centers of galaxies, termed quasars, but on a much smaller and faster time scale, so the accreting neutron stars have been called microquasars. Using the Very Long Baseline Array radio telescopes, as well as optical telescopes, astronomers measured the motion of Scorpius X-1 and projected its position back in time to develop its history. Its orbit about the Milky Way shows that it originated in the region of the globular clusters, which orbit high above the plane of galaxy, unlike most stars, which are found in the flat disk. Most likely explanation for both having acquired a companion star and for not still being in a globular cluster, involves a close encounter with other stars in the dense center of the globular.

Martian lakes - A new analysis of the altitude map of Mars made by the Mars Global Surveyor spacecraft has concluded that many of the areas that appear to be river channels are connected together by what were probably lakes. The apparent lake beds are in some cases as large as the Earth's Great Lakes, and show evidence of large amounts of sedimentation. This lends more support to those who theorize that Mars was warmer and wetter for long periods of time in the past, as opposed to those who support only short flood periods. Conditions on Mars now do not allow for liquid water to remain; it immediately either freezes due to low temperatures, or vaporizes due to low atmospheric pressure.

Hubble Space Telescope (HST) - has for the first time measured the side-to-side wobble induced in a star by its orbiting planets tugging gravitationally. All previous measurements of this wobble have been made along the line of sight, not side-to-side, by watching the spectral lines shift as the star wobbles toward or away from the observer. This wobble along the line of sight, made with Earth-based telescopes, has allowed over 100 planets outside our Solar system to be discovered in the last several years. But the side-to-side wobble has been too small to measure until now. The result was that we could not calculate the mass of the planet, but only a lower limit for the mass. The problem is that the tilt of the orbit could not be measured.

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The larger this unknown tilt, then the more massive the planet would have to be to induce the observed wobble. But the new technique shows when the star wobbles in each of the 3 dimensions, so the orbital tilt can be determined, and the planet's mass calculated.

The new observation was made with the HST's guiders, not with its instruments, since the guiders are most sensitive to locking on the location of a star. It was measured 100 times more precisely than the size of a pixel in HST's cameras. The planet is one of the 2 known to be orbiting star Gliese 876, and the mass determined is about 2.1 times that of Jupiter. The old method yielded only "greater than 1.9" Jupiters. The only other extra-Solar planet whose mass has been determined (rather than just a limit) was one that happened to pass in front of its star, so we then knew its orbital tilt. The technique will be applied to the nearer of the known extra-Solar planets, but is not sensitive enough for farther ones. The planned Space Interferometry Mission will be able to measure all the known planets by this technique. Knowing the masses of these planets will help distinguish them from brown dwarfs or even tiny stars, and will also help develop theories of planet formation.

Neptunian moons - Using 4-meter telescopes in Hawaii and Chile, three more moons have been discovered orbiting Neptune, bringing its total to 11. These are the first moons discovered at that planet since the Voyager spacecraft found several in 1989. From their brightness, about 25th magnitude (10 million times dimmer than the planet itself), it is estimated that the diameters of these new moons are about 20 to 25 miles. It now appears that all gas giant planets have substantial numbers of irregular satellites, those with quite elliptical and considerably tilted orbits, usually distant from the planet. These irregulars were probably formed by collisions of earlier satellites that formed in the regular manner, which results in nearly circular orbits in the plane of the planet's equator.

Neptune Trojan - Since 1906 it has been known that some asteroids travel in Jupiter's orbit, but about 60 degrees ahead or behind the giant planet. Lagrange proved centuries before that those were stable points where small bodies could orbit. The first ones discovered were by chance named after ancient Trojan heroes, so asteroids sharing a planet's orbit are now known as Trojan asteroids. Although over 1500 of these asteroids have been found in Jupiter's orbit, none was ever found in Neptune's orbit until now: asteroid 2001 QR322 has had its orbit determined to be in Neptune's orbit, but leading the planet by 60 degrees. It is estimated from its brightness to be 140 miles in diameter.

Giant star planet - All but 4 of the more than 100 planets found outside our Solar System have been found orbiting Sun-like stars. It has generally been too difficult with giant stars, much larger than the Sun, to distinguish the wobbles induced in the star's motion by a planet from wobbles induced by the pulsations, rapid rotation and star spots common in giant stars. It was also thought that when a star reached the point in its life when it swells into a giant, that it might engulf or vaporize all its planets. So many astronomers would not spend the time to search for planets about giant stars, where they felt there was little chance of finding them. Careful analysis of the spectral wobbles of giant star HD 47536 has shown that none of the other explanations fit the observations well, so it indeed has a planet. This is by far the largest giant star with a known planet. At 396 light-years from Earth, it is the 2nd remotest planet known. The planet is about twice as far from its star as the Earth is from the Sun, takes 712 days for each orbit, and has 5 to 10 times the mass of Jupiter. The discovery was the result of a spectroscopic study of 80 giant stars. Some giant stars have been found to have excess amounts of the element lithium, which should be destroyed by the star reasonably quickly. It has been theorized that the lithium is the result of a planet being absorbed by the star as it swells into a giant. So those theorists, to support that theory, have been looking (until now) for evidence of planets orbiting giant stars that might someday get absorbed.

T Tauri stars and disks - T Tauri stars are stellar adolescents, less than 10 million years old, which will become stars similar to the Sun as they age. There are 2 types of T Tauri stars: the younger ones that are always surrounded by a thick disk of dust and gas, often called a protoplanetary disk because it is the raw material out of which planets form; and naked T Tauri stars, where no disk is found. The accepted theory has been that the disks dissipate in only a few million years, either because the material falls into the star or is blown away. A new theory is that the disk does not dissipate, but stops giving off the infrared light that we use to see these disks. The dust just agglomerates into larger particles that are not efficient in giving off infrared. The first evidence for the new theory has been announced in the form of an observation of a hydrogen disk about a naked T Tauri star. If the disk did dissipate, rather than change form, the hydrogen should be gone also, but it wasn't. Further observations of naked T Tauri stars will be made to confirm this. This has consequences for how common planets are.

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The old theory was that T Tauri disks dissipated before planets could form, but the new one says that the first steps of planetary formation (agglomeration of dust) is happening. Thus planet formation should be much more common.

Chondrules - Scientists have long debated how chondrules formed. They are millimeter-sized blobs of once-melted minerals found within chondritic meteorites, which are thought to be the oldest objects in the Solar system. In some of these meteorites, chondrules are rimmed by fine silicate dust particles that have reacted with water. Previous theories, such as collisions between the meteorites and ice, would not produce exactly the minerals found in the meteorites. A new theory has been developed that involves shock waves hitting the icy nebula in which the meteorites formed, and it appears that it fits the evidence. The minerals that reacted with water would be formed quickly in the high-temperature, high-pressure water vapor the forms briefly from the shock wave. The shock wave would also melt the chondrules in agreement with their appearance.

Instant AstroSpace Updates:

The POLAR satellite has detected waves traveling down the magnetic field lines of the Earth at speeds up to 25 million mph; the waves are thought to supply power to the auroras, and may be caused by breakage and reconnection of magnetic field lines.

HST has discovered a very young small galaxy relatively nearby (68 million light years), proving that the formation of small galaxies known to have occurred early in the history of the Universe is continuing today; it is only 900 light-years across and contains only 10 million stars.

The Chandra X-ray observatory has discovered the largest disk of hot X-ray emitting gas known, 90,000 light years across in elliptical galaxy NGC 1700; this rules out some theories of elliptical galaxy formation that would have wiped out such a disk.

OCA waves goodbye to long time member Bill Kuhn.

John Sanford

It is with regret I report the passing yesterday (1/26/03) of Bill Kuhn, a member of the Orange County Astronomers and personally responsible for the construction of the OCA 22-inch cassegrain which is doing good work at the club's observatory at Anza, California.

William Kuhn rose through the ranks in WWII and received a theater (Italy) commission during the war, eventually retiring as a Lt. Colonel in the U.S. Army Reserve. Most of his adult life he worked in the aerospace bearing industry. He retired about 1992 although he kept active, contributing to several industry standards committees.

Bill volunteered to build the club's telescope before a site was chosen, and he visited several observatories and made over 150 mechanical drawings before starting construction in 1973. He worked on the telescope through the 1970's and it was installed in its roll-off observatory in the Southern California desert in 1982.

Meanwhile the mirrors (f/8 and f/16) were finished by Jerry Brunache when he was employed at the Perkin-Elmer optical shop in Costa Mesa.

Bill Kuhn was an inventive mechanical engineer who also built a beautiful 6 inch f/15 refractor which resided in a dome in his backyard in northeastern Santa Ana for many years, and which was used by many Orange County students visiting his home. Bill also built an aluminum cabin cruiser when he lived in the Detroit area and his last big project was a biwing RC airplane which has a wingspan of about 6 feet.

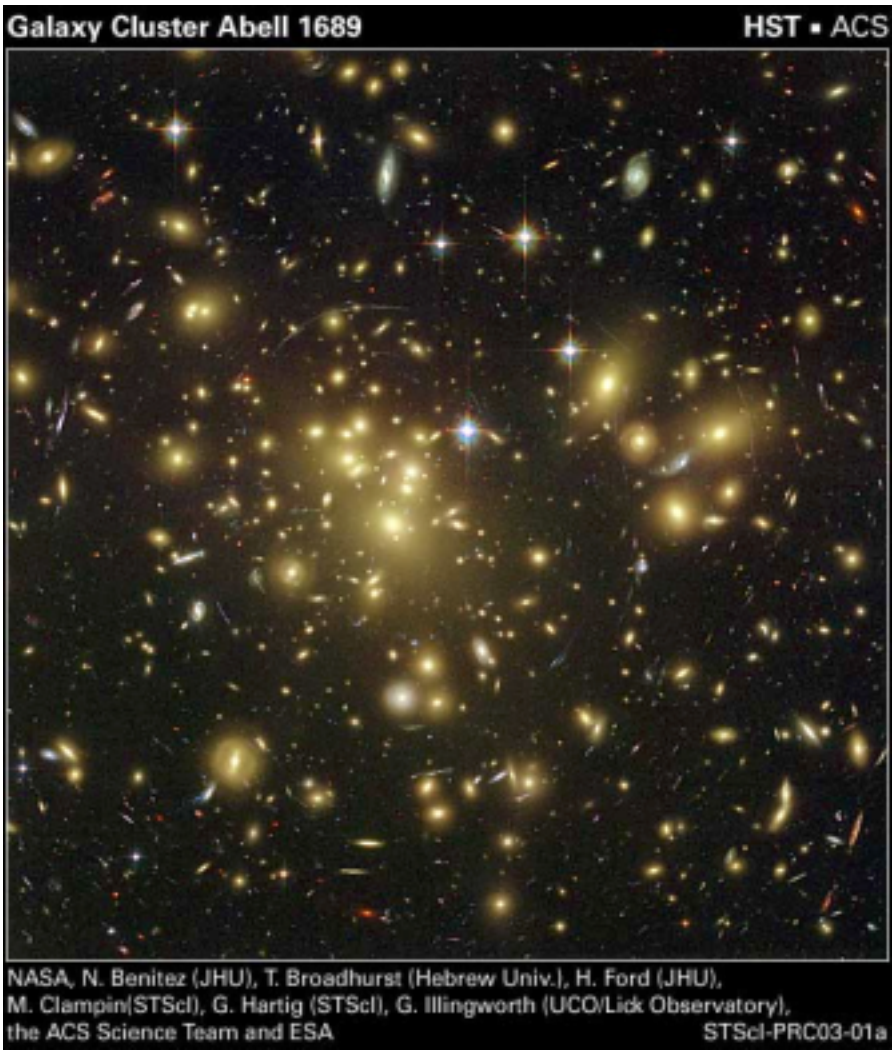
He was a member of Mensa and raised a family of three lovely daughters and a son. He is survived by his wife Dorothy and the children (now adults)."

Biggest 'Zoom Lens' in Space Takes Hubble Deeper into the Universe

The Advanced Camera for Surveys aboard NASA's Hubble Space Telescope has used a natural "zoom lens" in space to boost its view of the distant universe. Besides offering an unprecedented and dramatic new view of the cosmos, the results promise to shed light on galaxy evolution and dark matter in space.

Hubble peered straight through the center of one of the most massive galaxy clusters known, called Abell 1689. This required that Hubble gaze at the distant cluster, located 2.2 billion light-years away, for over 13 hours. The gravity of the cluster's trillion stars — plus dark matter — acts as a 2-million-light-year-wide "lens" in space. This "gravitational lens" bends and magnifies the light of galaxies located far behind it.

The Advanced Camera's IMAX movie-quality sharpness, combined with the behemoth lens, reveals remote galaxies previously beyond even Hubble's reach.



A few may be twice as faint as those photographed in the Hubble Deep Field, which previously pushed the telescope to its sensitivity limits. Though much more analysis is needed, Hubble astronomers speculate that some of the faintest objects in the picture are probably over 13 billion light-years away (redshift value 6).

In the image hundreds of galaxies many billions of light-years away are smeared by the gravitational bending of light into a spider-web tracing of blue and red arcs of light. Though gravitational lensing has been studied previously with Hubble and ground-based telescopes, this phenomenon has never been seen before in such detail. The ACS picture reveals 10 times more arcs than would be seen by a ground-based telescope. The ACS is 5 times more sensitive and provides pictures that are twice as sharp as the previous work-horse Hubble cameras. So it can see the very faintest arcs with greater clarity. The picture presents an immense jigsaw puzzle for Hubble astronomers to spend months untangling. Interspersed with the foreground cluster are thousands of galaxies, which are lensed images of the galaxies in the background universe.

Detailed analysis of the images promises to shed light on the mystery of dark matter. Dark matter is an invisible form of matter. It is the source of most of the gravity in the universe because it is much more abundant than the "normal matter" that makes up planets, stars and galaxies. The lensing allows astronomers to map the distribution of dark matter in galaxy clusters. This should offer new clues to the nature of dark matter. By studying the lensed distant galaxies, astronomers expect to better trace the history of star formation in the universe, over the past 13 billion years.

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The picture is an exquisite demonstration of Albert Einstein's prediction that gravity warps space and therefore distorts a beam of light, like a rippled shower curtain. Though Einstein realized this effect would happen in space, he thought it could never be observed from Earth. Though individual stars lens background light, the deflection was too small to ever be seen from Earth. When the laws of relativity were formulated in the early 20th century, scientists did not know that stars were organized into galaxies beyond our own Milky Way. Great clusters of galaxies are massive enough to warp space and deflect light in a way that is detectable from Earth. The Abell cluster is the ideal target because it is so massive. The more massive a cluster, the larger the effects of gravitational lensing.

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Contact:
Don Savage
NASA Headquarters, Washington
(Phone: 202/358-1547; E-mail: dsavage@hq.nasa.gov)
Mark Hess
Goddard Space Flight Center, Greenbelt, MD
(Phone: 301/286-8982; E-mail: mhess@pop100.gsfc.nasa.gov)
Ray Villard
Space Telescope Science Institute, Baltimore, MD
(Phone: 410/338-4514; E-mail: villard@stsci.edu)

An aging star's last hurrah is creating a flurry of glowing knots of gas that appear to be streaking through space in this close-up image of the Dumbbell Nebula, taken with NASA's Hubble Space Telescope.

Close-Up of M27, the Dumbbell Nebula

The Dumbbell, a nearby planetary nebula residing more than 1,200 light-years away, is the result of an old star that has shed its outer layers in a glowing display of color. The nebula, also known as Messier 27 (M27), was the first planetary nebula ever discovered. French astronomer Charles Messier spotted it in 1764.

The Hubble images of the Dumbbell show many knots, but their shapes vary. Some look like fingers pointing at the central star, located just off the upper left of the image; others are isolated clouds, with or without tails. Their sizes typically range from 11 - 35 billion miles (17 - 56 billion kilometers), which is several times larger than the distance from the Sun to Pluto. Each contains as much mass as three Earths.

The knots are forming at the interface between the hot (ionized) and cool (neutral) portion of the nebula. This area of temperature differentiation moves outward from the central star as the nebula evolves. In the Dumbbell astronomers are seeing the knots soon after this hot gas passed by.

Dense knots of gas and dust seem to be a natural part of the evolution of planetary nebulae. They form in the early stages, and their shape changes as the nebula expands. Similar knots have been discovered in other nearby planetary nebulae that are all part of the same evolutionary scheme. They can be seen in Hubble telescope photos of the Ring Nebula (NGC 6720), the Eskimo Nebula (NGC 2392) and the Retina Nebula (IC 4406). The detection of these knots in all the nearby planetaries imaged by the Hubble telescope allows astronomers to hypothesize that knots may be a feature common in all planetary nebulae.

This image, created by the Hubble Heritage Team (STScI), was taken by Hubble's Wide Field Planetary Camera 2 in November 2001, by Bob O'Dell (Vanderbilt University) and collaborators. The filters used to create this color image show oxygen in blue, hydrogen in green and a combination of sulfur and nitrogen emission in red.

Image Credit: NASA and the Hubble Heritage Team (STScI/AURA)
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