Report from the Officers

This is starting to get a little old. The skies over Lawrence looked promising for a short time during the last Sunday in August, but they eventually clouded over and our first public observing session of the Fall semester was cancelled. Our next session is the last Sunday in Sept. and, whether the skies are clear or not, we will have our first monthly meeting of the Fall. The meetings will begin at 7:00 PM at the Baker Wetlands Discovery Center and, after the meeting is completed by ~8:15 PM, public observing on site will begin. Our speaker for Sept. is someone you are all familiar with if you’ve kept up with looking through the newsletter. The work by Dr. Adrian Melott and his collaborators has been featured regularly in the national scientific news as they discover new and amazing facts about the connection between the evolution of the Earth and the evolution of stars well beyond the local solar neighborhood. His talk will emphasize the recent work demonstrating conclusively that supernovae, potentially multiple supernovae, altered the evolution of life by triggering mass extinctions only a few million years ago. Please spread the word (there is a poster on pg. 6) and hopefully we can have the first in what will be a regular crowd in attendance at both the meetings and the observing sessions.

(Continued on page 2)

CITIZEN SCIENCE FOLLOWUP

Two cosmic structures show evidence for a remarkable change in behavior of a supermassive black hole in a distant galaxy. Using data from NASA’s Chandra X-ray Observatory and other telescopes, astronomers are piecing together clues from a cosmic “blob” and a gas bubble that could be a new way to probe the past activity of a giant black hole and its effect on its host galaxy.

The Green Blob, a renowned cosmic structure also called “Hanny’s Voorwerp” (which means “Hanny’s object” in Dutch), is located about 650 million light years from Earth. This object was discovered in 2007 by Hanny van Arkel, at the time a school teacher, as part of the citizen science project called Galaxy Zoo.

Astronomers think that a blast of ultraviolet and X-ray radiation produced by a supermassive black hole at the center of the galaxy IC 2497 (only 200,000 light years away) excited the oxygen atoms in a gas cloud, giving the Green Blob its emerald glow. At present the black hole is growing slowly and not producing nearly enough radiation to cause such a glow.

(Continued on page 2)
One of the topics for discussion at the meeting will be club activities for the coming year. We recently received the following note from the librarian at Lawrence Public Library: I’m a librarian at the Lawrence Public Library in the Information Services department. My colleagues and I are planning a MOOC (massive, open, online course) event about the History of Human Spaceflight, running from Oct. 10th through Nov. 14th. During the course, we will be learning about the topic through writings, documentaries, films, speakers and more. Inspired by our upcoming conversation with the International Space Station, our hope for this class is that it will capture our community’s imagination about space travel. We plan to finish our class with a viewing party on the 14th, which is also the night of the Supermoon. Another colleague mentioned recently that your group has planned Supermoon viewings in the past, with great success. Would you consider partnering with us for this event? We are open and flexible to ideas, locations and more, and look forward to hearing your thoughts.

The LPL has been very supportive in the past, providing space and cosponsoring events for the club, so this should be given serious consideration. As usual, with the start of a new era for the club, hopefully we can expand the club activities and reach a broader audience who may be interested but don’t want to commit a significant chunk of their time to astronomy. Please come to the meeting loaded with ideas! If you have any questions regarding the new arrangement, please feel free to contact the any of the club officers.

Any suggestions for improving the club or the newsletter are always welcome.

(Continued from page 1)

However, the distance of the Green Blob from IC 2497 is large enough that we may be observing a delayed response, or an echo of past activity, from a rapidly growing black hole. Such a black hole would produce copious amounts of radiation from infalling material, categorizing it as a “quasar.”

If the black hole was growing at a much higher rate in the past and then slowed down dramatically in the past 200,000 years, the glow of the Green Blob could be consistent with the present low activity of the black hole. In this scenario, the blob would become much dimmer in the distant future, as reduced ultraviolet and X-radiation levels from the faded quasar finally reach the cloud.

In this new composite image of IC 2497 (top object) and the Green Blob (bottom), X-rays from Chandra are purple and optical data from the Hubble Space Telescope are red, green, and blue.

(Continued on page 3)
New observations with Chandra show that the black hole is still producing large amounts of energy even though it is no longer generating intense radiation as a quasar. The evidence for this change in the black hole’s activity comes from hot gas in the center of IC 2497 detected in a long exposure by Chandra. The center of the X-ray emission shows cooler gas, which astronomers interpret as a large bubble in the gas.

Astronomers suspect this bubble may have been created when a pair of jets from the black hole blew away the hot gas. In this scenario, the energy produced by the supermassive black hole has changed from that of a quasar, when energy is radiated in a broad beam, to more concentrated output in the form of collimated jets of particles and consistent with the observed radio emission in this source.

Such changes in behavior from strong radiation to strong outflow are seen in stellar-mass black holes that weigh about ten times that of the Sun, taking place over only a few weeks. The much higher mass of the black hole in IC 2497 results in much slower changes over many thousands of years.

The citizen and professional scientists of the Galaxy Zoo project have continued to hunt for objects like the Green Blob. Many smaller versions of the Green Blob have been found (dubbed “Voorwerpjes” or “little objects” in Dutch.) These latest results from Chandra suggest that fading quasars identified as Voorwerpjes are good places to search for examples of supermassive black holes affecting their surroundings.

P Cyg’s claim-to-fame is that it is usually considered to be the first ‘luminous blue variable’ found. Although P Cyg is one of the earliest stars identified as a luminous blue variable, those astronomers who study this class of stars call them S Doradus variables, after a prototype star in the Large Magellanic Cloud, only visible in the southern hemisphere. There is only a small population of these stars, and only 13 such stars are identified as LBVs in the General Catalog of Variable Stars (based on a GCVS search I did in mid July, 2016).

Note that the star today is a B1 class (color) star, at the blue end of the spectrum. Blue stars are large and very hot (blue-hot is hotter than red-hot).

There has been observed a small increase in the average brightness of the star in visual light (about .15 magnitude / century). This is not because the star is producing more energy overall, it is because it is producing more energy in the visible spectrum. Why? Very hot stars produce a lot of energy in the ultraviolet, and a bit of cooling associated with that star has shifted some of that UV ‘light’ to visible. This means that the star is getting redder as time goes on and it begins the long journey toward becoming a red giant star. Typically, stars like this normally stay on the main sequence of the HR diagram, but when they’re in outburst (i.e. brighter) the star moves horizontally on HR diagram, meaning that it becomes redder but retains the same luminosity. The instability strip on the HR diagram is represented by a wide vertical line to the right of the main sequence line -- which goes from lower right to upper left.

High mass (50 solar masses or so) stars like this one are characteristically live-fast-die-young stars that don’t spend a lot of time in mid-life. P Cyg is likely to be in late mid life, but a long way from becoming a supernova. When this happens it’ll be spectacular if there’s anyone on earth to see it.

The star is well placed for observing right now; it transits in mid-August at about 11:30 p.m., 9:30 PM in mid-Sept.
Is there a super-Earth in the Solar System out beyond Neptune?

By Ethan Siegel

When the advent of large telescopes brought us the discoveries of Uranus and then Neptune, they also brought the great hope of a Solar System even richer in terms of large, massive worlds. While the asteroid belt and the Kuiper belt were each found to possess a large number of substantial icy-and-rocky worlds, none of them approached even Earth in size or mass, much less the true giant worlds. Meanwhile, all-sky infrared surveys, sensitive to red dwarfs, brown dwarfs and Jupiter-mass gas giants, were unable to detect anything new that was closer than Proxima Centauri. At the same time, Kepler taught us that super-Earths, planets between Earth and Neptune in size, were the galaxy’s most common, despite our Solar System having none.

The discovery of Sedna in 2003 turned out to be even more groundbreaking than astronomers realized. Although many Trans-Neptunian Objects (TNOs) were discovered beginning in the 1990s, Sedna had properties all the others didn’t. With an extremely eccentric orbit and an aphelion taking it farther from the Sun than any other world known at the time, it represented our first glimpse of the hypothetical Oort cloud: a spherical distribution of bodies ranging from hundreds to tens of thousands of A.U. from the Sun. Since the discovery of Sedna, five other long-period, very eccentric TNOs were found prior to 2016 as well. While you’d expect their orbital parameters to be randomly distributed if they occurred by chance, their orbital orientations with respect to the Sun are clustered extremely narrowly: with less than a 1-in-10,000 chance of such an effect appearing randomly.

Whenever we see a new phenomenon with a surprisingly non-random appearance, our scientific intuition calls out for a physical explanation. Astronomers Konstantin Batygin and Mike Brown provided a compelling possibility earlier this year: perhaps a massive perturbing body very distant from the Sun provided the gravitational “kick” to hurl these objects towards the Sun. A single addition to the Solar System would explain the orbits of all of these long-period TNOs, a planet about 10 times the mass of Earth approximately 200 A.U. from the Sun, referred to as Planet Nine.

More Sedna-like TNOs with similarly aligned orbits are predicted, and since January of 2016, another was found, with its orbit aligning perfectly with these predictions.

Ten meter class telescopes like Keck and Subaru, plus NASA’s NEOWISE mission, are currently searching for this hypothetical, massive world. If it exists, it invites the question of its origin: did it form along with our Solar System, or was it captured from another star’s vicinity much more recently? Regardless, if Batygin and Brown are right and this object is real, our Solar System may contain a super-Earth after all.

A possible super-Earth/mini-Neptune world hundreds of times more distant than Earth is from the Sun.
Image credit: R. Hurt / Caltech (IPAC)
Hubble Uncovers a Galaxy Pair Coming in from the Wilderness

NASA's Hubble Space Telescope has uncovered two tiny dwarf galaxies that have wandered from a vast cosmic wilderness into a nearby "big city" packed with galaxies. After being quiescent for billions of years, they are ready for partying by starting a firestorm of star birth.

"These Hubble images may be snapshots of what present-day dwarf galaxies may have been like at earlier epochs," said lead researcher Erik Tollerud of the Space Telescope Science Institute in Baltimore, Maryland. "Studying these and other similar galaxies can provide further clues to dwarf galaxy formation and evolution."

The Hubble observations suggest that the galaxies, called Pisces A and B, are late bloomers because they have spent most of their existence in the Local Void, a region of the universe sparsely populated with galaxies. The Local Void is roughly 150 million light-years across.

Under the steady pull of gravity from the galactic big city, the loner dwarf galaxies have at last entered a crowded region that is denser in intergalactic gas. In this gas-rich environment, star birth may have been triggered by gas raining down on the galaxies as they plow through the denser region. Another idea is that the duo may have encountered a gaseous filament, which compresses gas in the galaxies and stokes star birth. Based on the galaxies'...
DEATH STARS!

or

TERRESTRIAL EFFECTS OF NEARBY SUPERNOVAE IN THE EARLY PLEISTOCENE

Dr. Adrian Melott
Astrobiologist
Department of Physics & Astronomy, KU
SUNDAY SEPTEMBER 25
7:00 PM
BAKER WETLANDS DISCOVERY CENTER
Free and Open to the Public
the recent Chandra data suggests that G11.2-0.3 is one of the youngest such supernovas in the Milky Way. The youngest, Cassiopeia A, also has an age determined from the expansion of its remnant, and like G11.2-0.3 was not seen at its estimated explosion date of 1680 CE due to dust obscuration. So far, the Crab nebula, the remnant of a supernova seen in 1054 CE, remains the only firmly identified historical remnant of a massive star explosion in our galaxy.

This latest image of G11.2-0.3 shows low-energy X-rays in red, the medium range in green, and the high-energy X-rays detected by Chandra in blue. The X-ray data have been overlaid on an optical field from the Digitized Sky Survey, showing stars in the foreground.

Although the Chandra image appears to show the remnant has a very circular, symmetrical shape, the details of the data indicate that the gas that the remnant is expanding into is uneven. Because of this, researchers propose that the exploded star had lost almost all of its outer regions, either in an asymmetric wind of gas blowing away from the star, or in an interaction with a companion star. They think the smaller star left behind would then have blown gas outwards at an even faster rate, sweeping up gas that was previously lost in the wind, forming the dense shell. The star would then have exploded, producing the G11.2-0.3 supernova remnant seen today.

The supernova explosion also produced a pulsar – a rapidly rotating neutron star – and a pulsar wind nebula, shown by the blue X-ray emission in the center of the remnant. The combination of the pulsar's rapid rotation and strong magnetic field generates an intense electromagnetic field that creates jets of matter and anti-matter moving away from the north and south poles of the pulsar, and an intense wind flowing out along its equator.

(Continued from page 5)

Dwarf galaxies are the building blocks from which larger galaxies were formed billions of years ago in the early universe. Inhabiting a sparse desert of largely empty space for most of the universe's history, these two galaxies avoided that busy construction period.

"These galaxies may have spent most of their history in the void," Tollerud explained. "If this is true, the void environment would have slowed their evolution. Evidence for the galaxies' void address is that their hydrogen content is somewhat high relative to similar galaxies. In the past, galaxies contained higher concentrations of hydrogen, the fuel needed to make stars. But these galaxies seem to retain that more primitive composition, rather than the enriched composition of contemporary galaxies, due to a less vigorous history of star formation. The galaxies also are quite compact relative to the typical star-forming galaxies in our galactic neighborhood."

The dwarf galaxies are small and faint, so finding them is extremely difficult. Astronomers spotted them by using radio telescopes in a unique survey to measure the hydrogen content in our Milky Way. The observations captured thousands of small blobs of dense hydrogen gas. Most of them are gas clouds within our galaxy, but astronomers identified 30 to 50 of those blobs as possible galaxies. The researchers used the WIYN telescope in Arizona to study 15 of the most promising candidates in visible light. Based on those observations, Tollerud's team selected the two that were the most likely candidates to be nearby galaxies and analyzed them with Hubble's Advanced Camera for Surveys. Hubble's sharp vision helped the astronomers confirm that both of them, Pisces A and B, are dwarf galaxies.

The Hubble telescope is aptly suited to study nearby, dim dwarf galaxies because its sharp vision can resolve individual stars and help astronomers estimate the galaxies' distances. Distance is important for determining a galaxy's brightness, and, in these Hubble observations, for calculating how far away the galaxies are from nearby voids. Pisces A is about 19 million light-years from Earth and Pisces B roughly 30 million light-years away.

An analysis of the stars' colors allowed the astronomers to trace the star formation history of both galaxies. Each galaxy contains about 20 to 30 bright blue stars, a sign that they are very young, less than 100 million years old. Tollerud's team estimates that less than 100 million years ago, the galaxies doubled their star-formation rate. Eventually, the star formation may slow down again if the galaxies become satellites of a much larger galaxy.

"The galaxies could even probably stop forming stars all together, because they will stop getting new gas to make stars," Tollerud said. "So they will use up their existing gas. But it's hard to tell right now exactly when that would happen, so it's a reasonable guess that the star formation will ramp up at least for a while."

Tollerud's team hopes to observe other similar galaxies with Hubble. He also plans to scour the Panoramic Survey Telescope & Rapid Response System (Pan-STARRS) survey for potential dwarf galaxies. Future wide-survey telescopes, such as the Large Synoptic Survey Telescope (LSST) in Chile and the large radio telescope in China, should be able to find many of these puny galactic neighbors.
For years, astronomers have puzzled over a massive star lodged deep in the Milky Way that shows conflicting signs of being extremely old and extremely young.

Researchers initially classified the star as elderly, perhaps a red supergiant. But a new study by a NASA-led team of researchers suggests that the object, labeled IRAS 19312+1950, might be something quite different -- a proto-star, a star still in the making.

"Astronomers recognized this object as noteworthy around the year 2000 and have been trying ever since to decide how far along its development is," said Martin Cordiner, an astrochemist working at NASA's Goddard Space Flight Center in Greenbelt, Maryland. He is the lead author of a paper in the Astrophysical Journal describing the team's findings, from observations made using NASA's Spitzer Space Telescope and ESA's Herschel Space Observatory.

Located more than 12,000 light-years from Earth, the object first stood out as peculiar when it was observed at particular radio frequencies. Several teams of astronomers studied it using ground-based telescopes and concluded that it is an oxygen-rich star about 10 times as massive as the sun. The question was: What kind of star?

Some researchers favor the idea that the star is evolved -- past the peak of its life cycle and on the decline. For most of their lives, stars obtain their energy by fusing hydrogen in their cores, as the sun does now. But older stars have used up most of their hydrogen and must rely on heavier fuels that don't last as long, leading to rapid deterioration.

Two early clues -- intense radio sources called masers -- suggested the star was old. In astronomy, masers occur...
when the molecules in certain kinds of gases get revved up and emit a lot of radiation over a very limited range of frequencies. The result is a powerful radio beacon -- the microwave equivalent of a laser.

One maser observed with IRAS 19312+1950 is almost exclusively associated with late-stage stars. This is the silicon oxide maser, produced by molecules made of one silicon atom and one oxygen atom. Researchers don't know why this maser is nearly always restricted to elderly stars, but of thousands of known silicon oxide masers, only a few exceptions to this rule have been noted.

Also spotted with the star was a hydroxyl maser, produced by molecules comprised of one oxygen atom and one hydrogen atom. Hydroxyl masers can occur in various kinds of astronomical objects, but when one occurs with an elderly star, the radio signal has a distinctive pattern -- it's especially strong at a frequency of 1612 megahertz. That's the pattern researchers found in this case.

Even so, the object didn't entirely fit with evolved stars. Especially puzzling was the smorgasbord of chemicals found in the large cloud of material surrounding the star. A chemical-rich cloud like this is typical of the regions where new stars are born, but no such stellar nursery had been identified near this star.

Scientists initially proposed that the object was an old star surrounded by a surprising cloud typical of the kind that usually accompanies young stars. Another idea was that the observations might somehow be capturing two objects: a very old star and an embryonic cloud of star-making material in the same field.

Cordiner and his colleagues began to reconsider the object, conducting observations using ESA's Herschel Space Observatory and analyzing data gathered earlier with NASA's Spitzer Space Telescope. Both telescopes operate at infrared wavelengths, which gave the team new insight into the gases, dust and ices in the cloud surrounding the star.

The additional information leads Cordiner and colleagues to think the star is in a very early stage of formation. The object is much brighter than it first appeared, they say, emitting about 20,000 times the energy of our sun. The team found large quantities of ices made from water and carbon dioxide in the cloud around the object. These ices are located on dust grains relatively close to the star, and all this dust and ice blocks out starlight making the star seem dimmer than it really is.

In addition, the dense cloud around the object appears to be collapsing, which happens when a growing star pulls in material. In contrast, the material around an evolved star is expanding and is in the process of escaping to the interstellar medium. The entire envelope of material has an estimated mass of 500 to 700 suns, which is much more than could have been produced by an elderly or dying star.

"We think the star is probably in an embryonic stage, getting near the end of its accretion stage -- the period when it pulls in new material to fuel its growth," said Cordiner.

Also supporting the idea of a young star are the very fast wind speeds measured in two jets of gas streaming away from opposite poles of the star. Such jets of material, known as a bipolar outflow, can be seen emanating from young or old stars. However, fast, narrowly focused jets are rarely observed in evolved stars. In this case, the team measured winds at the breakneck speed of at least 200,000 miles per hour (90 kilometers per second) -- a common characteristic of a protostar.

Still, the researchers acknowledge that the object is not a typical protostar. For reasons they can't explain yet, the star has spectacular features of both a very young and a very old star.

"No matter how one looks at this object, it's fascinating, and it has something new to tell us about the life cycles of stars," said Steven Charnley, a Goddard astrochemist and co-author of the paper.

The result is based on data from a large group of observatories in space and on the ground including Chandra, NASA's Hubble Space Telescope and Spitzer Space Telescope, ESA's XMM-Newton and Herschel Space Observatory, the NSF's Karl G. Jansky Very Large Array, the Atacama Large Millimeter/submillimeter Array (ALMA), the Institut de Radioastronomie Millimetrique Northern Extended Millimeter Array (IRAM NOEMA), and ESO's Very Large Telescope.
Record-Breaking Galaxy Cluster Discovered

A new record for the most distant galaxy cluster has been set using NASA’s Chandra X-ray Observatory and other telescopes. This galaxy cluster may have been caught right after birth, a brief, but important stage of evolution never seen before.

The galaxy cluster is called CL J1001+0220 (CL J1001 for short) and is located about 11.1 billion light years from Earth. The discovery of this object pushes back the formation time of galaxy clusters – the largest structures in the Universe held together by gravity – by about 700 million years.

“This galaxy cluster isn’t just remarkable for its distance, it’s also going through an amazing growth spurt unlike any we’ve ever seen,” said Tao Wang of the French Alternative Energies and Atomic Energy Commission (CEA) who led the study.

The core of CL J1001 contains eleven massive galaxies – nine of which are experiencing an impressive baby boom of stars. Specifically, stars are forming in the cluster’s core at a rate that is equivalent to over 3,000 Suns forming per year, a remarkably high value for a galaxy cluster, including those that are almost as distant, and therefore as young, as CL J1001.

The diffuse X-ray emission detected by Chandra and ESA’s XMM-Newton Observatory comes from a large amount of hot gas, one of the defining features of a true galaxy cluster.

“It appears that we have captured this galaxy cluster at a critical stage just as it has shifted from a loose collection of galaxies into a young, but fully formed galaxy cluster,” said co-author David Elbaz from CEA.

Previously, only these loose collections of galaxies, known as protoclusters, had been seen at greater distances than CL J1001.

The results suggest that elliptical galaxies in galaxy clusters like CL J1001 may form their stars during shorter and more violent outbursts than elliptical galaxies that are outside clusters. Also, this discovery suggests that much of the star formation in these galaxies happens after the galaxies fall onto the cluster, not before.

In comparing their results to computer simulations of the formation of clusters performed by other scientists, the team of astronomers found that CL J1001 has an unexpectedly high amount of mass in stars compared to the...
Supernova Ejected from the Pages of History

A new look at the debris from an exploded star in our galaxy has astronomers re-examining when the supernova actually happened. Recent observations of the supernova remnant called G11.2-0.3 with NASA’s Chandra X-ray Observatory have stripped away its connection to an event recorded by the Chinese in 386 CE.

Historical supernovas and their remnants can be tied to both current astronomical observations as well as historical records of the event. Since it can be difficult to determine from present observations of their remnant exactly when a supernova occurred, historical supernovas provide important information on stellar timelines. Stellar debris can tell us a great deal about the nature of the exploded star, but the interpretation is much more straightforward given a known age.

New Chandra data on G11.2-0.3 show that dense clouds of gas lie along the line of sight from the supernova remnant to Earth. Infrared observations with the Palomar 5-meter Hale Telescope had previously indicated that parts of the remnant were heavily obscured by dust. This means that the supernova responsible for this object would simply have appeared too faint to be seen with the naked eye in 386 CE. This leaves the nature of the observed 386 CE event a mystery.

A new image of G11.2-0.3 is being released in conjunction with this week’s workshop titled “Chandra Science for the Next Decade” being held in Cambridge, Massachusetts. While the workshop will focus on the innovative and exciting science Chandra can do in the next ten years, G11.2-0.3 is an example of how this “Great Observatory” helps us better understand the complex history of the Universe and the objects within it.

Taking advantage of Chandra’s successful operations since its launch into space in 1999, astronomers were able to compare observations of G11.2-0.3 from 2000 to those taken in 2003 and more recently in 2013. This long baseline allowed scientists to measure how fast the remnant is expanding. Using this data to extrapolate backwards, they determined that the star that created G11.2-0.3 exploded between 1,400 and 2,400 years ago as seen from Earth.

Previous data from other observatories had shown this remnant is the product of a “core-collapse” supernova, one that is created from the collapse and explosion of a massive star. The revised timeframe for the explosion based on

(Continued on page 7)
Celestial Observations

P Cyg – Luminous Blue Variable

By Bill Pellerin, Astronomical League

Object: P Cyg
Class: Luminous Blue Variable
Constellation: Cyg
Magnitude: 4.8
R.A.: 20 h, 17 m, 47 s
Dec: 38° 01’ 59”
Size/Spectral: B1
Distance: 6500 +/- ly

Optics needed: A small telescope to pick this star out in a crowded field.

This star has a Bayer designation, ‘P’, but, as is often the case, the star is a variable but it retains its Bayer name. The naming convention for variable stars is different; the first variable in a constellation is typically called ‘R’. You can also find P Cyg using the following catalog names: SAO 069773 or HD 193237. Not much attention has historically been directed to a 5th magnitude star in a crowded field of stars, but in the year 1600 the star had the audacity to brighten to about 3rd magnitude, six times brighter than it was, and now is, at 5th magnitude. Over the time that this star was observed it brightened and dimmed a few more times. If you look at the data on the star today (AAVSO.org) you’ll find that it has dimmed and brightened (over a period of a few days) by a fraction of magnitude, hard to detect visually, but easy to detect photometrically.

Light curve from AAVSO.org

(Continued on page 3)