COMING EVENTS
PUBLIC OBSERVING
SUN. JAN. 25, 7:30 PM
Prairie Park Nature Center

FEBRUARY Meeting
FRIDAY, Feb. 13, 2015
7:30 PM
2001 Malott
TBD

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Report from the Officers
The final meeting of the year included the usual holiday celebration, door prizes for all in attendance, and an entertaining talk on the near completion of the New Horizons Mission to Pluto and the Kuiper Belt. NH is scheduled to arrive at Pluto in July 2015 after traveling for 9 years. If it works as planned, it will revolutionize our understanding of the outer solar system and the increasingly complex system of trans-Neptunian objects epitomized by Pluto and Sedna. As part of the expanded interest in the outer solar system and the Kuiper Belt asteroids, the 40 year old suggestion of the existence of a planet called Nemesis has been resurrected, though the justification is on slightly stronger ground this time, not a difficult bar to meet. The primary rational is the existence of similar orbital

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A Happy 2015 Welcome to new club member
RYAN GREEN
and returning club member
JOHN DICKSON

Of Local Interest

The Science of INTERSTELLAR
Associate Professor Greg Rudnick of KU has closed out the semester in the news for two very different reasons. First, he appeared on the radio broadcast of CENTRAL STANDARD from KCUR in Kansas City to discuss the science and science fiction behind the recent film "Interstellar". The complete podcast can be accessed at https://itunes.apple.com/us/podcast/central-standard-from-kcur/id403272013?mt=2

Second, his collaborative research on gas flows in active galaxies demonstrates for the first time that "nuclear bursts of star formation are capable of ejecting large amounts of cold gas from the central regions of galaxies, thereby strongly affecting their evolution by truncating star formation and redistributing matter." The result was deemed significant enough to generate a News & Views commentary on the result within NATURE, a premiere refereed science journal, accessible at http://www.nature.com/nature/journal/v516/n7529/full/516044a.html.
The great tradition of dark sky observing continues with the 37th Annual
TENNAS STAR PARTY, May 10-17, 2015!

Staying on the Ranch in housing, RV, or camping? Staying off-site in other accommodations?
Everyone needs to enter the TSP drawing, held in late January.

You should submit a Registration/Reservation Request Form to ENTER THE TSP DRAWING before January 21, 2015. This will provide you the highest possible chance of being selected as one of the 500 people who will be able to attend TSP this year.

Follow this link to get started!
https://texasstarparty.org/get-started/
SIGN UP NOW!

You can find out the status of your TSP Registration at any time by visiting
https://texasstarparty.org/account/

Get info on our new AstroLearn Workshop at
https://texasstarparty.org/astrolearn/

Need funds to help pay for your trip to TSP? You can find out about getting paid while at TSP at:
https://texasstarparty.org/paid-workers-needed/

Check out the latest news at:
https://texasstarparty.org/news/

Questions? Visit our web site for the latest and complete details!
https://texasstarparty.org/ or email TSPRooms@TexasStarParty.org

We look forward to seeing you next May!
Sincerely,
the volunteers for Texas Star Party

(Continued from page 1)
characteristics for about a dozen of the recently discovered Kuiper Belt objects. For more on New Horizons, check out the NASA web site: http://www.nasa.gov/mission_pages/newhorizons/main/. For a story on the new nemesis, check out https://www.sciencenews.org/article/distant-planet-may-lurk-far-beyond-neptune. Bad weather clouded out our Dec. public observing; the next public observing session is tentatively scheduled for Sunday, Jan. 25 at 7:30 PM at Prairie Park Nature Center. The Super Bowl is the following Sunday!

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

About the Astronomy Associates of Lawrence

The club is open to all people interested in sharing their love for astronomy. Monthly meetings are typically on the second Friday of each month and often feature guest speakers, presentations by club members, and a chance to exchange amateur astronomy tips. Approximately the last Sunday of each month we have an open house at the Prairie Park Nature Center. Periodic star parties are scheduled as well. For more information, please contact the club officers: president, Rick Heschmeyer at rcjbm@sbcglobal.net; webmaster, Howard Edin, at howard@howardedin.com; AICor William Winkler, at billwink10@yahoo.com; or faculty advisor, Prof. Bruce Twarog at btwarog@ku.edu. Because of the flexibility of the schedule due to holidays and alternate events, it is always best to check the Web site for the exact Fridays and Sundays when events are scheduled. The information about AAL can be found at
http://www.physics.ku.edu/aal/
Copies of the Celestial Mechanic can also be found on the web at
http://www.physics.ku.edu/aal/celestialmechanic
Tales from a Martian rock: New chemical analysis of ancient Martian meteorite provides clues to planet's history of habitability

A new analysis of a Martian rock that meteorite hunters plucked from an Antarctic ice field 30 years ago this month reveals a record of the planet's climate billions of years ago, back when water likely washed across its surface and any life that ever formed there might have emerged. Scientists from the University of California, San Diego, NASA and the Smithsonian Institution report detailed measurements of minerals within the meteorite in the early online edition of the Proceedings of the National Academy of Sciences this week.

"Minerals within the meteorite hold a snapshot of the planet's ancient chemistry, of interactions between water and atmosphere," said Robina Shaheen, a project scientist at UC San Diego and the lead author of the report.

The unlovely stone, which fell to Earth 13 thousand years ago, looked a lot like a potato and has quite a history. Designated ALH84001, it is the oldest meteorite we have from Mars, a chunk of solidified magma from a volcano that erupted four billion years ago. Since then something liquid, probably water, seeped through pores in the rock and deposited globules of carbonates and other minerals. The carbonates vary subtly depending on the sources of their carbon and oxygen atoms. Both carbon and oxygen occur in heavier and lighter versions, or isotopes. The relative abundances of isotopes forms a chemical signature that careful analysis and sensitive measurements can uncover. Mars's atmosphere is mostly carbon dioxide but contains some ozone. The balance of oxygen isotopes within ozone are strikingly weird with enrichment of heavy isotopes through a physical chemical phenomenon first described by co-author Mark Thiemens, a professor of chemistry at UC San Diego, and colleagues 25 years ago.

"When ozone reacts with carbon dioxide in the atmosphere, it transfers its isotopic weirdness to the new molecule," said Shaheen, who investigated this process of oxygen isotope exchange as a graduate student at the University of Heidelberg in Germany. When carbon dioxide reacts with water to make carbonates, the isotopic signature continues to be preserved. The degree of isotopic weirdness in the carbonates reflects how much water and ozone was present when they formed. It's a record of climate 3.9 billion years ago, locked in a stable mineral. The more water, the smaller the weird ozone signal. This team measured a pronounced ozone signal in the carbonates within the meteorite, suggesting that although Mars had water back then, vast oceans were unlikely. Instead, the early Martian landscape probably held smaller seas.

"What's also new is our simultaneous measurements of carbon isotopes on the same samples. The mix of carbon isotopes suggest that the different minerals within the meteorite had separate origins," Shaheen said. "They tell us the story of the chemical and isotopic compositions of the atmospheric carbon dioxide."

ALH84001 held tiny tubes of carbonate that some scientists saw as potential evidence of microbial life, though a biological origin for the structures has been discarded. On December 16, NASA announced another potential whiff of Martian life in the form of methane sniffed by the rover Curiosity. Carbonates can be deposited by living things that scavenge the minerals to build their skeletons, but that is not the case for the minerals measured by this team. The carbonate we see is not from living things," Shaheen said. "It has anomalous oxygen isotopes that tell us this carbonate is abiotic." By measuring the isotopes in multiple ways, the chemists found carbonates depleted in carbon-13 and enriched in oxygen-18. That is, Mars's atmosphere in this era, a period of great bombardment, had much less carbon-13 than it does today. The change in relative abundances of carbon and oxygen isotopes may have occurred through extensive loss of Martian atmosphere. A thicker atmosphere would likely have been required for liquid water to flow on the planet's chilly surface.

"We now have a much deeper and specific insight into the earliest oxygen-water system in the solar system," Thiemens said. "The question that remains is when did planets, Earth and Mars, get water, and in the case of Mars, where did it go? We've made great progress, but still deep mysteries remain."
In late July 2013, Tropical Storm Flossie barreled furiously toward Hawaii. The question was not if it would strike, but when and where it might do so. During the afternoon hours of July 29, forecasts predicted landfall later that week on the state’s Big Island; however, by the time residents of the 50th state awoke the following morning things had changed. NOAA’s Central Pacific Hurricane Center warned that the islands of Oahu, Molokai and Maui were now at a greater risk.

This overnight recalculation was thanks to the Day/Night Band viewing capabilities of the Visible Infrared Imaging Radiometer Suite, or VIIRS, on board the Suomi National Polar-Orbiting Partnership (Suomi NPP) satellite. VIIRS is able to collect visible imagery at night, according to Mitch Goldberg, program scientist for NOAA’s Joint Polar Satellite System (JPSS), of which Suomi NPP is a part. That means it was able to spot some high-level circulation further north than expected during the nighttime hours. This was an important observation which impacted the whole forecast. Without this forecast, said the Hurricane Center’s Tom Evans, “we would have basically been guessing on Tropical Storm Flossie’s center.”

Polar-orbiting satellites, like Suomi NPP and the future JPSS-1 and JPSS-2 (scheduled for launch in 2017 and 2021, respectively), sweep in a longitudinal path over Earth as the planet rotates beneath them—scanning the globe twice a day. VIIRS, the imager that will be aboard all the JPSS satellites, images 3,000 km-wide swaths on each orbit, with each swath overlapping the next by 200 km to ensure uninterrupted global coverage. This high-resolution, rapidly updating coverage allows researchers to see weather patterns change in near real-time.

Instruments on Suomi NPP allow scientists to study such long-term changes too—things like, “the patterns of sea surface temperature, or coral bleaching,” says Goldberg. They are even used by the World Bank to determine how much energy is burned off and wasted from natural gas flares on oil drilling platforms.

While scientists are excited by the JPSS series’ wide range of capabilities, the ability to address pressing immediate concerns is, for many, the most tangible value. That was certainly the case in July 2013, when thanks to Suomi NPP, authorities had ample time to close ports and facilities, open shelters, activate emergency procedures, and issue flash flood warnings. Despite heavy rains, high surf, and widespread power outages, accidents and injuries were few. By the time the storm passed, Hawaii was soaked.

But it was largely unharmed.

Learn more about JPSS here: [http://www.jpss.noaa.gov](http://www.jpss.noaa.gov). Kids can learn all about how hurricanes form at NASA’s Space Place: [http://spaceplace.nasa.gov/hurricanes](http://spaceplace.nasa.gov/hurricanes)
NASA's Kepler Reborn, Makes First Exoplanet Find of New Mission

NASA's planet-hunting Kepler spacecraft makes a comeback with the discovery of the first exoplanet found using its new mission -- K2.

The discovery was made when astronomers and engineers devised an ingenious way to repurpose Kepler for the K2 mission and continue its search of the cosmos for other worlds.

"Last summer, the possibility of a scientifically productive mission for Kepler after its reaction wheel failure in its extended mission was not part of the conversation," said Paul Hertz, NASA's astrophysics division director at the agency's headquarters in Washington.

"Today, thanks to an innovative idea and lots of hard work by the NASA and Ball Aerospace team, Kepler may well deliver the first candidates for follow-up study by the James Webb Space Telescope to characterize the atmospheres of distant worlds and search for signatures of life."

Lead researcher Andrew Vanderburg, a graduate student at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, studied publicly available data collected by the spacecraft during a test of K2 in February 2014. The discovery was confirmed with measurements taken by the HARPS-North spectrograph of the Telescopio Nazionale Galileo in the Canary Islands, which captured the wobble of the star caused by the planet's gravitational tug as it orbits.

The newly confirmed planet, HIP 116454b, is 2.5 times the diameter of Earth and follows a close, nine-day orbit around a star that is smaller and cooler than our sun, making the planet too hot for life as we know it. HIP 116454b and its star are 180 light-years from Earth, toward the constellation Pisces.

Kepler's onboard camera detects planets by looking for transits -- when a distant star dims slightly as a planet crosses in front of it. The smaller the planet, the weaker the dimming, so brightness measurements must be exquisitely precise. To enable that precision, the spacecraft must maintain steady pointing. In May 2013, data collection during Kepler's extended prime mission came to an end with the failure of the second of four reaction wheels, which are used to stabilize the spacecraft.

Rather than giving up on the stalwart spacecraft, a team of scientists and engineers crafted a resourceful strategy to use pressure from sunlight as a "virtual reaction wheel" to help control the spacecraft. The resulting K2 mission promises to not only continue Kepler's planet hunt, but also to expand the search to bright nearby stars that harbor planets that can be studied in detail and better understand their composition. K2 also will introduce new opportunities to observe star clusters, active galaxies and supernovae.

Small planets like HIP 116454b, orbiting nearby bright stars, are a scientific sweet spot for K2 as they are good prospects for follow-up ground studies to obtain mass measurements. Using K2's size measurements and ground-
**Herschel's view of the early Universe reveals galaxy cluster fireworks**

Astronomers using ESA's Herschel space observatory have found, for the first time, fireworks of star birth within galaxies at the dense core of a massive early Universe galaxy cluster. This frenzy of star formation reveals the young lives of now "red and dead" elliptical galaxies and gives new clues to the evolution of some of the largest structures in the Universe.

Among the biggest questions faced by today's astronomers are how and where galaxies form their stars and how this has changed over cosmic time. The answers are likely to lie in the Universe's galaxy clusters, gravitationally bound groups of hundreds, or even thousands, of galaxies which provide a valuable laboratory to explore the birth of stars and how galaxies evolve.

The galaxy clusters we observe in the local Universe exist more or less in the present; 13.8 billion years after the Big Bang. Observing clusters in this late epoch of the Universe's history means we are seeing them after a long period of evolution, and it shows.

The red and dead elliptical galaxies concentrated in the densely packed and aging cores of these local clusters are devoid of bright blue stars, making them appear "red" and, for the most part, they also lack the gas reservoirs needed to create new stars. This makes these galaxies, for all intents and purposes, "dead", and means that star formation in the present day is limited to the cluster outskirts, or in the regions outside these giant clusters, taking place only in low density environments.

Yet, the presence of large numbers of now aging stars in these elliptical galaxies tells us that there must once have been a frenzy of star formation in these crowded cores, at a time when star birth favored high density environments. To uncover clues to how the relation between star formation and the density of the region in which it takes place has evolved over time, astronomers have sought to observe star formation in the densely packed central regions of massive galaxy clusters in the cosmic past. Now, for the first time, astronomers using Herschel have observed a state of furious star formation within the central regions of the massive cluster XDCPJ0044.0-2033, which lies well beyond our local Universe. At a redshift of almost 1.6, we are seeing this cluster as it was 9.6 billion years ago, 4.1 billion years after the Big Bang.

"Until now we have generally found that the cores of massive clusters are depleted of star formation, akin to galaxy graveyards," explains Joana Santos, an INAF researcher at Osservatorio Astrofisico di Arcetri, Italy, and lead author of a study published today in MNRAS Letters. "But now, by hunting for more distant clusters we can look back in time across the cosmic ages to search for the epoch when galaxies in clusters were giving birth to stars."

The cluster's mass was calculated using data from NASA's Chandra X-ray observatory to be about four hundred thousand billion times that of our Sun making this the most massive cluster known at such a great distance and providing valuable insight into the behavior of massive clusters in the early years of the Universe.

Using Herschel the team searched XDCPJ0044.0-2033 for the far-infrared radiation that would reveal interstellar dust was being heated by young, hot, stars. They found clear signs of vigorous star formation within the cluster's galaxies.

"Because the clues to quantifying star formation lie in a cluster's infrared signature Herschel is the perfect telescope for the job," says Göran Pilbratt, ESA's Herschel project scientist. "Herschel has allowed astronomers to map the star formation in these clusters by measuring the far-infrared emission from the particles of dust that are

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Galactic Get-Together Has Impressive Light Display

At this time of year, there are lots of gatherings often decorated with festive lights. When galaxies get together, there is the chance of a spectacular light show as is the case with NGC 2207 and IC 2163.

Located about 130 million light years from Earth, in the constellation of Canis Major, this pair of spiral galaxies has been caught in a grazing encounter. NGC 2207 and IC 2163 have hosted three supernova explosions in the past 15 years and have produced one of the most bountiful collections of super bright X-ray lights known. These special objects – known as “ultraluminous X-ray sources” (ULXs) – have been found using data from NASA’s Chandra X-ray Observatory.

As in our Milky Way galaxy, NGC 2207 and IC 2163 are sprinkled with many star systems known as X-ray binaries, which consist of a star in a tight orbit around either a neutron star or a “stellar-mass” black hole. The strong gravity of the neutron star or black hole pulls matter from the companion star. As this matter falls toward the neutron star or black hole, it is heated to millions of degrees and generates X-rays. ULXs have far brighter X-rays than most “normal” X-ray binaries. The true nature of ULXs is still debated, but they are likely a peculiar type of X-ray binary. The black holes in some ULXs may be heavier than stellar mass black holes and could represent a hypothesized, but as yet unconfirmed, intermediate-mass category of black holes.

This composite image of NGC 2207 and IC 2163 contains Chandra data in pink, optical light data from the Hubble Space Telescope in red, green, and blue (appearing as blue, white, orange, and brown), and infrared data from the Spitzer Space Telescope in red.

The new Chandra image contains about five times more observing time than previous efforts to study ULXs in this galaxy pair. Scientists now tally a total of 28 ULXs between NGC 2207 and IC 2163. Twelve of these vary over a span of several years, including seven that were not detected before because they were in a “quiet” phase during earlier observations.

The scientists involved in studying this system note that there is a strong correlation between the number of X-ray sources in different regions of the galaxies and the rate at which stars are forming in these regions. The composite image shows this correlation through X-ray sources concentrated in the spiral arms of the galaxies, where large amounts of stars are known to be forming. This correlation also suggests that the companion star in the binary systems is young and massive.

Colliding galaxies like this pair are well known to contain intense star formation. Shock waves – like the sonic booms from supersonic aircraft – form during the collision, leading to the collapse of clouds of gas and the formation of star clusters. In fact, researchers estimate that the stars associated with the ULXs are very young and may only be about 10 million years old. In contrast, our Sun is about halfway through its 10-billion-year lifetime. Moreover, analysis shows that stars of various masses are forming in this galaxy pair at a rate equivalent to form 24 stars the mass of our sun per year. In comparison, a galaxy like our Milky Way is expected to spawn new stars at a rate equivalent to only about one to three new suns every year.
A new feature in the evolution of galaxies has been captured in this image of galactic interactions. The two galaxies seen here -- NGC 3226 at the top (and in call-out to right), NGC 3227 at the bottom -- are awash in the remains of a departed third galaxy, cannibalized by the gravity of the surviving galaxies. The surge of warm gas flowing into NGC 3226, seen as a blue filament, appears to be shutting down this galaxy's star formation, disrupting the cool gas needed to make fresh stars.

The findings come courtesy of the European Space Agency's Herschel space observatory, in which NASA played a key role, and NASA's Spitzer and Hubble space telescopes. Adding material to galaxies often rejuvenates them, triggering new rounds of star birth as gas and dust gel together. Yet data from the three telescopes all indicate that NGC 3226 has a very low rate of star formation.

In this instance, material falling into NGC 3226 is heating up as it collides with other galactic gas and dust, quenching star formation instead of fueling it. As this warm gas chills out in the future, though, NGC 3226 should get a second wind in its stalled-out production of new stars.

The gray scale in this image shows optical starlight captured by the MegaCam instrument at the Canada France Hawaii Telescope (CFHT) telescope on Mauna Kea in Hawaii, and reveals loops of stars flung about by the galactic cannibalism. The blue color represents cool hydrogen gas seen in radio waves by the Very Large Array near Socorro, New Mexico. The big plume of gas above NGC 3226 is being drawn into the galaxy by its gravity. The red color shows infrared light emissions, captured by Spitzer, from warm gas and dust at the tip of the plume's infalling stream of material into NGC 3226, as well as from features within NGC 3227.

Other Spitzer observations reveal a disk of warm molecular gas at the core of NGC 3226, fed by the plume. Herschel observations, not shown in the image, were used to create a galactic star-formation model, which confirms NGC 3226's very low star-formation rate.

The interacting galaxies are located 49 million light-years away in the constellation Leo.

Visible starlight at wavelengths of 550 to 700 nanometers is shown in gray scale. The infrared glow of dust at 8 microns, as seen by Spitzer, is displayed in red, while the radio glow of hydrogen gas at 21 centimeters, from the VLA, is shown in blue.
Horsehead of a Different Color

Sometimes a horse of a different color hardly seems to be a horse at all, as, for example, in this newly released image from NASA's Spitzer Space Telescope. The famous Horsehead nebula makes a ghostly appearance on the far right side of the image, but is almost unrecognizable in this infrared view. In visible-light images, the nebula has a distinctively dark and dusty horse-shaped silhouette, but when viewed in infrared light, dust becomes transparent and the nebula appears as a wispy arc.

The Horsehead is only one small feature in the Orion Molecular Cloud Complex, dominated in the center of this view by the brilliant Flame nebula (NGC 2024). The smaller, glowing cavity falling between the Flame nebula and the Horsehead is called NGC 2023. These regions are about 1,200 light-years away.

The two carved-out cavities of the Flame nebula and NGC 2023 were created by the destructive glare of recently formed massive stars within their confines. They can be seen tracing a spine of glowing dust that runs through the image. The Flame nebula sits adjacent to the star Alnitak, the easternmost star in Orion's belt, seen here as the bright blue dot near the top of the nebula.

In this infrared image from Spitzer, blue represents light emitted at a wavelength of 3.6-microns, and cyan (blue-green) represents 4.5-microns, both of which come mainly from hot stars. Green represents 8-micron light and red represents 24-micron light. Relatively cooler objects, such as the dust of the nebulae, appear green and red. Some regions along the top and bottom of the image extending beyond Spitzer's observations were filled in using data from NASA's Wide-field Infrared Survey Explorer, or WISE, which covered similar wavelengths across the whole sky.

(Continued from page 5)

Based mass measurements, astronomers can calculate the density of a planet to determine whether it is likely a rocky, watery or gaseous world.

"The Kepler mission showed us that planets larger in size than Earth and smaller than Neptune are common in the galaxy, yet they are absent in our solar system," said Steve Howell, Kepler/K2 project scientist at NASA's Ames Research Center in Moffett Field, California. "K2 is uniquely positioned to dramatically refine our understanding of these alien worlds and further define the boundary between rocky worlds like Earth and ice giants like Neptune."

Since the K2 mission officially began in May 2014, it has observed more than 35,000 stars and collected data on star clusters, dense star-forming regions, and several planetary objects within our own solar system. It is currently in its third campaign.
The Astronomy in Chile Educator Ambassadors Program (ACEAP) is a collaboration between AUI (http://www.aui.edu/), the National Radio Astronomy Observatory (https://www.nrao.edu/), National Optical Astronomy Observatory (http://www.noao.edu/), and Gemini Observatory (http://www.gemini.edu/), and is supported by the National Science Foundation (http://www.nsf.gov) (NSF 1439408). The Program brings amateur astronomers, planetarium personnel, and K-16 formal and informal astronomy educators to US astronomy facilities in Chile. While at these facilities, ACEAP Ambassadors will receive extensive training about the instruments, the science, data products, and communicating science, technology, engineering, and mathematics (STEM) concepts. When they return home, the Ambassadors will share their experiences and observatory resources with schools and community groups across the US.

The program is open to amateur astronomers, K through college formal and informal educators who teach astronomy as part of their curriculum or program, and planetarium educators, who are U.S. Citizens. Check it out at https://public.nrao.edu/look-deeper/aceap.

"Herschel's view into the far-infrared Universe allowed us to map the energy distribution within the cluster's galaxies and we found not only that there are definitely stars forming in the inner region but also how many stars are being formed," Santos says.

By mapping the infrared radiation from the galaxies the team was able to work out how hot the gas and dust within the galaxies was and what amount of star birth would be needed to heat it to this level. By doing this for galaxies in the inner region of the cluster, an area measuring over one and half million light years across, the team found that the cluster has a star formation rate of almost two thousand solar masses per year, four times the rate found in its outer regions.

The detection of such an unprecedented level of star formation in the cluster makes the discovery a first for clusters of this mass and tells us that we are witnessing a very early stage in galaxy cluster evolution. These, potentially fleeting, fireworks will form huge numbers of stars before, at some stage, the process halts and the cluster's core becomes like those we see in our local Universe – filled with aging elliptical galaxies.

The true significance of this prolificacy of star formation is evident when compared to other clusters of a similar mass. The cluster XMMU J2235.3-2557, for example, has a very similar mass and lies only a little more than half a billion years later in cosmic history at 4.8 billion years after the Big Bang and yet shows no signs of star formation in its inner regions. Nor does a significant amount of star formation take place in the inner regions of any massive cluster found between us and XDCPJ0044.0-2033. Finding star birth in the core of XDCPJ0044.0-2033 is an important step towards establishing at what period in cosmic history the star formation preference changed from the high density environments in cluster cores, as with XDCPJ0044.0-2033 just 4.1 billion years after the Big Bang, to the low density settings outside clusters, like the star formation we see in our local Universe. To better determine the epoch in which this change occurred astronomers will need to find and study other massive clusters at these large look-back times and search for signs of star birth in their cores.

"There is still much to learn about the lifecycle of these episodes of vigorous star formation and what this can tell us about the evolution of the Universe. To gain a more detailed picture we need to keep searching for massive clusters and distant fireworks with the best astronomical facilities," remarks Santos.