February 2012

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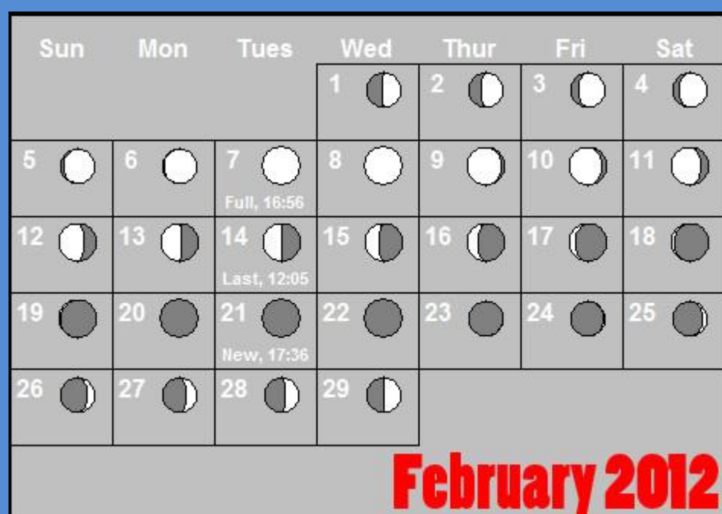
## February Meeting

The next meeting of S*T*A*R will be at 8pm on Thursday, February 2nd, 2012. Our guest speaker will be Dr. Tad Pryor, a professor in the Department of Physics and Astronomy at Rutgers University. His talk is titled “Measuring the Motions of Satellite Galaxies with the Hubble Space Telescope.”

## Calendar

- February 2nd 2012 – Dr. Tad Pryor
- February 29th 2012 – Mill Lake Elementary School Star Party




## March Issue

**Please submit articles and contributions for the next *Spectrogram* by February 27th.** Please email to fowler@verizon.net.

# Star Parties:

**Astronomy Night**

Mill Lake Elementary School in Monroe Township is holding their annual Astronomy Night on Tuesday, February 29$^{th}$ 2012. They have asked if we could set up several telescopes for the students and parents. The school is located at 115 Monmouth Road, Monroe Township, NJ 08831.

We can arrive and set up in the rear of the school at 6:00. In the past there was pizza, subs and soda for the astronomers. The students will start to arrive at 6:30 and it should end about 8:30.

This event goes on rain or cloud. There are indoor stations where the students are engaged in hands-on activities supervised by the teachers. There will be a Starlab Planetarium and an exhibit of Moon rocks. There are about 180 students plus parents and siblings but they will come out to observe in class sized groups.

The last two years we were able to observe but the two previous years the skies were overcast and the astronomers did the observations through breaks in the clouds or came inside the gym and showed the students how their telescopes worked and viewed pictures of galaxies across the room.

Please post if you can help.
Please monitor "Events and Observation Plans" link on our web site for updates.

Russ Drum and Dennis O'Leary are contacts for the Club.

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# Are you a S*T*A*R Member?

S*T*A*R, The Society of Telescopy, Astronomy, and Radio, has promoted amateur astronomy since 1957 when it was organized by an energetic group of observers who participated in Project Moonwatch, a program in which a worldwide network of observers tracked the path of Sputnik among the stars of the night sky to obtain information on how the earth's atmosphere affects satellite orbits. This group soon evolved into an amateur astronomy club which was incorporated under its present name in 1969.

Today, S*T*A*R is the focal point for amateur astronomy in Monmouth County, NJ, attracting members of all ages, occupations and educational backgrounds. Its objectives are to promote the enjoyment of astronomy, and to increase the level of astronomical knowledge among its members and the public. The club achieves these goals through its regular meetings, observing nights, field trips, cooperation and exchange of information with other clubs, and special activities such as assisting Bayonet Farm in Holmdel and other park systems in conducting public astronomy programs.

S*T*A*R meetings are held on the first Thursday of the month from September to June, at 8 pm at the Monmouth Museum on the campus of Brookdale Community College, Lincroft, NJ. Programs generally consist of lectures and discussions by members or guest speakers on a variety of interesting topics on astronomy. Refreshments are served during the meeting and, weather permitting, a short observing session may occur afterwards.

The club owns 8" f/8, 13" f/4.5 and 25" f/5 Dobsonian telescopes which are available for use by members. Because of its large size use of the 25" requires the supervision of two qualified operators. To borrow a telescope or become a qualified operator of the 25", please contact the Vice President.

The current officers of S*T*A*R are:

| | |
|---|---|
| President | Rob Nunn |
| Vice President | Kevin Gallagher |
| Secretary | Steve Fedor |
| Treasurer | Arturo Cisneros |
| Member at Large | Dave Britz |

S*T*A*R is a member of United Astronomy Clubs of New Jersey (UACNJ), the Astronomical League (AL), and the International Dark Sky Association (IDA).

Memberships:
( ) Individual....$35
( ) Family...$45
( ) Student… $15

Name________________________________________

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Phone________________________________________

Email________________________________________

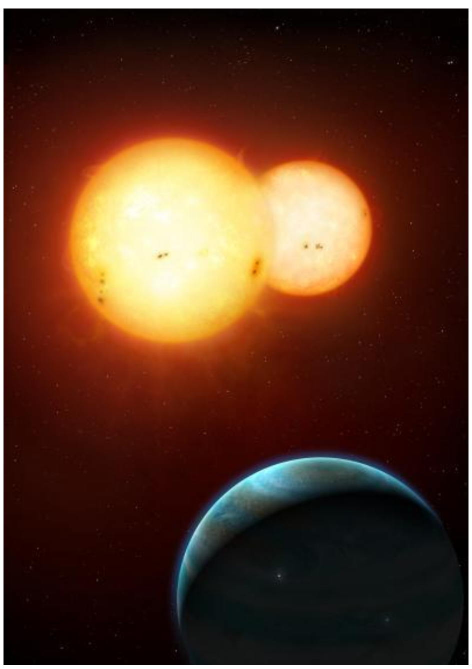
Make checks payable to: S*T*A*R Astronomy Society, Inc. and mail to P.O. Box 863, Red Bank, NJ 07701

# New class of planetary systems: Astronomers find two new planets orbiting double suns

Using data from NASA's Kepler mission, a team that includes a University of Florida astronomer has discovered two new planets orbiting double star systems, something that had never been seen until last September.

The newly confirmed planets, called Kepler-34b and Kepler-35b, will be announced in Wednesday's online edition of the journal Nature, said Eric B. Ford, UF associate professor of astronomy. William F. Welsh, associate professor at San Diego State University, is the lead author on the paper.

Kepler-34b and Kepler-35b both orbit a "binary star." They are actually a pair of gravitationally bound stars that orbit each other. While the existence of such bodies, called "circumbinary planets," had long been predicted, they remained just a theory until the team discovered Kepler-16b in September 2011. They dubbed Kepler-16b "Tatooine" because of its resemblance to the two-sun world depicted in the "Star Wars" film series.



***This is an artist's rendition of the Kepler-35 planet system, in which a Saturn-size planet orbits a pair of stars. The larger star is similar to the size of the Sun, while the smaller star is 79 percent of the Sun's radius. The stars orbit and eclipse each other every 21 days, but the eclipses do not occur exactly periodically. This variation in the times of the eclipses motivated the search for the planet, which was discovered to transit the stars as it orbits the pair every 131 days. Analogous events led to the discovery of the planet Kepler-34. The discovery of these two new systems establishes a new class of 'circumbinary' planets, and suggests there are many millions of such giant planets in our Galaxy. Credit: Mark A. Garlick***

"We have long believed these kinds of planets to be possible, but they have been very difficult to detect for various technical reasons," Ford said. "With the discoveries of Kepler-16b, 34b and 35b, the Kepler mission has shown that the galaxy abounds with millions of planets orbiting two stars."

The planets were discovered by measuring the star light decrease as the planets pass in front of, or transit, either of the two stars. Kepler also measures the star light decrease when one of the stars passes in front of the other. The mutual gravitational tugs of the stars and planets cause the times of the transits to deviate from a regular schedule, allowing astronomers to confirm the planet and measure its mass.

Both planets are low-density gas giants, comparable in size to Jupiter, but much less massive. Compared to Jupiter, Kepler-34 is about 24 percent smaller in size, but has 78 percent less mass. It can complete a full orbit in 288 terrestrial days. Kepler-35 is about 26 percent smaller, has 88 percent less mass, and completes its orbit around the stars much faster – just 131 days.

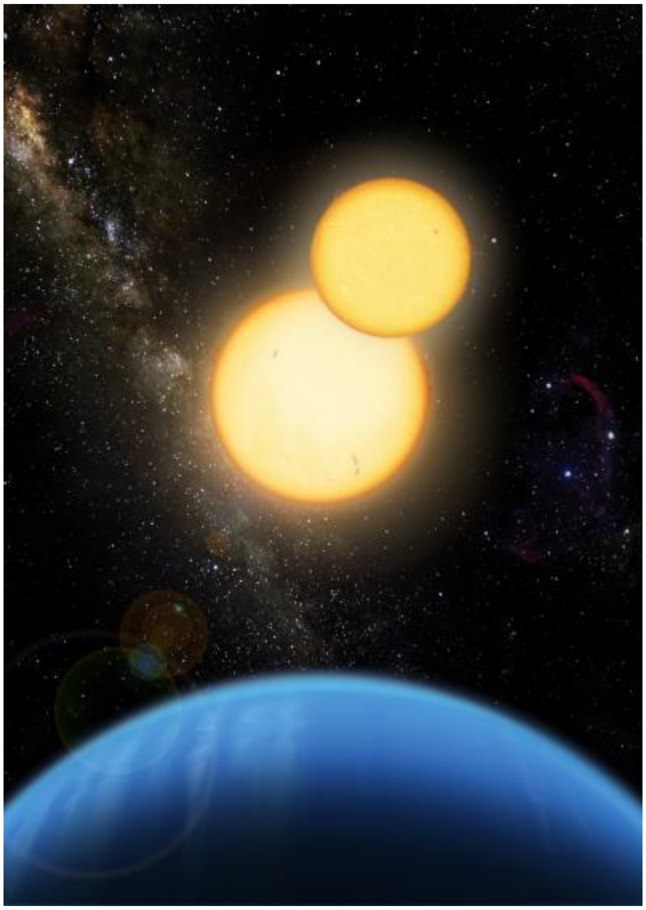
The astronomers believe the planets are made primarily of hydrogen and too hot to sustain life.

"Circumbinary planets can have much more complex climates, since the distance between the planet and each star change significantly during each orbital period, the length of an alien planet's year," Ford said. "For Kepler-35b, the amount of incoming star light changes by over 50 percent within a single Earth year. For Kepler-34b, each Earth-year brings 'summers' with 2.3 times as much star light as winters. Over the course of a year, the change in the amount of sunlight heating the Earth varies by only 6 percent."

NASA's Kepler mission, which began in March 2009, uses a 1-meter space telescope trained on one small portion of the Milky Way for several years. Astronomers analyze data from the telescope for periodic dimming that indicates a planet crossing in front of its host star. The mission's goal is to find the frequency of Earth-size planets in the habitable zone of their host stars – where a planet might have liquid water on its surface.

Most Sun-like stars in the galaxy are not alone, like the Earth's sun, but have a "dance partner," forming a binary system or binary star. Kepler has already identified about 2,165 eclipsing binaries, of the more than 160,000 stars being observed.

NASA originally planned to stop receiving data from the Kepler spacecraft in November 2012.



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"Astronomers are practically begging NASA to extend the Kepler mission until 2016, so it can characterize the masses and orbits of Earth-size planets in the habitable zone. Kepler is revolutionizing so many fields, not just planetary science," Ford said. "It would be a shame not to maximize the scientific return of this great observatory. Hopefully common sense will prevail and the mission will continue."

More information: "Transiting circumbinary planets Kepler-34 b and Kepler-35 b" by Welsh, et al., Nature: http://dx.doi.org/ … /nature10768

***Provided by University of Florida***

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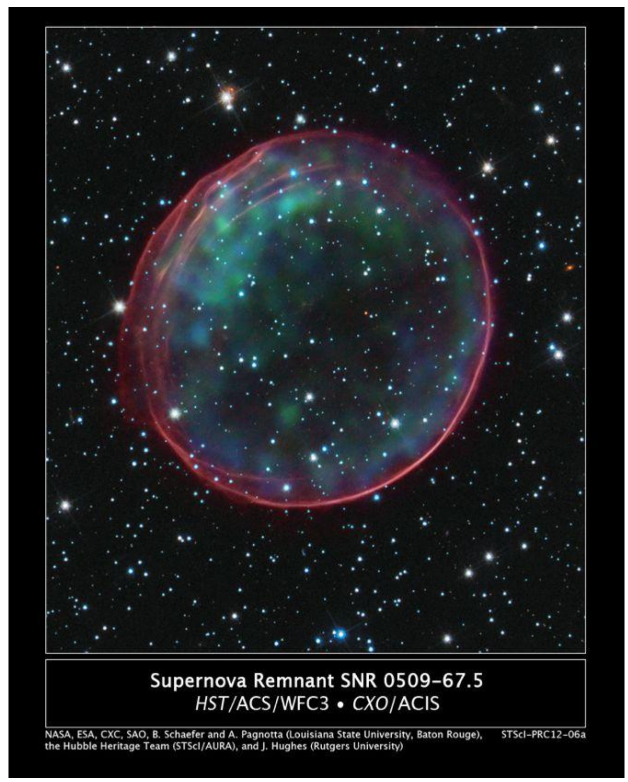
# Origin of thermonuclear supernova discovered

Using NASA's Hubble Space Telescope, astronomers have solved a longstanding mystery on the type of star, or so-called progenitor, which caused a supernova seen in a nearby galaxy. The finding yields new observational data for pinpointing one of several scenarios that trigger such outbursts.

Based on previous observations from ground-based telescopes, astronomers knew that a kind of supernova called a Type Ia supernova created a remnant named SNR 0509-67.5, which lies 170,000 light-years away in the Large Magellanic Cloud galaxy.




***This image of Type Ia Supernova Remnant 0509-67.5 was made by combining data from two of NASA's Great Observatories. The result shows soft green and blue hues of heated material from the X-ray data surrounded by the glowing pink optical shell, which shows the ambient gas being shocked by the expanding blast wave from the supernova. Credit: NASA, ESA, and B. Schaefer and A. Pagnotta (Louisiana State University, Baton Rouge); Image Credit: NASA, ESA, CXC, SAO, the Hubble Heritage Team (STScI/AURA), J. Hughes (Rutgers University)***

The type of system that leads to this kind of supernova explosion has long been a high importance problem with various proposed solutions but no decisive answer. All these solutions involve a white dwarf star that somehow increases in mass to the highest limit.

Astronomers failed to find any companion star near the center of the remnant, and this rules out all but one solution, so the only remaining possibility is that this one Type Ia supernova came from a pair of white dwarfs in close orbit.

“We know that Hubble has the sensitivity necessary to detect the faintest white dwarf remnants that could have caused such explosions,” said lead investigator Bradley Schaefer of Louisiana State University (LSU) in Baton Rouge. “The logic here is the same as the famous quote from Sherlock Holmes: ‘when you have eliminated the impossible, whatever remains, however improbable, must be the truth.’”

The cause of SNR 0509-67.5 can be explained best by two tightly orbiting white dwarf stars spiraling closer and closer until they collided and exploded.

The results are being reported today at the meeting of the American Astronomical Society in Austin, Texas [presentation number 418.08D]. A paper on the results was published in the Jan. 12 issue of the journal Nature.

For four decades, the search for Type Ia supernovae progenitors has been a key question in astrophysics. The problem has taken on special importance over the last decade with Type Ia supernovae being the premier tools for measuring the accelerating universe.

Type Ia supernovae are tremendous explosions of energy in which the light produced is often brighter than a whole galaxy of stars. The problem has been to identify the type of star system that pushes the white dwarf’s mass over the edge and triggers this type of explosion. Many possibilities have been suggested, but most require that a companion star near the exploding white dwarf be left behind after the explosion.

Therefore, a possible way to distinguish between the various progenitor models has been to look deep in the center of an old supernova remnant to search for the ex-companion star.

In 2010, Schaefer and Ashley Pagnotta of LSU were preparing a proposal to look for any faint ex-companion stars in the center of four supernova remnants in the Large Magellanic Cloud when they discovered that the Hubble Space Telescope had already taken the desired image of one of their target remnants, SNR 0509-67.5, for the Hubble Heritage program, which collects images of especially photogenic astronomical targets.

In analyzing the central region, they found it to be completely empty of stars down to the limit of the faintest objects that Hubble can detect in the photos. Schaefer reports that the best explanation left is the so-called “double degenerate model” in which two white dwarfs collide.

There are no recorded observations of the star exploding. However, researchers at the Space Telescope Science Institute in Baltimore, Md., have identified light from the supernova that was reflected off of interstellar dust, delaying its arrival at Earth by 400 years. This delay, called a light echo of the supernova explosion also allowed the astronomers to measure the spectral signature of the light from the explosion. By virtue of the color signature, astronomers were able to prove it was a Type Ia supernova.

Because the remnant appears as a nice symmetric shell or bubble, the geometric center can be accurately determined. These properties make SNR 0509-67.5 an ideal target to search for ex-companions. The young age also means that any surviving stars have not moved far from the site of the explosion.

The team plans to look at other supernova remnants in the Large Magellanic Cloud to further test their observations.

***Provided by Louisiana State University***

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# Earliest-yet observation of August SN2011fe supernova nails it: Destroyed star was white dwarf

Last year's discovery of the nearest Type Ia supernova in decades – captured only 11 hours after it exploded – allowed astronomers to finally cinch the identity of the stars behind these explosions, which have become key measures of cosmic distance.

That supernova, called SN2011fe, and presumably most Type Ia supernovae were originally white dwarfs extremely dense and compact stars composed mostly of carbon and oxygen.

Now, thanks to a much earlier, fluke observation of SN2011fe by a small robotic telescope on the island of Mallorca, University of California, Berkeley, and Lawrence Berkeley National Laboratory (LBNL) astronomers can boost confidence even higher that Type Ia supernovae originate from white dwarfs.

"A fortuitous observation only four hours after we think the star exploded allowed us to put much more constraining limits on the size of the thing that blew up," said Joshua Bloom, UC Berkeley associate professor of astronomy and first author of a paper interpreting the observation that will appear in the Jan. 10 issue of the Astrophysical Journal Letters. "The size of the progenitor is so small and the density so high, it pretty much rules out any other reasonable or even fringe possibility. This is a direct confirmation that what blew up is a carbon-oxygen white dwarf."

In 1998, two research teams used Type Ia supernovae as standard candles to conclude that the expansion of the universe is accelerating, presumably fueled by a mysterious dark energy. That discovery earned three astrophysicists, including UC Berkeley and LBNL's Saul Perlmutter, the 2011 Nobel Prize in Physics.

Bloom will present his results on Wednesday, Jan. 11, during an 11:30 a.m. CST media briefing at the national meeting of the American Astronomical Society in Austin, Texas.

**Smaller than a main sequence star**

Bloom and his colleagues were coauthors of two papers published Dec. 15, 2011, in the journal Nature that concluded that SN2011fe's progenitor star was a compact object with a diameter less than one-tenth that of the sun. Based on the brightness of the explosion, which occurred 21 million light years away in the Pinwheel Galaxy (M101), and the fact that the explosive debris contained large amounts of carbon and oxygen, coauthor Peter Nugent of LBNL and his colleagues concluded that before it exploded, the star was almost certainly a carbon-oxygen white dwarf.

UC Berkeley astronomer Weidong Li and colleagues concluded the same thing based on the inability of the Hubble Space Telescope to detect any star at that spot before the supernova ignited.

White dwarfs are very dense stars about the size of the Earth that burned all their hydrogen and helium into carbon and oxygen before stopping fusion altogether, destined to cool slowly into dark cinders.

After the papers were submitted to Nature in early November, UC Berkeley and LBNL astronomers learned that the 17-inch PIRATE telescope on Mallorca, operated as a remote-controlled teaching telescope by The Open University in the U.K., had obtained a deep, wide-field image of the Pinwheel Galaxy (M101) only four hours after the explosion. Because the supernova was not visible in the PIRATE image, Bloom and his colleagues, including Nugent, were able to put an even more stringent upper limit on the early brightness of the supernova.

The new analysis concludes that the progenitor star had a diameter less than one-fiftieth that of the sun – 5 to 10 times smaller than last year's limit – which implies a density 100 to 1,000 times higher.

While the previous limits ruled out hydrogen-burning main sequence stars and red giants – the most likely alternatives to a white dwarf, said Ken J. Shen, an Einstein postdoctoral fellow at LBNL and UC Berkeley – they only "placed weak constraints on smaller stars that burn helium or carbon in their cores. Only with this new observation can we now rule these out."

**Looking for light from the early shock wave**

UC Berkeley's Daniel Kasen, an assistant professor of physics, and Shen used theoretical models of exploding stars to estimate how bright a star of a given size would be within hours of ignition from the glow of the supernova's expanding shock wave. The bigger the star, the brighter the glow from the shock. The non-detection of the supernova four hours after it exploded enabled Kasen, Shen, Bloom and their colleagues to rule out stars larger than a white dwarf.

"This is the first time we can really be confident about what is exploding," Shen said.

Their analysis relied on theories of how a carbon-oxygen white dwarf explodes. Presumably, the white dwarf acquires mass from its binary companion until the temperature and pressure in the core rises high enough to restart fusion reactions. This time, carbon and oxygen are fused into nickel and iron in a reaction that consumes the star within seconds, blowing it up like a runaway thermonuclear bomb, Kasen said.

The first light from the explosion should be from the glow of superheated gas as the debris from the star plows through surrounding gas and dust. No one has ever caught this shockwave glow from a Type Ia supernova because it's quite dim and drops off quickly, Kasen said. The light astronomers see is from the decay of radioactive elements created in the explosion, which can shine brightly for weeks afterward.

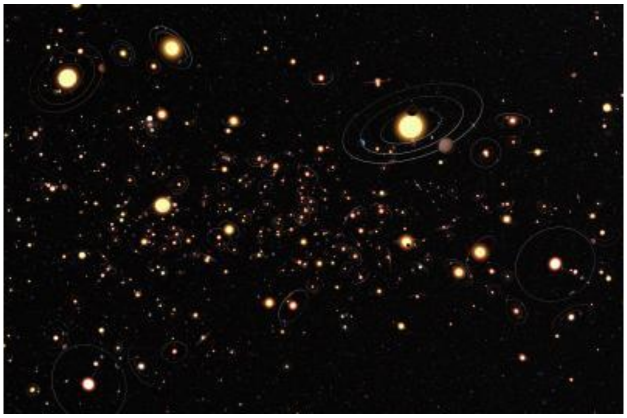
The inability to see SN2011fe four hours after the explosion, Kasen said, allowed the team to set much more stringent limits on the size of the progenitor star.

"The earlier you get on it (the supernova), or the nearer it is, the better your chance of actually seeing the glowing outflow from the shockwave," he said. "This is the closest we've gotten. If it had been 10 instead of 20 million light years from Earth, we might have seen something four hours after the explosion."

The PIRATE observation also narrowed the limits on the companion star published last month by Li and his colleagues. The diameter of the supernova's companion must be less than one-tenth that of the sun, ruling out red giant and normal main-sequence stars.

***Provided by University of California - Berkeley***

# A wealth of habitable planets in the Milky Way



***There are 100 billion stars in the Milky Way. Observations show that planets orbiting around stars are more the rule than the exception and approximately one out of every ten stars have a planet roughly the size of the Earth with an orbit that, if there was water and atmosphere, would create a temperature and climate roughly that same as on Earth -- we could live there. Credit: ESO/M. Kornmesser***

An international team has used the technique of gravitational microlensing to measure how common planets are in the Milky Way.

Six years of observations of millions of stars now show how common it is for stars to have planets in orbits around them. Using a method that is highly sensitive to planets that lie in a habitable zone around the host stars, astronomers, including members from the Niels Bohr Institute, have discovered that most of the Milky Way's 100 billion stars have planets that are very similar to the Earth-like planets in our own solar system – Mercury, Venus, Earth and Mars, while planets like Jupiter and Saturn are more rare. The results are published in the prestigious scientific journal, Nature.

"Our results show that planets orbiting around stars are more the rule than the exception. In a typical solar system approximately four planets have their orbits in the terrestrial zone, which is the distance from the star where you can find solid planets. On average, there are 1.6 planets in the area around the stars that corresponds to the area between Venus and Saturn" explains astronomer Uffe Gråe Jørgensen, head of the research group Astrophysics and Planetary Science at the Niels Bohr Institute at the University of Copenhagen.

**Searching for exoplanets**

Over 1000 exoplanets have been found in our galaxy, the Milky Way, and most have been found using either the radial velocity method or the transit method, both of which are best suited to be able to find planets that are large and relatively close to their host star. With the radial velocity method you can measure that a star rocks in small circular motions due to a revolving planet's gravitational force. With the transit method you measure periodic changes in the brightness of a star. When a planet moves in front of the star, there is a little dip in the star's brightness and if this little dip occurs regularly, further observations can reveal whether there it is a planet. With both methods you most often find large planets in such small orbits around their stars, that they have no equivalents in our own solar system.

**Habitable exoplanets**

In order to find planets similar to the planets we know from our own solar system, researchers must use a third method – gravitational microlensing observations. But the gravitational microlensing method requires very special conditions concerning the stars location in the galaxy.

Uffe Gråe Jørgensen explains that you need to have two stars that lie on a straight line in relation to us here on Earth. Then the light from the background star is amplified by the gravity of the foreground star, which thus acts as a magnifying glass. When the stars pass close by each other in the sky, astronomers can observe the light from the background star first increase and then decrease again. If there is a planet around the foreground star, there might be a little extra bump on the light curve. But if the planet is very close to the star, the bump 'drowns' on the light curve, and if the planet is very far from star, you do not see it. "Therefore the method is most sensitive to planets that lie at an Earth-like distance from a star," explains Uffe Gråe Jørgensen.

It is rare that two planets pass by each other closely enough to create a microlens. We have therefore implemented a strategic search on two levels. Every starry night the research group scans 100 million stars using telescopes in Chile and New Zealand. If the scanning identifies a stellar location with a possible microlensing effect, it is automatically registered and all researchers are notified. Then the best 'lenses' are observed more closely at high resolution and their light curves are analysed. One of the places this is done is at the Danish 1.5 meter telescope at ESO's La Silla Observatory in Chile.

"In a six year period from 2002 to 2007, we observed 500 stars at high resolution. In 10 of the stars we directly see the lens effect of a planet, and for the others we could use statistical arguments to determine how many planets the stars had on average. To be exact, we found that the zone that corresponds to the area between Venus and Saturn in our solar system had and average of 1.6 planets the size of five Earth masses or more," explains Uffe Gråe Jørgensen.

**Billions of habitable planets**

The microlensing results complement the best existing transit and radial velocity measurements. Using transit measurements, the American Kepler satellite has identified a very large number of relatively small planets in orbits smaller than even the innermost planet in our own solar system, Mercury, while many years of radial velocity measurements have revealed a large number of very large planets in both very small orbits and slightly larger orbits.

"Our microlensing data complements the other two methods by identifying small and large planets in the area midway between the transit and radial velocity measurements. Together, the three methods are, for the first time, able to say something about how common our own solar system is, as well as how many stars appear to have Earth-size planets in the orbital area where liquid what could, in principle, exist as lakes, rivers and oceans – that is to say, where life as we know it from Earth could exist in principle," says Uffe Gråe Jørgensen.

He explains that a statistical analysis of all three methods combined shows that out of the Milky Way's 100 billion stars, there are about 10 billion stars with planets in the habitable zone. This means that there may be billions of habitable planets in the Milky Way. For thousands of years people have been guessing how many planets there might be out there among the stars, where we could, in principle at least, live. Today we know this.

**Are we alone in the universe?**

But it is one thing, that the planets have the right temperature to be habitable in principle, but quite another thing, whether they are inhabited – whether there is life and perhaps even intelligent life on the planets.

"There are so many unique events in our solar system that have created the basis for the development of life on Earth. Comets brought water to our planet so that life could arise and a series of random events set in motion an evolution that lead to humans and intelligent life. It is very unlikely that the same circumstances would be present in other solar systems," believes Uffe Gråe Jørgensen, "but perhaps other coincidences in other solar systems have led to entirely different and exciting new forms of life. Recent research of planets around other stars has shown us that there is in any case billions of planets with orbits like Earth and of comparable size to the Earth."

***Provided by University of Copenhagen***

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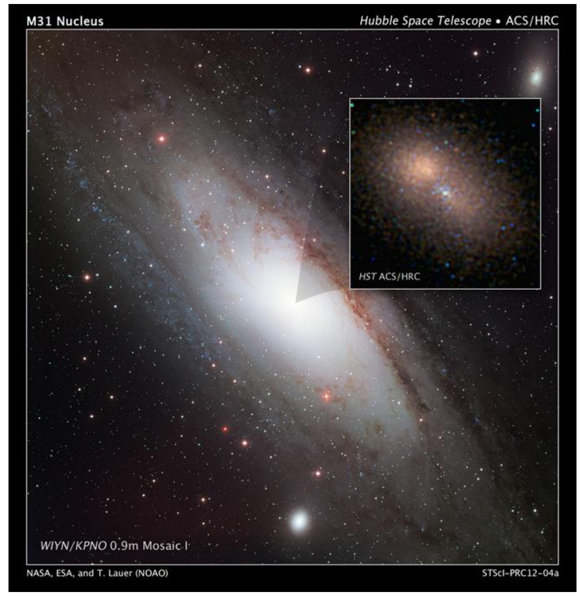
# Hubble zooms in on double nucleus in Andromeda galaxy

A new Hubble Space Telescope image centers on the 100-million-solar-mass black hole at the hub of the neighboring spiral galaxy M31, or the Andromeda galaxy, the only galaxy outside the Milky Way visible to the naked eye and the only other giant galaxy in the local group.

This is the sharpest visible-light image ever made of the nucleus of an external galaxy.




***This is a Hubble image of the 100-million-solar-mass black hole at the hub of the neighboring spiral galaxy M31, or the Andromeda galaxy. The compact cluster of blue stars is surrounded by the larger "double nucleus" of M31. The double nucleus is actually an elliptical ring of old reddish stars in orbit around the black hole but more distant than the blue stars. Credit: NASA, ESA, and T. Lauer (National Optical Astronomy Observatory)***

The event horizon, the closest region around the black hole where light can still escape, is too small to be seen, but it lies near the middle of a compact cluster of blue stars at the center of the image. The compact cluster of blue stars is surrounded by the larger "double nucleus" of M31, discovered with the Hubble Space Telescope in 1992. The double nucleus is actually an elliptical ring of old reddish stars in orbit around the black hole but more distant than the blue stars. When the stars are at the farthest point in their orbit they move slower, like cars on a crowded freeway. This gives the illusion of a second nucleus.

The blue stars surrounding the black hole are no more than 200 million years old, and therefore must have formed near the black hole in an abrupt burst of star formation. Massive blue stars are so short-lived that they would not have enough time to migrate to the black hole if they were formed elsewhere.

Astronomers are trying to understand how apparently young stars were formed so deep inside the black hole's gravitational grip and how they survive in an extreme environment.

The fact that young stars are also closely bound to the central black hole in our Milky Way galaxy suggests this may be a common phenomenon in spiral galaxies.

Tod R. Lauer of the National Optical Astronomy Observatory in Tucson, Ariz., assembled this image of the nuclear region by taking several blue and ultraviolet light exposures of the nucleus with Hubble's Advanced Camera for Surveys high-resolution channel, each time slightly moving the telescope to change how the camera sampled the region. By combining these pictures, he was able to construct an ultra-sharp view of the galaxy's core.

Lauer is presenting these Hubble observations this week at the meeting of the American Astronomical Society in Austin, Texas.

The image of the Andromeda galaxy was taken on Jan. 13, 2001, with the WIYN/KPNO 0.9-meter Mosaic I by T. Rector, University of Alaska in Anchorage.

***Provided by NASA's Goddard Space Flight Center***

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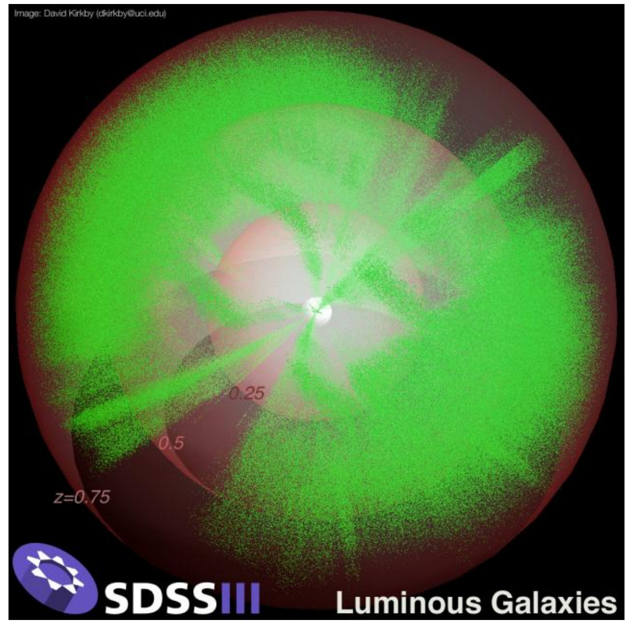
# Calculating what's in the universe from the biggest color 3-D map

Since 2000, the three Sloan Digital Sky Surveys (SDSS I, II, III) have surveyed well over a quarter of the night sky and produced the biggest color map of the universe in three dimensions ever. Now scientists at the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) and their SDSS colleagues, working with DOE's National Energy Research Scientific Computing Center (NERSC) based at Berkeley Lab, have used this visual information for the most accurate calculation yet of how matter clumps together – from a time when the universe was only half its present age until now.

"The way galaxies cluster together over vast expanses of the sky tells us how both ordinary visible matter and underlying invisible dark matter are distributed, across space and back in time," says Shirley Ho, an astrophysicist at Berkeley Lab and Carnegie Mellon University, who led the work. "The distribution gives us cosmic rulers to measure how the universe has expanded, and a basis for calculating what's in it: how much dark matter, how much dark energy, even the mass of the hard-to-see neutrinos it contains. What's left over is the ordinary matter and energy we're familiar with."

For the present study Ho and her colleagues first selected 900,000 luminous galaxies from among over 1.5 million such galaxies gathered by the Baryon Oscillation Spectrographic Survey, or BOSS, the largest component of the still-ongoing SDSS III. Most of these are ancient red galaxies, which contain only red stars because all their faster-burning stars are long gone, and which are exceptionally bright and visible at great distances. The galaxies chosen for this study populate the largest volume of space ever used for galaxy clustering measurements. Their brightness was measured in five different colors, allowing the redshift of each to be estimated.




***The Sloan Digital Sky Survey III surveyed 14,000 square degrees of the sky, more than a third of its total area, and delivered over a trillion pixels of imaging data. This image shows over a million luminous galaxies at redshifts indicating times when the universe was between seven and eleven billion years old, from which the sample in the current studies was selected. Credit: David Kirkby of the University of California at Irvine and the SDSS collaboration***

"By covering such a large area of sky and working at such large distances, these measurements are able to probe the clustering of galaxies on incredibly vast scales, giving us unprecedented constraints on the expansion history, contents, and evolution of the universe," says Martin White of Berkeley Lab's Physics Division, a professor of physics and astronomy at the University of California at Berkeley and chair of the BOSS science survey teams. "The clustering we're now measuring on the largest scales also contains vital information about the origin of the structure we see in our maps, all the way back to the epoch of inflation, and it helps us to constrain – or rule out – models of the very early universe."

After augmenting their study with information from other data sets, the team derived a number of such cosmological constraints, measurements of the universe's contents based on different cosmological models. Among the results: in the most widely accepted model, the researchers found – to less than two percent uncertainty – that dark energy accounts for 73 percent of the density of the universe.

The team's results are presented January 11 at the annual meeting of the American Astronomical Society in Austin, Texas, and have been submitted to the Astrophysical Journal. They are currently available online at http://arxiv.org/abs/1201.2137.

**The power of the universe**

"The way mass clusters on the largest scales is graphed in an angular power spectrum, which shows how matter statistically varies in density across the sky," says Ho. "The power spectrum gives a wealth of information, much of which is yet to be exploited." For example, information about inflation – how the universe rapidly expanded shortly after the big bang – can be derived from the power spectrum.

Closely related to the power spectrum are two "standard rulers," which can be used to measure the history of the expansion of the universe. One ruler has only a single mark – the time when matter and radiation were exactly equal in density.

"In the very early universe, shortly after the big bang, the universe was hot and dominated by photons, the fundamental particles of radiation," Ho explains. "But as it expanded, it began the transition to a universe dominated by matter. By about 50,000 years after the big bang, the density of matter and radiation were equal. Only when matter dominated could structure form."

The other cosmic ruler is also big, but it has many more than one mark in the power spectrum; this ruler is called BAO, for baryon acoustic oscillations. (Here, baryon is shorthand for ordinary matter.) Baryon acoustic oscillations are relics of the sound waves that traveled through the early universe when it was a hot, liquid-like soup of matter and photons. After about 50,000 years the matter began to dominate, and by about 300,000 years after the big bang the soup was finally cool enough for matter and light to go their separate ways.

Differences in density that the sound waves had created in the hot soup, however, left their signatures as statistical variations in the distribution of light, detectable as temperature variations in the cosmic microwave background (CMB), and in the distribution of baryons. The CMB is a kind of snapshot that can still be read today, almost 14 billion years later. Baryon oscillations – variations in galactic density peaking every 450 million light-years or so – descend directly from these fluctuations in the density of the early universe.

BAO is the target of the Baryon Oscillation Spectroscopic Survey. By the time it's completed, BOSS will have measured the individual spectra of 1.5 million galaxies, a highly precise way of measuring their redshifts. The first BOSS spectroscopic results are expected to be announced early in 2012.

Meanwhile the photometric study by Ho and her colleagues deliberately uses many of the same luminous galaxies but derives redshifts from their brightnesses in different colors, extending the BAO ruler back over a previously inaccessible redshift range, from $z = 0.45$ to $z = 0.65$ (z stands for redshift).

"As an oscillatory feature in the power spectrum, not many things can corrupt or confuse BAO, which is why it is considered one of the most trustworthy ways to measure dark energy," says Hee-Jong Seo of the Berkeley Center for Cosmological Physics at Berkeley Lab and the UC Berkeley Department of Physics, who led BAO measurement for the project. "We call BAO a standard ruler for a good reason. As dark energy stretches the universe against the gravity of dark matter, more dark energy places galaxies at a larger distance from us, and the BAO imprinted in their distribution looks smaller. As a standard ruler the true size of BAO is fixed, however. Thus the apparent size of BAO gives us an estimate of the cosmological distance to our target galaxies – which in turn depends on the properties of dark energy."

Says Ho, "Our study has produced the most precise photometric measurement of BAO. Using data from the newly accessible redshift range, we have traced these wiggles back to when the universe was about half its present age, all the way back to $z = 0.54$."

Seo adds, "And that's to an accuracy within 4.5 percent."

**Reining in the systematics**

"With such a large volume of the universe forming the basis of our study, precision cosmology was only possible if we could control for large-scale systematics," says Ho. Systematic errors are those with a physical basis, including differences in the brightness of the sky, or stars that mimic the colors of distant galaxies, or variations in weather affecting "seeing" at the SDSS's Sloan Telescope – a dedicated 2.5 meter telescope at the Apache Point Observatory in southern New Mexico.

After applying individual corrections to these and other systematics, the team cross-correlated the effects on the data and developed a novel procedure for deriving the best angular power-spectrum of the universe with the lowest statistical and systematic errors.

With the help of 40,000 central-processing-unit (CPU) hours at NERSC and another 20,000 CPU hours on the Riemann computer cluster at Berkeley Lab, NERSC's powerful computers and algorithms enabled the team to use all the information from galactic clustering in a huge volume of sky, including the full shape of the power spectrum and, independently, BAO, to get excellent cosmological constraints. The data as well as the analysis output are stored at NERSC.

"Our dataset is purely imaging data, but our results are competitive with the latest large-scale spectroscopic surveys," Ho says. "What we lack in redshift precision, we make up in sheer volume. This is good news for future imaging surveys like the Dark Energy Survey and the Large Synoptic Survey Telescope, suggesting they can achieve significant cosmological constraints even compared to future spectroscopy surveys."

"Clustering of Sloan Digital Sky Survey III photometric luminous galaxies: The measurement, systematics, and cosmological implications," by Shirley Ho, Antonio Cuesta, Hee-Jong Seo, Roland de Putter, Ashley J. Ross, Martin White, Nikhil Padmanabhan, Shun Saito, David J. Schlegel, Eddie Schlafly, Uroŝ Seljak, Carlos Hernández-Monteagudo, Ariel G. Sánchez, Will J. Percival, Michael Blanton, Ramin Skibba, Don Schneider, Beth Reid, Olga Mena, Matteo Viel, Daniel J. Eisenstein, Francisco Prada, Benjamin Weaver, Neta Bahcall, Dimitry Bizyaev, Howard Brewinton, Jon Brinkman, Luiz Nicolaci da Costa, John R. Gott, Elena Malanushenko, Viktor Malanushenko, Bob Nichol, Daniel Oravetz, Kaike Pan, Nathalie Palanque-Delabrouille, Nicholas P. Ross, Audrey Simmons, Fernando de Simoni, Stephanie Snedden,and Christophe Yeche, has been submitted to Astrophysical Journal and is now available online at http://arxiv.org/abs/1201.2137 .

"Acoustic scale from the angular power spectra of SDSS-III DR8 photometric luminous galaxies," by Hee-Jong Seo, Shirley Ho, Martin White, Antonio Cuesta, Ashley Ross, Shun Saito, Beth Reid, Nikhil Padmanabhan, Will J. Percival, Roland de Putter, David Schlegel, Daniel Eisenstein, Xiaoying Xu, Donald Schneider, Ramin Skibba, Licia Verde, Robert Nichol, Dmitry Bizyaev, Howard Brewington, J. Brinkmann, Luiz Costa, J. Gott III, Elena Malanushenko, Viktor Malanushenko, Dan Oravetz, Nathalie Palanque-Delabrouille, Kaike Pan, Francisco Prada, Nicholas Ross, Audrey Simmons, Fernando Simoni, Alaina Shelden, Stephanie Snedden, and Idit Zehavi, has been submitted to Astrophysical Journal and will be available online shortly.

***Provided by Lawrence Berkeley National Laboratory***

# NASA's Chandra Finds Largest Galaxy Cluster in Early Universe

An exceptional galaxy cluster, the largest seen in the distant universe, has been found using NASA's Chandra X-ray Observatory and the National Science Foundation-funded Atacama Cosmology Telescope (ACT) in Chile.

Officially known as ACT-CL J0102-4915, the galaxy cluster has been nicknamed "El Gordo" ("the big one" or "the fat one" in Spanish) by the researchers who discovered it. The name, in a nod to the Chilean connection, describes just one of the remarkable qualities of the cluster, which is located more than seven billion light years from Earth. This large distance means that it is being observed at a young age.

"This cluster is the most massive, the hottest, and gives off the most X-rays of any known cluster at this distance or beyond," said Felipe Menanteau of Rutgers University in New Brunswick, N.J., who led the study.

Galaxy clusters, the largest objects in the universe that are held together by gravity, form through the merger of smaller groups or sub-clusters of galaxies. Because the formation process depends on the amount of dark matter and dark energy in the universe, clusters can be used to study these mysterious phenomena.

Dark matter is material that can be inferred to exist through its gravitational effects, but does not emit and absorb detectable amounts of light. Dark energy is a hypothetical form of energy that permeates all space and exerts a negative pressure that causes the universe to expand at an ever-increasing rate.

"Gigantic galaxy clusters like this are just what we were aiming to find," said team member Jack Hughes, also of Rutgers. "We want to see if we understand how these extreme objects form using the best models of cosmology that are currently available."

Although a cluster of El Gordo's size and distance is extremely rare, it is likely that its formation can be understood in terms of the standard Big Bang model of cosmology. In this model, the universe is composed predominantly of dark matter and dark energy, and began with a Big Bang about 13.7 billion years ago.

The team of scientists found El Gordo using ACT thanks to the Sunyaev-Zeldovich effect. In this phenomenon, photons in the cosmic microwave background interact with electrons in the hot gas that pervades these enormous galaxy clusters. The photons acquire energy from this interaction, which distorts the signal from the microwave background in the direction of the clusters. The magnitude of this distortion depends on the density and temperature of the hot electrons and the physical size of the cluster.

X-ray data from Chandra and the European Southern Observatory's Very Large Telescope, an 8-meter optical observatory in Chile, show that El Gordo is, in fact, the site of two galaxy clusters running into one another at several million miles per hour. This and other characteristics make El Gordo akin to the well-known object called the Bullet Cluster, which is located almost 4 billion light years closer to Earth.

As with the Bullet Cluster, there is evidence that normal matter, mainly composed of hot, X-ray bright gas, has been wrenched apart from the dark matter in El Gordo. The hot gas in each cluster was slowed down by the collision, but the dark matter was not.

"This is the first time we've found a system like the Bullet Cluster at such a large distance," said Cristobal Sifon of Pontificia Universidad de Catolica de Chile (PUC) in Santiago. "It's like the expression says: if you want to understand where you're going, you have to know where you've been."

These results on El Gordo are being announced at the 219th meeting of the American Astronomical Society in Austin, Texas. A paper describing these results has been accepted for publication in The Astrophysical Journal.

NASA's Marshall Space Flight Center in Huntsville, Ala., manages the Chandra program for NASA's Science Mission Directorate in Washington. The Smithsonian Astrophysical Observatory controls Chandra's science and flight operations from Cambridge, Mass.

For Chandra images, multimedia and related materials, visit:

http://www.nasa.gov/chandra

For an additional interactive image, podcast and video on the finding, visit:

http://chandra.si.edu

***A composite image shows El Gordo in X-ray light from NASA's Chandra X-ray Observatory in blue, along with optical data from the European Southern Observatory's Very Large Telescope (VLT) in red, green, and blue, and infrared emission from the NASA's Spitzer Space Telescope in red and orange.***

***X-ray data from Chandra reveal a distinct cometary appearance of El Gordo, including two "tails" extending to the upper right of the image. Along with the VLT's optical data, this shows that El Gordo is, in fact, the site of two galaxy clusters running into one another at several million miles per hour. This and other characteristics make El Gordo akin to the well-known object called the Bullet Cluster, which is located almost 4 billion light years closer to Earth.***

***As with the Bullet Cluster, there is evidence that normal matter, mainly composed of hot, X-ray bright gas, has been wrenched apart from the dark matter in El Gordo. The hot gas in each cluster was slowed down by the collision, but the dark matter was not.***

***El Gordo is located over seven billion light years from Earth, meaning that it is being observed at a young age. According to the scientists involved in this study, this cluster of galaxies is the most massive, the hottest, and gives off the most X-rays of any known cluster at this distance or beyond.***

***The central galaxy in the middle of El Gordo is unusually bright and has surprisingly blue colors in optical wavelengths. The authors speculate that this extreme galaxy resulted from a collision and merger between the two galaxies at the center of each cluster.***

***Using Spitzer data and optical imaging it is estimated that about 1% of the total mass of the cluster is in stars, while the rest is found in the hot gas that fills the space between the stars and is detected by Chandra This ratio of stars to gas is similar with results from other massive clusters.***

***Credits: X-ray: NASA/CXC/Rutgers/J. Hughes et al; Optical: ESO/VLT & SOAR/Rutgers/F. Menanteau; IR: NASA/JPL/Rutgers/F. Menanteau***

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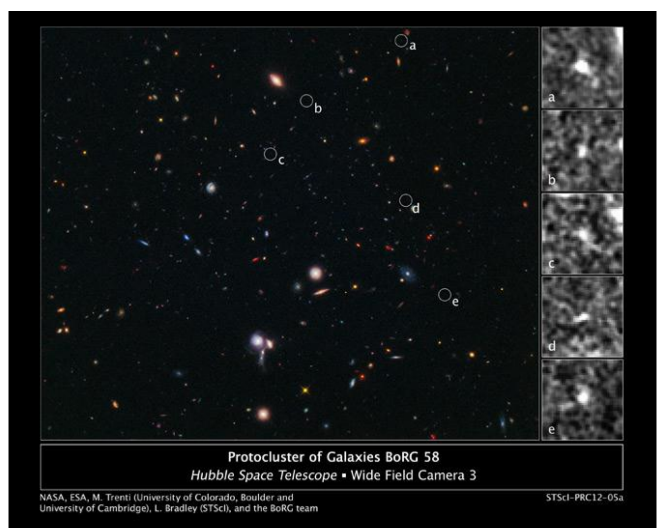
# Hubble Pinpoints Farthest Protocluster of Galaxies Ever Seen

Using NASA's Hubble Space Telescope, astronomers have uncovered a cluster of galaxies in the initial stages of development. It is the most distant such grouping ever observed in the early universe.




***The composite image taken in visible and near-infrared light, reveals the location of five tiny galaxies clustered together 13.1 billion light-years away. The circles pinpoint the galaxies. Credit: NASA, ESA, M. Trenti (University of Colorado, Boulder and Institute of Astronomy, University of Cambridge, U.K.), L. Bradley (Space Telescope Science Institute, Baltimore), and the BoRG team***

In a random sky survey made in near-infrared light, Hubble found five tiny galaxies clustered together 13.1 billion light-years away. They are among the brightest galaxies at that epoch and very young -- existing just 600 million years after the big bang.

Galaxy clusters are the largest structures in the universe, comprising hundreds to thousands of galaxies bound together by gravity. The developing cluster, or protocluster, is seen as it looked 13 billion years ago. Presumably, it has grown into one of today's massive galactic cities, comparable to the nearby Virgo cluster of more than 2,000 galaxies.

"These galaxies formed during the earliest stages of galaxy assembly, when galaxies had just started to cluster together," said Michele Trenti of the University of Colorado at Boulder and the Institute of Astronomy at the University of Cambridge in the United Kingdom. "The result confirms our theoretical understanding of the buildup of galaxy clusters. And, Hubble is just powerful enough to find the first examples of them at this distance."

Trenti presented the results today at the American Astronomical Society meeting in Austin, Texas. The study will be published in an upcoming issue of The Astrophysical Journal.

Most galaxies in the universe reside in groups and clusters, and astronomers have probed many mature galactic cities in detail as far as 11 billion light-years away. Finding clusters in the early phases of construction has been challenging because they are rare, dim and widely scattered across the sky.

"We need to look in many different areas because the odds of finding something this rare are very small," said Trenti, who used Hubble's sharp-eyed Wide Field Camera 3 (WFC3) to pinpoint the cluster galaxies. "The search is hit and miss. Typically, a region has nothing, but if we hit the right spot, we can find multiple galaxies."

Hubble’s observations demonstrate the progressive buildup of galaxies. They also provide further support for the hierarchical model of galaxy assembly, in which small objects accrete mass, or merge, to form bigger objects over a smooth and steady but dramatic process of collision and collection.

Because the distant, fledgling clusters are so dim, the team hunted for the systems' brightest galaxies. These galaxies act as billboards, advertising cluster construction zones. From computer simulations, the astronomers expect galaxies at early epochs to be clustered together. Because brightness correlates with mass, the most luminous galaxies pinpoint the location of developing clusters. These powerful light beacons live in deep wells of dark matter, an invisible form of matter that makes up the underlying gravitational scaffolding for construction. The team expects many fainter galaxies that were not seen in these observations to inhabit the same neighborhood.

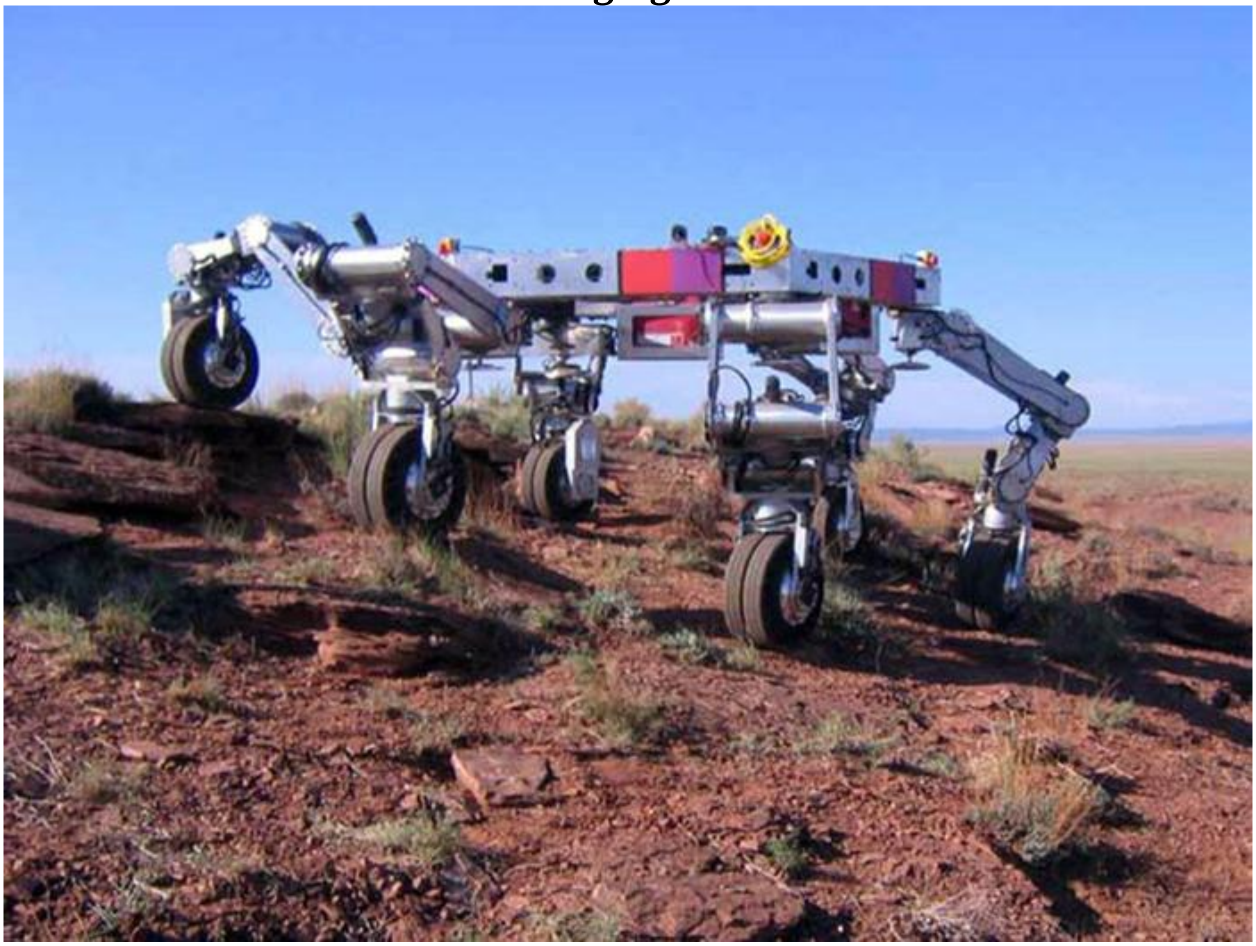
The five bright galaxies spotted by Hubble are about one-half to one-tenth the size of our Milky Way, yet are comparable in brightness. The galaxies are bright and massive because they are being fed large amounts of gas through mergers with other galaxies. The team's simulations show that the galaxies eventually will merge and form the brightest central galaxy in the cluster, a giant elliptical similar to the Virgo Cluster's M87.

The observations are part of the Brightest of Reionizing Galaxies survey, which uses Hubble's WFC3 to search for the brightest galaxies around 13 billion years ago, when light from the first stars burned off a fog of cold hydrogen in a process called reionization.

The team estimated the distance to the newly found galaxies based on their colors, but the astronomers plan to follow up with spectroscopic observations, which measure the expansion of space. Those observations will help astronomers precisely calculate the cluster's distance and yield the velocities of the galaxies, which will show whether they are gravitationally bound to each other.

The Hubble Space Telescope is a project of international cooperation between NASA and the European Space Agency. NASA's Goddard Space Flight Center in Greenbelt, Md., manages the telescope. The Space Telescope Science Institute (STScI) in Baltimore conducts Hubble science operations. STScI is operated for NASA by the Association of Universities for Research in Astronomy, Inc., in Washington.

# Year of the Solar System
## Far-Ranging Robots



***The All-Terrain Hex-Legged Extra-Terrestrial Explorer, known as ATHLETE, is a six-legged robotic lunar rover under development by NASA.***

Struggling to continue working under a sizzling sun, crawling along despite intense temperature extremes and scouring winds, or flying at record-breaking speeds -- just as intrepid explorers have braved harsh circumstances on Earth, our robotic missions have faced extreme conditions at other worlds! Scientists and engineers continue to find creative solutions to the challenges presented by conditions in our solar system.

**The Robots That Keep Going and Going**
The rovers Spirit and Opportunity landed on Mars in January 2004 for a three month mission. Spirit continued functioning for 6 years, and Opportunity is still at work today!

The MESSENGER robotic mission in orbit around Mercury faces intense heat due to the proximity of the sun. The current Mars rovers and the future rover Curiosity struggle with temperature variations from 35 to -90 degrees Celsius. In order to reach two different asteroids and go into orbits around each, the Dawn spacecraft is propelled by ion thrusters, performing a change in velocity of over 10 km/s, more than any other spacecraft has done after separation from its launch rocket. The electronics onboard the Juno robotic mission to Jupiter are shielded from the high speed particles accelerated by the powerful magnetic field that surrounds Jupiter.

The robotic technologies that we build to withstand these environments and study these distant worlds are also useful back home. Robotic spinoffs have been used to search dangerous or inaccessible areas here on Earth. Designed features can be useful for police, rescue and emergency personnel.
Join us this month, as we celebrate National Engineers Week, and explore the variety of robotic spacecraft in our solar system!

**2012 Feb. Celestial Events:** supplied by J. Randolph Walton (Randy)

| **Day** | **Date** | **Time (EDT)** | **Event** |
|---|---|---|---|
| Sat | 4 | 07:06 | Sunrise |
| | | 14:17 | Moon rise |
| | | 17:22 | Sunset |
| | | 20:10 | Mars Rises |
| | | 20:45 | Venus Sets |
| | | 23:20 | Saturn Rises |
| | | 23:50 | Jupiter Sets |
| Tue | 7 | 16:54 | **Full Moon** |
| | | 17:34 | Moon rise |
| Fri | 10 | After 19:00 | **Zodiacal Light** visible in W after evening twilight for next two weeks |
| Sat | 11 | 06:58 | Sunrise |
| | | 17:31 | Sunset |
| | | 17:45 | Mercury Sets |
| | | 19:35 | Mars Rises |
| | | 21:00 | Venus Sets |
| | | 22:15 | Moon rise |
| | | 22:50 | Saturn Rises |
| | | 23:25 | Jupiter Sets |
| Tue | 14 | 10:38 | Moon Set |
| | | 12:04 | **Last Quarter Moon** |
| Sat | 18 | 06:50 | Sunrise |
| | | 14:33 | Moon Set |
| | | 17:39 | Sunset |
| | | 18:25 | Mercury Sets |
| | | 19:00 | Mars Rises |
| | | 21:15 | Venus Sets |
| | | 22:25 | Saturn Rises |
| | | 23:05 | Jupiter Sets |
| Tue | 21 | 17:35 | **New Moon** |
| | | 17:47 | Moon Set |
| Sat | 25 | 06:40 | Sunrise |
| | | 17:47 | Sunset |
| | | 18:20 | Mars Rises |
| | | 19:05 | Mercury Sets |
| | | 21:25 | Venus Sets |
| | | 21:46 | Moon Set |
| | | 21:55 | Saturn Rises |
| | | 22:40 | Jupiter Sets |
| Wed | 29 | 10:23 | Moon rise |
| | | 20:21 | **First Quarter Moon** |
| **Sat** | **Mar 3** | **All night** | **Mars at opposition, largest apparent size in 2012** |
| | | | |
| | | | |

# In the Eyepiece

Here is a list of objects for this month. This is reproduced from www.skyhound.com with the kind permission of its creator and author of SkyTools Greg Crinklaw.

| Object(s) | Class | Con | RA | Dec | Mag |
|---|---|---|---|---|---|
| NGC 1501 | Planetary Nebula | Camelopardus | 04h06m59.4s | +60°55'14" | 13.3 |
| Cleopatra's Eye | Planetary Nebula | Eridanus | 04h14m15.8s | -12°44'21" | 9.6 |
| The California Nebula | Diffuse Nebula | Perseus | 04h03m12.0s | +36°22'00" | 5.0 |
| NGC 1664 | Open Cluster | Auriga | 04h51m04.4s | +43°42'04" | 7.2 |
| MSH 04-12 | Quasar | Eridanus | 04h07m48.4s | -12°11'36" | 14.8 |
| NGC 1360 | Planetary Nebula | Fornax | 03h33m14.6s | -25°52'18" | 9.6 |
| Crystal Ball | Planetary Nebula | Taurus | 04h09m17.0s | +30°46'33" | 10.0 |
| Palomar 2 | Globular Cluster | Auriga | 04h46m06.0s | +31°22'54" | 13.0 |
| K 2-1 | Planetary Nebula | Auriga | 05h07m07.1s | +30°49'18" | 13.8 |
| NGC 1624 | Open Cluster | Perseus | 04h40m25.4s | +50°26'49" | 11.8 |

Coordinates are epoch 2000.0