

and he has made subservient for you the night and the day and the sun and the moon, and the stars are made subservient by his commandment; most surely there are signs in this for a people who ponder

Holy Qur'an
16:12

A. R. C. NEWS

Latest Astronomical News on the Internet

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'Lego-block' galaxies found in early universe

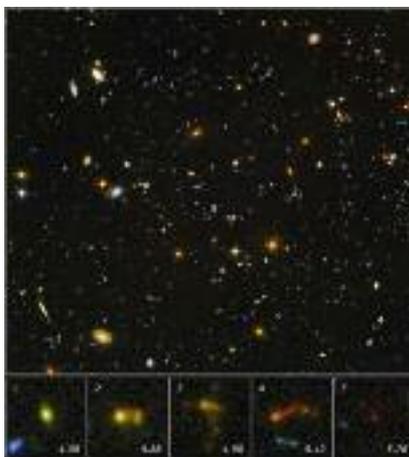
NASA's Hubble and Spitzer space telescopes have joined forces to discover nine of the smallest, faintest, most compact galaxies ever observed in the distant universe. Blazing with the brilliance of millions of stars, each of the newly discovered galaxies is 100 to 1,000 times smaller than our Milky Way galaxy.

"These are among the lowest mass galaxies ever directly observed in the early universe," said Nor Pirzkal of the Space Telescope Science Institute in Baltimore, Md.

The conventional model for galaxy evolution predicts that small galaxies in the early universe evolved into the massive galaxies of today by coalescing. These nine Lego-like "building block" galaxies initially detected by Hubble likely contributed to the construction of the universe as we know it.

Pirzkal was surprised to find that the galaxies' estimated masses were so small. Hubble's cousin observatory, Spitzer, was called upon to make precise determinations of their masses. The Spitzer observations confirmed that these galaxies are some of the smallest building blocks of the universe.

These young galaxies offer important new insights into the



of the investigators.

The galaxies were first identified by James Rhoads of Arizona State University and Chun Xu of the Shanghai Institute of Technical Physics in Shanghai, China, by their prominent and energetic light coming from glowing hydrogen. Three of the galaxies appear to be slightly disrupted; rather than being shaped like rounded blobs, they appear stretched into tadpole-like shapes. This is a sign that they may be interacting and merging with neighboring galaxies to form larger, cohesive structures.

The galaxies were observed in the well-known Hubble Ultra Deep Field with Hubble's Advanced Camera for Surveys and the Near Infrared Camera and Multi-object Spectrometer. Observations were also done with Spitzer's Infrared Array Camera and the European Southern Observatory's Infrared Spectrometer and Array Camera.

Pirzkal's main collaborators were Malhotra, Rhoads, Xu and the Grism Advanced Camera for Surveys Program for Extragalactic Science team.

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www.nasa.gov

universe's formative years, just one billion years after the Big Bang. Hubble detected sapphire blue stars residing within the nine pristine galaxies. The youthful stars are just a few million years old and are in the process of turning Big Bang elements, primarily hydrogen and helium, into heavier elements. The stars have probably not yet begun to pollute the surrounding space with elemental products forged within their cores.

"While blue light seen by Hubble shows the presence of young stars, it is the absence of red light in the sensitive Spitzer images that was conclusive in showing that these are truly young galaxies without an earlier generation of stars," says Sangeeta Malhotra of Arizona State University in Tempe, Ariz., one



Black holes in feeding frenzy

The merging of two galaxies has long been thought to be an efficient way of driving gas deeply into a galaxy to feed the central black hole, but there was only indirect evidence for such a mechanism until now.

Two University of Hawaii astronomers using the Hubble Space Telescope believe they have identified what makes at least some quasars shine: the black hole at the center of a massive galaxy with little gas of its own is gobbling up material from a colliding gas-rich galaxy. The merging of two galaxies has long been thought to be an efficient way of driving gas deeply into a galaxy to feed the central black hole, but there was only indirect evidence for such a mechanism until now.

It was already known that quasars, which are among the most powerful objects in the Universe, lie

Fu and Stockton also see a chaotic distribution of fast-moving patches of relatively pure hydrogen and helium scattered around the quasar, implying that black holes not only swallow things, but can also expel a large portion of their meal out to thousands of light-years away, likely through an energetic blast that happened millions of years ago.

at the centers of giant galaxies and consist of a massive black hole surrounded by a vortex of gas. Before the gas falls into the black hole, it spins faster and faster, and its temperature rises until it is hot enough to radiate up to a trillion times the power from the Sun.

The question that graduate student Hai Fu and astronomer Alan Stockton tried to answer is, "Where is the gas coming from?"

To answer the question, Fu and Stockton used a telescope-mounted spectroscope to find out what the gas is made of. "We found that the gas that is spiraling into the black hole is almost

pure hydrogen and helium, whereas the stars and other material in the surrounding giant galaxy are heavily contaminated by other elements such as carbon and oxygen," said Fu.

This difference implies that the infalling gas has recently come

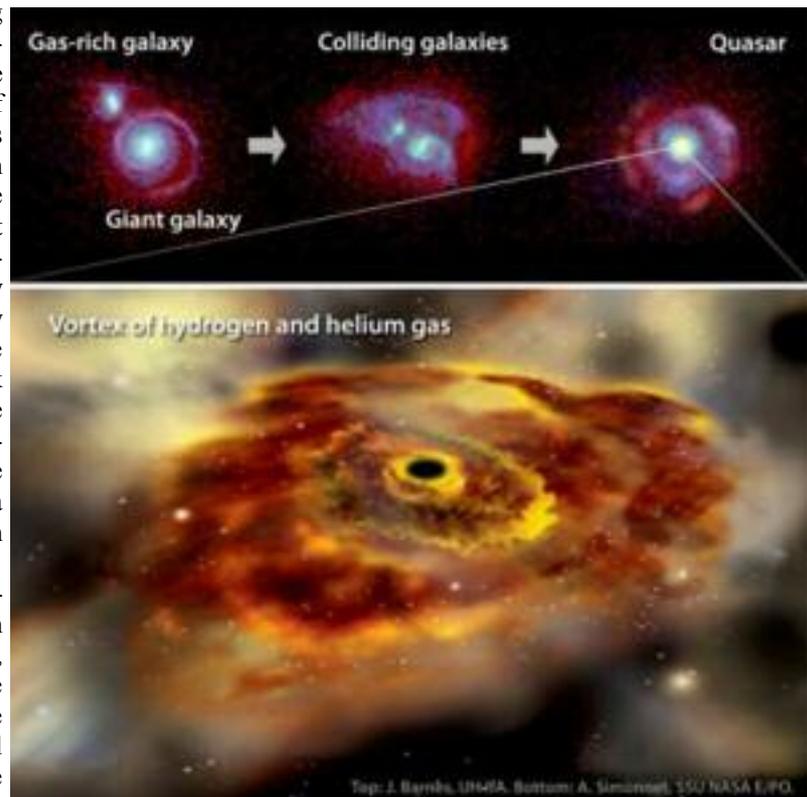
around Earth, and from the telescopes on Mauna Kea, the Big Island. Their work has been published in the August 1 issue of the *Astrophysical Journal Letters*.

The Institute for Astronomy at the University of Hawaii conducts research into galaxies, cosmology, stars, planets, and the sun. Its faculty and staff are also involved in astronomy education, deep space missions, and in the development and management of the observatories on Haleakala and Mauna Kea.

Established in 1907 and fully accredited by the Western As-

sociation of Schools and Colleges, the University of Hawaii is the state's sole public system of higher education. The UH System provides an array of undergraduate, graduate, and professional degrees and community programs on 10 campuses and through educational, training, and research centers across the state. UH enrolls more than 50,000 students from Hawaii, the U.S. mainland, and around the world.

September 2, 2007
ifa.hawaii.edu



Top: J. Barvainis, UH/IA. Bottom: A. Simonnet, LSU/NASA EPO.

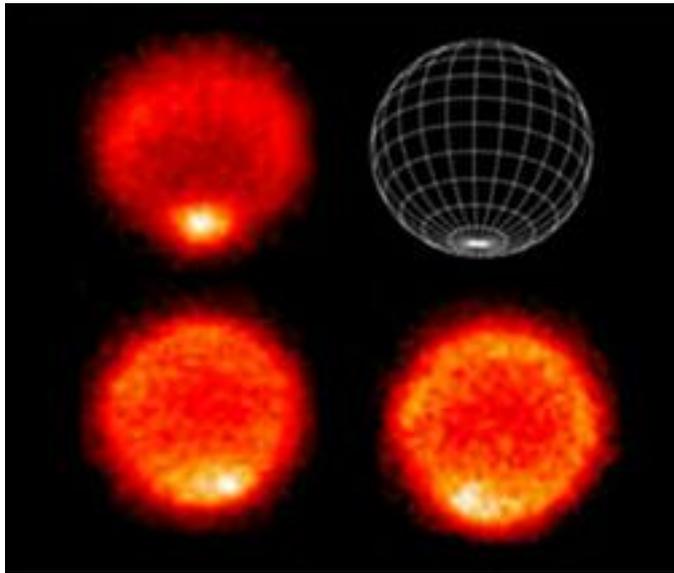
from outside the galaxy, most likely from another galaxy that is merging with the giant one. Fu and Stockton also see a chaotic distribution of fast-moving patches of relatively pure hydrogen and helium scattered around the quasar, implying that black holes not only swallow things, but can also expel a large portion of their meal out to thousands of light-years away, likely through an energetic blast that happened millions of years ago.

Fu and Stockton did their research at the UH Institute for Astronomy in Manoa valley using data from the Hubble Space Telescope, which is in orbit

A warm south pole? Yes, on Neptune!

An international team of astronomers has discovered that Neptune's south pole is much hotter than the rest of the planet. They have published the first temperature maps of the lowest portion of Neptune's atmosphere, which show that this warm south pole is providing an avenue for methane to escape out of the deep atmosphere.

"The temperatures are so high that methane gas, which should be frozen out in the upper part of Neptune's atmosphere, can leak out through this region," said Glenn Orton of NASA's Jet Propulsion Laboratory, Pasadena, Calif. Orton is lead author of a paper appearing in the Sept. 18 issue of the journal *Astronomy and Astrophysics*. These findings were made using the Very



Large Telescope, located in Chile, operated by the European Organization for Astronomical Research in the Southern Hemisphere (known as ESO).

In the paper, Orton and his colleagues report that the temperature at Neptune's south pole is hotter than anywhere else on the planet by about 10 degrees Celsius (18 degrees Fahrenheit). The average temperature on Neptune is about minus 200 degrees Celsius (minus 392 degrees Fahrenheit).

Neptune, the farthest known planet of our solar system, is located about 30 times farther away from the sun than Earth is. Only about one thousandth of the sunlight received by our planet reaches Neptune. Yet, the small amount of sunlight Neptune does receive significantly affects the planet's atmosphere.

The astronomers found that these temperature variations are consistent with seasonal changes. A Neptunian year lasts about 165 Earth years. It has been summer in the south pole of Neptune for about 40 years now, and they predict that as winter turns to summer at the north pole, an abundance of methane would

leak out of a warm north pole in about 80 years.

"Neptune's south pole is currently tilted toward the sun, just as the Earth's south pole is tilted toward sun during summer in the southern hemisphere," explains Orton. "But on Neptune the antarctic summer lasts 40 years instead of a few months, and a lot of solar energy input during that time can make big temperature differences between the regions in continual sunlight and those with day-night variations. This is a likely factor in Neptune having the strongest winds of any planet in the solar system; sometimes, the wind blows there at more than 2,000 kilometers per hour [240 miles per hour]," said Orton.

The new observations also reveal mysterious high-latitude "hot spots" in the stratosphere

that have no immediate analogue in other planetary atmospheres. The astronomers think this feature was generated by upwelling gas from much deeper in the atmosphere.

Methane is not the primary constituent of Neptune's atmosphere, which, as a giant planet, is mostly composed of the light gases, hydrogen and helium. But it is the methane in Neptune's upper atmosphere that absorbs the red light from the sun and reflects the blue light from the sun back into space, making Neptune appear blue.

The new results were obtained with the Very Large Telescope and spectrometer for the mid-infrared, operated by the European Organization for Astronomical Research in the Southern Hemisphere (known as ESO).

In addition to Orton, the team of astronomers includes Cédric Leyrat and A. James Friedson of JPL; Thérèse Encrenaz of Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique, Paris, France; and Richard Puetter of the Center for Astrophysics and Space Sciences, University of California, San Diego.

JPL is managed for NASA by the California Institute of Technology in Pasadena.

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jpl.nasa.gov

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Scientists model cornucopia of Earth-sized planets

The team calculated how gravity would compress planets of varying compositions. The resulting computer models predict a planet's diameter for a given composition and mass. For example, a 1-Earth-mass planet made of pure water will be about 9,500 miles across, whereas an iron planet with the same mass will be only about 3,000 miles in diameter.

"All materials compress in a similar way because of the structure of solids," explains Seager. "If you squeeze a rock, nothing much happens until you reach some critical pressure, then it crushes. Planets behave the same way, but they react at different pressures depending on the composition. This is a big step forward in our fundamental understanding of planets."

In the Star Wars movies fictional planets are covered with forests, oceans, deserts, and volcanoes. But new models from a team of MIT, NASA, and Carnegie scientists begin to describe an even wider range of Earth-size planets that astronomers might actually be able to find in the near future.

Sara Seager, Massachusetts Institute of Technology, Cambridge, Mass.; Marc Kuchner, NASA Goddard Space Flight Center, Greenbelt, Md.; Catherine Hier-Majumder, Carnegie Institution of Washington, (deceased); and Burkhard Militzer, Carnegie, have created models for 14 different types of solid planets that might exist in our galaxy. The 14 types have various compositions, and the team calculated how large each planet would be for a given mass. Some are pure water ice, carbon, iron, silicate, carbon monoxide, and silicon carbide; others are mixtures of these various compounds.

"We're thinking seriously about the different kinds of roughly Earth-size planets that might be out there, like George Lucas, but for real," says Kuchner.

The team took a different approach from previous studies. Rather than assume that planets around other stars are scaled-up or scaled-down versions of the planets in our solar system, they considered all types of planets that might be possible, given what astronomers know about the composition of protoplanetary disks around young stars.

"We have learned that extrasolar giant planets often differ tremendously from the worlds in our solar system, so we let our imaginations run wild and tried to cover all the bases with our models of smaller planets," says Kuchner. "We can make edu-

cated guesses about where these different kinds of planets might be found. For example, carbon planets and carbon-monoxide planets might favor evolved stars such as white dwarfs and pulsars, or they might form in carbon-rich



disks like the one around the star Beta Pictoris. But ultimately, we need observations to give us the answers."

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Some of the results were expected, such as the fact that pure water planets (similar to the moons of the outer planets in our solar system, which consist mostly of water ice) were the least dense of the solid planets, and pure iron planets are the most dense. But there were some surprises. The team discovered that no matter what material a planet is made of, the mass/diameter relationship follows a similar pattern.

"All materials compress in a similar way because of the structure of solids," explains Seager. "If you squeeze a rock, nothing much happens until you reach some critical pressure, then it crushes. Planets behave the same way, but they react at different pressures depending on the composition. This is a big step forward in our fundamental understanding of planets."

The team hopes that these models will yield insights into planet compositions when astronomers start finding Earth-sized planets around other stars. Missions such as the French Corot satellite, which launched on December 27, 2006, and NASA's Kepler spacecraft, scheduled to launch in 2009, can find planets not much larger than Earth by watching them pass in front of their host stars, events known as transits. The transits yield the planet's size, and follow-up studies can measure the mass. By comparing a planet's size and mass, astronomers might be able to determine whether it is mostly water ice or mostly iron, for example.

But astronomers using the transit method will find it difficult at best to distinguish a silicate planet from a carbon planet, because they're about the same size for a given mass. "To make this finer distinction, we will need some help from NASA's James Webb Space Telescope or Terrestrial Planet Finder," says Kuchner. "With these instruments, we could take spectra of Earth-mass planets, which will tell us about their chemistries."

The team's paper is currently scheduled to appear in the October 20 issue of the *Astrophysical Journal*.

September 24, 2007
www.nasa.gov

Orphan stars discovered in long galaxy tail

Astronomers have found evidence that stars have been forming in a long tail of gas that extends well outside its parent galaxy. This discovery suggests that such "orphan" stars may be much more prevalent than previously thought.

The comet-like tail was observed in X-ray light with NASA's Chandra X-ray Observatory and in optical light with the Southern Astrophysical Research (SOAR) telescope in Chile. The feature extends for more than 200,000 light years and was created as gas was stripped from a galaxy called ESO 137-001 that is plunging toward the center of Abell 3627, a giant cluster of galaxies.

"This is one of the longest tails like this we have ever seen," said Ming Sun of Michigan State University, who led the study. "And, it turns out that this is a giant wake of creation, not of destruction."

The observations indicate that the gas in the tail has formed millions of stars. Because the large amounts of gas and dust needed to form stars are typically found only within galaxies, astronomers have previously thought it unlikely that large numbers of stars would form outside a galaxy.

"This isn't the first time that stars have been seen to form between galaxies," said team member Megan Donahue, also of MSU. "But the number of stars forming here is unprecedented."

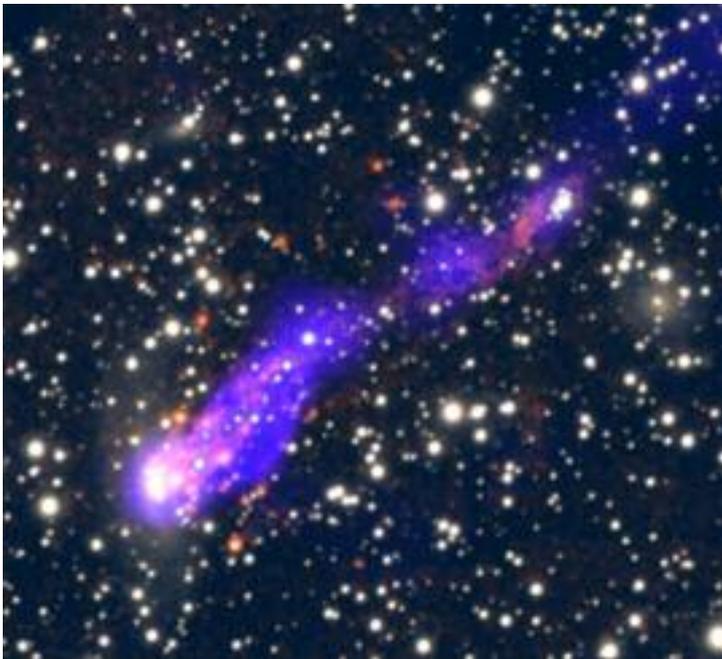
The evidence for star formation in this tail includes 29 regions of

ionized hydrogen glowing in optical light, thought to be from newly formed stars. These regions are all downstream of the galaxy, located in or near the tail. Two Chandra X-ray sources are near these regions, another indication of star formation activity. The researchers believe the orphan stars formed within the last 10 million years or so.

The stars in the tail of this fast-moving galaxy, which is some 220 million light years away,

cluster. Eventually most of the gas will be scoured from the galaxy, depleting the raw material for new stars, and effectively stopping further star formation in the galaxy.

This process may represent an important but short-lived stage in the transformation of a galaxy. Although apparently rare in the present-day universe, galactic tails of gas and orphan stars may have been more common billions of years ago when galaxies were



younger and richer in star-forming gas. These results will appear in the December 10th issue of The Astrophysical Journal. NASA's Marshall Space Flight Center, Huntsville, Ala., manages the Chandra program for the agency's Science Mission Directorate. The Smithsonian Astrophysical

Observatory controls science and flight operations from the Chandra X-ray Center in Cambridge, Mass. The SOAR (Southern Astrophysical Research Telescope) is a joint project of Michigan State University, Conselho Nacional de Pesquisas Científicas e Tecnológicas (CNPq-Brazil), The University of North Carolina at Chapel Hill, and the National Optical Astronomy Observatory.

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chandra.harvard.edu

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Shining light on objects 'weirder than black holes'

Researchers from Duke University and the University of Cambridge think there is a way to determine whether some black holes are not actually black.

Finding such an unmasked form of what physicists term a singularity "would shock the foundation of general relativity," said Arlie Petters, a Duke professor of mathematics and physics who worked with Marcus Werner, Cambridge graduate student in astrophysics, on a report posted online Monday, Sept. 24, for the research journal *Physical Review D*.

"It would show that nature has surprises even weirder than black holes," Petters added.

Albert Einstein originally theorized that stars bigger than the sun can collapse and compress into singularities, entities so confining and massively dense that the laws of physics break down inside them.

Astronomers have since found indirect evidence for these entities, which are popularly known as black holes because of the "cosmic censorship conjecture." This conjecture is that "realistic" singularities -- meaning those that can be formed in nature -- must always hide within a barrier known as an "event horizon" from which light can never escape. That makes them appear perpetually black to the rest of the universe.

But cosmic censorship is "an open conjecture that is very difficult to prove, and very difficult to disprove," said Petters.

And, despite the general support for the universality of black holes, Kip Thorne and John Preskill, two experts in the cosmology of relativity at the California Institute of Technology, have suggested for more than a decade that naked singularities could exist in certain instances. Now

Petters and Werner have devised a way to test for their presence.

Astronomers cannot say for sure whether all black holes are actually black, having never fully penetrated the obscuring outward matter surrounding such objects, Petters said. As their main evidence, scientists can only point to effects that the massive gravitational pull of certain unseen entities exert on surrounding matter. Those effects include emissions of highly energetic radiation, or the extreme orbits of nearby stars.

Petters is an expert in "gravitational lensing," another effect of relativity that permits massive sources of gravity to split light from background astronomical features into multiple images.

In earlier reports in the November, 2005 and February, 2006 issues of *Physical Review D*, he and Charles Keeton of Rutgers University suggested a way to use gravitational lensing to show whether cosmic censorship can ever be violated.

However, that evaluation was limited to non-spinning singularities that are considered only theoretically possible. The suspected singularities astronomers have found in space so far all appear to be rapidly spinning, sometimes at more than 1,000 times a second.

So Petters and Werner teamed up to see if they could generalize such an application of gravitational lensing to all realistic spinning singularities. Their surprising result was yes, Petters said.

In work supported by the National Science Foundation in the United States and the Science and Technology Facilities Council in the United Kingdom, the pair employed a finding that a black hole could be shed of its event horizon and become a na-

ked singularity if its angular momentum -- an effect of its spin -- is greater than its mass.

That would translate into a spin of a few thousand rotations a second in the case of a black hole weighing about 10 times more than our Sun, said Werner.

In the event that the required conditions were met, Petters' and Werner's calculations show that a naked singularity's massive gravitation would split the light of background stars or galaxies in telltale ways that are potentially detectable by astronomers using existing or soon-to-be instruments.

Those possible ways are outlined by six different equations in their study that connect a singularity's spin to the separations, angular alignments and brightness of the two split images.

"If you ask me whether I believe that naked singularities exist, I will tell you that I'm sitting on the fence," said Petters. "In a sense, I hope they are not there. I would prefer to have covered-up black holes. But I'm still open-minded enough to entertain the 'otherwise' possibility."

September 26, 2007
www.dukenews.duke.edu

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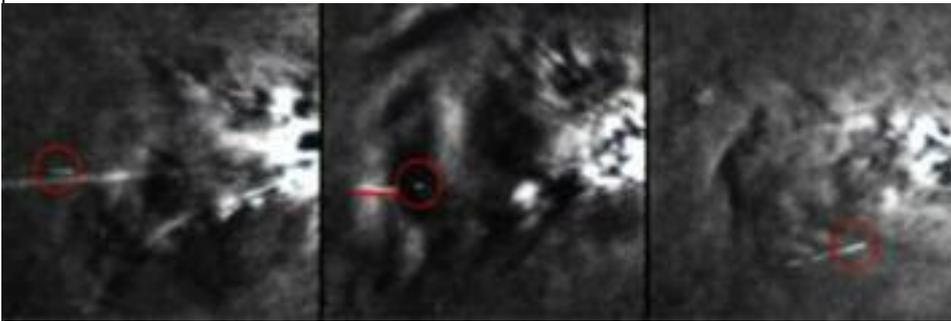
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Satellite sees solar hurricane detach comet tail

A NASA satellite has captured the first images of a collision between a comet and a solar hurricane. It is the first time scientists have witnessed such an event on another cosmic body. One of NASA's pair of Solar Terrestrial Relations Observatory satellites, known as STEREO, recorded the event April 20.

Halley's comet was the first. Scientists at the Naval Research Laboratory made the observations using the Heliospheric Imager in its Sun Earth Connection Coronal and Heliospheric Investigation telescope suite aboard the STEREO-A spacecraft. The results will be published in the Oct. 10 issue of the

the disconnection likely is triggered by what is known as magnetic reconnection, in which the oppositely directed magnetic fields around the comet are crunched together by the magnetic fields in the coronal mass ejection. The comet fields suddenly link together, reconnecting, to release a burst of energy that detaches the comet's tail. A similar process takes place in Earth's magnetosphere during geomagnetic storms, powering the aurora borealis and other phenomena.



The phenomenon was caused by a coronal mass ejection, a large cloud of magnetized gas cast into space by the sun. The collision resulted in the complete detachment of the plasma tail of Encke's comet. Observations of the comet reveal the brightening of its tail as the coronal mass ejection swept by and the tail's subsequent separation as it was carried away by the front of the ejection. The researchers combined the images into a movie.

"We were awestruck when we saw these images," says Angelos Vourlidas, lead author and researcher at the Naval Research Laboratory, Washington. "This is the first time we've witnessed a collision between a coronal mass ejection and a comet and the surprise of seeing the disconnection of the tail was the icing on the cake."

Encke's comet was traveling within the orbit of Mercury when a coronal mass ejection first crunched the tail then ripped it completely away. The comet is only the second repeating, or periodic, comet ever identified.

Astrophysical Journal Letters. Coronal mass ejections are violent eruptions with masses greater than a few billion tons. They travel from 60 to more than 2,000 miles per second. They have been compared to hurricanes because of the widespread disruption they can cause when directed at Earth. These solar hurricanes cause geomagnetic storms that can present hazards for satellites, radio communications and power systems. However, coronal mass ejections are spread over a large volume of space, mitigating their mass and power to create an impact softer than a baby's breath.

Scientists have been aware of the disconnection of the entire plasma tail of a comet for some time, but the conditions that lead to these events remained a mystery. It was suspected that coronal mass ejections could be responsible for some of the disconnected events, but the interaction between a coronal mass ejection and a comet never had been observed.

Preliminary analysis suggests

Comets are icy leftovers from the solar system's formation billions of years ago. They usually reside in the cold, distant regions of the solar system. Occasionally, the gravitational tug from a planet, another comet or a nearby star sends a comet into the inner solar system, where the sun's heat and radiation vaporizes gas and dust from the comet to form its tail. Comets typically have two tails: one of dust and a fainter one of electrically conducting gas called plasma.

"Even though STEREO is primarily designed to study coronal mass ejections, particularly their impact on Earth, we hope this impact will provide many insights to scientists studying comets," said Michael Kaiser, STEREO project scientist at NASA's Goddard Space Flight Center, Greenbelt, Md.

October 01, 2007
www.nasa.gov

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Some of the activities:

- ◆ Educational Facilities
- ◆ Research Facilities
- ◆ Receive and Transmit Atomic-Clock waves
- ◆ Institution of a virtual observatory
- ◆ Cosmic radio observation project
- ◆ Calculation and distribution of timings of religious duties
- ◆ Organizing scientific conferences with invitations to scholars and experts
- ◆ Publishing new titles on the field of Astronomy
- ◆ Building an observatory and a big planetarium

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SPECIAL REPORT

Conditions found 'just right' for building an Earth

An Earth-like planet is likely forming 424 light-years away in a star system called HD 113766, say astronomers using NASA's Spitzer Space Telescope.

Scientists have discovered a huge belt of warm dust - enough to build a Mars-size planet or larger - swirling around a distant star that is just slightly more massive than our sun. The dust belt, which they suspect is clumping together into planets, is located in the middle of the system's terrestrial habitable zone. This is the region around a star where liquid water could exist on any rocky planets that might form. Earth is located in the middle of our sun's terrestrial habitable zone.

At approximately 10 million years old, the star is also at just the right age for forming rocky planets.

"The timing for this system to be building an Earth is very good," says Dr. Carey Lisse, of the Johns Hopkins University Applied Physics Laboratory, Laurel, Md. "If the system was too young, its planet-forming disk would be full of gas, and it would be making gas-giant planets like Jupiter instead. If the system was too old, then dust aggregation or clumping would have already occurred and all the system's rocky planets would have already formed."

According to Lisse, the conditions for forming an Earth-like planet are more than just being in the right place at the right time and around the right star - it's also about the right mix of dusty materials.

Using Spitzer's infrared spectrometer instrument, he determined that the material in HD 113766 is more processed than the snowball-like stuff that makes up infant solar systems and comets, which are considered cosmic "refrigerators" because they contain pristine ingredients from the early solar system. However, it is also not as processed as the stuff found in mature planets and the largest asteroids. This means the dust belt must be in a transitional phase, when rocky planets are just beginning to form.

How do scientists know the material is more processed than that of comets? From missions like NASA's Deep Impact - in which an 820-pound impactor spacecraft collided with comet Tempel 1 - scientists know that early star systems contain a lot of fragile organic material. That material includes polycyclic aromatic hydrocarbons (carbon-based molecules found on charred barbecue grills and automobile exhaust on Earth), water ice, and carbonates (chalk). Lisse says that HD 113766 does not contain any water ice, carbonates or fragile organic materials.

From meteorite studies on Earth, scientists also have a good idea of what makes up asteroids - the more processed rocky leftovers of planet formation. These studies tell us that metals began separating from rocks in Earth's early days, when the planet's body was completely molten. During this time, almost all the heavy metals fell to Earth's center in a process called "differentiation." Lisse says

that, unlike planets and asteroids, the metals in HD 113766 have not totally separated from the rocky material, suggesting that rocky planets have not yet formed.

"The material mix in this belt is most reminiscent of the stuff found in lava flows on Earth. I thought of Mauna Kea material when I first saw the dust composition in this system - it contains raw rock and is abundant in iron sulfides, which are similar to fool's gold," says Lisse, referring to a well-known Hawaiian volcano.

"It is fantastic to think we are able to detect the process of terrestrial planet formation. Stay tuned - I expect lots more fireworks as the planet in HD113766 grows," he adds.

Lisse has written a paper (Click here to read Lisse's paper, Circumstellar Dust Created by Terrestrial Planet Formation in HD 113766) on his research that will be published in an upcoming issue of *Astrophysical Journal*; he will also present his findings next week at the American Astronomical Society Division for Planetary Sciences meeting in Orlando, Fla. Lisse's research was funded through a Johns Hopkins Applied Physics Laboratory Stuart S. Janney Fellowship and a Spitzer Space Telescope guest observer grant.

October 01, 2007
www.jhuapl.edu

