The Celestial Mechanic

The Official Newsletter of the Astronomy Associates of Lawrence

Volume 33 Number 06 **June 2007**

Calendar of Events

SUMMER PUBLIC OBSERVING SCHEDULE

EVERY WEDNESDAY

Weather Permitting

June 6—July 18

After the Band Concerts

~9:30 PM

SOUTH PARK

WEST OF MASS. ST.

Downtown Lawrence

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Observing Clubs
Doug Fay

INSIDE THIS ISSUE

Report from the Officers on the MAY Meeting:

Talk about saving the best for last—our last meeting of the semester featured an excellent turnout, including a number of students needing to complete assignments and one new club member. A hearty welcome to **GEORGE BRENNER**, a recent arrival from Oklahoma, where he was also an astro club member. Returning to the presentation, Dave Kolb gave an outstanding tutorial on the dos and don'ts of imaging with a small telescope, the type of equipment and software to look for, while illustrating his presentation with some truly

(Continued on page 2)

Of Local (Galactic) Interest

Solar System Formation—Kelly Beatty, skypub.com

It's an exciting time to be a cosmochemist. State-of-the-art laboratory techniques for analyzing traces of elemental isotopes are now so good that the "born on" date for billion-year-old rocks and minerals can be pinpointed to well within a million years. This kind of precision has opened dramatic new windows on how our solar system came to exist 4,567,200,000 years ago.

Take, for example, the radioisotope iron-60 (^{60}Fe). The discovery that ancient meteorites contained this key geochemical marker, together with aluminum-26 and calcium-41, requires that some violent astrophysical event led to the collapse of the interstellar cloud that formed our solar system. And since ^{60}Fe can *only* be forged during a supernova, for decades theorists have generally agreed that shock waves from the demise of a nearby star triggered the cloud's collapse.

But most likely it didn't happen that way. In the May 25th issue of *Science,* Martin Bizzarro (University of Copenhagen) and five colleagues describe their studies of ^{60}Fe in some of the oldest known meteorites. Iron-60 has a half-life of just 1.5 million years, so Bizzarro and his team assayed the nickel-60 created when the short-lived isotope decayed. Surprisingly, they found that the very oldest meteorites contain vestiges of ^{26}Al but lacked the decayed ^{60}Fe that should have been there. Yet the iron *was* present in meteorites that crystallized about a million years later. By implication, the solar system was already coming together when the putative supernova went "bang!"

So what *did* trigger the cloud's collapse? Several years ago Roger Chevalier (University of Virginia) pointed out that solar system could have garnered its ^{26}Al from matter violently expelled by a huge neighboring star, one dozens of times more massive than our Sun. Such giants burn fast and die young, exploding as supernovas in just a few million years. So this dying star delivered a powerful one-two punch: its ^{26}Al-rich winds jump-started the solar system,

(Continued on page 2)

From the Officers, continued

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astonishing images, many competitive with those obtained by professional observers with significantly larger telescopes. On the local observing front, as many of you have seen through the month of May, observing in Kansas in the summertime can be a frustrating exercise. As we have for the past few years, we will attempt to have public observing downtown (weather permitting) after the summer band concerts every Wed. between June 6 and July 18. The concerts actually begin May 30, but the weather prediction for the first week is rain. We will set up scopes west of Massachusetts St. in South Park around 9-9:15, with a probable observing start at 9:30, when it finally gets dark. If you have the time and/or interest in taking part, please contact Bruce Twarog (btwarog@ku.edu).

COMING EVENTS: The Heart of America Star Party, run by the Astronomical Society of KC, is scheduled for June 12-17. Detailed info on the event can be found at www.hoasp.org or by contacting Dan Johnson at gdj102356@hotmail.com. Brochures are also available for the Nebraska Star Party, scheduled for July 15-20, 2007 near Valentine, NE. The web site for this event is www.NebraskaStarParty.com.

A little farther afield is the **Green Bank Star Quest**—it takes place on **July 4-7** at Green Bank Observatory in West Virginia. I've included announcement sheets in the newsletters for some of the members; if there isn't one attached to your newsletter, but you would like to know more, visit their web site at www.greenbankstarquest.org for more info and registration. They have a first class set of speakers for the event.

If you have any suggestions for talks, speakers, or public events, please feel free to contact us, particularly Rick Heschmeyer (rcjbm@sbcglobal.net), the events coordinator for the club. Hope to see you at the observing downtown next week**.** ALL for now.

(Continued from page 1)

and its annihilation soon thereafter infused the gas-and-dust disk surrounding the newborn Sun with ^{60}Fe and other by-products. Our solar system may have condensed in a crowded stellar neighborhood inside a massive cloud of gas and dust. The Orion Nebula, illuminated by a cluster of hot, young stars at its center, is just such a place. Hundreds of stars are forming in the folds of Its billowing gas clouds.

"Very massive stars do not form alone, but in clusters" Bizzarro notes. "We therefore hypothesize that this is the kind of environment where our solar system was formed: a dense stellar cluster, in association with numerous massive stars." We see just this sort of environment today in the Orion Nebula, where hundreds of suns are emerging from the huge nebular cloud surrounding the dazzling Trapezium stars at its center.

"I view this as a paradigm shift," observes Alan Boss (Carnegie Institution of Washington), a planet-formation theorist. Not only would the death throes of a nearby supermassive star account for the puzzling iron-60 results, he observes, but those strong winds and shock waves might also explain other solar-system oddities such as how Uranus and Neptune were left with so little hydrogen.

Having our solar system come together in a crowded stellar neighborhood might also explain why a growing number of objects in the distant Kuiper Belt, such as 90377 Sedna, have swollen, highly elongated orbits that can't be explained by planetary interactions long ago. Most likely, dynamicists say, a star drifted through the Sun's immediate neighborhood early in solar system history and "stirred up" the Kuiper Belt. And the odds of that chance encounter are much higher if our Sun formed in a close-packed cluster of siblings.

About the Astronomy Associates of Lawrence

The club is open to all people interested in sharing their love for astronomy. Monthly meetings are typically on the second Friday of each month and often feature guest speakers, presentations by club members, and a chance to exchange amateur astronomy tips. Approximately the last Sunday of each month we have an open house on Memorial Stadium. Periodic star parties are scheduled as well. For more information, please contact the club officers:Luis Vargas at lcvargas@ku.edu, Gary Webber at gwebber@ku.edu, our faculty advisor, Prof. Bruce Twarog at btwarog@ku.edu. our events coordinator, Rick Heschmeyer at rcjbm@sbcglobal.net. Because of the flexibility of the schedule due to holidays and alternate events, it is always best to check the Web site for the exact Fridays and Sundays when events are scheduled. The information about AAL can be found at **http://www.ku.edu/~aal.**

Copies of the *Celestial Mechanic* can also be found on the web at
http://www.ku.edu/~aal/celestialmechanic

THE DEATH OF COSMOLOGY ?

Physicists are now foretelling the death of cosmology, or the study of our universe, as we know it. Thankfully, cosmologists won't be jobless for a couple trillion years. The universe is rapidly expanding--perhaps not rapidly enough to rip to shreds, but enough that distant galaxies will eventually be moving away faster than the speed of light. This much has been known for a few years. Once all these galaxies blink out of existence, scientists ask in an upcoming issue of *The Journal of Relativity and Gravitation*, how will future intelligent beings study space if the human race's knowledge is long gone? Will they be able to figure out if the Big Bang happened? Or rediscover relativity?

For the most part, said Lawrence Krauss, a theoretical physicist at Case Western Reserve University in Cleveland, Ohio, and co-author of the journal article, future observers will be out of luck. "They'll be stuck in an endless black void," Krauss said, noting that any galaxies outside of our own cluster will disappear in about 100 billion years. "They'll feel very special after that happens, because our tiny cluster of galaxies will be the observable universe to them."

Without a cosmological frame of reference, Krauss explained, future observers will be clueless that their universe is still expanding. "It will be a sort of twisted situation, where thinking returns to what it was at the turn of the 20th century," he said. In other words, observers will think the universe is just a static--or non-expanding--cluster of galaxies just as scientists thought until the 1920s. "The static universe," as the journal article states, "will have returned with a vengeance."

An additional issue for future observers will be the disappearance of cosmic microwave background radiation--the fingerprint of the Big Bang's occurrence--in about 250 billion years. Without it, Krauss said, observers can't be certain about how the universe was created, not to mention when. The problem relates to the Doppler effect: When a speeding train approaches, the sound waves from its whistle are squished together to make a higher pitch. As it passes, the sound waves are stretched out like a slinky and become lower in pitch and fainter. Similarly, as the universe expands outward, the "pitch" of light will lengthen and fade away. "The wavelength of light will be so large it will eventually reach the size of our galaxy," Krauss said. "It will just be absorbed."

Krauss, however, is confident that someone (presumably human in form) will be the next Einstein and rediscover general relativity. He's also hopeful that future observers will be able to explain the creation of the solar system by studying stars within the galaxy.

And, said Krauss, there's a positive side to not knowing the universe's true history: "There'll be almost no static on their TV screens," Krauss said, explaining that if there are no distant galaxies around to emit cosmic rays, the airways will be a lot cleaner.

(Continued from page 5)

"The report as it stands is not valid. The recommendations that they made are based on an exceptional set of asteroids that they picked rather than what is most likely to be needed to be deflected," Schweickart told *SPACE.com*. "It's a flawed report."

Schweickart said that "NASA basically pulled off a federal agency version of civil disobedience" by not recommending a program or budget in dealing with the dangers from NEOs. "NASA has just refused to obey the law...that's not good news."

Wanted: mission rules

In dubbing the NEO issue as a "cosmic natural hazard"-nobody is responsible for handling the threat, within the U.S. government or any other government, Schweickart said. He urged conference attendees to write the U.S. Congress and demand a hearing on the results of the NASA report.

"In the next 15 years, the population of the world is going to be concerned about this issue," Schweickart said. The former Apollo astronaut called for "Mission Rules" for NEO deflection to be drawn up by the international community.

"If we do our homework right, never again should an asteroid that can do damage on the ground impact the Earth," Schweickart suggested. "We're living at a time -- with our technology -- we have the capability to eliminate this major shaper of evolution - the evolution of life on this planet."

"We're now on the top of the heap. Enough cosmic gardener, you're fired. That's the task...that's the challenge," Schweickart concluded.

NASA's Space Place

The Ions of Dawn

by Patrick L. Barry

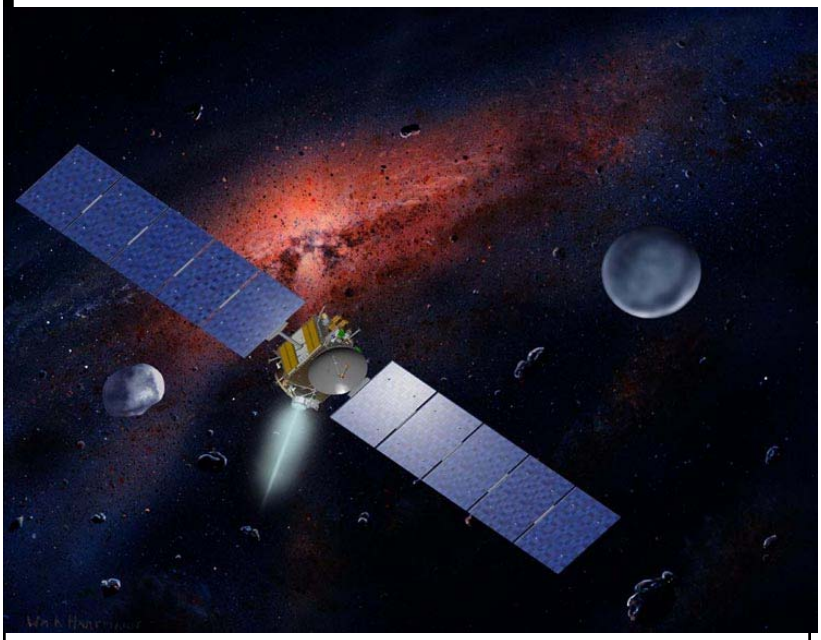
This summer, NASA will launch a probe bound for two unexplored worlds in our solar system's asteroid belt—giant asteroids Ceres and Vesta. The probe, called Dawn, will orbit first one body and then the other in a never-before-attempted maneuver.

It has never been attempted, in part, because this mission would be virtually impossible with conventional propulsion. “Even if we were just going to go to Vesta, we would need one of the largest rockets that the U.S. has to carry all that propellant,” says Marc Rayman, Project System Engineer for Dawn at JPL. Traveling to both worlds in one mission would require an even bigger rocket. This is a trip that calls for the *un*conventional. “We’re using ion propulsion,” says Rayman.

The ion engines for the Dawn spacecraft proved themselves aboard an earlier, experimental mission known as Deep Space 1 (DS1). Because ion propulsion is a relatively new technology that’s very different from conventional rockets, it was a perfect candidate for DS1, a part of NASA's New Millennium Program, which flight-tests new technologies so that missions such as Dawn can use those technologies reliably.

“The fact that those same engines are now making the Dawn mission possible shows that New Millennium accomplished what it set out to,” Rayman says.

Ion engines work on a principle different from conventional rockets. A normal rocket engine burns a chemical fuel to produce thrust. An ion engine doesn't burn anything; a strong electric field in the engine propels charged atoms such as xenon to very high speed. The thrust produced is tiny—roughly equivalent to the weight of a piece of paper—but over time, it can generate as much speed as a conventional rocket while using only about 1/10 as much propellant.



Artist’s rendering of Dawn spacecraft, with asteroids. Largest are Vesta and Ceres. Credits: Dawn spacecraft—Orbital Sciences Corporation; background art—William K. Hartmann, courtesy UCLA.

And Dawn will need lots of propulsion. It must first climb into Vesta's orbit, which is tilted about 7 degrees from the plane of the solar system. After studying Vesta, it will have to escape its gravity and maneuver to insert itself in an orbit around Ceres—the first spacecraft to orbit two distant bodies. Dawn's up-close views of these worlds will help scientists understand the early solar system.

“They're remnants from the time the planets were being formed,” Rayman says. “They have preserved a record of the conditions at the dawn of the solar system.”

Find out about other New Millennium Program validated technologies and how they are being used in science missions at http://nmp/TECHNOLOGY/infusion.html . While you’re there, you can also download “Professor Starr’s Dream Trip,” a storybook for grown-ups about how ion propulsion enabled a scientist’s dream of visiting the asteroids come true. A simpler children’s version is available at http://spaceplace.nasa.gov/en/kids/nmp/starr.

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

Ex-Astronaut Says NASA Asteroid Report Flawed
By Leonard David

A former Apollo astronaut blasted the U.S. space agency today in its handling of a Congressionally-mandated study on dealing with the threat of Near Earth Objects (NEOs) striking the Earth. Russell "Rusty" Schweickart, the lunar module pilot for the Apollo 9 mission, called a recently issued NASA report on dealing with Earth-threatening asteroids, "flawed" and "not valid."

Schweickart noted that Earth impacts of huge space rocks are rare. But as history has shown, a cosmic-smashing event is a very real occasion-when both the Earth and an asteroid can be at an ugly intersection of time and space. "It's those circumstances which we want to avoid," Schweickart said here today at the 26th annual National Space Society's International Space Development Conference.

In fact, next year is the celebration of the 100th anniversary of the Siberia-smacking Tunguska event of a 45 to 50 meter diameter asteroid. "Had it hit a couple of hours later it might have wiped out London or Moscow...instead it wiped out 2,000 square kilometers of Siberia forest and maybe a few reindeer," Schweickart observed.

Schweickart is Chairman of the B612 Foundation, a confab of scientists, technologists, astronomers, astronauts, and other specialists dedicated to significantly alter the orbit of an asteroid in a controlled manner by 2015. He was also wearing his hat as a member of the Association of Space Explorer's (ASE) Committee on Near Earth Objects.

Through the ASE organization, a set of international workshops, stretching over a year and a half, are being held to further detail the NEO threat and promote a global response to potential Earth-menacing objects. The results of those workshops, Schweickart said, are to be submitted in the spring of 2009 to the UN Committee on the Peaceful Uses of Outer Space.

Earth: Control-Alt-Delete

"What we're talking about here is the possibility-in an evolutionary sense-of a Control-Alt-Delete; a [computer-like] reboot of the evolutionary system that has already occurred many times on Earth," Schweickart said.

In any dealings with space rocks, there's need for early warning, a deflection capability and an international decision-making capability, Schweickart said.

Schweickart reported that by 2019 asteroid watchers will have on the books upwards of 10,000 objects with a non-zero probability of impacting Earth. "The bottom line," he said, "is that in the next 10 to 12 years, we are going to, in all likelihood, have to make decisions...not because one of these things is going to hit us...but because several of them look as though they might hit us."

"We're going to have to act in a timely way," Schweickart said. "What is changing dramatically in the next decade is our knowledge of the NEO environment. You have to take action based on your knowledge...your best understanding of the truth."

Civil disobedience

NASA recently responded to a study request from Congress-an assessment of how best to track, catalog, as well as deter a NEO found to be on a collision course with Earth. As one of its major conclusions, the study advised that use of nuclear explosions can deflect such an Earth-bruising event.

That approach is wrong-headed, Schweickart responded. Rather, using existing robot impactor technology, as well as a gravity-tractor method of altering the asteroids trajectory ever-so-slightly, would give you both the oomph and the precision that you need to re-direct a NEO from an Earth impact.

"Right now, I put NASA in the same category of technical accuracy as Hollywood with Deep Impact and Armageddon," he noted, two less-than-accurate movies that featured Earth-impacting objects.

"NASA did a terrible technical analysis which led them to that conclusion," Schweickart said. "It's wrong, wrong, wrong."

(Continued on page 3)

Small Stars Create Big Fuss

By Ker Than, space.com

A "failed star" with only 24 times the mass of Jupiter is the smallest known object to spout jets of matter from its poles, a phenomenon typically associated with much larger black holes and young stars.

The new finding, detailed in the current issue of *Astrophysical Journal*, confirms that a wide range of celestial objects is capable of generating such outflows. "There are black holes that are 3 million solar masses spewing jets, and there's this thing, which is 2 percent of a solar mass, doing the same thing," said study team member Ray Jayawardhana of the University of Toronto. The discovery also raises the possibility that large gas giant planets like Jupiter or Saturn might also have been gushers some time early in their history.

A gushing brown dwarf

The new jet-spewing object is a previously identified brown dwarf-celestial objects with masses between 13 and 75 times that of the Jupiter, too massive to be a planet but too small to sustain the internal nuclear fires needed to become stars. For this reason, brown dwarfs are sometimes called failed stars. Called 2M1207a, the spurting brown dwarf is ringed by gas and dust, similar to the protoplanetary disks from which planets form around young stars. Indeed, 2M1207a is known to harbor a 5-Jupiter-mass planetary companion. Called 2M1207b, the gas giant was one of the first planets outside of our solar system to have its picture taken directly.

2M1207a's streaming jets were discovered using the European Southern Observatory's Very Large Telescope (VLT). The jets extend about 620 million miles (1 billion km) into space and are speeding away from the brown dwarf at a few kilometers per second.

"Preliminary results suggest that a brown-dwarf jet is just scaled down from what we see in a low mass star," said study leader Emma Whelan of the Dublin Institute for Advanced Physics in Ireland. In 2005, Whelan's team discovered the first jet-spewing brown dwarf, but that one was about 60 Jupiter masses.

Jets and star formation

Scientists are still not sure of the role jets play in star formation. One idea is that by ejecting large amounts of material into space, the jets help determine the final size and mass of the star.

Another hypothesis is that jets actually play a major role in initiating star formation in the first place. Stars are thought to form from enormous, spinning clouds of gas and dust that somehow collapse and contract into blazing balls of fire. To do this, the clouds must get rid of a lot of spin energy, or "angular momentum."

"One of the best ways to get rid of that is to put it into a jet," Jayawardhana told *SPACE.com*. "So these jets might actually be spinning and carrying out the angular momentum of the formed object."

The new gushing nature of 2M1207a could help shed light on how jets are formed and sustained.

"The only way to test these models for launching jets is to test them at extreme examples," Jayawardhana said in a telephone interview. The mechanism has to "work for such a low-mass object, and that puts interesting constraints on what types of launching mechanisms might work."

Planetary jets?

Because 2M1207a is so small, the discovery suggests gas giant planets in our solar system and beyond could also drive outflows. "It seems like almost any time you have accretion disk around an object, some of the material that's accreted is also spewed out," Jayawardhana said.

Both Saturn and Jupiter are thought to have grown out of accretion disks. Saturn's disk is still clearly visible in the form of its rings. Some theorists have proposed an alternative scenario for planet formation different from the standard model in which large gas planets can form from gravitational collapse similar to stars. If a jet-spewing gas giant were ever spotted, it would be evidence of another common similarity between star and planet formation. Jayawardhana said it is too early to draw that connection, since the new observations pertain only to brown dwarfs.

"I would say this is explicitly a similarity between brown dwarfs and stars," he said.

Baby Stars Hatching in Orion's Head

Written by Linda Vu, Spitzer Science Center

A new image from NASA's Spitzer Space Telescope shows infant stars "hatching" in the head of Orion, the famous hunter constellation visible from northern hemispheres during winter nights. Astronomers suspect that shockwaves from a 3-million-year-old explosion of a massive star may have initiated this newfound birth. The region featured in the Spitzer image is called Barnard 30. It is located approximately 1,300 light-years away and sits on the right side of Orion's head, just north of the massive star Lambda Orionis.

"When we decided to study this region, it was barely known, despite the fact that its properties made it a nice target. Our aim was to carry out a comprehensive study of the region's different properties," said Dr. David Barrado y Navascués, of the Laboratorio de Astrofísica Espacial y Física Fundamental in Madrid, Spain, who led the Spitzer observations.

"We now know, thanks to Spitzer, that there is a large population of low-mass stars and brown dwarfs [or failed stars]," he added.

A visibly dark and murky cosmic cloud is bright and clear in Spitzer's infrared image. Organic molecules called polycyclic aromatic hydrocarbons (PAHs) can be seen as wisps of green. These molecules are formed anytime carbon-based materials are burned incompletely. On Earth, they can be found in the sooty exhaust from automobile and airplane engines. They also coat the grills where charcoal-broiled meats are cooked.

Tints of orange-red seen in the cloud are dust particles warmed by the newly forming stars. The reddish-pink dots at the top of the cloud are very young stars embedded in a cocoon of cosmic gas and dust. Blue spots throughout the image are background Milky Way stars along this line of sight. When Barrado y Navascués first saw this image of Barnard 30, he was so impressed that he decided to use it for the cover of his upcoming astronomy textbook.

"I found the original black and white science images breathtaking, fascinating," said Barrado y Navascués.

"Once I saw the color image, it was clear it had to be the cover of the book. From the aesthetical point of view, [the image] is beautiful, it catches the eye. From the astronomical point of view, it has everything an astronomer wants -- high- and low-mass stars, brown dwarfs and a dark dust cloud. It is a gift from nature."

The inspiration for Barrado y Navascués' textbook came from his one-year-old astronomical reference blog, *Cuaderno de Bitacora Estelar*. The blog is one of the most widely read astronomy blogs in Spanish, with a large audience in Europe, South America, and United States. He decided to turn his blog into a textbook a few months ago when a Spanish editorial company asked him to.

"After hesitating and a lot of thinking about how to do it, we decided to go ahead," said Barrado y Navascués. "As far as we know, it is one of the first blogs to be converted into a book in Spanish. It is possibly the first academic blog to undergo such a conversion and, for sure, the first related to astronomy." As for Barnard 30 and the other infant stars hatching in Orion's head, Barrado y Navascués says that this region "will no doubt become one of the cornerstones of stellar astrophysics, one of the most relevant young stellar clusters."

Gamma-ray burst discovery announced

U.S. astronomers have determined flares seen after a gamma-ray burst are apparently a continuation of the burst itself.

Gamma-ray bursts release in seconds the same amount of energy the sun will emit during its expected 10 billion-year lifetime. That energy comes from the core of a massive star collapsing to form a black hole or neutron star.

Early in its mission, the National Aeronautics and Space Administration's Swift satellite's X-ray Telescope discovered the initial pulse of gamma-rays -- known as prompt emission -- is often followed by short-lived but powerful, X-ray flares, suggesting a GRB's central engines remain active long after the prompt emission.

In the latest study, Hans Krimm and colleagues at the Universities Space Research Association and the Goddard Space Flight Center demonstrated X-ray flares are indeed a continuation of the prompt emission.

"This pattern points to a continuous injection of energy from the central engine, perhaps fueled by sporadic in-fall of material onto a black hole," said Krimm. "The black hole just keeps gobbling up gas and the engine keeps spewing out energy."

(Continued from page 9)

slow down under the pull of gravity and pile up, like cars bunched up on a freeway.

"By studying this collision, we are seeing how dark matter responds to gravity," said team member Holland Ford of Johns Hopkins University. "Nature is doing an experiment for us that we can't do in a lab, and it agrees with our theoretical models."

Dark matter makes up most of the universe's material. Ordinary matter, which makes up stars and planets, comprises only a few percent of the universe's matter.

Tracing dark matter is not an easy task, because it does not shine or reflect light. Astronomers can only detect its influence by how its gravity affects light. To find it, astronomers study how faint light from more distant galaxies is distorted and smeared into arcs and streaks by the gravity of the dark matter in a foreground galaxy cluster, a powerful trick called gravitational lensing. By mapping the distorted light, astronomers can deduce the cluster's mass and trace how dark matter is distributed in the cluster.

"The collision between the two galaxy clusters created a ripple of dark matter that left distinct footprints in the shapes of the background galaxies," Jee explained. "It's like looking at the pebbles on the bottom of a pond with ripples on the surface. The pebbles' shapes appear to change as the ripples pass over them. So, too, the background galaxies behind the ring show coherent changes in their shapes due to the presence of the dense ring."

Jee and his colleagues used Hubble's Advanced Camera for Surveys to detect the faint, distorted, faraway galaxies behind the cluster that cannot be resolved with ground-based telescopes. "Hubble's exquisite images and unparalleled sensitivity to faint galaxies make it the only tool for this measurement," said team member Richard White of the Space Telescope Science Institute in Baltimore.

Previous observations of the Bullet Cluster with Hubble and the Chandra X-ray Observatory presented a sideways view of a similar encounter between two galaxy clusters. In that collision, the dark matter was pulled apart from the hot cluster gas, but the dark matter still followed the distribution of cluster galaxies. Cl 0024+17 is the first cluster to show a dark matter distribution that differs from the distribution of both the galaxies and the hot gas.

The team's paper will appear in the June 1 issue of the Astrophysical Journal.

RINGS of DARK MATTER
HST Press Release

Astronomers using NASA's Hubble Space Telescope have discovered a ghostly ring of dark matter that formed long ago during a titanic collision between two massive galaxy clusters.

The ring's discovery is among the strongest evidence yet that dark matter exists. Astronomers have long suspected the existence of the invisible substance as the source of additional gravity that holds together galaxy clusters. Such clusters would fly apart if they relied only on the gravity from their visible stars. Although astronomers don't know what dark matter is made of, they hypothesize that it is a type of elementary particle that pervades the universe.

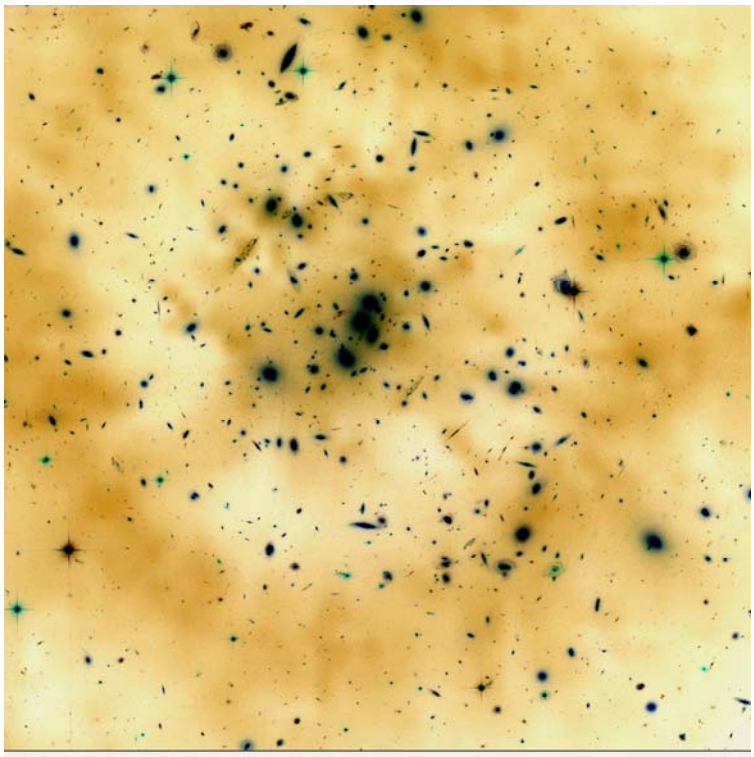
"This is the first time we have detected dark matter as having a unique structure that is different from both the gas and galaxies in the cluster," said astronomer M. James Jee of Johns Hopkins University in Baltimore, Md., a member of the team that spotted the dark-matter ring.

The researchers spotted the ring unexpectedly while they were mapping the distribution of dark matter within the galaxy cluster Cl 0024+17 (ZwCl 0024+1652), located 5 billion light-years from Earth. The ring measures 2.6 million light-years across. Although astronomers cannot see dark matter, they can infer its existence in galaxy clusters by observing how its gravity bends the light of more distant background galaxies.

"Although the invisible matter has been found before in other galaxy clusters, it has never been detected to be so largely separated from the hot gas and the galaxies that make up galaxy clusters," Jee said. "By seeing a dark-matter structure that is not traced by galaxies and hot gas, we can study how it behaves differently from normal matter."

During the team's dark-matter analysis, they noticed a ripple in the mysterious substance, somewhat like the ripples created in a pond from a stone plopping into the water.

"I was annoyed when I saw the ring because I thought it was an artifact, which would have implied a flaw in our data reduction," Jee explained. "I couldn't believe my result. But the more I tried to remove the ring, the more it showed up. It took more than a year to convince myself that the ring was real. I've looked at a number of clusters and I haven't seen anything like this."



Dark Matter Ring in Galaxy Cluster Cl 0024+17 (ZwCl 0024+1652)
Hubble Space Telescope • ACS/WFC

Curious about why the ring was in the cluster and how it had formed, Jee found previous research that suggested the cluster had collided with another cluster 1 to 2 billion years ago. The research, published in 2002 by Oliver Czoske of the Argelander-Institut fur Astronomie at the Universitat Bonn, was based on spectroscopic observations of the cluster's three-dimensional structure. The study revealed two distinct groupings of galaxies clusters, indicating a collision between both clusters.

Astronomers have a head-on view of the collision because it occurred fortuitously along Earth's line of sight. From this perspective, the dark-matter structure looks like a ring.

Computer simulations of galaxy cluster collisions, created by the team, show that when two clusters smash together, the dark matter falls to the center of the combined cluster and sloshes back out. As the dark matter moves outward, it begins to

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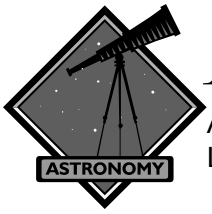

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