The Celestial Mechanic

The Official Newsletter of the Astronomy Associates of Lawrence

Volume 31 Number 10 **OCTOBER 2005**

Calendar of Events

OCTOBER EVENT:

MONDAY OCT. 24
Alderson Auditorium, Kansas Union 7:30 PM
Dr. Jim Kasting, Penn State

Gaia Revisited: The Interplay Between Climate and Life on the Early Earth

PUBLIC OBSERVING
Sunday Oct. 30
8:00PM, Memorial Stadium

November Meeting
Friday, NOV. 11,2005
7:30 PM
1001 Malott

President:
Hannah Swift
hkswift@ku.edu

Treasurer:
Dr. Steve Shawl
Shawl@ku.edu

University Advisor:
Dr. Bruce Twarog
btwarog@ku.edu

Webmaster:
Gary Webber
gwebber@ku.edu

Events Coordinator
Rick Heschmeyer
rcjbm@sbcglobal.net

F r o m t h e O f f i c e r s

Report From the Officers on the September Meeting:

The September meeting went well, with excellent attendance by some longstanding members and a nice group of students and others from the general public. The topic of the talk was the evolution of our galaxy and the latest results from a number of large surveys undertaken in recent years at both optical and infrared wavelengths.

For next month, we will not have our traditional meeting. The reason for this is to avoid the problem that everyone faces, too much to to and too little time. Our normal meeting would have been Friday, October 14, which occurs in the middle of Fall Break at KU, making use of the facilities difficult and attendance sparse. We could delay one week, but there is a special event co-sponsored by the Department of Physics & Astronomy that takes place on Monday Oct. 24. Rather than asking that people attend a talk on Friday, then recommend that they attend another lecture on Monday, we are encouraging all of our members to attend the lecture by Dr. Jim Kasting of Penn State. His talk, at 7:30 PM in Alderson Auditorium, is on the concept of GAIA and the early climate of the Earth. Dr. Kasting is visiting the department to interact with the growing research group at KU involved in the rather hot field of Astrobiology, the origin and evolution of life on Earth and elsewhere, the latter becoming a plausible topic for conversation and observation only in the last decade.

We will return to our normal meeting schedule in November and we have an important event arranged for that night. Rick Heschmeyer has coordinated a lecture for the Scouts in the area. They will attend on Nov. 11, learn about the basics of astronomy and

(Continued on page 2)

INSIDE THIS ISSUE

From the Officers, continued

the solar system, followed by an observing session out on the lawn outside Malott. This will be a significant number of students and a good opportunity to communicate and encourage an interest in amateur astronomy. More important, we will need to have a number of telescopes set up outside, weather permitting, to handle the observing load for the group. This would be a great time to bring your equipment to show these students what is available for the amateur and how well it works. We will fill you in with more details in the next newsletter, but please keep this date open on your schedule because we will need some help.

Speaking of observing, we had our first successful open observing session at Memorial Stadium on Sunday, Sept. 25. Almost 60 people came through to have a look, including students from Steve Shawl's class at KU and Kent McDonald's class at Lawrence High. Bill Winkler brought his semi-automated Dobsonian and Rick Heschmeyer was on hand to help guide people to some understanding of what they were seeing. Many thanks to these club members for their help and for steering people to the event. Our next planned open viewing is Sunday, Oct. 30 and coincides with the real near approach of Mars for 2005. The planet will be 20" across (as opposed to 25" in 2003) and should be quite spectacular through the 8-inch scopes. So, come along and bring your telescope—we can expect a good crowd if the weather cooperates.

As noted on the front page, October is also the month when PBS/Nova is presenting one of their special shows. On Tuesday Oct. 11, there is a 2-hour presentation of "$E=mc^2$, Einstein's Famous Equation". This show is in honor of the 100th anniversary of Einstein's extraordinary year of genius, 1905, when he published 5 papers that revolutionized the field of Physics, including the one on $E=mc^2$. The year 2005 has also been designated as the Year of Physics, so tune in and enjoy.

The Astronomical League has many activities to encourage amateur astronomy including Observing Clubs. The Observing Clubs offer certificates of accomplishment for demonstrating observing skills with a variety of instruments and objects. Each Club offers a certificate based upon achieving certain observing goals. These are usually in the form of a specific number of objects of a specific group with a given type of instrument. Occasionally there are multiple levels of accomplishment within the club. There is no time limit for completing the required observing, but good record keeping is required. When you have reached the requisite number of objects, your observing logs are examined by the appropriate authority and you will receive a certificate and pin to proclaim to all that you have reached your goal. Many local astronomical societies even post lists of those who have obtained their certificates. This month we feature the details on the **Globular Clusters Club.** The purpose of this observing club is to introduce observers to some of the finest globular clusters in the heavens. You may use any telescope, although an 8-inch is probably necessary for light-polluted skies. This program is meant to allow you to enjoy comparing one type of celestial object to each other, not test your equipment. For the Astronomical League's Globular Cluster Observing Club, the observer is required to observe 50 globular clusters, with at least 1 globular cluster from the Challenge List. This program is completely customizable to the observer's interests and their equipment. The observer chooses just 50 globulars they are interested in observing from the list of 190 globular clusters listed in the observing guide. Since comparison is a principal goal of this program, if possible, all observations should be done with the same telescope. It is recommended that one eyepiece (power of magnification) be chosen for consistency, one that at least shows all of M13 in the field of view. If multiple telescopes are used to observe the globular clusters you have selected for your program, try to use the same power of magnification that is consistent with each telescope. For each globular cluster, the observer needs to record all of the data usually required for Astronomical League observing clubs, along with the concentration class of each object observed. The observing guide has pages you can copy to help you record this information. For info about the club and the observing guide, visit http://www.astroleague.org/al/obsclubs/globular/globular1.html.

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 in 3 weeks at the Gaia Lecture. ALL for now.

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:Hannah Swift at hkswift@ku.edu, Gary Webber at gwebber@ku.edu, our faculty advisor, Prof. Bruce Twarog at btwarog@ku.edu. or 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

New Target of Opportunity: Erebus Crater

By Leonard David, Space.com

Even on Mars, size counts.

NASA's Opportunity rover at Meridiani Planum has wheeled up to "Erebus Crater" – a sizable feature about 984 feet (300 meters) across. The decision has been made by scientists and engineers operating the robot to go west, counterclockwise around the crater. Erebus is nearly twice the diameter of Endurance Crater, an earlier "pit stop" of Opportunity that produced a bonanza of science data.

"We're there, for all intents and purposes," said Steve Squyres of Cornell University in Ithaca, New York. Squyres is principal investigator for the Opportunity and Spirit Mars rover science instruments. "We can see most of the crater from where we are right now, and we've made the decision that we're going to traverse around it on its western side," Squyres told *SPACE.com*. "We're actually going to start the drive around the crater by going north a little bit…to get onto terrain that's mostly bedrock…before we swing west."

Squyres said that as Opportunity makes its way counterclockwise around the crater, the science team and rover drivers are keeping their eyes sharp, looking for a safe place to possibly enter Erebus Crater. "The goal being to get to a place we've named the 'Mogollon Rim'…on the western side. If we can find a safe place to go in, that's great... if we can't, we'll just continue on to the south," Squyres added.

Nasty-looking places

On the other side of Mars—within Gusev Crater—the Spirit robot has been intently surveying the summit of Husband Hill. Session work has included studying "Cliffhanger"—a windblown drift. Stereo imaging of "Tennessee Valley" from the summit is also on the action item list.

Increased attention is being paid on how best to get down from the summit, Squyres noted in an update on the Cornell University-based Mars Exploration Rover website. Which way to go and what route should be picked are under discussion, he reported. "The hill is very steep in places….and the orbital images show a lot of tasty geology, some of it in pretty nasty-looking places. All in all, the next several weeks are going to present us with some of the most interesting route-finding decisions that we've faced in a long time, on both sides of the planet," Squyres noted.

Meteor search campaign

Spirit has also turned nighttime sky-watcher. The Mars machinery is engaged in "shooting sessions"—not only imaging the two moons of the red planet, Phobos and Deimos, but will also be on the lookout for shooting stars.

"We're almost done with our Phobos and Deimos astrometric and color imaging," said Jim Bell, an Associate Professor in the Cornell University Astronomy Department. Bell is lead scientist for the Panoramic Camera color imaging system carried by both Spirit and Opportunity. "We have a few more sequences to run…and we'll also be trying to image Phobos going into and out of the Mars shadow in a 'lunar' eclipse later in October for additional orbit timing data," Bell explained.

"Next we are going to start our meteor search campaign in earnest," Bell told *SPACE.com*. "We have to finish up our nighttime observation campaigns relatively soon. That's because we're at the peak of our power availability now on Spirit over the coming months, as the Sun starts to get lower and Mars gets farther from the Sun." Bell said rover engineers for Spirit may not be able to muster enough power to operate the cameras at night. "So the clock is ticking," he added.

Back on the other side of Mars, nighttime observations of the martian sky by Opportunity for a longer period of time may be possible, Bell said, because that rover is closer to the equator. However, Opportunity is also dealing with a power-draining heater unit. It is stuck in the on position. Too early to tell if that situation may deter the robot's nighttime sky scanning, he said.

Huge Quake Cracks Star

By Bjorn Carey, Space.com

Astronomers have found the first evidence of cracks in a neutron star's crust. The star cracked when it was rocked by the strongest "starquake" ever recorded, researchers said last week. Last December, astronomers worldwide monitored the explosion that caused this starquake. The eruption was huge – in the first 200 milliseconds of the event the star released energy equivalent to what our Sun produces in 250,000 years. The explosion was the brightest event ever detected outside of our Solar System. Now scientists have used a collection of data from various satellites to provide the first observational evidence that the blast caused the star to form cracks several miles long. Scientists hope these cracks will provide a window into the mysterious interiors of neutron stars.

There are millions of neutron stars in the Milky Way galaxy alone, and some of these have magnetic fields trillions of times stronger than Earth's, the strongest of which are called magnetars. This particular magnetar – SGR 1806-20 – is surrounded by the strongest magnetic field known in the universe. This could explain why the starquake – caused when the magnetar's crust could no longer contain the magnetic stress building in the star's interior – was so intense. A magnetar's interior is a dense, liquid-like mix of neutrons, protons, and electrons – making it a terrific conductor of electricity. Because it has the characteristics of a fluid, it moves around a lot. The magnetar's magnetic field loops around the star, and all this movement in the interior messes with the field's shape, winding it up like you might do with a rubber band.

But the magnetar's exterior crust is not so pliable. The crust is made mostly of iron. The magnetic field passes through it in places, which isn't a problem for normal neutron stars. But in magnetars, the field interacts with the core and shifts around erratically, causing crustal stress. Eventually, the stress reaches the point where the crust cracks.

"Imagine threading a rubber band between two cards, and then twisting the middle," study leader Steve Schwartz of the Imperial College of London told *SPACE.com*. "All those twisting stresses accumulate at the points where the rubber band threads through the card to the outside. Keep twisting long enough and you will rip the card." The first crack to form was three miles (five kilometers long) – significant since this magnetar is only six miles (10 kilometers) in diameter. Radiation spewed from this crack, causing a steep initial increase in detectable radiation. But that was just the beginning. Radiation continued to spill out of the star, but at a much slower rate than the initial burst. This suggests that cracks continued to form.

"Whether this is a set of long, [three mile] cracks, or a multitude of much smaller ones isn't obvious to me," Schwartz said. "My hunch is therefore: one big one, followed by lots and lots of ongoing smaller ones." What this means for SGR 1806-20 isn't clear, but it seems that cracks form more to relieve pressure than as a sign that the star is blowing apart.

"The result of the cracking is to relax the interior and exterior field to a less twisted state," Schwartz said. "This has very little impact on the star itself, other than the fact that it will take time to twist up the field again."

SGR 1806-20 is 50,000 light-years away, but the blast was so huge it temporarily blinded some satellites and briefly altered Earth's upper atmosphere. A similar blast occurring within 10 light-years of our planet would fry Earth's ozone layer. But don't worry – the closest magnetar is 13,000 light-years away. Two satellites designed to study the Earth's magnetosphere – the European Space Agency's Cluster and Double Star satellites – didn't go offline and recorded the entire event. Data from these two satellites was combined with observations from around the world to uncover the cracks. So far, nine magnetars have been firmly identified, and four of these repeatedly emit bursts of X-rays and gamma rays. SGR 1806-20, which has a magnetic field more powerful than any other object in the universe, is one of these so-called soft gamma repeaters.

Researchers still don't know why SGR 1806-20's burst was so incredible, but they hope that a look into its cracks will help solve the mystery.

The Department of Physics & Astronomy presents

Gaia Revisited:

The Interplay Between Climate and Life on the Early Earth

Dr. James F. Kasting

Distinguished Professor of Geosciences and Meteorology,
Penn State University

MONDAY, OCTOBER 24, 2005

7:30 PM, ALDERSON AUDITORIUM

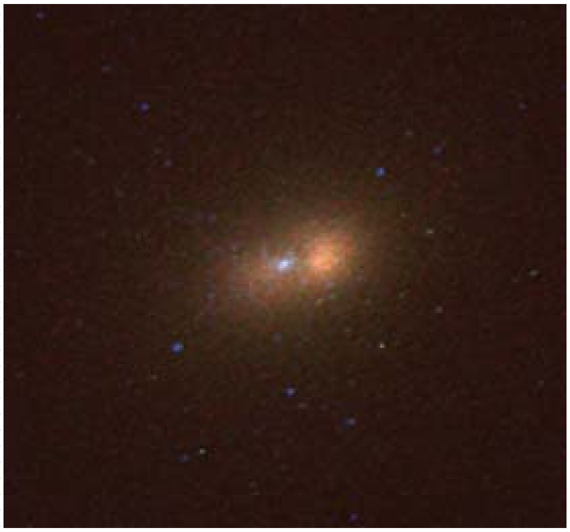
KANSAS UNION

FREE & OPEN TO THE PUBLIC

Andromeda's Black Hole Surrounded by Young Stars

By Lisa R. Johnston, Skypub.com

It's no secret that supermassive black holes are thought to dwell in the centers of most galaxies, but what might be less well known is that only two black holes have been directly proven to exist under there. Now, thanks to some blue stars in a very unlikely place, make that three.



The Andromeda Galaxy, about 2.5 million light-years away, contains a black hole with the mass of 140 million Suns that has a strange disk (blue) of young hot stars within 1/2 light-year of it. *John Kormendy*

The Andromeda Galaxy (M31) has long been known as a likely candidate for harboring a black hole. Its innermost nucleus emits the X-rays expected from an accretion disk of gas spiraling into one. In addition, for almost a decade astronomers have noted a mysterious blue light at the core. Using Hubble's Space Telescope Imaging Spectrograph (STIS), astronomers have now identified this blue glow as a flat disk of more than 200 young, hot stars no more than half a light-year from the nucleus. The stars' unlikely nesting ground gave astronomers the most solid evidence to date that the Andromeda Galaxy contains a black hole – and it's twice as big as they thought, weighing as much as 140 million solar masses.

Ralph Bender (Max Planck Institute, Germany), lead author of the paper published in the September 20th *Astrophysical Journal,* and his team measured orbital velocities in the star disk by the redshifts and blueshifts of its different parts. The hot, young stars revolve around the central black hole much the way the planets in our solar system revolve around the Sun. But these stars feel a much stronger gravitational pull and orbit with measured velocities averaging 1,000 kilometers per second. With such a close proximity to the center, this system required a central mass of 140 million Suns. And this mass is dark, so under these stiff constraints all other possiblities are ruled out, other than a black hole. "We think this has been correct all along," says John Kormendy (University of Texas, Austin) who in 1988 was one of the several astronomers to find evidence that M31 must have a central black hole, "but now we can exclude all other possibilities."

The theoretical "other possibilities" mainly involve a vast number of dark, dead stars somehow dumped into the center of a galaxy like a mass grave: neutron stars, brown dwarfs, or Jupiters are all pretty dark objects. But to create a dark cluster in the nucleus of M31 as defined by the blue star ring, it would be like crowding 140 million solar masses into a space the size of the Oort cloud (nearly a one light-year radius around the Sun). Such a dark cluster couldn't help but light up. "You just can't get away with it," says Kormendy. "The production of supernovae, stellar remnants, stars hitting each other – not good news. We would notice something like this. The alternative must really be true."

So far, dark clusters have been fully ruled out in two other black-hole candidate galaxies, NGC 4258 and our Milky Way. "This is a significant accomplishment for Hubble," says Kormendy. "It has been used to see over 30 possible black-hole candidates in other galaxies; now three have been confirmed."

Meanwhile, astronomers still can't explain how the ring of blue stars could form around the black hole in the first place. "With this little tiny blue cluster we have a dichotomy. On the one hand, you wonder why is it there, but on the other, you are eager to exploit it," says Kormendy.

The massive stars seem to have formed in a burst of activity about 200 million years ago. But current theories in star formation say that this is impossible. For a star to form, there must be enough gravity and pressure to collapse a cloud of interstellar gas. This shouldn't happen with strong tidal forces from the black hole trying to rip any large gas cloud apart. "Although we don't understand why they are there," comments Kormendy, "we can certainly use them."

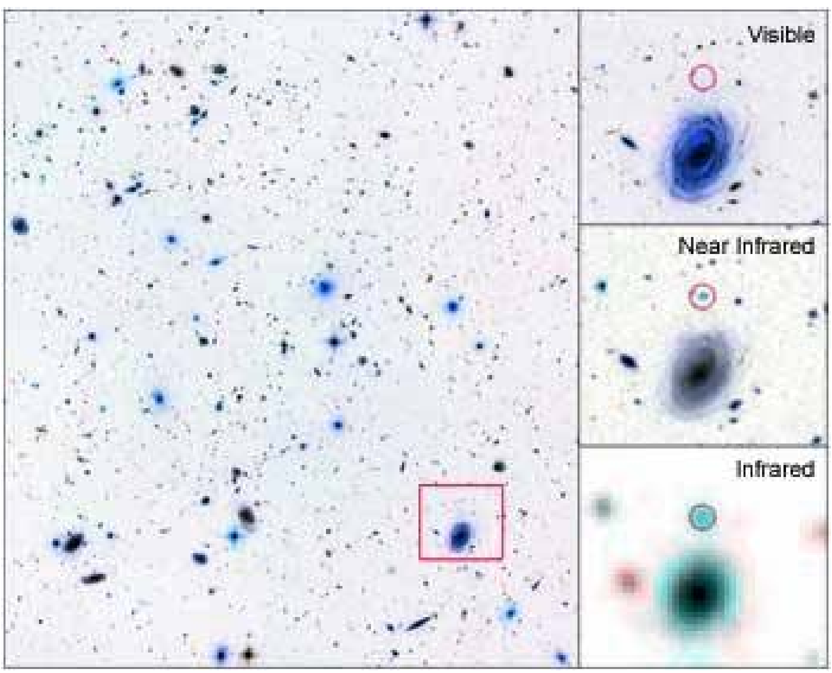
Big Baby Galaxies in the Newborn Universe

HST Press Release

Two of NASA's Great Observatories, the Spitzer and Hubble Space Telescopes, have teamed up to "weigh" the stars in several very distant galaxies. One of these galaxies, among the most distant ever seen, appears to be unusually massive and mature for its place in the young universe. This comes as a surprise to astronomers because the earliest galaxies in the universe are commonly thought to have been much smaller agglomerations of stars that gradually merged together to build large majestic galaxies like our Milky Way.

"This galaxy appears to have 'bulked up' amazingly quickly, within the first few hundred million years after the Big Bang," says Bahram Mobasher of the Space Telescope Science Institute and the European Space Agency, a member of the team which discovered the galaxy. "It made about eight times more mass in stars than are found in our own Milky Way today, and then, just as suddenly, it stopped forming new stars. It appears to have grown old prematurely."

The galaxy was pinpointed among approximately 10,000 others in a small patch of sky called the Hubble Ultra Deep Field. Thanks to the Hubble Space Telescope, this area is captured in the deepest images of the universe ever made by humankind at optical and near-infrared wavelengths. It is also within the deepest survey from the Spitzer Space Telescope, the Great Observatories Origins Deep Survey (or GOODS). The galaxy is believed to be about as far away as the most distant galaxies and quasars now known. The light reaching us today began its journey when the universe was only about 800 million years old. Scientists studying the Ultra Deep Field found this galaxy in Hubble's infrared images and expected it to be a very young "baby" galaxy, like others known at similar distances. Instead, they found a "teenager," much bigger than other galaxies known from this young cosmic era, and already quite mature."



Left - The galaxy, named HUDF-JD2, was pinpointed among approximately 10,000 others in a small area of sky called the Hubble Ultra Deep Field (HUDF). This is the deepest image of the universe ever made at optical andnear-infrared wavelengths. ***Upper Right*** - A blow-up of one small area of the HUDF is used to identify where the distant galaxy is located (inside green circle). This indicates that the galaxy's visible light has been absorbed by traveling billions of light-years through intervening hydrogen. ***Center Right*** - The galaxy was detected using Hubble's Near Infrared Camera and Multi-Object Spectrometer (NICMOS). But at near-infrared wavelengths it is very faint and red. ***Bottom Right*** - The Spitzer Infrared Array Camera (IRAC), easily detects the galaxy at longer infrared wavelengths. Spitzer's IRAC is sensitive to the light from older, redder stars which should make up most of the mass in a galaxy. The brightness of the infrared galaxy suggests that it is quite massive.

Hubble's Advanced Camera for Surveys (ACS) does not see the galaxy at all, despite the fact that the Ultra Deep Field is the deepest image ever taken in optical light. This indicates that the galaxy's blue light has been absorbed by traveling billions of light-years through intervening hydrogen gas (imagine trying to see the bottom of a silt-laden pond). The galaxy was detected using Hubble's infrared camera, the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), and also with an infrared camera on the Very Large Telescope (VLT) at the

(Continued on pg. 8)

(Continued from page 7)

European Southern Observatory, but at those wavelengths it is very faint and red.

However, the big surprise was how much brighter the galaxy is in images from Spitzer's Infrared Array Camera (IRAC), which easily detects it at wavelengths as much as five times longer than those seen by the Hubble. Spitzer's IRAC is sensitive to the light from older, redder stars which should make up most of the mass in a galaxy, and the brightness of the galaxy suggests that it is quite massive indeed. "This would be quite a big galaxy even today," says Mark Dickinson of the National Optical Astronomy Observatory (NOAO). "At a time when the universe was only 800 million years old, it's positively gigantic."

The object is also well detected with Spitzer's Multiband Imaging Photometer (MIPS) which covers wavelengths fifteeen times longer than those of the Hubble, making it sensitive to energetic processes in galaxies. This observation is consistent with the object hosting a supermassive black hole at its center, if indeed it is this massive and was formed at this early stage in the history of the universe.
The GOODS Spitzer observations have previously revealed evidence for mature stars in more ordinary, less massive galaxies at similar distances. Lawrence Eyles from the University of Exeter and collaborators, and Haojing Yan of the Spitzer Science Center, working with other members of the GOODS team, have published joint Spitzer and Hubble analyses that identify other galaxies nearly as massive as the Milky Way, seen when the universe was less than one billion years old. The new observations by Mobasher and his colleagues dramatically extend this notion of surprisingly mature "baby galaxies" to an object which is perhaps ten times more massive, and which seemed to form its stars even earlier in the history of the universe.

Mobasher and his collaborators estimated the distance to this galaxy by combining the information provided by the Hubble, Spitzer, and VLT observations. Together, these observatories cover a wide swath of the electromagnetic spectrum, from visible to mid-infrared wavelengths (0.4 to 24 microns). The relative brightness of the galaxy at different wavelengths is influenced by the expanding universe, and allows astronomers to estimate its distance. At the same time, they can also get an idea of the make-up of the galaxy in terms of the mass and age of its stars. The team has tried to confirm the distance estimate with spectroscopic measurements from the largest ground-based telescopes, the VLT, Keck, and Gemini observatories, but the object has proven to be too faint for such observations. However, thanks to the many wavelengths at which the galaxy has been observed, the color signature appears to be unique, and the estimates of the distance and mass seem robust. "While we cannot completely discard other scenarios, this appears to be the most plausible interpretation, given the available data," says Henry C. Ferguson, a member of the team.

Astronomers generally believe most galaxies were built up piecewise by mergers of smaller galaxies. However, the discovery of this object suggests that at least a few galaxies formed quickly and in their entirety, long ago, as some older theories of "monolithic" galaxy formation have suggested. For such a large galaxy, this would have been a tremendously explosive event, and the energy from the quick emergence of those stars would have helped reheat the universe very shortly after it cooled following the Big Bang. This early epoch (the first 5 percent of the universe's age) is fertile ground awaiting the James Webb Space Telescope (JWST), which will have the infrared sensitivity to possibly look all the way back to the very first stars that ignited after the Big Bang.

Planned for launch in 2013, the JWST will have the light collecting power not only to see more distant objects, but to measure their spectral fingerprints as well, yielding even more reliable distances and chemical composition information.

The Mobasher findings will be published in the December 20, 2005 issue of the Astrophysical Journal. Additional findings with Spitzer by Yan will be published in the November 2005 issue of the journal.

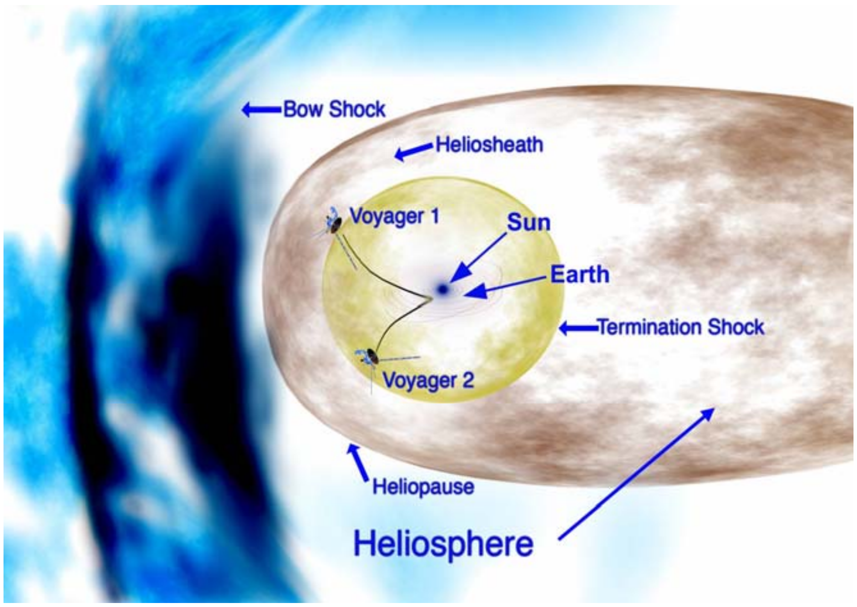
Where No Spacecraft Has Gone Before

by Dr. Tony Phillips

In 1977, Voyager 1 left our planet. Its mission: to visit Jupiter and Saturn and to study their moons. The flybys were an enormous success. Voyager 1 discovered active volcanoes on Io, found evidence for submerged oceans on Europa, and photographed dark rings around Jupiter itself. Later, the spacecraft buzzed Saturn's moon Titan—alerting astronomers that it was a very strange place indeed! —and flew behind Saturn's rings, seeing what was hidden from Earth.

Beyond Saturn, Neptune and Uranus beckoned, but Voyager 1's planet-tour ended there. Saturn's gravity seized Voyager 1 and slingshot it into deep space. Voyager 1 was heading for the stars—just as NASA had planned. Now, in 2005, the spacecraft is nine billion miles (96 astronomical units) from the Sun, and it has entered a strange region of space no ship has ever visited before.

"We call this region 'the heliosheath.' It's where the solar wind piles up against the interstellar medium at the outer edge of our solar system," says Ed Stone, project scientist for the Voyager mission at the Jet Propulsion Laboratory.



Out in the Milky Way, where Voyager 1 is trying to go, the "empty space" between stars is not really empty. It's filled with clouds of gas and dust. The wind from the Sun blows a gigantic bubble in this cloudy "interstellar medium." All nine planets from Mercury to Pluto fit comfortably inside. The heliosheath is, essentially, the bubble's skin.

"The heliosheath is different from any other place we've been," says Stone. Near the Sun, the solar wind moves at a million miles per hour. At the heliosheath, the solar wind slows eventually to a dead stop. The slowing wind becomes denser, more turbulent, and its magnetic field—a remnant of the sun's own magnetism--grows stronger. So far from Earth, this turbulent magnetic gas is curiously important to human life. "The heliosheath is a shield against galactic cosmic rays," explains Stone. Subatomic particles blasted in our direction by distant supernovas and black holes are deflected by the heliosheath, protecting the inner solar system from much deadly radiation.

Voyager 1 is exploring this shield for the first time. "We'll remain inside the heliosheath for 8 to 10 years," predicts Stone, "then we'll break through, finally reaching interstellar space."

What's out there? Stay tuned…

For more about the twin Voyager spacecraft, visit voyager.jpl.nasa.gov. Kids can learn about Voyager 1 and 2 and their grand tour of the outer planets at spaceplace.nasa.gov/en/kids/vgr_fact3.shtml .

AAL
Astronomy Associates of Lawrence

University of Kansas
Malott Hall
1251 Wescoe Hall Dr, Room 1082
Lawrence, KS 66045-7582