Southwest Florida Astronomical Society
SWFAS

The Eyepiece
June 2015

Contents:

A MESSAGE FROM THE PRESIDENT

Summer is here and the planets are well placed for observing in the evening sky.

As I won't be at the meeting this month, I want to thank Bruce Dissette for taking over and Carol Morin for doing the presentation.

June is when we report to the Astronomical League our membership. I have received a few responses to the dues notice I sent out. I will send one last message out. If I send you the dues email and I have not been contacted by the 15th, your name will be dropped from the AL list and the Reflector mailing.

We have a few summer events on the calendar.

I have built a wheely setup for the Meade RCX-400, so now we can easily move it around at the planetarium and I was able to get the focus/collimation motors working. It provides some very nice view of the planets.

As I have mentioned before, the CPC-800 and the PST are available for members to check out. Just get in contact with me.

Brian

In the Sky this Month

Moon: June – Full, 2nd; Last Quarter, 9th; New, 16th; 1st Quarter, 24th.

The Planets: Excellent planetary views again this month featuring the "big three" all month long.
Venus begins the month at 35° above the western horizon at dusk. It will reach a -4.4 to -4.6 magnitude during this month. The sunlit portion of its disc will shrink to half lit at beginning of the month as it forms a straight line with Pollux and Castor, then closes with M44 by mid-month.
Jupiter will shine at magnitude -1.9 most of the month. On morning of the 4th, a double shadow transit will occur from 12:59 to 2:14 am EDT. By end of the month, it will near a conjunction with Venus in the western sky.
Saturn will be visible all night during the month. It will shine at magnitude 0.1, the brightest it's been for 8 years. This is due to the ring tilt near a maximum of 24° from edgewise. On night of the 1st, it will be near the nearly full moon, close enough so you can view it drawing away during the night.
Mercury will appear again as a morning star low in the eastern sky last third of the month.

International Space Station: The ISS is visible in the evening starting May 30 & 31. In June the dates are 1, 3, and 18-24.
See this link for specific times: http://www.heavens-above.com/

Photos by Chuck

Saturn

M 51

Future Events

Star Party and Event Schedule

Date	Event	Location	Time	Info/Contact
June 4th	Monthly Meeting – Program: Moon Musings by Carol Morin	Calusa Nature Center & Planetarium	7:30 pm	Bruce Dissette
June 13th	Star Party		Dusk	Bruce Dissette
July 18th	Cape Coral Parks And Rec Discover Parks Day	CC Yacht Club	10-1	Brian Risley
July 18th	Star Party		Dusk	Bruce Dissette
August 15th	Star Party		Dusk	Bruce Dissette
Sept. 12th	Star Party		Dusk	Bruce Dissette
Sept. 19th	International Observe the Moon Night/Astronomy Day	TBD		Brian Risley
October 10th	Star Party		Dusk	Bruce Dissette
October 18th	Ding Darling Days	Sanibel	10-4	Brian Risley
November 14th	Star Party		Dusk	Bruce Dissette
December 12th	Star Party		Dusk	Bruce Dissette

<u>MOON MUSINGS</u> – History & Culture, Moon Science, and the Future!

We'll explore how our Moon has affected mankind throughout history, what we've learned from exploring the Moon, how to observe the Moon, and some possibilities in store for the future! Please bring any collectibles and books you may have related to the Moon for display at the meeting.

This is for all ages and handouts will be available for further lunar explorations.

Presented by Carol Morin, new S.W.F.A.S. member from the Kalamazoo Astronomical Society in Michigan, where she enjoyed teaching outreach and scout Astronomy for over 15 years.

Minutes of the Southwest Florida Astronomical Society – May 7, 2015

The monthly meeting of the Southwest Florida Astronomical Society was called to order at 7:40 pm by President Brian Risley in the Calusa Nature Center Planetarium.

Approximately 35 members and visitors were present. Several new members/visitors were introduced. Some had learned of SWFAS through the new Facebook and Website updates. Thanks to Bill Francis, Becky Brooks, and Carol Morin for their efforts to update these connections to the public. Brian reported that we now have approximately 120 members. Brian noted that Carol will send the final membership list to the Astronomical League soon, so annual dues should be paid asap.

Tony still has some eyepieces and an eyepiece box for sale to benefit the observatory at Florida Southwestern State College.

Brian Risley received volunteer help offer from Brian Shultis to provide a new Ethernet connection for the Planetarium. A motion was made by Ron Madl/seconded by Bruce Dissette to purchase needed materials for the piping, fiber wire, elbows, and connectors to complete the job. Motion passed.

Brian Risley announced that long time honorary member Dr. Manual Mon has donated a 10" Meade RCX-400 system. Manny just retired from teaching astronomy at FGCU.

The CPC 1100 telescope recently donated to the club by John Sefick was on display in the Planetarium lobby along with the RCX 400. The CPC 1100 will be stationed at the planetarium and will be used for events linked with CNCP programs.

Changes will be made to the Website, Facebook and brochures to eliminate the option for SWFAS newsletter mailings. This should not be necessary in the future with electronic options available. A motion was made and passed to make this the standard method of delivery of the newsletter. Those who have no email at this time will still be mailed if requested.

April events -

On April 17th Carol had about 170 attendees at a program at Sunshine Elementary in Lehigh Acres.

The Club Star Party at CRP on April 18th did not have good weather, but there were some periods of open sky for good viewing.

National Astronomy Day program at the planetarium on April 25th featured excellent solar viewing with a great prominence photographed by Tony.

May events – May 16th Star Party at CRP. Gary will also be asked to see if Seahawk Park can be available as an alternate site.
Sanibel School STEM evening 5-7 pm (Thursday). Brian cannot be there.
Need volunteer(s) to do this one.

April Minutes were approved after motion to accept by Brian Shultis/second by Bruce Dissette.
April Treasurer's report was read and accepted after motion by Brian Shultis/second by Bruce Dissette.

The Astronomical League has a program whereby it provides small, tabletop telescopes to be provided to local libraries for the public to check out.
The League needs for local Astronomy Clubs (SWFAS) to accept the telescopes and modify them to make them as durable and user friendly as possible. They provide the protocol for the modifications. We need to make contact with the local libraries to initiate the program. If they agree, then we will request the telescopes, do the modifications, and provide them to the libraries.

We are still seeking a program coordinator. The June program is pending. Brian has other commitments for June meeting date, so Bruce will lead meeting.

The business meeting was adjourned at 8:35 pm.

Dr. David Hanson, James & Barbara Moore Observatory (not Planetarium), Florida Southwestern State College was introduced to present the evening's program, a History of Astronomy. He gave an engaging presentation on Astronomy, beginning with it being the first science, since it predicted future events. He led us through the questions that were answered throughout history. Does the earth move? How large is it? How do we know it is a sphere? We learned that logarithms and calculus were developed to answer some of these questions. He passed around a meteorite fragment that is older than the solar system and discussed the chemical and nuclear reactions occurring in the sun.
Some sources he recommended for further information were:
Milankovitch cycles
Galileo's Daughter
Skypub.com
Google.com/moon
Nasa.gov

He offered a follow up presentation on "application of spectroscopy to astronomy". We need to book a date for him.

submitted by Ron Madl, acting secretary

Reliving Memories at the Kennedy Space Center

By Michael J. McCauley
Member, South West Florida Astronomical Society

The early 1960's, growing up in Connecticut, I became infatuated with the United States Space Program and the space race with the Soviet Union. I was a little too young to remember the launch of Sputnik in October of 1957. I do, however, remember, in April 1961, Yuri Gagarin, a Russian cosmonaut, becoming the first man to orbit the earth and adding to the American anxiety about being so far behind in space technology. A second Russian cosmonaut, Gherman Titov, orbited the earth shortly thereafter showing the world the Gagarin ride was not a fluke and further driving home the point that the Americans had a lot of catching up to do.

I remember the American outlook beginning to brighten a bit as Alan Shepard, in May 1961, made his 15 minute sub-orbital flight on Freedom 7. Less that a year later, in February 1962, John Glenn became the first American to orbit the earth in Friendship 7 and was given a hero's welcome upon his return to earth. In 1965 America began sending 2 astronauts in space together as the Gemini program replaced the Mercury program. Progress was fast and the times were exciting. I remember watching the Gemini launches and splashdowns in elementary school as the teachers rolled out the black and white television sets with the rabbit ear antennas, and we watched in awe while at the same time getting a reprieve from whatever subject was temporarily cast aside for something more important. These were great times! The Russians beat us again when on March 18, 1965 Cosmonaut Alexey Leonov stepped outside his Voskhod 2 spacecraft for a 12 minute spacewalk. Wow! These guys were good. A few months later, however, Ed White became the latest American hero when on June 3, 1965 he stepped outside his Gemini 4 spacecraft for the first American spacewalk, or extra vehicular activity, to use the newest space jargon. In December of that year Frank Borman and Jim Lovell stayed in orbit for almost 14 days aboard Gemini 7. The United States went from a 15 minute sub-orbital flight in May, 1961 to 2 weeks in orbit by the end of 1965. The vision of landing on the moon was becoming closer to reality.

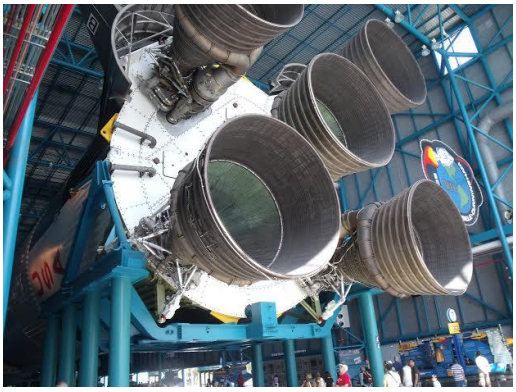
The later Gemini flights in 1966 were used to perfect docking procedures for the Apollo Program and the eventual moon landing. On January 27, 1967 America was reminded of just how dangerous space flight could be when Ed White, America's first spacewalker, Gus Grissom, and Roger Chaffee died in the Apollo 1 fire while conducting a launch rehearsal at Cape Canaveral. America recovered from this tragedy with new determination and on Christmas Eve, 1968, while sitting in our family room with my parents, we , watched Frank Borman, James Lovell, and William Anders read Bible verses from lunar orbit. They were the first human beings to travel beyond low earth orbit. Six short months later the whole world watched as Neil Armstrong and Buzz Aldrin touched down on the Sea of Tranquility. Who could ever forget Walter Cronkite's reporting of the event and Neil Armstrong's voice with the words, "Houston, Tranquility Base here. The Eagle has landed."

I have, of course, remained a huge supporter of the United States space program ever since my youth, and I still check the Voyager website weekly to see what the latest data from these vintage spacecraft, launched in the early 70's, tells us as they make their way to interstellar space. However, it wasn't until I retired and moved to Florida, that I was able to find the time to visit the place where it all began. My wife and I finally planned a visit to Cocoa Beach and the Kennedy Space Center.

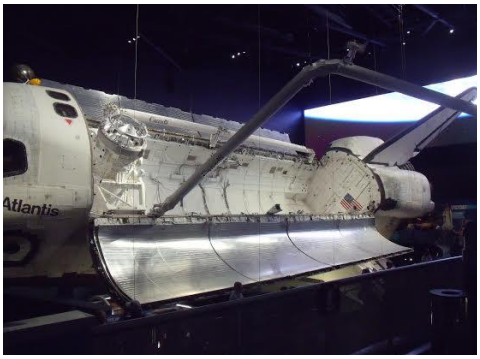
The first order of business was to go to the KSC website, kennedyspacecenter.com, to get information about the tours being offered. The first thing I noticed was that there was a schedule of rocket launches at Cape Canaveral. It just so happened that a launch was scheduled for the night of March 12th. The decision was made immediately. We would make the 4-hour drive from Cape Coral to Cocoa Beach on Wednesday, March 11th and enjoy sitting on the beach that afternoon. On Thursday, March 12th we would spend the entire day at the Space Center and cap the day off by watching the rocket launch from Cocoa Beach scheduled for 10:44 that evening. The following morning we would visit the Merritt Island National Wildlife refuge in Titusville to take some wildlife photographs before heading back to Cape Coral.

The Kennedy Space Center ticket office opens at 8:45am, and the space center opens at 9:00am. I suggest you get there early as the lines form quickly although the crowds were never an issue during the visit. We bought admission tickets for $50.00 each and with the senior discount we both gained admission for under $100.00. It was well worth it. At 9:00 sharp a very touching rendition of the national anthem was played and the gates opened. The first thing you notice when you walk in is how clean and meticulously manicured the grounds are kept. Disney World has nothing on the Kennedy Space Center. You then notice that the Rocket Garden is right in front of you where you are surrounded by the actual rockets of the Mercury, Gemini, and Apollo space programs. These things are massive and you stand there in awe just thinking about the tremendous amount of thrust they generated to get off the ground, let alone achieve orbit, and then reach the moon. Standing in front of these rockets that as a young boy I watched roar into space convinced me immediately that I was in for an exciting day.

After recovering from the exhilaration of the Rocket Garden our next stop was the Early Space Exploration exhibit which highlights the Mercury and Gemini Space Programs. This exhibit features artifacts from the first manned space flights and houses the original Mercury mission control consoles. Photographs and stories about the original Mercury 7 astronauts and actual Mercury and Gemini capsules brought old memories to life. I was very pleased to see that contributors to space flight who were not American were also given places of honor. Russian mathematician and theoretician Konstantin Tsiolkovsky and of course, Russian Cosmonaut Yuri Gagarin were duly honored with impressive exhibits for their contributions to manned space flight. Sputnik also assumed its rightful place in this exhibit as did Americans Orville and Wilbur Wright and space pioneer Robert Goddard. This day just kept getting better.



Next on the agenda was a bus ride which took us by The NASA Vehicle Assembly Building and Launch Control Center before delivering us to the Apollo/ Saturn V Center. The trip was included in our admission fee. We probably spent more time here than anywhere else because there was so much to see, but mostly because what we saw was just so spectacular. Suspended from the ceiling in spectacular fashion was a complete Apollo Launch Vehicle broken up into stages beginning with the Saturn V rocket along with the service and command modules. You couldn't stop staring at this awesome display of human engineering and technology. The floor exhibits were equally impressive relaying stories about each Apollo flight and the men who flew them. You could easily spend hours walking from exhibit to exhibit, becoming prouder with every step as you think about the remarkable men and women who landed men on the moon over 45 years ago. One very impressive exhibit showed the front pages of international newspapers with their headlines announcing the American accomplishment. I got a good case of goosebumps reading these newspapers. Another memory from my childhood was brought to life as I stood in front of a tribute to Gus Grissom, Ed White, and Roger Chaffee. These three astronauts, who lost their lives in the January, 1967 Apollo fire are immortalized with a very touching tribute to their bravery and contributions to the American space effort.



Back at the main visitor complex, we visited the Atlantis Space Shuttle Exhibit. When entering this exhibit the first thing you see is a quote from my personal hero, Carl Sagan. His words, "The sky calls to us" very simply explain mankind's yearning to explore new frontiers. Inside the building, much like the Apollo/Saturn V Center, the actual Space Shuttle Atlantis, with the cargo bay door open, hangs from the ceiling. Numerous floor exhibits tell the story of the Space Shuttle Program, the Hubble Space Telescope, and the International Space

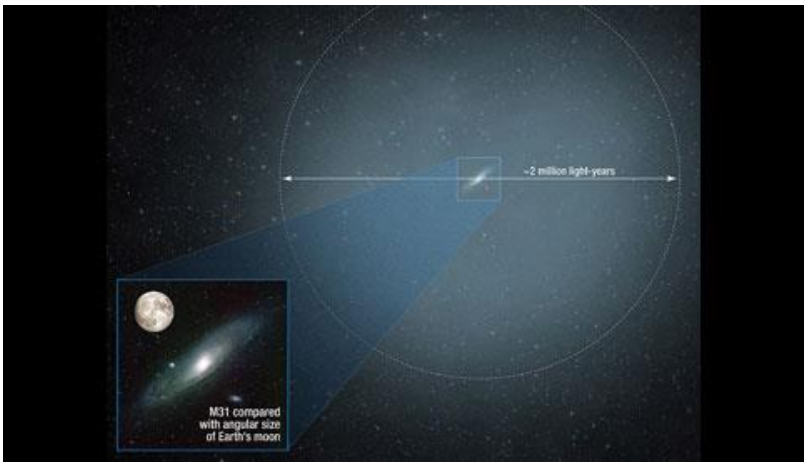
Station. It was a great way to end a very exciting and educational day.

We left Kennedy Space Center knowing we still had a little excitement left to our visit. At 10:44pm, weather permitting, a rocket launch from Cape Canaveral was scheduled. . The weather remained perfect and at about 10:30pm we joined hundreds of other people on Cocoa Beach, cameras in hand, waiting for what was to be an awesome close to an awesome day. At almost exactly 10:44pm we noticed a bright glow in the distance which after a few long moments began to rise into the sky, gaining speed. Then the sound reached us. We could hear the roar of the rocket as the bright glow gained momentum and climbed higher into the night sky. Whoops and shouts and cheers of those watching accompanied the rocket roar. The sound and the glow soon disappeared but the excitement on the beach remained for a while before the crowd began to disperse. This was a great day and more great memories were created.

Spotting Andromeda Galaxy's Giant Halo

By: Monica Young

Astronomers have detected a massive yet elusive nimbus of hot gas surrounding Andromeda Galaxy.



Andromeda's Halo dwarfs the galaxy itself, extending out to a million light-years from the galaxy's center.
NASA

Our sister galaxy, astronomers have discovered, lounges in a gargantuan cushion of hot gas that extends out to at least a million light-years, almost halfway to the Milky Way.

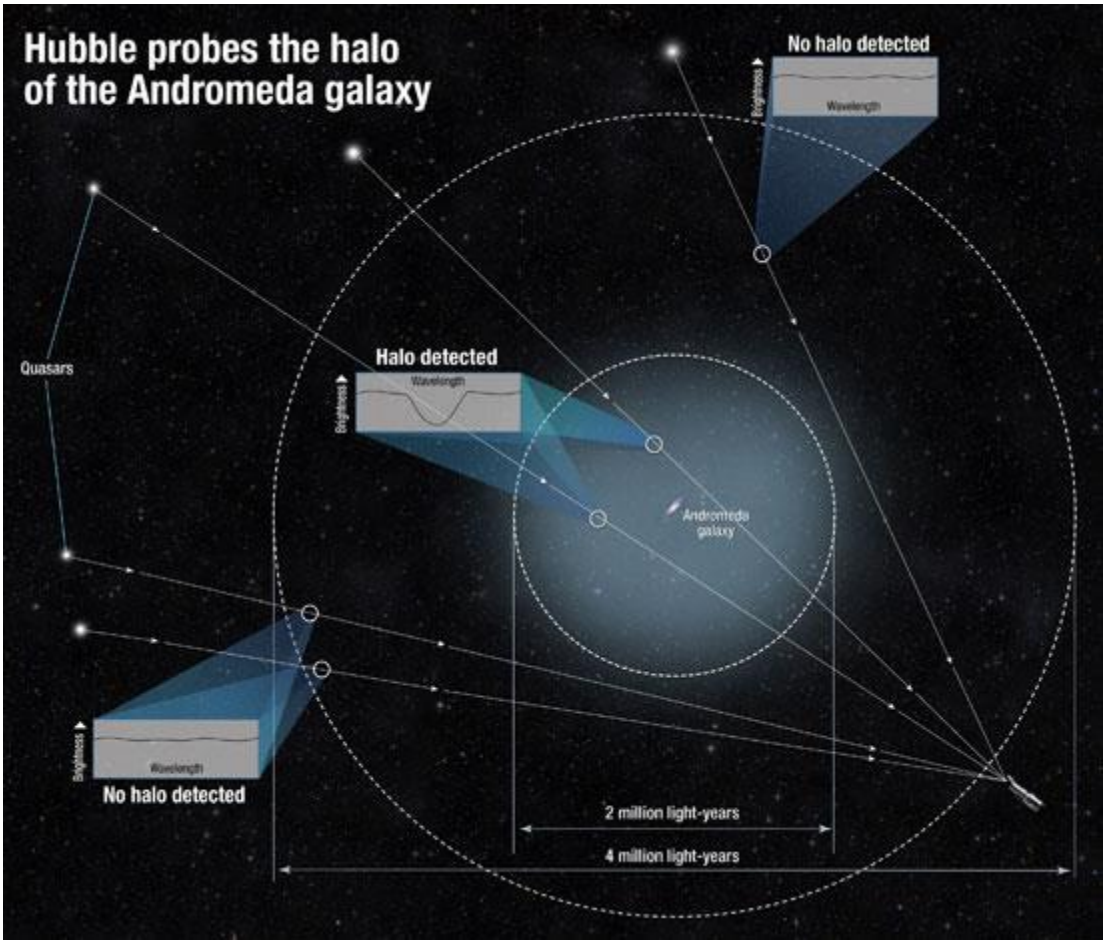
Andromeda Galaxy is in Milky Way's weight class, 220,000 light-years across and containing hundreds of billions of stars. And it turns out its halo is almost as massive as the galaxy itself — Nicolas Lehner (University of Notre Dame) and colleagues calculate in the May 10th *Astrophysical Journal* that at least 10 billion Suns' worth of gas floats outside Andromeda.

Despite its mass and extent, this halo has proven difficult to study. Its gas is hot (around 10,000 or 100,000 degrees), mostly made of ionized hydrogen (bare protons and electrons floating in the intergalactic breeze), and so sparse that hydrogen's signal can't be detected.

Yet astronomers have long suspected that this kind of halo must surround most galaxies. Of the universe's mass, 17% is normal matter (not the mysterious, dark variety). Based on a galaxy's dark mass, which can be measured for example by the galaxy's rotation curve, you expect a certain amount of accompanying normal matter. But if you add up a galaxy's normal matter in the form of stars, cold interstellar gas, and X-ray-emitting (read: *very* hot) halo gas, you come up short. Only about 40% of normal matter is accounted for.

The missing matter must be hiding somewhere, undetected, and the most likely spot is galactic halos. Simulations agree: hot gas, both inflowing and outflowing, ought to envelop growing galaxies.

To reveal this gas, Lehner's team pinointed 18 distant quasars whose light streams through the space where Andromeda's halo ought to be. Heavier (and rarer) elements stripped of their outer electrons, such as doubly ionized silicon, will cast a shadow on this background light, and the Hubble Space Telescope recorded the specific ultraviolet wavelengths that the halo gas absorbed.



To detect Andromeda's gargantuan halo, Lehner's team looked through the halo to 18 distant quasars (not all of them shown here), measuring where and how the halo absorbed their light. *NASA*

The measurements show that Andromeda's circumgalactic medium is massive, containing 3 billion Suns' worth of gas within 200,000 light-years and probably 10 times that out to a million light-years.

Almost all of this gas is ionized, and in fact, Lehner's team finds that the gas gets even more ionized further from the galaxy, confirming theoretical predictions. Because the

hotter gas is more difficult to detect (and can't be detected within these Hubble observations), it's possible the halo continues even further than what the team was able to record.

In short, Lehner says, this study and an accompanying study of halos in more distant galaxies have "essentially solved" the missing matter problem.

- See more at: http://www.skyandtelescope.com/astronomy-news/spotting-andromeda-galaxys-giant-halo/?et_mid=751456&rid=246752253#sthash.TBhgvoQu.dpuf

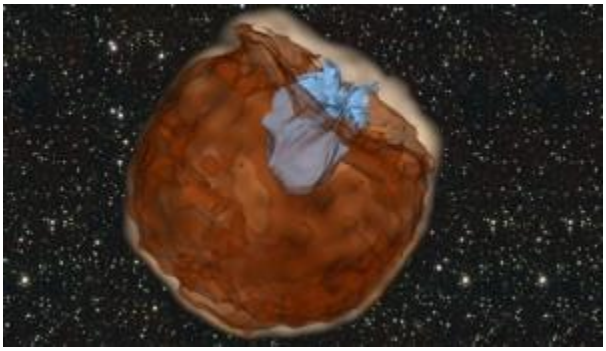
Supernova, Two Ways

By: Camille M. Carlisle

Two new studies confirm that the white dwarfs that explode as Type Ia supernovae can approach death in two different ways.

Astronomers care a lot about white dwarfs. These stellar cores are left behind when stars like the Sun slough off their outer layers. They're a couple hundred thousand times as dense as our planet, capable of shoving half a Sun's worth of mass into an Earth-size ball. (Mass-wise, it would take about 300,000 Earths to make the Sun.)

But astronomers care most about white dwarfs when they die. When white dwarfs eat too much, they burst through a strict weight restriction called the Chandrasekhar limit and trigger a thermonuclear blast deep inside themselves. This fusion bomb generally annihilates the white dwarf in what's called a Type Ia supernova.



This simulated image depicts the explosive death of a white dwarf as a Type Ia supernova with a stellar companion. When the supernova explodes (dark brown), its ejected material slams into the companion star (light blue). The violent collision produces an ultraviolet pulse, which is emitted from the conical hole carved out by the companion star. *Dan Kasen*

Type Ia explosions are so dependable in how their light brightens and fades, and in how those changes depend on the supernova's intrinsic brightness, that astronomers can use them to gauge the distances to the dying white dwarfs — and, therefore, to the galaxies they sit in. They can also calculate how those distances are changing: measuring how fast Type Ia host galaxies are receding from us led astronomers to the unsettling discovery that the universe is now expanding at an accelerating rate.

But although Type Ia help form the backbone of the cosmic distance ladder, astronomers don't know the nuts and bolts of the systems that spawn these explosions. For many years, astronomers have debated just how the white dwarf maxes out its mass. There are two scenarios: either it siphons gas from a "living" companion star until it just can't swallow any more (called the *single-degenerate model*), or it merges with

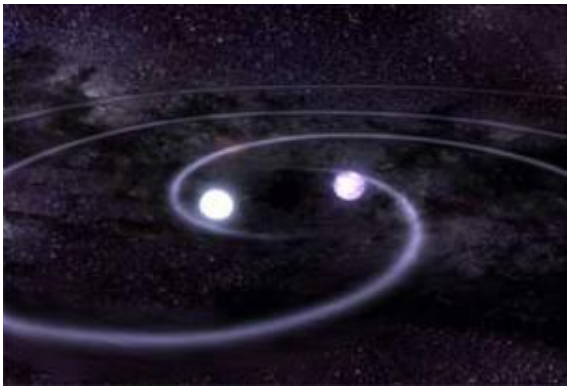
another dead star like itself (the *double-degenerate model*). Which scenario is more likely depends on whom you ask and which particular supernova you're looking at. In fact, papers and press releases proclaiming evidence of one solution or the other have become so common that I've frankly started ignoring them. The growing sense — and not just because of my journalistic cynicism — is that white dwarfs probably die both ways.

Two papers in the May 21st *Nature* support this suspicion. One reports an ultraviolet pulse from a supernova that, the authors say, is a telltale signal that the white dwarf was stealing material from a companion star. The other study finds no evidence for such a signal from three supernovae.

How to Destroy a White Dwarf

Yi Cao (Caltech) and colleagues detected the extra UV in light from the Type Ia supernova iPTF14atg. They caught the supernova's start with the intermediate Palomar Transient Factory (iPTF) survey, then followed up with the UV and X-ray capabilities of NASA's Swift satellite. The latter revealed an uptick in UV emission for four days after the explosion, a pulse that the authors propose arose when the exploding white dwarf's ejecta slammed into its companion star. The signal would then have disappeared once the ejecta engulfed the companion enough to hide the shocked gas created by the collision.

Rob Olling (University of Maryland) and colleagues took a different approach: they used archival observations from the Kepler mission to study three supernovae that lit up in the space telescope's field of view. Two of these supernovae (KSN 2011b and KSN 2012a) are clearly Type Ia; the third (KSN 2011c) is probably one. The team used the same theoretical predictions as Cao's team did to analyze their data and found no sign of ejecta slamming into companion stars.



In this NASA illustration, a close pair of orbiting white dwarf stars throw off spiral waves of gravitational radiation.

Kepler doesn't look in UV, and Cao's team didn't see iPTF14atg's ejecta shock in visible wavelengths. But Olling says that Kepler's sensitivity is so tremendous that, had there been a signal from material colliding with a companion star, his team would have seen it in visible light. Thus, the astronomers favor a dual white dwarf death as the origin for these three (likely) Type Ia events.

So basically, the Type Ia supernovae in these two studies have different origins.

iPTF14atg is an oddball Type Ia: it's intrinsically dimmer than a normal Type Ia. Two other, less luminous Type Ia events also appear to come from single-degenerate systems: SN 2008ha and SN 2012Z. Cao's team tentatively suggests that all subluminous Type Ia supernovae might come from white dwarfs with companion stars.

But stellar astronomer Ryan Foley (University of Illinois at Urbana-Champaign) cautions against jumping to that conclusion. iPTF14atg is a "weird" supernova, similar to a family of subluminous supernovae named after their founding father, SN 2002es. And the other dim supernovae, SN 2008ha and SN 2012Z, both appear to be yet another breed of Type Ia, called Type Iax, with lower peak brightnesses and ejecta velocities. These two families are both low-energy explosions, and they don't necessary work the same way that a typical Type Ia does.

So although these dim supernovae might all have been single-degenerate systems, that doesn't mean all subluminous Type Ia events signal the death of white dwarfs sucking material from normal companion stars. It essentially boils down to the old logical fallacy: all cows eat grass, but that doesn't mean that all grass-eaters are cows.

Now the question is, which scenario is more common? A recent review favors the double degenerate pathway, but I'd wager that won't be the last word in this debate. Nor, of course, will this blog.

References:

Yi Cao et al. "A strong ultraviolet pulse from a newborn type Ia supernova." *Nature*. May 21, 2015.

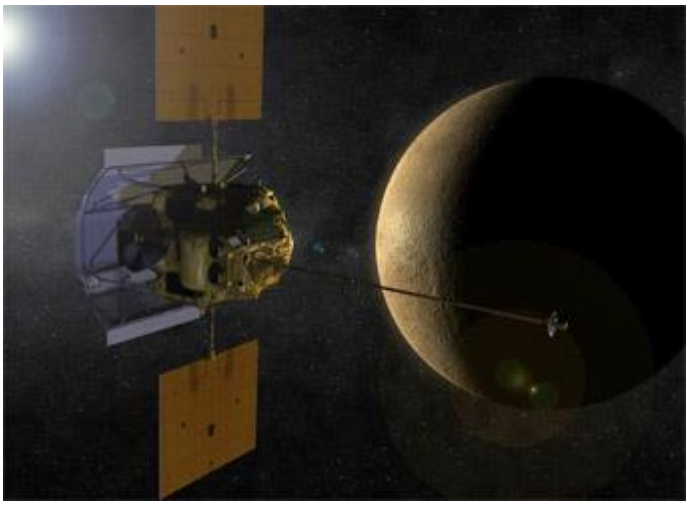
Rob P. Olling et al. "No signature of ejecta interaction with a stellar companion in three type Ia supernovae." *Nature*. May 21, 2015.

Dan Maoz, Filippo Mannucci,and Gijs Nelemans. "Observational Clues to the Progenitors of Type Ia Supernovae." *Annual Review of Astronomy and Astrophysics*. Vol. 52: 107-170 (August 2014).

Messenger Crashes, Its Results Endure

By: Kelly Beatty

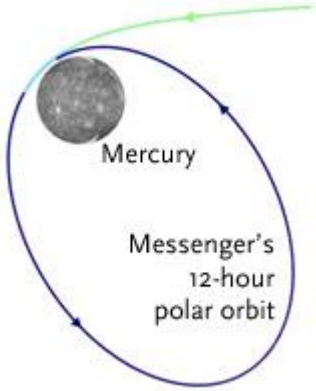
After four years at Mercury, NASA's Messenger orbiter has finished its remarkable mission and crashed into the planet.



An artist's portrayal of the Messenger spacecraft after its arrival at Mercury. *NASA / JHU-APL / Carnegie Inst.*

We've known for months that NASA's Messenger spacecraft was operating on borrowed time. Its fuel tanks nearly empty after a decade of interplanetary maneuvering, the spacecraft could only fire its engine so many times before the pull of Mercury's gravity — coupled with the Sun's perturbing pull — forced it to crash into the planet. The end came yesterday at 19:26 Universal Time (3:26 p.m. Eastern Daylight Time).

Actually, missions engineers can only assume that the spacecraft crashed as predicted because the impact occurred on the planet's unseen side. Presumably it skimmed over the large crater Shakespeare before striking an unnamed ridge located at 54.5° north, 210.1° east.

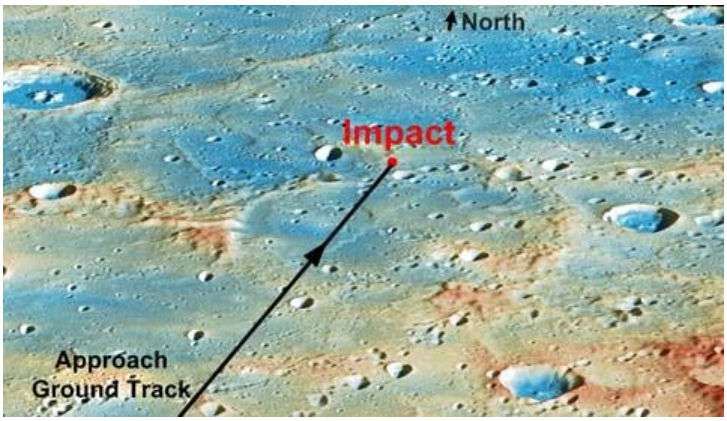


Messenger's initial polar orbit around Mercury ranged in altitude from just 120 miles (200 km) to about 10,000 miles (15,000 km). Later the orbit was adjusted so the spacecraft passed even closer.

A few minutes later, when the spacecraft would have emerged from behind the planet and been in view from Earth, no radio signal was received. The mood in the mission control center at Johns Hopkins University's Applied Physics Laboratory was "both celebratory and somber" as team members watched the final transmissions arrive after 4,105 orbits around Mercury.

Launched in August 2004, Messenger first became acquainted with Mercury during three close flybys in 2008–09. (The spacecraft's name, by the way, is a contraction for Mercury Surface, Space Environment, Geochemistry, and Ranging.) When Messenger finally settled around the planet for keeps, on March 18, 2011 (Universal Time), it assumed an elliptical orbit that ranged in altitude from 15,000 km (9,300 miles) to as close as 200 km (120 miles) every 12 hours.

The nominal mission was to be only a year, but with the spacecraft still healthy NASA managers opted to continue the mission and, in March 2014, to lower the periapse (close point) of each orbit to less than 50 km. These mission extensions, particularly moving the spacecraft closer in, paid big dividends in terms of surface photography and geochemical assays.

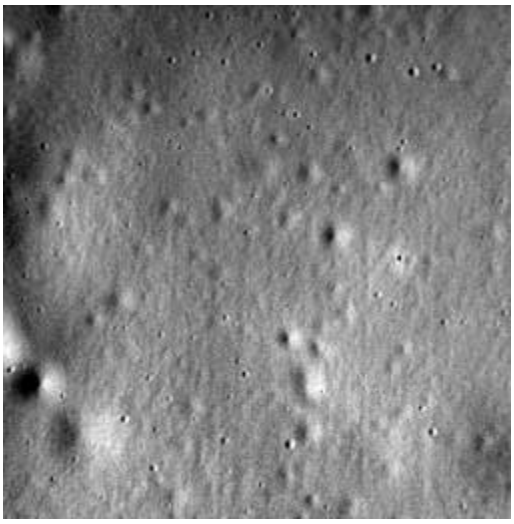


Messenger's impact on Mercury took place on the planet's unseen side on April 30, 2015. The crater at upper left, Janacek, is 48 km (30 miles) across. Color indicates terrain altitude, with the tallest regions shown in red.
NASA / JHU-APL / Carnegie Inst. of Washington

But it also meant more frequent thruster firings to keep the spacecraft from swooping too low and striking Mercury prematurely. Engineers milked every last drop propellant — and then even expelled the fuel tanks' helium pressurant — to maneuver the craft in the mission's final weeks.

During a news briefing on April 16th, project scientist Sean Solomon ran through his "top 10" list of scientific results. Rather than detail those here, I invite you to view that list (along with helpful animations) on the mission's website. There you'll also find the mission's top 10 technological innovations, as presented by Daniel O'Shaughnessy (the mission's systems engineer) and Helene Winters (project manager).

Why is Mercury So Dark?

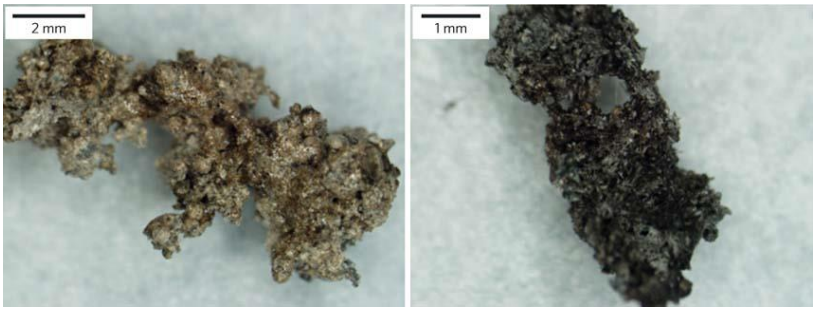


Before it crashed into Mercury on April 30, 2015, the Messenger spacecraft relayed this snapshot of the floor of Jokai crater. The smallest details are just 2 meters (7 feet) across. NASA / JHU-APL / Carnegie Inst. of Washington

One of the mission's most unexpected results is that the rocks and dust on Mercury's surface contain very little iron. It's baffling, actually, because this planet has a huge, iron-dominated core that takes up three-fourths of the planet's diameter and half its volume. So geochemists expected that the planet's surface would contain an abundance of iron-rich minerals.

This finding, curious in itself, has a bearing on another Mercurian mystery. The planet's surface is very dark, reflecting only about 7% of the sunlight striking it. That's even darker than the Moon. Researchers have long known that the lunar surface becomes less reflective over time because tiny meteorites pepper the lunar dust, momentarily flash-melting its iron-bearing silicate minerals and creating submicroscopic bits of metallic iron. These iron particles are what make the Moon appear dark. But given Mercury's iron-poor surface, some other process must be involved.

In the March 31st issue of *Nature Geoscience,* a trio of researchers led by Megan Bruck Syal (Lawrence Livermore National Laboratory) offer a reasonable alternative. "One thing that hadn't been considered was that Mercury gets dumped on by a lot of material derived from comets, Syal notes in a press release from Brown University.



High-velocity experiments show that a mix of simulated lunar soil and quartz sand *(left)* yields neutrally colored particle clusters. However, when the target is a mixture of the lunar simulant and sugar *(right)*, the result is a dark, carbon-rich aggregate. *Nature Geoscience / M. Syal & others*

She and her colleagues first estimated that the infall of comets and cometary dust over the past 200 million years could have infused the top layer of Mercurian dirt with 3% to 6% carbon. Then they conducted impact simulations at the NASA Ames Vertical Gun Range to confirm that the comet-borne carbon would actually stick around, in the form of tiny particle clusters called agglutinates.

Moreover, the resulting surface would have a very bland spectrum, exactly what Messenger found. "We show that carbon acts like a stealth darkening agent," explains team member Peter Schultz (Brown University). "From the standpoint of spectral analysis, it's like an invisible paint" that has been building up on Mercury's surface for billions of years.

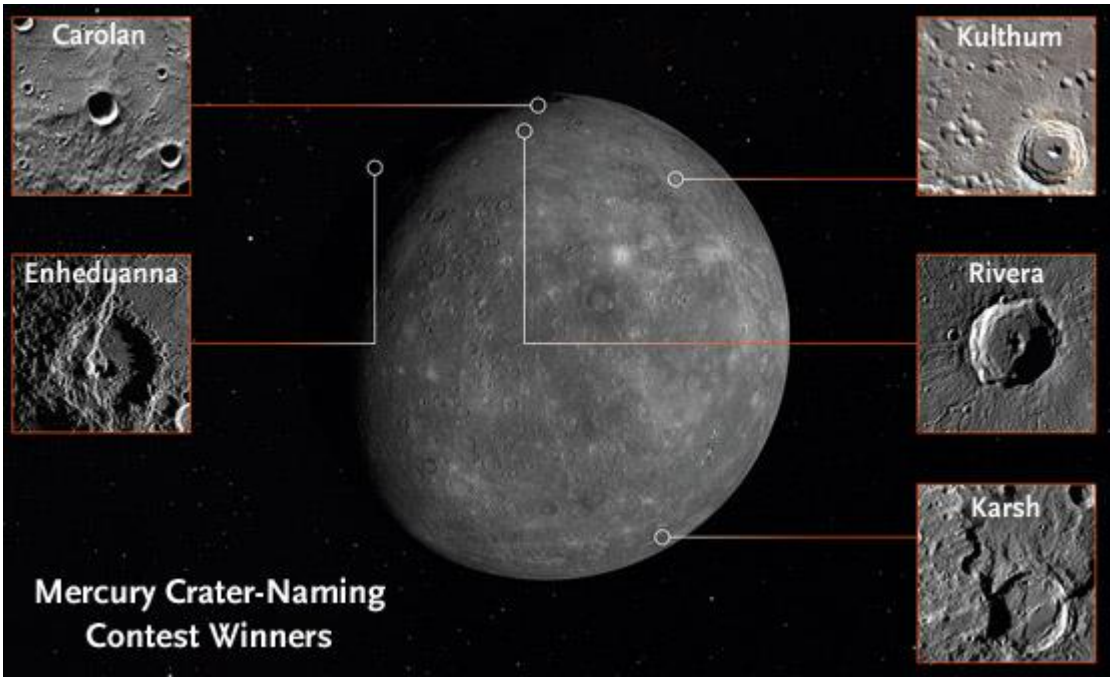
Messenger's Name Game

As the Messenger mission wound down, its team joined with the Carnegie Institution for Science and the International Astronomical Union to hold a crater-naming contest. The submission rules were strict — for example, the nominees must have been recognized as an A-lister for at least 50 years and must have died in 2011 or earlier. Special emphasis was accorded nations and cultural groups who've been under-represented on other planetary bodies.

The contest drew more than 3,600 entries. The five winners, announced on April 29th, are:

- **Carolan** (83.8°N, 31.7°E): named for Irish musician and composer Turlough O'Carolan (1670-1738)
- **Enheduanna** (48.3°N, 326.2°E): named for the author and poet from ancient Mesopotamia
- **Karsh** (35.6°S, 78.9°E): named for Yousuf Karsh (1908–2002), Armenian-Canadian portrait photographer

- **Kulthum**(50.7°N, 93.5°E): named for Umm Kulthum (d. 1975), Egyptian singer, songwriter, and actress
- **Rivera** (69.3°N, 32.4°E): named for Diego Rivera (1886–1957), Mexican painter and muralist



Five craters on Mercury now bear names submitted by the public. *IAU / NASA / Messenger team*

Progress on BepiColombo

Messenger's mission is over, but the next step in our exploration of the innermost planet is taking shape at the European Space Research and Technology Centre in Noordwijk, the Netherlands. That's where European Space Agency engineers are assembling a spacecraft called BepiColombo. You've likely never heard of this mission, but it's a big deal for the European Space Agency. Plans call for a launch in 2017 and arrival at Mercury in 2024.

BepiColombo will actually consist of two orbiters: one to study Mercury itself and the other to probe the planet's unusual magnetosphere. (Messenger discovered that Mercury's magnetic field, while only about 1% the strength of Earth's, is offset from the core by about 500 km, or 20% of the planet's radius, in direction of its north pole.)

The Mercury Magnetospheric Orbiter, Japan's contribution to the BepiColombo mission, arrives at ESA's test center in the Netherlands. *ESA / A. Le Floc'h*

ESA is building one half, the Mercury Planetary Orbiter, and Japan is supplying the Mercury Magnetospheric Orbiter. The latter arrived at ESTEC just this week, where it was unboxed and checked out. In time they'll both be mated to a service vehicle called the Mercury Transfer Module, now finished, that will handle the navigation and propulsion duties en route to Mercury.

In case you're wondering, BepiColombo honors Italian researcher Giuseppe "Bepi" Colombo (1920–84). He first deduced that Mercury has a spin-orbit resonance, showing that the planet rotates three times for every two orbits it completes around the Sun. Colombo also realized that NASA's Mariner 10 spacecraft could be placed in a heliocentric orbit that synched with Mercury's — a discovery that allowed Mariner 10 to make three flybys of the innermost planet in 1974–75.

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