May 2011

THE SPECTROGRAM

Newsletter for the Society of Telescopy, Astronomy, and Radio

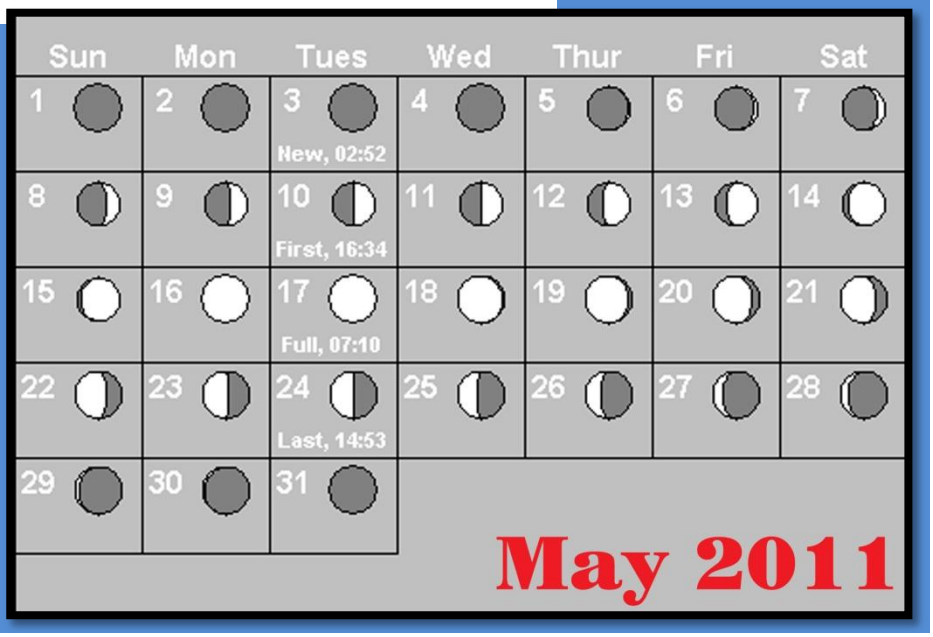
Inside this Issue:

May Meeting

The next meeting of S*T*A*R will be on Thursday, May 5th 2011. Dr. Robert Lupton from Princton will talk about astronomical surveys from the Sloan Digital Sky Survey (SDSS) to the Large Synoptic Survey Telescopes (LSST) via the Subaru Hyper Suprime-Cam (HSC) survey.

Calendar

- May 5th 2011 – Dr. Robert Lupton: Sky Surveys



June Issue

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

April Meeting Minutes

The April 7, 2011 meeting of S*T*A*R Astronomy Club began at 8:12 p.m. The meeting was attended by about 32 people. President Nancy McGuire chaired the meeting and began by presenting the agenda and asking if there were first-time attendees. There were seven new attendees. Nancy noted the upcoming star party for Brookdale astronomy students, to be held April 26, and asked club members to bring their telescopes. She also noted that elections for club officers will be held at the June meeting, and that candidates for the positions of president and vice president are needed.

Nancy then introduced the speaker for the evening. Dr. William Gutsch is a professor at St. Peter's College in New Jersey, where he teaches courses in several fields, including astronomy and meteorology. His talk was titled "Lights, Action, Universe," and described work he has done through his career to introduce astronomy to the public. He has worked at planetariums, including the Hayden planetarium in New York City, where he developed programs to add dramatic effects to the presentations. At science centers around the world he helped to make programs more interactive. At a science center in South Korea, students plan a trip to a moon of Jupiter, and measure the speed of light to help in their planning. He arranged for students to plan observing time with a telescope being flown at high altitude on an airplane, and to plan observing time for several orbits of the Hubble Space Telescope. Dr. Gutsch finished by showing a video made by NASA planners of a simulation of a proposed final mission of the Cassini spacecraft that would bring it into an orbit inside Saturn's D ring.

Ken Legal presented events of the month. He noted that at the end of April a number of planets will be in close alignment. Saturn's rings are becoming more visible, with their angle of view about 8 degrees. The Lyrid meteor shower is approaching, and sunspot activity is increasing.

Following Ken's announcement was a 20 minute break for refreshments.

After the break a vote was taken on the proposal to allow the club to sell the 25-inch telescope. With eighteen members in attendance, the vote was sixteen in favor, and one opposed. There was some discussion of setting a minimum price, but the club decided that such a step wasn't necessary.

Ken Legal thanked those who helped with the Sayreville star party. Randy Walton announced a star party with Aetna on April 30. The 50/50 winning ticket was held by Rob Nunn, who won seven dollars. The meeting concluded at 10:48.

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

Meetings are the first Thursday of each month, except July and August, at 8:00 PM at the Monmouth Museum on the Brookdale Community College campus. Meetings generally consist of lectures and discussions by members or guest speakers on a variety of interesting astronomical topics. S*T*A*R is a member of United Astronomy Clubs of New Jersey (UACNJ), the Astronomical League (AL), and the International Dark Sky Association (IDA).

Memberships: ( )Individual....$25 ( ) Family...$35

Name_____

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

NASA's Hubble Celebrates 21st Anniversary with 'Rose' of Galaxies

To celebrate the 21st anniversary of the Hubble Space Telescope's deployment into space, astronomers at the Space Telescope Science Institute in Baltimore, Md., pointed Hubble's eye at an especially photogenic pair of interacting galaxies called Arp 273.

"For 21 years, Hubble has profoundly changed our view of the universe, allowing us to see deep into the past while opening our eyes to the majesty and wonders around us," NASA Administrator Charles Bolden said."I was privileged to pilot space shuttle Discovery as it deployed Hubble. After all this time, new Hubble images still inspire awe and are a testament to the extraordinary work of the many people behind the world's most famous observatory."

Hubble was launched April 24, 1990, aboard Discovery's STS-31 mission. Hubble discoveries revolutionized nearly all areas of current astronomical research from planetary science to cosmology.

"Hubble is America's gift to the world," Sen. Barbara Mikulski of Maryland said. "Its jaw-dropping images have rewritten the textbooks and inspired generations of schoolchildren to study math and science. It has been documenting the history of our universe for 21 years. Thanks to the daring of our brave astronauts, a successful servicing mission in 2009 gave Hubble new life. I look forward to Hubble's amazing images and inspiring discoveries for years to come."

The newly released Hubble image shows a large spiral galaxy, known as UGC 1810, with a disk that is distorted into a rose-like shape by the gravitational tidal pull of the companion galaxy below it, known as UGC 1813. A swath of blue jewel-like points across the top is the combined light from clusters of intensely bright and hot young blue stars. These massive stars glow fiercely in ultraviolet light.

The smaller, nearly edge-on companion shows distinct signs of intense star formation at its nucleus, perhaps triggered by the encounter with the companion galaxy.

Arp 273 lies in the constellation Andromeda and is roughly 300 million light-years away from Earth. The image shows a tenuous tidal bridge of material between the two galaxies that are separated from each other by tens of thousands of light-years.

A series of uncommon spiral patterns in the large galaxy are a tell-tale sign of interaction. The large, outer arm appears partially as a ring, a feature seen when interacting galaxies actually pass through one another. This suggests the smaller companion dived deep, but off-center, through UGC 1810. The inner set of spiral arms is highly warped out of the plane, with one of the arms going behind the bulge and coming back out the other side. How these two spiral patterns connect is not precisely known.

To celebrate the 21st anniversary of the Hubble Space Telescope's deployment into space, astronomers at the Space Telescope Science Institute in Baltimore, Md., pointed Hubble's eye at an especially photogenic pair of interacting galaxies called Arp 273. The larger of the spiral galaxies, known as UGC 1810, has a disk that is distorted into a rose-like shape by the gravitational tidal pull of the companion galaxy below it, known as UGC 1813. This image is a composite of Hubble Wide Field Camera 3 data taken on December 17, 2010, with three separate filters that allow a broad range of wavelengths covering the ultraviolet, blue, and red portions of the spectrum.Credit: NASA

The larger galaxy in the UGC 1810 - UGC 1813 pair has a mass about five times that of the smaller galaxy. In unequal pairs such as this, the relatively rapid passage of a companion galaxy produces the lopsided or asymmetric structure in the main spiral. Also in such encounters, the starburst activity typically begins in the minor galaxies earlier than in the major galaxies. These effects could be because the smaller galaxies have consumed less of the gas present in their nuclei, from which new stars are born.

The interaction was imaged on Dec. 17, 2010, with Hubble's Wide Field Camera 3 (WFC3). The picture is a composite of data taken with three separate filters on WFC3 that allow a broad range of wavelengths covering the ultraviolet, blue, and red portions of the spectrum.

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

NASA Dawn Spacecraft Reaches Milestone Approaching Asteroid

WASHINGTON -- NASA's Dawn spacecraft has reached its official approach phase to the asteroid Vesta and will begin using cameras for the first time to aid navigation for an expected July 16 orbital encounter. The large asteroid is known as a protoplanet – a celestial body that almost formed into a planet.

At the start of this three-month final approach to this massive body in the asteroid belt, Dawn is 752,000 miles (1.21 million kilometers) from Vesta, or about three times the distance between the Earth and the moon. During the approach phase, the spacecraft's main activity will be thrusting with a special, hyper-efficient ion engine that uses electricity to ionize and accelerate xenon to generate thrust. The 12-inch-wide ion thrusters provide less thrust than conventional engines, but will provide propulsion for years during the mission and provide far greater capability to change velocity.

"We feel a little like Columbus approaching the shores of the New World," said Christopher Russell, Dawn principal investigator, based at the University of California in Los Angeles (UCLA). "The Dawn team can't wait to start mapping this Terra Incognita."

Dawn previously navigated by measuring the radio signal between the spacecraft and Earth, and used other methods that did not involve Vesta. But as the spacecraft closes in on its target, navigation requires more precise measurements. By analyzing where Vesta appears relative to stars, navigators will pin down its location and enable engineers to refine the spacecraft's trajectory. Using its ion engine to match Vesta's orbit around the sun, the spacecraft will spiral gently into orbit around the asteroid. When Dawn gets approximately 9,900 miles (16,000 kilometers) from Vesta, the asteroid's gravity will capture the spacecraft in orbit.

"After more than three and a half years of interplanetary travel, we are finally closing in on our first destination," said Marc Rayman, Dawn's chief engineer, at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif. "We're not there yet, but Dawn will soon bring into focus an entire world that has been, for most of the two centuries scientists have been studying it, little more than a pinpoint of light."

Scientists will search the framing camera images for possible moons around Vesta. None of the images from ground-based and Earth-orbiting telescopes have seen any moons, but Dawn will give scientists much more detailed images to determine whether small objects have gone undiscovered.

The gamma ray and neutron detector instrument also will gather information on cosmic rays during the approach phase, providing a baseline for comparison when Dawn is much closer to Vesta. Simultaneously, Dawn's visible and infrared mapping spectrometer will take early measurements to ensure it is calibrated and ready when the spacecraft enters orbit around Vesta.

Dawn's odyssey, which will take it on a 3-billion-mile journey, began on Sept. 27, 2007, with its launch from Cape Canaveral Air Force Station in Florida. It will stay in orbit around Vesta for one year. After another long cruise phase, Dawn will arrive at its second destination, an even more massive body in the asteroid belt called Ceres, in 2015.

These two icons of the asteroid belt will help scientists unlock the secrets of our solar system's early history. The mission will compare and contrast the two giant asteroids, which were shaped by different forces. Dawn's science instrument suite will measure surface composition, topography and texture. In addition, the Dawn spacecraft will measure the tug of gravity from Vesta and Ceres to learn more about their internal structures.

The Dawn mission to Vesta and Ceres is managed by JPL for NASA's Science Mission Directorate (SMD) in Washington. Dawn is a project of SMD's Discovery Program, which is managed by NASA's Marshall Space Flight Center in Huntsville, Ala. UCLA is responsible for overall Dawn mission science. Orbital Sciences Corp. of Dulles, Va., designed and built the Dawn spacecraft. The framing cameras have been developed and built under the leadership of the Max Planck Institute for Solar System Research in Katlenburg-Lindau in Germany, with significant contributions by the German Aerospace Center (DLR) Institute of Planetary Research in Berlin, and in coordination with the Institute of Computer and Communication Network Engineering in Braunschweig. The framing camera project is funded by NASA, the Max Planck Society and DLR.

NASA Test Stand Passes Review for Next-Generation Rocket Engine Testing

Forty-five years after its first Saturn V rocket stage test and 35 years after its first space shuttle main engine test, the A-2 Test Stand at NASA’s John C. Stennis Space Center achieved a milestone in preparation for its third major rocket engine test project.

A facility readiness review in mid-March indicated all major modifications have been completed on the historic A-2 stand to begin testing the next-generation J-2X rocket engine this summer.

The new test project comes as Stennis celebrates its 50th anniversary year. On Oct. 26, 1961, NASA publicly

announced plans to build the south Mississippi facility to test the massive Saturn V rocket stages for the Apollo Program.

Operators at NASA's John C. Stennis Space Center conduct the last scheduled space shuttle main engine test on the A-2 Test Stand on July 29, 2009. Image Credit: NASA

The first test of a Saturn V second stage at Stennis was performed at the A-2 stand on April 23, 1966. Stennis engineers tested 27 first and second Saturn V rocket stages for the Apollo Program, including those used to carry humans to the moon.

In the mid-1970s, the stand was modified from Apollo Program parameters to allow testing of space shuttle main engines. The first space shuttle main engine test on the A-2 stand was conducted 35 years ago, on March 31, 1976. In ensuing decades, Stennis engineers tested space shuttle main engines used to power more than 130 missions. The last scheduled space shuttle main engine test was performed on the A-2 stand in July 2009.

After a decommissioning period, Stennis employees spent 10 months converting the A-2 stand from space shuttle main engine parameters to those needed for the new engine test series. The March 16-17 facility readiness review identified no major actions, which means the A-2 Test Stand is ready to receive the J-2X engine and begin checkout testing activation of engine critical systems. Stand employees now will work through the final items to be completed before installation of a J-2X engine in early June.

"Some of the hardware was decades old and nearing the end of its serviceability," said Gary Benton, manager of the J-2X engine testing project at Stennis. "Also, the J-2X has different testing requirements than the space shuttle main engine. It was a major transition completed on a very demanding schedule."

The transition work from the space shuttle main engine project to the J-2X test project included structural, electrical and plumbing modifications to accommodate the different geometry of the J-2X engine, and included the installation of a new J-2X engine start system. Liquid oxygen and liquid hydrogen transfer lines that dated back to the 1960s also were replaced, as was other piping on the stand. Control systems also were upgraded on the stand.

The J-2X engine is being developed by Pratt & Whitney Rocketdyne for NASA as a next-generation engine that can carry humans beyond low-Earth orbit to deep space. Engineers at NASA's Marshall Space Flight Center in Huntsville, Ala., manage J-2X engine development. Stennis is preparing three stands to test the new engine. Power pack testing is scheduled on the A-1 Test Stand. Verification and sea-level testing will be conducted on the A-2 Test Stand. The A-3 Test Stand under construction and set for activation in 2013 will allow operators to test new engines at simulated altitudes up to 100,000 feet, a critical requirement for a deep space engine.

Plans now are to install a J-2X research-and-development engine on the A-2 Test Stand this summer. Testing will begin soon afterward and continue throughout the year. Various verification and start-sequence tests will be performed.

"This is the future for American space exploration," Benton said. "We are excited to play a key part in the progress of the nation's space program."

NASA Telescopes Help Discover Surprisingly Young Galaxy

PASADENA, Calif. -- Astronomers have uncovered one of the youngest galaxies in the distant universe, with stars that formed 13.5 billion years ago, a mere 200 million years after the Big Bang. The finding addresses questions about when the first galaxies arose, and how the early universe evolved.

NASA's Hubble Space Telescope was the first to spot the newfound galaxy. Detailed observations from the W.M. Keck Observatory on Mauna Kea in Hawaii revealed the observed light dates to when the universe was only 950 million years old; the universe formed about 13.7 billion years ago.

Infrared data from both Hubble and the post-coolant, or "warm," phase of NASA's Spitzer Space Telescope mission revealed the galaxy's stars are quite mature, which means they must have formed when the universe was just a toddler.

"This challenges theories of how soon galaxies formed in the first years of the universe," said Johan Richard of the Centre de Recherche Astronomique de Lyon, Université Lyon 1 in France, lead author of a new study accepted for publication in the Monthly Notices of the Royal Astronomical Society. "It could even help solve the mystery of how the hydrogen fog that filled the early universe was cleared."

This galaxy is not the most distant ever observed, but it is one of the youngest to be observed with such clarity. Normally, galaxies like this one are extremely faint and difficult to study, but, in this case, nature has provided the astronomers with a cosmic magnifying glass. The galaxy's image is being magnified by the gravity of a massive cluster of galaxies parked in front of it, making it appear 11 times brighter. This phenomenon is called gravitational lensing.

The giant cluster of elliptical galaxies in the center of this image contains so much dark matter mass that its gravity bends light. This means that for very distant galaxies in the background, the cluster¹s gravitational field acts as a sort of magnifying glass, bending and concentrating the distant objects' light. These gravitational lenses are one tool astronomers can use to extend the vision of telescopes beyond what they would normally be capable of observing. This particular lens, called Abell 383, was used to find a galaxy so far away that we see it as it was less than a billion years after the Big Bang. This distant galaxy's light has been warped into two, very faint images that are hard to see in this view. Image credit: NASA, ESA, CRAL, LAM, STScI

"Without this big lens in space, we could not study galaxies this faint with currently available observing facilities," said co-author Eiichi Egami of the University of Arizona in Tucson. "Thanks to nature, we have this great opportunity to see our universe as it was eons ago."

The findings may help explain how the early universe became "reionized." At some point in our universe's early history, it transitioned from the so-called dark ages to a period of light, as the first stars and galaxies began to ignite. This starlight ionized neutral hydrogen atoms floating around in space, giving them a charge. Ultraviolet light could then travel unimpeded through what had been an obscuring fog.

The discovery of a galaxy possessing stars that formed only 200 million years after the big bang helps astronomers probe this cosmic reionization epoch. When this galaxy was developing, its hot, young stars would have ionized vast amounts of the neutral hydrogen gas in intergalactic space. A population of similar galaxies probably also contributed to this reionization, but they are too faint to see without the magnifying effects of gravitational lensing.

NASA's James Webb Space Telescope (JWST), scheduled to launch later this decade, will be able to see these faint galaxies lacking magnification. A successor to Hubble and Spitzer, JWST will see infrared light from the missing population of early galaxies. As a result, the mission will reveal some of our universe's best-kept secrets.

"Seeing a galaxy as it appeared near the beginning of the universe is an awe-inspiring feat enabled by innovative technology and the fortuitous effect of gravitational lensing," said Jon Morse, NASA's Astrophysics Division director at the agency's headquarters in Washington. "Observations like this open a window across space and time, but more importantly, they inspire future work to one day peer at the stars that lit up the universe following the big bang."

NASA's Jet Propulsion Laboratory, Pasadena, Calif., manages the Spitzer Space Telescope mission for NASA's Science Mission Directorate, Washington. Science operations are conducted at the Spitzer Science Center at the California Institute of Technology in Pasadena. Caltech manages JPL for NASA. For more information about Spitzer, visit http://spitzer.caltech.edu/ and http://www.nasa.gov/spitzer .

Voyager Set to Enter Interstellar Space

More than 30 years after they left Earth, NASA's twin Voyager probes are now at the edge of the solar system. Not only that, they're still working. And with each passing day they are beaming back a message that, to scientists, is both unsettling and thrilling.

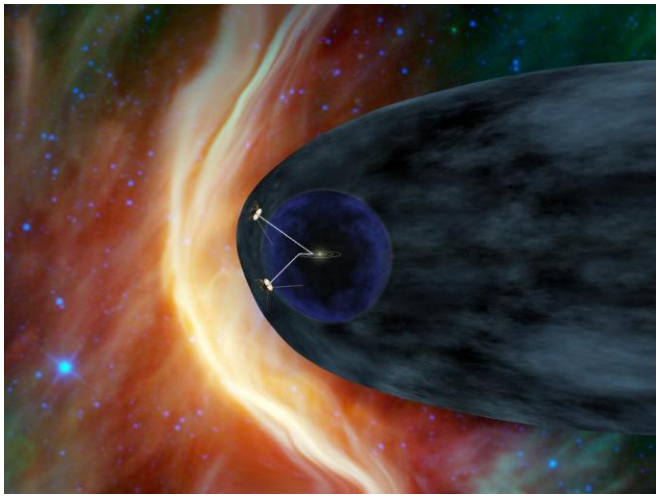
The message is, "Expect the unexpected."

"It's uncanny," says Ed Stone of Caltech, Voyager Project Scientist since 1972. "Voyager 1 and 2 have a knack for making discoveries."

Today, April 28, 2011, NASA held a press conference to reflect on what the Voyager mission has accomplished--and to preview what lies ahead as the probes prepare to enter the realm of the Milky Way itself.

The adventure began in the late 1970s when the probes took advantage of a rare alignment of outer planets for an unprecedented Grand Tour. Voyager 1 visited Jupiter and Saturn, while Voyager 2 flew past Jupiter, Saturn, Uranus and Neptune. (Voyager 2 is still the only probe to visit Uranus and Neptune.)

When pressed to name the top discoveries from those encounters, Stone pauses, not for lack of material, but rather an embarrassment of riches. "It's so hard to choose," he says.



This artist's concept shows NASA's two Voyager spacecraft exploring a turbulent region of space known as the heliosheath, the outer shell of the bubble of charged particles around our sun. Image credit: NASA/JPL-Caltech

Stone's partial list includes the discovery of volcanoes on Jupiter's moon Io; evidence for an ocean beneath the icy surface of Europa; hints of methane rain on Saturn's moon Titan; the crazily-tipped magnetic poles of Uranus and Neptune; icy geysers on Neptune's moon Triton; planetary winds that blow faster and faster with increasing distance from the sun.

"Each of these discoveries changed the way we thought of other worlds," he says Stone.

In 1980, Voyager 1 used the gravity of Saturn to fling itself slingshot-style out of the plane of the Solar System. In 1989, Voyager 2 got a similar assist from Neptune. Both probes set sail into the void.

Sailing into the void sounds like a quiet time, but the discoveries have continued.

Stone sets the stage by directing our attention to the kitchen sink. "Turn on the faucet," he instructs. "Where the water hits the sink, that's the sun, and the thin sheet of water flowing radially away from that point is the solar wind. Note how the sun 'blows a bubble' around itself."
There really is such a bubble, researchers call it the "heliosphere," and it is gargantuan. Made of solar plasma and magnetic fields, the heliosphere is about three times wider than the orbit of Pluto. Every planet, asteroid, spacecraft, and life form belonging to our solar system lies inside.

Artist concept of the Voyager spacecraft in space. Credit: NASA

The Voyagers are trying to get out, but they're not there yet. To locate them, Stone peers back into the sink: "As the water (or solar wind) expands, it gets thinner and thinner, and it can't push as hard. Abruptly, a sluggish, turbulent ring forms. That outer ring is the heliosheath--and that is where the Voyagers are now."

The heliosheath is a very strange place, filled with a magnetic froth no spacecraft has ever encountered before, echoing with low-frequency radio bursts heard only in the outer reaches of the solar system, so far from home that the sun is a mere pinprick of light.

"In many ways, the heliosheath is not like our models predicted," says Stone.
In June 2010 Voyager 1 beamed back a startling number: zero. That's the outward velocity of the solar wind where the probe is now. No one thinks the solar wind has completely stopped; it may have just turned a corner. But which way? Voyager 1 is trying to figure that out through a series of "weather vane" maneuvers, in which V1 turns itself in a different direction to track the local breeze. The old spacecraft still has some moves left, it seems.

No one knows exactly how many more miles the Voyagers must travel before they "pop free" into interstellar space. Most researchers believe, however, that the end is near. "The heliosheath is 3 to 4 billion miles in thickness," estimates Stone. "That means we'll be out within five years or so."

There is plenty of power for the rest of the journey. Both Voyagers are energized by the radioactive decay of a Plutonium 238 heat source. This should keep critical subsystems running through at least 2020.

After that, he says, "Voyager will become our silent ambassador to the stars."
Each probe is famously equipped with a Golden Record, literally, a gold-coated copper phonograph record. It contains 118 photographs of Earth; 90 minutes of the world's

greatest music; an audio essay entitled Sounds of Earth (featuring everything from burbling mud pots to barking dogs to a roaring Saturn 5 liftoff); greetings in 55 human languages and one whale language; the brain waves of a young woman in love; and salutations from the Secretary General of the United Nations. A team led by Carl Sagan assembled the record as a message to possible extraterrestrial civilizations that might encounter the spacecraft.

"A billion years from now, when everything on Earth we've ever made has crumbled into dust, when the continents have changed beyond recognition and our species is unimaginably altered or extinct, the Voyager record will speak for us," wrote Carl Sagan and Ann Druyan in an introduction to a CD version of the record.

Some people note that the chance of aliens finding the Golden Record is fantastically remote. The Voyager probes won't come within a few light years of another star for some 40,000 years. What are the odds of making contact under such circumstances?

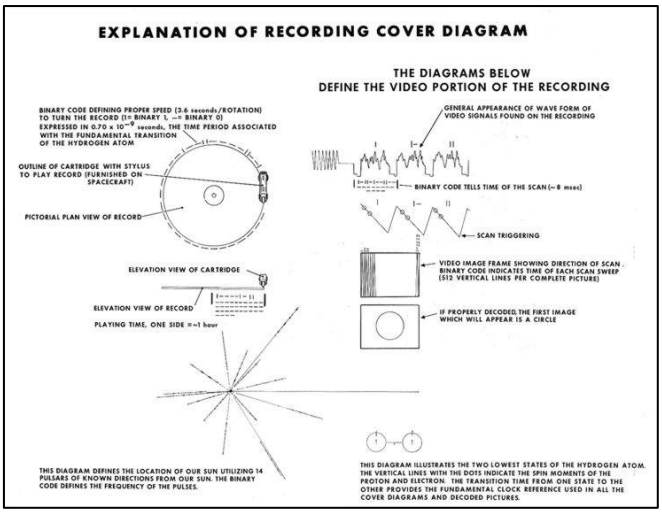
On the other hand, what are the odds of a race of primates evolving to sentience, developing spaceflight, and sending the sound of barking dogs into the cosmos?

Expect the unexpected, indeed.

The “Golden Record” Explained

In the upper left-hand corner is an easily recognized drawing of the phonograph record and the stylus carried with it. The stylus is in the correct position to play the record from the beginning. Written around it in binary arithmetic is the correct time of one rotation of the record, 3.6 seconds, expressed in time units of 0,70 billionths of a second, the time period associated with a fundamental transition of the hydrogen atom. The drawing indicates that the record should be played from the outside in. Below this drawing is a side view of the record and stylus, with a binary number giving the time to play one side of the record - about an hour.

The information in the upper right-hand portion of the cover is designed to show how pictures are to be constructed from the recorded signals. The top drawing shows the typical signal that occurs at the start of a picture. The picture is made from this signal, which traces the picture as a series of vertical lines, similar to ordinary television (in which the picture is a series of horizontal lines). Picture lines 1, 2 and 3 are noted in binary numbers, and the duration of one of the "picture lines," about 8 milliseconds, is noted. The drawing immediately below shows how these lines are to be drawn vertically, with staggered "interlace" to give the correct picture rendition. Immediately below this is a drawing of an entire picture raster, showing that there are 512 vertical lines in a complete picture. Immediately below this is a replica of the first picture on the record to permit the recipients to verify that they are decoding the signals correctly. A circle was used in this picture to insure that the recipients use the correct ratio of horizontal to vertical height in picture reconstruction.



Aboard each Voyager spacecraft is a golden record containing a collection of sites, sounds and greetings from Earth. Credit: NASA/JPL

The drawing in the lower left-hand corner of the cover is the pulsar map previously sent as part of the plaques on Pioneers 10 and 11. It shows the location of the solar system with respect to 14 pulsars, whose precise periods are given. The drawing containing two circles in the lower right-hand corner is a drawing of the hydrogen atom in its two lowest states, with a connecting line and digit 1 to indicate that the time interval associated with the transition from one state to the other is to be used as the fundamental time scale, both for the time given on the cover and in the decoded pictures.

Electroplated onto the record's cover is an ultra-pure source of uranium-238 with a radioactivity of about 0.00026 microcuries. The steady decay of the uranium source into its daughter isotopes makes it a kind of radioactive clock. Half of the uranium-238 will decay in 4.51 billion years. Thus, by examining this two-centimeter diameter area on the record plate and measuring the amount of daughter elements to the remaining uranium-238, an extraterrestrial recipient of the Voyager spacecraft could calculate the time elapsed since a spot of uranium was placed aboard the spacecraft. This should be a check on the epoch of launch, which is also described by the pulsar map on the record cover.

2011 May. Celestial Events:

supplied by J. Randolph Walton (Randy)

Day	Date	Time (EDT)	Event
Tue	3	02:51	**New Moon**
		05:51	Moon rise
Fri	6	09:00	**Eta-Aquarid meteors (ZHR=60)**
Sat	7	04:40	Saturn Sets
		04:50	Venus Rises
		05:10	Mercury Rises
		05:00	Jupiter Rises
		05:05	Mars Rises
		05:53	Sunrise
		09:05	Moon rise
		20:00	Sunset
Tue	10	01:00	**Lunar X near crater Werner**
		16:33	**First Quarter Moon**
		23:00	**Lunar Straight Wall visible**
Sat	14	04:15	Saturn Sets
		04:35	Jupiter Rises
		04:45	Venus Rises
		04:51	Mars Rises
		04:52	Mercury Rises
		05:46	Sunrise
		17:10	Moon rise
		20:07	Sunset
Tue	17	07:09	**Full Moon**
		20:51	Moon rise
Sat	21	03:50	Saturn Sets
		04:10	Jupiter Rises
		04:40	Venus Rises
		04:40	Mars Rises
		04:45	Mercury Rises
		05:40	Sunrise
		09:35	Moon Set
		20:14	Sunset
Tue	24	12:41	Moon Set
		14:52	**Last Quarter Moon**
Wed	25	05:33	**Double shadow transit on Jupiter**
Sat	28	03:20	Saturn Sets
		03:50	Jupiter Rises
		04:25	Mars Rises
		04:40	Venus Rises
		04:47	Mercury Rises
		05:35	Sunrise
		16:33	Moon Set
		20:20	Sunset
Wed	**June 1**	07:26	**Double shadow transit on Jupiter**
		17:03	**New Moon**
		17:03	**Partial Solar Eclipse, not visible in NJ**

In the Eyepiece

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

Object(s)	Class	Con	RA	Dec	Mag
Izar	Multiple Star	Bootes	14h44m59.2s	+27°04'27"	2.4
Xi Boo	Multiple Star	Bootes	14h51m23.4s	+19°06'02"	4.5
44 Boo	Multiple Star	Bootes	15h03m47.4s	+47°39'15"	4.8
M 3	Globular Cluster	Canes Venatici	13h42m11.8s	+28°22'24"	6.3
NGC 5466	Globular Cluster	Bootes	14h05m27.7s	+28°31'49"	9.2
39 Boo	Multiple Star	Bootes	14h49m41.3s	+48°43'15"	5.7
M 53	Globular Cluster	Coma Berenices	13h12m56.2s	+18°09'56"	7.7
Pi 1 Boo	Multiple Star	Bootes	14h40m43.6s	+16°25'06"	4.5
Whirlpool (M51)	Galaxy	Canes Venatici	13h29m52.4s	+47°11'41"	8.9
The Pinwheel (M101)	Galaxy	Ursa Major	14h03m12.5s	+54°20'53"	8.3
NGC 5474 & Co.	Galaxies near M101	Ursa Major	14h05m01.4s	+53°39'45"	11.3
NGC 5529	Galaxy	Bootes	14h15m34.2s	+36°13'35"	12.7
IC 5217	Planetary nebula	Lacerta	22h23m55.7s	+50°58'00"	12.6
NGC 5774 & 5775	Galaxy Pair	Virgo	14h53m42.6s	+03°34'55"	12.8
NGC 5371	Galaxy	Canes Venatici	13h55m39.8s	+40°27'43"	11.5
Hickson 68	Galaxy Group	Canes Venatici	13h53m40.9s	+40°19'41"	10.5
NGC 5634	Globular Cluster	Virgo	14h29m38.1s	-05°58'42"	9.5
NGC 5053	Globular Cluster	Coma Berenices	13h16m28.2s	+17°41'44"	9.0
Arp 84	Interacting Galaxies	Canes Venatici	13h58m38.0s	+37°25'28"	12.1
IC 972	Planetary Nebula	Virgo	14h04m26.0s	-17°13'41"	14.9
UGC 7321	Superthin Galaxy	Com	12h17m34.1s	+22°32'26"	14.1

Coordinates are epoch 2000.0