May 2009

Inside this Issue

S*T*A*R
P.O. Box 863
Red Bank, NJ 07701
On the web at:
http://www.starastronomy.org

Edited by: Ahmad & Hanna Jrad

May's Meeting

The next meeting of S*T*A*R will be on Thursday, May 7. Our program will be ***"Mars Science Laboratory"*** with guest speaker DJ Byrne of JPL. All are welcome. The meeting will begin promptly at 8:00pm at the Monmouth Museum on the Brookdale Community College campus.

Editor's Corner

Many thanks to Gavin Warnes, Steve Fedor, Barlow Bob & Randy Walton for contributing to this month's Spectrogram.

Reminder to pay membership dues $25/individual, $35/family. Donations are appreciated. Make payments to our treasurer Rob Nunn at the May meeting or mail a check payable to S*T*A*R Astronomy Society Inc to:

S*T*A*R Astronomy Society

P.O. Box 863

Red Bank, NJ 07701

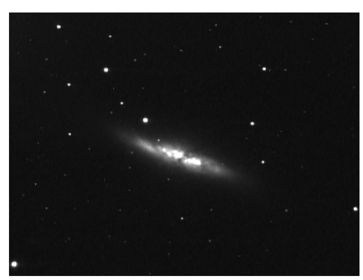
June Issue

Please submit articles and contributions for the next *Spectrogram* by May 25.
Please email to stargaze07@verizon.net.

M1, The Crab Nebula. Image Taken at Chiefland.
Credit: Ernie Rossi using Stellacam

Calendar

- Sep 4, 2008 – "***Past Saturn and 7 More Years to Pluto:***" New Horizons Mission, Michael Lewis, NASA Solar System Ambassador
- Oct 2, 2008 – ***" An Idea That Would Not Die"*** by Robert Zimmerman
- Nov 6, 2008 – ***"Tour of Monmouth Museum & Demonstration of Planetarium"*** by S*T*A*R's own Dennis O'Leary
- Dec 4, 2008 – ***"Why does the sun shine for billions of years?"*** by S*T*A*R's own Arturo Cisneros
- Jan 8, 2009 - ***"Celestial Navigation"*** by Justin Dimmell, Island School, Eleuthera, Bahamas
- Feb 5, 2009 - ***" ATM Night"*** S*T*A*R Members will bring and talk about their home made telescopes
- Mar 5, 2009 - ***"Solar Telescopes"*** by Alan Traino of Lunt Solar Systems
- Apr 2, 2009 – "***The Origin of Star Names***" S*T*A*R's own Ahmad Jrad will talk about how the stars got their names
- May 7, 2009 – ***"Mars Science Laboratory"*** by DJ Byrne of JPL
- Jun 4, 2009 – AGM



M82 – Cigar Galaxy
By: Ernie Rossi, Chieflands

President's Corner

By Gavin Warnes

We should have a great presentation this week by D J Byrne from JPL. Charlie mentioned that his son was working on the Mars Science Laboratory project so I thought it would be a great opportunity to learn about a major JPL project from an insider. Fortunately our May meeting date fitting in with DJ's busy, testing schedule so he will b here to tell us all about it.

We held our annual solar observing session on April 26th under a blistering 90F sun. Thank you very much to Dave Britz, Steve Lewis, Rich Solomon and Kevin Gallagher who turned out to talk the public. Bayonet Farm is a great venue – we should find a way to use it more. The sun was in its current funk with nothing to observer – hopefully it will be back in action next year.

I'm very happy to announce that our 13.5" telescope is ready for use. It now features a new primary cell and spider which it will make it much easier to collimate and faster to cool down. It has also gone on a diet that Dr Atkins would envy so it is much lighter. Mike Lindner, Andy Zangle and Allen Malsbury have worked too hard to create a great instrument we can all share and enjoy – thank you very much guys!

In June we hold our annual elections. Both Dennis O'Leary and I are seeking to step down this year so please let Frank Loso know if you are interested in serving as an officer.

Keep looking up!

Gavin

Register For ALCON EXPO 2009
(www.alcon2009.org)

The Amateur Observers' Society of New York (AOS-NY) located on Long Island, N.Y., is hosting the annual Astronomical League Convention, the ALCON EXPO 2009.

Please be sure to attend ALCON EXPO 2009. For more details and to Register for the Convention, please see the ALCON website at alcon2009.org. Note: Early Registration is open and will continue through June 30, 2009. (Aug 7-8, 2009)

April Meeting Minutes

By Steve Fedor

The April 2009 meeting of S*T*A*R Astronomy Club began promptly at 8:00 pm on 4/2. There were 38 members and non-members in attendance. Vice President Dennis O'Leary chaired the meeting and began by welcoming four first time attendees, discussing the evening's agenda and upcoming events such as NEAF and Earth Day at Bayonet Farm on Sun. 4/26.

STAR's own Ahmad Jrad presented the evening's lecture. The topic was "The Origin of Star Names." Ahmad presented a Fascinating talk, which covered a wide range of information regarding how the names of stars came to be. He included many stories on the mythology of the constellations as well as discussing the languages from which the stars got their names. He accented the lively talk with many charts and a quiz on the constellations. Special emphasis was given to Andromeda and Cetus.

The talk ended at 9:52 at which time Nancy McQuire began her monthly "Object of the Month" presentation. This month Nancy presented Arcturus and discussed its properties. The challenge objects were NGC-4567 and 4568, a galaxy pair in Virgo. The meeting was then recessed for coffee break.

The meeting reconvened 10:08

Dennis O'Leary, our resident NASA Solar System Ambassador, discussed the Kepler mission. This exciting project uses a space-based telescope equipped with a huge 95 mega pixel camera to detect planets orbiting other stars within their habitable zone by the transit method. We all look forward to seeing the results, which according to NASA should be available for short-period giant planets within a few months.

Dennis again mentioned the Earth Day event at Bayonet Farms on Sunday 4/26.

Randy Walton announced a star party at A.S.T.R.A. to be held on 4/3.

Charlie Byrne discussed a Lunar & Planetary conference.

Dan Pontone announced that Galileo's telescopes are on display at the Franklin Institute in Philadelphia.

The 50/50 was drawn. The meeting was adjourned.

The Swiss Army Knife of Weather Satellites

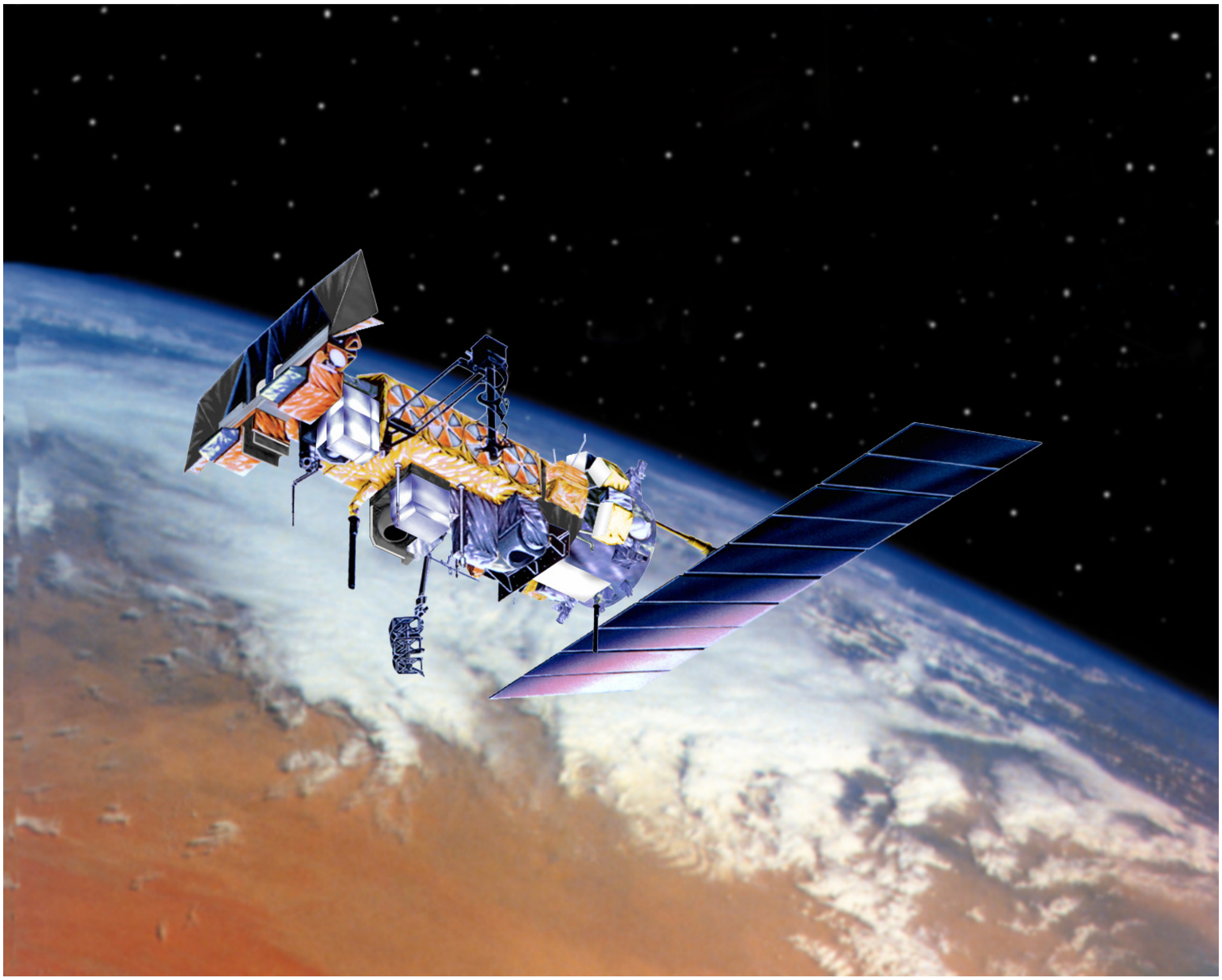
Spotting volcanic eruptions, monitoring the health of crops, pinpointing distress signals for search and rescue teams.

It's not what you might expect from a weather satellite. But these are just a few of the abilities of NOAA's newest polar-orbiting weather satellite, launched by NASA on February 6 and turned over to NOAA for full-time operations on February 26.

Formerly called NOAA-N Prime and now renamed NOAA-19, it is the last in its line of weather satellites that stretches back almost 50 years to the dawn of the Space Age. Over the decades, the abilities of these Television Infrared Observation Satellites (TIROS) have gradually improved and expanded, starting from the grainy, black-and-white images of Earth's cloud cover taken by TIROS-1 and culminating in NOAA-19's amazing array of capabilities.

"This TIROS series has become quite the Swiss army knife of weather satellites, and NOAA-19 is the most capable one yet," says Tom Wrublewski, NOAA-19 Satellite Acquisition Manager at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

The evolution of TIROS began in 1998 with NOAA-K. The satellites have carried microwave sensors that can measure temperature variations as small as 1 degree Celsius between Earth's surface and an altitude of 40 kilometers—even through clouds. Other missions have added the ability to track large icebergs for cargo ships, monitor sea surface temperatures to aid climate change research, measure the amount of ozone in Earth's protective ozone layer, and even detect hazardous particles from solar flares that can affect communications and endanger satellites, astronauts in orbit, and city power grids.



The new NOAA-19 is the last and most capable in the long line of Television Infrared Observation Satellites (TIROS).

NOAA-19 marks the end of the TIROS line, and for the next four years it will bridge the gap to a new series of satellites called the National Polar-orbiting Operational Environmental Satellite System. NPOESS will merge civilian and military weather satellites into a single system. Like NOAA-19, NPOESS satellites will orbit Earth from pole to pole, circling the planet roughly every 100 minutes and observing every location at least twice each day.

NPOESS will have yet more capabilities drawn from its military heritage. Dim-light sensors will improve observations of the Earth at night, and the satellites will better monitor winds over the ocean — important information for ships at sea and for weather and climate models.

"A lot more capability is going to come out of NPOESS, improving upon the 161 various environmental data products we already produce today," Wrublewski says.

Not even a Swiss army knife can do that many things, he points out.

For more on the NPOESS, check out http://www.npoess.noaa.gov. Kids can find out about another NOAA satellite capability—tracking endangered migrating species—and play a fun memory game at http://spaceplace.nasa.gov/en/kids/poes_tracking.

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

Spectroscopy History – Part 2

Compiled and Edited By Barlow Bob

For more than half a century, the Sun's Frauenhofer lines remained a useful, but unexplained phenomenon. By the late 1850's, the University of Heidelberg had become one of the great centers of scientific research in the world. Two of its brightest scientists were a physicist named Gustav Kirchoff and a chemist named Robert Bunsen.

In 1859, they repeated Foucault's experiment of passing sunlight through a strong sodium flame. To aid their investigation, Bunsen and Kirchoff developed the first spectroscope. Earlier scientists used a prism to diffract the light source to a separate viewing scope, and detailed measurements were difficult to perform. The spectroscope that Bunsen and Kirchoff developed had an integrated slit, prism, and collimator. The results of their experiment were the same as Foucault's: the sodium flame produced dark lines in the solar spectrum. Kirchoff repeated the experiment with lithium, which had no corresponding solar lines. When he performed the lithium test, he saw absorption lines. How could two superimposed bright light sources produce dark lines? To answer this question, Kirchoff and Bunsen recorded the spectra of lithium, sodium, potassium, calcium, strontium, and barium salts in flames. The showed that the solar absorption spectra were the reverse of the spectra that the solar atmosphere produced. Kirchoff showed strong evidence for the presence of iron, magnesium, sodium, nickel, and chromium in the atmosphere of the Sun.

In conducting these experiments, Kirchoff and Bunsen discovered two new elements: cesium and rubidium. Kirchoff and Bunsen's use of spectral analysis to determine chemistry is considered to be the beginning of the science of spectroscopy.

Bunsen invented to burner found in practically every high school chemistry lab. He was an expert in what is called analytical chemistry. This is the branch of science devoted to purifying and identifying samples of chemical compounds. He began doing detailed chemical analyses of the gases produced in the manufacturer of cast iron. By the 1850's, he was at Heidelberg working on techniques for identifying gases by looking at the color of the flames they produce when burned. The Bunsen burner was developed so that metal samples could be burned in a hot, non luminous flame.

Meanwhile, Gustav Kirchhoff was beginning a parallel career through the German university system. In 1847, he graduated from the University of Königsberg. At the age of 21, he formulated the laws that govern the voltages and currents in electrical circuits, laws which still bear his name. In 1854, he went to Heidelberg. In talks with Bunsen, he suggested that instead of just looking at the colors of the flames, they should look at the spectrum of light being emitted. It had been known for some time that the light from burning materials, when passed through a prism, splits up into a series of sharp lines called spectral lines, rather than a continuum, as happens with sunlight. What Kirchhoff suggested was that those bright lines would make a good "tag" by which to detect fine distinctions between different compounds.

The two took this idea seriously and put together the world's first instrument for analyzing spectra from a couple of old telescopes, a prism, and a cigar box. The idea was to look at light from burning materials in a systematic way, cataloging the positions of various spectral lines.

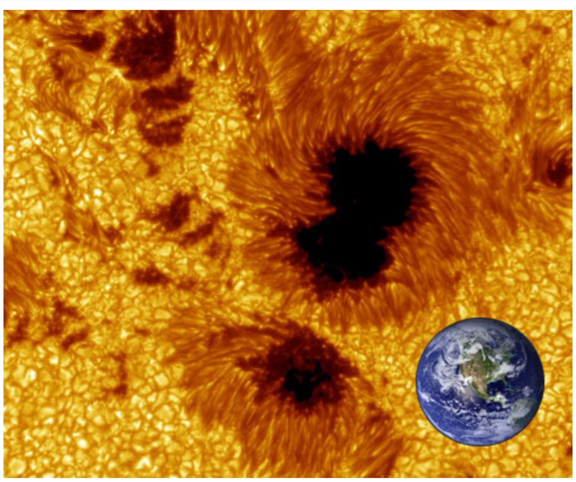
During the run-up to the main experiments in the autumn of 1859, however, Kirchhoff stumbled on an observation that was to change the face of astronomy. He was running sunlight through their apparatus, looking at Fraunhofer lines. He had already detected a correspondence between the bright lines in the light from burning metals and the dark

Fraunhofer lines. What he noticed, however, is that if he passed sunlight through a sodium flame before bringing it into his apparatus, certain Fraunhofer lines became darker.

After thinking about this finding overnight, Kirchhoff realized that the dark lines occurred when light was absorbed by atoms. Fraunhofer lines were created when white light from the Sun's core was absorbed by the sodium atoms in the solar atmosphere. Even more light was absorbed by Kirchhoff's flame. This is why the lines became darker. This not only explained a fundamental property of radiation, it opened a new window on the universe. For the first time in history, a human being had detected the presence of a specific chemical element (sodium) on a non-terrestrial body.

In 1861 Bunsen and Kirchhoff performed experiments leading to the conclusion that the dark lines in the solar spectrum, observed by Wollaston and Fraunhofer, arise due to the absorption of light by gases in the solar atmosphere that are cooler than those emitting the light.

Today we know that the atom has a heavy, positively-charged nucleus around which electrons move in specified orbits. When an electron jumps from a higher orbit to a lower one, light is emitted. The energy of the light moving away from the atom is precisely equal to the difference in energy of the electron in the two orbits. When an atom absorbs light, on the other hand, the electron jumps from a lower orbit to a higher orbit, and the energy absorbed from the light is precisely equal to the energy needed to lift the electron up.



Bright and sunny, with a noontime high of 4000 degrees. A sunspot next to Earth (for comparison only).

Kirchhoff didn't know about electrons, of course. Their discovery was decades in his future. From his experiments, he realized that an atom that emits a particular wavelength of light will also absorb at that wavelength. Why absorption? Where the original photon may have been coming straight along your line of sight, the one that's re-emitted can head off in any direction. The result is a drop in intensity for the light given off by that element, which shows up as the absorption line.

Armed with their new insight, Kirchhoff and Bunsen displayed the "killer instinct" you would expect from world-class researchers by identifying two new chemical elements: Cesium (from the Latin for "sky blue") and rubidium ("dark red") from drops of mineral water. The elements were named for the brightest colors in the spectrum. In the following years many additional elements were identified by their unique spectra.

While chemists were using the newfound ability to analyze spectra to flesh out the Periodic Table, young astronomers were not slow in applying the analysis of spectra to the study of the heavens.

One amateur astronomer in England, Norman Lockyer, acquired a small spectroscope to fit in his six inch backyard telescope and used it to make a series of stunning discoveries about the Sun. Examining light from sunspots, he noted that the Fraunhofer lines were darker than those from neighboring areas, demonstrating that sunspots are cooler than their surroundings. He used the spectroscope to make the first observation of a solar prominence in the absence of an eclipse. He discovered and named the solar chromosphere, because of the bright red hydrogen spectral line that created the image. For these discoveries, Lockyer, who was a professional science writer and clerk in the War Office, was elected to the Royal Society.

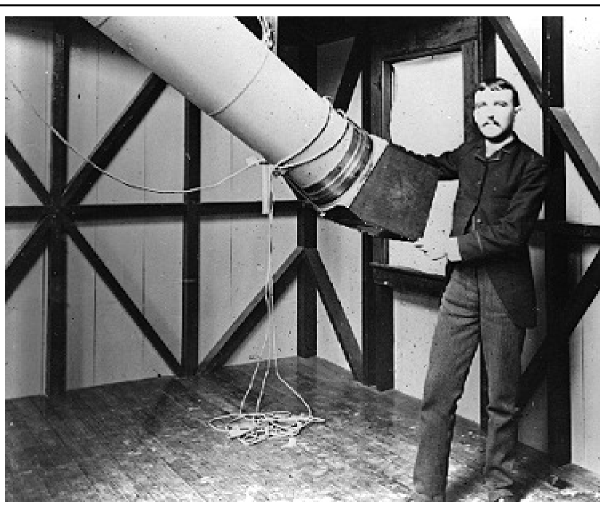
In 1868, he made a rather starling discovery. In the spectrum of the Sun, nestled between two bright yellow sodium lines, he saw a spectral line that just was not supposed to be there. At least, it didn't belong to any element known to chemists. Lockyer concluded that what he observed was a new element, one that didn't appear on Earth. He named the element helium, from Helios, the Greek word for Sun.

Today, the use of spectra to analyze the chemical composition of celestial objects is so widespread that a spectrometer is as common as a telescope in an astronomer's studies. The introduction of spectroscopy by Kirchhoff and Bunsen marked the transition from astronomy to astrophysics, between worrying about where objects are in the sky to worrying about what they are.

Sir William Huggins was one of the wealthy British "amateurs" who contributed so much to 19th century science. At age 30 he sold the family business and built a private observatory outside of London. He carried our extensive observations of the spectral emission lines and absorption lines of various celestial objects. He took chemicals and batteries into the observatory to compare laboratory spectra with those of stars. First visually and then photographically, he explored the spectra of stars, nebulae and comets.

He was the first to distinguish between nebulas and galaxies by showing that some like the Orion Nebula had pure emission spectra characteristic of gases, while others like the Andromeda Galaxy had spectra characteristic of stars. Huggins was assisted in the analysis of spectra by his neighbor, the chemist William Allen Miller. He discovered dark-line spectra in 1863 and in 1864 he examined the spectrum of a planetary nebula, NGC 6543 in Draco, and found that it had a bright emission line spectrum. He therefore concluded that this nebula was not composed of stars, which have a continuous spectrum, but of glowing gas. In 1866, he made the first spectroscopic observation of a nova, Nova Coronae 1866, and found emission lines of Hydrogen. In 1868 he took the spectrum of a comet and identified the spectral lines of ethylene in this spectrum. After 1875 his observations were made jointly with his talented wife, the former Margaret Lindsay Murray, who was a capable astronomer in her own right. She encouraged her husband's photography and helped to systemize their research.

In America, the driving force behind the gathering backlog of astronomical data was largely the legacy of one man; a wealthy physician and amateur astronomer named Henry Draper. In 1872, he was the first to photograph a stellar spectra spectrum, introducing the world to an incredibly powerful tool for probing he physical properties of stars.



Henry Draper, photographic plates, and zoom lens.

Since astronomers didn't employ uniform observing techniques during the late 1800's, they could not simply pool their accumulating data. However, the Henry Draper Memorial changed all of that. Here, for the first time with the Henry Draper (HD) Catalog, data was consistently gathered on uniform manufactured and developed photographic plates. A single plate could capture 200 spectra for later analysis. This was a year's work to the previous generation of astronomers. Multiply hundreds of spectra per plate by an endless flow of plates, and you get a feel for the magnitude of the Draper Catalog project as it began in 1886.

The first step in the data organization was to determine the stellar coordinates for assigning HD numbers to the objects. These designations are used to this day. Then came the overwhelming task of identifying spectral features on one-half-inch-long smears of light and dark strips. The placement and intensity of the dark strips needed to be determined precisely to properly classify a particular star.

When all was said and done by the middle of the 20th century, Henry Draper's namesake catalog would contain positions and spectral information for nearly a quarter of a million stars.

Visit any modern observatory, and along with telescopes you will find many computers. No matter what astronomers study, they need computers to help them examine the huge amounts of information that telescopes gather. More than 100 years have passed since "computers" began working at observatories. However, at the beginning of this 100 years the computers were not machines at all, they were women. Like the rest of America, astronomy was changing. Photography invented in 1839 was successfully applied to astronomy in 1850. Once astronomers started taking photographs, the amount of information they had to work with increased. Astronomers could no longer work efficiently alone. They needed assistants to handle and study the photographs, produced on rectangular glass plates.

Toward the end of the 1800's, American observatories began to resemble factories, with different workers producing, handling, and studying astronomical photographs. In the 1880's, Harvard College Observatory in Cambridge, Massachusetts began hiring women to do daytime work with photographs. Women observatory workers were called "computers" because their work often involved measuring and computing star positions. They also compared similar photographs to find stars that vary in brightness over time. Some women studied photographs of star spectra, produced when a prism is attached to the telescope. In these photographs, each star is a smear of light containing lines that, like fingerprints, reveal a star's unique characteristics. The Harvard "computers" worked with the spectra gathered with an eight-inch Bache refractor.

Draper's ultimate goal was to photograph stellar spectra across the northern and southern hemispheres. He was convinced that in spectra lay the answers to fundamental questions about the universe. Unfortunately, Draper would never achieve his ultimate goal. He died suddenly in 1882. His shocked and grieving widow, Anna Palmer Draper, was determined that her husband's dream be realized.

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

S*T*A*R is the proud owner of a monstrous 25" Dobsonian Obsession reflector – which members can gain access to!

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____

Address______________________________________

City_____________________State___Zip________

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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

2009 May Celestial Events

Supplied by J. Randolph Walton (Randy)

Day	Date	Time (EDT)	Event
Fri	1	12:05	Moon Rise
		16:44	**First Quarter Moon**
		20:45	Mercury left of Pleiades-M45
Sat	2	02:50	Jupiter Rises
		03:55	Saturn Sets
		04:20	Venus Rises
		04:40	Mars Rises
		05:59	Sunrise
		13:17	Moon Rise
		19:56	Sunset
		20:00	Lunar Straight Wall visible
		21:37	Mercury Sets
Tue	5	20:00	Eta-Aquarid meteors (ZHR=60)
Sat	9	00:01	**Full Moon**
		02:25	Jupiter Rises
		03:30	Saturn Sets
		04:05	Venus Rises
		04:25	Mars Rises
		05:39	Moon Set
		20:03	Sunset
		21:05	Mercury Sets
Fri	15	01:26	Titan's shadow on Saturn
Sat	16	01:22	Moon Rise
		02:00	Jupiter Rises
		03:00	Saturn Sets
		03:50	Venus Rises
		04:10	Mars Rises
		05:44	Sunrise
		20:10	Sunset
		20:20	Mercury Sets
Sun	17	01:47	Moon Rise
		03:26	**Last Quarter Moon**
		03:56	Double shadow transit on Jupiter
Sat	23	01:35	Jupiter Rises
		02:35	Saturn Sets
		03:40	Venus Rises
		03:55	Mars Rises
		04:30	Moon Rise
		05:38	Sunrise
		20:16	Sunset
Sun	24	05:16	Moon Rise
		08:11	**New Moon**
Sat	23	01:05	Jupiter Rises
		02:05	Saturn Sets
		03:30	Venus Rises
		03:40	Mars Rises
		05:34	Sunrise
		12:19	Moon Rise
		20:21	Sunset
		23:22	**First Quarter Moon**

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.

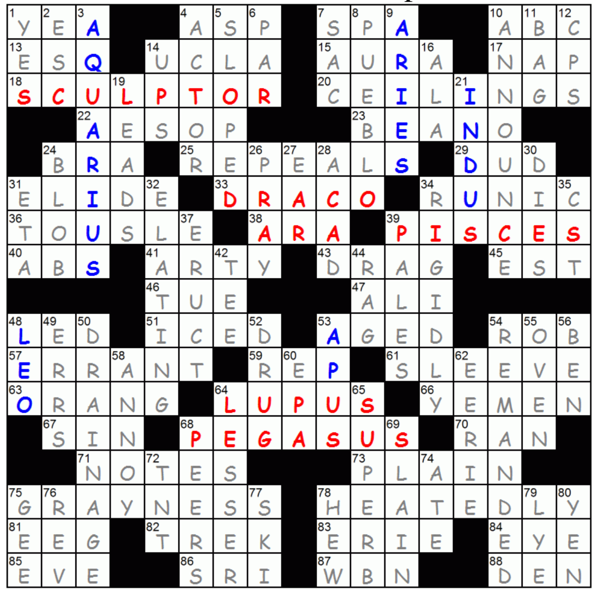
Object(s)	Class	Con	RA	Dec	Mag
M 81 & M 82	Galaxies	Ursa Major	09h55m34.1s	+69°03'59"	7.8
NGC 3511	Galaxy	Crater	11h03m23.7s	-23°05'11"	11.5
Spindle	Galaxy	Sextans	10h05m14.1s	-07°43'07"	10.1
Ghost of Jupiter/Eye	Planetary Nebula	Hydra	10h24m46.1s	-18°38'32"	8.6
NGC 2903	Galaxy	Leo	09h32m09.7s	+21°30'03"	9.6
M 95	Galaxy	Leo	10h44m00.0s	+11°41'57"	10.5
M 96	Galaxy	Leo	10h46m48.1s	+11°48'54"	10.1
The Leo I Dwarf	Galaxy	Leo	10h08m30.6s	+12°18'07"	11.2
Markarian 421	Galaxy	Ursa Major	11h04m27.4s	+38°12'34"	14.8
NGC 3395	Galaxy	Leo Minor	10h49m52.4s	+32°58'35"	12.4
NGC 2818/A	Planetary Nebula in Open Cluster	Pyxis	09h16m01.5s	-36°36'37"	13.0
PHL 1811	Quasar	Cap	21h55m01.6s	-09°22'24"	13.8?
Focus On the Twin Quasar	Quasar	Ursa Major	10h01m20.8s	+55°53'54"	17.0
Hickson 44	Galaxy Group	Leo	10h18m00.4s	+21°48'44"	10.0
Abell 33	Planetary Nebula	Hydra	09h39m09.2s	-02°48'35"	13.4
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
Whirlpool (M51)	Galaxy	Canes Venatici	13h29m52.4s	+47°11'41"	8.9

Moon Phases

Apr 25 May 1 May 9 May 17

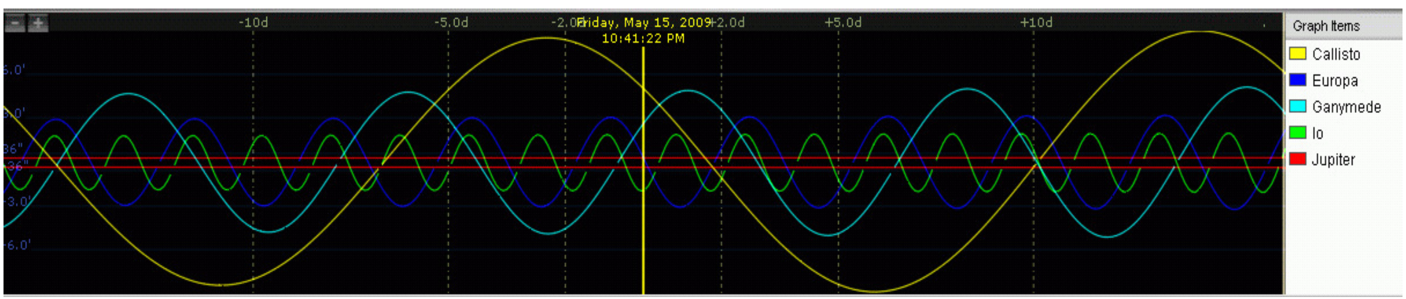
May 23 June 7 June 15 June 22

AstroPuzzle Solution for April 2009



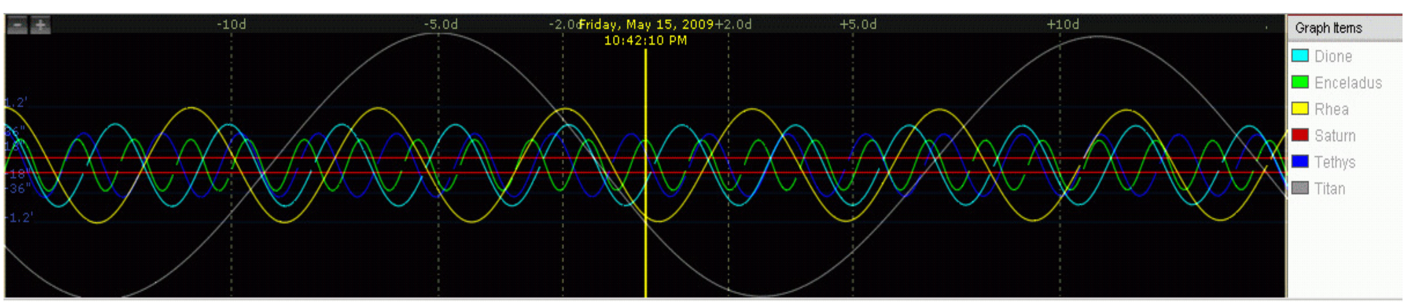
Jupiter Moon Calendar

Here is a graphical depiction of the visible moons of Jupiter for the month of May 2009.

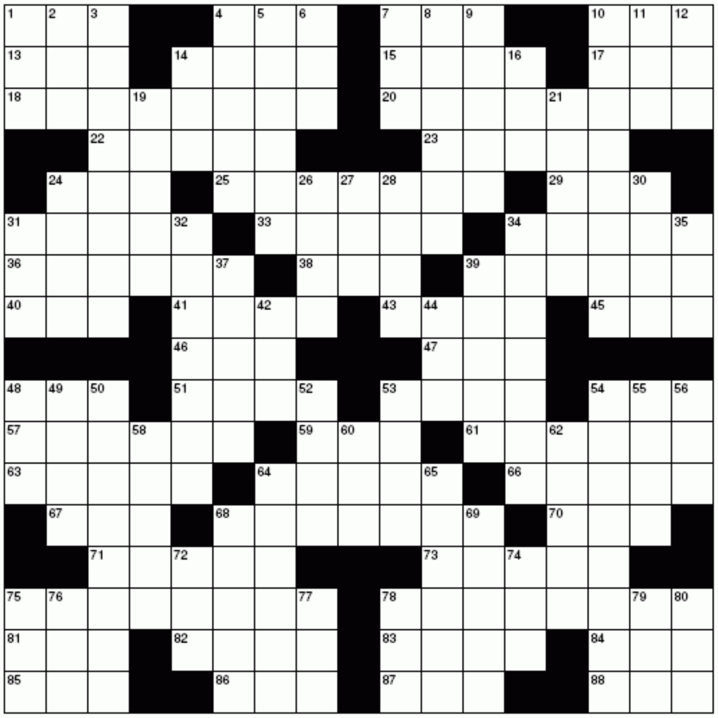


Saturn Moon Calendar

Here is a graphical depiction of the visible moons of Saturn for the month of May 2009.



May 2009 – Astro Crossword Puzzle



ACROSS

4 Petrol
7 Maturity
10 Pigpen
13 Kimono sash
14 Nimbus
15 Byway
17 Ball holder
18 ***The path the Sun, Moon, and planets all follow in the sky.***
20 From Estonia
22 Frock
23 George, plaster cast artist
24 Those who make the food laws (abbr.)
25 Soviet leader Boris
29 Water
31 ***Recently kicked out of the exclusive Solar System Planetary club.***
33 Pancake need
34 ***Second largest moon in the solar system.***
36 Withdraw
38 Grain
39 Military attack
40 Wild ox
41 Input
43 ***Any deposit of sand-sized (1/16 to 2 mm in diameter) windblown material.***
45 Often poetically
46 Brassiere
47 Goof
48 Escudo
51 Short for aluminum
53 Male parent
54 Small
57 Kitchen seats
59 Bullfight cheer
61 Mediterranean island
63 Jewel
64 Owl noises
66 Smooth tightly twisted thread
67 Pounds per square inch
68 ***M16 is in this Constellation***
70 "To the right!"
71 Keyed
73 Sea
75 Neighed
78 Move forward
81 Cooking tool
82 Volcano
83 Air (prefix)
84 Scene
85 Chinese seasoning
86 Cow food
87 South southeast
88 Surface to air missile

DOWN

1 Caviar
2 Alphabet
3 ***Common Name for M11***
4 Spirited
5 Stands up
6 Pouch
7 Be
8 Rumors
9 Dine
10 Type of blade
11 British drink
12 Shekel
14 Gorilla
16 Man's best friend
19 Wrathful
21 ***That point on the celestial sphere directly below the observer.***
24 Tiny insect
26 ***M56 is in this Constellation***
27 Judge
28 Took to court
30 Child
31 Open forcefully
32 Nut
34 Digit shell
35 Mesh
37 Dukes
39 Trims
42 ***A negatively charged lepton, similar to an electron or a muon but much more massive and very short-lived.***
44 United States
48 Extra-sensory perception
49 Stair
50 Moving effortlessly
52 Secure
53 Peter, for short
54 Wisdom
55 Women's magazine
56 Peeper
58 ***Common Name for M42***
60 Cut
62 ***Common Name for M82***
64 Capital of Montana
65 What people do in their sleep
68 Quoth
69 Music
72 North northeast
74 Self
75 Words per minute
76 In possession of
77 ***Amount of time it takes the Earth to spin once on its axis.***
78 Pop (plr.)
79 Ocean
80 Short-term memory