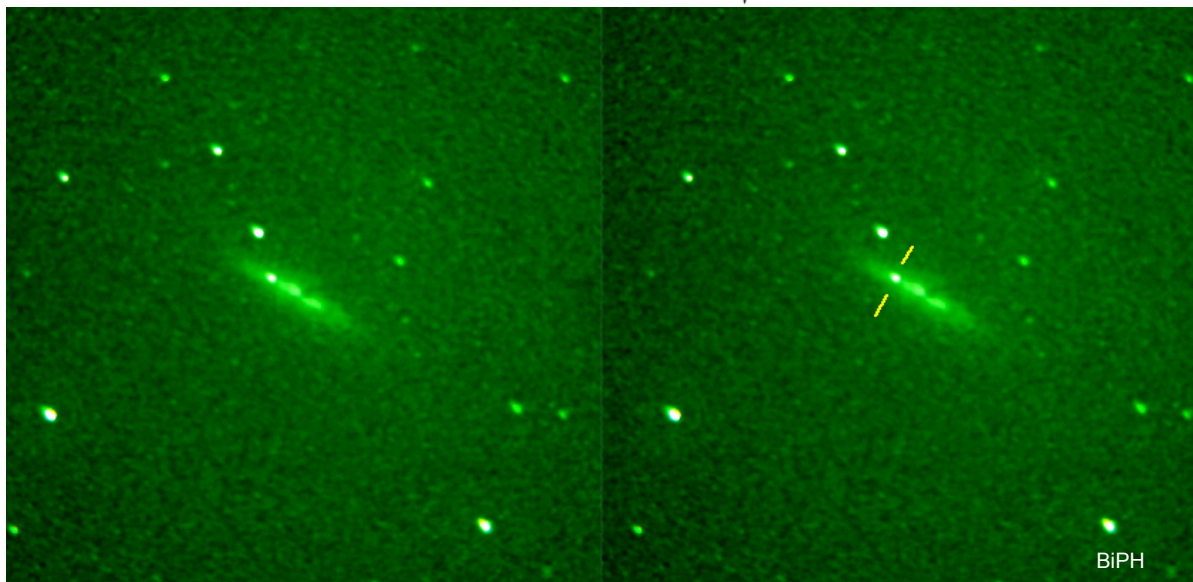


# Sky WAATCH



## New Supernova

John Paladini captured the above images of Supernova 2014J in M82, the "Cigar" galaxy in Ursa Major, on the night of January 23<sup>rd</sup>. He used the BiPH image intensifier and a Canon EOS camera. On the night of the 26<sup>th</sup>, he imaged the supernova with a Mallincam through a 5.5" (f/3.6) "comet-catcher" scope (right).

The Type Ia supernova was magnitude 11.3 and may still be visible during the first week of February. John managed a 1-second shot of the object through the BiPH in near-zero degree weather, writing "It was cold to the point of pain." The supernova was discovered by students at London's University College on January 21<sup>st</sup>. It was an unexpected find during a teaching session demonstrating the use of a CCD camera on one of the school's 14" telescopes located within the London city limits just 8½ miles northwest of Trafalgar Square.



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## Events for February 2014

### WAA February Lecture

**“Ancient Astronomy: Observations and Theories”**

**Friday February 7<sup>th</sup>, 7:30pm**

**Lienhard Lecture Hall, Pace University  
Pleasantville, NY**

Dozens of structures in Ireland and Britain dating back more than 4000 years ago are believed to have been constructed according to the astronomical year such as the sites at Newgrange (Ireland), Stonehenge (England), and Stennis (Scotland). Not much is known about the people who constructed these monuments.

Extensive Babylonian observations dating back 3000 years exist today on clay tablets. These observations were probably accessible to the Greeks who applied geometry to develop a concept of the universe. The development of their geometry that led to Ptolemy's theories will be discussed in Brother Robert Novak's presentation. He will argue that fundamentally, the Ptolemaic and the Copernican views are consistent, except that Ptolemy used a geocentric perspective while Copernicus used a heliocentric perspective. The difference is a translation of reference points. With better data, Kepler perfected the geometry of these orbits by using ellipses, while Newton, with the laws of motion and the concept of gravity, added the theoretical basis to today's view of the solar system.

Br. Robert is a Professor of Physics and Chair of the Physics and Astronomy Department at Iona College; he has been a full time faculty member there since 1980. He holds degrees in Physics from Iona College (B.S., 1972), Stevens Institute of Technology (M.S., 1977), and Columbia University (M.Phil, Ph.D., 1980). Lectures are free and open to the public. [Directions](#) and [Map](#).

### Upcoming Lectures

**Lienhard Lecture Hall,  
Pace University Pleasantville, NY**

On March 7<sup>th</sup>, Mr. Al Witzgall will speak on the geology of the Moon. Mr. Witzgall is a Senior Optician for Fastpulse Optics in Saddle River, N.J. Free and open to the public.

**Call: 1-877-456-5778 (toll free)** for announcements, weather cancellations, or questions. Also, don't forget to periodically visit the [WAA website](#).

### Starway to Heaven

**Meadow Picnic Area,  
Ward Pound Ridge Reservation,  
Cross River, NY**

There will be no public Starway to Heaven observing event in February. Starway to Heaven events will resume on March 22<sup>nd</sup> at 7pm. The rain/cloud date is March 29<sup>th</sup>. **Note:** By attending our star parties you are subject to our rules and expectations, [here](#).

### Renewing Members. . .

Michael Membrado - Bedford Corners

### Renewing Members. . .

Jeffrey Jacobs - Rye

Harry S. Butcher, Jr. - Mahopac

Anthony Sarro - Scarsdale

Jonathan Gold - Ossining

Bob Quigley - Eastchester

David Butler - Mohegan Lake

Joseph Depietro - Mamaroneck

Jay Friedman - Katonah



source for photo

### John Dobson

On January 15<sup>th</sup>, John Dobson passed away at the age of 98. It is difficult to summarize such an eclectic and generous life (a brief biography is available [here](#)). Suffice it to say, through his development of the dobsonian telescope and leadership in public outreach programs, Mr. Dobson introduced thousands of amateur astronomers and others to the wonders of the night-sky. He left a legacy of spectacular memories--both experienced and yet to be enjoyed.

## Almanac

*For February 2014 by Bob Kelly*

Go out about mid-evening and look straight up at the five-sided figure of Auriga. Then you'll be a spoke on the great wheel of our galaxy, your feet toward the center of the galaxy and your head pointed toward the edge of our galaxy. If you look low in the northwest at bright Deneb and extend your arms toward it, you'll be pointing in the direction our solar system is moving around the center of the galaxy beneath your feet. Get outside and start surfing our galaxy, no telescope needed!

Now that we have our bearings for our galactic voyage, it's hard to keep our eyes from the wonders of the winter sky extending from the Pleiades, through the Hyades, past outstanding Orion. Don't forget Canis Major; owning the brightest star in the sky makes this a serious constellation, but it, too, has several Messier objects in and near it. If you have dark skies, check out the rabbit, Lepus, below Orion with no conspicuous stars. Of course, hiding from Orion the hunter, a bunny would want to be hard to notice. Then we have Canis Minor to the upper left, nothing exciting there, except for the bright star Procyon (he gets his own discussion later).

Next up are the twins, Gemini, with Jupiter blazing brightly and inviting us to get the telescope out to see if the Great Red Spot has really become easier to see and if the giant planet has both its major dark belts. Can you see the differences of Jupiter's four brightest moons?

The Moon on the 10<sup>th</sup> looks like it is being kicked out of the way, with the feet of the Twins doing a good job of protecting their goalie. The brightness of the Moon is likely to drown out fainter stars nearby, making it harder to see this scene. Perhaps we are also blinded by Jupiter, playing the part of a photographer's bright flash? Around the 10<sup>th</sup>, the Sun will be rising on the Jade Rabbit rover in Mare Imbrium. Will Yutu have survived another lunar night?

Will the supernova in galaxy M82 still be bright in February? At this writing, it was 11<sup>th</sup> magnitude, visible in moderate-sized telescopes. M82 is found in front of what the English call the 'plough', as if it were some drift of snow pushed out ahead of what we call the Dipper. If you haven't seen M82 before, all the excitement makes it a good time to look for it, then go back after the nova has dimmed to see what it looked



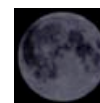
Feb 6



Feb 14



Feb 22



Mar 1

like before the supernova photobombed the galaxy. This supernova outside our galaxy is much brighter in absolute brightness than last summer's Nova Delphinis in our galaxy, since Nova Del wasn't a supernova, 'only' a plain nova, though much closer to us.

Mercury completes its best appearance in the evening sky for the northern hemisphere this year, low in the southwest. Mercury made its furthest elongation on January 30<sup>th</sup>, following 18 degrees after the Sun, so it gets dimmer and dives to the horizon during the first week in February. Find it in SOHO's C3 camera around inferior conjunction on the 15<sup>th</sup>. Mercury comes back into view, joining the rest of the bright planets in the morning sky, rising less than an hour before sunrise. But Mercury hangs out in the morning sky into April. The Moon proves it can be hard to find, too, when the faint crescent passes just to the upper right of Mercury on the 27<sup>th</sup>.

Venus also stays low to the horizon before sunrise in February, and in March, April, May, June, July, August and September. Venus is brightest at magnitude minus 4.9 at midmonth, only 5½ light minutes away, the nearest bright natural object in the sky, except for the Moon at 1½ light seconds away. And in apparent size, Venus is larger than mighty Jupiter until midmonth. On the 26<sup>th</sup>, the Moon looks like a baseball mitt ready to catch Venus, a nice photo op if you have a clear southeast horizon.

Mars brightens up from magnitude +0.3 to minus 0.5 this month. It's still tiny, only one-quarter the apparent size of Jupiter, but its 10.7 arc second diameter by the end of the month is putting some details within the reach of our telescopes. To see the super photos of the planets to see if Mars' north polar ice cap is still around, check out <http://alpo-j.asahikawa-med.ac.jp/Latest/index.html>.

Saturn is up in the southern sky. The planet's shadow cast against the rings, open 23 degrees wide, makes a wonderful sight in a good telescope. The International Space Station is an evening sight almost every night this month. Check [heavens-above.com](http://heavens-above.com) for times each night.

## Articles and Photos

### Procyon – Before the Dog by Bob Kelly

Canis Minor may be a little dog in the sky with nothing exciting going on in the neighborhood, but it does have one of the brightest stars in the sky, Procyon. The Little Dog is often depicted on star maps as a line connecting its two brightest stars, thus making it a handy response if someone challenges you to draw a constellation as quickly as possible. Among its commercial uses is as an icon for the Canis Minor dog and cat boutique in Tribeca. I'm not sure about the other stars depicted here, but it's easy to see the constellation is correctly drawn.

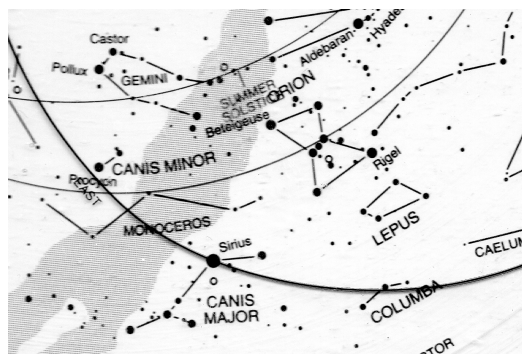


Procyon is from two words in Greek that combine to mean 'before the dog'. The [earthsky.org](http://earthsky.org) website, and a number of other references, say Procyon's name comes from its rising before Sirius in Canis Major in the mid-to-low latitudes in the Northern Hemisphere. That seems a bit odd, as I don't remember Procyon up in the sky without Sirius, and Procyon is *east* of Sirius on the map of the heavens. But Procyon is closer to the celestial north pole, which puts it in place to barely nose out Sirius for earliest rising time.

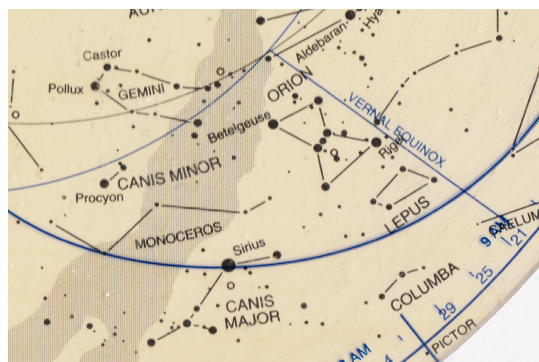
Why does this matter? Thousands of years ago, Egyptians noticed each year's first sighting of Sirius occurred just before the annual flooding of the Nile, so seeing the bright 'before the dog' star rising just before Sirius let them know the big dog was about to arrive and the farmers' fields would soon be flooded with life-giving water and silt from the Nile. A little time-traveling with a special planisphere<sup>1</sup> shows how, four to five-thousand years ago, Procyon had more of a head start on Sirius, as a result of the periodic shift in the Earth's axis.

Here's part of the planisphere showing the sky when Sirius rises.....

in 2000 A.D.....<sup>1</sup>



and in 3000 BC.....



The curved line is the horizon for 30 degrees north (Egypt's latitude) in each case, with Procyon farther above the horizon than Sirius at its rising in 3000 BC than today.

One can imagine the royal observers of that age, sending out the young apprentice each day at the crack of dawn to look for the first day when Sirius could be seen before sunrise. One of those sages might muse, "I wonder if he'll fall for that 'star before the dog' trick and report it as the rising of the Dog Star?" They may have had a few laughs at the youngster's expense.

<sup>1</sup> Precession of the Equinoxes Historical Planisphere for 30 degrees North Latitude: Milton D. Heifetz

**Join WAA at NEAF, April 12-13  
Rockland Community College, Suffern, NY**

[NEAF](http://NEAF) is one of the largest astronomy shows in the world. Besides the many equipment, book and supply vendors there are lectures and, weather cooperating, the Solar Star Party. WAA will again have a booth at NEAF and we hope you will donate an hour or more of your time to help man the booth. Meet and mingle with fellow WAA members and other astronomy enthusiasts from all over the country, express your enthusiasm for our hobby and have a place to leave your stuff. A separate request for your participation will be emailed in February. Put NEAF in your calendar now!

## *The Origin of the Moon* by Larry Faltz



The Earth from Apollo 8, December 24, 1968

For those of us Boomers who grew up with the anticipation and then the achievement of space travel, one of our most memorable events was the circumnavigation of the Moon by Apollo 8, the first mission in which human beings had left the gravitational boundary of Earth. The astronauts' live broadcast on Christmas Eve 1968, featuring the haunting image of a rising, gibbous Earth, put each of us inside that tiny spacecraft at least for a moment, and it brought home that we really could do it, to actually land on the Moon. It was a remarkable respite from the terrible events of that year: the Tet Offensive in Vietnam, the assassinations of Martin Luther King and Robert Kennedy, college campus protests (I was a senior at Columbia and got a bird's eye view of the campus occupation there while reporting for the college radio station WKCR), the riots at the Democratic convention in Chicago and, at least for some of us, the election of Richard Nixon. But in December 1968 the Moon was no longer distant.

Some 9 years earlier, I had gotten a Christmas present from my parents, a copy of *The World We Live In*, a hardbound collection of thirteen lavishly illustrated articles on the scientific history of the planet Earth (as understood at the time) that were originally published in *Life* magazine between 1952 and 1954. The articles surveyed astronomy, geology, paleontology, ecology and biology, with particular emphasis on the diversity of life in its different terrestrial habitats. I received the book shortly after I had begun to show an independent interest in science, encouraged by the remarkable change in my school's curriculum after Sputnik in

1957 and a number of family trips to the Hayden Planetarium, which had to be timed for the rare Saturdays when I didn't have a piano lesson. It was also in 1959 that I started creating pyrotechnical mayhem with my Gilbert chemistry set.



May 27, 2012, 80 mm f/6 refractor, Canon T3i (LF)

The first chapter of *The World We Live In*, "The Earth is Born" (originally published in *Life* on December 8, 1952) described the formation of our planet from a protoplanetary nebula through the development of its continents, oceans and atmosphere. Theories of solar system formation had not advanced very much since they were first formulated in the eighteenth century, perhaps because terrestrial telescopes in use at the time (the largest being only 5 meters in diameter) were poor at detecting infrared wavelengths that are so critical to the observation of nascent planetary systems outside our own. The article was illustrated by none other than Chesley Bonestell, the "Father of Space Art" whose work is well known to space enthusiasts of a certain age. His most famous images are in a wonderful book, *The Conquest of Space* (1949), written with astronomer Willy Ley. The talented and creative Bonestell also designed sets and special effects for many 1950's science fiction movies, as well as other Hollywood films including *Citizen Kane*, and he did architectural designs, most notably the Art Deco façade of the Chrysler Building. Bonestell died in 1986 at the age of 98.

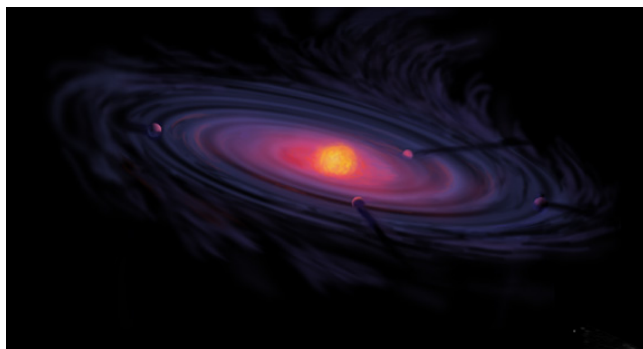
For me, the most striking image in “The Earth is Born” was a two-page panorama of the newborn planet’s molten lava ocean over which a huge Moon is rising amidst clouds, lightning and falling meteors, the young lunar surface still relatively unmarked.



Bonestell’s illustration of the nascent Earth, from “The Earth Is Born” (actual size 20”x9.6”)

In the almost 55 years since I first saw that image, I always recall it whenever I read something about the formation of the solar system.

The text of *The World We Live In* was written primarily by Lincoln Barnett, one of *Life’s* senior editors. The purple prose is a little dated, typical of much popular feature writing of the day. “The Earth is Born” begins, “Prisoned in his paved cities, blindfolded by his impulses and necessities, man tends to disregard the system of nature in which he stands. It is only at infrequent moments when he finds himself beneath the stars, at sea perhaps, or in a moonlit meadow or on a foreign shore, that he contemplates the natural world—and he wonders.” There’s palpable and altogether justified excitement throughout what is a whirlwind introduction to astronomy (ancient Egyptians to Newton in one paragraph, for example) for an American public that was flush with optimism and confidence following victory in World War II. Science, so critical to the war effort, was clearly the key to the future.



Cartoon of a protoplanetary disc system (NASA)

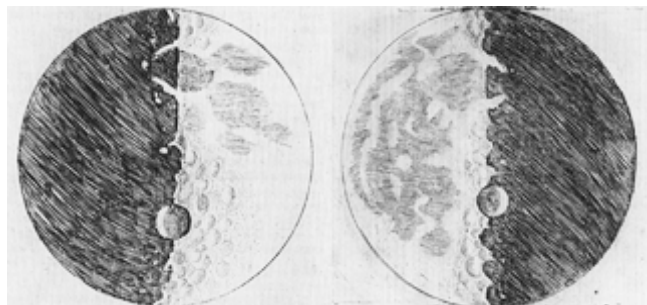
For the origin of the solar system, Barnett invokes the “nebular hypothesis” first proposed by Swedenborg in 1734, then elaborated by Kant in 1755 and Laplace in 1796. Barnett describes the rotating infant sun surrounded by “rings” of “inchoate matter” which condensed into the bodies of the solar system. “Inside the whorl from which our earth congealed, a still smaller one coagulated into our Moon.” In the caption of an adjacent picture labeled “New-born Earth and Moon” showing two molten spheres, the young Moon is noted to be “a few thousand miles” from the Earth, only later spiraling out to its present distance.

There were, at the time, three competing theories for the origin of the Moon. The accretion hypothesis held that the Earth and Moon formed together from the protoplanetary accretion disk, just as Barnett described. The capture hypothesis stated that the Moon had an independent origin but was captured by the Earth. The fission theory described a spinning molten Earth that elongated and eventually ejected a bit of its mass, which condensed as the Moon. All three theories were developed before the era of space travel and the remarkable flourishing of chemistry, physics and computer science in the 20<sup>th</sup> century.

These competing theories, and the interesting personalities behind them, are beautifully described in *The Big Splat, Or How Our Moon Came to Be*, by science writer Dana Mackenzie (Wiley, 2003). I picked this book up a couple of years ago in one of my perambulations in the astronomy section of the Strand bookstore on Broadway and 12<sup>th</sup> Street but just got around to reading it, stimulated by some recent research articles in *Science*. It’s an impressively well-written and nicely paced history of man’s search to understand the Moon, starting in ancient times with civilizations that used the Moon as a calendar. Mackenzie surveys the Greek philosophers and then the Roman writer Plutarch, whom he identifies as the first “loonie”, someone who was genuinely interested in the Moon for its own sake, rather than as an astronomical afterthought. Plutarch’s *De Facie* (On the Face, 70 AD) is a dialogue about the nature of the Moon and its markings. Although many of his explanations for lunar features are fanciful, Plutarch does give one of his characters the idea that the spots on the Moon are shadows of mountains or valleys. Although this explanation is a little off the mark, Plutarch appears to be one of the first to consider that the Moon has topography.

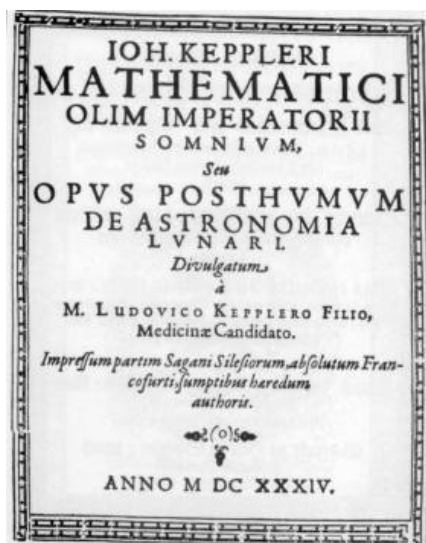
Galileo was the first person to observe the Moon through a telescope, and clearly identified lunar markings as topographical features. He was the first to see craters (although he mistook them for valleys).

His suggestion that the lunar *maria* might be covered with water held sway for some time thereafter and is why we name them as such.



Galileo's drawings of the Moon (*Sidereus Nuncius*, 1610)

Galileo's lunar findings appeared in the *Sidereus Nuncius* (Starry Messenger) in March 1610. Johannes Kepler responded the following month with *Conversations with the Starry Messenger*, and around the same time wrote a peculiar Moon-themed work of fiction, with some science mixed in, *Somnium* (The Dream), which was published in 1634. Kepler noted "The objective...was to work out, through the example of the Moon, an argument for the motion of the Earth." The Copernican theory was still new, and Kepler was one of its most vocal supporters. In *Somnium*, Kepler posits a habitable Moon with beings who observe the Earth, thus allowing him to examine aspects of terrestrial rotation and revolution. Some of the ideas are fanciful, such as craters being reservoirs built by the Moon people, but there was some science as well, and he correctly elucidated the precession of lunar nodes in this work.



Title page of Kepler's *Somnium* (1634)

With the development of better telescopes in the 17<sup>th</sup> century, the scientific study of the heavens moved out to the planets and then to deep space, most notably with the work of Messier and Herschel. Kant's explanation of the nebular hypothesis included the co-formation of the Moon with the Earth, but he recognized tidal forces were acting on the Earth-Moon system. It was already accepted that the Earth's rotation would be slowed tidally by the Moon, but Kant mistakenly believed that the Earth contracted as it cooled, counteracting the slowing. Heating of the Earth's interior by radioactive decay of heavy elements was obviously not known in the 18<sup>th</sup> century.

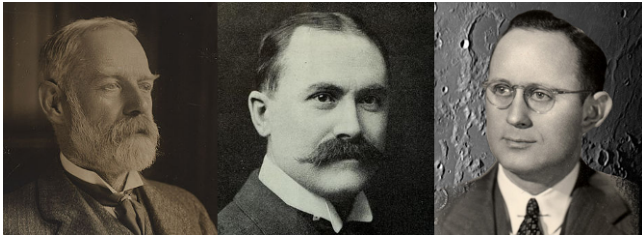
The main interest of 19<sup>th</sup> century astronomy was the study of stars. The resurgence of interest in the dynamics of the Moon was stimulated by a non-astronomer, Sir George Darwin (1845-1912), second of five sons of the naturalist Charles Darwin. Trained in mathematics, George Darwin became interested in the tides and variations in the Earth's axis, which led to an interest in the Moon and eventually to a theory about its origin, which he published in 1879. His calculations suggested that the rotating, molten, nascent Earth elongated under tidal forces and eventually a bit of its matter was thrown off to form the Moon. Over time, the tidal and centrifugal relationships between the two bodies, as calculated by Darwin, permitted them to achieve their current distances, periods and rotations. Darwin's hypothesis hinged on the fact that the Earth and Moon were getting farther apart over time. It was a natural thought to extrapolate backwards in time, leading inevitably to their merger.

Two other theories could be fitted to the facts as were known in the late 19<sup>th</sup> century. One was the capture hypothesis, which held that the Moon was a separate planet that wandered too close to the larger Earth early in the solar system's history, and became gravitationally bound. This was the brainchild of an odd and cantankerous individual, Thomas Jefferson Jackson See (1866-1962). Initially warned away from studying the origin of the planets on the advice of the noted astronomer Simon Newcomb, he became an observer of double stars. Arrogant and difficult, he battled unsuccessfully for top status in the Astronomy Department of the University of Chicago with George Ellery Hale. Eventually he ended up at the US Naval Observatory in Washington, only to be posted to Mare Island in San Francisco Bay as the Navy's timekeeper. It was there that he developed his capture theory, which he announced in 1909. One of the requirements of his theory was the existence of some form of

“resisting medium” in space that would slow down the planets, eventually allowing one to be captured by Earth. Lack of evidence for this substance was a problem.

The third theory, co-accretion, was a natural outgrowth of the nebular hypothesis. In 1850, French astronomer Eduard Roche showed that the outer limit of Saturn’s rings is almost exactly at the limit of stability for a solid satellite, in Saturn’s case 2.46 radii, now known as the Roche Limit. Closer to the planet, tidal forces would prevent coalescence of any particles into a solid body. In 1873, Roche came to the conclusion that the Earth and Moon could have co-accreted from the primordial solar nebula as long as the Moon formed more distant than 2.4 Earth radii but less than 237 radii.

Mackenzie presents a description of each theory, how its originators came to develop it and the evidence for and against, and how the theories competed until a fourth theory, the giant impact hypothesis, was developed in the mid-20<sup>th</sup> century, eventually pushing the earlier explanations completely off the map.

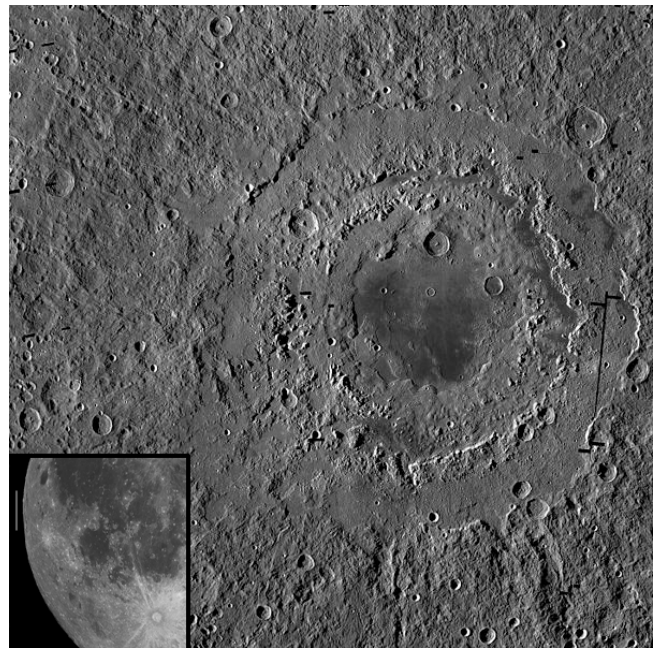


Left to right: Darwin, See, Baldwin

The earliest observations that set the stage for the impact theory were made by amateur astronomer Ralph Baldwin (1912-2010). Not formally trained as an astronomer, Baldwin took a job at the Adler Planetarium in Chicago in 1941 and out of curiosity started examining large, detailed photographs of the Moon made early in the 20<sup>th</sup> century at Wilson and Lick observatories. He noted a system of grooves that appeared to radiate from the Mare Imbrium and concluded that they could only have been made by an enormous explosion. At the time, lunar craters were almost universally thought to be volcanic in origin even though their true impact origin had been hypothesized as early as 1829. In 1948, Baldwin published a book, *The Face of the Moon*, which elaborated his hypothesis, in part using detailed calculations to compare measurements of the width and depth of man-made explosive craters to lunar craters. Baldwin’s book stimulated the young Eugene Shoemaker, the geologist whose exacting lunar mapping for the Apollo project was instrumental in its success, to study the Moon.

*The Face of the Moon* also influenced chemist Harold Urey, the 1941 Nobel Prize winner (for the discovery of deuterium) to take up an interest in lunar science. Urey identified a relative dearth of iron in the Moon from density measurements. Urey also did important work on oxygen isotopes in the solar system, founding the field of cosmochemistry. His famous experiment with Stanley Miller, published in 1954, showed that amino acids, the building blocks of proteins, could be produced when electric sparks simulating lightning were passed through a mixture of methane, ammonia, hydrogen, water vapor and carbon monoxide, thought to represent the atmosphere of the early Earth. This suggested that life could arise spontaneously on Earth.

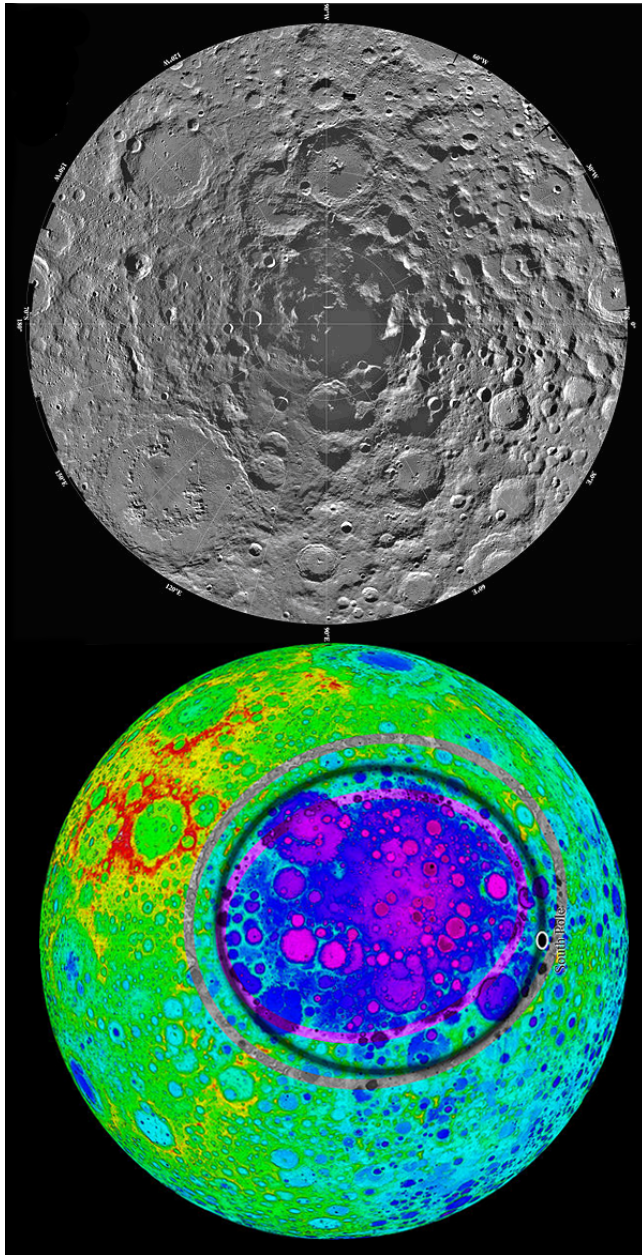
In 1946 geologist Reginald Aldworth Daly speculated that the Moon might have been formed after a planetoid struck the Earth with a glancing blow. His paper received little notice, but the idea was revived by William Hartmann, who worked at the Lunar and Planetary Laboratory at the University of Arizona. In the 1960’s, Hartmann noted that the Mare Orientale, which is merely a sliver on the lunar edge as seen from Earth, appeared as a gigantic impact basin when early orbiter images were projected onto a globe.



Mare Orientale from Lunar Reconnaissance Orbiter (Inset: Photo from Earth; the line shows location of Mare Orientale)

Hartmann also argued from the measurement of mountain sizes along the Moon’s southern edge that there must be a very large impact basin just on the back side of the Moon, near the lunar South Pole. This feature was found by Soviet Zond spacecraft that orbited the Moon between 1968 and 1970. It’s now

known as the South Pole-Aitken basin. It is 2500 km in diameter and 13 km deeper than the surrounding lunar surface.



South Pole-Aitken Basin (Top: Clementine image, Bottom: Kaguya topographic data)

From these observations, and others, Hartmann realized that if the early Moon could be bombarded by objects large enough to make these features, the Earth could have been hit by something even larger. In 1974 he announced the giant impact hypothesis. It was the geologic analysis of 841 pounds of lunar rock samples brought back by the Apollo missions, coupled with the growing power of computer simulation, that gave this theory so much credibility. In Hartmann's model, a

planet about the size of Mars (referred to as Theia, the mother of Selene, the Greek Moon goddess) smashed obliquely into the nascent Earth (which had 90% of its current mass) shortly after its formation. The iron core of Theia was mostly retained by the Earth (the Moon has a very small iron core), but much of the mantle material was mixed and some of it broke off, spiraled around the Earth and congealed into the Moon in a fairly short period of time (the Hayden Planetarium sky show "Cosmic Collisions" a few years ago suggested this took only 30 days). The nascent moon orbited only 25,000 miles from Earth. The Moon's geology and mineralogy suggest a mantle origin for its surface rocks. There is a dearth of siderophilic (iron-loving) elements, which would have sunk into the Earth's core and would not have been freed by the impact. There was also evidence that the lunar surface is composed of basaltic rocks from a "magma ocean" that was present after the Moon was formed. The intense heat of the molten rock would have driven off low-boiling elements and water, whose lunar concentration is lower than Earth's.

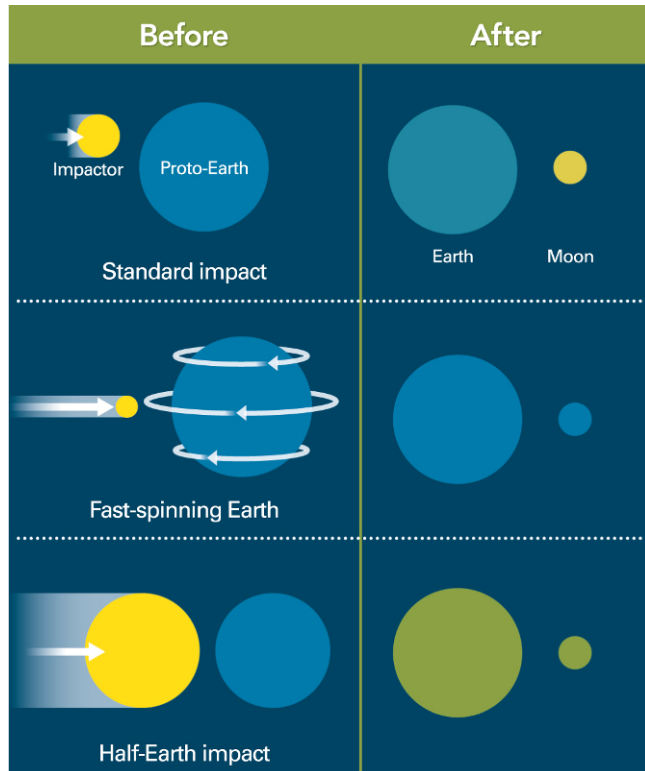


Lunar basalt 70017 (Apollo 17)

The Moon quickly became tidally locked to the Earth, so that it continually presents the same face to us. Orbital dynamics and both solar and terrestrial tidal forces caused the Moon's distance to grow, and even now it recedes from the Earth at a rate of 3.8 cm (1.5 in) per year, accurately determined by laser ranging experiments utilizing mirrors left by the Apollo missions. The masses in the original giant impact hypothesis were chosen to dial in the actual angular momentum exhibited by the Earth-Moon system.

Since Apollo 17 in 1972 there have been only 3 successful (unmanned) Moon landings, Soviet Luna 21 [1973] and 24 [1976] and Chinese Chang'e 3 [2013]. However, more than a dozen orbiters have provided a vast amount of new data that has refined

and to some extent challenged the giant impact hypothesis. Arguing against the hypothesis is the similarity of isotope ratios on the Earth and the Moon. It would be expected that mantle rocks on Earth and Theia, having formed at different radii in the protoplanetary nebula, would have different isotope ratios, most tellingly of oxygen and titanium. Only if mantle mixing between Theia and Earth was sufficient could the Earth-Moon ratios be so similar, but early computer simulations suggested that the Moon would be composed mostly of material from Theia's mantle rather than Earth's.



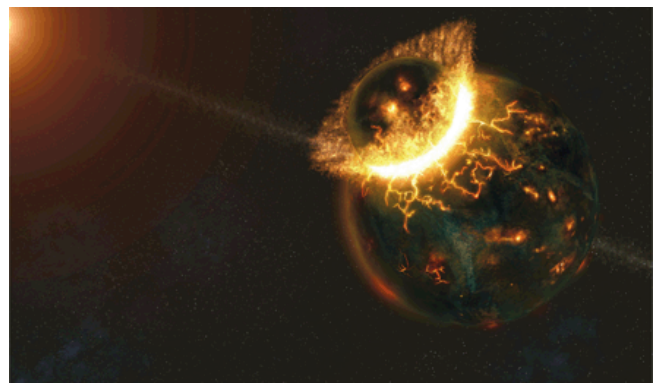
The standard giant impact hypothesis (top) and variations by Cuk and Steward (middle) and Canup (bottom). *Science* 2013; 342:183-185

Two papers in *Science* in November 2012 used supercomputers to model alternatives to the originally suggested size and speed of Theia, finding that the giant impact hypothesis could be rescued from concerns about isotope ratios if the impactor was not Mars-sized. Matija Cuk and Sarah Stewart of Harvard propose that a very small impactor hit a rapidly spinning Earth. Robin Canup of the Southwest Research Institute posits a larger, almost Earth-sized impactor. Criticism of these results hinges on the fact that they seem to leave the Earth-Moon system with more angular momentum than it really has, but each group has an answer: "evection resonance," a process that depends on the Sun-Moon interaction to remove angular momentum from the Earth-Moon system.

However, at a recent (September 2013) conference at the Royal Society in London, the strength and longevity of evection resonance was questioned.

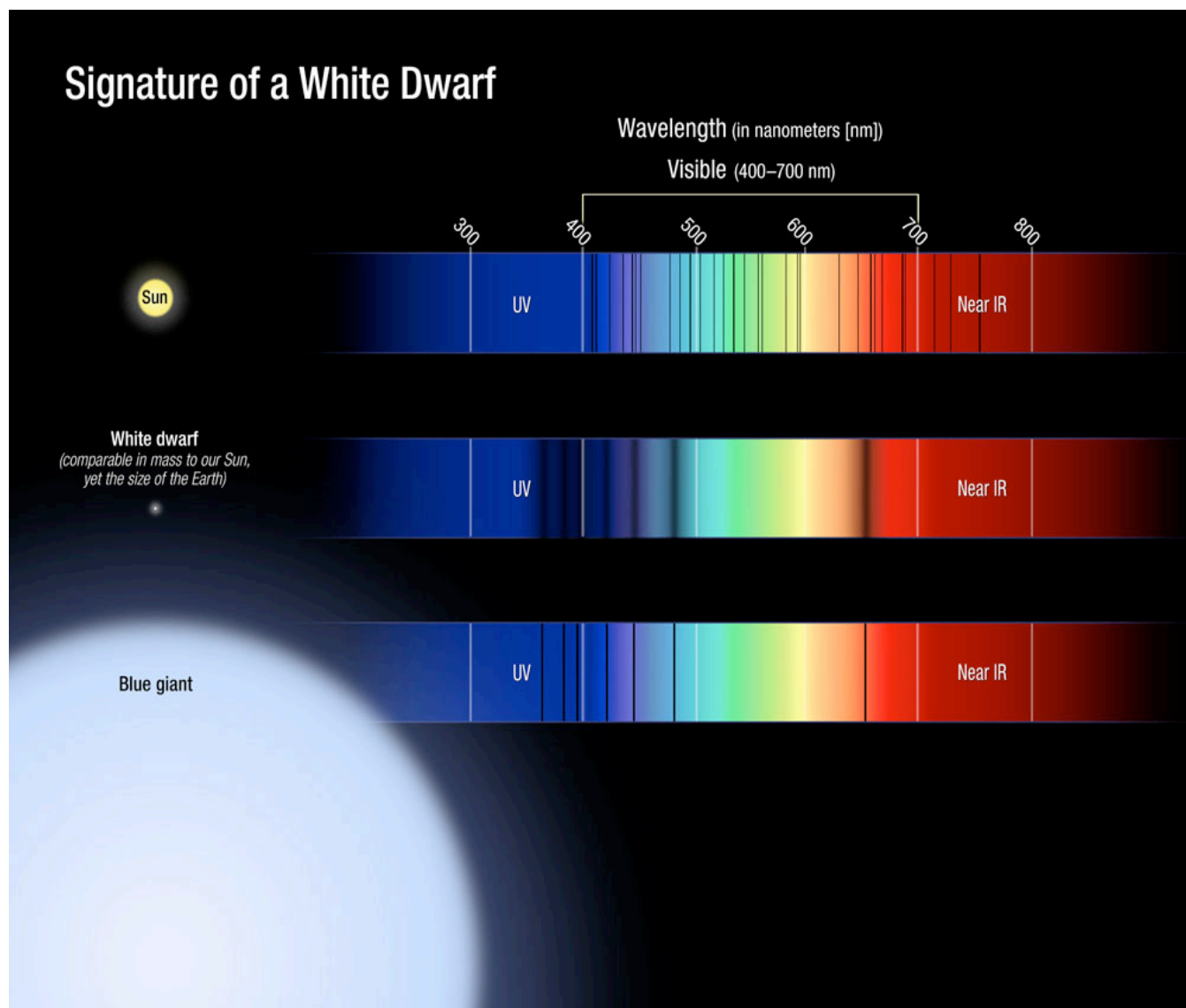
It is presumed that isotope ratios in solar system bodies are different depending on the distance from the Sun that the body formed. We know that meteorites from the asteroid belt, bits of cometary debris and Martian rocks all have isotope ratios quite different from Earth. An interesting exception to this is the hydrogen/deuterium ratio in magmatic melt inclusions, which is similar in samples from Earth, the Moon and carbonaceous chondrite meteors, but not other solar system bodies (Saal, AE, et. al., *Science* 2013; 340:1317). This suggests a common origin for water in the mantles of the Earth and Moon, which the authors take as evidence in favor of the giant impact. The one body whose isotope composition remains completely unknown is Venus. Together the Earth and Venus contain 80% of the mass of the inner solar system. If rocks from Venus and Earth have the same isotope composition across all the elements, it may indeed have been possible for Theia to have a similar composition as well. That would eliminate some major objections to the giant impact hypothesis. Getting rocks from Venus may well be impossible, however, at least for the foreseeable future.

Mackenzie's 2003 treatment is sufficiently clear and detailed, without ever dragging or being academically obscure, to provide a solid understanding of the subject and an excellent basis to comprehend new data published in the past decade. He treats unresolved issues that challenge the giant impact hypothesis fairly. I really enjoyed reading this book and you will too. There seem to be plenty of copies on Amazon.



Did this happen? Image from *Science* 2013; 342:183-185.

## *The Balmer Series* *Compiled by Barlow Bob*



The spectrum of the Sun, a white dwarf, and blue giant. Image taken from: [pasthorizonspr.com/index.php/archives/06/2012/stellar-archaeology-traces-milky-ways-history](http://pasthorizonspr.com/index.php/archives/06/2012/stellar-archaeology-traces-milky-ways-history)

The February 2014 issue of *Astronomy* magazine contained an article about the fate of the Sun. There was an illustration showing the differences between the various types of dark Fraunhofer absorption lines in the spectrum of the Sun, a hot blue star and a white dwarf star.

The solar spectrum consisted of many thin dark lines of different elements. The hot blue star spectrum consisted of only thin dark lines of the *Balmer Series* of hydrogen. The white dwarf spectrum also contained

only the *Balmer Series* lines. In the white dwarf spectrum, however, these lines were very thick.

Reference books and articles about spectroscopy state that the Fraunhofer lines in the spectrum of hot stars with a high-pressure atmosphere are thin. The lines of cool stars with a low-pressure atmosphere are thick. Why does a white dwarf with an extremely high-pressure atmosphere have wide Fraunhofer lines in its spectrum?

Sue French provided the explanation, which is reprinted here with permission.

“It’s a question of density and pressure differences between the different luminosity classes of stars. Hydrogen lines broaden from luminosity class I (luminous supergiant) to luminosity class V (main sequence). The lines are generated by collisions in a star’s photosphere. Close-passing atoms can slightly disturb an electron’s energy level such that the electron can absorb at a wavelength that is a bit offset from the center of the line. Whole bunches of these interactions put together broaden the line, and higher photospheric density (class V) promotes more interactions. For example, a B5V star and a B5I star would have about the same photospheric temperature, but the lines would be broader in the former because of its higher photospheric density. Thus for the white dwarf, where the photospheric density is very high, the lines are broadened with respect to stars of similar photospheric temperature.”

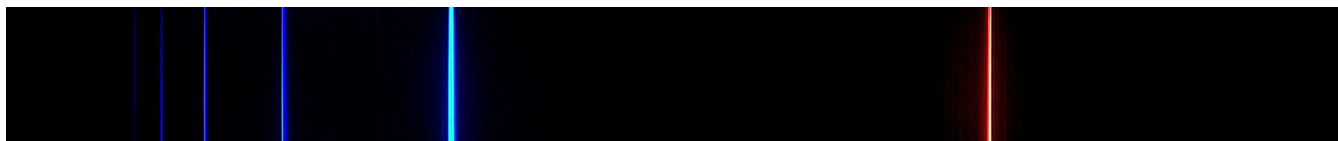
From 1859 until his death at age 73, Johann Jakob Balmer (1825-1898) was a high school teacher at a girl’s school in Basel, Switzerland. His primary academic interest was geometry, but in the middle 1880’s he became fascinated with four numbers: 6,562.10, 4,860.74, 4,340.1, and 4,101.2. These were the wavelengths, in units of Angströms, of the four visible spectral lines in the hydrogen atom spectrum measured by Anders Jonas Angström (1814-1874). These are not pretty numbers, but for the mathematician Balmer, they became an intriguing puzzle. Was there a pattern to the four numbers that could be represented mathematically? By the time Balmer became interested in the problem, the spectra of many chemical elements had been studied and it was clear that each element gave rise to a unique set of spectral lines. Balmer was a devoted Pythagorean: he believed that simple numbers lay behind the mysteries

of the universe. His interest was not directed toward spectra, which he knew little about, nor was it directed toward the discovery of some hidden physical mechanism inside the atom that would explain the observed spectra. Balmer was intrigued by the numbers themselves.

In 1885, Balmer published a paper in which his successful formulation was communicated to the scientific world. Balmer showed that the four wavelengths could be obtained with the formula that bears his name:  $\text{wavelength} = B \cdot (m^2)/(m^2 - n^2)$ , with  $B = 3645.6$  Angströms. He had found a simple mathematical formula that expressed a law by which the hydrogen wavelengths could be represented with striking precision. He further suggested that there might be additional lines in the hydrogen spectrum and these were later found by other scientists.

Angström measured the wavelengths of the spectral lines of hydrogen, but Balmer showed that the wavelengths are not arbitrary. The values of the wavelengths are the expression of a single mathematical formula – and this Balmer Series equation altered how scientists thought about spectral lines. Before Balmer published his results, scientists drew an analogy between spectral lines and musical harmonies. They assumed that there were simple harmonic ratios between the frequencies of spectral lines. After Balmer’s work, all scientists recognized that spectral wavelengths could be represented by simple numerical relationships. This discovery was fundamental to the eventual discovery of the quantum.

Balmer disappeared from the ranks of working scientists and continued his classroom work teaching young women mathematics. Neither he nor his students recognized that his paper on the spectrum of hydrogen would bring him scientific immortality. The spectral lines of hydrogen that were the focus of Balmer’s attention are now known as the *Balmer Series*.



The Balmer Series for hydrogen. Image taken from [en.wikipedia.org/wiki/Balmer\\_series](http://en.wikipedia.org/wiki/Balmer_series)

## Shooting Crescent Venus by Larry Faltz



6 consecutive frames from an avi capture of Venus on 12/25/13

Venus was a lovely sight all autumn, brighter than magnitude -4 in the western sky after dusk, a true Evening Star. As it revolved in its orbit and interposed itself between the Earth and the Sun it became more crescent-shaped, although you couldn't tell that with the naked eye, since the decreasing extent of illumination was balanced by the growing angular size of the planet as it got closer to Earth. Imaging the crescent phase of Venus is never easy. Venus never gets more than  $47^\circ$  from the Sun. Because of this proximity, observing it after sunset (or before dawn after conjunction on Jan. 11<sup>th</sup>) requires looking fairly close to the horizon, thus encountering more of the atmosphere than when observing objects overhead. Daylight imaging might reduce that problem, although at this time of the year the ecliptic is far to the south and so even when it culminates (crosses the meridian) Venus is still relatively low in the sky. On Christmas day, culmination was at 1:39 pm, at an elevation of  $29^\circ$ . But I figured I'd give it a go that afternoon from the parking lot at the Quaker Ridge School on Weaver Street in Scarsdale.



127 mm Mak with extension shade on the dew shield

My 127 mm (5") f/12.1 Orion Maksutov is a pretty good planetary scope. I put it on an iOptron Minitower GPS go-to alt-az mount and image with a Celestron NexImage 5 color planetary camera. A flip-mirror (described in my article in the [April 2012 newsletter](#)) allows me switch between an eyepiece and the camera, keeping both in focus. Because Venus was close to the sun ( $24.5^\circ$  on Christmas) a regular dew shield would not fully block sunlight from falling on the scope's corrector plate, which could wash out the image. I found a thin sheet of slightly stiff vinyl to serve as an extension on the sun side of the dew shield and simply bungeed it on the end.

After letting the scope cool for an hour in the 28 degree weather, I put a Baader mylar solar filter on the 50mm finder, and, keeping the dust cover on the telescope, aligned on the Sun. Slewing to Venus, I removed the filter, centered Venus, uncapped the scope and then centered the planet in the eyepiece. I switched the flip mirror to illuminate the camera, then refocused while observing the image on a netbook screen with Celestron's iCap camera control software. I binned the pixels 2x2 at 640x480 resolution. Binning increases sensitivity at the expense of a smaller image scale. The software captured 55 frames per second, each frame being exposed at about 1/700 sec. I played with the gain until I got a reasonable balance between the planet and the background.

Rather typical for daytime observing, the seeing wasn't that great, perhaps 3-4/10, primarily due to high winds in the upper atmosphere pushing more clouds than I would have liked swiftly across the sky. There was some high haze at times, complete obstruction at others, but several clear intervals permitted decent captures. The image on the screen vibrated and gyrated quite a bit (see the raw frames, above) from the changing atmospheric diffraction. The iOptron mount tracks extremely well, and so I was able to capture about a dozen avi files (1000-3000 frames each) with very little need for re-centering. In

between captures, I flipped the mirror to observe visually with a 12 mm Plossl eyepiece. The thin crescent was brilliant against the blue sky, with occasional moments of stability in the turbulent atmosphere.

Returning home, I transferred the video files (which are in the 1-3 gigabyte range) to an i3 laptop where I loaded image processing software. I picked out what I thought was the best of the lot, with the least interference from clouds and turbulence, and opened the file in Autostakkaert 2, a free image stacking program that's particularly good for planetary and lunar imaging. It analyzes the images and with minimal user input it chooses, aligns and stacks the best images. I limited the stack to the best 100 images from the 1288 in the file.

The Autostakkaert software is pretty amazing. From a bunch of blurry frames emerged a reasonable facsimile of a crescent. Its edges were still a little indistinct, so I saved the file in tif format and opened it in Registax 6.1. This free software (which is also a capable image analysis and stacking program) has a "wavelet"

function which can sharpen images substantially. Wavelet processing can bring out remarkable detail but can also introduce noise. There isn't a lot of science to this part of the workflow: it's mostly trial and error. There are some noise-reducing controls in the program but they too work by guessing. After a little finagling in Registax and making compromises between sharpness, artifact and noise, I settled on an image which I saved and then opened in an old version of Photoshop. I darkened the sky and adjusted contrast and brightness to make a pleasing image.

I am by no means an experienced astrophotographer, and this image has many shortcomings. WAA member John Paladini, my mentor in these things, diplomatically commented "not bad considering all issues." It would have helped, of course, to have a larger scope on top of a mountain where the atmosphere could have been thinner and less turbulent. But I did what I could, and here's Venus, interposed between us and the Sun, showing the crescent that 403 years ago made Galileo certain that the Copernican theory of the solar system was correct.





Members of Mrs. Chee's MESA program

### A Note from Francis J. O'Reilly

On December 8, 2013, I attended a star party at The Navajo Technical University in Crown Point, New Mexico at the invitation of Dee Friesen, president of the Albuquerque Astronomical Society. Skies were dark and clear; the weather was frigid. Approximately thirty members of the Navajo Nation attended, including ten children who were part of Mrs. Chee's MESA program (Mathematics, Engineering, Science Achievement).

Venus and the Pleiades were prominent and of great interest to the group. One gentleman regaled us with stories of the significance of various constellations in Navajo culture. While the Navajo language was not as prominently spoken as it was when I lived in New Mexico in the late 1970's, I was thrilled to see that the culture is thriving. The children had a wonderful time and we are all looking forward to the dedication of Chaco Canyon as a International Dark Sky site in April 2014.



Francis J. O'Reilly manning a twenty inch Sidewalk mounted telescope



### ◀ Double Rainbow

Mike Cefola took this image some years back in Santa Fe, New Mexico of a double rainbow. He submitted it to *Astronomy* magazine in response to an article by James O'Meara on Rainbow phenomena. The original article was in the June 2013 issue and Mike's photo with accompanying letter was included in the October 2013 issue.



### ◀ Jupiter

John Paladini captured this image of Jupiter through a Celestron C9.25 SCT with a modified webcam. Notes John: The image picked up nice blue-pink in the central region.



### ◀ Happy Birthday

On January 25<sup>th</sup> 2014, the Opportunity rover marked the 10<sup>th</sup> anniversary of its landing on Mars. After more than 3,500 sols (Mars solar days) the golf cart-sized robot from Earth is still actively exploring the Red Planet, though its original mission plan was for three months. This self-portrait was made with Opportunity's panoramic camera earlier in January.

Image Credit: [NASA/JPL-Caltech/Cornell/Arizona State U.](#)