nightwatch

Newsletter of the Pomona Valley Amateur Astronomers

Another day, another ball of fire rising in the sky..
narration to ***"The Naked City"***

Volume 31 Number 03 ***nightwatch*** **March 2011**

How We Got to Saturn and What Cassini is Finding

Join Dave Doody, lead Engineer for real-time flight operations of the Cassini-Huygens Mission, for his discussion on how we got to Saturn and what we have discovered there. He will describe some of the historic achievements that led to interplanetary flight, share the latest discoveries by the Cassini Spacecraft from Saturn and its diverse moons, and elaborate on plans for the mission's future. Join us for this unique opportunity to hear from someone who is directly involved with exploring our solar system.

About Our Speaker

After serving in the U.S. Air Force, Dave Doody worked as an instructor for Japan Air Lines teaching Captains and First Officers of JAL. At the same time, he led an instructional systems development effort at the JAL flight crew training center. Having landed at Catalina Island after sailing the coast, Dave worked as a systems engineer there for three years before joining the NASA-JPL Deep Space Network in Pasadena to create instructional systems and training materials for operators of the worldwide spacecraft-communications systems.

On completion of the Deep Space Network contract, Dave got his master's degree and then went to work on the NASA Voyager mission flight operations team while Voyager 2 cruised from Saturn to Uranus and Neptune. Flight operations on Magellan, the Venus mapper, then led to flight ops work on the Cassini-Huygens mission to Saturn and Titan, where he has been since 1994.

All during the Voyager, Magellan, and Cassini mission operations, Dave has also been publishing in the technical and popular literature, teaching short courses, and speaking in public about space-flight related subjects.

Once in a while you can find Dave playing sidewalk astronomer in Pasadena, offering free telescope views of the planets to passers-by. And once a year, Dave welcomes participants in his "Basics of Interplanetary Flight" seminar with Art Center College of Design Public Programs in Pasadena.

Links to Follow

Dave's Basics of Interplanetary Flight Course (Registration opens April 11, 2011): http://people.artcenter.edu/doody/

Dave's latest book: Deep Space Craft, an overview of interplanetary flight (Springer 2009): http://www.amazon.com/

TheCassini-HuygensWebsite: http://saturn.jpl.nasa.gov/index.cfm

Dave's JPL website: Basics of Space Flight online tutorial: http://www2.jpl.nasa.gov/basics/index.php

Images you can view and print in full resolution: http://photojournal.jpl.nasa.gov/

Notes on some images from Saturn: http://www2.jpl.nasa.gov/basics/saturn/

All about JPL: http://www.jpl.nasa.gov/

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The World's Largest Telescopes, Part 7: The 100-inch Hooker Telescope

This is the seventh installment in an almost-monthly series covering the world's largest single-aperture optical telescopes in reverse chronological order. The last installment (*Nightwatch*, January 2010) covered the 200-inch Hale telescope, the largest and last of Hale's astronomical offspring. The 200-inch telescope was deliberately conceived to be the largest optical telescope possible at the time it was built. Hale and his group of astronomers and engineers took on that audacious project in part because their previous efforts on the 60-inch and 100-inch telescopes at Mount Wilson had been so successful. But the 100-inch telescope was much more than a stepping-stone to the 200-inch. Although it was also used for crucial feasibility studies for its bigger sibling, it was the world's premiere astronomical research instrument for more than three decades, and its impact on our conception of the universe is arguably greater than that of any other large observatory telescope--even the "glass giant of Palomar".

In the first decade of the 20th century, George Ellery Hale was on a roll. In 1904, he founded Mount Wilson Solar Observatory--the second, after Yerkes, that he had founded. In 1908, the 60-inch reflector on Mount Wilson saw first light--the second time, after the Yerkes 40-inch, that Hale had built the world's largest telescope. Hale's own solar research program was in full swing, with the Snow solar telescope and the 60-foot solar telescope starting observations in 1905 and 1908, respectively. *The Astrophysical Journal*, which he had co-founded in 1895, was rapidly becoming the leading journal in the fledgling field of astrophysics. Hale had deliberately set out to use the sun to learn more about stars, writing,

"In the long run, every advance in our knowledge of the sun is likely to find application in the study of other stars. The principle of initiating many stellar researches from suggestions afforded by solar investigations, and of preparing an observing program which intimately unites both of these classes of work with laboratory studies, is undoubtedly sound, and should continue to form the basis of our procedure."

In 1908, Hale's vision of a unified astronomy was coming to fruition. He was 40 years old.

And, as ever, Hale was not just thinking about the next telescope, but taking steps to see that it was built. In 1906, two years before the 60-inch telescope would be completed, he met with Los Angeles millionaire John D. Hooker to talk about possible funding for an 84-inch telescope. Hooker was flattered by the attention, and Hale spoke in glowing terms about the accolades that would naturally come to the world's largest telescope and its donor. Both men wanted an even larger telescope--Hale because Aperture Rules, then as now, and Hooker because he didn't want anyone upstaging him. They settled on 100 inches (2.5 meters) as a nice round number, and Hooker pledged $45,000 to build the instrument (the final cost was about 10 times greater, and much of it was supplied by Andrew Carnegie).

In the same way that the later 200-inch telescope would build on the lessons learned from the 100-inch, the 100-inch in turn was built on experience Hale and his team had gained from the 60-inch. Once again Hale chose the venerable Saint-Gobain glassworks, founded in Paris in 1665, to cast the disk. Like that of the 60-inch telescope, beneath its reflective coating the primary mirror of the Hooker telescope is dark green wine-bottle glass. Even Saint-Gobain did not have crucibles large enough to pour the five tons of glass required for the mirror blank. Instead the mold was filled with three pours of 1.5 tons each, the first time that multiple pours had been attempted for a single disk. The blank was annealed for a year before it started its long journey to California. It was delivered to the optical shop in Pasadena on December 7, 1908, the same day that the 60-inch telescope was installed on Mount Wilson.

It was a disaster. The three separate pours had not annealed properly, and were separated by extensive sheets of bubbles. George Willis Ritchey, whom Hale had hired as the primary optician on the 100-inch project, did not believe that the mirror would hold a useful figure. Saint-Gobain agreed to try again, and Ritchey went to Paris to oversee the pour. A second disk was successfully poured in 1910, but broke during annealing. Time was passing.

Back in California, Hooker was threatening to pull out of the project, and Hale was suffering through a series of nervous breakdowns. Walter Adams, the assistant director at Mount Wilson, did some tests on the bubbly disk and thought that it might bear grinding and polishing after all. Hale ordered Ritchey to get to work, even as they hoped for better news from Paris.

Better news was not forthcoming, at least not from France. Saint-Gobain poured a third disk, which broke during cooling in 1911. A fourth disk survived, but it was so thin that it probably would have deformed under its own weight if used as a telescope mirror.

Fortunately, things were looking up in Pasadena. The bubbly disk was ground to a sphere, and seemed to hold a good figure. Ritchey was still opposed to investing any time or effort into the flawed disk, so Hale and Adams did the optical testing themselves. The mirror was good enough for work to go forward. It was time to start designing a complete telescope around the mirror.

Here, too, Hale and Ritchey had strong differences of opinion. Ritchey wanted a deep curve on the primary mirror and a complex hyperboloid on the secondary, to yield a fast focal-ratio telescope capable of delivering sharp images over a very wide field. Hale knew that the project was already skating too close to the edge, budget-wise, and that the 100-inch telescope would have to serve observers with many different interests, so he opted for a more conventional Newtonian design. Ritchey complained ever more loudly about the bubbly disk, insisting to anyone who would listen--including reporters--that it would never yield a satisfactory mirror. Hale ordered him off the project. In the 1920s, Ritchey would work with French inventor and astronomer Henri Chrétien to develop his wide-angle, flat-field telescope, a design known today as the Ritchey-Chrétien.

In the end, Hale and Adams were right about the quality of the bubbly blank, and Ritchey and Hooker were wrong. Hale managed to cajole the skeptical businessman back on board the project, and the newly-completed 100-inch Hooker telescope saw first light on November 1, 1917. It was a legendarily agonizing night for the Mount Wilson astronomers. Of their first target, Jupiter, Walter Adams wrote, "The sight appalled us, for

Club Events Calendar

March 18 – General Meeting - Dave Doody

April 2 - Star Party - Mt. Baldy RV Park
April 7 - Board Meeting, 6:15
April 15 – General Meeting - Christine Pearce of Columbia Memorial Space Center
May 5 - Board Meeting, 6:15
May 6 – Wildlands Conservancy
May 7 - Star Party
May 7 - International Sidewalk Astonomy Night. Claremont
May 13 – General Meeting - Albert Dicanzio PHD, "Remembering Galileo, an Astronomer's Legacy
May 14 - Girl Scout Camporee, 4:30
May 25 - 30 RTMC

June 3 - Project Bright Sky - Cottonwood Springs
June 4 - Star Party - Cottonwood Springs
June 9 - Board Meeting, 6:15
June 17 – General Meeting

July 7 - Board Meeting, 6:15
July 12 - Star Party - Galster Park Nature Center
July 15 – General Meeting
July 30 - Star Party - White Mountain

August 4 - Board Meeting, 6:15
August 9 – Main Branch, Ontario Library, 7 – 9 PM
August 12 – General Meeting - Vatche Sahakian
Aug 27 - Star Party

September 9 – General Meeting

October 8 - International Observe the Moon Night, Claremont

October 14 – General Meeting

The detailed story, and backstory, of the 100-inch telescope is told in *The Perfect Machine*, by Ronald Florence. The book includes detailed information on how the 100-inch telescope served as a testbed for the 200-inch telescope, which I did not have room to go into here. Another valuable resource is the article, "Building the 100-inch telescope", by Mike Simmons, on the Mount Wilson Observatory website (http://www.mtwilson.edu/his/art/g1a4.php).

For more information on Hale and his telescopes, please see CalTech's page on the history of the Palomar Observatory (http://www.astro.caltech.edu/palomar/history.html).

The World's Largest Telescopes Continued

instead of a single image we had six or seven partially overlapping images irregularly spaced and filling much of the eyepiece." It turned out that the dome had been left open during the day and the mirror had not had time to thermally equilibrate. Dejected, Hale and Adams agreed to meet back at the telescope at 3:00 AM, and retired to their rooms. Neither man slept, and mutual impatience led them back to the telescope half an hour early. Jupiter had set by then, so they turned the 100-ton telescope to the star Vega, which was resolved as a brilliant pinpoint of light. As Adams later told it, "With his first glimpse, Hale's depression vanished."

The telescope worked beautifully--when it worked. The mirror was extremely sensitive to changes in temperature, and the dome had to be heavily insulated. And the mirror did deform a bit under its own weight, so that the resolving power of the telescope dropped off slightly at certain elevations. Nevertheless, Hale now had both of the world's largest optical telescopes on the same mountain with the world's best solar telescopes, and he dropped 'solar' from the observatory's name to make it simply Mount Wilson Observatory. Predictably, rather than resting on his laurels, he started preliminary work on the 200-inch telescope almost immediately (see the previous issue of *Nightwatch* for that story).

The 100-inch telescope passed into the hands of the working observers. None would become more famous than the observing team of Edwin Hubble and Milton Humason, who used the Hooker telescope to discover Cepheid variable stars in Andromeda and other spiral nebulae, and thereby confirmed that these objects are in fact "island universes" or galaxies similar to our own. Shortly thereafter, in 1929, they discovered the redshift/distance relationship of external galaxies, wherein the more distant a galaxy is from us, the faster it appears to be receding. These observations fit well with then-current developments in the general theory of relativity, which predicted that the universe could be expanding. The marriage of Hubble's and Humason's observations with Einstein's theory provided the basis for what became known as the Big Bang model of cosmology.

In 1943, while LA was under World War II blackouts, Walter Baade used the Hooker telescope to resolve individual stars in the center of the Andromeda galaxy for the first time. It was not merely an observational feat--he used data gleaned from his photograph to identify two distinct populations of stars, somewhat unimaginatively known today as Population I and Population II. Baade would in turn use his new discoveries about stellar evolution to revise Hubble's estimates of galactic distances and roughly double the size of known universe.

Hubble's and Baade's discoveries were made during the narrow window, from 1917 to 1948, when the Hooker telescope was the largest optical instrument on Earth. It is not a coincidence that the reign of the Hooker telescope aligns so well with the period of cosmological revolution that it facilitated. It is doubtful if any other single telescope since Galileo's "Old Discoverer" has had such a profound impact on our understanding of the universe.

Mathew Wedel

What's Up? Twin Asses, Bees and an Eskimo

The twin asses refers to Asellus Borealis and Asellus Australis, the north ass and south ass of Cancer (Crab). They are two 4th magnitude stars that were seen as asses feeding on the nearby Praesepe or manger of delicious hay. Praesepe is one of the nearest brightest open star clusters. Seen as a "little cloud" by Hipparchus in 130 B.C. Galileo observed it by telescope and saw it as being full of stars. Its telescopic star cluster shapes show many triangular patterns which might suggest bees. Eventually it became the Beehive Cluster (M44), but the two ass stars remained to feed on bees. Easily visible to the unaided eye it was traditionally used as a visual indicator of impending storm clouds. Another good star cluster is M67 just south of the Beehive in Cancer.

Crabby Cancer is the faintest of the 12 Zodiac constellations. It was honored as being the smallest of brave creatures that dared fight Hercules. Sadly it has since become a feared disease. The writers of horoscopes refer to those born under Cancer as Moon Children, so they won't become depressed and stop paying their astrologers. In ancient times the Sun reached its most northerly point in Cancer. On this Summer Solstice day the Sun was directly overhead at latitude 23 north which became the Tropic of Cancer. The sun would then move backward, perhaps like a crab. A similar upside down zodiac event occurs in the south where it gives its name to the Tropic of Capricorn. The sunny winterless zone in between, centered on the Equator, is called the Tropics. Unfortunately for Cancer the Earth's orbital procession has shifted the Summer Solstice into Taurus.

Next to Cancer is a bigger twin, Gemini (Twins). Its twin first magnitude stars Castor and Pollux are close enough to impress superstitious viewers. There were many myths about these iconic Heavenly Twins in Greco-Roman times, they often appeared on silver coins. Sometimes they were Romulus and Remus the founders of Rome or just symbols of brotherly bonding. There's a ruined Roman temple of Castor and Pollux. The poet Shelly wrote A HYMN TO CASTOR AND POLLUX. Something to read while waiting for the Geminid Meteor shower around December 13-14.

The dimmer of the two, Castor (horseman), is an unusually complex star system. A telescope will easily separate Castor A and B, but there is also a third C star orbiting farther out. A spectroscopic analysis shows all three to also be very close binary stars. This makes a total of six stars in what appears at first to be one Castor. Pollux (fighter) the brighter twin is eleven times the size of the sun. It has a small distant companion star. Double stars make up 75% of all known stars, complex multiple systems are less common.

The oddest deep sky object in Gemini is the Eskimo Planetary Nebula (NGC 2392) or Clown Face (pictured). It was missed by Messier but discovered by William Herschel in 1787 who saw it as a star with a surrounding atmosphere. It's now known to be a planetary nebula caused by shells of gas puffed off by a star late in its life. This parka hooded Eskimo has a brighter than usual central star. Just to the south is the dimmer, fragmented Medusa Planetary Nebula.

An open cluster visible to the unaided eye in Gemini is M35 with its neighboring cluster NGC 2158 near Castor's foot. The four stars in Castor's feet have been a constellation of their own, the Chinese called it The Battle Ax. Here begins Messier's only cluster line up M35, M36, M37 and M38. The last three being to the north in Auriga.

Auriga (herdsman) contains the sixth brightest star, the "goat star" Capella. It's a close binary accompanied by seven red dwarf stars. This she-goat star guards "the kids", a triangle of three near by stars. Epsilon Aurigae (Almaaz), the closest of these, is a mysterious variable binary. One star eclipses another in some weird way yet to be understood. Also in Auriga is a complex gaseous nebula called the Flaming Star Nebula IC 405). It's illuminated by a big star which is drifting toward the nebula.

Next to Auriga is the large but dimly illusive constellation of Lynx. Added in 1687 by Hevelius who said one needed the eyes of a lynx to see it. It does contain the most remote of globular clusters known as the Intergalactic Wanderer (NGC 2419). Difficult to locate, it lies beyond the edge of our galaxy at a distance of 182,000 ly. This is farther than either of the Magellanic Clouds.

So, this area around Cancer and Gemini, two iconic Zodiac constellations, features bright open star clusters, dimly distant nebulae, even an Intergalactic Wanderer.

Lee Collins

Sidewalk Astronomy in Claremont

My first experience doing sidewalk astronomy was on Saturday, April 4, 2009. It was the last night of the global 100 Hours of Astronomy event, part of the International Year of Astronomy. Only until that Saturday evening, the LA part of the 100 Hours of Astronomy had been more like the 50 Hours of Holy Crap It's Overcast and Sprinkling. But then the sky just magically cleared, so I took my little travel telescope to downtown Claremont, set up in the public square in front of the Laemmle Theater, and started offering passersby a look at the moon. In two and a half hours, 144 people stopped by for a look.

In the two years since that first night, I've done sidewalk astronomy two dozen times. Not all sessions are as successful as that first one; in 24 sessions I've had 1391 people stop by (keeping a mental tally of how many people have stopped by is a fun way to amuse yourself). I usually go out around the first quarter moon. The moon is a big, easy target, looks good in any scope, and punches through the occasional haze better than anything else in the sky. I will also show off any planets that happen to be up, and the occasional double star or open cluster.

My M.O. is pretty simple: I set up the scope on the sidewalk near the fountains, and start asking people walking by if they'd like to look at the moon (or Saturn, etc.). About 80% of people immediately take me up on the offer. Another 10% look interested but skeptical, like they expect me to prank them or hit them up for money. I usually tell these people that having a look is fast and free, and they'll be glad they did, and that's enough to get them to the eyepiece. A final 10% of people just aren't interested, and that's fine.

I have noticed some patterns. Women of all ages are far more likely to come over for a look than men. Many couples come by because the woman wanted a look and basically dragged the guy over. I don't know if that has to do with (stupid) male aloofness vs. a tendency for women to be more personable, or a vast untapped astronomical curiosity amongst womankind, or what, but the difference between the sexes is often striking.

Smart-alecks are rare, and they have all been young men (to a man, as it were). And they all say the same thing.

Me (pointing to telescope):

"Hey, would you like to look at the moon?"

Them (glancing skyward):

"Nah, I can see it just fine."

I would have thought that would really get on my nerves, but it doesn't. I'm offering a free service, and if people didn't want to look, okay. If they want to get a quip out of it, poor choice, but not my loss. Plus, about half the time the dude who smarts off gets dragged over to the telescope by his wife or girlfriend and ends up looking anyway, and watching the battle between gratitude and embarrassment in his demeanor afterward is, I'm sad to say, extremely satisfying.

In fact, the entire experience is extremely satisfying. People's responses are always overwhelmingly positive, and sometimes they tell me it was the highlight of their evening. I've met lots of nice people and had some genuinely interesting conversations. One family was so grateful that they invited me along on a tour of JPL.

You may be wondering why, if I'm doing all this sidewalk astronomy and enjoying it so much, I haven't invited anyone to join me. It's mainly because I have no fixed schedule and never plan anything. Often I get a random impulse to go downtown and I'm all set up 20 minutes later. Also, I'm a night owl and the father of a little boy with a bedtime, so I often don't get started until after 8:00 and don't shut down until after 10:00. That said, now that the weather is getting a little more predictable, it would be easy to plan some sessions in advance. Please email me (mathew.wedel@gmail.com) if you're interested in setting something up.

There are even a couple of worldwide events every year to celebrate sidewalk astronomy. One is International Sidewalk Astronomy Night (ISAN), which will be on Saturday, May 7, 2011. The other is International Observe the Moon Night (InOMN), on Saturday, October 8. I think these could be great opportunities for outreach events. If we publicized the events in the Claremont Courier and other local newspapers, I think we could probably see a very good turnout.

The most valuable thing I've gotten out of sidewalk astronomy is a passion for outreach. When I go camping now, I always visit the nearby campsites and invite people to come look through my scope. I've come to agree with John Dobson that the only real measure of a telescope's quality is the enjoyment that people have gotten from looking through it. By that metric, my scopes are getting better all the time.

Mathew Wedel

Free Equipment Ad

Hi! A friend gave me a Meade hand control #495 and some small eyepieces. These probably came from a 10 year old ETX or other Meade scope. I have no use for them and wondered if there is a someone in the club who could use them.

Ken Crowder

lcrowder@roadrunner.com

Voyage Into Deep Space

In April 2011 a NASA interactive astronomy web cast will be available for viewing by blind individuals around the world. All that is needed is access to the Internet. This project is a joint venture between Astronomers Without Borders, Israel's Bareket Observatory, Chicago's Adler Planetarium, Design Rhytmics Sonification Research Lab, and NASA Langley.

Voyage Into Deep Space will be fully narrated by astronomer Mark Hammergren from the Adler Planetarium. Live telescope images from the Bareket Observatory will be available to enjoy on the Internet. Each telescope image will be enhanced with state of the art sonification technology. Sonification turns the information and data of each of the telescope images into music, making the images cognitively available for totally blind individuals.

Whether you are sighted or totally blind sit back and let your mind wonder as you travel millions of light years into deep space. NASA will provide the needed bandwidth to make Voyage Into Deep Space available to anyone in the world with internet access.

Voyage Into Deep Space is scheduled to play in April 2011. For the exact dates, times and website to start your voyage contact me.

Frank Busutil
fbusutil2002@yahoo.com

How Does It Work?

In December 2010 we looked at a spherical primary mirror. Now let's look at a parabolic primary. A parabolic primary can be visualized as taking a parabola and rotating it around a line through the focus and apex. This is the only line which contains a focus and all rays which are paraxial to the center line will end up at the focal point.

Probably the first liquid parabolic mirror was made by rotating a pool of mercury about a vertical axis. The centrifugal force and gravity operating on a spinning liquid will produce a parabolic surface.

Today large mirrors can be made by rotating a melt of Pyrex. This must be done very carefully. The Pyrex must be uniformly liquid throughout when rotated. Then it must solidify while rotating. Once solidified, it must be cooled very slowly. This takes a very large well controlled oven.

For small telescopes the performance is similar whether a spherical or parabolic primary is used. The difference lies in the rays which are distant from the center line. A parabolic mirror will perform well with a larger aperture. Any paraxial ray which hits a parabolic mirror is focused at the same point.

This is not true of the spherical mirror. As discussed in December, a ray which is paraxial to the telescope center line but at the edge of the mirror will be focused at a point determined by Snell's Law and a line through the center of the sphere to the point of reflection. At that point the angle of reflection will equal the angle of incidence. A simple two dimensional sketch will show that the ray passes very near the desired focus for large F number mirrors. But at about F/10 or smaller this becomes noticeable. The result is called spherical aberration. The image is smeared even with the best focus.

Large aperture telescopes therefore usually require a parabolic primary. They both have aberrations associated with off axis images which result from a wide FOV. These can be corrected by putting a thin lens at the entrance of the telescope. A Newtonian scope could benefit from this, but it isn't usually necessary for most amateurs. A satisfactory design uses a narrow FOV where the aberrations are similar to the smear due to the diffraction limit.

Most amateur scopes today are designed to be between F/5 and F/10. This keeps the cost affordable. The Newtonian or Dobsonian designs are frequently F/5 to reduce the height of the eyepiece when viewing the Zenith.

The Cassegrain scopes are more complex with a small F number primary and secondary. The common one is called a Schmidt Cassegrain which refers to the corrector plate at the entrance aperture. They are mostly F/10.

This leads to another discussion on Cassegrain designs and corrector plates which I'll have to leave for another time.

Ken Crowder