

Sky WAA tch



Image Copyright: Mauri Rosenthal

Winter Showpiece

Mauri Rosenthal provided this beautiful example of the imaging possible from an urban environment—a photo of M42, the Great Orion Nebula. Notes Mauri: I took this November 10th from my yard in Beech Hill, Yonkers. This is my most successful image to date using the portable system I've been assembling around a 3.5" Questar telescope. The imaging camera is a Starlight Xpress Trius SX-9C (a one shot color camera) cooled to -20° C, and using a 0.6x focal reducer. I've modified the Questar mount for autoguiding and I guide with an SBIG-STi guider using PHD. This image used a stack of 11 x 4 min + 16 x 2 min + 60 x 1-5 second exposures, processed with Nebulosity 3.2 and GIMP.

In This Issue . . .

pg. 2	Events For December
pg. 3	Almanac
pg. 3	In Remembrance of John James
pg. 4	November Starway to Heaven
pg. 5	Size Matters
pg. 11	Where the Heavenliest of Showers Come From
pg. 11	Copernicus Crater

Events for December 2014

WAA December Lecture and Annual Meeting

“Why is Gravity So Weak – What Can the ATLAS at the LHC Tell Us?”

Friday December 5th, 7:30pm

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

The Standard Particle Model describes the fundamental particles (quarks and leptons) found in nature as well as the fundamental forces (electromagnetic, weak and strong) between those particles. It has worked remarkably well, describing all current experimental evidence. However, there is one remaining force that is not included in that model, gravity--the force of gravity is so weak compared to all the other forces that it typically plays no role in particle physics experiments, although it shapes the large-scale structure of the universe. We do not yet know why the force of gravity is so weak; but some theories in particular string theories and others based on extra dimensions of space may offer an explanation. Dr. Michael Tuts will describe how these theories could lead to an explanation of why gravity is so weak, and how the [ATLAS](#) experiment searches for evidence of the existence of extra dimensions.

Michael Tuts is an experimental particle physicist who has spent his career exploring the sub-atomic world. He has been a member of numerous experiments that have led to the discovery of new fundamental particles such as upsilon mesons, the top quark (the heaviest known fundamental particle) and the long sought after Higgs boson. He received his PhD from the State University of New York at Stony Brook in 1979, and then joined the Columbia Physics Department in 1983. He enjoys talking about the LHC and the ATLAS experiment with general audiences as well as teaching introductory physics courses. He now serves as the chairman of the Columbia Physics Department. Free and open to the public. [Directions](#) and [Map](#).

A brief annual meeting will be held before the lecture (election of officers and a membership report).

Starway to Heaven

**Ward Pound Ridge Reservation,
Cross River, NY**

There will be no Starway to Heaven observing dates for December, January or February. Monthly observing sessions will recommence in March 2015.

New Members. . .

Arun Goyal - Katonah
Mauri Rosenthal - Scarsdale
John Higbee - Alexandria
Elaine Miller - Pound Ridge
Rose Sanders - White Plain
George Gerbacia - Scarsdale

Renewing Members. . .

Kevin Mathisson - Millwood
Kevin Shea - Ossining
Al Forman - Croton-on-Hudson
Woody Umanoff - Mount Kisco
Sharon and Steve Gould - White Plains
Edgar S Edelmann - Tarrytown
Bob Kelly - Ardsley
Scott Nammacher - White Plains
MaryPat Hughes - Briarcliff

Editorial Milestone

This is the 100th issue of the WAA *SkyWaatch* newsletter I've edited since taking over from Dick Shaw and Bob Davidson in September 2006. I'd like to thank the many people who have contributed to the newsletter over the years and encourage others to submit their articles and photos in the future.

-- Tom Boustead

WAA Apparel

Charlie Gibson will be bringing WAA apparel for sale to WAA meetings. Items include:

- Caps and Tee Shirts (\$10)
- Short Sleeve Polos (\$12)
- Hoodies (\$20)
- Outerwear (\$30)

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

Almanac

For December 2014 by Bob Kelly

Manhattan's alignment of east-west streets with the rising sun happens around December 5th and in early January. The solstice happens on the 21st at 6:03pm EST, with latest sunrise on the first week of January and the earliest sunset around the end of the first week of December. Now you know enough information to set up your own Stonehenge.

Post-Christmas, users of new (or trusty old) telescopes will have the beautiful winter stars to look at while anxiously waiting for jumbo Jupiter to rise after 8pm. Jupiter is now 40 arc-seconds wide, large for a planet as seen from Earth, but only the size of a largish lunar crater. Visions of Jupiter's moons will dance in the heads of astronomers of all ages. The four Galilean moons cast their shadows on Jupiter, sometimes two at a time, as on the 8th/9th and the 16th. Filters, or even sunglasses, can reduce the bright glare that comes with gathering so much light in a telescope of a magnitude -2.3 planet, and make it easier to pick out Jupiter's bands and markings.

Mars is low to the southwest in the evening; it's been there so long it practically owns the place. Mars sets at 8pm local time all month. Venus brilliantly, but cautiously, approaches from the lower right. Mercury tags along below, well into the twilight—the planets set about an hour apart. A faint, thin Moon lines up alongside Venus on the 22nd and hangs over it on the 23rd.

Mars continues to shrink, from Earth's point of view, decreasing past 5 arc-seconds. Even Uranus and Neptune aren't much smaller, at 3½ and 2 arc-seconds,



Dec 6



Dec 14



Dec 21



Dec 28

respectively. Get a chart for these outer planets and note how they compare to nearby stars in the telescope. What color are they? Does it change with changing magnification?

Saturn rises into the morning sky by mid-month. The rings are tilted 24 degrees toward Earth and can be seen almost all the way around the planet. A skinny Moon points to Saturn on the 19th.

Meteors spout from the heads of Gemini, best anytime after Gemini levitates well above the horizon after 10pm. After midnight, the number of meteors increases, but the last quarter Moon may wash out fainter ones.

The Moon is near Uranus on the 1st and 29th. It splits the Hyades on the 5th. Surprise your friends by making the Hyades appear in your telescope as the nearly full Moon outshines the stars to the naked eye. Mars is to the Moon's left on the 24th and the Moon is a fascinating object for many days afterwards.

With Mars and Venus trying to move away from Earth, Mercury continues to be the closest planet to Earth this month, and during the first quarter of 2015. Not that being the closest does this tiny planet much good from our viewpoint—at 5 arc-seconds and so close to the Sun, it's hard to see details.

The International Space Station is an evening delight, arching over us in the evening twilight from December 5th through 29th.

In Remembrance of John James

It's with deep regret that I relay the passing of my friend and fellow WAA'er, John James, who died suddenly in late October. I first met John in 1984 at Manhattan Family Court, where we both worked as court clerks. John's quick intellect allowed him to rise through the ranks, and over the years he was promoted to a top Court Clerk position at Bronx Supreme Court in the Civil Division, where again, we worked in the same building. I would occasionally stop by his desk and we'd trade stories of growing up in Harlem in the '50s. Along with another WAA member, Frank Jones,

we never knew we lived within a half a mile of each other back then.

I got John interested in astronomy in the 1990's when, a co-worker of his, a woman in her 60's, had won a cheap "Tasco" type, telescope and wanted to set it up. John knew I was into astronomy and asked me if I could assist her. John told me she lived in Co-op City. I told her she should show up with the scope at one of our star parties. The woman didn't drive, so John came from Sunnyside, Queens, and picked her up to take her to Pound Ridge. I remember John being mildly curious about the hobby but his main reason being

there was to help the lady out. The setup for his co-worker became so frustrating that she discarded the scope, but John's interest in astronomy was piqued. He became an integral part of our club around Bob Davidson, and was our treasurer at one time. He was a regular at Stellafane and an all-around stand-up guy.

Many of us saw John as recently as Friday, October 24th, when we attended Bill Newell's Sci-fi Night.

Afterwards, I was talking with John about the good old times in the various courthouses we worked. Before I left, I wished John a happy upcoming birthday (Nov. 19th) and looked forward to seeing him again soon. He was taken too soon from us.

-- Charlie Gibson

November Starway to Heaven

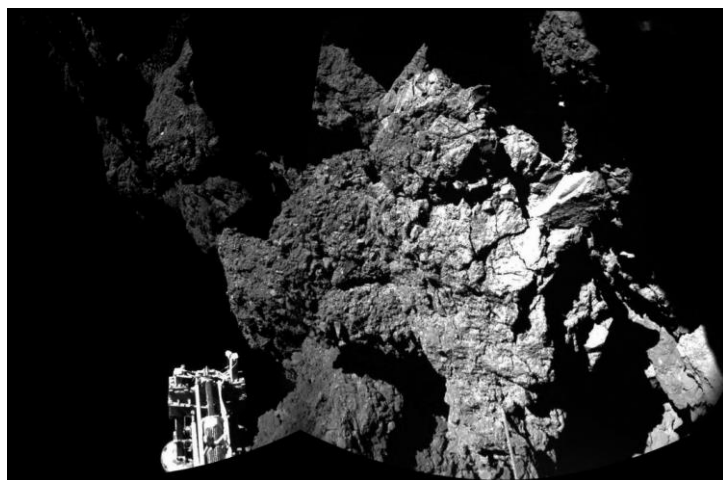
On Saturday the 15th, we had a clear but cold night for our star party.

We started with about six scopes and few joined us later. It was quiet at first, but with the earliest sunset of our star parties. Darkness came around 5pm! Then lots of the public wandered in over the next few hours. Two buses arrived about 6pm from Fordham; their students well dressed for the cold. We oriented them to the sky and they went from scope to scope to visit and ask good questions about bright objects, double stars, galaxies and other sights. Early in the evening

our guests spotted quite a few faint satellites passing overhead. The Milky Way arched overhead, looking like cirrus clouds. We were treated to several very bright meteors, at least one with a trail, perhaps some of the Taurid meteors catching up to the Earth as they orbited the Sun. By 8pm, the Fordham students were drifting back to their buses. By that time, the temperature had dropped to 23 degrees. We had some nice-sized telescopes, with several newcomers – thank you for sharing your equipment!

-- Bob Kelly

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← Welcome to a Comet

[The Rosetta Mission](#) lander is safely on a comet. One of Philae's feet appears at the bottom left of this spectacular image of the surface of C67/P Churyumov-Gerasimenko. Still a [happy lander](#), Philae bounced twice before settling and returning images from the surface, traveling a kilometer or so after initially touching at the targeted site Agilkia. A [surface panorama](#) suggests that the lander has come to rest tilted and near a shadowing wall, with its solar panels getting less illumination than hoped. Philae's [science instruments](#) are working as planned and data is being relayed during communications windows, when the Rosetta spacecraft is above the [lander's new horizon](#).

Credit: [APOD](#)

Image Credit: [ESA/Rosetta/Philae/CIVA](#)

Size Matters

Larry Faltz

We are in an era of vast astronomical discovery. Less than 100 years ago, we were only able to see with our eyes (even with spectroscopy and photography), but starting with Jansky's discovery of radio waves from space in 1932, and aided by spaceflight, we've expanded our range of perception. We can now examine space at nearly every frequency in the electromagnetic spectrum, from energetic gamma and X-rays to long-wave radio. The previously hidden bands have been opened through new technology, particularly through space telescopes. We've been able to investigate the infrared part of the electromagnetic spectrum, allowing us to peer through to the center of the Milky Way, to see planets orbiting other stars, to examine distant galaxies and to picture the birth of the universe. Earthly telescope sensitivity and resolution have increased through the employment of ultrasensitive CCD sensors, ever-larger mirrors, better mounts, adaptive optics and the installation of big scopes at ideal locations in Hawaii, Chile and the Canary Islands. Advancements in computing power facilitate modeling the most complex astronomical problems in amazing detail. The Internet has allowed astronomers all over the world to share data, with immediate access to data sets, images and catalogs through sites such as the [Centre de Données Astronomiques de Strasbourg](#) (Strasbourg Astronomical Data Center), the [Sloane Digital Sky Survey](#) and the [Hubble Legacy Site](#) (these are only a few of the available data repositories). Original papers in astronomy and physics are posted daily on [arXiv](#), maintained by the Cornell University Library, and are freely open to the public. While most of the arXiv papers are highly technical, a few are of more general interest.

The range of problems currently interesting researchers is vast, and the arXiv astrophysics web site posts papers on everything from solar chemistry to black hole theory. It's worth a look just to bask in the language that's current in the world of advanced astronomy. How about "Quasars as tracers of cosmic flows", or "The Cocoon Nebula and its ionizing star: do stellar and nebular abundances agree?" or "Distinguishing $f(R)$ gravity with cosmic voids?" [$f(R)$ gravity is one of several theories that compete with general relativity]. These are just 3 of the 65 astronomy and astrophysics postings the day I wrote this part of the article.

There are two problems for observational astronomy that seem to hold center stage right now: the possibility of life on exoplanets and the search for the first stars. The investigation of these problems depends on the development of telescopes, particularly optical instruments, with more light-gathering capacity and resolution than is currently available either with the largest telescopes on Earth, 10 meters in diameter, or the 94" (2.4-meter) Hubble Space Telescope.

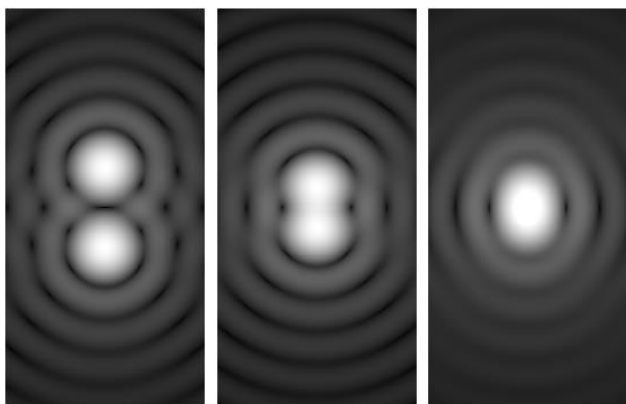
Light-gathering is a function of aperture. We can compare the light-gathering capabilities of two telescopes by calculating the difference in the surface areas of their primaries, recalling that the formula for the surface area A of a circle is $A=\pi r^2$, but since we describe telescope objectives or mirrors by their diameter, $A=\pi(D/2)^2$. So the light gathering difference between two scopes is $\Delta A = \pi(D_1/2)^2 \div \pi(D_2/2)^2$. The π terms cancel, simplifying the calculation (it's hard to memorize the 3.141592 times table anyway). For example, a step up from a 6" telescope to an 8" telescope gets you $(8/2)^2 \div (6/2)^2 = 4^2/3^2 = 16/9 = 1.77$ times as much light. From an 8" (0.2 m) telescope to the Keck (10 meters) is $5^2/0.1^2 = 25/0.01 = 2500$.

You will sometimes see manufacturers use the term "light gathering power", which is a telescope's theoretical ability to deliver light to your fully dilated eye. It depends on the aperture and the maximum pupil diameter, which for a young person is 7mm, decreasing by at least a millimeter in us oldsters. The formula is $(D/7)^2$ with D in millimeters. Again, this calculation is most useful for comparisons, so the 6" (152.4 mm) and 8" (203.2 mm) scopes have light gathering powers of $(152.4/7)^2 = 474$ and $(203.2/7)^2 = 843$. Seen this way, the comparison formula is really the same as the area calculation since the constants cancel, and so the ratio is still 1.77.

Limiting magnitude is a little more useful. It is the faintest star you can presumably see at a given aperture, if all conditions, including your eyesight, were perfect. The formula is an inexact one, but we generally use $7.7 + 5 \cdot \log(\text{aperture in cm})$. For the 6" scope, the limit is 13.6. An 8" scope can theoretically reach to magnitude 14.2. For the Keck, it calculates to 22.7 but the formula underestimates the sensitivity of larger research scopes. You can break the limiting magnitude barrier with imaging sensors, since the efficiency of your dark-adapted eye is only about 6-10% for en-

tering photons, while the best sensors today are getting above 90%. For those large research telescopes, no one actually looks through them visually anyway, although it would be really cool to pop your 13 mm Ethos into a 10-meter scope. I doubt anyone sells the right adaptor, though. Big research scopes are said to have a limiting magnitude of >30 .

Resolution is another critical characteristic. The resolution of a telescope is the minimum distance between two objects that can be distinguished. Resolution is limited by a number of factors, but the main ones are the inherent quantum wave nature of light, the atmosphere and the quality of the optical surfaces. An Airy disk is the ring-shaped pattern of interference fringes created when light passes through a circular opening, like a telescope aperture. When objects are close together, their Airy disks overlap and at some narrow gap the two objects cannot be distinguished.



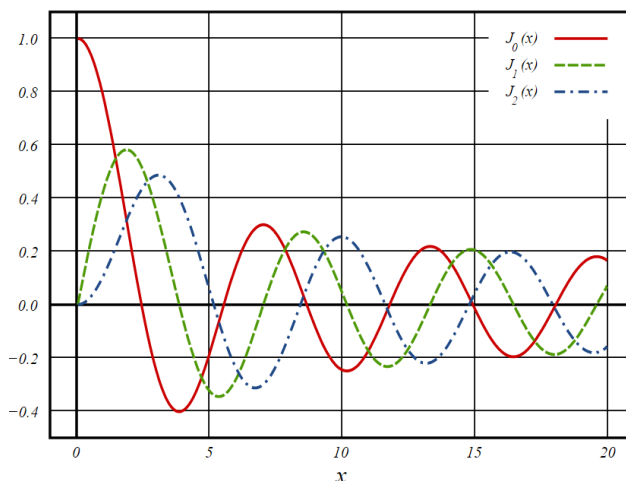
Airy disks of two artificial stars whose spacing decreases from left to right (Spencer Bliven)

The Rayleigh criterion, developed by British physicist Lord Rayleigh (1842-1919), says that two point sources can be just resolved if the principal maximum diffraction ring of one image coincides with the first minimum of the other. This is dependent on aperture and the wavelength of light according to the formula

$$\theta = 1.220 \frac{\lambda}{D}$$

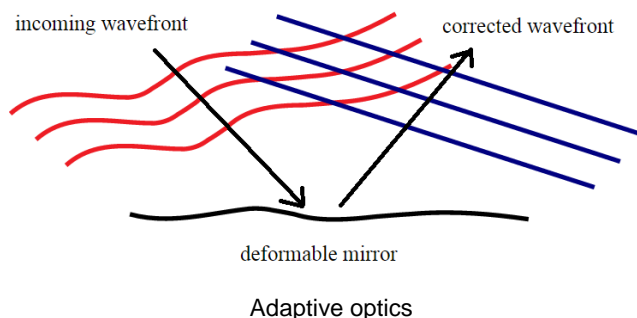
where θ is the angular resolution in radians, λ the wavelength of light and D is the diameter of the telescope. The factor 1.220 is derived from the mathematics of the rings, which are described by a differential equation called a Bessel function. The mathematics are beyond this paper (and a little beyond me), but a graph of the solutions to a Bessel function has the kind of oscillating, slowly decreasing amplitude that we see in an out-of-focus star image when we do a

“star test” for collimation or assessment of our optics. It gives a sense of where the rings in an Airy disk come from.



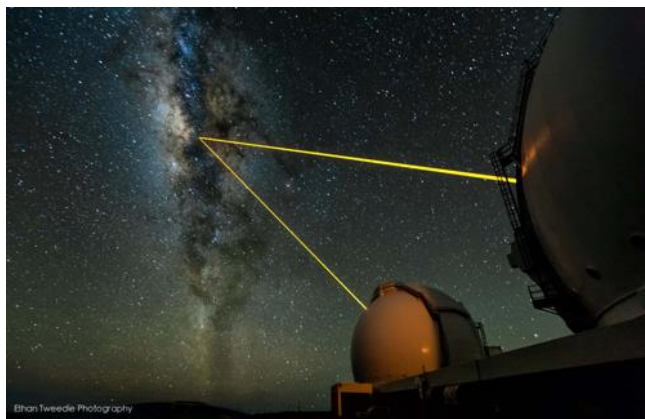
Graph of a Bessel function

“Seeing,” the steadiness of the atmosphere through which the light passes, has a major impact on resolution. Unavoidable heat currents change the refractive index of atmospheric gases, scrambling the wavefront as it moves towards the telescope. Placing the scope at high altitude reduces (or eliminates, as in the case of space telescopes) the amount of atmosphere through which the light passes, mitigating the problem. Today’s large terrestrial research scopes use adaptive optics, in which deformable mirrors (usually secondaries) are mechanically bent in response to the nearly instantaneous computer analysis of the incoming light. There are a number of techniques to do this, but the one the most advanced instruments analyze an artificial star created by a laser beam projected 15-25 km into the stratosphere. With this technique, the Keck telescope can improve its resolution from 1 arc second (1000 milli-arc-seconds) to 30-60 milli-arc-seconds in the important infrared waveband.



Atmospheric water vapor is a potent absorber of IR wavelengths, which are so important for exoplanet

research. Higher and drier observatory sites mean that more photons in the critical IR wavelengths will enter the instrument.



Sodium lasers (589 nm) from Keck I and 2 (Keck)

The largest optical telescopes in the world today are the Gran Telescopio Canarias (10.4 meters), the two 10-meter Keck telescopes on Mauna Kea in Hawaii, the Southern African Large Telescope (9.2 meters), and the Hobby-Eberle Telescope (9.2 meters) at McDonald Observatory in Texas. All of these scopes use segmented hexagonal mirrors rather than a single piece of glass. The largest single-glass mirrors are just above 8-meters in diameter. The two mirrors of the Large Binocular Telescope on Arizona's Mt. Graham are each 8.4 meters (see my article about this fabulous, behemoth instrument in the [October 2011 news-letter](#)). The four Very Large Telescope mirrors at Paranal Observatory in Chile have 8.2 meters (housed in 4 separate mounts). The Subaru Telescope on Mauna Kea's has a mirror 8.2 meters in diameter; across the caldera is the Gemini North instrument (8.1 meters), which has a twin, Gemini South, in Chile.



Subaru, Keck 1 and Keck 2 on Mauna Kea (LF)

Telescopes can be increased in size virtually by interferometry. The Kecks were built with an interferometer that can connect the two mirrors, creating a virtual telescope of 85 meters diameter with resolution of 5 milli-arc-seconds, but the device is currently in mothballs for lack of funding. The two mirrors of the Large

Binocular Telescope can also be synthesized by interferometry into a 22.8 meter light-gathering surface. The four Very Large Telescope mirrors can be synthesized by interferometry into a device that gives a remarkable 0.8 milli-arc-second resolution. Interferometry has a cost, though: there's a significant reduction in total light intensity. For example, to achieve its remarkable interferometric resolution, the VLT optical beam has to reflect off 32 surfaces, resulting in losses of 95% at 1 μm , 90 percent at 2 μm and 75 percent at 10 μm (all infrared wavelengths).



Lowell Observatory's Anderson Mesa site, with the Navy Precision Optical Interferometer (Google Earth)

Interferometry has been used to achieve very high angular resolution with smaller mirrors, such as the Navy Precision Optical Interferometer at Lowell Observatory's Anderson Mesa facility near Flagstaff, AZ. This device, and similar dedicated optical interferometers around the world, is used primarily for astrometry and imaging individual stars in order to resolve their surfaces. The best angular resolution in the world, 0.5 milli-arc-seconds, is achieved by the CHARA Array, an optical interferometer using six 1-meter mirrors with a maximum separation of 330 meters, located at Mt. Wilson in California. This may be surpassed when the Magdalena Ridge Interferometer, located near Socorro, NM, comes on line in a few years.

Interferometry has been used for years in radio astronomy. Resolution depends on the separation of the components of the device. The Very Large Array near Magdalena, NM, has twenty-eight 25-meter (82-foot) radio telescopes in a Y-shaped configuration. The maximum length of each limb of the Y is 23 miles. Maximum resolution is 4 milli-arc-seconds. The Very

Long Baseline Array is made up of ten 25-meter dishes at sites ranging from Mauna Kea in Hawaii to St. Croix in the Caribbean. With an effective angular separation of 8,611 miles, the VLBA can achieve at least 0.17 mill-arc-second resolution at some wavelengths. Each VBLA antenna records the signal using an atomic clock to keep precise time, so that the data can be correlated later and images produced.

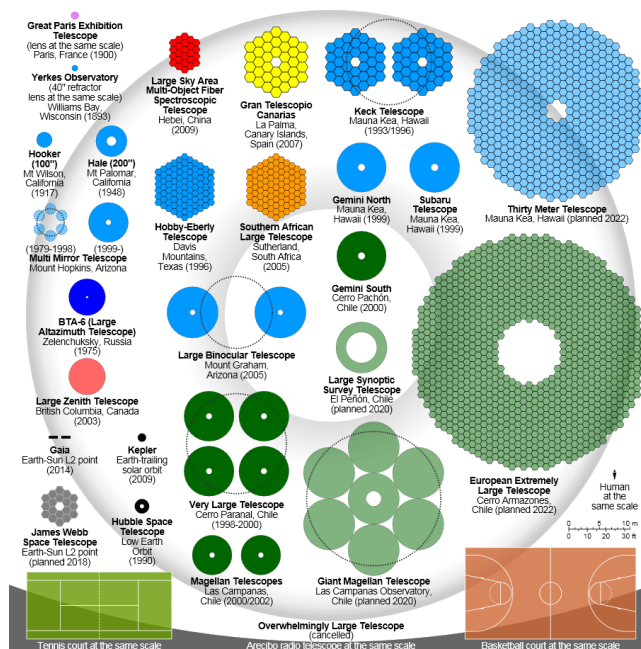


The VLBA dish at Mauna Kea in 2012, as seen from the summit (LF)

Radio waves are good for high-energy studies, but to get more data in the infrared, we need to build bigger and better optical telescopes with sensitive IR detectors. The spectacular images and scientific results from the relatively small Hubble Space Telescope show that getting out of the atmosphere is a big help. Its successor, the James Webb Space Telescope, is being readied for launch in October 2018 if all goes well and funding continues. For \$8 billion (16 times the expected cost when it was approved in 1996), you get a 6.5 meter diameter segmented-mirror infrared telescope orbiting a million miles from Earth, projected to be operational for 5 years with an outside window of 10 years. If something goes wrong with the complex deployment of the mirror segments or the heat shield, it can't be repaired. After it runs out of fuel or coolant, it's just a big space brick. If all goes well, the scientific output of the Webb Telescope will be prodigious, but it's more of a gamble than some people would like to take.

The advances in optical technology that brought us to our current level of telescope grandeur are now being employed to build much larger Earth-based telescopes. Positioned in high, dry climates in Chile and Hawaii, these behemoths will have more light-gathering capacity and better resolution than Hubble

and will rival, if not surpass, the Webb telescope for resolution, not only because of their size but by virtue of having been designed around adaptive optics systems (rather than having them added on later).

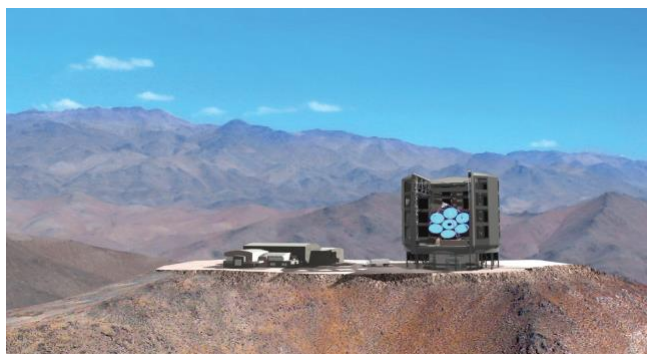


Comparison of telescope mirrors (Cmglee)

We were invited to a presentation on September 10th at the Morgan Library in Manhattan sponsored by the Smithsonian Institution to introduce us to the Giant Magellan Telescope. The Smithsonian is one of the partners in the GMT, which is in the early stages of construction in Chile. The mountaintop site has been leveled and 3 of the mirrors have been cast at the University of Arizona's Steward Observatory Mirror Lab, the makers of the Large Binocular Telescope mirrors. The GMT will have seven 8.4-meter cast mirrors (six off-axis) polished to $\frac{1}{20}$ wave, providing the equivalent of a 24.5-meter telescope. The adaptive optics system will use hundreds of actuators that flex the secondary mirror to compensate for atmospheric distortion. It will have 5-10 times the light-gathering capacity of current telescopes and resolution will be 10 times better than Hubble. Operations are scheduled to begin in 2020 with at least 4 of the mirrors installed. Like all of the large telescopes built since the 1970's, it will use an alt-az mounting and field rotators to compensate for the lack of a true polar axis.

In his introduction at the meeting, Charles Alcock, Director of the Harvard-Smithsonian Center for Astrophysics, noted advantages that make large Earth-based telescopes preferable to space telescopes. They are much cheaper to build and they last a lot longer.

The disadvantage of having them sited in remote places (Mauna Kea is not all that remote!) is compensated by the Internet's ability to move enormous amounts of data throughout the world. Astronomers using the instrument may never actually have to visit it.



Artist's drawing of the Giant Magellan Telescope (GMT)

Following Dr. Alcock's presentation there was a staged "conversation" with Brian Schmidt of the Australian National Observatory. Schmidt is a Harvard-trained astrophysicist who directed the High-Z Supernova Search Team collaboration. Along with Adam Riess of the High-Z project and Saul Perlmutter, director of the Supernova Cosmology Project at the Lawrence Berkeley Laboratory of the University of California, Schmidt was awarded the 2011 Nobel Prize for the discovery of the accelerated expansion of the universe, based on measurements of supernova brightness. Schmidt reviewed, in fairly non-technical terms, the evolution of the universe and made the case for studying the first stars and galaxies with new, large telescopes. He related some interesting and even humorous anecdotes about receiving the Nobel Prize.

At the conclusion of the presentation, there was a question-and-answer session for the 100 or so guests, most of whom did not seem to be very astronomically sophisticated. Not wanting to appear excessively geeky, I held a more technical question for a hoped-for one-on-one at the cocktail party that followed.

Schmidt's discovery of accelerated expansion hinges on examining supernovas in distant galaxies. Type Ia supernovas are considered to be "standard candles" with essentially uniform brightness, a consequence of their being one component of a binary system in which one star donates mass to the other. When that star reaches the Chandrasekhar Limit (1.4 solar masses) the balance between gravity and nuclear fusion is tipped and the star collapses and then explodes. All type Ia supernovas should therefore be pretty much the same, being created at the 1.4 solar mass level.

The detailed physics of the explosion is, however, not fully understood. A paper published just a few days before the event, "Early ^{56}Ni decay gamma rays from SN2014J suggest an unusual explosion," by Roland Diehl of the Max Planck Institute and a dozen international colleagues (*Science* 2014; 345: 1162-1165), implies that there may be more variation in the mechanism than was previously thought. These astronomers studied the recent supernova in M82 using the gamma ray spectrometer on the International Gamma Ray Astrophysics Laboratory (INTEGRAL) space mission. They measured the abundance of ^{56}Ni at different times after the supernova was detected. The abstract is informative:

Type Ia supernovae result from binary systems that include a carbon-oxygen white dwarf, and these thermonuclear explosions typically produce 0.5 solar mass of radioactive ^{56}Ni . The ^{56}Ni is commonly believed to be buried deeply in the expanding supernova cloud. In SN2014J, we detected the lines at 158 and 812 kilo-electron volts from ^{56}Ni decay (time ~ 8.8 days) earlier than the expected several-week time scale, only ~ 20 days after the explosion and with flux levels corresponding to roughly 10% of the total expected amount of ^{56}Ni . Some mechanism must break the spherical symmetry of the supernova and at the same time create a major amount of ^{56}Ni at the outskirts. A plausible explanation is that a belt of helium from the companion star is accreted by the white dwarf, where this material explodes and then triggers the supernova event.

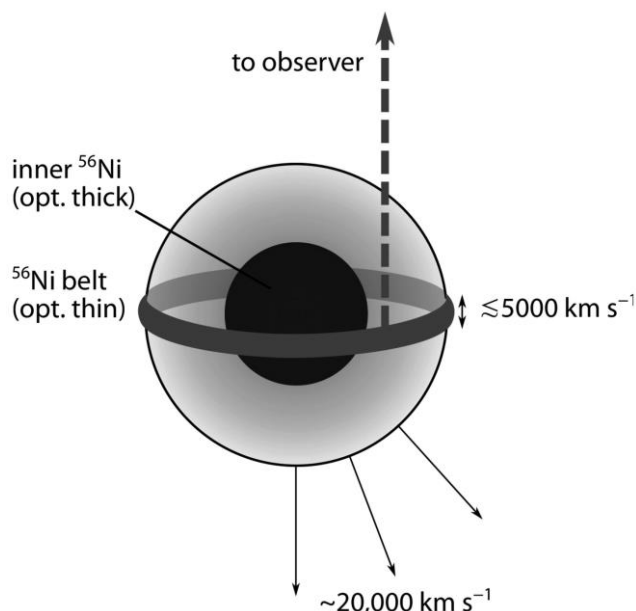
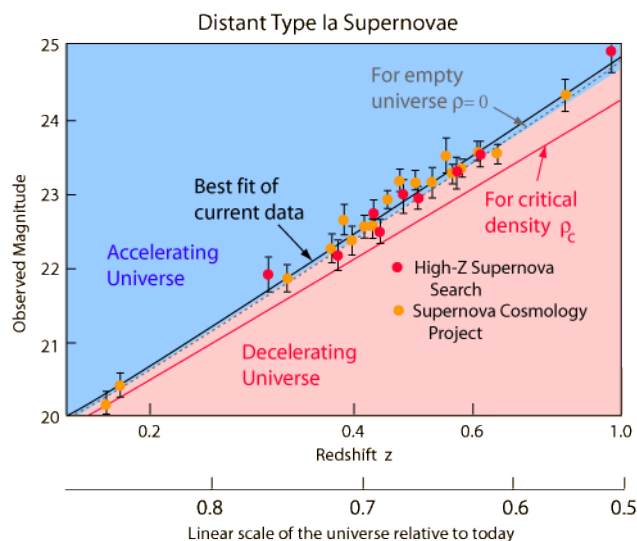


Fig. 3 from Diehl *et. al.* The caption states "He accreted in a belt before the explosion produces the ^{56}Ni belt at the surface of the ejecta. The gamma rays can escape from the belt material, whereas the ^{56}Ni in the core (black) is still buried at high optical depths"

This is an interesting result, because if true it would be direct evidence that material from the companion is falling onto the equator of the star prior to its explosion, and it provides an explanation for at least some of the physics that takes place. There is a possibility that this may be only one of a number of scenarios that precede supernova explosions since the composition of any accreted material depends on the companion star, which can have a range of sizes and compositions. That means that the nuclear physics of the explosions, and their light curves, might vary in different supernovas. Perhaps Type Ia supernovas are not such standard candles after all, or at least not as standard as the High-Z and Supernova Cosmology teams assumed them to be.

One of the things that has always interested me about the data that both the High-Z and Supernova Cosmology groups presented was that the conclusions aren't based a whole lot of data points. Yet many cosmologists have analyzed the findings and have come to the same conclusion as the authors: the expansion rate of the universe is increasing. I mentioned the data point problem to Dr. Schmidt, and asked whether the results in Diehl *et. al.* might mean that the Type Ia supernovas are not standard candles. The error bars could thus be broad enough to overlap the predictions of other scenarios, challenging the conclusion of accelerated universal expansion.



Data from both supernova projects (graphic from Georgia St. University)

Schmidt was, I think, rather grateful to have to answer a question of at least some scientific sophistication. He told me that a nuclear chemist member of his group had some reservations about the data analysis

presented by Diehl's research team, but as the paper was just a few days old more study of the details was required. More to the point of my concerns, he told me that the analyses of the supernova data by his team (and presumably Perlmutter's) took into account enough variation in supernova explosion physics to cover a range of energies that might result from variations in companion star composition or explosion mechanism. In other words, my suspicions are unfounded. The data is still good.



Brian Schmidt (L) and yours truly at the Morgan Library. Schmidt's gold lapel pin is a miniature version of his Nobel Prize medal. (Elyse Faltz)

I thanked him for his explanation, gave him a WAA business card, and let him go on to the many guests who wanted to meet and be photographed with him. You don't meet Nobel Prize winners every day!

It was an interesting evening and an opportunity to meet some people from the Harvard-Smithsonian Center for Astrophysics. Of course it was really a fund-raiser and a week later, as expected, I received a letter asking for a generous contribution to the project. At least \$700 million is needed, which sounds like a lot, but it's less than 10% of the cost of the Webb, and in a real sense that makes it a real bargain and worth supporting.

The Giant Magellan Telescope is not the end of the line for leviathan telescopes. Ground-breaking has taken place for the Thirty Meter Telescope on Mauna Kea, with 492 hexagonal mirrors slated for first light in 2022, and early construction work has begun in Chile on the European Extremely Large Telescope, a 39.3-meter behemoth with 798 hexagonal component mirrors slated for first light in 2024. The staggering light-gathering and resolving power of these instruments should bring vast amounts of new science.

Where the Heavenliest of Showers Come From

By Dr. Ethan Siegel

You might think that, so long as Earth can successfully dodge the paths of rogue asteroids and comets that hurtle our way, it's going to be smooth, unimpeded sailing in our annual orbit around the sun. But the meteor showers that illuminate the night sky periodically throughout the year not only put on spectacular shows for us, they're direct evidence that interplanetary space isn't so empty after all!

When comets (or even asteroids) enter the inner solar system, they heat up, develop tails, and experience much larger tidal forces than they usually experience. Small pieces of the original object—often multiple kilometers in diameter—break off with each pass near the sun, continuing in an *almost* identical orbit, either slightly ahead-or-behind the object's main nucleus. While both the dust and ion tails are blown well off of the main orbit, the small pieces that break off are stretched, over time, into a diffuse ellipse following the same orbit as the comet or asteroid it arose from. And each time the Earth crosses the path of that orbit, the potential for a meteor shower is there, *even after* the parent comet or asteroid is completely gone!

This relationship was first uncovered by the British astronomer John Couch Adams, who found that the Leonid dust trail must have an orbital period of 33.25 years, and that the contemporaneously discovered comet Tempel-Tuttle shared its orbit. The most famous meteor showers in the night sky all have parent bodies identified with them, including the Lyrids (comet Thatcher), the Perseids (comet Swift-Tuttle), and what promises to be the best meteor shower of 2014: the Geminids (asteroid 3200 Phaethon). With an orbit of *only* 1.4 years, the Geminids have increased in strength since they first appeared in the mid-1800s, from only 10-to-20 meteors per hour up to *more than 100* per hour at their peak today! Your best bet to catch the most is the night of December 13th, when they ought to be at maximum, before the Moon rises at about midnight.

The cometary (or asteroidal) dust density is always greatest around the parent body itself, so whenever it enters the inner solar system and the Earth passes near to it, there's a chance for a **meteor storm**, where observers at dark sky sites might see *thousands* of meteors an hour! The Leonids are well known for this, having presented spectacular shows in 1833, 1866, 1966 and a longer-period storm in the years 1998-2002. No

meteor storms are anticipated for the immediate future, but the heavenliest of showers will continue to delight skywatchers for all the foreseeable years to come!

What's the best way to see a meteor shower? Check out this article to find out:

<http://www.nasa.gov/jpl/asteroids/best-meteor-showers>.

Kids can learn all about meteor showers at NASA's Space Place:

<http://spaceplace.nasa.gov/meteor-shower>.

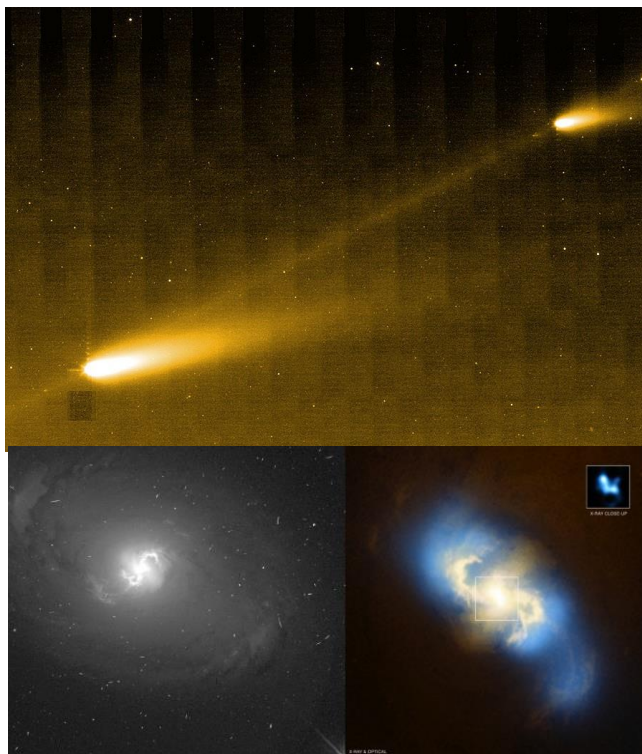
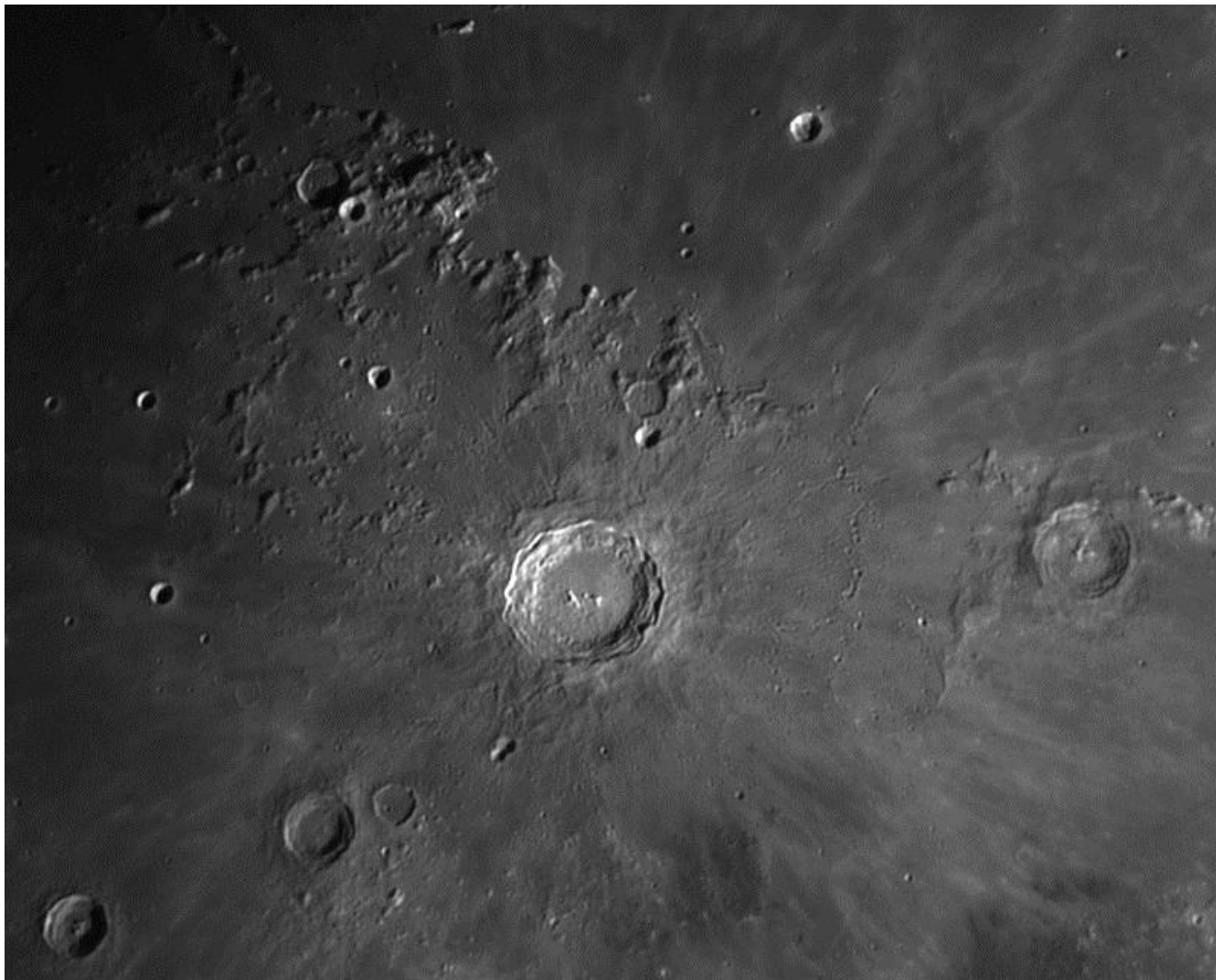


Image credit: NASA / JPL-Caltech / W. Reach (SSC/Caltech), of Comet 73P/Schwassman-Wachmann 3, via NASA's Spitzer Space Telescope, 2006.

Westchester
Amateur Astronomers

Copernicus Crater



This image of Copernicus was captured on September 4th from Larchmont when the 10-day old waxing crescent moon was 75% illuminated. I used my usual lunar imaging set-up: Orion 127 Maksutov on an iOptron MiniTower alt-az mount and Celestron Skyris 445 monochrome camera with #25 red filter to improve contrast and sharpness. The best 400 of 3000 frames were stacked with Autostakkert!2, followed by mild wavelet processing in Registax 6 and final contrast adjustment in my ancient version of Photoshop Elements. The skies were clear and there was fair-to-good seeing, 6/10 on the [Pickering scale](#). I'm learning not to get too aggressive with the wavelets, which can oversharpen the image and compress the grayscale levels so there are not enough tones between pure white and pure black. It's the Ansel Adams zone system applied to astroimaging.

Just above Copernicus at about 1 o'clock is the flat crater Gay-Lussac, with the deeper crater Gay-Lussac A just a slight bit closer to Copernicus. To the right at 3 o'clock is the larger crater Eratosthenes. At 7 o'clock are the craters Reinhold and, further away, Lansberg. At 9 o'clock is the small crater Hortensius, and at 10:30 o'clock the sharp crater T. Mayer C. The Montes Carpatus (Carpathian Mountains) are to the north, above which is the southern edge of the Mare Imbrium with the crater Pytheas. Copernicus is a young crater (perhaps 1.1 billion years old, which is young by lunar standards) and the bright rays produced by the impact are very prominent.

Copernicus is 56 miles in diameter. Its height, from the floor to the upper edge of its walls, is about 11,400 feet.

-- Larry Faltz