SkyWAAtch

A Triple Play

Mauri Rosenthal imaged the Leo Trio from his yard in Scarsdale using his TV-85 on a Sky-Watcher Star Adventurer mount. "I was pleased that I could achieve this result with 10 pounds of telescope on a portable tracking mount by using short exposures with a ZWO ASI1600MC camera. Live stacking with SharpCap makes it possible to accumulate 10 minutes of exposure time using 15 or 30 second bites, which in turn reduces the requirements for high precision tracking." Two hours of total exposure time from two nights in early March were processed with PixInsight to generate this image.

The three galaxies in the group (M65, M66, and NGC 3628) are some 30 to 35 million light years from us but only half a million light years from each other.

In This Issue . . .

Events for April

WAA April Lecture

"Astrovisualization"
Friday April 6th, 7:30pm
Lienhard Hall, Pace University, Pleasantville, NY

We are pleased to have as our April speaker Carter Emmart, who is probably the world's leading expert on using computer software to make detailed video imagery from digital astronomical data. He directs the American Museum of Natural History's groundbreaking space shows and administers development of an interactive 3D compendium "The Digital Universe." He coordinates scientists, programmers and artists to produce scientifically accurate yet visually stunning and immersive space experiences in the AMNH's cutting-edge Hayden Planetarium. Mr. Emmart, who previously worked at NASA Ames Research Center and the National Center for Atmospheric Research, received his B.A. in geophysics from the University of Colorado, where he was an organizer of the Case for Mars Conference series. In May 2006, he received an honorary Ph.D. from Linköping University in Sweden; he has spoked on TED. Directions and Map.

Upcoming Lectures

Leinhard Lecture Hall
Pace University, Pleasantville, NY

Our speaker on May 4th will be Father John Cunningham, Associate Professor, Department of Physics and Engineering Science at Fordham University. He will speak on core collapse of supernovae. Free and open to the public.

Starway to Heaven

Saturday April 14th, Dusk.
Ward Pound Ridge Reservation, Cross River, NY

This is our scheduled Starway to Heaven observing date for April, weather permitting. Free and open to the public. The rain/cloud date is April 21st. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

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

New Members. . .

David Janes - Tarrytown
Allison Steinberg - Tarrytown
Fredrick N. Veio - Clearlake Park
Dor Zaidenberg - White Plains
Nicolette Calamari - Pelham
Jon Gumowitz - White Plains

Renewing Members. . .

Ireneo Fante - White Plains
Frank Jones - New Rochelle
John Benfatti - Bronx
Theresa C. Kratschmer - Yorktown Heights
William Sawicki - Bronx
Alex Meleney - Greenwich
John Markowitz - Ossining
John & Maryann Fusco - Yonkers

Join WAA at NEAF, April 21-22nd
Rockland Community College, Suffern, NY

WAA will have a booth at the Northeast Astronomy Forum, to be held at Rockland Community College on Saturday, April 21st and Sunday, April 22nd. This is the nation's premier astronomy show, with a vast diversity of exhibitors, vendors, equipment, lectures by leading astronomy figures and, weather permitting, the famous Solar Star Party.

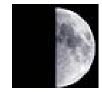
We need volunteers to staff our booth. It's an opportunity to meet and chat with fellow club members and other astronomy enthusiasts, and to help recruit new members to the club. It also is a place where you can store your swag while attending lectures or other events. Last year 20 club members participated, we recruited new members and we made many new friends. Put NEAF in your calendar now.

Westchester Amateur Astronomers

ALMANAC
For April 2018 by Bob Kelly


Apr 8


Apr 16


Apr 22


Apr 30

Jupiter is a wonderful sight in a telescope at 44 arcseconds wide from mid-April through early June. It's highest in our skies after midnight – in June Jupiter will be highest in the prime-time evening skies, but why wait, given the late sunrises due to daylight time? It'll get warmer soon, won't it?

Saturn and Mars patiently wait offstage for Jupiter to have its time in the spotlight. They start out April right next to each other, hovering over the teapot of Sagittarius. They make a wonderful contrast as they pair up in the morning sky around the 2nd. One is reddish; one is yellowish. They drift apart as the month goes on. A plump Moon joins the planetary couple on the morning of the 7th for a nice photo op.

Mars and Saturn start April at the same brightness, but Mars jumps a full magnitude brighter by the end of the month. Mars still appears smaller than Saturn's disk, even as Mars gets large enough by the end of the month for moderate-sized telescopes to see some details. Does Mars leave Saturn for a dwarf planet? Mars happens to pass Pluto's neighborhood in the sky near the end of April. It'll be nice to use Mars to point out Pluto's location.

Mercury is in conjunction with the Sun on the 1st. Then it makes a weak swing into the morning sky; not very easy to see from the Northern Hemisphere. It'll be easier to see online in the Solar and Heliospheric Observatory's C3 camera view through the 6th. Uranus's conjunction with the Sun will be harder to see as it crosses the C3's field from the 10th through the 27th. Mercury yields the title of 'closest planet to Earth' to Mars at the end of April. Mars keeps the title until Venus becomes the closest in mid-September through the rest of 2018.

Venus continues to arch higher from the western horizon, setting hours after the Sun. At the far side of its orbit from Earth, it looks as tiny as Mars and does not have much of a phase at 90 percent lit. Even then, it's still the brightest planet at magnitude minus 3.9. At the end of the month, Aldebaran sinks down, passing upgoing Venus. Orion, to their left, looks to make a hasty departure from the evening skies. Perhaps he left his eveningwear behind and feels underdressed. Or, is his arm, upstretched from Betelgeuse, waving in distress as he sinks below the horizon?

Vesta is the brightest minor planet. It passes through magnitude plus 6 on its way to magnitude +5.3 at opposition in June. It's hanging out about 10 degrees to the upper right of Saturn in our skies.

The Lyrid meteors peak during the afternoon on the 22nd. We have the chance to see up to a dozen Lyrids an hour near their peak, with the best numbers before dawn. Elevated numbers of Lyrids are visible on the mornings of the 21st and 23rd as well.

Overflights of the very bright International Space Station are visible most evenings through the 12th. Tiangong 1 is slowly falling out of orbit and may reenter our atmosphere as soon as the end of April. Slamming into even the few molecules of air per cubic meter of the Earth's thermosphere at 18,000 miles per hour saps orbital energy from China's first space station. As its orbit changes more rapidly, projecting sighting times will need to be recalculated. As of now, Tiangong may be viewed from our area in the morning twilight for the first third of the month. The Chinese space agency lost communications with Tiangong 1 and its reentry will be uncontrolled. At 35 feet long, Tiangong 1 is one-third the length of the USA's Skylab. Skylab made an uncontrolled fall to Earth in 1979 west of Australia; the Russian Mir reentered by remote control over the South Pacific in 2001.

In The Naked Eye Sky

For April 2018: Looking for Orion's Head

by Scott Levine

A couple of weeks ago, woven between the second and third nor'easters, we had a clear, open, cloudless day that stretched off into a gorgeous sunset with only some fat contrails spoiling the glow over the hilltops across the Hudson. After a long day, my family and I took a break and headed out to find a couple of planets. We figured Venus and Mercury would do the trick, and there they were.

I always love the contrast between the bright sunsets to the west, and the quickly deepening eastern skies. This time of year, that difference seems sharper, and it felt like we were stepping directly across the line from day into night, crossing the terminator itself, just by turning back toward the house.

High above us toward the north sat Ursa Major. For a constellation as famous and omnipresent as the Great Bear, it also seems like it's one of the least appreciated and understood. Most of its fame, of course, comes from the Big Dipper. Those few second-magnitude stars are among the easiest to find in that end of the sky, and they're there every night. They're hard to miss. Yet, it seems to be only the most committed of sky watchers who can name more than Alcor and Mizar (ζ UMa), the horse and rider-slash-ancient eye test, and maybe Merak (β UMa) and Dubhe (α UMa), the constellation's brightest.

Beyond the Dipper, Ursa Major is an enormous, but dim, constellation. It's the third biggest of them all by area (can you name the first two?) and is full of exciting star clusters and distant galaxies, for instance the Pinwheel (Messier 101) and even its own meteor shower. It's also the home of the Hubble Deep Field: the sky study done by the Hubble Space telescope years ago, which has helped us understand the early universe.

With the naked eye, especially in our over-lit skies, though, there's little to see other than the Big Dipper and a sparse scattering of other stars.

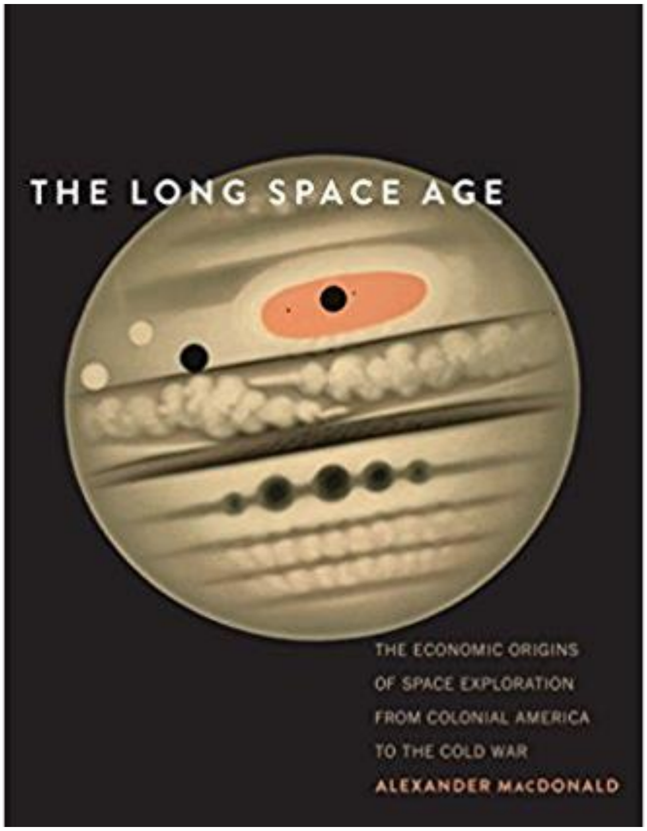
This time of year, though, is a great time to see a less famous asterism, the Three Leaps of the Gazelle. In the middle part of these early spring evenings, around 9:00, the Bear walks sideways, climbing the sky along the backs of Leo, Leo Minor, and Lynx; the flying space cats. The Leaps are three pairs of third-magnitude stars, one each at three of the Bear's paws, that run upward from the horizon. The first leap, lowest to the ground, are Alula Borealis (ν UMa) and Alula Australias (ξ UMa). Near Leo Minor, are Tania Borealis (λ UMa) and Tania Australis (μ UMa), the Northern and Southern Tanias. Finally, up at the top, past the Dipper's bowl, are Talitha Borealis (ι UMa) and Talitha Australis (κ UMa). These stars names come from Arabic for First, Second and Third leap, and it's not hard imagining a gazelle leaping and leaving its hoofprints on the night.

As the breeze picked up, we stayed outside for an extra couple of minutes and had some fun searching for them and climbing the sky along with the Bear and the Gazelle. I hope you'll take a look this month.

Westchester Amateur Astronomers

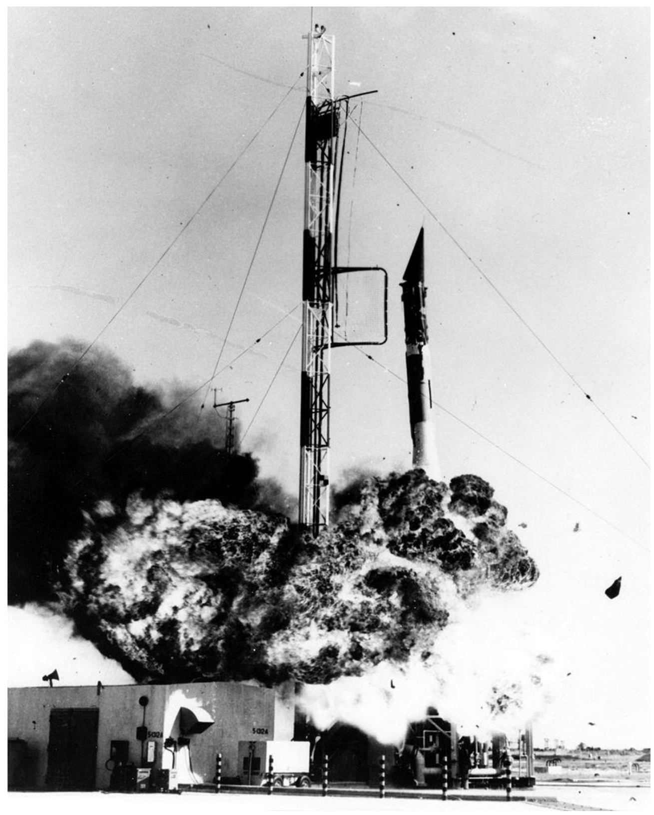
Book Review and Commentary: *The Long Space Age* by Alexander MacDonald

Larry Faltz



On December 6, 1957, a black-and-white television set was wheeled into my 5th grade classroom at P.S. 96 in the Bronx. Two months after the Soviets' surprise launch of Sputnik 1 and a month later the larger, dog-carrying Sputnik 2, the humiliated United States was going to join the space race. Vanguard Test Vehicle 3, the 3-stage rocket carrying a 1.3-kg spherical satellite with simple instrumentation, solar cells and a transmitter, was built by the Martin-Marietta company under contract with the United States Naval Research Laboratory. To send a message to the world that our intentions were scientific and peaceful, NRL's Vanguard was chosen as the first US orbital booster over the US Army's Juno. Vanguard was to be seen as a creation of idealism and public spirit, a rocket for peace. Juno, developed by Wernher von Braun, had a military (and in a sense even a Nazi) genesis. Braun claimed to have been ready to launch a year earlier, but was held back because of the Eisenhower administration's insistence on sending the right signal, a decision that was made in 1954.

As Walter Cronkite intoned the countdown, we were all set for an American triumph, but it was not to be. Vanguard TV3 belched out its flaming exhaust for 2 seconds, rose 4 feet in the air and exploded. Down went America's dream, and down went Martin-Marietta stock, with the NYSE suspending trading in it within minutes of the failure. Wags dubbed the mission "Kaputnik." It would be 2 months before von Braun was unleashed and Explorer 1, a satellite built by the Jet Propulsion Laboratory, was successfully orbited on top of Juno. Actually, no one really seemed to care that June had a military background.



Oops. Vanguard TV3

The Soviets beat us with the first satellite in space, the first dog, the first man, the first woman, the first multi-passenger spacecraft, the first spacewalk and the first lunar orbital spacecraft, but we won the big prize, the landing on the Moon. We continued to send the message that the US is focused on peaceful uses of space, primarily with our many research missions and continued support of the non-military International Space Station. Our recent reliance on Russian rockets for crew transportation to and from the ISS is a bit embarrassing, but trusting those spacecraft had both economic and signaling purposes, the signal being that we are cooperative and not competitive.

Launch of the Falcon Heavy

For those who saw Vanguard TV3, the memory of that spectacular failure has to accompany the viewing of any rocket launch. Success is never a guarantee, even with 60 years of rocketry experience. I certainly thought about Vanguard when I watched the launch of the SpaceX Falcon Heavy on the afternoon of February 6, 2018. I had just finished an interesting book, *The Long Space Age*, by the Jet Propulsion Laboratory's resident economist, Alexander MacDonald. That JPL has an economist seems a little odd. I assume they have accountants, auditors, even financial managers, but economics as a scholarly field requiring expertise at JPL seems at first glance alien to space science.

The success of SpaceX and Falcon Heavy validates one of MacDonald's theses: that private investment and initiative, embodied by the current crop of entrepreneurial space enthusiasts of whom Elon Musk is the most visible, has had a much greater role in space exploration that people realize. Today, we think of the "space race" as the battle of governments and ideologies in the 1950's and 60's, but if we take a larger view of what it means to explore space, the identity and motivations of its proponents are often quite different.

The book's subtitle is "The Economic Origins of Space Exploration from Colonial America to the Cold War." MacDonald doesn't view space exploration as only meaning rocket-propelled space travel. He insists that the space race began with the building of observatories. He writes:

> The American astronomical observatories of the nineteenth century are considered as projects from an earlier phase of American space exploration, effectively equivalent in motivation and purpose—and in relative economic importance within their respective historical contexts—to robotic space missions to the planets in the twentieth and twenty first centuries. Although the technology involved is different, they are each relatively complex, capital-intensive projects motivated by desires to explain the heavens.

America, a young country, came late to the observatory business. National observatories had been founded in France, England and Russia in the 17th century and in many European countries in the 18th. The first observatory of any permanence in the United States was established in 1781 by Philadelphia inventor, surveyor and craftsman David Rittenhouse, who was the first Director of the US Mint and the surveyor of the Mason-Dixon Line. Rittenhouse made observations of the 1769 Transit of Venus, correctly calculating the Astronomical unit to be 93 million miles. The following year he crafted sophisticated orreries that he sold to the College of New Jersey and the College of Philadelphia for £300 each. Their quality and elegance can be judged from the fact that 3 years earlier Harvard bought an orrery from a famous London craftsman for £92 10s 6d. Rittenhouse was hailed as the nation's leading astronomer, not that there were many others at that time. With pubic recognition came grants from the Pennsylvania legislature for construction of the observatory, which operated until 1810.

The Rittenhouse orrery at the University of Pennsylvania library. 16 feet wide, 8 feet high.

Although there were attempts to establish observatories at the University of Virginia and Harvard in the first quarter of the 19th century, it wasn't until 1826 that the first university observatory was founded, at

Yale. This was during the administration of John Quincy Adams, the 6th president of the US. Quincy Adams had been a student at Leiden University in the Netherlands, where an observatory had been established in 1633. An advocate of higher education, in his first message to Congress in 1825 he proposed a national university with an observatory. He appealed to national pride in the new and growing nation perhaps more than to science. An additional impetus for establishing some of these observatories was religion: observation of the universe would show God's handiwork, and thus was worthy of study. We should be reminded that higher education, indeed much of the public ethos, was significantly tied to theist, if not overtly religious, mindsets. The cosmos was taken as evidence of intelligent design by the all-powerful and beneficent Creator. There were some skeptics, but few atheists, in those days.

By 1844 observatories had been built at Yale, the University of North Carolina, Williams College, the Western Reserve Academy, Philadelphia High School, West Point, Washington (the US Naval Observatory), University of Cincinnati, Harvard, and Georgetown. By the end of the 19th century, another 2 dozen had been added. Some of these were purely university efforts, although generally endowed by wealthy contributors. Others were civic organizations which raised funds by subscription from among the well-to-do, giving donors the rights to use the facilities as a kind of exclusive astronomy club. The actual interest in astronomy among many donors to these kinds of facilities was often minimal. Participation often resulted from social pressure within the moneyed class.

MacDonald analyzes the costs of these institutions, in order to compare them across the years to each other and to current astronomical efforts. He normalizes them using two economic conversion factors. One is the cost of production worker compensation (PWC) and the other is the ratio of the Gross Domestic Product (GDP) that the project represents. MacDonald shows that these projects were major expenditures, some of them on the scale of today's space missions, and almost exclusively (96%) funded privately. For example, the Harvard College Observatory, built in 1844, cost a 2015 GDP-equivalent of $530 million. For comparison, the New Horizons mission to Pluto cost about $700 million in 2015 dollars.

MacDonald focuses on the "signaling" intent of these facilities. What do the funders intend for the observatory to say about them? How does their association with the endeavor (scientific progress, exploration, craftsmanship, an edifice, an endowed chair) transmit the message that they want to send into the world? MacDonald says "As expensive investments that result in strong representational differentiation, space exploration activities are classic signals." By the end of the 19th century, that motivation was obvious, and capitalized on by none other than telescope impresario George Ellery Hale. He convinced Charles T. Yerkes, a picaresque and much-disliked Chicago businessman, to fund the eponymous Wisconsin observatory that houses the world's largest refractor. Clearly Yerkes was sending a signal by doing this: "I'm not a total crook; in fact, I'm enlightened." He then convinced Los Angeles businessman John D. Hooker to fund another world's largest scope, the 100-inch at Mt. Wilson. All charitable giving has a signaling value; for small donors it's internal; for the very wealthy, it's clearly public and designed to send a message, perhaps even one at odds with other aspects of their personas. Personally I don't agree at all with the Koch Brothers' support of the fossil fuel industry or the Republican Party, but I am grateful for their generosity to the arts and sciences. The signal they send out through their charitable support undermines some of my antipathy towards them. Clever boys!

The mid-20th century space race between the US and the Soviet Union was driven by the need to signal intent, capabilities and ideological values. This aspect of the Cold War required rapid technological progress and massive expenditures, and so government funding was required. MacDonald cites the work of liquid-fuel rocket pioneer Robert Goddard, who predated the real space race by decades, as the transition from private to public funding in the economics of space exploration.

Goddard's appetite for rocketry was not merely technical, nor did he focus on military applications exclusively in his career. Goddard was interested in space flight, exploration and colonization of the Moon and planets. He believed he could build a rocket that could reach the Moon. On February 5, 1920, Captain Claude Collins of the New York City Air Police announced he would be willing to fly to Mars on an as-yet unrealized Goddard rocket, so long as he was provided with a $10,000 insurance policy. Over the next few years, over a hundred people volunteered to go to Mars on a Goddard spacecraft. This is a perfect analog of the current Mars One project, for which 202,586 applications were received in 2013 for the one-way trip that was proposed for 2023. It's not very likely that anyone is going to Mars in 2023, so perhaps Mars One's real goal was to collect the application fees ($5-$75, depending on the applicant's country of residence), but they still have a nice web site, and one can always hope. For more on the complexities of Mars travel, read my review of *The Martian* in the December 2015 SkyWAAtch.

Robert Goddard and the first liquid fuel rocket, March 16, 1926, Auburn, Massachusetts

MacDonald meticulously analyzes Goddard's career. Nearly every grant and donation he received is tabulated and compared to current costs using PWC and GDP corrections. Even $190 he received from the American Association for the Advancement of Science in 1924 is included. Goddard received quite a bit of support from the Guggenheim Foundation, but overall 51.4% of the $447,057 he received for research and development came from government (primarily military) sources. Goddard paved the way for the government's sponsorship of space exploration.

The Space Race as we think of it today, bound up with all of the complexities and maneuverings of the Cold War, had to be a government funded program. Science too became substantially a public enterprise, through the National Science Foundation and NASA. Private funding persisted primarily in the funding of new observatories. Examples that come to mind are the Keck Observatory on Mauna Kea, funded by the Keck Foundation, and the Lowell Observatory's Discovery Channel Telescope in Arizona, a project that received substantial support from the cable station of the same name. Today, observatories compete for government research grants for ongoing work and receive additional funding through university consortia, supported by generous donors. Many have "friend" organizations that ask for annual dues, and of course they get support from the occasional knick-knacks purchased in the gift shop (I have Keck and JPL polo shirts and a Lowell cap.)

The American space program was always a co-project with private industry. The U.S. government does not have manufacturing facilities or chemical plants that make rocket fuel, and much of the detailed planning is done under contract with entities like the Jet Propulsion Laboratory (an arm of Caltech). Manufacturing is totally dependent on contractors, and has always been. What has returned to private funding is the motivation and general contracting aspect of space exploration. When it became clear that the Space Shuttle would sunset, leaving a gap in large boosters for satellite insertions and supply missions to ISS, private initiative jumped into the void. In addition, the possibility of economic development of space, primarily through the mining of natural resources in the asteroid belt, the moon or even the planets (collecting helium from Jupiter for example) might create opportunities for real profit. The idea of a mining operation disfiguring the face of the Moon or Mars is somewhat unappealing. In reality we wouldn't be able to see anything from Earth, but it still offends. I don't think I'd have any objection to taking a few asteroids, however.

The Falcon Heavy launch was exciting for two reasons. The first, of course, was the launch itself. The roar, flame and smoke of a rocket launch are always a cause for exhilaration. But I thought the ballet-like landing of the two side boosters back at Cape Canaveral was a thing of beauty. They didn't just fall into the ocean as unwanted garbage. They returned to their place of origin, like salmon swimming upstream to their spawning grounds, and elegantly settled on the ground in tandem. Sadly, the center booster, which goes higher than the two side boosters and must land down-range on a floating pad, missed by about 100 meters because it ran out of the fuel used to control descent. Still, two out of three ain't bad.

The retrograde landing of the two boosters brought back memories of 1950's TV space adventures like "Rocky Jones, Space Ranger,' but the real space program never tried to engineer such a return mechanism until now, choosing to make boosters, landers and return vehicles disposable. Both the United States and the Soviet Union calculated that the technology, cost and risk of controlled descent were too daunting.

Landing of the side boosters. They are going down, not up.

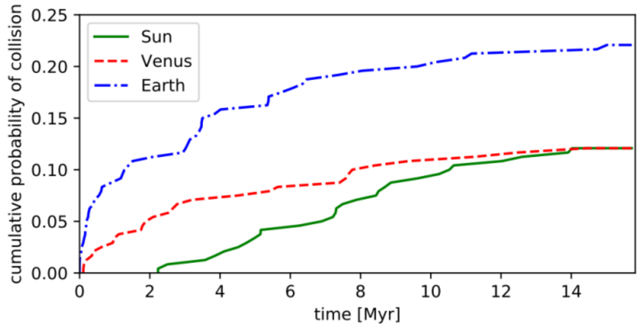
President Trump, at a cabinet meeting on March 7th, lauded the Falcon Heavy launch, was also thrilled by the booster landing, perhaps revealing that he too watched Rocky Jones in the day. But he also said:

> We're using a lot of private money, a lot of people that love rockets and they're rich.… So we're really at the forefront and we're doing it in a very private manner….I noticed the prices of the last one they say cost $80 million. If the government did it, the same thing would have cost probably 40 or 50 times that amount of money. I mean literally. When I heard $80 million, I'm so used to hearing different numbers with NASA.'

Besides the fact that a NASA booster now wouldn't be "40 or 50 times" the cost, one has to remember that all of the research and development in American rocketry after the early years of Goddard's career had been financed by the government. A lot of the problems in engine design and construction, fuel science, guidance technology, materials development and even project management were solved with public funds. The costs of those efforts don't have to be amortized in SpaceX's budgets. SpaceX made impressive innovations, of course, but they had a head start over, say, the Atlas or Saturn or even Space Shuttle programs, and reaped the benefit of the investments those programs made for future spacefarers. But that's what progress (and government investment) is for. There *is* a shift in the meaning of Musk's (and Trump's) signal: it's not just that capitalism is better than communism, it's that corporate enterprise is better than government enterprise. You may not agree with that viewpoint, but it's what they want you to believe.

Elon Musk made it easy for us to understand his signal. As payload ballast he used his red Tesla (another Musk corporation) roadster with a dummy astronaut at the wheel. It was frequently said on the SpaceX telecast that it would circle the Sun between the orbits of Earth and Mars for a billion years. Unable to resist, astronomers Hanno Rein (Canada), Daniel Tamay (Canada) and David Vokrouhlický (Czech Republic) analyzed the orbital dynamics of the Tesla.[1] Using N-body simulations, they found that:

> We calculate a dynamical half-life of the Tesla of approximately 15 million years, with some 22%, 12% and 12% of Roadster orbit realizations impacting the Earth, Venus, and the Sun within one half-life, respectively.



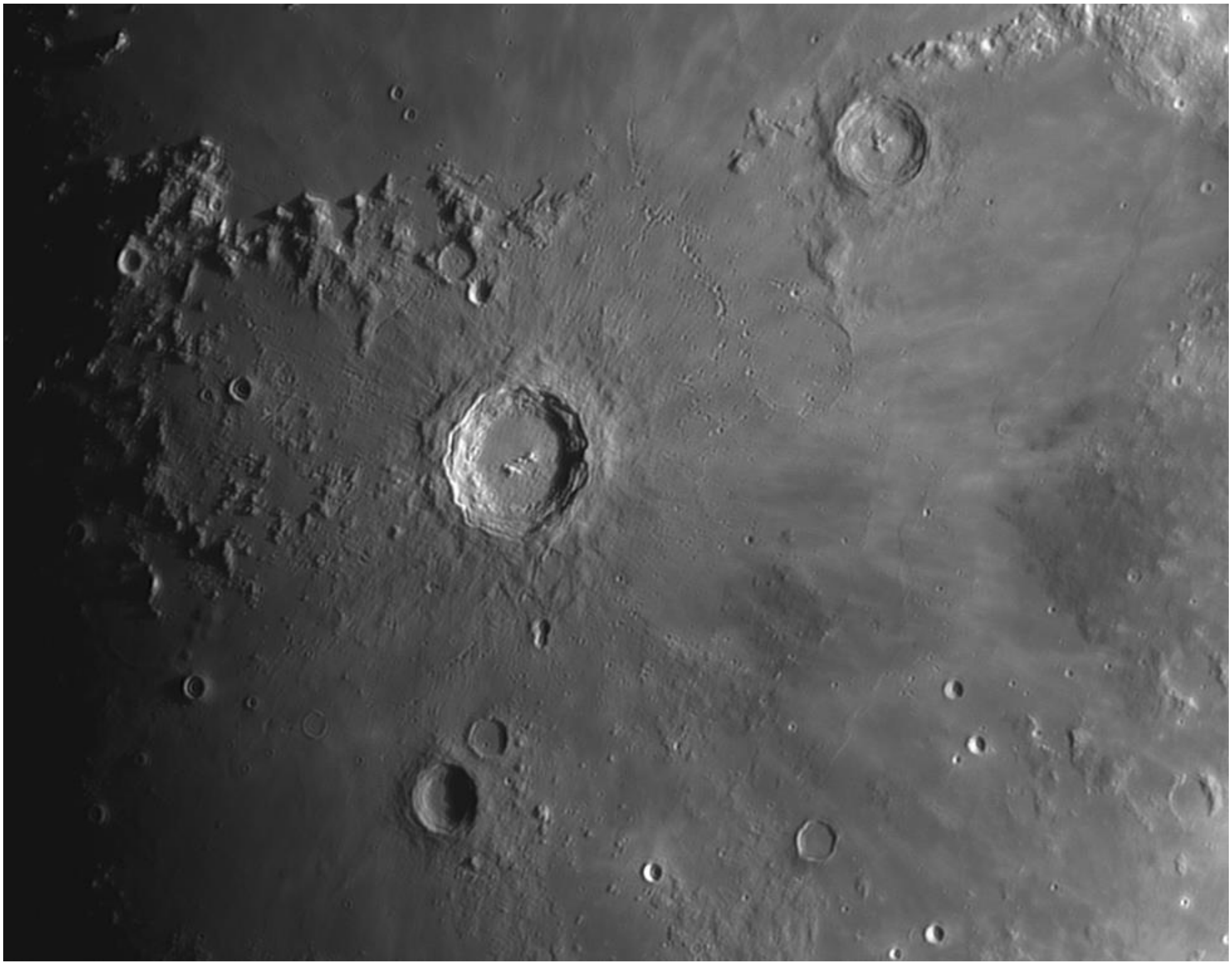
Part of Fig 4 from Rein, et. al., showing the likelihood of Tesla impacts in the next 15 million years

The Long Space Age is an interesting, if somewhat arcane, book. The history of American observatories is particularly absorbing. The detailed enumeration of Goddard's fundraising efforts reminded me of the old saying "Genius is an infinite capacity for taking pains," in Goddard's case not only his engineering but also his perseverance in approaching charitable organizations (primarily the Guggenheim Fund) and military agencies. The idea of "signaling" gets a thorough analysis. The concept is most obvious as it pertains to the Cold War space race, but how the establishment of those early private and college observatories projected their founders' signals is particularly enlightening. As the 19th century went on, the history of space science illustrates, among other things, the transition from a religious view of creation to a scientific one as science matured and began to discover the truth about reality. Darwin, Maxwell, Mendeleev and their contemporaries made searching for a Maker's hand in nature a much less meaningful pursuit.

■

[1] Rein, H, Tamay, D, Vokrouhlický, D, The random walk of cars and their collision probabilities with planets, https://arxiv.org/pdf/1802.04718.pdf, submitted to the *Monthly Notices of the Royal Astronomical Society*

Copernicus



My favorite lunar crater is Copernicus. It's optimally visible on a 9½-day moon when 75% of the moon's face is illuminated (officially a 58% phase) and the terminator is 200-300 km to the west of the 93-km wide, 3,760m deep crater. Its sun-facing scalloped walls, double central peaks and surrounding impact rays are always a treat in a scope of any size when the moon is at this stage of its cycle. On March 26, 2018 at 9 pm the Moon was high in the sky, over 65 degrees elevation, and so with minimal atmospheric extinction on a clear night with good seeing (perhaps 6/10), I set up an Orion 127 mm f/12.1 Maksutov on an iOptron Minitower alt-az mount on in front of my house in Larchmont. I captured the image with a monochrome QHY-5L-II camera, shooting through a Wratten 25A red filter, using Torsten Edelmann's FireCapture software (it's free and the best planetary capture software out there!) to make an avi file of 3,030 frames at a shutter speed of just 3.109 milliseconds per 1280x960 pixel frame (capture time was 3' 26" at 14 frames/sec, set by the software). I aligned and stacked with AutoStakkert!2 using the 25% best frames then did some very slight wavelet processing in Registax 6.1 before cropping and reorienting to the correct image in Photoshop Elements. The crater Eratosthenes is to the lunar northeast (upper right). Reinhold is to the south, with the lava-filled Reinhold B just above it. The Montes Carpatus (Carpathians) are northwest, with the terminator to the west. The image shows an area about 750 km across.

Larry Faltz

Measuring the Movement of Water on Earth
Teagan Wall

As far as we know, water is essential for every form of life. It's a simple molecule, and we know a lot about it. Water has two hydrogen atoms and one oxygen atom. It boils at 212° Fahrenheit (100° Celsius) and freezes at 32° Fahrenheit (0° Celsius). The Earth's surface is more than 70 percent covered in water.

On our planet, we find water at every stage: liquid, solid (ice), and gas (steam and vapor). Our bodies are mostly water. We use it to drink, bathe, clean, grow crops, make energy, and more. With everything it does, measuring where the water on Earth is, and how it moves, is no easy task.

The world's oceans, lakes, rivers and streams are water. However, there's also water frozen in the ice caps, glaciers, and icebergs. There's water held in the tiny spaces between rocks and soils deep underground. With so much water all over the planet—including some of it hidden where we can't see—NASA scientists have to get creative to study it all. One way that NASA will measure where all that water is and how it moves, is by launching a set of spacecraft this spring called GRACE-FO.

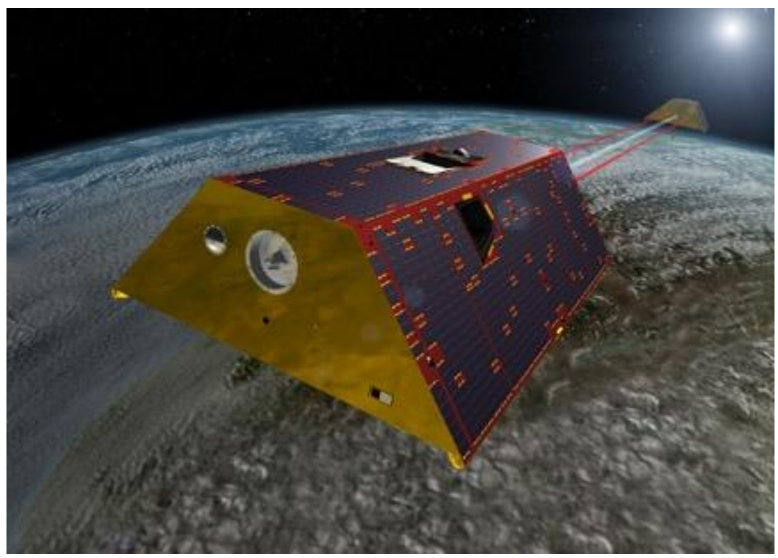
GRACE-FO stands for the "Gravity Recovery and Climate Experiment Follow-on." "Follow-on" means it's the second satellite mission like this—a follow-up to the original GRACE mission. GRACE-FO will use two satellites. One satellite will be about 137 miles (220 km) behind the other as they orbit the Earth. As the satellites move, the gravity of the Earth will pull on them.

Gravity isn't the same everywhere on Earth. Areas with more mass—like big mountains—have a stronger gravitational pull than areas with less mass. When the GRACE-FO satellites fly towards an area with stronger gravitational pull, the first satellite will be pulled a little faster. When the second GRACE-FO satellite reaches the stronger gravity area, it will be pulled faster, and catch up.

Scientists combine this distance between the two satellites with lots of other information to create a map of Earth's gravity field each month. The changes in that map will tell them how land and water move on our planet. For example, a melting glacier will have less water, and so less mass, as it melts. Less mass means less gravitational pull, so the GRACE-FO satellites will have less distance between them. That data can be used to help scientists figure out if the glacier is melting.

GRACE-FO will also be able to look at how Earth's overall weather changes from year to year. For example, the satellite can monitor certain regions to help us figure out how severe a drought is. These satellites will help us keep track of one of the most important things to all life on this planet: water. You can learn more about our planet's most important molecule here: https://spaceplace.nasa.gov/water.

This article is provided by NASA Space Place. With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit spaceplace.nasa.gov to explore space and Earth science!



An artist's rendering of the twin GRACE-FO spacecraft in orbit around Earth. Credit: NASA

The WAA Annual Picnic, Saturday June 9, 2018
Eva Andersen, Assistant Vice President and Picnic Co-Chairperson

Statement: $25 will give you and your family a membership to Westchester Amateur Astronomers for one year.

Questions: a. Is it worth it?
b. What do I get for my investment?

Answer: a. YES. b. A LOT.

In addition to monthly star parties where other members will share the wonders of the night sky with a variety of telescopes and show planets, stars and overhead constellations with a safely used laser pointer (and answer all your questions), you also can attend monthly lectures at Pace University's Pleasantville campus where the best and the brightest discuss their research and findings on topics such as "Astronomical Search for Aliens on Mars", "The Antikythera Mechanism", "The Jellyfish Nebula: Cosmic Ray Accelerator", "Neutrinos", "Cosmology", "Cassini: a 20 Year Voyage by a NASA Solar System Ambassador" and "The Wobbly Universe," among many topics covering the broad range of today's astronomy.

You also receive the club's monthly newsletter which we're sure is the best astronomy newsletter this side of the Oort Cloud, filled with thoughtful articles and excellent astrophotography submitted by fellow members.

You also can participate in astronomy-related community and school outreach events,

You also can come to the annual member's picnic where you can enjoy a lazy afternoon of food, drink and conversation with old friends and new acquaintances (rain or shine).

By being a member you'll get our frequent email announcements of all of the above activities.

Last year's picnic was enjoyed by nearly 60 club members and their families (and even some dogs) in attendance. It was held on the grounds of The Danish Home for the Aged, built in 1930 and located in Croton-on-Hudson, NY. We enjoyed hotdogs, hamburgers, veggie burgers and BBQ chicken, and there were lots of salads, side-dishes, beverages and fabulous desserts. An impromptu movie theater set up in the former horse barn played several episodes of Fireball XL5, a futuristic TV program which ran for a single season in 1962-63 and used "Supermarionation." Fireball XL5 was part of the fleet of interplanetary rockets protecting Sector 25 of the Solar System from alien invasion under the supervision of the World Space Patrol. In command of XL5 was Steve Zodiac, and his crew consisted of Venus, a doctor, Professor Matic, the science officer, and Robert the Robot, the rocket's mechanical copilot. Well, you had to see it to believe it!

Ice cream sundaes, beer, door prizes and an astronomy-based trivia game ended the afternoon. A great time was had by all. If you're not a member, please join so you can join us for this year's picnic on Saturday June 9th from 12 noon to 4 pm at the Danish Home, rain or shine.

Scenes from the 2017 WAA Picnic

Member & Club Equipment for Sale

April 2018

Item	Description	Asking price	Name/Email
Celestron 8" SCT on Advanced VX mount	Purchased in 2016. Equatorial mount, potable power supply, polar scope, AC adaptor, manual, new condition.	$1450	Santian Vataj spvataj@hotmail.com
Televue 2X Powermate	PMT-2200. 2" version, with 2"-1¼" eyepiece adaptor. 4 elements, 48mm filter thread. Al Nagler's improvement on the Barlow. Big, weighs 22 oz. New condition. In polypropylene bolt case. Link.	$175	Larry Faltz lfaltzmd@gmail.com
ADM VCW Counterweight system	Clamping plate for a V series dovetail. 5" long ½" thick threaded rod for counterweights. Original ADM 3.5 lb counterweight plus a second weight. New condition. Lists at $55. Link.	$35	WAA ads@westchesterastronomers.org
Celestron Ultima-LX 5 mm eyepiece Celestron Ultima-LX 8 mm eyepiece	70° FOV, fits 2" and 1¼". 16mm eye relief. 28 mm clear aperture eye lens. 8 elements. Rubber coated bodies. Ergonometric contours. Extendable twist-up eyeguards. Takes 1¼" filters. These are large, impressive eyepieces, no longer in production! New condition.	$50 each	WAA ads@westchesterastronomers.org
Meade 395 90 mm achromatic refractor	Long-tube refractor, f/11 (focal length 1000 mm). Straight-through finder. Rings but no dovetail. 1.25" rack-and-pinion focuser. No eyepiece. Excellent condition. A "planet killer." Donated to WAA.	$200	WAA ads@westchesterastronomers.org
Interfit 487 large rolling storage bag	39½x22x16" fabric-sided standing gear bag with rollers, Velcro compartments. Excellent condition. Donated to WAA.	$25	WAA ads@westchesterastronomers.org

Want to list something for sale in the next issue of the WAA newsletter? Send the description and asking price to ads@westchesterastronomers.org. Member submissions only. Please only submit serous and useful astronomy equipment. WAA reserves the right not to list items we think are not of value to members.

Buying and selling items is at your own risk. WAA is not responsible for the satisfaction of the buyer or seller. Commercial listings are not accepted. Items must be the property of the member. WAA takes no responsibility for the condition or value of the item or accuracy of any description. We expect, but cannot guarantee, that descriptions are accurate. Items are subject to prior sale. WAA is not a party to any sale unless the equipment belongs to WAA (and will be so identified). Sales of WAA equipment are final. *Caveat emptor*!