SkyWAAtch

A Berlin Night Sky

The 3-day old crescent moon and to its right magnitude -4.0 Venus are setting behind Berlin's famous Brandenburg Gate one hour after sunset on June 16, 2018. In front of the gate is the always crowd-filled Pariser Platz, a hub for both tourists and Berliners and the main focal point of the entire city. I planned the shot using Cartes du Ciel and Google Earth as well as looking up the height of the gate and doing some simple trigonometry. Making this image was suggested by J. Kelly Beatty of Sky & Telescope, who knew I was going to be in Berlin on vacation. I used a tripod-mounted Sony DSC-RX100 20.2 megapixel point-and-shoot camera that has a Zeiss lens.

-- Larry Faltz

In This Issue . . .

Events for July

Upcoming Lectures

Pace University, Pleasantville, NY

There will be no lectures for the months of July and August. Lectures resume on September 14th with Members Presentations Night. It's a WAA tradition to start the fall meeting series with Members' Night. WAA'ers present talks on their astronomy travels, equipment, imaging techniques and observing experiences. It's our most popular meeting and a great way to start off the academic year

Starway to Heaven

Saturday July 7th, Dusk.
Ward Pound Ridge Reservation, Cross River, NY

This is our scheduled Starway to Heaven observing date for July, weather permitting. Free and open to the public. The rain/cloud date is July 14th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Barry Butler - Fairfield
Veepat Vishnu - Mr. Vernon

Renewing Members. . .

Arun Agarwal - Chappaqua
Tom Crayns - Brooklyn
Ernest Wieting - Cortlandt Manor
Karen Seiter - Larchmont
John Paladini - Mahopac
Dante Torrese - Ardsley
Gary Miller - Pleasantville
Rena Hecht - Rye
Jordan Webber - Rye Brook
Arthur Linker - Scarsdale
Roman Tytla - North Salem
Michael & Angela Virsinger - Seaford
Paul Alimena - Rye
Donna Cincotta - Yonkers

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

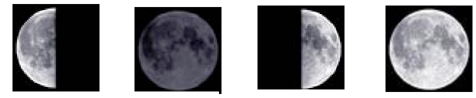
Rocket Plume Shadow Points to the Moon

Why would the shadow of a space shuttle launch plume point toward the Moon? In early 2001 during a launch of Atlantis, the Sun, Earth, Moon, and rocket were all properly aligned for this photogenic coincidence. First, for the space shuttle's plume to cast a long shadow, the time of day must be either near sunrise or sunset. Only then will the shadow be its longest and extend all the way to the horizon. Finally, during a Full Moon, the Sun and Moon are on opposite sides of the sky. Just after sunset, for example, the Sun is slightly below the horizon, and, in the other direction, the Moon is slightly above the horizon. Therefore, as Atlantis blasted off, just after sunset, its shadow projected away from the Sun toward the opposite horizon, where the Full Moon happened to be.

Credit: APOD

Image Credit: Pat McCraken, NASA

ALMANAC
For July 2018 by Bob Kelly



Jul 6 Jul 13 Jul 19 Jul 27

Rise up! It's time for opposition! We make a close pass at Mars at month's end, which follows the oppositions of Jupiter in early May and Saturn at the end of June. With Venus and Mercury findable in the west after sunset, July is not only a month of opposition but a full house, a planetary straight, or five-of-a-kind, as we can see the five classical planets in one night. Okay, this was also true in June. Some friends in Elmsford saw four of the five with me on June 25th. I wasn't up for being up at Mars' rising at 11pm EDT, so we didn't complete the royal flush.

Here's the lineup card for July:

Venus	Sets 10pm	Magnitude -4.1	17 arc seconds wide ("), waning gibbous
Jupiter	Due south at end of twilight	-2.2	40"
Saturn	Rises before sunset	+0.1	18", not counting rings
Mars	Rises just after sunset, low in the southeast	-2.5	23"
Mercury	Low in west in evening twilight	+0.5	8" and waning rapidly. Greatest elongation on the 11th.

These are in order from west to east, right to left in the northern hemisphere, except for Mercury, which we can't see until the sky gets darker, so we have to come back for Mercury. Can you see the Beehive Cluster next to it on the 4th? A thin moon makes a close pass on the 14th. We come to opposition with magnitude +15 Pluto on the 12th, just southeast of Sagittarius' teaspoon. It's right next to a magnitude +5.5 star, 50 Sagittarii that night. The New Horizons spacecraft, on its way to a Kuiper Belt object they've nicknamed "Ultima Thule" is in the teaspoon, beyond our sight.

It's possible to see all five classical planets at one time in mid-July, but Mars will be just rising and Mercury just setting.

Mars' south polar cap is rapidly shrinking as the southern hemisphere summer approaches, but clouds over the polar cap may make it look larger. This is the best time for small scopes as the remaining polar cloud hood has high contrast with the orange-yellow dust storm covering the much of Mars now. The storm may leave behind enough dust to make much of Mars salmon-hued until local winds blow away the accumulated dust and the gray areas appear again.

Mars is closest to the Sun in September 2018 and Earth's aphelion is on July 5th, so that makes the two planets closer than usual at this opposition. There will be a similar circumstance at the October 2020 opposition, with Mars' perihelion in our month of August, but Earth being closer to the Sun and a bit further from Mars. After that, Mars' oppositions with Earth will be when it is nearer to its aphelion and Earth's perihelion and we won't get as close. The September perihelion also causes Mars to be closest to Earth on July 30th, when opposition is on the 27th.

Jupiter's Great Red Spot is back. It's a spot looking like a red bump on the southern equatorial belt, but still noticeably smaller than in previous centuries and redder (through my telescope) than earlier this century.

Saturn stays bigger and brighter in July, taking the breath away of observers with a 30-power or more scope. The rings continue to tilt well toward earth, giving the planet a hat-like appearance. A plus 10th magnitude star will pass behind Saturn from midnight to 3am on the 4th-5th. Saturn appears so much brighter than the star, it will be hard to see, except in telescopes of perhaps 8-inches or more.

Venus gets brighter, even as we start to notice its thinning phase. By the end of July, Venus will be still a bit more than half-lit but decreasing. It will also be lower in the sky, despite not reaching its greatest elongation until August. Its phase is easier to see in daytime or bright twilight. Regulus tries to hide in Venus' brightness on the 9th and the crescent Moon gets close for a great photo-op with Venus on the 15th.

We don't get to see the partial solar eclipse over the waters between Australia and Antarctica on the 13th. Neither do we see the deep total lunar eclipse most of the rest of the world sees on the 27th.

We do get to experience larger-than-normal tides around and after the new moon on the 12th-13th. Lunar perigee is five hours after new moon. The full moon on the 27th is furthest away full moon of the year. I guess we shall call it "mini-moon".

The International Space Station is visible from our area after midnight through the 22nd. Visible overflights in the evening start around the 18th. From the 18th-19th through the 21st-22nd the ISS makes five visible passes a night. For some of these passes, the ISS is almost as bright as Venus.

Sunspots are a rarity as the sun continues toward solar minimum.

In the Naked Eye Sky

For July 2018: Constellations, Occultations, Oppositions

by Scott Levine

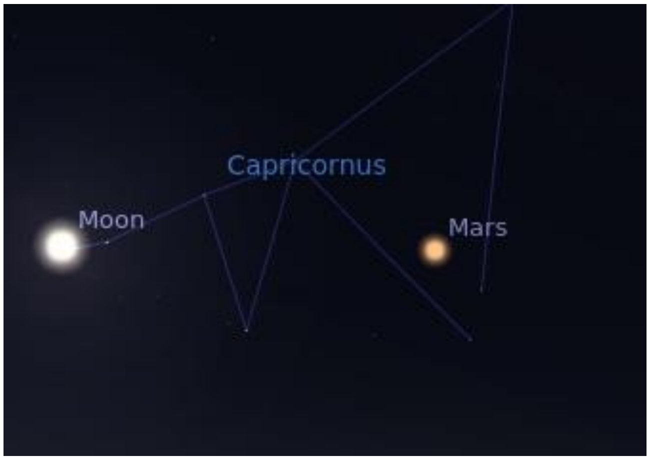
The thing about watching the sky with the naked eye is the subtlety of the things we watch. Without lenses, we'll never stare up at a broad set of rings tilted toward us, or a line of four giant moons stretched across your entire field of view, each giving us an idea of what it would be like to see Mercury from half a billion miles away. We'll never see a whole galaxy stretched in front of us, hundreds of billions of stars, countless planets, countless moons.

Instead, it's enough to watch and wait. Wait for the Sun to set, so we can see the blue fade to orange, pink, and purple. We wait for the stars to poke through the night, and follow the story, as one by one, the constellations constellate right before our eyes. If that wasn't a word before, it is now.

Over the next few weeks, telescopes around the world will be pointed along the ecliptic, and out across the face of the solar system. Our moon pulled Saturn and it's five dozen into the night on June 27 among the stars of the constellation Sagittarius, the puzzling half-horse, half-human archer of ancient mythology whose name took me five tries to spell correctly.

Its most famous stars are probably **Rukbat** (α Sgr**)** or **Nunki** (σ Sgr), both a couple hundred light years away. These stars aren't particularly bright, and neither are the dozen or so Messier objects within the constellation's boundaries, but as the Moon and Saturn move through, we'll have a chance to look out through our solar system and into the deepest corners of our galaxy. That night, Saturn was at opposition, directly opposite the Sun in our sky. The Moon, too, was at opposition, bright and full. With one glance out thataway, as they skirted low across Westchester's southern skies, we got to see our nearest neighbor, 1.5 light seconds away, then Saturn, about 80 light minutes. Space gets very big very quickly after that, and before long it's out into the center of the Milky Way, which sits tens of thousands of light years behind Sagittarius's main asterism; the pattern of stars that look like a tea pot.

At the end of June, the Moon meets up with Mars. When they meet up again at the end of July, the Moon will be full, a couple of days before it's Mars's turn at the opposition game. Mars is in Capricornus now. That asterism always looked more like a boat to me than anything else, but if people are willing to go along with it being a half-goat, half-fish sea monster, who am I to ruin their fun? Capricornus is another dim group in a patch of sky that seems almost empty. **Deneb Algedi** (δ Cap), it's brightest star, is about 40 LY away, and is an Algol-type variable. Its light dips predictably when a companion star passes in front of the main star from our perspective and blocks some of its light. Among the sparseness of that part of the sky, Mars will stand out like nothing else around it as we zoom past each other.



The naked eye fun won't be in looking though our telescopes at the canals dug by ancient civilizations there, but at watching it brighten and then dim through the summer as the Moon glides by three times before school starts back up. Just after midnight on July 2, we'll even be able to watch the Moon pass right in front of Deneb Algedi, and occult it; block it out.

It takes some planning and an appreciation for the subtle, but there's amazing things to be seen in the skies this summer, with or without lenses. I hope you'll have a look.

Westchester Amateur Astronomers

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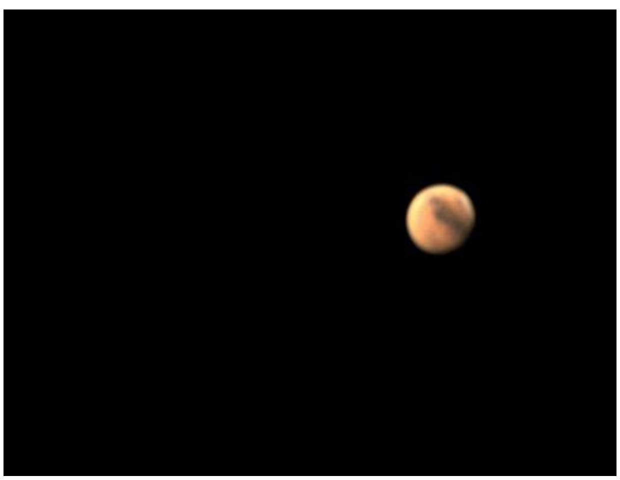
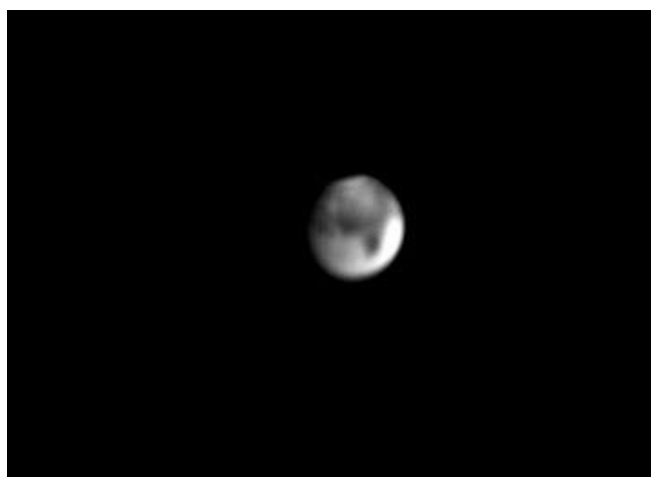




John Paladini provided these images of Mars taken with his Orion 7-inch Maksutov and an ASI120mc camera. The black and white photo shows a dust storm (images cropped by editor).

Punching Past Pollution: Target Selection Part 2

Mauri Rosenthal

Last month I described how to determine whether and when a specific astro target – in this case the "Thor's Helmet" nebula – will be accessible from my yard. This month I will discuss matching up equipment choices against the target. Presently, I have a range of scopes which I can use, with focal lengths ranging from 200 mm to 1600. But when I started this hobby I only had the one Maksutov-Cassegrain scope at the top end of that range, so the question was "which targets are practical for my set-up?" I learned the hard way that my Mak would not be helpful for imaging comets – but what would? So my question became, "what does each new piece of equipment – optics or camera – buy me in terms of capability for additional targets?"

My recent and previous attempts at the Crescent Nebula, a small but bright emission Nebula in Cygnus rich in H-alpha regions, should work well for illustrating the tradeoffs involved here. First a wide shot – I wasn't even planning on picking up the Crescent but it snuck into the bottom right corner of this take on the extensive nebulosity around the star Sadr:

Figure 1. With a 200 mm focal length lens the Crescent adds interest to this wide shot but this would not be satisfying for someone who wanted a good look at it. Borg 55FL astrograph/ZWO ASI 1600MC

Next I'll show two variations on zooming in on the target. First is an older image using my Questar – the Mak with 1600 mm focal length, but tamed by a .5X focal reducer. Note that like many precision components, you could buy a decent "budget" refractor for the price of this lens which was configured for the unusual Questar optical train and is unlikely to ever see any use with other scopes. But it did serve to broaden the targets I could reach with the scope. With an H-alpha filter to bring out nebular detail from the background, I got this:

Figure 2. An H-alpha enhanced image of the Crescent at 1000 mm focal length, with smaller camera chip (9x6.7mm). Questar 3.5"/.5X focal reducer/Starlight Xpress Trius SX-9C

I got a similar, albeit less detailed, view – with considerably less effort -- by placing a 2X Powermate (Barlow lens) on a 400mm lens – for an 800mm focal length. Different camera, different filters, different processing, different image. But similar in composition as a close-up centered on the nebula:

Figure 3. 800mm focal length achieved with a 400mm lens and 2X Barlow; larger camera chip (18 x 13mm). Borg 71FL/2X Powermate/ZWO ASI 1600MC

And finally, for the Goldilocks in all of us, the 400 mm lens produced this nice shot with the nebula in a starring role, but with plenty of context:

Figure 4. 400mm focal length highlights the nebula in a wider context Borg 71FL/ZWO ASI 1600MC.

Ok which is the "right" image? Hey I love all my kids (and my dog) so I don't play that game. I wouldn't call the first wide shot an image of the Crescent Nebula, though. Otherwise, each has some charm for different reasons, including the rich star fields in the wider shots which always startle me based on my expectations for the skies over Yonkers.

Now we are back to my questions about the best approach for imaging Thor's Helmet or any other specific target. One great tool for this is an app called CCD Calc. Originally a companion to the seminal astrophotography text, "The New CCD Astronomy" by Ron Wodaski, it is available as freeware here:

http://www.newastro.com/book_new/camera_app.html

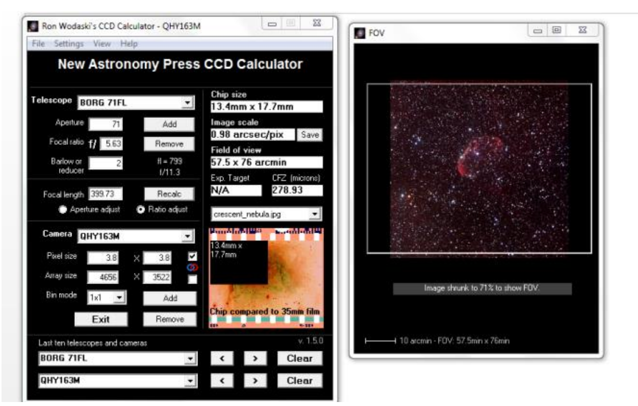


Figure 5. CCDCalc screenshot showing how the Crescent Nebula should appear with the configuration used in Fig.3.

The app appears as two small windows; one for inputs and one that displays how selected targets will appear with a given optics/camera configuration.

Let's take a closer look at the input screen:

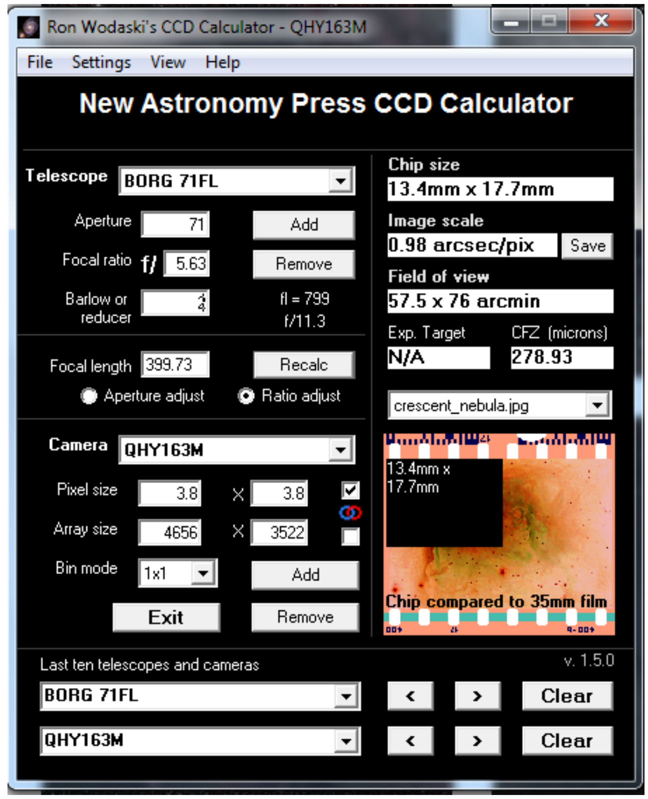


Figure 6. CCDCalc Inputs have defaults for equipment available 10-15 years ago, but it is easy to add in the data for newer devices.

For your optics you need to know two of these three numbers: Focal length; Aperture; and/or Focal Ratio (the third can be calculated from the other two). You can enter a multiplier for a Barlow (e.g. 2X) or Focal Reducer (e.g. 0.5X). For the camera you should find these specs: Pixel Size in microns, and the size of the Pixel Array. From these it will calculate the chip size and image scale. Once you enter the attributes for a given product you can save it in the drop-down menus for future use.

The graphic on the right side of the input screen shows the size of your camera's chip relative to a full frame 35 mm chip. This is a helpful reference when first considering cameras. Experienced imagers are very familiar with the limitations of planetary cameras – these less expensive devices work perfectly well for imaging Jupiter or as guide cameras, but the tiny chips will be overwhelmed by the wide image circle of just about any telescope. I have helped a couple of people who were struggling with their first attempts to use a planetary camera in part because they didn't know what to expect when their high focal length telescope was pointed at the moon. Once they understood that a scope that fills a 35mm frame with the face of the full moon will only fit a few highly magnified craters on a much smaller chip, it was easier to bring those craters into focus for the first time.

The drop-down box just above the frame graphic lets you select different targets which will appear in the FOV window with a rectangle which provide a good idea of how a given target will appear with a specific configuration. A large target like the Andromeda Galaxy spills over the edges of all but the lowest focal lengths, while small targets like the Ring appear as little dots at these focal lengths. It is clear that you can't do both of them justice with the same set-up.

Target sizes can also be found in star maps like Cartes du Ciel. The sun and moon are the same apparent size in the sky (hence eclipses) at half a degree in diameter. Larger targets include the Rosette Nebula (1.3°), the North America Nebula (2°), and the Andromeda Galaxy (3°). The smallest targets include distant galaxies which may appear to be elongated stars at any focal length – there is no lower bound! Smaller deep sky targets have their sizes displayed in arc-seconds (1° = 60' = 3600"), with the Ring Nebula weighing in at 86" and the Owl Nebula at 200".

So what configuration do I want to use to shoot at Thor's Helmet? Using Cartes du Ciel I can see that the dimensions of NGC 2359 are 10' x 5'. I can answer the question without referring to CCDCalc because we can simply compare this to the Crescent Nebula, displayed above, which is 20' x 10'. So it's half the size of the Crescent, which means that I could get an adequate shot in context at 400 mm – similar to Figure 4. A good close-up, however, will require one of my high focal length configurations.

I can use CCDCalc to check this assumption by plugging in the information in the app for the same configuration I show in Figure 3, which is a 400 mm focal length lens doubled with a 2X Barlow. As shown below, the FOV window demonstrates that this will produce a strong composition emphasizing the nebula, and is likely to be the approach I choose when the time comes early next year to work on this image.

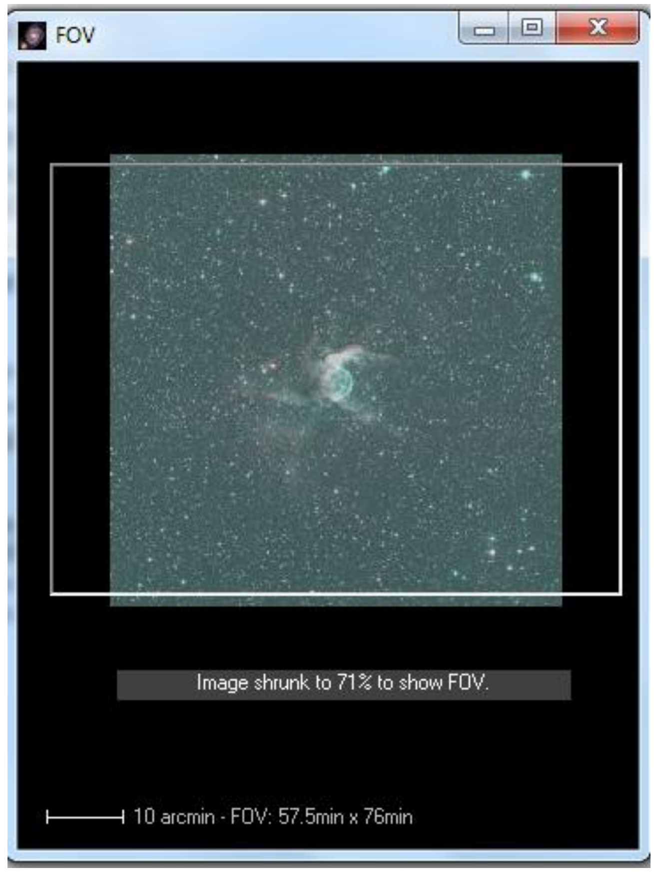


Figure 7. This screencap of the CCDCalc FOV window shows how the target will fit in the frame for the configuration used, which in this case has an 800mm focal length. In this case the "sample" image is derived from Digitized Sky Survey images, reconfigured to work with the app. There is already an extensive set of target images available for use with CCDCalc.

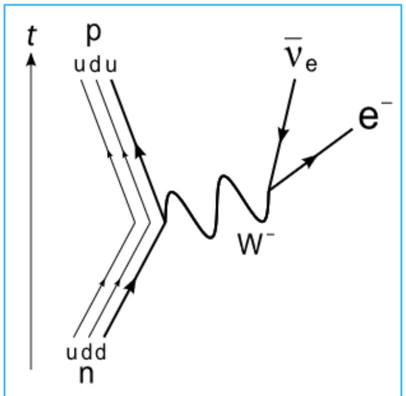
Note: This article is appearing simultaneously in *Eyepiece*, the newsletter of NYC based Amateur Astronomers Association of New York and *SkyWAAtch*, the newsletter of Westchester Amateur Astronomers. I'm a member and supporter of both organizations.

Westchester
Amateur Astronomers

The Astronomical Life of the Neutron

Larry Faltz

Consider the neutron. Happily living inside a nucleus with just the right number of proton and neutron neighbors, it's stable until the end of time, or at least as stable as the proton, whose lifespan as determined from experiments is now known to be at least 10^{33} years and may be infinite. The neutron's component quarks, one up and two down, are apparently content being up and down quarks forever, happy in their fundamental quarkness. But under the right circumstances, with something amiss in their neighborhood when there are just a few more neutrons living in the nucleus than makes for a "perfect" nuclear community (imagine for example a large family moving onto your block with one more car than can fit in their driveway) one of those down quarks gets itchy and decides to become an up quark. The neutron becomes a proton, and to preserve electrical neutrality an electron is emitted, along with an electron antineutrino. This is beta decay.



Feynman diagram of beta-decay

The rate at which beta decay occurs depends on the specific nucleus. The simplest example is tritium, a hydrogen nucleus with one proton and two neutrons. Deuterium, with one proton and one neutron, is stable. Add that second neutron and one of them in each nucleus can undergo beta decay at a rate such that after 12.32 years, half the tritium nuclei will have been converted to helium-3. Which nucleus? Which neutrons (or, which down quarks)? Why 12.32 years? Similarly, carbon-14, with 6 protons and 8 neutrons, will undergo beta decay to nitrogen-14 with a half-life of 5,700 years. Again, which neutrons, which nuclei, why 5,700 years?

Beta decay operates through the "weak" force, mediated by the emission of a W^- boson which quickly decays into an electron and antineutrino. There are theories about the structure of the nucleus, particularly the "nuclear shell" model, which describe the intra-nuclear environment that produces beta-decay. Like everything taking place deep down in the atom, it's a quantum process, specifically described by the Standard Model of particle physics and its quark-defining component, quantum chromodynamics. In other words, nature is indeed playing dice. Sorry, Albert.

Early in the life of the universe, when matter emerged after inflation, there was just a soup of elementary particles. In the hot, dense universe the temperature was so high (>10^{15} K) that quarks were free and in thermal equilibrium with the other fundamental particles: gluons, photons, electrons, positrons, neutrinos, even Higgs bosons and perhaps dark matter particles, whatever they might be. As the universe cooled and the temperature dropped to 10^{12} K, the quarks were confined into protons and neutrons, but the temperature was still high enough for protons and neutrons to exist in equal amounts and even to mutate into each other. After more expansion and cooling the temperature dropped to a point below which neutrons didn't have enough energy to be turned back into protons. This temperature was achieved at t=1 second, and at that time there were 6 protons for every neutron, a ratio that is due to the mass difference between protons and neutrons. This is known as the "freeze out." The temperature of the universe was 1.5×10^{10} K. That's 15 billion degrees. Some freezing!

The original description of this process, published when protons and neutrons were thought to be fundamental particles themselves and not made up of quarks, was given in the famous "Alpha Beta Gamma" paper by Ralph Alpher, Hans Bethe and George Gamow ("The Origin of the Chemical Elements" *Physical Review* 1948; 73:803-804). In this brief 6-paragraph communication, the authors state that

> …various nuclear species must have originated not as the result of an equilibrium corresponding to a certain temperature and density, but rather as a consequence of a continuous building-up process arrested by a rapid expansion and cooling of the primordial matter….
>
> … the observed slope of the abundance curve must not be related to the temperature of the original neutron gas, but rather to the time period permitted by the expansion process. Also, the individual abundances of

various nuclear species must depend not so much on their intrinsic stabilities (mass defects) as on the values of their neutron capture cross sections.

Gamow, an early proponent of the Big Bang theory, thought that neutron capture could create all of the elements, but we now know that nuclei heavier than an atomic weight of 7 weren't made by this process. The main contribution of this paper was to show that there was a distinct time after the Big Bang when nucleosynthesis first started, and a distinct time when it ended.

[It's always necessary, when quoting this seminal work, to tell the tale that Gamow, then at George Washington University, included Hans Bethe (Cornell) as an author even though Bethe had little to do with the work, the details of which had been worked out by Gamow's graduate student Alpher for his Ph.D. dissertation. The playful Gamow, a strong advocate for the then still theoretical Big Bang, included Bethe to make a pun out of the title, "Alpher Bethe, Gamow" being analogous to "alpha, beta, gamma", the first 3 letters of the Greek alphabet. It's an apt pun considering they were talking about the beginning of chemistry.]

For the next fraction of a minute after freeze-out, the protons and neutrons existed in a thermal soup. The high temperature prohibited their pairing into atomic nuclei, but by 20 seconds further expansion and cooling permitted the formation of neutron-containing nuclei.

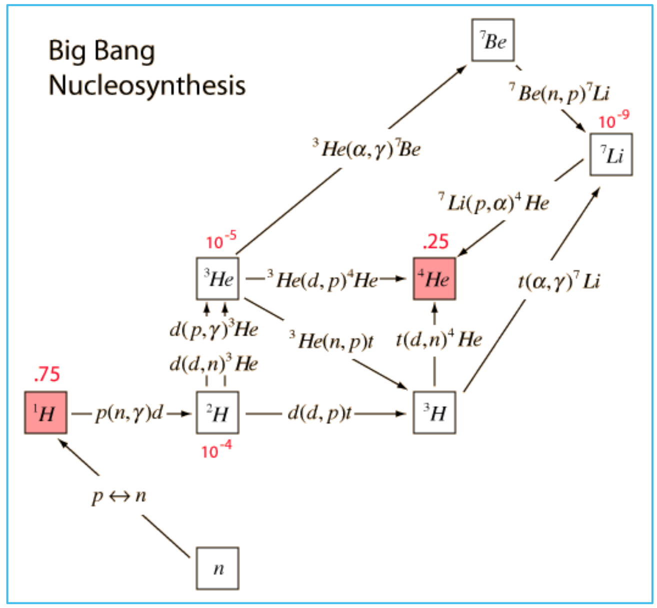
The details of nuclear synthesis are interesting. The first reaction is the synthesis of deuterium from the merger of a proton and a neutron, with the emission of a photon:

$$p + n \leftrightarrow {}^{2}_{1}H + \gamma$$

This is a reversible reaction if the photon energy is high enough ("photodisintegration"). At one second the content of the universe was 10^9 photons for every baryon. The average energy of photons then was about 1 MeV, but the statistical black-body distribution of photon energies meant that enough of them were above the threshold required for photodisintegration of new deuterium nuclei, 2.23 MeV, to prevent the survival of all the newly formed deuterium, and so no further nuclear synthesis could take place. This is sometimes referred to as the "deuterium bottleneck." By 3 minutes, however, there were fewer high energy photons above the threshold than the number of new deuterium nuclei, so the deuterium lifetime was long enough for it to participate in other reactions. Synthesis of helium began at that point.

There are just 4 reactions that take place during primordial nucleosynthesis:

- A neutron is captured with emission of a photon
- A proton is captured with emission of a photon
- A deuteron is captured with emission of neutron
- A deuteron is captured with emission of a proton.

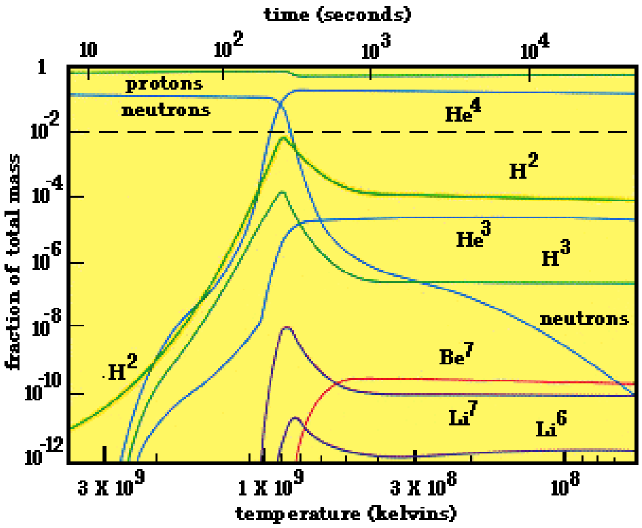


The main reactions of Big Bang Nucleosynthesis (Hyperphysics, George State University)

The process of nucleosynthesis stops at beryllium for two reasons: (1) the falling cosmic temperature precludes further fusion (we will have to wait for stars to form and temperatures to rise high enough in their cores to restart fusion); (2) there are no stable nuclei with masses of 5 or 8, meaning if a nucleus with that mass is created by any of the 4 processes, it will very quickly decay to one of lower mass. In addition, free neutrons undergo beta decay, reducing their numbers and decreasing neutron capture reaction rates. This also proportionally increases the number of available protons, favoring the reactions that capture protons.

The final atomic census of the primordial universe was set by 20 minutes when the temperature dropped below 5×10^8 K, too low for neutron capture to occur at all. Whatever free neutrons remained simply underwent beta decay and did not contribute to further nucleosynthesis. The chemical composition of the universe was set for the next hundred million years or so, until the first stars fired up.

Calculations show that the estimated mass content of ^4He in the universe should be around 24%, and observations of low-metallicity interstellar gas, that is, primordial gas not contaminated with the output from stellar nucleosynthesis that forms the elements heavier than lithium, are consistent with that value. These regions of pristine gas are detected by radio astronomy observations of the 21-cm hydrogen line (which is now red-shifted to longer radio wavelengths).



Abundances of nuclei at the beginning of the Universe

Most of the values that inform theoretical predictions of primordial nucleosynthesis are very well known. The masses of neutrons and protons are known to ten decimal places, for example. The lifespan of the free neutron, however, is known to far less precision. The generally quoted figure is 881.5 ± 1.5 seconds. Half-life and lifespan are related by ln(2) = 0.693, so the free neutron half-life is 611.0 ± 1.0 seconds.

Measuring the neutron lifespan is a difficult technological challenge. Two methods have been employed. The "beam" method utilizes a well-characterized beam of low-energy ("cold") neutrons. The neutrons are passed through a Penning trap composed of magnetic and electric fields. Periodically the trap is emptied and the protons resulting from beta decay are counted. Using this technique the average neutron life span was measured to be 887.7 ± 2.2 seconds in 2013. The "bottle" method employs a magnetic trap and gravity. Slow-moving, ultracold neutrons with nano-electron volt energies settle in the trap and periodically the neutrons are counted directly.

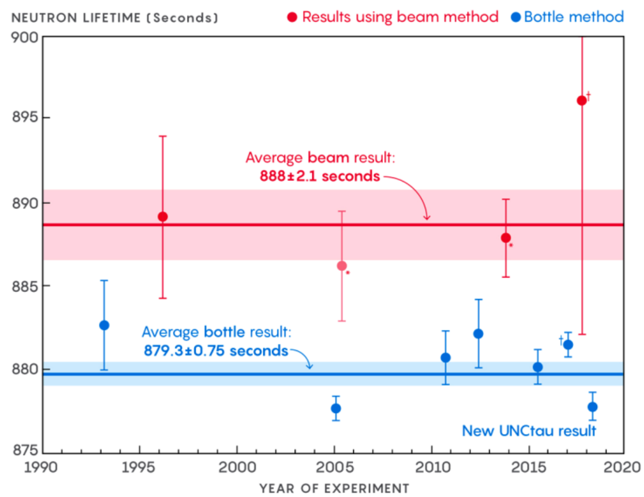
The neutron "bottle" at Los Alamos

Recently, an international group working at the Los Alamos National Laboratory utilized the bottle method to make the most accurate measurement of the neutron lifetime to date, 877.7 ± 0.7 seconds.[1] The bottle and beam methods consistently give results that differ by nearly 4 standard deviations. This difference impacts calculations of the expected amount of helium in the primordial universe, which would vary by a few percent depending on the exact neutron lifespan. This has implications for star and galaxy formation and cosmological evolution.

This discrepancy will have to be resolved in order to nail down primordial nuclear abundances. It is also a test of the Standard Model. The SM calculation of the life of the neutron depends on a value called g_A, the strength of a nucleon's coupling to the weak axial current, a feature of the W^- boson that mediates beta decay. The calculation of this value depends on solving equations by an iterative process of the enormously complicated Lattice Quantum Chromodynamics (LQC)

[1] Pattie et. al., Measurement of the neutron lifetime using a magneto-gravitational trap and in situ detection, *Science* 2018; 360627-632

theory. A team from the Lawrence Livermore Laboratory used the Titan supercomputer at the Oak Ridge National Laboratory to make LQC calculations by simulating a volume of space a few neutron diameters wide containing one neutron and many virtual quark-antiquark pairs coming in and out of existence as predicted by the Heisenberg Uncertainty Principle. Doing the math would have taken 600,000 years on a very powerful laptop. The result was a value of $g_A = 1.271 \pm 0.013$, which translates into a neutron lifespan of 880 ± 14 seconds (1.6%). This isn't enough to support either the lower bottle results or the higher beam results, but supercomputer computations are processing more iterations and by 2020 the error might be less than 0.3%. The study was published on line in *Nature* on May 30th.



To further complicate matters, the lifespan of a low energy neutron in a (relative) vacuum may not be the lifetime of a neutron a few minutes after the Big Bang. We know that the neutron's local environment must alter its lifespan, because there's no other way to account for the fact that beta decay doesn't occur at a constant rate in all eligible nuclei. For example, beryllium-10 has a half-life of 1.39×10^6 years, while beryllium-11 has a half-life of 13.81 seconds and beryllium 12 a half-life of 21.29 milliseconds.

At 100 seconds after the Big Bang, the density of the universe, derived from the Friedmann equation, was at least 10^4 kg/m^3. Compared to the density of an atomic nucleus, 2.3×10^{17} kg/m^3, it's almost a vacuum, but it's still about half the density of solid gold. Also, the temperature was, as we have said, in the range of a billion degrees. These conditions might affect the stability of a down quark or its coupling to the W^- boson and thus alter the neutron's lifespan. In a paper posted (arXiv 1805.06543) just 2 days after the publication of the *Science* paper, Yang, Birrell and Rafelski from the Universities of Arizona and Massachusetts noted that free neutron beta decay might be impeded by the hot plasma environment of the early universe during the primordial nucleogenesis era, and they calculated that during this period the actual average neutron life span would by increased, resulting in an enrichment of free neutrons by 6.4%. This would change the ratio of hydrogen to helium at the end of nucleogenesis.

One interpretation of the different results from the beam and bottle experiments was proposed in January by Bartosz Fornal and Benjamin Grinstein from the University of California at San Diego (arXiv:1801.01124). They postulated that the two methods gave disparate values because the theoretical description of the neutron might not be complete. They suggested that about 1% of free neutrons decay by emitting a dark matter particle! The two physicists think there could be experimental methods to find this decay mode. Grinstein, the chairman of physics at UCSD, notes "When the lifetime of the neutron is measured by two different approaches, and the results differ, we have a crisis. Is our basic understanding of the laws of physics wrong?"

Lately I've noticed that dark matter, and rather complex dark matter at that, seems to be invoked whenever there's an unexpected mystery in the results of experiments or observations. Unexpectedly cool temperatures in the gas forming the first stars? Dark matter cooling. Arrangement of satellite galaxies around the Milky Way? Dark matter halo. Periodic cometary extinctions of terrestrial life? Another dark matter halo. Differing results for neutron lifespans from two types of experiments? Neutron decay into dark matter particles. It's kind of a *deus ex machina*, and why not? We seem to be near the end of "normal" physics. We have reasonable proof of the existence of some kind of matter that interacts minimally, if at all, through the electromagnetic, weak and strong forces, but it doesn't fit anywhere in the Standard Model and there may be 5 times as much of it as SM matter. Everyone seems to be hoping that the Standard Model is just a bit wrong, and in a sense it must be because as good as it is in describing subatomic physics, it still can't explain many detectable phenomena (of which the most obvious is gravity). Perhaps resolving the lifespan of the neutron will shed some light on "dark" physics. ■

My Trip to Iceland to View the Northern Lights

David Parmet

This past April my daughter and I traveled to Iceland. It was the second time for me, the first for Lucy. Since bad weather plagued my first trip, I hoped we'd luck out and get a solid week of sunshine and clear skies. Fortunately, my wish came true.

April is still winter in Iceland and you're just as likely to get caught in a snowstorm (as I did in 2017) as you are to get a sunny day. The temperature hovers in the upper-30s to low-40s. In fact, during our week in Iceland, the thermometer in Reykjavik topped that in New York. During the summer and fall, Iceland becomes the land of the Midnight Sun. But even in April the sun never truly sets. There's always a bit of red, just a hint of sunset /sunrise, on the horizon.

What causes an aurora? According to the Canada-based Northern Lights Centre, collisions between molecules in the Earth's atmosphere and charged particles released from the surface of the Sun and flung towards Earth generate an aurora. The specific atmospheric gases the charged particle interact with create the different colors of the Northern Lights. For example, oxygen molecules cause the most common color, a pale yellowish-green. Rarely, the interaction between the charged particles and oxygen at a higher altitude (up to 200 miles) will result in a red color. Rarer still, a purple color results from nitrogen interacting with the charged particles.

The first time we saw the Lights on this trip was while driving back to Reykjavik from a day-long tour of the Snaefellsnes Peninsula. Despite a full moon, our guide, like all good guides in Iceland, checked the solar weather with his colleagues. As we were driving south, he asked (ordered) us to keep an eye on the rear window for even a hint of green.

About an hour out of Reykjavik we caught a glimpse of a faint green blob about halfway up from the horizon. My daughter describes it as looking like the green ghost from Ghostbusters. Our guide quickly pulled over to the side of the road. But by the time I reached for my camera and tripod, it had faded further. I managed to capture it before it fully faded but more importantly, my daughter got her first look at the Northern Lights.

On the final night of our stay in Iceland, I arranged for another trip, this time specifically to see and photograph the Northern Lights. Our guide took us about an hour out of Reykjavik, to a field just east of Keflavik Airport. The forecast for that night wasn't promising but our guide confidently predicted we'd get a show. After an hour's wait under crystal clear skies, a faint green glow on the northern horizon grew to a bright green cloud reaching from the north towards Reykjavik, across the sky to the west and about a quarter to a third of the way to the zenith.

Northern Lights for near Keflavik Airport

The brighter the Northern Lights get, the more you can see them move and shimmer. The Lights provided quite a show that night, but my photos certainly don't do it justice. We even got a bit of red, which quickly shifted against the green background, moving from east to west and back again. All of the twists and turns you see in my photos were clearly visible in the night sky.

If you do go to Iceland (and you should), I recommend hiring Arctic Shots as your photo guides. Accomplished photographers and experienced aurora hunters, Bragi and Siggi of Arctic Shots will help guarantee you get the best shots possible. They can find the best place any particular night to see the lights as often the skies are better in one part of Iceland than others. Since the Lights can be very faint visually, an experienced guide can point them out to the untrained eye. I admit the first time I saw the Northern Lights last year, I wouldn't have known it unless Bragi pointed them out to me.

Now that I'm back and reviewing my photos, I'm already planning my next (third) trip to Iceland.

Westchester Amateur Astronomers

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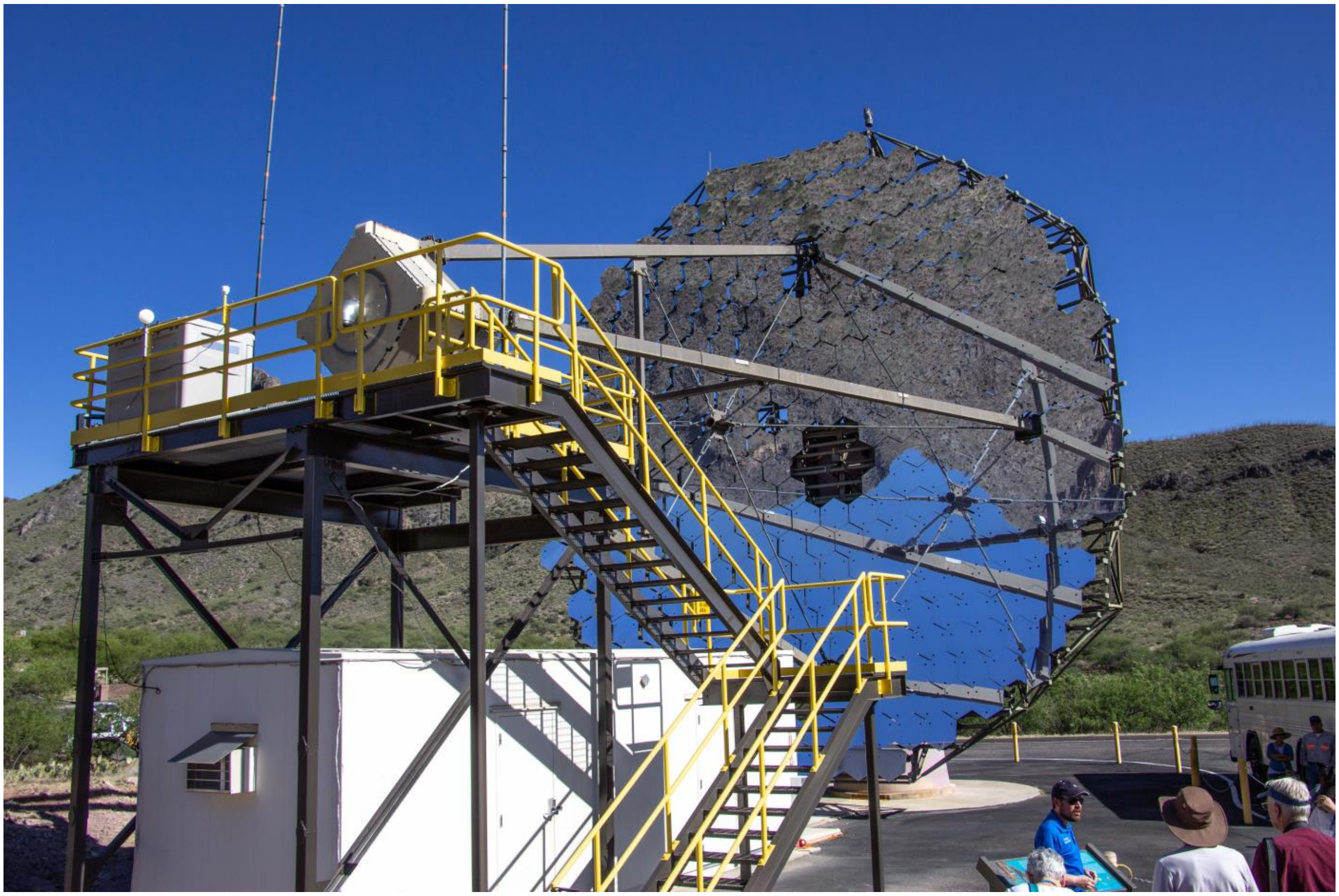
Courtesy of Gary Miller is this image of M101, the Pinwheel Galaxy in Ursa Major. Also visible in the lower left is its companion dwarf galaxy NGC 5474.

VERITAS



Tom Boustead snapped this picture of the Very Energetic Radiation Imaging Telescope Array System (VERITAS) at the Fred Lawrence Whipple Observatory in southern Arizona. VERITAS is an array of four 12 -meter Cherenkov telescopes (one of which is shown above), each consisting of 350 individual mirrors.

These telescopes seek to indirectly record gamma rays possessing energies ranging from 50GeV to 50TeV—essentially particles millions of times more energetic than visible light. Thankfully for life on Earth, gamma rays do not penetrate our atmosphere. Instead, when they strike the molecules in our atmosphere, the gamma rays create a cascade of electrons and positrons known as Cherenkov radiation. It is this radiation that VERITAS processes.

VERITAS is the northern hemisphere's most sensitive ground-based instrument for detecting high energy radiation. Along with the Fermi space-based telescope, it offers insight into some the Universe's most exotic objects such as supermassive black holes, pulsars and gamma ray bursts.

Member & Club Equipment for Sale

July 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
Celestron CPC800 8” SCT (alt-az mount)	Newly donated to WAA. Like new condition, perfect optics. Starizona Hyperstar-ready secondary (allows interchangeable conversion to 8” f/2 astrograph if you bought a Hyperstar and wedge). ADM top rail, Starizona counterweight bottom rail. Telrad finder. Many counterweights. ADM 100 mm diameter rings with ADM saddles for piggy-back mounting. SCT-to-T adapter for prime focus imaging with Canon EOS adapter. 2” CPC steel tripod. AC power supply. No eyepieces or diagonal.	$1500	WAA ads@westchesterastronomers.org
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.	$150	WAA ads@westchesterastronomers.org
William Optics E-BINO-P Binoviewer	1¼” nosepiece. Comes with a pair of 20 mm 66° eyepieces, 1.6x Barlow. Compression ring eyepiece holders, BaK4 prism. New condition in original packaging. Lists @ $268.	$150	Larry Faltz lfaltzmd@gmail.com

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.

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