SkyWAAtch

Overlooked Gem in Orion

From his backyard in Pleasantville Olivier Prache took this image of M78, a beautiful reflection nebula in Orion. He used his 12” Hyperion astrograph and an ML16803 camera; the exposure time was 7.5 hours.

At a distance of 1600 light years Messier 78 is an extended object of about 6 by 8 arcminutes. The nebula can be found 2 degrees north and 1.5 degrees east of Alnitak, the easternmost star of Orion’s Belt. Another patch of nebulosity—NGC 2071—can be found at the eleven o’clock position in this image.

In This Issue . . .

Events for March

WAA March Lecture

“Bright Lights from Gravitational Wave Sources: Simulations of merging black holes and neutron star systems”
Friday March 2nd, 7:30pm
Auditorium at Phelps Hospital
Sleepy Hollow, NY

Our speaker is Andrew MacFayden, Ph.D., Associate Professor of Physics, New York University, who will discuss gravitational waves. Gravitational waves are subtle ripples in spacetime, flowing through the universe. Albert Einstein predicted their existence in his famous theory of general relativity published in 1916, but it took a hundred years of strenuous effort for humans to detect them. In 2015, the Laser Interferometer Gravitational-Wave Observatory (LIGO) detected gravitational waves from the inspiral and merger of two blacks hole. This achievement resulted in LIGO’s leaders receiving the 2017 Nobel prize for physics. This past summer, on August 17, 2017, an even more exciting event for astronomers occurred: the merging of two neutron stars accompanied by a gamma-ray burst and a "kilonova" along with long-lived afterglow radiation which is still being detected. Prof. MacFayden will discuss recent research on black hole mergers, including supermassive black holes, along with predictions for ongoing astronomical observations of the merging neutron star event.

Dr. MacFayden is Associate Professor of Physics at NYU, specializing in computational astrophysics. He obtained his degrees in astrophysics from Columbia (BA) and UC Santa Cruz (PhD) and was a postdoctoral fellow at Caltech and the Institute for Advanced Study in Princeton before coming to NYU. Free and open to the public.

NOTE: THIS IS A LOCATION CHANGE. The Auditorium at Phelps Hospital is 3.2 miles from Pace. See the following for location details.

Upcoming Lectures

Leinhard Lecture Hall
Pace University, Pleasantville, NY

Our speaker on April 6th will be Carter Emmert, director of Astrovisualization at the Rose Center for Earth and Space at the American Museum of Natural History. Free and open to the public.

Starway to Heaven

Saturday March 17th, Dusk.
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for March, weather permitting. Free and open to the public. The rain/cloud date is March 24th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Mark Hefter - Dobbs Ferry
Jijy Easow - Yonkers

Renewing Members. . .

Jinny Gerstle - West Harrison
Al Collins - Stamford
Rick Bria - Greenwich
Jay Friedman - Katonah
Joseph Depietro - Mamaroneck

Courtesy of Claudia Parrington is this photo of the February meeting of the WAA Board meeting.

Set Your Clock

The later sunrises that come with the arrival of ‘Daylight Time’ on Sunday morning the 11th will make the bright objects in the morning sky more accessible to morning commuters.

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

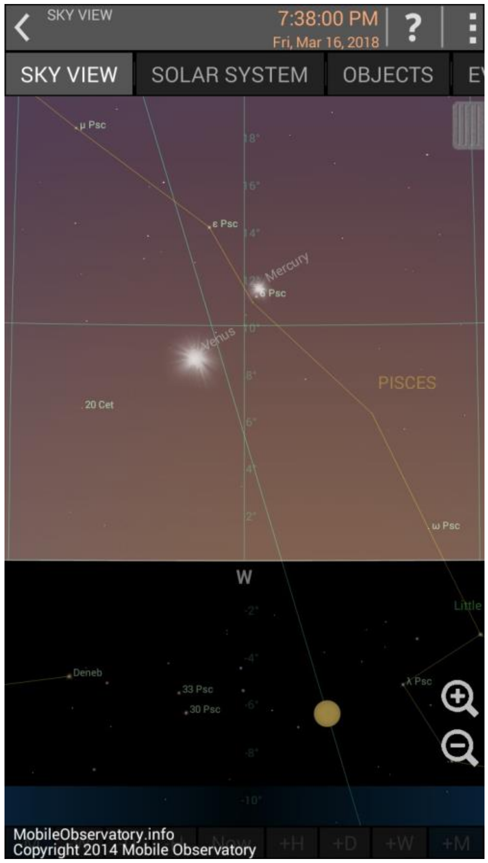
ALMANAC
For March 2018 by Bob Kelly


Mar 2

Mar 9

Mar 17

Mar 24



Venus and Mercury orbit out from behind the Sun in March. Mercury spends the first two-thirds of the month higher in the sky than Venus, but Venus (magnitude -3.9) will be easier to spot. It provides an aid for locating somewhat less luminous Mercury (peak magnitude -1.3).

Mercury sets as much as 1½ hours after the Sun, making this a good apparition for us northern hemisphere folks. Its greatest brightness occurs at the start of the month when it will still be hard to find without optical aid. The two planets are low in the west.

Mercury's greatest elongation will be on the 13th when it will be down to magnitude -0.5. Venus and Mercury will make a great pair in binoculars for much of the month. Venus stays almost fully lit while Mercury's phase goes from a tiny full disk to a slightly larger half-lit disk that approaches Venus' apparent size.

Jupiter is outstanding in the south at sunrise, low enough that you might be observe it from a south-facing window. Jupiter grows to 40 arcseconds this month, within 10 percent of maximum size at opposition in May. Saturn's starting to look good, slowly getting larger at 16 arcseconds wide. However, it's low in the southeastern sky, even lower than Jupiter. Finding detail on Mars is still a struggle at 7 arcseconds wide. Just wait for early summer, when it will appear larger than Saturn's disk.

The Moon will join the Venus/Mercury party on the 18th although Mercury will be fainter during the latter half of the month. Earlier in the month the Moon crosses over the top of Jupiter on the 7th and settles between Saturn and Mars on the 11th. Note the distance between Mars and Saturn on the 11th. By the end of the month Saturn will be within two degrees of Mars, a compelling view.

Uranus is falling into evening twilight. Venus tries to point it out by passing close on the evening of the 28th. But Uranus will be hard to spot near the dazzling Evening Star, even in a telescope.

Another month of blue lunacy! Two full Moons this month, just like in January. Hang in there; you won't have to hear about it again until October 2020. Lunar perigee is three and five days ahead of the March 1st and March 31st full Moons, respectively. Here's hoping not to hear about 'almost supermoons'. Perigee continues to slip further ahead of the date of full Moon for the rest of the year.

Get a sturdy, immovable, opaque object to block the early afternoon Sun and see if you can find Venus and Mercury trailing the Sun in the sky. Look online for the distance and direction from the Sun and for the time you want to try to catch planets in the daytime. A day with excellent transparency will help, indicated by a deep blue sky.

The disco ball, 'Humanity Star', launched from New Zealand, will start to be visible, but just barely, this month. Heavens-above.com calculates a maximum possible brightness of magnitude +1.5, but this month, they calculate overflights with apparent brightness ranging from +8.1 to +4.4.

Tiangong 1, the falling formerly-manned Chinese space station makes some zero-magnitude evening sky passes over us in the first half of March. Tiangong 2, still under active control, is projected to be visible in the morning skies for the latter two-thirds of the month. The International Space Station outshines them all (except for Iridium flares), with pre-sunrise overflights through the 21st, followed by evening views for the rest of the month.

In The Naked Eye Sky

For March 2018: Looking for Orion's Head

by Scott Levine

I'll admit it. One thing I never get tired of is looking at is Orion. Maybe that's like saying your favorite flavor of ice cream is vanilla, but mine is, and I'm always happy to spend a good, long time with Orion after a long day.

As we come careening into the last couple of weeks of winter, Orion is in his best nighttime viewing for the year. He's patrolling high over the southern skies by mid-evening, holding off and protecting us from Taurus for another night.

Most of us think of Orion as those seven famous, bright stars that form a vague rectangle with a line across the middle. The three of his belt are instantly recognizable against the night and make him easy to find for even the most casual astronomy fan. The fun and excitement in his sword are another spectacular bunch.

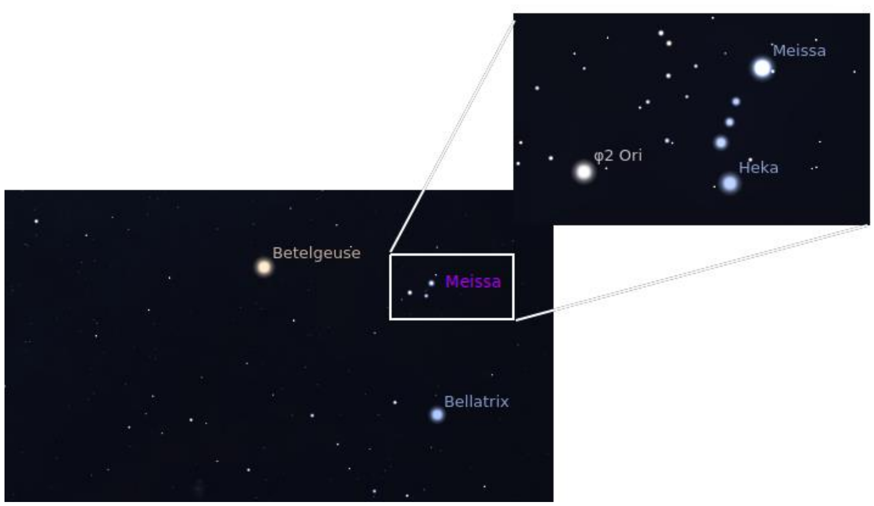
One of the most amazing things about Orion is, despite all of the bold things that you can't help but stare at, there's some wonderful subtlety hidden just beyond the bright lights.

As the nights go on, I love to look for Meissa (λ Orionis), which forms Orion's head. It's a great show with the naked eye where it looks like a modest third-magnitude star: soft and unassuming. It's actually a binary pair, over thousand light years away. The primary is a blue giant about 30 times more massive than the Sun, and about 10 times bigger across. That's close to a billion miles wide; big enough, as the old comparison for Betelgeuse (α Ori) goes, that it would just about reach to Saturn's orbit if it were dropped down in the middle of our solar system. It's a big, furiously hot star.

Meissa, which is the brightest star of the open cluster Collinder 69, looks like the top corner of a lopsided, triangular asterism. That triangle, itself, is at the top of the triangle formed by it and the stars of Orion's shoulders, Betelgeuse and Bellatrix (γ Ori). A small pair of binoculars or a telescope bring out several more of Collinder 69's young stars, about 1,300 light years away.

Focus your gaze on it and see if you can pick out the two other stars of Meissa's triangle: Phi1 (φ1 Ori) at the lower left, and Phi2 (φ2 Ori) at the lower right. In an exciting twist, I've seen all three of these stars referred to as Heka, as well. If you catch things just right, you'll also see a small ladder of three stars running from Phi2 up to Meissa. I haven't been able to find very much information about those, and I confess I haven't looked very hard, but that's okay. Those anonymous stars, the far-flung, deep and distant ones add color and texture to the rest of the night.

Through the frustrating glare of Westchester's bright skies, I often have trouble spotting it, but when things are just right, tracking down Meissa and the stars of Orion's head are a great way to spend an evening. I hope you'll take a look.



Experiments with Filters for Combatting Light Pollution

Mauri Rosenthal

The weather has been terribly non-cooperative for astro-imagers in our region this winter. If you can remember back to the cold snap in early January, we had a run of clear nights but it was so frigid that my plastic cables and adapters started fracturing! Later in the month I had a chance to experiment with the impact of different filters on a wide target, the Christmas Tree Cluster which is nestled in an area of considerable nebulosity.

Here is my "finished" image, the result of several nights of imaging using different filter combinations:

Figure 1: Finished HαLRGB image of the Christmas Tree Cluster

Just in case it's not obvious, the "Christmas Tree" is dead center here although it is leaning a bit to the right. The Cone Nebula is found just above the tree and the Fox Fur Nebula lies just below. I chose this target for imaging based on its size and position in the sky; I had never seen it and didn't know anything else about it before I began shooting.

Actually, though, I still didn't know what it looked like after my first night of imaging. I usually keep a "broadband" light pollution filter on my camera. The one I use is an Astronomik CLS filter, which passes most wavelengths but suppresses the wavelengths associated with the mercury and sodium vapor lamps that are commonly associated with city lighting. They transmit most wavelengths well but block light from 540 to 640 nanometers. As city lighting becomes "whiter" with LED street lighting, this approach will become less and less effective. So I wanted to check what would happen if I used no filter at all, and here is how it came out:

Figure 2: Unfiltered RGB image from January 18th

From this first view, I was very curious about the reddish band to the left of the Christmas Tree (yes, the alignment is slightly different as a result of my quasi-manual technique). Was this a big band of nebulosity, like Barnard's Loop, or just some sort of artifact? I was pleased to have uncovered the Christmas Tree but still was unsure of what I was viewing.

The answer to this question became clear after a night of imaging with an H-alpha filter. H-alpha is the most common wavelength of light emitted when an excited electron in a hydrogen atom drops down to a lower energy state. At 656.28 nanometers, it's a specific shade of red, which is why so many images you see of prominent nebulae (e.g. North America, Pelican, Rosette, California) show big regions of hydrogen-based dust and gas glowing red. Luckily for us, this shade is sufficiently different from the reddish wavelengths of city lights that a narrowband Hα filter passes the light of the nebula but screens out the city light pollution. I'm showing the monochrome version here because color images are built up from red, green and blue monochrome layers and only the red layer from my color camera has useful information when an Hα filter has blocked all but a fraction of red light.

Figure 3: Monochrome H-alpha image from January 24th

What is clear from this version is that the nebular regions in space don't match the red blobs in my unfiltered image – that band that was prominent on the 18th did not even exist when I used Hα on the 24th! What gives?

Here is my explanation: The image geometry is a little bit complicated when it comes to matching the top and bottom of the photo to terrestrial reality. But once I checked this carefully against my star map, it was clear that the region of the image closest to the southern horizon –the direction towards New York City from my yard in Westchester – is the left side of this image. So that band in the unfiltered shot is a gradient caused by the city's light dome! The reddish tinge seems about right, and the curved shape could be a function of the movement across the sky between 11:04 pm when the first data started to accumulate and 11:29 pm when the last sub was recorded. In other words the orientation of the horizon changes as the target is tracked across the sky so you're seeing an "average" horizon. So I conclude the following from this experiment: The unfiltered image is not merely deficient in detail, it actually substitutes a fake or artefactual region of nebulosity for the real regions of nebulosity revealed in the filtered image.

In between shooting unfiltered and with the Hα filter, I also had one evening's worth of data using my CLS broadband filter. For the most part, this showed very little besides the stars – but it also eliminated that artefactual band of red on the left. You can make out some of the actual nebula but it would take a lot of processing skill and effort to approximate the "finished" image shown in Figure 1. So to create that view, I used only the blue and green channels from the CLS image and combined them with the Hα image, which served as both the red layer and the "luminance" layer to form the HαLRGB image at the start of the article.

Figure 4: Astronomik CLS broadband light pollution filter version from January 20th.

My finished image can be found displayed in higher resolution on my Flickr site at

https://www.flickr.com/photos/124244349@N07/28107500639/in/dateposted/

Like most of my astrophotos, it is far from the best version you can find online, but it is not dramatically different from typical amateur captures, even from much darker sites than the New York suburbs. It is well known that narrowband imaging using H-alpha, O-III (oxygen), and sometimes S-II (sulfur) is a great leveler for enabling imaging from light polluted locations.

Based on this experiment, I am unlikely to ever shoot again from my yard or the city without a light pollution filter because I simply don't want to have to worry about displaying features which… um…don't exist! I'm not sure what I'll do when LED lighting completely replaces the filterable, red-tinted security lighting but I hope that new options for filters and processing will still allow us to explore deep space without having to leave the area.

A note regarding the equipment used here: All images shown were taken with a Borg 55FL astrograph using a ZWO ASI1600MC color astro camera, mounted on an iOptron CubePro 8200 mount. I used SharpCap live stacks of eight-second exposures totaling four hours (1 hour CLS; three hours Hα) and processed the images in PixInsight.

■

Book Review & Commentary: *Dark Matter and the Dinosaurs* (Lisa Randall)

Larry Faltz

You're a dinosaur, say *Tyrannosaurus rex* (you might as well be the tough guy on the block) and you're feeling pretty good. You and your reptile ancestors dominate the Earth and its oceans and have done so for 175 million years. There's a lot to eat: either abundant plant life for vegans like *Brontosaurus*, fish for your aquatic cousins or, for carnivores like you, other dinosaurs and occasionally some tiny but delicious (and surprisingly warm) mammals. You don't have to think too hard, because life is simple and sweet and anyway your brain isn't very large, so why bother? And then one day there's a flash and everything goes to hell. In a fairly short time, you're extinct.

Science has fairly well settled on the theory that a large asteroid or cometary impact in the Yucatan around 66 million years ago resulted in an initial heat wave and then global cooling from particulates in the atmosphere. Cold-blooded dinosaurs weren't able to adapt, and they died out, leaving warm-blooded birds and mammals as the dominant terrestrial animal species. The evidence for this cataclysmic event is found in the world-wide iridium layer that dates to about 66 million years ago and the finding of a large crater at Chicxulub in the Yucatan. See my review of Ted Nield's *The Falling Sky* in the June 2013 SkyWAAtch for more detail about the iridium layer and its cosmic source.

We have taken seriously the vulnerability of the Earth to potentially devastating impacts by bodies that cross the Earth's orbit, either asteroids or comets. In 2010, the Space Studies Board of the National Research Council published *Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies*, a report documenting the risk of major impacts by space bodies. The report can be downloaded from the National Research Council's web site. It details current and future detection strategies in addition to describing risk mitigation by a variety of space missions. The report's risk assessment goal was to detect 90% of all potentially hazardous near-Earth objects larger than 140 meters in diameter by 2020. Current efforts are loosely organized under the Spaceguard Survey label. Among the new instruments that could participate in this effort, the Discovery Channel Telescope at Lowell Observatory (located at the quaintly named Happy Jack, Arizona) is already operational and the Large Synoptic Survey Telescope in Chile is under construction (see the August 2017 SkyWAAtch newsletter article on astronomy in Chile for some information on the unique LSST mirror). PANSTARRS, on Mt. Haleakala in Maui, has been very productive as a single telescope, and there is a proposal to build three more PANSTARRS telescopes on the mountain. The University of Arizona proposes to augment its currently operating Catalina Sky Survey (a 1.5-meter instrument on Mt. Lemmon in Arizona and a 68 cm telescope nearby) by using two of the mothballed 1.8-meter Multi-Mirror Telescope mirrors in a new binocular instrument to be located either in Mexico or Arizona. The NRC report also details a number of proposed space-based detection instruments.

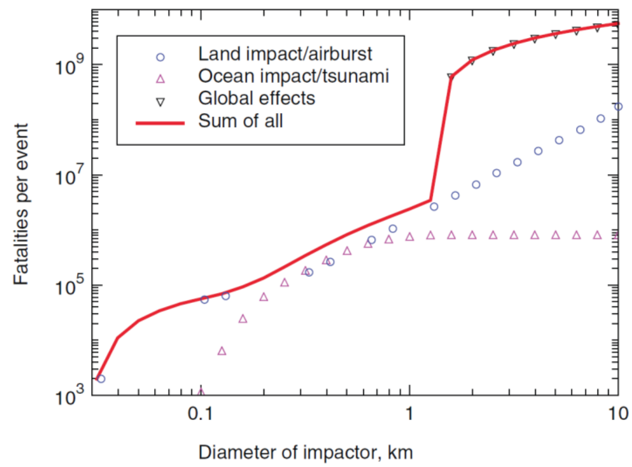
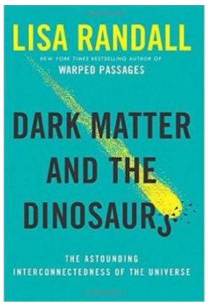


Fig. 2.5 from the NRC report. The Chicxulub impactor was thought to be at least 10 km in diameter, meaning that if it hit earth today there might ultimately be several billion fatalities.

What do we know about the Chicxulub impactor that wiped out the dinosaurs? Was it a near-Earth object or something from beyond the orbits of the known planets as has been proposed for the 1908 Tunguska impactor? We think that there are billions of icy objects in the Oort Cloud that are held precariously in the Sun's gravitational well. It has been proposed that passing stars can easily perturb the orbits of these bodies, sending some towards the inner solar system. Perhaps the Sun is part of a binary system with an as-yet undiscovered component, nicknamed "Nemesis," that periodically scrambles Oort cloud objects. Could this have been the source of the impact that exterminated the race of dinosaurs?

Lisa Randall is a theoretical physicist and cosmologist on the Harvard faculty. In addition to her scientific output, she wrote three well-received popular science books (*Warped Passages* (2006) about the possibility of hidden dimensions, *Knocking on Heaven's Door* (2011) about modern particle physics and the future of science, and *Higgs Discovery: The Power of Empty Space* (2012) about, you guessed it, the Higgs boson). In 2015 she published *Dark Matter and the Dinosaurs*, an examination of the Chicxulub event in the context of cosmic evolution, the history of extinctions on Earth and the evidence that Earth impact events seem to have a periodicity.



I finally got to read the book last fall. It's a well-written, highly detailed and closely-reasoned analysis with a surprising conclusion, although maybe not so surprising considering Randall's professional interests. She notes that the Sun and its solar system cycle above and below the plane in their 250-million year orbit of the galaxy, a phenomenon that was first noted in the 1970's. It was connected to mass extinctions and cratering impacts on Earth in 1984 by Rampino and Stothers (*Nature* 308: 715-717). Each time the solar system passes through the plane of the Milky Way, gravitational perturbations knock Oort Cloud objects out of their stable orbits and some of them head towards the Sun. A small fraction of these will be Earthbound. These authors suggested that galactic matter, stars and gas clouds, provided the gravitational impetus for the perturbations. Randall, however, discounts the possibility that stars and gas clouds in the plane of the Milky Way have enough mass to create sufficiently strong gravitational anomalies. She then proposes that there is a disc of dark matter in the plane of the Milky Way that has the requisite gravitational field to disturb the Oort cloud.

Dark Matter and the Dinosaurs opens with a review of cosmology. Randall traces the origin of galaxies and the solar system. She examines the evidence for dark matter from gravitational lensing, galaxy rotation and cosmic microwave background data. Much of this material will be familiar to amateur astronomers, but it's an amazing story that never fades on retelling by someone who knows what they're talking about. A lengthy review of asteroids and the risk of impacts follows (Randall includes some graphs from the NRC report I mentioned above). Then she looks critically at the data that suggests that there's a periodicity to impacts. Craters are found by scrutinizing satellite imagery and dated by isotopic analysis of samples obtained in the field. The results are analyzed statistically. The statistical significance of the periodicity calculations is not terribly strong. A range of intervals that can fit the data have been proposed, as Randall admits, but the mind wants to identify patterns and her analysis points to 35-million years as the strongest resonance.

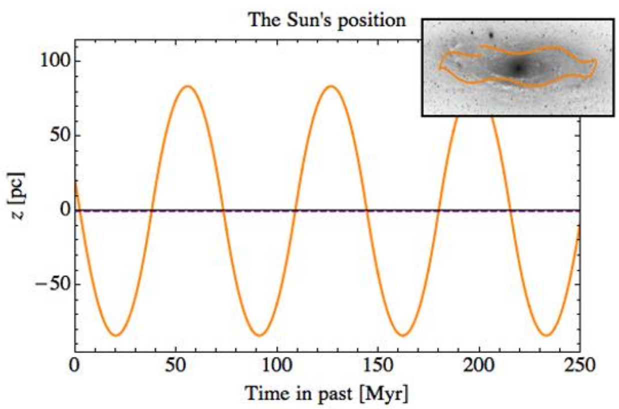


Fig 1 from Randall & Reece's paper on dark matter and cometary impacts. They calculate a model of the Sun's height above the galactic plane as a function of time. The Inset is an illustration of how the Sun moves around the galactic center while also oscillating vertically; the vertical oscillation is exaggerated for visibility.

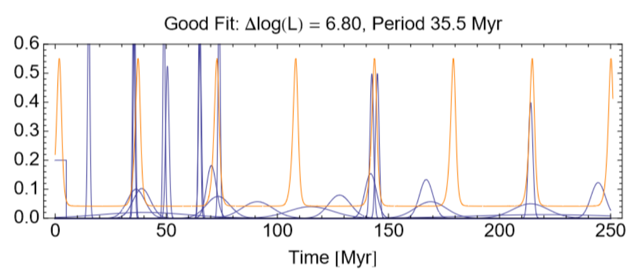
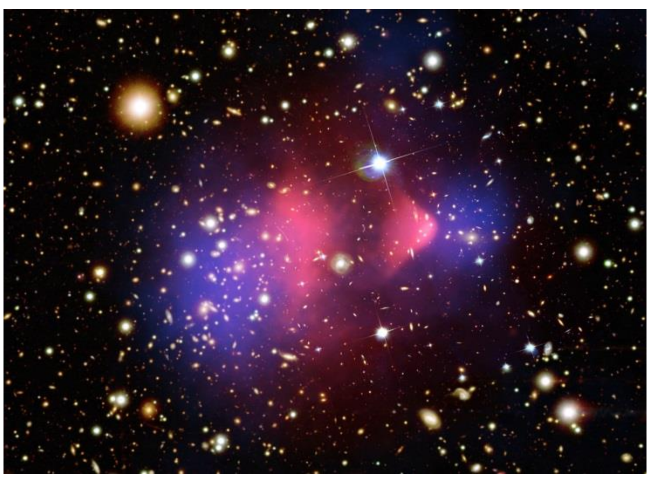


Fig 3 from Randall & Reece, showing one possible correlation of calculated cometary impacts (orange) with actual impacts (blue).

Finally, Randall describes some intriguing possibilities for the behavior of dark matter that might lead to the formation of a dark matter disc in the plane of the Milky Way, in addition to the homogeneous spherical halo distribution of dark matter surrounding galaxies that current cosmology believes. Although baryonic (regular) matter in the Milky Way might organize, through gravitational forces into a co-planar cold dark matter disc, calculations suggest there isn't enough baryonic mass to affect the dark matter.

Randall's first article in the scientific literature suggesting that dark matter could form a disk-like structure was a 2013 paper in *Physical Review Letters* with her Harvard colleagues Ji-Ji Fan, Audrey Katz and Matthew Reece entitled "A Dark-Disk Universe" (online at https://arxiv.org/pdf/1303.3271.pdf). This has a detailed, mathematical treatment regarding the possibility that dark matter has more components than merely a single type of non-interacting particle, something she calls Partially Interacting Dark Matter (PIDM). If at least some component of dark matter is not cold and collisionless but has interactions that are the dark-equivalents of electromagnetism, there could be dark angular momentum and dark heat dissipation that fosters the creation of a dark matter galactic disc analogous to but independent of what we detect in our regular matter world. The authors even discuss the evolution of dark matter in the universe in the context of there being dark protons, dark electrons and even dark antimatter. There appears to be a growing literature that addresses these possibilities, but there's as yet no direct evidence that they actually exist. The authors conclude that up to 5% of the dark matter in the Milky Way could be localized in a thin disc that is coplanar with the galaxy we see. Any amount more than that would create scenarios at odds with observations, such as the distribution of regular and dark matter in the Bullet Cluster, and it would screw up simulations of galaxy formation in the cosmic web that seem to fit very closely with reality.



The Bullet Cluster, 1E 0657-56. Hot X-ray emitting gas in red, gravitating mass (from lensing) in blue. NASA.

In 2014, Randall and Matthew Reece published a paper "Dark Matter as a Trigger for Periodic Comet Impacts" (online at https://physics.aps.org/featured-article-pdf/10.1103/PhysRevLett.112.161301) that is the basis for Randall's book.

In both the 2013 and 2014 papers and in the book, the Gaia space mission is mentioned as a having the ability to verify the distribution of dark matter. Gaia is a mission of the European Space Agency that launched in 2013. The space telescope is parked at the L2 Lagrangian point, opposite the Earth from the Sun. It is making positional and radial velocity measurements of 1 billion stars (1-2% of the Milky Way's stellar population) with the accuracy needed to produce a stereoscopic and kinematic census that could shed light on the gravitational forces in the galaxy. Each star will be measured 70 times with accuracy 200 times better than the Hipparcos mission.

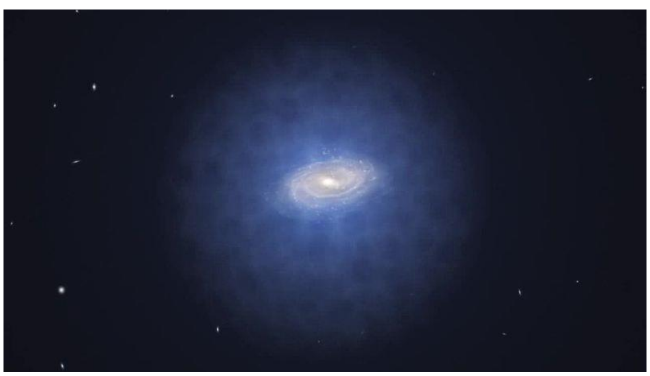
Well, preliminary results were just released in a prepublication paper posted in November 2017 (arXiv 1711.03103). The Gaia team examined data from 2 million Tycho catalog stars that were also measured by Gaia. Here is the paper's abstract:

> If a component of the dark matter has dissipative interactions, it could collapse to form a thin dark disk in our Galaxy that is coplanar with the baryonic disk. It has been suggested that dark disks could explain a variety of observed phenomena, including periodic comet impacts. Using the first data release from the Gaia space observatory, we search for a dark disk via its effect on stellar kinematics in the Milky Way. Our new limits disfavor the presence of a thin dark matter disk, and we present updated measurements on the total matter density in the solar neighborhood.

We'll see what the billion-star data set shows after it is analyzed, but things aren't looking so good for Randall's enticingly clever theory. Nevertheless, I think you would enjoy reading Randall's book. Her approach is scientific and she provides a cornucopia of interesting information spanning a range of important astronomical and cosmological topics.

Although Gaia may moot the idea of a dinosaur-killing dark matter disk co-planar with the Milky Way, there may be other dark matter structures that address the nature of dark matter and challenge the current idea that it is made of a single type of non-interacting particle.

The main theory of the universe is "ΛCDM" ("lambda-cold dark matter"), which holds that the universe is made of 4.9% regular matter (baryons, neutrinos, photons and bosons), 26.8% cold dark matter (most likely "weakly interacting massive particles", or WIMPs) and 68.3% dark energy in the form of a "cosmological constant," repulsive energy inherent in space that's accelerating the expansion of the cosmos. The dark matter is responsible for the growth of cosmological structures, particularly the cosmic web that organizes galaxies and galaxy clusters. Supercomputer simulations using inputs from ΛCDM produce virtual universes that agree remarkably with what has been found from galaxy surveys. Conformity with a simulation is hardly proof of a theory, but it's all we've got right now, since neither dark matter nor dark energy has been directly detected. However, ΛCDM can't account for the distribution of satellite galaxies of the Milky Way or the Andromeda Galaxy. These small galaxies, many dominated by dark matter, ought to be distributed spherically around their host galaxies if dark matter in ΛCDM is truly non-interacting. However, they are found primarily in an inclined "Disc of Satellites" around the Milky Way. The first evidence for this was published in 1976 by Donald Lynden-Bell, a noted British astronomer who in 1969 first proposed that quasars are powered by supermassive black holes. Lynden-Bell was the first director of Cambridge's Institute of Astronomy and was President of the Royal Astronomical Society. He received many awards. Sadly, Lynden-Bell died in early February this year at the age of 83.

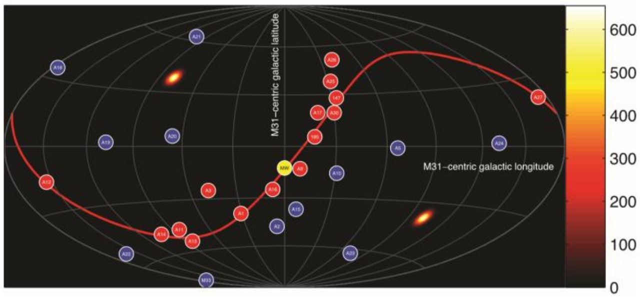


A spiral galaxy embedded in a spherical dark matter halo as predicted by ΛCDM (the dark matter colored blue, so we can see it!) Artist's conception, from ESO.

Dwarf galaxies range in size from 100 million to several billion stars, far less than the Milky Way's several hundred billion and M31's one trillion stars. The Milky Way is surrounded by at least 59 dwarf galaxies as of last count; some may be satellites of satellites and not directly orbiting the galaxy itself. Most dwarf galaxies are faint. The two brightest are the Large and Small Magellanic Clouds, with perhaps 30 billion and 3 billion stars respectively. The LMC is on the borderline of being a full-fledged galaxy, perhaps a small spiral. The glorious globular cluster Omega Centauri is very likely the core of a dwarf galaxy and even has a black hole at its center. A more typical example is the Sculptor Dwarf Galaxy, discovered in 1937 by Harlow Shapley with a 24-inch refractor. Spectroscopy shows that the stars in the galaxy have very low metallicity, suggesting an ancient origin. Early theories suggested that dwarf galaxies were created by galactic tides during early galactic evolution, but it is certainly possible that these small satellite galaxies formed in the early universe under the influence of dark matter, rather than being secondary offshoots of their host galaxies. Observations of stellar motion suggest that the ratio of dark matter to regular "baryonic" matter is much greater in dwarf galaxies than in the Milky Way. It's possible that tidal interactions with the Milky Way have stripped stars and gas from these satellites, leaving the dark matter that was present when the dwarfs formed. Or, there's something about the way dark matter interacts that caused it to form clumps, attracting some matter as a result. Maybe PIDM isn't wrong.

The Sculptor Dwarf Galaxy imaged by the ESO Digitized Sky Survey.

Perhaps the positions of dwarf galaxies reflect gravitational interactions with the host galaxy. If so, we might expect that they would primarily be found in the galactic plane. The distribution of the Milky Way's dwarf galaxies is indeed disk-like, but the orientation of the disk is not coplanar. Of course, dwarf galaxies in the Milky Way's plane might be very difficult to pick out among our galaxy's stars, gas and dust. That we find them out of the plane might be like the old saw about the drunk looking for his keys under the lamppost. In 2013 an international group studied the dwarf galaxies of the Andromeda Galaxy, M31, and determined that they were aligned in a disc that was inclined significantly from the giant spiral’s plane. This vets the finding of the Milky Way’s “Disk of Satellites,” and it also poses a big challenge for ΛCDM since it predicts that the satellites would be spherically distributed.



Map of the satellite galaxies of M31 as seen from the perspective of the center of the galaxy, from Ibata, RA, et. al., A Vast Thin Plane of Co-rotating Dwarf Galaxies Orbiting the Andromeda Galaxy. Originally published in *Nature*, online at https://arxiv.org/ftp/arxiv/papers/1301/1301.0446.pdf.

A recent paper (https://arxiv.org/pdf/1712.07818.pdf) submitted to *Astronomy and Astrophysics* uses simulations to analyze the distribution of dwarf galaxies and suggests, among other things, that the location of our galaxy with respect to the cosmic web in which it resides influences the locations of the satellites. The simulations seem to favor a co-planar distribution at certain distances from the host galaxy, but further away the probability of satellites being co-planar decreases.

Centaurus A (NASA)

A paper published just a few weeks ago (Müller, O, et. al, A whirling plane of satellite galaxies around Centaurus A challenges cold dark matter cosmology, *Science* 2018; 359: 534-537) maps dwarf galaxies around the galaxy Centaurus A and measures their motions. ΛCDM predicts a random distribution of satellites and random motions. The group found that satellites of Centaurus A are generally distributed in a thin plane, and their rotation is correlated.

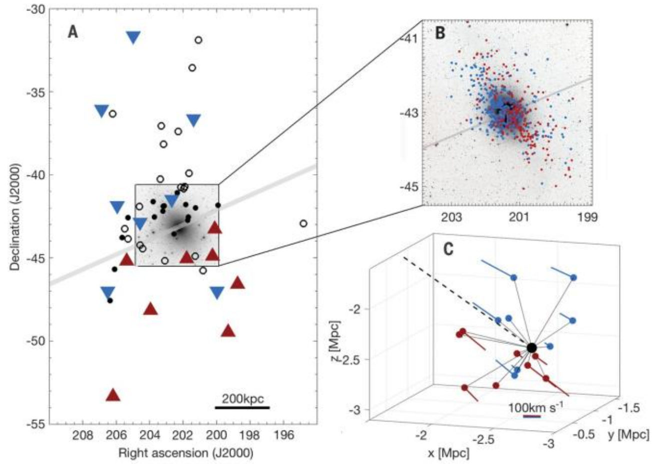


Fig 1 from Müller et. al. showing the distribution and motions of the satellite galaxies of Centaurus A.

The plane of the satellites is at an angle of about 110° from the dust lane of Centaurus A, which is most likely the galaxy’s plane of rotation. Perhaps there is a dark matter disc offset at this 110° angle to organize the satellite plane. This provides no support for Randall’s co-planar dark matter disc theory, but it may still back her idea of PIDM. What it does for sure is to challenge ΛCDM. As the authors note,

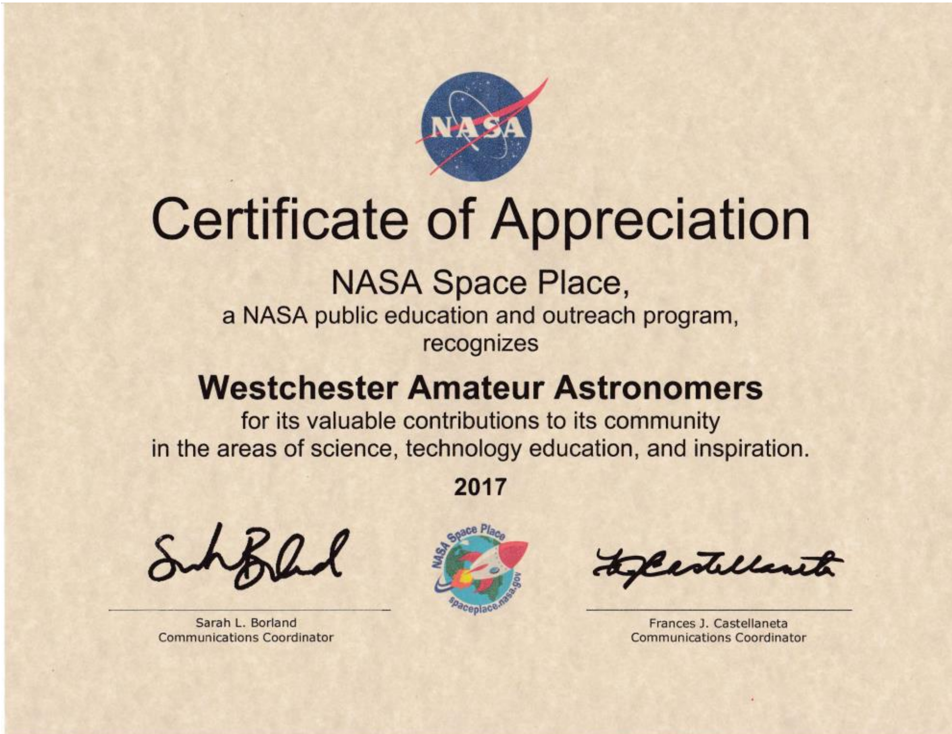
> Here, we have provided evidence for a kinematically coherent plane of satellite galaxies around Cen A, demonstrating that the phenomenon is not restricted to the Milky Way and Andromeda galaxies. The kinematic coherence can be understood if the satellites are corotating within the plane, as seen around the Milky Way. Considering that the likelihood of finding a single kinematically coherent plane is $\leq 0.5\%$ in cosmological ΛCDM simulations, finding three such systems in the nearby universe seems extremely unlikely.

Michael Boylan Kolchin of the University of Texas notes in a commentary to the study,

> [Proponents of ΛCDM] are in the uncomfortable position of having a theory that explains most astronomical observations by invoking a postulated material that has eluded increasingly sophisticated attempts at detection.

We know so much and we know so little at the same time. What could possibly be more interesting? ■

Everyone Take A Bow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2017

Sarah L. Borland
Communications Coordinator

Frances J. Castellaneta
Communications Coordinator

The public education and outreach efforts of the WAA have been noticed.

Courtesy of Bob Kelly is this image of the January Supermoon setting in trees behind downtown Ardsley .The morning following full moon and perigee. Canon XS on tripod 250mm zoom lens f/7.1, 1/250 seconds, ISO-400. Cropped from wider view.

What Is the Ionosphere?

Linda Hermans-Killiam

High above Earth is a very active part of our upper atmosphere called the ionosphere. The ionosphere gets its name from ions—tiny charged particles that blow around in this layer of the atmosphere. How did all those ions get there? They were made by energy from the Sun!

Everything in the universe that takes up space is made up of matter, and matter is made of tiny particles called atoms. At the ionosphere, atoms from the Earth's atmosphere meet up with energy from the Sun. This energy, called radiation, strips away parts of the atom. What's left is a positively or negatively charged atom, called an ion.

The ionosphere is filled with ions. These particles move about in a giant wind. However, conditions in the ionosphere change all the time. Earth's seasons and weather can cause changes in the ionosphere, as well as radiation and particles from the Sun—called space weather.

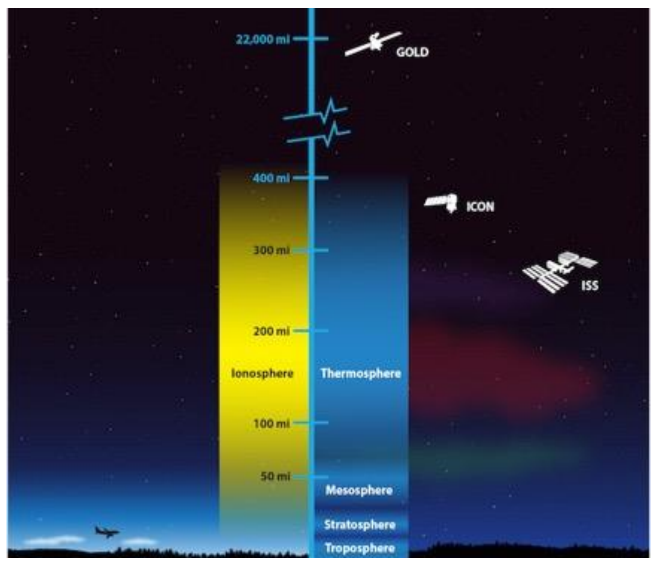
These changes in the ionosphere can cause problems for humans. For example, they can interfere with radio signals between Earth and satellites. This could make it difficult to use many of the tools we take for granted here on Earth, such as GPS. Radio signals also allow us to communicate with astronauts on board the International Space Station, which orbits Earth within the ionosphere. Learning more about this region of our atmosphere may help us improve forecasts about when these radio signals could be distorted and help keep humans safe.

In 2018, NASA has plans to launch two missions that will work together to study the ionosphere. NASA's GOLD (Global-scale Observations of the Limb and Disk) mission launched in January 2018. GOLD will orbit 22,000 miles above Earth. From way up there, it will be able to create a map of the ionosphere over the Americas every half hour. It will measure the temperature and makeup of gases in the ionosphere. GOLD will also study bubbles of charged gas that are known to cause communication problems.

A second NASA mission, called ICON, short for Ionospheric Connection Explorer, will launch later in 2018. It will be placed in an orbit just 350 miles above Earth—through the ionosphere. This means it will have a close-up view of the upper atmosphere to pair with GOLD's wider view. ICON will study the forces that shape this part of the upper atmosphere.

Both missions will study how the ionosphere is affected by Earth and space weather. Together, they will give us better observations of this part of our atmosphere than we have ever had before.

To learn more about the ionosphere, check out NASA Space Place: https://spaceplace.nasa.gov/ionosphere.
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!



This illustration shows the layers of Earth's atmosphere. NASA's GOLD and ICON missions will work together to study the ionosphere, a region of charged particles in Earth's upper atmosphere. Changes in the ionosphere can interfere with the radio waves used to communicate with satellites and astronauts in the International Space Station (ISS). Credit: NASA's Goddard Space Flight Center/Duberstein (modified)

Member & Club Equipment for Sale

March 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.	$50	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.

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