SkyWAAtch

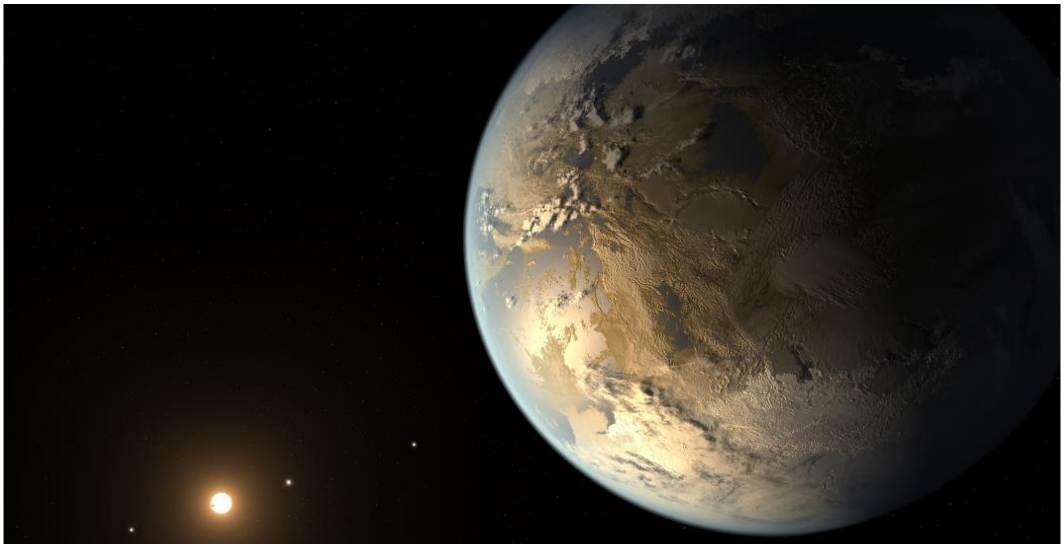


Illustration Credit: NASA Ames / SETI Institute / JPL-Caltech, **Discovery:** Elisa V. Quintana, et al.

Earth-size Kepler-186f

Planet Kepler-186f is the first known Earth-size planet to lie within the habitable zone of a star beyond the Sun. Discovered using data from the prolific planet-hunting Kepler spacecraft, the distant world orbits its parent star, a cool, dim, M dwarf star about half the size and mass of the Sun, some 500 light-years away in the constellation Cygnus. M dwarfs are common, making up about 70 percent of the stars in our Milky Way galaxy. To be within the habitable zone, where surface temperatures allowing liquid water are possible, Kepler-186f orbits close, within 53 million kilometers (about the Mercury-Sun distance) of the M dwarf star, once every 130 days. Four other planets are known in the distant system. All four are only a little larger than Earth and in much closer orbits, also illustrated in the tantalizing artist's vision. While the size and orbit of Kepler-186f are known, its mass and composition are not, and can't be determined by Kepler's transit technique. Still, models suggest that it could be rocky and have an atmosphere, making it potentially the most Earth-like exoplanet discovered so far (source and credit: APOD).

In This Issue . . .

Events for May 2014

WAA May Lecture

"The Universe: Our Mysterious Home"
Friday May 2nd, 7:30 pm
Lienhard Lecture Hall, Pace University
Pleasantville, NY

Our speaker is Dr. Anže Slosar. As Dr. Slosar notes: Lev Landau, a famous Russian physicist, once quipped that cosmologists are often in error, but never in doubt. Not that long ago, they could afford to be like that, because measurements of the behavior of the Universe were few and far apart and riddled with large uncertainties. The last decade has changed that. We have now characterized our universe with a number of interlocking experimental probes that give a coherent picture about the history, evolution and contents of the Universe. The picture that emerges, however, poses more new questions than it resolves: in addition to the matter we know and are made of, the universe contains two additional mysterious components dubbed dark matter and dark energy. Dr Slosar will describe this entertaining story. Free and open to the public.

Anže Slosar obtained his PhD from the University of Cambridge in 2003. He worked at Oxford and Berkeley and is currently an Associate Scientist at the Brookhaven National Laboratory on Long Island. He received the prestigious Department of Energy Early Career Award in 2011 and was named one of the Brilliant Ten in 2012 by the *Popular Science* magazine. Directions and Map.

Upcoming Lectures

Lienhard Lecture Hall,
Pace University Pleasantville, NY

On June 6th, Glenn Butler will present "From Underwater to Outer Space--How the STS-61 *ENDEAVOR* astronauts trained underwater to repair the Hubble Space Telescope." Mr. Butler is the founder and CEO of the Life Support Technologies group.

Starway to Heaven

Saturday May 24th, 8 pm.
Meadow Picnic Area,
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for May, weather permitting. Free and open to the public. The rain/cloud date is May 31st. **Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions.

WAA Club Picnic

Saturday June 14th, 1:30 pm
Trailside Museum, Ward Pound Ridge

The event is for WAA members and their guests **only**. Club members are encouraged to bring side-dishes, salads and desserts. Tell the guard at the gatehouse you are going to the WAA Picnic. Further details will be provided by email blasts. Directions.

New Members. . .

Charles Gulian - Ossining
Beth Gelles - Scarsdale
Alex Fijman - Chappaqua
George Maroulis - Mamaroneck
Red Scully - Cortlandt Manor
Robert Danehy - White Plains
Scott Rubin - Yorktown Heights
Chris Di Menna - Brewster
Jeff Schreier - Katonah
John Benfatti - Bronx

Renewing Members. . .

Lee Mingione - New Rochelle
Theodore Keltz - New Rochelle
Gary Miller - Pleasantville
Ernest Wieting Cortlandt Manor
Raymond Herbst - Mahopac
George N. Thomas - Irvington
James Peale - Bronxville
William Sawicki - Bronx
Craig and Aaron Ross - Glendale
Tim Holden - White Plains
Jimmy Gondek and Jennifer Jukich - Jefferson Valley

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

Westchester
Amateur Astronomers

Almanac
For May 2014 by Bob Kelly

May 6 May 14 May 21 May 28

Jupiter is found lower in the west, getting smaller, but still a joy in telescopes. Get a wide-field photo of Jupiter and the twins as the Gemini stand up on the horizon! The Moon joins their dance line, bouncing on Pollux' knee, on the 3rd and the 31st.

Mars also shrinks quickly as it moves away, but still attracts attention as the third brightest planet in the evening sky. Clouds over the Hellas desert look like a large polar cap; the large contrast with the rest of the ruddy planet making Mars look out of round, and sending people to check the alignment of their telescopes. The northern polar cap is tipped toward us, but is very tiny since it is the northern Martian summer. Asteroids Vesta and Ceres are lurking a just few degrees from Mars, with Ceres waiting for a visit from the Dawn space probe next February. How long of a camera exposure do you need to get all except Dawn in the same photo? The Moon 'photo-bombs' the scene around the 10th.

Mercury starts out May as the second brightest planet in the evening sky. But it's deep in the solar glare after hiding behind the Sun at superior conjunction. It gets dimmer all month but easier to find by mid-May as it gets up to 23 degrees from the Sun. It's the best show for Mercury in our evening skies this year. Catch it before it fades away after the Memorial Day weekend. Use high magnification to watch its rapidly changing phases.

Saturn is closest for the year around the 10th. The ringed planet makes a splendid appearance in any reasonable optical device over 30 power. Saturn's moons are a highlight all by themselves. Titan is in reach of smaller scopes. Rhea and Dione are noticeable much of the time in moderate scopes.

Iapetus' orbit is tilted more than the others, so it passes to the north of Saturn in early May. Even at magnitude +11 it is sometimes easier to find, away from the distracting bright rings. If you follow Iapetus' progress this month, it will get dimmer as it revolves to Saturn's east. That's when we'll see the darker side of the two-faced moon. Around opposition near the 10th, with the Sun behind us from Saturn's point of view, the tiny particles in Saturn's ring reflect more light back toward its source, making the rings look brighter than usual. The Moon rings in with a close pass on the 14th.

Venus seems very comfortable, staying low in the east, settling in well to the right of the rising Sun all through the summer months. Our 'evil twin' planet is looking smaller each week as it moves swiftly away from Earth, but will be two-thirds lit and getting fuller this month. These two factors will offset to keep Venus near a blazing-bright magnitude minus 4.0. Even with a telescope, the gibbous nature of Venus can be hard to distinguish, but it's easier in a twilight sky. The Moon is nearby during the Memorial Day weekend. See how long you can spot Venus after sunrise, especially with the Moon as a guide.

We may have a new meteor shower this month. Set your alarm before 3am EDT on the 24th. The Earth's orbit is expected to pass through the plane of Comet 209P/LINEAR's orbit before dawn that day. The cloud of particles shed by the comet on its trips through the inner solar system is predicted to be thick enough to produce a good meteor shower. The meteors will appear to radiate from the direction of the constellation Camelopardalis, the Camel, a faint constellation near the celestial North Pole. Look overhead or in the darkest, least obstructed part of your sky to see the most meteors. Keep count! Don't be disappointed if you only see a few meteors; the ones you see are likely to be brighter and slower moving than meteors you typically see. The comet itself is predicted to be 11th magnitude or fainter when it passes at a safe distance from Earth five days later.

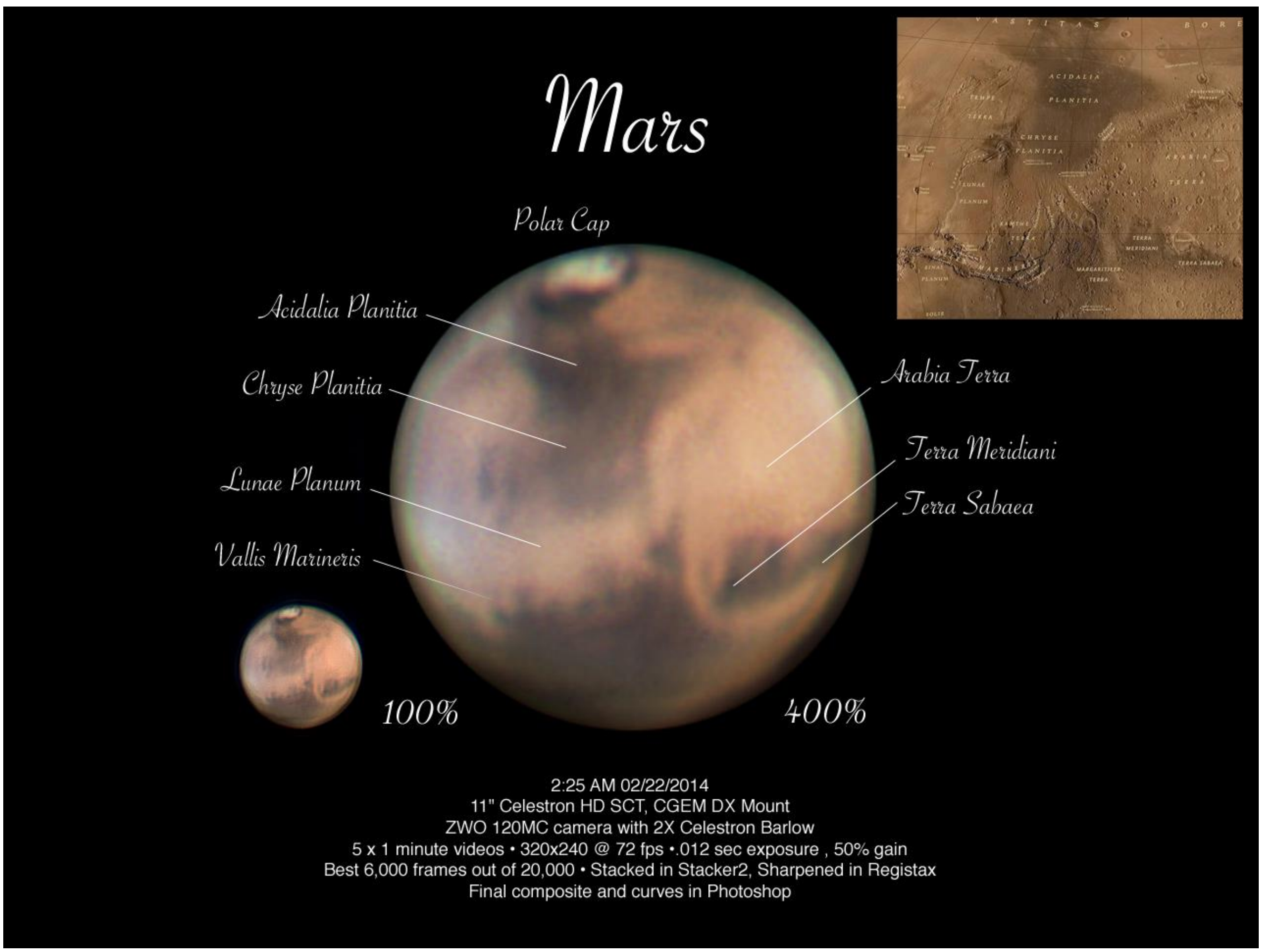
Telescopic observers of the Moon on the evenings of the 4th and 6th may notice a fifth magnitude star near the dark limb of the Moon. On the 6th, the Moon stays up long enough for us to see the star blocked out by the Moon, at about

1125pm EDT. Lovers of Luna might want to view the Moon around the 19th, when it will be near perigee for the month. The heavily cratered South Polar Region will be tipped a bit more than usual toward Earth. The rugged terrain has lots of details, and may be the site of a future Moon base, so crank up the power and see for yourself!

Another comet discovered by the PanSTARRS sky survey—C C/2012 K1—will be a binocular object inside the handle of the Big Dipper in early May. SS sightings will resume in the morning sky after the 14th. In early June, you can see as many as five passes a night.

Mars Imaged

By Carl Lydon



Inset map National Geographic Society. See: *http://www.my-walls.org/wallpapers/2013/03/Mars-Map-Planet-1080x1920.jpg*

Old Universe, Older Stars?
By Larry Faltz

We've learned a lot about our universe in the past 100 years. Einstein's General Theory of Relativity gave us the first coherent description of space and matter. Einstein believed that spacetime was infinite and static, and in order to counteract the attractive, potentially collapsing gravitational effects of mass he added a term that counteracts gravity, the "cosmological constant" Λ (lambda), to his beautiful field equation that describes how matter curves space:

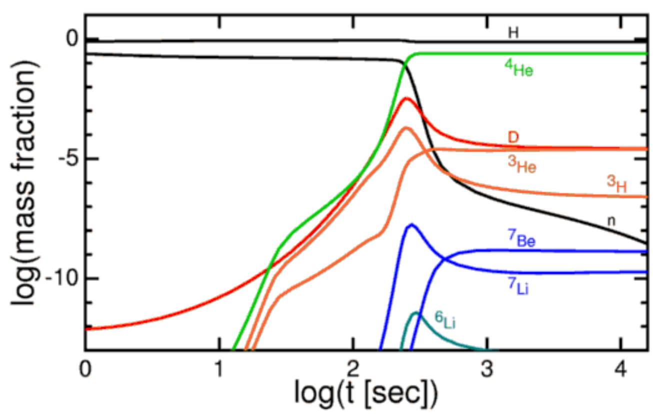
$$R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R + g_{\mu\nu}\Lambda = \frac{8\pi G}{c^4} T_{\mu\nu}$$

In 1922 Aleksandr Friedmann published a model derived from General Relativity that described an initial explosive creation event followed by a period of expansion, then contraction to a big crunch. He also proposed models in which the universe expands infinitely and one in which the expansion slows asymptotically towards stasis. In 1929, Edwin Hubble showed that the universe was indeed expanding, causing Einstein to withdraw (ultimately erroneously, as we have recently learned) the cosmological constant.

As astronomers, physicists and cosmologists worked through the implications of an expanding universe, their attention naturally turned to its origin. Rolling the movie backwards led inevitably to the Big Bang and interest in how fundamental particles were created in that event. By the late 1940's, enough was known, or at least known within a theoretically consistent framework, to postulate a mechanism for the creation of atoms and make a prediction of their abundances in the early universe.

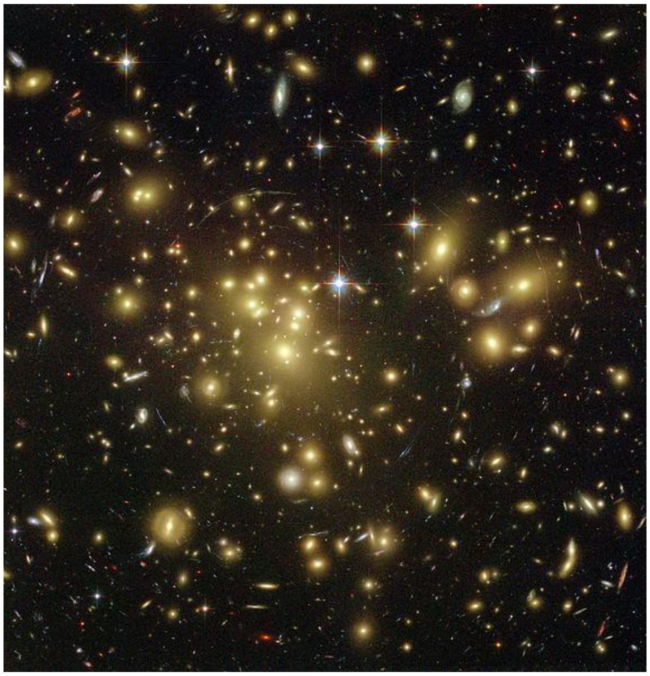
The seminal paper was a letter to *Physical Review* in 1948 entitled "The Origin of Chemical Elements" by Ralph Alpher, Hans Bethe and George Gamow. As has often been told, the eminent Bethe (who was the first to explain the mechanism of stellar nucleosynthesis due to hydrogen fusion) was actually not involved in the writing of the paper, although he did review it prior to publication. His name was inserted by the playful Gamow so that the authors' names would be a pun on the first three letters of the Greek alphabet, alpha, beta and gamma.

The paper proposed that the origin of the atomic content of the early universe was a consequence of the cooling of a "highly compressed neutron gas which started decaying into protons and electrons when the pressure fell down as the result of universal expansion." Neutron capture was chosen as the mechanism for the origin of nuclei heavier than hydrogen (which consists of a single proton). Atom formation started at about 20 seconds after the Big Bang, when the density of the universe was $2.5*10^5$ g/cm^3, and lasted for about 20 minutes, resulting in a universe containing mostly hydrogen and helium. Subsequent theory, astronomical observations and experience with nuclear chemistry identified stellar nucleosynthesis and supernova explosions, rather than pure neutron capture, as the mechanism for the formation of heavier atoms, but the paper appears to be accurate in its description of the opening round of cosmic chemistry. Refined calculations show that Big Bang Nucleosynthesis (BBN), as it is now known, started when the universe had a temperature of $1.16*10^{11}$ °K and ended when expansion dropped the temperature to $1.2*10^9$ °K. The resulting plasma had a composition (by mass) of 75% hydrogen-1 (protons), 25% helium-4, about 0.01% hydrogen-2 (deuterium) and trace amounts (less than 10^{-10}) of lithium-7 and beryllium-9. There was nothing heavier. It was out of this material that the first stars formed.



Atomic abundances due to Big Bang Nucleosynthesis. Protons (H) and neutrons (n) were created at the end of the quark-gluon plasma era (10^{-6} seconds after the Big Bang). Tritium (^{3}H) has a half-life of 12.3 years, so any made in BBN has decayed, as did any free neutrons ($T_{1/2}$ of 15 minutes). (UCLA)

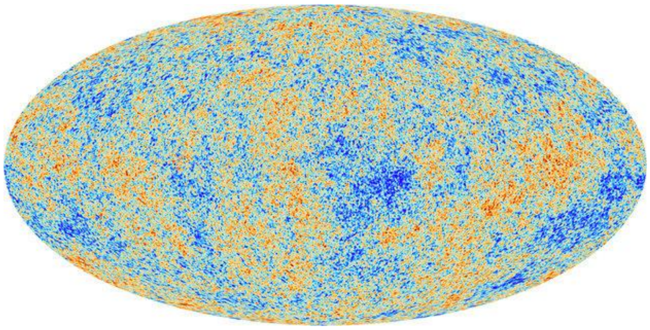
Prior to the creation of atoms, perhaps even prior to the materialization of quarks, dark matter particles were created. We know nothing about what these particles are, although we are certain that they exist, comprise nearly 85% of all the matter in the universe and interact with other particles almost solely through the gravitational force. The existence of dark matter was first proposed by Jan Oort in 1932, based on his observations of the velocities of Milky Way stars. Observations of the orbital velocities of galaxies in clusters published by Fritz Zwicky in 1933 also pointed to the existence of unseen mass.



Galaxy cluster Abell 1689. Top: Hubble image showing more distant galaxies gravitationally lensed into a series of arcs. Bottom: Map of the dark matter (blue) derived from analysis of the lensing.

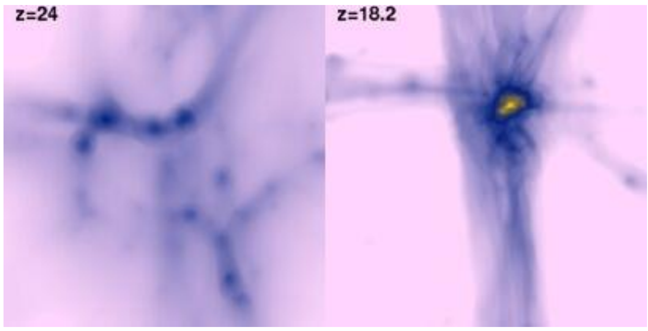
Many observations on galactic scales can only be logically interpreted by invoking the existence of large amounts of unseen mass within galaxies and clusters. When images of distant galaxies gravitationally lensed into arcs by foreground clusters are analyzed, the mass of the cluster calculated from the visible matter is inadequate to account for the amount of lensing observed. Some of the features of the WMAP and Planck cosmic microwave background data are best explained by dark matter.

After BBN, the early universe was so hot that positively charged nuclei (protons in hydrogen or helium nuclei with 2 protons and two neutrons) and negatively charged electrons were not coupled into atoms, existing instead as a plasma. Photons scatter off free charged particles, and as a result space was an impenetrable fog. About 380,000 years after the beginning, expansion had cooled the universe to a temperature of 3,000° K, allowing the nuclei and electrons to couple as atoms. This allowed space to become transparent to photons. Those photons (with a range of wavelengths of a 3,000° degree "blackbody") were free to travel across the expanding universe, the wavelengths lengthening with expansion. We detect them today as the cosmic microwave background radiation, exhibiting a thermal black body spectrum with a temperature of 2.72548±0.00057 °K. When these were detected in 1965 by Penzias and Wilson, the case for the Big Bang was made. You can actually observe some of these photons yourself if you still have one of those old analog television sets. Put a "rabbit ears" antenna on the TV and tune the set to channel 6. You'll see a lot of "snow". A few percent of the dots on the screen are due to photons from the cosmic microwave background. Unfortunately, you can't tell them apart from all of the other static. To see faint objects in a telescope, you use "averted vision" but for this you'll have to use "averted imagination."



The Cosmic Microwave Background as imaged by the Planck space telescope

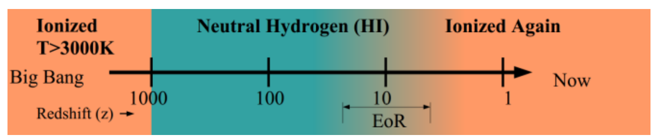
The interaction of the hydrogen/helium regular matter and the dark matter, both slightly inhomogeneous due to quantum effects at the end of cosmic inflation (10^{-32} seconds after the Big Bang) slowly condensed the matter into the first stars, called Population III in a kind of backwards nomenclature. Population II are older stars that are the progeny of these first stars, born relatively early in cosmic history in an environment with more "metals", which in cosmic parlance means anything heavier than helium, than the nearly pure H/He primal universe of Population III. Population I stars are recent, relatively metal-rich (1-2%). No Population III stars have ever been directly seen. They have all long ago burned their nuclear fuel and blown up as supernovas, enriching their environments with heavier elements that were incorporated into the next generation of stars. We can perhaps have a glimpse of their primal light in images of the earliest galaxies from the Hubble deep field or in faint, distant galaxies that have been gravitationally lensed by foreground clusters, but it's suggested that most of those galaxies were formed from the progeny of Population III stars, rather than containing the original stars themselves.



Two frames from a computer simulation of the condensation of hydrogen and dark matter the early universe (z=red shift, 24 corresponds to about 120 million years and 18.2 to about 200 million years after the Big Bang) Simulation by Abel, Bryan and Norman (2000). A good article on computer simulations was published by Abel in Physics Today.

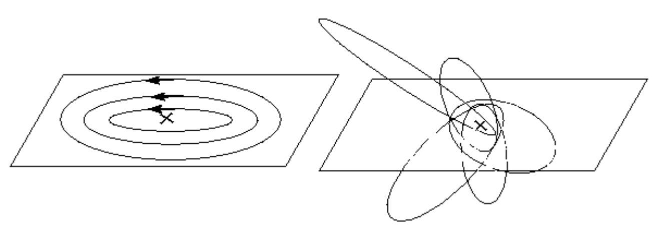
Much of the research on the formation of the earliest stars is done by computer simulation, with some observational assistance due to advancement in terrestrial telescope technology (larger mirrors, mountaintop settings, adaptive optics, refined spectroscopes and interferometry) and the remarkably capable space telescopes that image in spectral ranges not available on Earth because of our atmosphere. If all of the important attributes of the starting material are properly taken into account and the programming closely simulates the actual initial conditions and dynamical interactions (which means it was a very good guess, since we don't *really* know the actual initial conditions and dynamical interactions) and there's enough computer power, the output resembles something that makes sense and can be squared with what we observe today. Based on these simulations, it appears that filaments of dark matter large enough to condense massive amounts of hydrogen around them began to materialize as early as 100 million years after the Big Bang. The earliest star-forming hydrogen-dark matter clumps are estimated to have weighed 10^5 to 10^6 solar masses. From this material, it seems likely that one large star formed, with the remaining gas more or less dispersed within the condensing filament, eventually forming a galaxy in the next round of cosmic history, at least several hundred million years later. The dark matter in a primordial clump remained in a spherical halo, but the regular matter, which was capable of absorbing or emitting radiation and thus transferring energy, began to rotate and formed a disk, which later became the galaxy.

Population III stars were huge, hot and had short lifetimes, perhaps only 3 million years. They probably weighed 10^2 to 10^3 solar masses and had surface temperatures of 10^5 °K. Their intense ultraviolet emissions re-ionized any neutral hydrogen surrounding them, resulting in bubbles of ionized hydrogen plasma that were, like the pre-CMB universe, opaque to photons, a kind of "hydrogen fog" that eventually dissipated over the next 900 million years as these very hot stars ran out of fuel, went supernova and created both black holes and heavier nuclei that were incorporated into the next generation of stars.



The state of hydrogen in the universe. EOR=Era of Reionization. Graphic from Aaron Parsons, UC Berkeley (https://casper.berkeley.edu/papers/2004-11-17_Ay228_EoR.pdf)

Population III stars are all gone, extinct, blown up. Population II stars are the next generation, metal-poor compared with young Population I stars like our Sun, but nevertheless much richer in heavier elements than their Population III forbearers. Because they formed in a more complex environment of gas, dust, supernova winds and galactic gravitation than Population III stars, they are smaller and longer-lived, and many of them are still around today, in and surrounding our galaxy. A few are actually not very far away from us.



Population I stars: ordered motion. Circular orbits in the disk plane; younger, more metal-rich.

Population II stars: random motion. Eccentric orbits passing through disk plane; older, more metal-poor.

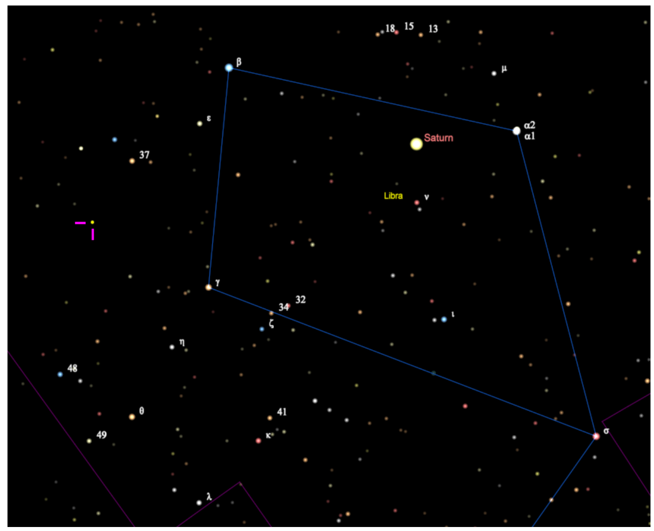
Population II stars have metal abundances 0.001 to 0.3 times that in our Sun, which itself contains about 2% metals. The stars in the globular clusters that form a spherical shell surrounding our galaxy are Population

II. There are also Population II stars in eccentric orbits around the center of the Milky Way, while younger, metal-rich Population I stars form a disk that makes a familiar sight in our sky. The wayward Population II stars were probably formed in dwarf galaxies that were disrupted by the tidal force of the Milky Way.

M53, a cluster of mostly Population II stars (Hubble)

You might expect Population II stars, which formed in the first billion years of the universe right after the brief Population I era ended, to be very far away and seen only in distant galaxies at enormous red shifts. But some of them are right next-door. It is true that what is very far away is old, but some things that are old are not far away. After all, even our little bit of personal space is just as old, cosmically speaking, as the rest of the universe. So some old Population II stars formed not far from us and they stayed in our galactic neighborhood even as the universe expanded, the result of local gravity being stronger than the force of universal expansion. Other Population II stars ran out of fuel, blew up and contributed their metals into the local stellar environment for the eventual creation of Population I stars.

HD 140283, a 7.2 magnitude star in Libra just 190 light years from Earth, was found over a century ago to have a very high proper motion (that is, it moves on a trajectory across the sky detectably over time). Its spectrum shows a metal content of about 0.4% of the Sun's, making it a member of Population II. Its parallax was accurately determined and so its distance and luminosity could also be calculated. These data, combined with its surface temperature of 5,777° K, give HD 140283 an age of 14.46 ± 0.8 billion years. Oops! That's older than the universe, but we are saved by the error bars in the data and some of the bolder assumptions within the calculations. [We discount the inevitable claims by creationists that the conflicting result proves that the Big Bang never happened and God arranged all this information just to fool us in our 6,000 year-old universe!] In any case, this star had to have formed quite early in cosmic time, and it's been hanging around our part of space since then. We should be able to view it at one of our WAA star parties this summer, when it will be low in the southern sky, not far from Saturn.



Location of HD 140283 (pink ticks). Map is for June 15, 2014. (Cartes du Ciel)

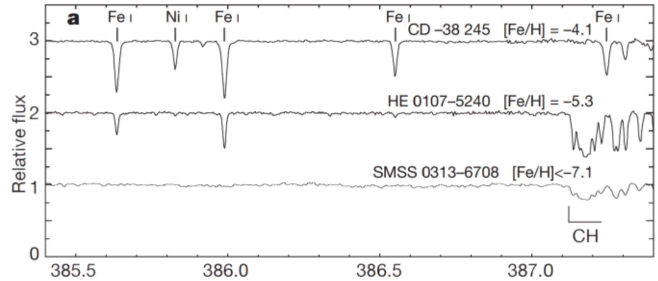
A recent paper (Keller, SC, *et. al.*, A single low-energy, iron-poor supernova as the source of metals in the star SMSS J031300.36-670839.3, *Nature* 2014; 506: 463-465) examines a 14.7 magnitude star in our galaxy in the southern constellation Hydrus. The star was imaged by the SkyMapper telescope, an automated 1.3-meter survey instrument at the Siding Spring Observatory in Australia. The heart of the f/4.9 instrument is a custom-built 268 megapixel camera that captures a field 29 times larger than the full moon every minute. A series of filters enables the camera to accurately record stellar brightness and spectrum, from which age, mass and temperature can be derived.

Observations with the filter system showed that SMSS 0313-6708, as it is called, has a remarkably low ratio of iron to hydrogen. For this star, the actual ratio of iron to hydrogen is $< 10^{-7.1}$ but non-integer exponents are confusing so [Fe/H] is given as a logarithmic ratio, < -7.1. This metal content is a lot lower than in previously found ultra-low metallicity Population II stars, the metal-poorest of which, HE 1327-2326, has a [Fe/H] ratio of -5.6, much lower than our neighbor HD140283's ratio of -2.4.

SkyMapper, Siding Spring, Australia

Based on models of galactic chemical evolution, supernova dynamics and the abundances of calcium, magnesium and carbon in the star, the authors propose that it formed from gas that came from only one relatively low-energy Population III supernova, whereas previously detected metal-poor Population II stars probably formed from composites of several supernovas. Not only that, the mass of the progenitor Population III supernova was calculated to be somewhere between 10-70 solar masses. That's relatively small for a Population III citizen if previous models are to be believed. Additional data supporting this claim is that supernovas of less than 10 solar masses release large amounts of iron, while those greater than 70 solar masses do not produce the amount of carbon seen in SMSS 0313-6708.

The image below shows the spectrum of SMSS 0313-6708 in the range of several strong iron bands. There is essentially no absorption by stellar iron. The baseline just doesn't budge.

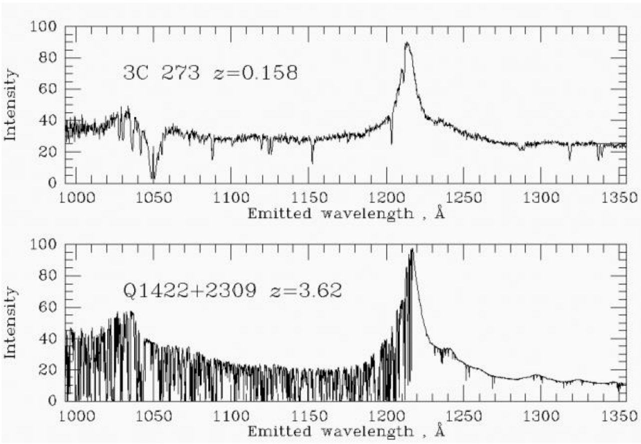


Data from Keller *et. al*. showing absence of iron in SMSS 0313-6708 compared to previously discovered low-metallicity Population II stars

The authors say that, "In this model, a central black hole is formed into which the core of the massive [progenitor Population III] star is subsumed. The extensive fallback of material into the black hole traps the centrally located iron and other heavy elements synthesized during the star's lifetime. Lighter elements, for example carbon and magnesium, residing at larger radii within the supernova progenitor are dispersed in the explosion." An important implication of this research is that if there were many smaller Population III stars and they exploded in relatively low-energy supernovas, the cosmic environment would have not been very enriched in metals, which would permit the continued formation of Population III stars for at least a bit longer than previously thought. That information would have to be included in any models of galaxy formation in the early universe.

At the time of the Cosmic Microwave Background (red shift z=1,096), the universe had cooled enough for atoms to form, making it transparent to photons. But once the first hot, massive stars formed (z= 20-25), their ultraviolet radiation provided enough energy to re-ionize hydrogen in interstellar and intergalactic space, a process that probably continued because early galaxies had a lot of hot stars. This era of reionization is estimated to have ended at a red shift of about 6, about 950 million years after the Big Bang. We can study it by looking at the spectra of distant quasars whose light passes through the intergalactic medium.

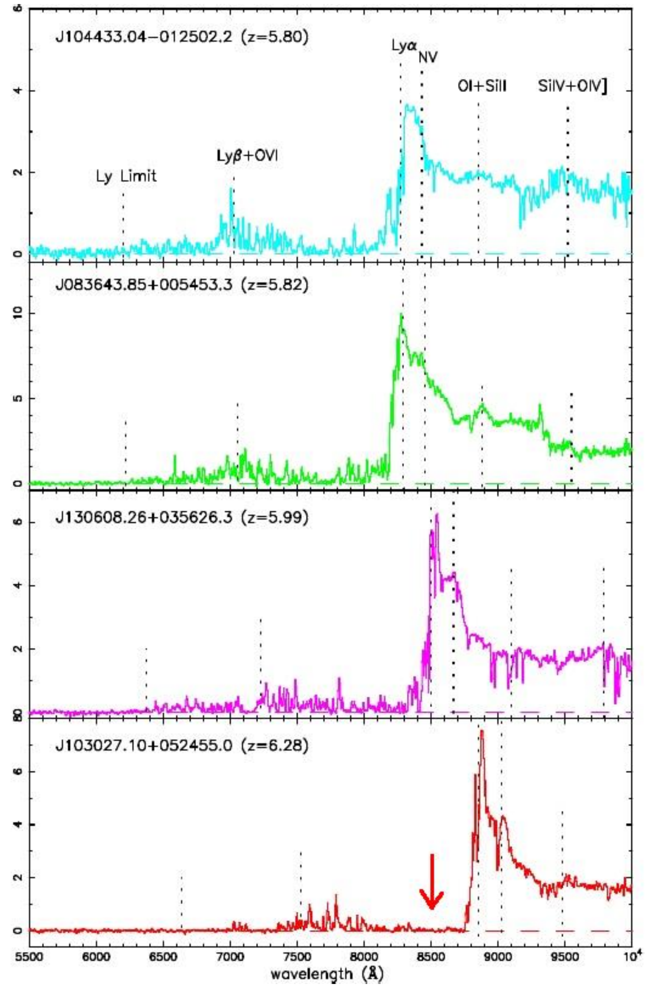
The spectrum of hydrogen atoms has a peak at 1216 Å in the ultraviolet, resulting from the transition of the electron between the first and the second excited state (principal quantum number *n* 1 and 2). This is the Lyman-alpha (Lyα) line. Because of the expansion of the universe, the Lyα line is red-shifted to longer wavelengths, the amount of shift depending on the distance of the hydrogen from us. Any light from distant quasars will be absorbed at different wavelengths as it passes through hydrogen clouds at different distances. The collection of different absorption lines in the quasar's spectrum due to intervening neutral hydrogen clouds is called the Lyman-alpha forest, discovered by Roger Lynds in 1970.



The Lyman-alpha forest in a high-redshift quasar (bottom) caused by light passing through neutral hydrogen clouds at various intervening red shifts. There is little neutral hydrogen between us and the closer quasar (top). (http://www.astr.ua.edu/keel/agn/forest.html)

When we observe quasars with red shifts greater than z=6, there is a suppression of quasar emissions in the forest at wavelengths lower than the Lyman-alpha peak at the quasar's redshift. This is called the Gunn–Peterson trough and is taken as evidence of reionization. Since younger (closer) quasars lack this feature, reionization must have ended around z=6.

Even though Population III stars have never been observed, there are detailed theoretical models of how they form, how they burn their nuclear fuel and what happens to them when they've exhausted their atomic nutrients. Population III stars between 40 and 65 solar masses could have a series of pulsations that could go on for years or even centuries before black hole collapse. The pulsations could eject some metals synthesized inside the star into the surrounding medium. Stars between 65 and 133 solar masses would be disrupted by a single pulse and spew their material directly into space, while stars >133 solar masses would be expected to collapse directly into to a black hole. In any case, stellar nucleosynthesis in a Population III star will create the expected species of heavier elements during its lifetime (up to iron), as well as cataclysmically creating of all the elements in the Periodic Table when it goes supernova.



Spectra of quasars with high redshifts. The lowest panel shows a quasar with z=6.28. The red arrow shows a dearth of Lyman-alpha forest lines, the Gunn-Peterson trough, just to the left of the main Lyα peak. From Becker, RH, *et. al*., Evidence for reionization at Z~6: Detection of a Gunn-Peterson trough in a Z=6.28, *Astronomical Journal* 2001; 122:2850.

You might appropriately ask why the universe is transparent to photons now even though hydrogen got re-ionized during the era z=6-20. Cosmic expansion has so separated the matter in the universe that photons are relatively unlikely to encounter any matter at all during their journey across space. Interstellar space has about 10^6 atoms per cubic meter, which sounds like a lot, but it's basically empty considering that one cubic meter of water has over 10^{29} atoms. Intergalactic space is emptier still, with a matter density of only 1 atom per cubic meter. The atoms individually have a lot of kinetic energy, with temperatures of 10^5 to 10^7 K. In a sense, empty space is hot. But the truth is the atoms are pretty lonely and photons crossing the universe almost never encounter them.

WAA at the Greenburgh Library

Bob Kelly demonstrating with Halleyscope

WAA was invited to give two educational presentations at the Greenburgh Library this spring as part of a focus on astronomy. The first was held on April 22nd. We were asked to give a practical, show-and-tell session about telescopes to a mixed audience of adults and children. Participating from WAA were Vice President for Field Events Bob Kelly, member Kevin Parrington, Senior Vice President Charlie Gibson, and President Larry Faltz. There was substantial interest in the program, and an audience of 28 gathered in the spacious and well-equipped Multipurpose Room of the impressive library facility on Route 119 and Knollwood Road in Greenburgh (near Exit 4 on Route 287).

Bob Kelly took the lead and provided a wonderfully organized, accessible and thorough introduction to the history of optics and the basics of telescopes, illustrating the phenomenon of refraction with the simple example of water in a glass bending the image of a pencil and the practical demonstration of reflection with an aluminum bowl. Moving on to small refractors including a simple cardboard tube refractor of his own manufacture and then to Charlie Gibson's 8-inch Newtonian reflector in a Dobsonian configuration, Bob talked about the advantages and disadvantages of different types of telescopes and stressed the importance of a stable mount for effective viewing. Larry brought a CG-4 equatorial mount to show its capabilities. Kevin Parrington brought his marvelous self-aligning computerized "talking" Meade LS 8-inch SCT and demonstrated its capabilities. A Celestron Nexstar C90 exemplified the other end of the high-technology spectrum.

After the formal talk, the audience mingled with the WAAers and checked out the individual telescopes. We gave out informative brochures from Celestron about buying a first telescope. (We had picked some up at NEAF and made the appropriate disclaimer to the audience, since WAA does not endorse a particular manufacturer) A large number of astronomy books at every level were on display, some from the library and some brought by Bob.

On May 20th at 7:00 pm, Larry Faltz will give a lecture on "What Can We See in the Night Sky?"

Thanks to librarian Megan Fenton for the invitation and wonderful hospitality and enthusiasm.

Kevin Parrington with the Meade LS-90

WAA at NEAF

We had a very successful NEAF experience this year. Our booth was fully staffed with 18 members volunteering to take at least one shift. A number of other members stopped by to schmooze and some to store their swag, which this year included books, eyepieces, planetary cameras, finders, a tie and sundry other useful and/or fanciful items.

We recruited six new members and two former members renewed, including Jimmy Gondek, who we are most happy to see back on the membership roster. Twenty-two folks signed up for a month of free eblasts, and we hope some of them will join when they see what we're about.

Officially staffing the booth were Bob Kelly, Charlie Gibson, Claudia Parrington, Darryl Ciucci, Pat Mahon, Dede Raver, Ed Edelman, Harry Butcher, Jeffrey Jacobs, Joe Depetro, Larry Faltz, Elyse Faltz, Michael Membrado, Paul Alimena, Tim Holden, Hans Minnich, Gary Miller and Rick Bria.

Former WAA President Mike Virsinger was an exhibitor at the Solar Star Party, bringing his spectacular 100mm Lunt double-stacked hydrogen-alpha scope. A number of viewers remarked that it gave the best image of any of the scopes on the field, which included a 152mm Lunt.

As usual, the lectures were fascinating and the vendors eager to demonstrate their wares, including lots of new technology and many beautifully machined mounts and scopes, some from manufacturers new to the hobby.

Elyse Faltz and Angie Virsinger at the Solar Star Party

Bob Kelly and Doug Baum at the WAA booth

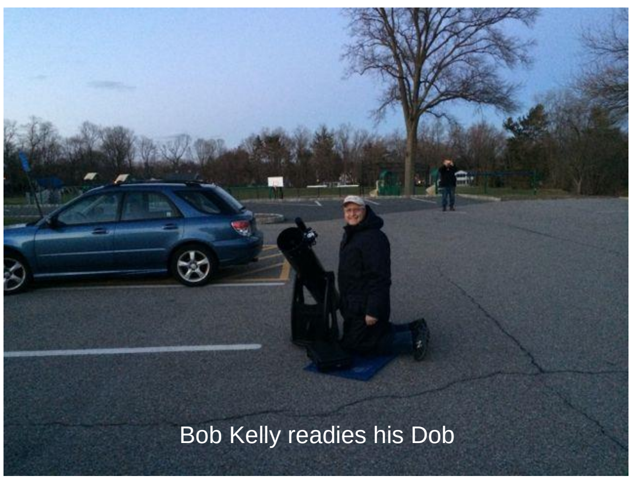
Jeffrey Jacobs and Tim Holden at the WAA booth

Mike Virsinger and the Lunt 100mm

NEAF Panorama

WAA at Quaker Ridge School

Blustery winds and temperatures reminiscent of early March failed to daunt more than a dozen WAA members who operated 16 telescopes for public viewing at the Quaker Ridge School in Scarsdale on the evening of Saturday April 5th. Well over a 100 students and parents attended. They were treated to views of the Moon, Jupiter and Mars as well as such deep sky objects as the Orion nebula, M81 and M82 and the Eskimo Nebula (NGC2392).



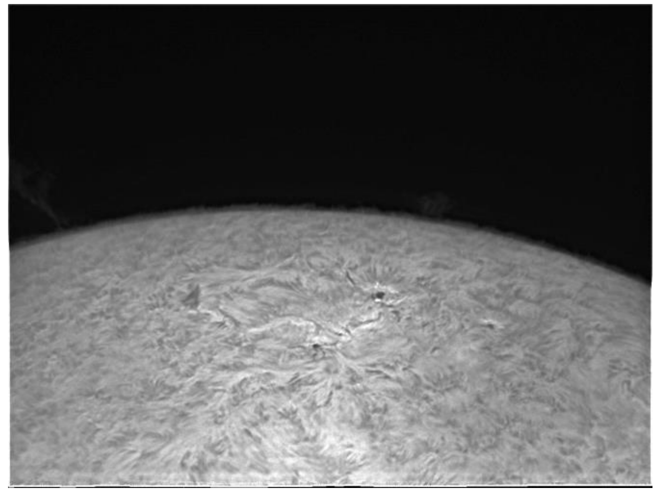
Bob Kelly readies his Dob

WAAers setting up in the parking lot

Photos

Lunar Eclipse

Although clouds plagued Westchester viewers of the April 15th Lunar eclipse, Bob Kelly was able to capture this early morning image of the eclipse underway. He used a Canon Rebel XS with a 55-250mm Canon zoom lens on a tripod (FL 250mm, manual focus, 0.6 sec exposure at F5.6 and ISO 800).



Solar Scope and Image

Courtesy of John Paladini is this image of the solar edge taken through his home made solar scope.

Solar Disk

Courtesy of Larry Faltz, here's a whole-disc image of the Sun in hydrogen-alpha light taken on April 19th with the QHY camera using a double-stacked Lunt 60mm Hα scope and a 0.5x focal reducer (best 25% of 3,100 frames, Autostakkaert2, minimal wavelet processing in Registax, several unsharp mask passes in Photoshop and minimal level adjustment). The camera is so sensitive—75% quantum efficiency in the green part of the spectrum and 50% at the Hα line—that Larry added a neutral density filter to the optical train. Even with the filter and the software set at very low gain, the exposure was only about 1.6 milliseconds per frame.