SkyWAAtch

Comet 45P

Comet 45P/Honda-Mrkos-Pajdusakova received some attention in the news as a comet that might be visible during its closest approach to Earth around Valentine's Day. From his yard in Scarsdale, Mauri Rosenthal found it invisible even with binoculars, but he was able to get this image on Feb 23rd. Here the comet has just crossed into Ursa Major and is about 0.18 au (17 million miles) from Earth as it recedes from the Sun. This image is a PixInsight processed stack of 40 two and three minute exposures using a Borg 71FL lens on a Starlight Xpress SX-694C camera, mounted on an Ioptron CubePro configured in guided equatorial mode.

In This Issue . . .

Events for March

WAA March Lecture

"Going to Mars or Bust"
Friday March 3rd, 7:30pm
Leinhard Lecture Hall,
Pace University, Pleasantville, NY

Continuing our Mars Mania presentations, Al Witzgall will discuss prospects and problems of travel to the Red Planet. Mr. Witzgall is a frequent speaker on astronomy topics. He holds a Bachelor's degree in Earth Sciences from Kean University. He is an active long-term member of the Amateur Astronomers, Inc. of Cranford, NJ, and is a past president of that organization. He is also active at the New Jersey Astronomical Association in High Bridge, NJ, serving there as its Vice-president. He is currently a senior optician for ESCO Optics of Oak Ridge, NJ. His career in optics started with building telescopes in his basement during his high school years. In 1977, one of them, a 10-inch reflector, took First Award at Stellafane. Directions and Map.

Upcoming Lectures

Pace University, Pleasantville, NY

On April 7th, our presenter will be Hans Minnich who lectures on astronomy at Fordham University.

Starway to Heaven

Saturday March 18th, 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 25th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Brian Devaney - Port Chester

Renewing Members. . .

Kenneth and Michael Masiello - Ardsley
Ireneo Fante - White Plains
Rick Bria - Greenwich
Joseph Depietro - Mamaroneck
Alex Meleney - Greenwich
William Sawicki - Bronx
MaryPat Hughes - Briarcliff
Michael & Angela Virsinger - Seaford
Jay Friedman - Katonah
Kevin Doherty - White Plains
John Markowitz - Ossining

Join WAA at NEAF, April 8-9th Rockland Community College, Suffern, NY

WAA will have a booth at the Northeast Astronomy Forum, to be held at Rockland Community College on Saturday, April 8th and Sunday, April 9th. This is the nation's premier astronomy show, with a vast diversity of exhibitors, vendors, equipment, lectures by leading astronomy figures and, weather permitting, the famous Solar Star Party.

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

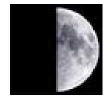
Wanted Assistant Editor

The WAA newsletter (the *SkyWaatch*) is seeking an Assistant Editor. If you can help, please let us know. Your participation in editing, compositing and proofreading tasks or submitting articles or images, will be much appreciated. Email Tom at waa-newsletter@westchesterastronomers.org.

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

Westchester Amateur Astronomers

ALMANAC
For March 2017 by Bob Kelly


Mar 5


Mar 12


Mar 20


Mar 28

Venus plays peek-a-boo around the Sun, giving us a two-fer late in March. Did you notice Venus looking higher in the sky in February? It's closer to the Sun, but higher up the Ecliptic, ahead of the Sun's on its path, so from our point of view in the Northern Hemisphere, it seems to be moving to line up directly over the Sun as it sets.

From night-to-night, Venus appears to slide down the Ecliptic into the solar glare after its long run in the evening sky. Then, from March 15th though the 25th, Venus sets after the sun but also rises before the Sun. That's because Venus sails 'high and wide' of the Sun, passing 8 degrees north of the Sun on the 25th as Venus swings between the Earth and Sun this month. Seasoned daytime observers may be able to block the Sun and follow Venus day-to-day throughout this inferior conjunction with the Sun. The rest of us can see how many days we can see Venus in both the morning and evening skies.

Mercury's starts out March in the Sun's glare. Find it in the SOHO C3 camera through the 15th. Venus misses the camera's field. Mercury and Venus pass each other, but far apart, on the 18th. Mercury goes on to give the best view in the evening sky this year for the Northern Hemisphere.

Mars, the solar system's middle child, is still chillin' above the southwestern evening horizon. Now it's slowly moving toward the horizon, wondering 'where have all the planets gone?' No details to be seen on its disk, due to its being so far away on the other side of its orbit. But Mars is fun to track, seeming to float on the evening twilight.

Jupiter swells a few more arc-seconds wider on its way to opposition with Earth on April 7th. It's still highest after midnight, but views are getting better for late evening observers as Jupiter rises by 9pm. Jupiter shows the most detail of any planet in our telescopes. During the last opposition, I could just make out some detail in the zone just downstream of the Great Red Spot. Some great amateur photos showed it as an area that looked like 'bubbles' and confirmed I was seeing something real, even if I couldn't quite resolve it. So you never know what you might notice, if you give the planet some time in some steady skies. This year, Jupiter is about its furthest from the Sun, so not quite as large as past years.

Sunrise, local time, jumps from 6:13am to 7:11am on the 11th. Sunset shows a similar jump to 6:58pm, as we switch to Daylight Time. Watch Orion and Sirius 'back up' in the sky when viewed at the same clock time just before and after the change to Daylight Time.

The time change makes puts Saturn in a darker sky before work. The ringed planet, with rings on full display, is low in the southern sky. Two-faced Iapetus is directly north of Saturn on the 10th, dimming as it heads eastward.

The Moon makes another pass at Aldebran, the brightest of the Hyades, but it's only an honorary member of the cluster. On the evening of the 4th, the quarter Moon blocks out the red giant for only about 20 minutes shortly after 11pm EST. With the Moon only half-lit, it will be easier to see the star disappear behind the dark edge, maybe even without optical aid. Steadily held binoculars or any telescope will make the view even better. The edge of the occultation zone is just to our north. If you get to where the star grazes the lunar limb, you may be able to see Aldebran appear to wink on and off as it cruises behind lunar mountains and crater rims. To find out a good location up on the Taconic Parkway if you want to see this, see http://occultations.org/aldebaran/

Find your way to the gap between Leo and Cancer to watch 41P/Tuttle-Giacobini-Kresak sprint through on its way to the Ursa Major. 41P (or TGK to its friends?) becomes circumpolar in April as it passes 13 million miles from Earth at perihelion. A binocular object? Or better?

The International Space Station is the morning sky until the last week of March when it's back in the evening sky.

Westchester Amateur Astronomers

The Astronomer at the Movies: *Arrival*

Larry Faltz

Denis Villeneuve's film *Arrival* opened in November 2016. The film's plot revolves around the sudden appearance around the world of a dozen lozenge-shaped alien space ships and our efforts to communicate with the extraterrestrial beings that pilot them, but the resolution of the action hinges on the nature of time.

Contact with alien civilizations is a subject worthy of amateur astronomer interest and I've written about it on several occasions in these pages. Suffice it to say that this film mostly eschews the paranoid view of first contact, the one that allows the special effects guys to put in lots of explosions as seen in films such as *War of the Worlds*, *Independence Day*, or even the earnest 1950's classic *Earth vs. the Flying Saucers* (with special effects by the great stop-motion artist Ray Harryhausen). It's doubtful that the first alien visitors will be violent conquerors. Although we can't be certain that their moral code will be similar to ours, we have reasonable hopes that their evolution and conquest of space make them rational and beneficent. First Contact will be a problem of communication, a job for linguists and cryptographers on both sides. For an excellent discussion of these points and others relating to the impact on our own society of discovering or encountering extraterrestrial life, read *The Impact of Discovering Life Beyond Earth* edited by astrobiologist Steven Dick (Cambridge, 2015).

Something useful happening in Congress, in *Earth vs. the Flying Saucers* (1956)

Arrival's protagonist is linguist Louise Banks (played by a subdued and effective Amy Adams), a college professor who is recruited to assist in deciphering the aliens' language. Some sounds have been recorded, but they seem more like two iron sheets scraping against each other than any spoken or articulated language. Ultimately it is the aliens' written language that is deciphered. Dr. Banks' story begins with the line "This is your story," and we see scenes of her daughter's birth, childhood and premature death as a teenager from a rare, untreatable disease. Flashbacks of these scenes reappear throughout the movie, giving the impression that Dr. Banks is having trouble staying focused on the problem at hand.

As the plot builds towards its climax, we learn that Banks is not remembering the past but she is actually "remembering" the future. Her daughter has not yet lived, and some of the clues that help her decipher the aliens' written language come from the future. The language itself, it turns out, allows its users to see both forward and backward in time. The interweaving of the daughter's story with Banks' progress in solving the riddle is done with great tenderness, and it exposes a moral choice for the protagonist that the film doesn't avoid: if you knew your future child was destined to have a short life, seemingly happy but with some terminal suffering, would you still conceive? Of course, if it's the actual future, you wouldn't have a choice, would you?

Why is it that we don't remember the future? Obviously, it hasn't happened yet. Perhaps it was not such a good idea for the required suspension of disbelief that when I saw the movie I was in the middle of reading Sean Carroll's excellent book about time *From Eternity to Here* (2010). Our inability to remember the future is one of the questions Carroll considers in his analysis of why time flows in only one direction, and my thinking about the film is distinctly scientific.

What is time? This is one of the questions for which absolutely no one has come up with a satisfactory answer. It has no clear scientific explanation, yet it is part of every scientific process. Only mathematics can dispense with time or merely include it as a variable when it needs to. Any colloquial definition we have of time includes or refers to time itself in some way, and so is more or less circular. The American Heritage Dictionary (1969) defines time as “A nonspatial continuum in which events occur in apparently irreversible succession from the past through the present to the future.” The more practical Webster’s New Collegiate Dictionary (1977) defines it as “the measured or measurable period during which an action, process or condition exists or continues.” The Columbia-Viking Desk Encyclopedia (2nd ed., 1960) ducks the question altogether by stating that time is a “concept variously defined from philosophical, psychological, physical and biological aspects” and goes no further. Einstein’s definition is “time is what clocks measure.” The great gravitational physicist and coiner of the term “black hole” John Archibald Wheeler said, “Time is what prevents everything from happening at once.” On the other hand, the Wheeler-Dewitt equation, one of the first attempts to merge general relativity and quantum mechanics into a theory of quantum gravity, has no time term. Wheeler has suggested that time is “emergent” in reality (that is, other physical laws are more fundamental). This formulation has many nay-sayers and has been more or less superseded by string theory. But none of these definitions tell us what time is. “Time” is the most used noun in the English language, and I suspect that holds true in other languages. Poets and philosophers seem to do better than scientists or lexicographers.

> Time is a sort of river of passing events, and strong its current; no sooner is a thing brought to sight than it is swept by and another takes its place, and this too will be swept away. (Marcus Aurelius, *Meditations,* c. 175 AD)

The nature of time is a reasonable subject for astronomers since our appreciation and understanding of the universe is so bound up with its temporal evolution. At star parties we always amaze the audience when we point out that the light from the Andromeda Galaxy (M31) started out 2 million years ago, or even that we see the Sun as it was 8 minutes ago. The universe contains the matter and energy that it does because of events that happened “at the beginning”, and so we are fascinated by occurrences in the earliest moments and we are wont to say, especially to sceptics or the uninitiated, things like “time began with the Big Bang” or “time comes to an end inside a black hole.” Time flirts with *rubato* (for non-musicians, that’s the slight alteration of tempo within the fixed meter of a piece during a performance…listen to any good pianist play Chopin) in the relativistic Einsteinian spacetime universe of clocks slowing at high velocity or in a gravitational field, even though our daily experience is that time marches inexorably forward at a fixed rate of 1 second per second in Newton’s infinitude of fixed spatial and temporal coordinates.

One characteristic everyone will agree on (except perhaps writers looking for plot twists) is that time as we experience it has an unalterable “arrow,” as the American Heritage Dictionary definition emphasizes by using the word “irreversible.” Why is that? Of all the mysteries of the universe, that to me is the most fascinating. It may possibly be unsolvable.

There is good evidence that the laws of physics are time-reversible. The best example of this is CPT invariance. A fundamental particle has identical but opposite properties to its antiparticle if its spatial configuration is reversed (P, for parity), the electrical charge is reversed (C) and the direction of time is taken to run backward instead of forward (T). All three transformations are required by the Standard Model of particle physics. It’s the fundamental symmetry of nature at the subatomic level, and experimental data confirms it to be true. The combination of CP (without T) is asymmetric, as shown by the decay of the neutral kaon, an experiment that won the Nobel Prize to Fitch and Cronin in 1980 and that may explain the dominance of matter over antimatter in our universe. But when time is taken into account, the combination of CPT is always symmetrical. This certainly means that time is “reversible” in some sense at the subatomic particle level. One consequence of CPT invariance is that a particle and its antiparticle should have exactly the same mass.

An ingenious experiment[1] recently addressed this question. Researchers at the Max Planck Institute studied a hybrid helium atom in which one of the electrons was replaced by an antiproton (negatively charged, like the electron). Suspending these atoms in a bath of ultra-cold regular helium at 1.7° K gave them microsecond lifetimes, long enough to be excited to higher energy states with lasers. As the antiprotons decayed to lower energies, they emitted photons in the visible and infrared range. From the spectroscopy data the mass of the antiproton could be determined. It was found to be 1836.1526734(15) times the mass of the electron, within $8x10^{-10}$ of the well-characterized mass of a (non-antimatter) proton. This was one of several results of this remarkable experiment that confirmed CPT invariance. Time should be reversible.

But it's not, at least not at the level of our experience or our description of the universe as a whole.

Like many scientists who approach the issue of the arrow of time, Carroll's primary argument centers on the Second Law of Thermodynamics. The Second Law is often cited as stating that "everything tends to disorder" but it's a poor definition: the existence of life is one proof that order can be built in the universe.

There are a number of accurate formulations of the Second Law of Thermodynamics. In its original form, the result of Carnot's experiments with steam engines in the early 1820's, it describes the physics of heat transfer and the quantity known as entropy. The more modern definition, attributable to Boltzmann's theory of statistical mechanics (1877), states that in any system the greater the number of microstates that can describe a macrostate, the higher the entropy. Entropy is truly remarkable in that it is a quantity that is possessed by a collection of objects but not by the individual objects themselves. You wouldn't say that an atom has any entropy, but a collection of atoms does. Entropy in a closed system, where there is no input of energy to do work, will rise over time and reach a maximum, when the components will be in thermal equilibrium. As far as we know, the entire universe is a closed system. If there's a multiverse, all bets are off, but the multiverse is as yet just an idea.

[1] Hori, M, et. al, Buffer-gas cooling of antiprotonic helium to 1.5 to 1.7 K, and antiproton-to-electron mass ratio, Science 2016; 354: 610-614

The common examples that demonstrate what increasing entropy means are the breaking of an egg, the mixing of milk and coffee and the melting of ice. The egg has a distinct order: there are only a certain number of ways it can be put together and still be an egg. But when you drop one on the ground, there are lots of ways that the parts can end up. The smashed egg has more microstates than a whole egg, so it has more entropy. Similarly, when a small amount of milk is added to coffee, at the beginning there may be only one way to describe the microstates: all of the milk molecules over here, and all the coffee molecules over there. But when they are mixed, there are lots of ways that the individual milk and coffee molecules can be arranged and still look exactly the same on the macro level. The entropy has increased. And, once mixed, there is very little likelihood that the particles will unmix themselves, at least not without the application of a large amount of energy in the form of some sophisticated device than can separate the milk and coffee particles. That means that the system is no longer closed. Ice melts because heat always flows from a warm body to a cool body. When two phases of a substance are at different temperatures, there are fewer ways to arrange the components at the micro level than if the temperature was uniform.

Can't entropy decrease, even a little, if the system is closed? The Second Law is statistical and allows some eddies and currents in the form of quantum fluctuations at the local level. Brownian motion is an example. Fluctuations could increase entropy transiently in a tiny local area, but other fluctuations average everything out. The universe would be different if entropy could decrease easily on its own to a large degree without the input of energy, creating massive fluctuations that have longevity. If this could occur in an already-high entropy universe, conscious, self-aware entities could spontaneously pop into existence without the benefit of evolution. Carroll talks a lot about these "Boltzmann brains." Compared to the eventual end-state of a universe in thermal equilibrium, the entropy of the current universe is low, so this potential event could only occur in the far future. It would take enormous amounts of time (more than 10^{100} years) for the right combination of fluctuations to actually happen, if they happen at all.

Boltzmann brains are an analogue of the possibility, which is true on a statistical basis, that on their own all of the milk particles will at some time move to one side of the coffee cup and all the coffee molecules to the other, and they will separate themselves. The molecules are, after all, moving around randomly, and random chance could have them moving all in the same direction, couldn't it? There is nothing in the laws of physics to forbid it. But to get all of them moving all the time in the same direction is statistically unlikely. It's the equivalent of those monkeys typing out the works of Shakespeare. It could happen, but it won't. The statistical likelihood is much, much longer than the predictable or even possible future age of the universe in current models. I wouldn't bet on anything with odds that are at best 10^{100} to 1.

The unidirectional temporal increase of the universe's entropy may have something to do with what Carroll calls the Past Hypothesis: that the universe had to start in a minimal entropy state and must evolve towards a maximum entropy state, carrying with it the arrow of time. Even though the universe, instants after the Big Bang, was a tiny but roiling chaos of energy at an enormous temperature, it still had relatively low entropy compared with our larger, cooler universe. A problem I have with this argument, even though it seems to be eminently sensible, is that like the definitions of time given earlier it seems to require time itself. It uses the word "started," and that appears to indicate that time was already present in the universe. How can you start something if time doesn't exist? Does maximization of entropy cause the flow of time, or is the change in entropy a consequence of time? As Samuel Butler once said, "A chicken is only an egg's way of making another egg."

There are other arguments in *From Eternity to Here* that may be related to the necessity of time to be unidirectional. One that seems to me to have weight is that the collapse of the quantum mechanical wave function is certainly irreversible. Once a wave function (described by the Schrodinger equation) collapses, such as when a particle is observed or interacts, its past is completely obliterated. The wave function only describes probabilities, but once an observation is made, we can't reconstruct those probabilities. We only know the particle is here, now. This is the "Copenhagen Interpretation" of quantum mechanics. It still begs the question of whether this creates time, or is simply a consequence of quantum mechanics happening in time, but it certainly shuts off a return to the past. In discussing this, Carrol points out that an alternative explanation of quantum mechanics, the "Many Worlds" hypothesis, in which the wave function never actually collapses, might be a way of maintaining time reversibility even in the quantum world.

Black holes also may play a role. Matter and energy disappear when they pass the event horizon. Hawking radiation can't be used to do useful work since it won't be radiated until the temperature of the cosmic microwave background is lower than the surface temperature of the event horizon, which is very low. A one-stellar mass black hole has a surface temperature of 10^{-7} K, and so will absorb radiation from the 2.7 K cosmic microwave background until the universe has expanded enough for the CMB to drop to less than that temperature. This will happen when the universe is about 10^{40} years old. But supermassive black holes have even lower surface temperatures and so they will not start radiating until perhaps 10^{70} years. One of Hawking's two great contributions to physics was his description, with Bekenstein, that the entropy of a black hole is proportional to its surface area. In fact, black holes have the largest amount of entropy in the universe. Their longevity and persistence near the end of a universe in which all matter has decayed may also be a clue to the direction of time.

When entropy is maximal and the entire universe is in thermal equilibrium, there won't be any clocks. Building them and operating them would require energy, and when entropy is maximal, all free energy is gone. If indeed Einstein is right and "time is what clocks measure," (and how often wasn't Einstein right?) then time might indeed stop. However, one can still ask "If there are no clocks to measure time, does it still exist?" (This is analogous to whether a tree falling in the forest makes a sound if there's no one there to hear it.)

There's also a time problem at the low entropy end of the universe. The current origin prediction of cosmology is that after the Big Bang, whatever that really was, the hot, dense universe had enormous mass-energy. At the 10^{-43} seconds (the Planck time), gravity separated from the other 3 forces (which were still united in the so-called Grand Unified Theory). The universe is calculated to have had a diameter at that point of 10^{-33} cm and a temperature of 10^{32} K. Inflation, if it really occurred, ended at around 10^{-35} seconds. The universe was perhaps 100 cm across but its temperature was still 10^{28} K and the mass-energy density (and so gravity) was still insanely high. General relativity tells us that clocks run slower in a gravitational field, and these intense fields would make the clocks run slowly indeed. In a paper posted on the arXiv server in June 2016 entitled "Scientific Realism and Primordial Cosmology," Azhar and Butterfield also note that "at sufficiently early times after the Big Bang, energies are so high that atoms and even nuclei 'melt', so that the proverbial clock and rod with which we measure time and space cannot possibly exist. So we need to scrutinize the limits of the application of our temporal and spatial concepts in such regimes." And so, how "long" did the various phase transitions in the early universe "actually" take? Or is the question meaningless and our counting of 10^{-43} and 10^{-35} seconds not even permitted? It seems that at either end of reality, time may not exist.

Whatever time really is, for reasons that I discussed in my review of *Interstellar*, I don't think time travel can happen. Carroll spends a good deal of his book discussing the point that we can't remember the future. If we could it would be a form of time travel. Information could be sent from the future into its past, and that's enough to trigger the Grandfather Paradox. In this case, you don't go back in time to kill your grandfather, but someone could send you a message to kill theirs, so the paradox still holds. We have to disregard the impossibility of time travel of any form to enjoy the conclusion to the plot of *Arrival,* and it's not hard to do since the way in which it is revealed that Dr. Banks' flashbacks are really flash-forwards is done with drama and poignancy. The entire justification for the aliens' mission to Earth also poses a logical problem for me. The aliens mention that in 3000 years we will need to help them and so they are teaching us this time-defying language. If they knew what was coming and they needed help, why didn't they do something to stop it themselves? Remember, in *Interstellar* the worm hole was put there by humans from the future for a similar purpose, creating the same logical problem. I forgot…it's a movie!

If we could recall the future, we would not have free will. Our future would be irrevocable. We would already have decided everything about ourselves. In fact, we would have decided it as soon as we achieved consciousness. Recall Laplace's Demon (1814), a secular creature who knew the location and momentum of every particle in the Newtonian universe and would therefore be able to plot out the entire course of the future, thus eliminating everyone's free will. Quantum mechanics saved the future for us. (We are not, of course, talking about the religious issue of free will, whether an omnipotent deity totally controls everything about us and we can only act out His plan, as Luther and Calvin believed but Augustine denied.)

Arrival was based on an award-winning short story, "Story of Your Life," by Ted Chiang. In the story, a good bit of technical detail is given about the aliens' verbal and written languages, which are quite different from each other and thoroughly different from human speech and languages. The aliens' complex written language is discovered to use many levels of "center-embedded clauses". Center embedding creates difficulties for parsing, and meaning can get lost even though the speaker's intention is to preserve content while reducing sentence length. When I read about this, I suddenly recalled something that I learned in my symbolic logic class at Columbia five decades ago: the sentence "The bird the cat the dog bit ate died" is actually syntactically correct even though it appears to make so sense whatsoever! It's an example of extreme center-embedding. Its opacity is why one should avoid trying to tighten a sentence too much. The real sentence is "The dog bit the cat that ate the bird that died." I also am somewhat bewildered (and perhaps embarrassed) that I remembered this silly bit of useless information, while most of the details of symbolic logic, far more interesting and important, have long been forgotten. Such is memory. It doesn't come from the future: it only comes from the past and it is not something we can always control. A description of the quirks of memory that I'm particularly fond of comes from the great movie *Citizen Kane*. Bernstein, a long-time associate of Kane's but now in the 1930's an old man, is answering questions from a reporter about Kane's early days. The reporter is trying to find out if he knows anything about the meaning of Kane's dying word, "Rosebud."

> A fellow will remember things you wouldn't think he'd remember. You take me. One day, back in 1896, I was crossing over to Jersey on a ferry and as we pulled out, there was another ferry pulling in and on it, there was a girl waiting to get off. A white dress she had on, and she was carrying a white parasol. I only saw her for one second and she didn't see me at all - but I'll bet a month hasn't gone by since that I haven't thought of that girl.

Don't we all have memories of that kind? We remember only the past, and that peculiarly.

The written *Arrival* story explains more about how the aliens' language reflects their perception of reality. They comprehend past, present and future as a single entity. Dr. Banks is clearly transformed by learning the aliens' language and that allows her to adapt to their time-defying world view. This opens up some very interesting intellectual avenues, for example the Sapir–Whorf hypothesis, a minority view within the field of linguistics that holds that language structures affect the speakers' perceptions of reality. Most linguists believe that either it's the other way around or that cognition is simply a common universal human trait and language is completely independent of it. Like much of linguistics, the issue isn't settled.

One of the movie's essential themes (but not addressed at all in the original story) is how the world's people and governments react to the aliens. At first, the various countries are cooperating in trying to decipher the alien language, but very slow progress is being made. The Chinese try to breach the language barrier by playing a game with the aliens (not a bad idea, since many games can be taught by example and not with language, as many dog owners know). But games are competition, and the word "weapon" seems to pop up as something the aliens want to use. That gets almost everybody except our heroine crazed for fear that what is happening is an alien invasion. She correctly realizes that they mean something more like "tool" and because of her growing realization that she can read the future she communicates with the Chinese, who are ready to blast the aliens, and they stand down, permitting the remainder of the problem to be solved cooperatively. At the end of the film we see that she has published a book about the alien language and appears to have won the Nobel Prize, uniting all the world's governments and societies in the process.

What would be our response to first contact? We have boundless examples of successful and unsuccessful scenarios, from *Star Trek: First Contact* (nice Vulcans) to the famous Twilight Zone episode "To Serve Man" (benevolent-appearing but ultimately evil cannibals) to violent Earth-conquering invaders (too numerous to list). We might discover spectroscopic evidence of civilization in the atmospheres of exoplanets. It's less likely that we will receive electromagnetic signals and least likely of all that we would actually encounter aliens, interstellar distances and the special relativity being what they are. In his book on SETI, *The Eerie Silence*, astrobiologist Paul Davies, who runs the provocatively named "Beyond Center for Fundamental Concepts in Science" at Arizona State University, doesn't even mention the possibility of direct encounter. But coming face-to-face with intelligent aliens would be far more dramatic than picking up a signal, and, as in *Arrival*, newly landed aliens would encounter our own messy social and political world. In the film, the first response of the masses seems to be rioting and looting, but then again that seems to be the first response to any crisis these days. Unlike in *The Day the Earth Stood Still* the aliens will not understand our contentious international political program nor is it likely that they could make sense of the plethora of competitive and mutually hostile religions on Earth. I can imagine finally learning their language and then trying to explain to them the animosity between Shiites and Sunnis, the difference between Reform and Orthodox Judaism, or why there are so many Christian sects.

What is it on Earth that speaks to our nobler nature and might make advanced aliens take us seriously? Surely it will be science. Although I'd love them to appreciate the piano sonatas of Beethoven, the paintings of Velasquez and the plays of Shakespeare, and even to get a laugh from a Woody Allen movie, we could not expect them to understand these socialized and culturally-grounded creations. But they would understand our scientific accomplishments, and an exposition of the history of science on Earth might allow them to grasp of the wider saga of humanity. Then perhaps we could risk exposing them to our currently competing social, moral and political movements. That is, until they come across the masses of idiots who deny evolution, global warming, the Big Bang and many evident events in history like the moon landing and the Holocaust. Then they will be fully justified in not taking us seriously. Whether they wipe us out, collect us for dinner or just move on, as they do at the end of *Arrival*, time, inexorably entropic, quantum mechanical and unidirectional, will tell.■

Solar Eclipse Provides Coronal Glimpse

Marcus Woo

On August 21, 2017, North Americans will enjoy a rare treat: The first total solar eclipse visible from the continent since 1979. The sky will darken and the temperature will drop, in one of the most dramatic cosmic events on Earth. It could be a once-in-a-lifetime show indeed. But it will also be an opportunity to do some science.

Only during an eclipse, when the moon blocks the light from the sun's surface, does the sun's corona fully reveal itself. The corona is the hot and wispy atmosphere of the sun, extending far beyond the solar disk. But it's relatively dim, merely as bright as the full moon at night. The glaring sun, about a million times brighter, renders the corona invisible.

"The beauty of eclipse observations is that they are, at present, the only opportunity where one can observe the corona [in visible light] starting from the solar surface out to several solar radii," says Shadia Habbal, an astronomer at the University of Hawaii. To study the corona, she's traveled the world having experienced 14 total eclipses (she missed only five due to weather). This summer, she and her team will set up identical imaging systems and spectrometers at five locations along the path of totality, collecting data that's normally impossible to get.

Ground-based coronagraphs, instruments designed to study the corona by blocking the sun, can't view the full extent of the corona. Solar space-based telescopes don't have the spectrographs needed to measure how the temperatures vary throughout the corona. These temperature variations show how the sun's chemical composition is distributed—crucial information for solving one of long-standing mysteries about the corona: how it gets so hot.

While the sun's surface is ~9980 Farenheit (~5800 Kelvin), the corona can reach several millions of degrees Farenheit. Researchers have proposed many explanations involving magneto-acoustic waves and the dissipation of magnetic fields, but none can account for the wide-ranging temperature distribution in the corona, Habbal says.

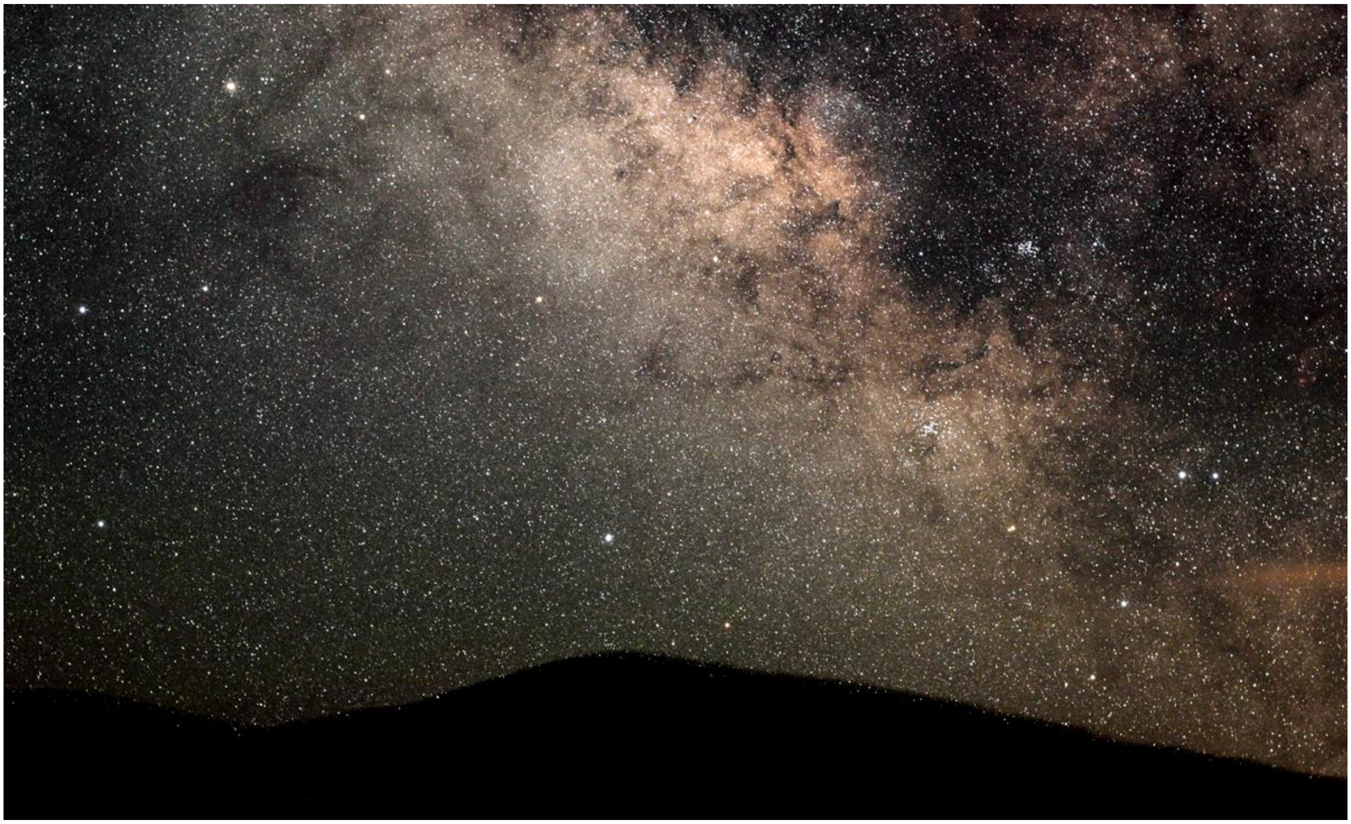
You too can contribute to science through one of several citizen science projects. For example, you can also help study the corona through the Citizen CATE experiment; help produce a high definition, time-expanded video of the eclipse; use your ham radio to probe how an eclipse affects the propagation of radio waves in the ionosphere; or even observe how wildlife responds to such a unique event.

Otherwise, Habbal still encourages everyone to experience the eclipse. Never look directly at the sun, of course (find more safety guidelines here: https://eclipse2017.nasa.gov/safety). But during the approximately 2.5 minutes of totality, you may remove your safety glasses and watch the eclipse directly—only then can you see the glorious corona. So enjoy the show. The next one visible from North America won't be until 2024.

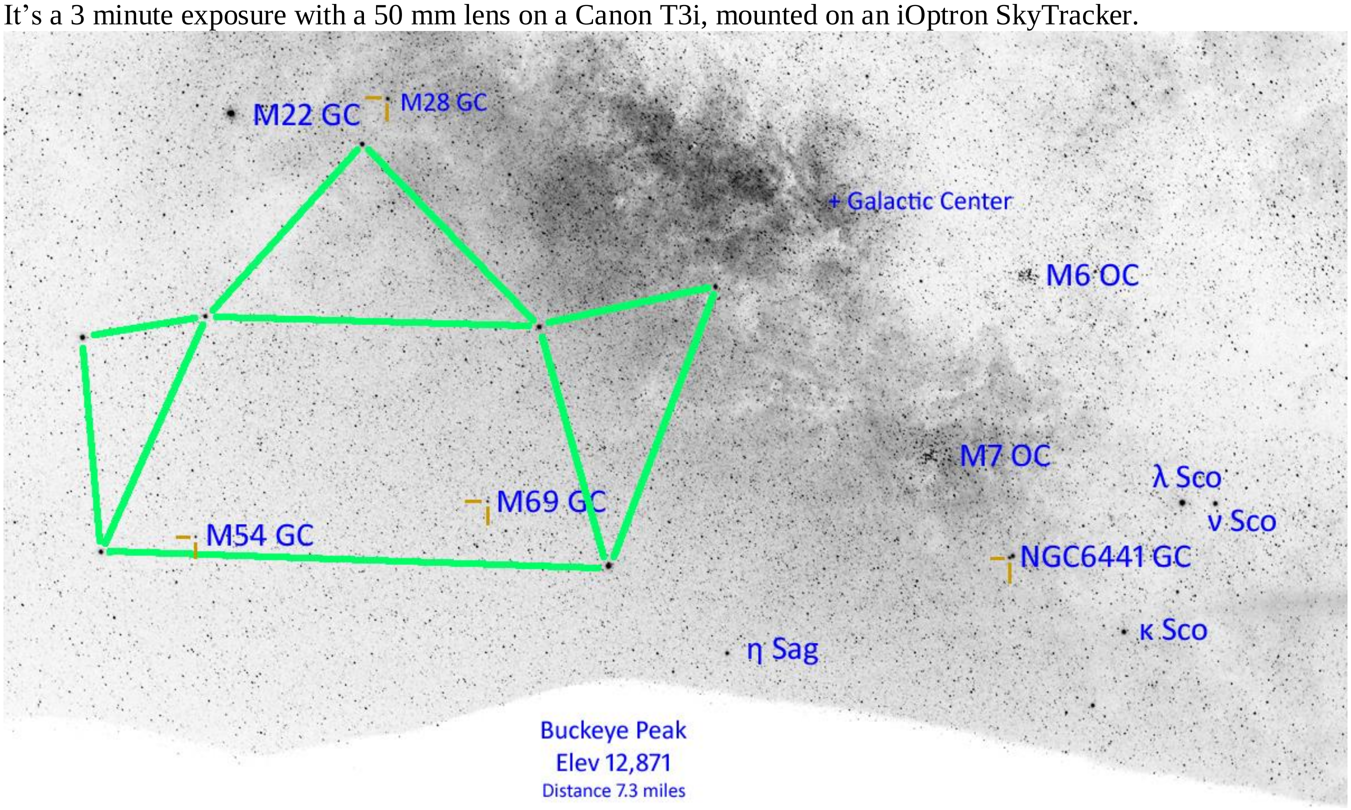
For more information about the upcoming eclipse, please see: NASA Eclipse citizen science page. Also see: NASA Eclipse safety guidelines**.** Want to teach kids about eclipses? Go to the NASA Space Place and see our article on solar and lunar eclipses! http://spaceplace.nasa.gov/eclipses/. **This article 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!

Illustration showing the United States during the total solar eclipse of August 21, 2017, with the umbra (black oval), penumbra (concentric shaded ovals), and path of totality (red) through or very near several major cities. Credit: Goddard Science Visualization Studio, NASA

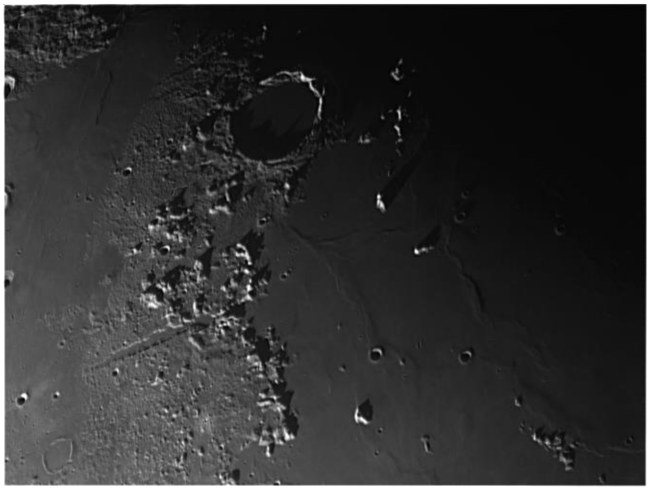
Sagittarius and the Tail of Scorpius

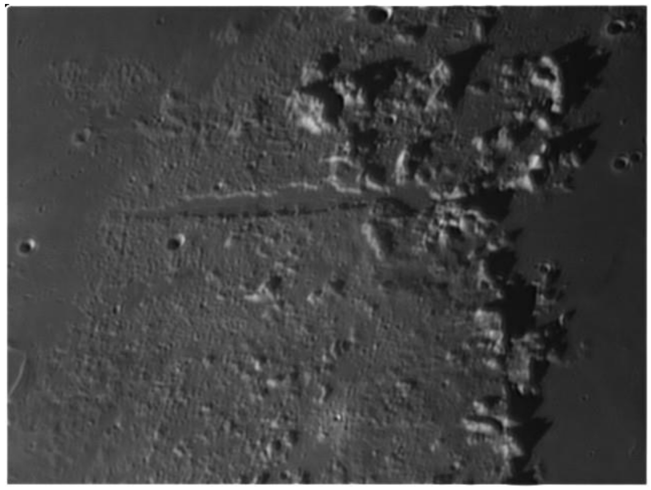


This image of the “Teapot” was made by Larry Faltz at Camp Hale, Colorado (elev. 9,235 feet), on July 6, 2016. It’s a 3 minute exposure with a 50 mm lens on a Canon T3i, mounted on an iOptron SkyTracker.

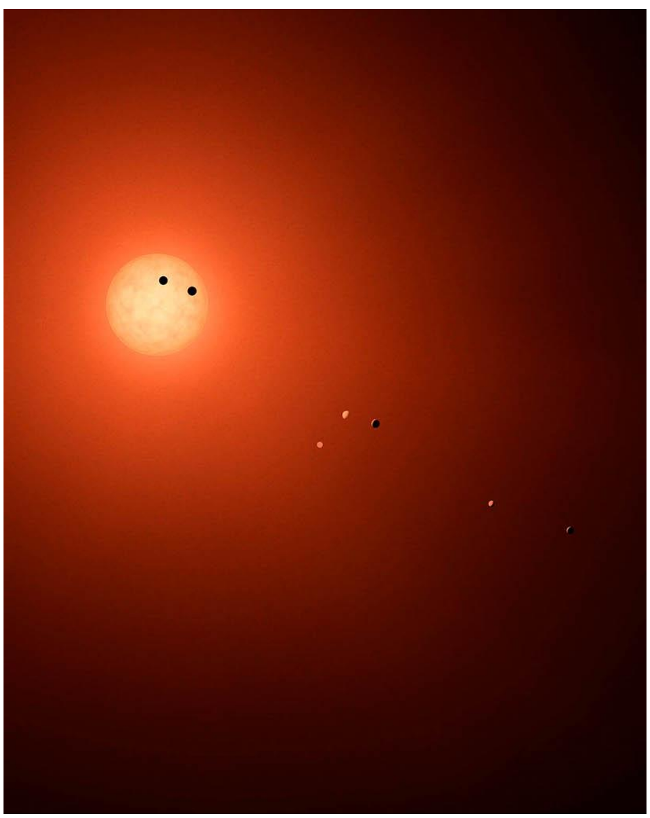


Astrophotos





John Paladini provided these images of the Moon's Vallis Alpes (Alpine Valley) taken by him through a 7" Maksutov. The left image show the Valley as well the Mare Imbrium (an impact basin) and the crater Plato. The right image focuses on the Valley and features the Valley's cleft-like rille



Seven Worlds

This artist's illustration depicts the seven worlds that orbit the ultracool dwarf star TRAPPIST-1, a mere 40 light-years away. In May 2016 astronomers using the Transiting Planets and Planetesimals Small Telescope (TRAPPIST) announced the discovery of three planets in the TRAPPIST-1 system. Just announced, additional confirmations and discoveries by the Spitzer Space Telescope and supporting ESO ground-based telescopes have increased the number of known planets to seven. The TRAPPIST-1 planets are likely all rocky and similar in size to Earth, the largest treasure trove of terrestrial planets ever detected around a single star. Because they orbit very close to their faint, tiny star they could also have regions where surface temperatures allow for the presence of liquid water, a key ingredient for life.

See APOD for more details.

Illustration Credit: NASA, JPL-Caltech, Spitzer Space Telescope, Robert Hurt (Spitzer, Caltech)