Far Far Out!

First Light

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Editorial

The practice of astronomy, from modern telescopes to simply looking up and wondering, is dependent on light. The eye - as well as lenses, mirrors, and detectors - count and collect as many precious photons as possible, travelers from afar telling stories beyond your wildest reckoning. It is the job of the astronomer to parse the difficult and ancient parlance, to record and model the world above. Long ago, the fire in the night warmed us, as we told stories imprinted on the celestial dome. The light from the fire, and all electromagnetic radiation around us and from above, is a dance between electricity and magnetism - an interplay between two seemingly distinct forces, yet truly the reflection of a deep symmetry in nature.

When a telescope points to the night sky and takes its first measurement, the moment is "first light". The history of astronomy is riddled - and has been advanced - by many first lights. Galileo pointed the "spyglass" to the sky in 1609, heralding the first light of the first telescope, and founding the field of modern astronomy. Over 400 years later, the Laser Interferometer Gravitational-wave Observatory (LIGO) saw gravitational waves - not light, but rather a gravitational analog - allowing us to see through a different window into the universe: the first light of a new cosmic messenger.

Welcome to FarFarOut, the newsletter of the South Texas Astronomical Society. In this issue, First Light, we open with an exciting discovery - the loneliest black hole in existence, detected by the changes in star light caused by the bending of spacetime. We then delve into black holes themselves, exploring their mathematics, taxonomy, and the first direct image ever taken of one. We turn toward the March equinox and investigate the notion of time, particularly the historical practice of saving it, and its relevant impact on us. We tour the March night sky with our founder, collect celestial treasures, and capture images of distant cosmic light with a telescope surrounded by birds and palms. I introduce to you, dear reader, to our wonderful crew of newsletter contributors and illustrators, without whom this newsletter would be far, far out of the question, and to begin a journey of friendship in science as we explore our cosmos together.

Wishing you clear skies,

Richard Camuccio
Editor-in-Chief

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Cosmic Coordinates
March 2022

South Texas Astronomical Society

FarFarOut was named in honor of the most distant object known in the Solar System, (2018) AG37, nicknamed FarFarOut. In 2018, astronomers Scott Sheppard, David Tholen, and Chad Trujillo saw a faint (>25 magnitude) object moving relative to the stars using the Mauna Kea Observatory. The object has an orbit bringing it out to beyond 130 AU and takes it on a seven-century journey around the Sun. And, when a farther object is eventually discovered, one can justifiably call that, too, "far, far out!"

The Loneliest Dude in the Hood

Dr. Mario Díaz

About a month ago, an international collaboration of almost 80 scientists who are members of different astronomical research groups throughout the world, announced the first discovery of an isolated Black Hole (BH), not too far from us.[1] This stellar object, which does not emit any light (so it is essentially completely invisible), is about 5,000 light years from us here on Earth. Considering that our Milky Way extends for about 100,000 light years from end to end, we can consider it as being almost in our neighborhood.

It has a mass that has roughly about seven times the mass of our Sun and it moves at a speed of approximately 100,000 miles per hour. In comparison the speed of our Sun, with respect to a stationary observer, is a little bit more than 40,000 miles an hour.

What is a BH? How many are out there? What does it mean that this one is a lonely one?

BHs are essentially stellar corpses. Stars are born when enough matter is attracted by the force of its own weight, and gets hot enough at its center to start a thermonuclear reaction (essentially a gigantic hydrogen power station). This is how the star energy is produced: as a result of the extremely simple hydrogen atoms - the lightest chemical element in nature - getting smashed together to fuse them into heavier helium atoms.

Eventually heavier elements are formed out of helium, and even heavier ones out of those heavy atoms already formed. But at some point, depending on how heavy the star is, the temperature is not hot enough to sustain the fusion process any longer.

Then, with no energy to counterbalance the inward pull of gravity, the star will collapse. When the mass of the star is about 20 times the mass of the sun, it will suffer a catastrophic explosion, called a supernova, and collapse into a very compact object, its mass so tightly packed, that nothing, not even light, can escape its gravitational pull: a BH.

How do we know that such objects exist? Predicted by Einstein's theory of General Relativity, the first BH ever detected was the one labeled now Cygnus X1. It is a very strong source of X-rays discovered in 1964 in the constellation of the Swan (from its Greek word, Cygnus). Located at a distance about 6,000 light years from us, it is one of the most observed astronomical objects in the Universe. It is what is called a binary system: two stars bound to dance one around the other one entangled by their common gravity. One of them is what is called a blue supergiant variable star. Its companion is an invisible object estimated to be no bigger than 200 miles in radius. This is an object smaller than a planet, even smaller than a large asteroid. Its mass is nonetheless estimated to be that of 20 Suns!

And we know this because this strange invisible object is surrounded by a disk of matter spinning so fast that emits extremely energetic X-rays which we can observe with space X-ray detectors. Systems like these are called X-ray binaries. The disks surrounding the BHs are called accretion disks, because the compact invisible object (a BH) is sucking matter from its big companion and spinning it extremely fast around it. Until 2015 all the BHs we knew were discovered in stellar systems like these. There are more than 400 X-ray binaries known in our Milky Way, and in our closest neighbor galaxies, the

Large and Small Magellanic Clouds.

A few more than two dozen of them are known to harbor BHs. On September 14 of 2015, the first detection of the gravitational waves emitted by a pair of BHs colliding inaugurated a new era in astronomy: gravitational wave astronomy. Since then, 90 collisions and mergers of compact objects have been detected. We know for sure that at least about 170 of the stellar objects involved were BHs. In all cases these were binary systems: all of them were pairs of compact objects. The majority of them were BHs. In a couple of cases the binary system was formed by a pair of neutron stars, and in another couple of events it was suspected that one of the pair of compact objects was a BH, while the other one was most likely a neutron star. Neutron stars are compact objects not as dense as BHs and with a limiting mass of about two Suns.

How was then this lonely BH detected?

Its detection is indeed a true feat of many years of observations, very skillful craftsmanship, and the use of the most powerful telescope (at least for now until the James Webb telescope becomes fully functional, which will be soon). The analysis required very precise measurements using an effect called gravitational lensing.

Massive objects, like stars, would deviate the path of light beams (i.e. from other stars) passing close to them. It is similar to the effect of an optical lens which by the effect of its curved surface bends the straight path of light rays passing through it and directs them to converge in a focal point. When the star in question is a BH getting in the way of a given star light, the lens magnifies the image of the source, producing an apparent increase in its brightness and creates an annular image called "Einstein ring". This effect is called microlensing and it was predicted by Einstein by 1936. Additionally this effect slightly shifts the apparent position of the source.

The groups involved in this research have been cataloging microlensing events spanning decades of observations. And for a long time the suspicion was out there that many of these events could be attributed to the existence of other undetectable BHs. But further refinements in the observations were needed. In particular, if the shift in the apparent position of the star forming the Einstein ring could be determined with precision, the characteristics of the compact object producing the effect could be measured with enough accuracy to determine if it was indeed a BH. And this is what this group of scientists did: they made precision astrometry (actual measurements of the stars position) using the Hubble Space Telescope.

And using these complementary studies – measuring the size of the Einstein's rings and the shift in the apparent position of the stars forming the rings – they found the loneliest BH in our galaxy...for now... ★

Notes
(1) https://arxiv.org/abs/2201.13296

Biography
Mario Díaz is Director of the Center of Gravitational Wave Astronomy and a Professor of Physics at UTRGV. He is Director of Cristina Torres Memorial Observatory, principal investigator of the Transient Robotic Observatory of the South Collaboration, and a member of the LIGO Scientific Collaboration. He received a PhD in general relativity and gravitation from University of Cordoba, Argentina.

Black Holes: The Birth of the Destroyer

Victor Jose Perez

1 What is a Black Hole?

A Black Hole (BH) is a region of space that has an extraordinary amount of mass packed into an infinitesimally small volume. Imagine trying to squeeze five Suns (one solar mass is equal to 1.98×10^{30} kg) into a ball the size of a spec of dust. It sounds impossible, but in reality, this is analogous to the cause of a BH. A very large amount of mass packed into such a tiny volume, which causes conditions so extreme that physics and math break down at its very center. A BH has many different features to it, the most common might be the accretion disk. The accretion disk is a region of space that is full of matter sped up to such high speeds that it radiates visible light, circling the BH until it eventually falls in toward the center, crossing the threshold known as the event horizon. The event horizon is the "place of no return" for a BH. Crossing this boundary means that you are in a region of space where not event light can escape the gravitational pull. BHs emit extremely large amounts of very high-energy radiation out of the "top" and "bottom" of itself known as a relativistic jet. The term "relativistic" comes from the fact that the radiation is shot with speed comparable to that of light. At the very center of the object, we have what is known as the singularity. The singularity is the aforementioned extremely small region (you can think of it as a point in space) where the extremely high mass is packed within. The current math and physics we use to describe the universe breaks down at this point.

1.1 Physical Representation

Thinking about BHs might be pretty easy - there are pictures of them everywhere, right? In reality, most of the BH media that you have seen is either simulations or renditions of what we *think* they look like. If you have ever seen Interstellar, you might have seen one of the most accurate simulations of what a BH can look like. You might be keen to think of a BH as a circle that has a very bright outer edge, yet a BH is actually a sphere. The accretion disk will actually appear to encircle the region past the event horizon no matter from what angle you look at it. The gravity from this object is strong enough to bend light around it from all directions. Looking at a BH from the same plane as the accretion disk, you will see the front facing accretion disk as well as the encircling accretion disk above and below the object to form a ring around it. You might notice that in most accurate depictions of a BH, one side of the apparent accretion disk is brighter than the other. This is due to the Doppler Effect. The matter that is brighter is actually being sped up toward the observer, while the more dim matter is being sped up away from the observer.

1.2 Mathematical Representation

When BHs were first predicted, they were nothing more than a theory. After all, it is extremely difficult to view an object that intrinsically emits no visible light. As with most theories in science, there needs to be some sort of evidence or claim to back the idea. For BHs, that comes in the form of pure mathematics. The mathematics of BHs may sound frightening, but if we understand step-by-step what each term represents, understanding how we use math to describe these objects becomes a little easier. Einstein had set the world of physics in disarray when he published his General Theory of Relativity in 1915. His field equation begged for solutions, something that Einstein was not able to resolve on his own. A little less than two months later, in 1917, Karl Schwarzschild solved Einstein's field equations to give the first mathematical description of an object with so much mass that the curvature of spacetime becomes too steep for even light to escape. The main mathematical representation of a BH comes from metrics. A metric is a distance function for finding distance between two points in a given coordinate system. Intuitively, this sounds like physicists and mathematicians are over complicating things. We are taught how to find distance between two points, however that only works for our three-dimensional flat (Euclidean) space. With general relativity, we think of space and time as connected on a surface, and the massive amount of gravity generated by the BH actually curves spacetime. We use a spherical coordinate system to describe the space around the BH. A four-dimensional spherical coordinate system can be described by four parameters: (t, r, θ, ϕ). The closer we get to a BH, the more space is curved, so we need a better coordinate system that (t, x, y, z) to describe a change in position. In 1915, Einstein published his work with general relativity, which was his attempt to see how space and time are related where gravitational effects were not negligible. Einstein attempted to describe the way the universe handled relativistic effects in all areas of space (flat or curved). You can think of flat space being that of the space near around you as you read this paper. We can call this a flat space because gravitational effects are minimal, there being a lack of a very strong gravitational force near the observer reading. A curved space can be described as space near a very intense gravitational field. Remember that out of the four basic forces, gravity is the weakest one. There needs to be a very, very large amount of mass to produce a gravitational force strong enough to curve space time sufficient to see effects on matter and time. With all this preamble, I have set up the math needed to help us understand how the metric describes the space near a BH. The metric we will look at describes the space near a static BH: a BH that does not rotate, has no charge, and the only intrinsic property we use to describe it is its own mass. The Schwarzschild metric [1] is given by

$$\mathrm{d}s^2 = -c^2\mathrm{d}\tau = -\left(1-\frac{R_s}{r}\right)c^2\mathrm{d}t^2 + \frac{\mathrm{d}r^2}{(1-\frac{R_s}{r})} + r^2\mathrm{d}\theta^2 + r^2\sin^2\theta\mathrm{d}\phi^2$$

where

$$R_s = \frac{2GM}{c^2}$$

What do we see? t is time. r is radius. θ is the angle on one axis. ϕ the angle that spans between axes. c is the speed of light. R is the Schwarzschild radius. G is the gravitational constant of the universe. M is the mass of the object.

The Schwarzschild radius tells us how close light can get to a BH before the gravitational field becomes too strong for light to escape. Special relativity states that nothing is able to move faster than the speed of light, so therefore, anything else at the Schwarzschild radius is already doomed to fall into the BH.

An important note is that dτ is the metric element that expands into

$$\mathrm{d}t^2 + \mathrm{d}r^2 + r^2\mathrm{d}\theta + r^2\sin^2\theta\mathrm{d}\phi^2$$

This is a pure calculus element of the metric, however the concept behind each of these terms is simple. Every *d-variable* term is a small change - an *infinitesimally* small - displacement for whatever variable is being considered. For example, dt represents a very small change in time. Similarly: dr, dθ, and dϕ represent infinitesimal changes in r, θ, and ϕ, respectively.

This is how physicists explain the space near a BH, with metrics of this form. This is a tool to describe the curvature of space near such high mass objects, which allows us to predict how objects will behave in four dimensions near these violent phenomena. There are many other metrics out there that solve Einstein's field equations, and that also account for a BH that is asymmetric, rotating, and electrically charged. Understanding the metric that describes a static BH is just the first step into the wonderful world of the mathematics of BHs.

2 What Are the Different Types of Black Holes?

There are a few different classes of BHs: primordial, stellar, intermediate, and supermassive. The two defining features that we use to classify these objects are their mass and how/when they formed. The oldest types of theorized BHs formed epochs before the first star was born, while the most commonly seen BHs are birthed from the death of a star.

2.1 Primordial Black Holes

The most theoretical (as in never observed, only predicted) are primordial black holes [2]. These objects are theorized to have formed in between the beginning of the Big Bang and one second after. This might not sound like a long time when you compare it to the age of the universe, but one second after the Big Bang is actually a relatively large amount of time. Within that one second, it is theorized that matter was not evenly distributed throughout the region of space that was the whole universe for that one second. This is similar to the matter distributed now, however it is imperative to remember that all the matter that ever was, and ever will be, was condensed into that very tiny region. This leads to extremely dense, extremely tiny points in space that collapse toward a BH. Primordial BHs can have mass ranging between 5-10 grams and 100,000 solar masses. This is depending on exactly what time they formed between the Big Bang and one second afterward. Due to Hawking Radiation, it is theorized that most of these types of BHs have already evaporated away, while some may still be undergoing that process.

2.2 Stellar Black Holes

With masses ranging between three and 100 solar masses, stellar BHs [3] are a very common form of BH. These objects are formed from the stellar collapse that happens at the death of a star. Stars are powered by nuclear processes within their core, which provides pressure pushing outward, keeping it from collapsing inward from its own gravity. As the star burns through its fuel, the nuclear processes slow down, the pressure pushing outward decreases, which eventually leads to a collapse inward as the mass of the BH becomes too heavy for the core to sustain. There are different outcomes for different stellar masses, but if a star has around three times the mass of our Sun, it will collapse with enough mass to produce a BH. The pressure will overcome repulsive forces, packing the subatomic particles that make up matter into a region so small we call it the singularity.

2.3 Intermediate Black Holes

With masses ranging between 100 and 100,000 solar masses, these intermediate BHs [4] are giant objects. Surprisingly enough, these BHs, while larger than stellar-mass BHs, have not been observed as much. The mechanism behind the birth of these objects is not exactly clear. Some theorize that these are merged BHs (the merger could have been a group of stars close together, or a merger between BHs themselves). Others believe these are actually larger primordial BHs, while still others say that these are just stellar BHs that fed on matter enough to get their mass up to that size.

2.4 Supermassive/AGN Black Holes

Supermassive BHs (SMBHs) [5] give rise to some of the most extreme conditions the universe has to offer. These BHs can be millions or even billions the mass of our Sun. They are typically found in the very center of galaxies, with Sagittarius A* being our host central SMBH (with a mass of about four million Suns). The birth of these SMBHs is still a mystery, with some scientists speculating that these are primordial BHs that ate matter around them as galaxies formed, causing them to be in the center. This is a nice theory, but there are way too many SMBHs for that to fall in line with primordial BH formation.

3 Seeing an Object That Emits No Light

Remember that BHs themselves do not emit light. The main source of radiation we can gather from them is the superheated sped up matter rotating around the event horizon, and the relativistic jets that are spewing from the "top" and "bottom" of itself. Consequently, observing a BH has been one of the greatest issues of the last century. The first recorded prediction of a BH was by John Michell [6] in 1783, where he theorized a star with gravity so intense that light could not escape it. Einstein's general theory of relativity in 1916 recreated that prediction, where the mass of an object causes a gravitational pull so great that light cannot escape past its Schwarzschild radius. We know that Einstein did not predict the so-called "dark star", but predicted a singularity point with mass so densely packed that it creates the most violent conditions in the universe. For centuries, these objects were purely theoretical; nobody had ever been able to capture direct proof of a BH. It was not until the 1960s that humanity had a breakthrough in trying to "see" this object which did not show light. Cygnus X-1 [7] became the first suspected system hosting a BH. Using radio astronomy (the science of "seeing" cosmological objects with radio waves), scientists found that there was an unknown X-ray signal coming from a seemingly empty region of space. The nearest star seemed to be part of a binary system (a system where two objects are orbiting each other), but the mass of the second object (which was approximated by looking at the trajectory of the star's orbit) seemed to be way greater than that of a neutron star (the observed object with the most mass at the time). Since there was no visible light, scientists knew that it could not be a neutron star, and the next heaviest object was the theoretical BH. The combined factor of the mass needed to create such an orbit, combined with no visible light coming from the object, meant that this was the perfect candidate to be the second half of the binary system. Fast forward to 2019, when the Event Horizon Telescope (EHT) [8] had an announcement that literally shook the science world. EHT was tasked with imaging the supermassive BH in M87. The team at EHT had pieced together the first ever actual image of a BH.[1] The EHT team was a worldwide collaboration, using a technique called Very Long Baseline Interferometry [9], which essentially created a radio telescope with a dish the size of the Earth. The biggest hurdles were storing and getting data that matched from Antarctica to Canada to Japan. The amount of data used was in the petabyte range, where one petabyte is 125,000 gigabytes. Storing and transferring these data from all over the world was a huge feat in and of itself. Additionally, the team had to synchronize and correct for aberrations in time for light to reach each telescope across the globe. Once all the data was collected and analyzed, a beautiful (and admittedly fuzzy) picture was created. As fuzzy as it is, this photo was as real, actual image of a BH, where we can see the Doppler Effect in action, we can see the event horizon and the black sphere in the center, the accretion disk in all its glory. The fuzziness is due to resolution, but for an object 50 million light years away, this image is relatively clear as day. The first image of a BH was a collaboration that took the minds of hundreds of brilliant, hardworking people, and turning what was only imagined into something we can physically see. I highly encourage each and every one of your to look up the EHT image, and admire the first actual image humanity produced of an object that evaded detection since its prediction centuries ago. ★

Notes

(1) I remember walking to my modern physics class, and when I got to class my professor was so excited about the news. I heard many professors around the world were jumping up and down, in tears, celebrating tackling one of the biggest hurdles in astronomy.

References

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Biography

Victor Perez is a graduate student at UTRGV, currently earning a master of science in physics, and working toward promoting physics and astronomy education in the Rio Grande Valley. Victor graduated from Brownsville Early College High School in 2017. He earned a bachelor of science in physics at UTRGV in 2020, where he focused on observational astronomy and became a lead observer at the Cristina Torres Memorial Observatory. Victor also has research experience from the University of Oregon (studying electron microscopy in 2019) as well as Brigham Young University (analyzing extreme UV diffraction data in 2020).

The How and Why the Clock Changes

Andrew Maurer

1 Introduction

It's almost that time of year again. *Spring forward. Fall back.* Anyone who has a clock at home in late March and in early November will hear these or similar phrases. They describe a time of the year called *"Daylight Savings Time" (DST)*, *"el horario de verano"*, or *"Summer Time"*. But what exactly is DST, and why do we observe it?

2 Definition

DST is the time of the year when we shift the time (*social clock*) forward to maximize the amount of daylight in the summer months [5] [6]. When we *"spring forward"*, we observe DST, and when we *"fall back"*, we observe "Standard Time". But why have DST in the first place?

3 Origins

The general consensus is that DST was made to conserve energy [1] [2] [3] [6]. The first countries to officially observe DST were the German Empire and Austria-Hungary in order to conserve coal during WWI [3]. Many countries implemented DST shortly thereafter. For the United States, DST has been consistently observed since 1966, and even expanded the amount of time observed in 2005; originally from late March to mid-March and from late October to early November [1] [2] [6]. However, there are states within the United States that do not observe DST. These states include Hawaii and Arizona (and not even all of Arizona!), in addition to several US territories including Puerto Rico and American Samoa. The reason for this comes down to how much sunlight they receive during the year, and that is determined by the tilt of the Earth's axis.

4 Tilt and Daytime

The Earth spins around an imaginary line that runs down the center of the Earth and goes through the North and South poles. This line is called the *axis*, and Earth rotates around its axis at a 23.5-degree tilt [4]. This axial tilt is the reason for the seasons; during the summer, the North Pole leans in toward the Sun while the South Pole faces away from the Sun. This orientation flips for the North during the winter and and vice versa for the South. These seasonal shifts directly affect the length of daytime at locations near the poles. At the equator, the length of daytime and nighttime are basically equal because of the amount of direct sunlight that part of the Earth receives. This is why places like Puerto Rico and Hawaii don't observe DST, because there is enough sunlight to be had even in *Standard Time*. As you travel toward a pole, that equality of daytime versus nighttime becomes disproportionate, and how daytime and nighttime are divided depends on whether the pole is facing toward or facing away from the Sun. But what does this axial tilt have to do with DST?

5 DST Impacts

There is a debate across the nation on whether DST is actually beneficial, and whether a permanent DST (*perennial DST*) or a permanent *Standard Time* ought to be observed [1] [2] [6]. For parts of the nation closer to the North Pole (at higher *latitudes*), the effects of DST are more noticeable because of the difference in available daylight in the summer versus in the winter [1] [3]. The original argument for DST conserving energy is highly debated [3]. Some reports detail a statistically slight decrease in energy consumption, though noting a slight increase in the early morning, especially after the first few days of DT, with an offset in energy consumption in the evening due to brighter afternoon hours [1] [3] [6]. However, some reports tell that energy consumption actually increases for locations closer to the equator during DST [1] [3] [6]. The other major issue is how DST affects our bodies (*circadian rhythm/clock*) [5]. Supporters of DST will argue an extended evening contributes to a better well-being because of more available time to spend on extracurricular after work [3] [5]. Opponents of DST will cite reports of increased traffic accidents, cardiac arrests, and suicide rates after the first few days of DST [3] [5]. Furthermore, DST may chronically affect the relationship between our circadian rhythm and the relative position of the Sun in the sky (*solar time*) by shifting that time (*social time*) eastward [5]. This relationship between our circadian rhythm and *solar time* is defined by sunlight activating enzymes responsible for regulating sleep cycles and metabolic activity [5]. In theory, exposure to light of the same intensity and wavelength as the Sun's would replicate the same biological processes, but no breakthroughs in this subject have come from the scientific community as this time [5].

5 Summary

Over a dozen states have enacted or are debating *perennial DST* legislation at this time [1] [2] [6]. The United States is not alone in this debate; while some nations contend over similar legislation for either *perennial DST* or permanent Standard Time, some want to begin the biannual clock change [3]. And as this periodic conversation heats up again, we are reminded that even our perception of time will change with the times. ★

Notes

(1) The article "Daylight Saving Time and Artificial Time Zones - A Battle Between Biological and Social Times" goes into much more detail about the physiological consequences of DST, and I strongly recommend this particular article for deeper insight into our biology and how it relates to time.

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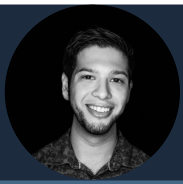
Biography

Andrew Maurer is a graduate of the University of Pittsburgh, where he received a bachelor of science in biology in 2016. He has keen interests and future goals of research in paleobiology, genetics, and zoology. Andrew currently works with the clinical molecular laboratory at MicroGen DX, and has previous clinical experience in the veterinary field.

RGV Hightlight: Capturing Light from the Other Side of the Cosmos



Victor De Los Santos

The Cristina V. Torres Memorial Astronomical Observatory, or "CTMO" for short, is the primary optical astronomical facility in the Rio Grande Valley. The observatory saw first light circa 2008 on the campus grounds of the University of Texas at Brownsville (now the University of Texas - Rio Grande Valley or UTRGV). As the city's growing light pollution became an issue for night sky observations, the facility was taken apart and rebuilt in its current home, amongst the diverse wildlife at Resaca de la Palma State Park.

The observatory's current system consists of a 17-inch PlaneWave reflector telescope (the 17" measurement refers to the size of the telescope's primary mirror) and a monochromatic camera in place of a typical telescope eyepiece.

CTMO is primarily operated by members of the Time Domain Astronomy Group within the UTRGV Department of Physics and Astronomy. Whereas *astronomy* in general refers to "the branch of science dealing with celestial objects, space, and the physical universe as a whole," the focus of *time-domain astronomy* is on astrophysical events called *transients* in which changes are observed over periods of time. The CCD camera installed onto the telescope is optimized to capture detailed information about the amount of light coming through the telescope's tube (CCD stands for "charge coupled device" and refers to an image sensor that converts light into electrical signals). Once a target object is selected - typically a *deep sky object*, which is one that resides outside our Solar System - a series of long-exposure images are taken across a specified period of time. Depending on the nature of the cosmic target, observation periods can last anywhere from a few minutes to multiple hours across multiple weeks, or even months. Once images are collected from the observatory, astronomers process the data through software pipelines designed to reduce the elements in the image that might distort the analyses - typical (and rightfully) referred to as "noise" - and produce a *light curve*, a graph that shows the brightness of an object over the observed period of time. Through the use of these light curves, astrophysicists can unlock key scientific information about a wide range of cosmic phenomena.

Astronomical objects typically researched at CTMO include:

- **Asteroids** - Rocky bodies orbiting the sun that sometimes pass into the range considered as "near-Earth"
- **Variable Stars** - Double-star systems that orbit each other, decreasing in brightness as one star eclipses the other
- **Exoplanets** - Planets orbiting stars that are not our sun; when these planets pass in front of their star, the light coming to Earth from that star experiences a noticeable decrease
- **Supernovae** - Bright and powerful explosions that occur at the last stages of the evolutionary life cycle of stars

Another type of transient event observed at CTMO is *kilonovae*, the visible remnant of explosions that follow the violent merger of two neutron stars (each with a total mass between 10 and 25 times the mass of our sun!). These catastrophic cosmic collisions produce ripples in the fabric of spacetime called *gravitational waves* which are detected by the Laser Interferometer Gravitational-wave Observatory (LIGO) network. These astrophysical events have the unique characteristic of being observable through different forms of energy - gravity and light - and have paved the way toward a new branch of astronomy: *multi-messenger astronomy.* Through optical observation of the first-ever detected binary neutron star merger (named GW170817 after its detection date of 17 August 2017), CTMO became a pioneering facility in this new era of multi-messenger astrophysics. Following the historic event, the 2017 Nobel Prize in Physics was awarded to members of the LIGO Scientific Collaboration - including UTRGV's Center for Gravitational Wave Astronomy - for the discovery of gravitational waves.

Though the observatory is primarily used for advancing scientific knowledge about our universe, education and public outreach have been a core value at CTMO since first light. Through public and private funding, the Center for Gravitational Wave Astronomy generates opportunities for local students and teachers to use the facility as an experience-based learning tool. Training is conducted by members of the CTMO observation group on operating the observatory and its various instrumentation. The UTRGV Department of Physics and Astronomy is currently developing an astronomical curriculum for local high school students in partnership with various local institutions.

In addition to the main dome at CTMO, nine miniature domes are currently in construction at the State Park. The additional observatories will allow for expanded access to the domes and the capability to conduct multiple observations simultaneously. Once completed, the entire *telescope farm* (ten observatories total) will have the capability to be operated via remote connection.

On several occasions throughout the year, including the monthly Night Hike hosted by Park Rangers at Resaca de la Palma State Park, CTMO opens its doors to the public so that the community may experience the beauty of the cosmos first-hand. By cultivating interest in astronomy and space science, CTMO and partner organizations such as STARS hope to inspire the next generation of explorers within the Rio Grande Valley. ★

Photo by Silver Salas

Biography

Victor De Los Santos is President and Executive Director of the South Texas Astronomical Society. Victor graduated from Hanna High School in 2013. He earned a bachelor of science in business from Texas A&M University in 2016. He has worked as a software development project leader for SoliSYSTEMS Corporation since 2016.

Astronomical images *(light)* captured at the Cristina Torres Memorial Observatory

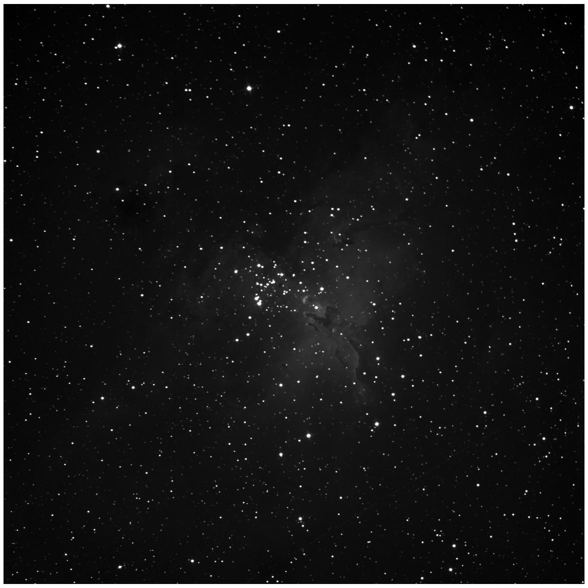
M42: The Orion Nebula

A nebula is a cloud of interstellar gas and dust. After millions of years, these cosmic clouds gravitate closer and closer, giving birth to new stars. Because of this, nebulae are often referred to as *stellar nurseries*. The Orion Nebula - about 1,344 light years from Earth - is one of the most visible nebulae and Messier objects in the night sky. It can be found as a green smudge in the easily noticeable constellation of Orion, near the three stars that resemble Orion's Belt.

M101: The Pinwheel Galaxy

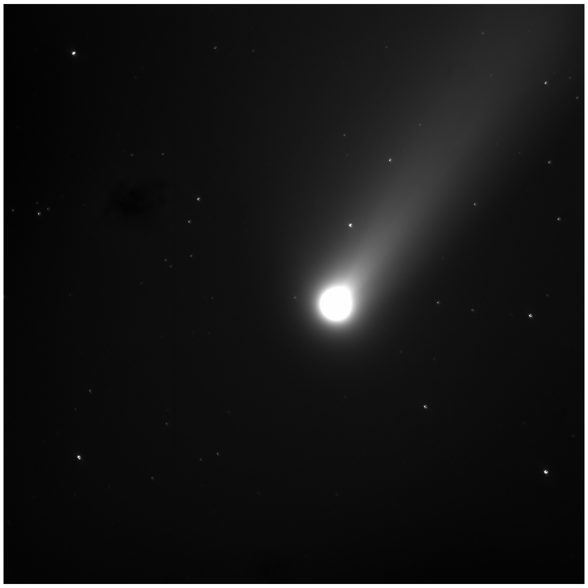
The Pinwheel Galaxy is located 21 million light years from Earth and has a diameter almost double the size of our own Milky Way galaxy (170,000 light years across). It is estimated to have at least one trillion stars. The spiral arms resemble nebulae, in which a total of more than 3,000 regions have been identified as areas constantly giving birth to new stars.

M16: The Eagle Nebula



This nebula is commonly known as the Pillars of Creation in the famous image captured by the Hubble Space Telescope. Though this nebula is over 5.5 million years old, it is considered young in comparison to other nebulae. The nebula lies in the direction of the Serpens constellation and can be seen even through smaller amateur telescopes from the Northern Hemisphere in July.

C/2020 F3 (NEOWISE)



Comets are commonly referred to as "dirty snowballs" - they are large rocks composed of frozen gases, rock, and dust that orbit the Sun. NEOWISE, or C/2020 F3, is a comet that was discovered on March 27, 2020. NEOWISE is the brightest comet to have been in the night sky since Comet Hale-Bopp in 1997. If you happened to be in a dark enough area, Comet NEOWISE would have been visible to the naked eye. If you missed it, don't worry - it will make its way back in about 6,000 years!

Carol's Corner of the Cosmos

Carol Lutsinger

Welcome to STARS for March, 2022. As our planet continues to wend its way around the Sun, we are rapidly approaching spring and the constellations of spring have begun rising as darkness falls. Look for the backward question mark of the head of Leo the Lion in the east, nearing the zenith. The hindquarters of the Lion King are denoted by a right triangle about a fist width from the head. Constellations were not designated at the beginning of time; they are figments of active imaginations of early cultures' sky watchers.

You can enjoy the same pastime by connecting the stars you are able to see into some figment of your imagination associated with your favorite sport, literary character, or whatever your brain concocts. At some point yours could even become part of the official list of constellations established long ago.

March 20 is the point in time when our Sun rises directly above the equator at the vertex of the equator and the ecliptic. The ecliptic is another one of those imaginary lines assigned by ancient astronomers to mark regions of the sky similar to the ones marked on Earth maps. On this day, the Vernal Equinox, the hemispheres of our planet receive almost equal hours of day and night because of our planet being tilted 23.5 degrees off a vertical position. The northern hemisphere will be having spring and the southern hemisphere will begin autumn. The tilt is the main reason we have different seasons on our home planet. Because of the tilt the Sun is in the sky for differing amounts of time, warming the surface it is above for longer or briefer periods of time which means greater or lesser heating - such a marvelous pattern and makes our life much more interesting. And if you live in South Texas you may experience all seasons in the course of a week or even a couple of days.

How about a little math fun? Astronomers locate particular objects using degrees of angles. That plastic protractor on every fifth grader's school supply list is a perfect tool to make a simple explanation of how they do it.

Think of the view you have of the "dome of the sky" with the flat ground below your feet as a giant protractor. Remember there are three hundred sixty degrees in a circle, so there are one hundred eighty degrees in that sky that you see. The angle formed by you, the point directly over your head, and the Earth below your feet and out to the horizon in front of you is a ninety-degree angle. So much math; think about the correlation here as you read about the degrees separating planets, how many degrees above the horizon to see Venus or Mercury, Jupiter or Saturn, and think about the measurements using your fists, fingers, etc. to help size things up.

Comparing the distances between objects in the sky or between the object and the horizon is done using degrees and minutes and seconds of arc which are determined by the length of time it takes the Sun to move from the east, south, and west in the sky as Earth rotates west to east. The Sun appears to move 15 degrees per hour in its path along the ecliptic.

If you are unsure of which direction is where in your neighborhood, then try this. Recall where the Sun rises - that is the general direction of east. Where it sets is the general direction of west and the Sun appears to trek across the south, from east to west. That leaves north easy to find.

Your fist measures about ten degrees when held at arm's length. A Full Moon measures about one-half degree, or your pinky held at arm's length. The V-shaped asterism known as the Hyades (Hi-uh-deez) is located about twenty degrees to the upper right of Orion. This so-called "face of Taurus the Bull" has a giant red star, named Aldebaran, (Al-DEB-uh-ron) marking the Bull's eye. These star patterns can be seen in the night sky in the southwest until about 9:00 PM. Daylight "Saving" time begins March 13 and the later sunset will limit viewing opportunities.

Early morning skies will share their space with Venus, Mars, Saturn, and for a brief time, Mercury before sunrise. You may want to measure the space between Venus and Mars and keep a record of their positions over time. Keeping an observer's notebook just might interest you. Galileo Galilei kept one and his notebooks can be accessed online so that you can see images of his sketches of the moons of Jupiter, Earth's Moon, and many other artifacts of his that still intrigue sky watchers today.

If you are interested in a list, perhaps this one could get you started. ★

Biography
Carol Lutsinger is the founder of the South Texas Astronomical Society (STARS). She has been a classroom teacher for Brownsville Independent School District for 36 years and a private school teacher for six. Carol became a Science Curriculum Coordinator for BISD in 1989, and is a Solar System Ambassador Master Teacher through JPL/NASA. Carol has written for the Brownsville Herald (her column, "Stargazer") since 1998, and also currently writes for the Valley Morning Star.

My Observing List_______________________________________

C=constellation S=star Object	Date /time Observed	Object	Date/time Observed
Albireo s			
Alcor			
Aldebaran s			
Algol s			
Altair s			
Aquila c			
Arcturus			
Auriga c			
Bellatrix s			
Betelgeuse (star)			
Big Dipper asterism		Moon phases	
Boötes c		Newest New Moon	
Canis Major c		Waxing crescent	
Canis Minor c		Waxing gibbous	
Capella s		Full Moon	
Castor s		Waning gibbous	
Cat's eyes asterism		Waning crescent	
Cetus c		Oldest waning crescent	
Cygnus c		Pisces Austrinus c	
Delphinus c		Pleiades c	
Deneb s		Pollux s	
Denebola s		Procyon s	
Dubhe s		Regulus s	
Fomalhaut s		Rigel s	
Gemini s		Sagittarius c	
Hercules c		Saturn	
Hyades asterism		Serpens c	
Hydra c		Scorpius c	
Jupiter		Sirius s	
Jupiter's moons		Spica s	
Leo c		Taurus c	
Libra c		Ursa Major c	
Lunar eclipse		Ursa Minor c	
Lyra c		Vega s	
Mars		Venus	
Messier Objects		Virgo c	
		Zubenelgenubi s	
		Zubeneschamali s	

I hope you enjoy collecting as many of these as possible. Meteor showers occur often and single meteors streak across the sky every night. Find a safe dark spot to hunt and have fun.

March 2022

Night Sky Bulletin
Brownsville, Texas

Conjunction of Mercury and Saturn
02 Mar 2022 06:34 CST

Appulse of Mercury and Saturn
02 Mar 2022 09:40 CST

New Moon
02 Mar 2022 11:36 CST

9P/Tempel at Perihelion
03 Mar 2022

Conjunction of Mars and Pluto
03 Mar 2022 19:41 CST

Conjunction of Venus and Pluto
05 Mar 2022 06:08 CST

Jupiter at Solar Conjunction
05 Mar 2022 07:55 CST

Lunar Occultation of Uranus
07 Mar 2022 00:46 CST

First Quarter Moon
10 Mar 2022 04:46 CST

Moon at Apogee
10 Mar 2022 17:03 CST

Conjunction of Venus and Mars
12 Mar 2022 07:13 CST

Neptune at Solar Conjunction
13 Mar 2022 06:34 CDT

Gamma Normids Peak
14 Mar 2022

Appulse of Venus and Mars
15 Mar 2022 21:30 CDT

22P/Kopff at Perihelion
16 Mar 2022

Full Moon
18 Mar 2022 02:17 CDT

Moon at Aphelion
20 Mar 2022 08:24 CDT

Venus at Greatest Western Elongation
20 Mar 2022 16:35 CDT

Venus at Dichotomy
21 Mar 2022 00:45 CDT

Moon at Perigee
23 Mar 2022 18:37 CDT

Last Quarter Moon
25 Mar 2022 00:37 CDT

Conjunction of Moon and Mars
27 Mar 2022 21:54 CDT

Appulse of Moon and Mars
28 Mar 2022 00:03 CDT

Conjunction of Moon and Venus
28 Mar 2022 04:50 CDT

Conjunction of Moon and Saturn
28 Mar 2022 06:42 CDT

Appulse of Moon, Venus, and Saturn
28 Mar 2022 08:51 CDT

Appulse of Moon and Saturn
28 Mar 2022 09:10 CDT

(136472) Makemake at Opposition
28 Mar 2022 15:50 CDT

Appulse of Venus and Saturn
28 Mar 2022 19:50 CDT

Conjunction of Venus and Saturn
29 Mar 2022 08:07 CDT

Moon at Perihelion
29 Mar 2022 17:06 CDT

Conjunction of Moon and Jupiter
30 Mar 2022 09:36 CDT

Definitions

Appulse – the minimum apparent separation in the sky of two astronomical objects.

Apsis – the farthest (*apoapsis*) or nearest (*periapsis*) an orbiting body gets to the primary body. Plural is *apsides*. Special terms are used for specific systems: *aphelion* and *perihelion* is for anything orbiting the Sun; *apogee* and *perigee* is for the Moon orbiting the Earth.

Conjunction – when two astronomical objects or spacecraft share the same right ascension or ecliptic longitude as observed from Earth. For superior planets, conjunction occurs when the planet passes behind the Sun (also called *solar conjunction*). For inferior planets, if the planet is passing in front of the Sun, it is called *inferior conjunction*; if behind, it is called *superior conjunction*. Conjunctions are the worst time to view a planet with a telescope.

Dichotomy – the phase of the Moon, or an inferior planet, in which half its disk appears illuminated.

Occlusion – when one astronomical object passes in front of the other. An *occultation* is when the foreground object completely blocks the background object. A *transit* is when the background object is not fully concealed by the foreground object. An *eclipse* is any occlusion that casts a shadow onto the observer.

Opposition – when two astronomical objects are on opposite sides of the celestial sphere. Opposition only occurs for superior planets, and is the best time to view a planet with a telescope.

Our Vision is that the South Texas Astronomical Society nurtures the innate human desire for exploration and discovery by fostering connections to science and the cosmos across the Rio Grande Valley.

Our Mission is to ignite curiosity in the Rio Grande Valley through space science education, outreach programs, and by serving as a liaison between community members and space organizations and resources.

The South Texas Astronomical Society (STARS) saw first light in the early 1990s, when passionate astronomy enthusiast and local resident Carol Lee Lutsinger became a member of JPL/NASA's inaugural class of Solar System Ambassadors. Since then, Carol has shared her love for space and science with her hometown community. As of March 2022, the future is looking brighter than ever for STARS. Over the past few years, we have had the privilege of expanding our network of partners through community events in collaboration with organizations and institutions such as the UTRGV Cristina Torres Memorial Observatory, Brownsville Public Library System, Children's Museum of Brownsville, Resaca de la Palma State Park, Brownsville Parks & Recreation Department, Girl Scouts of Greater South Texas, NASA, SpaceX, and many more. In March 2020, STARS received official recognition as a 501(c)(3) nonprofit organization providing educational outreach services for the local community; as of December 2021, the organization has been designated as the NASA Informal Education Community Anchor for the Rio Grande Valley.

Since its origins, STARS was founded for and fueled by the Brownsville/greater Rio Grande Valley community. Who could have predicted that within a couple of decades, our region would turn into one of the fastest growing hubs for space exploration activities? From rocket launches and astronomical observatories to cutting-edge research at the local university, it is truly an exciting time to be living in South Texas, and we are grateful to continue sharing the excitement with our community.

We hope you enjoyed the first issue of FarFarOut!

- The STARS Team

Awesome STARS logo by Brina Martinez ★

Colophon

Contributors
Andrew Maurer
Carol Lutsinger
Mario Diaz
Victor De Los Santos
Victor Perez

Illustrators
Gabrielle Camuccio

Production and Layout
Richard Camuccio
Victor De Los Santos

Editor-in-Chief
Richard Camuccio

Website
www.starsocietyrgv.org

Submissions

We encourage submissions from anyone interested in contributing to our newsletter. Any readers with ideas for our newsletter, or who are interested in submitting their own articles, illustrations, or other content, please contact the Editor-in-Chief at:

richard@starsocietyrgv.org