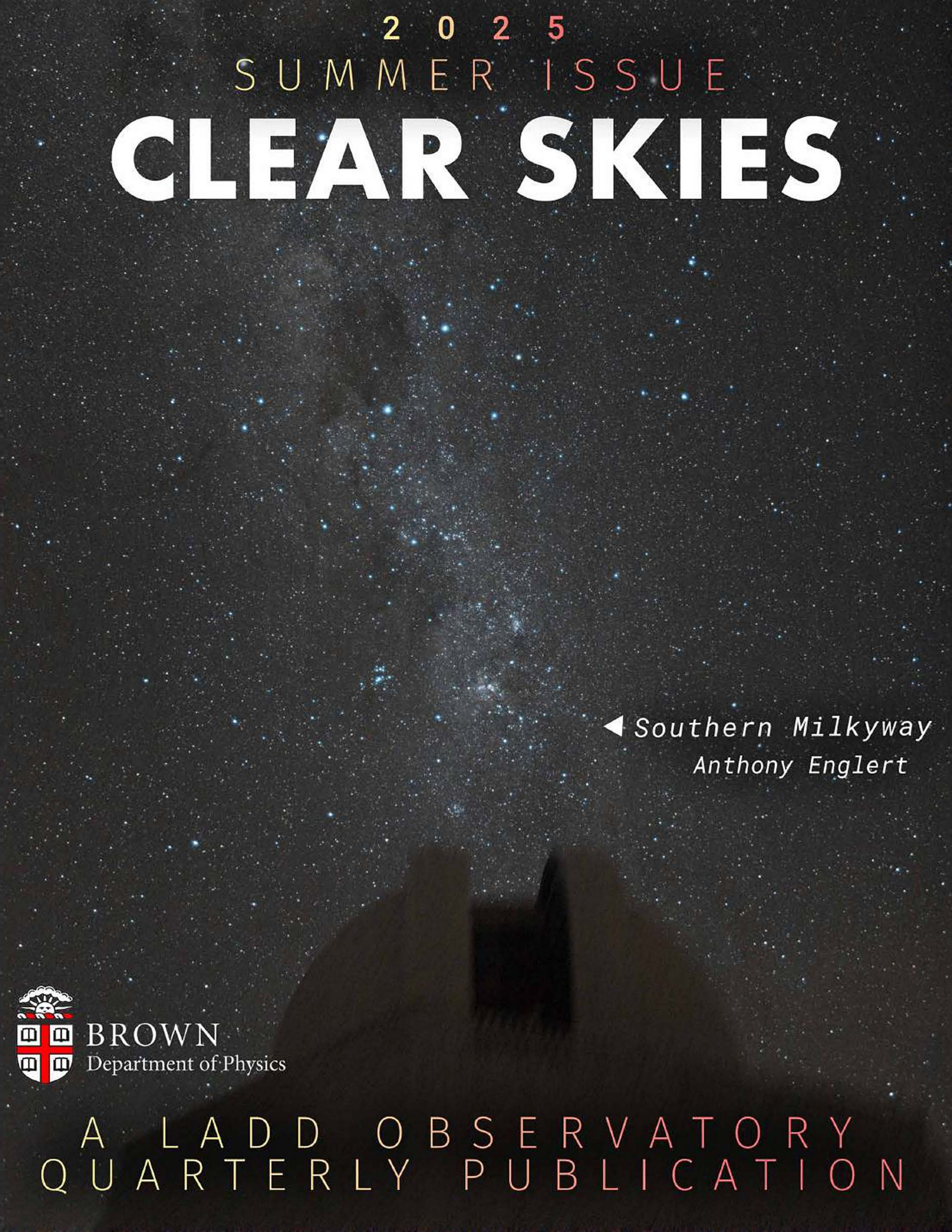
2025

SUMMER ISSUE

CLEAR SKIES



◀ Southern Milkyway
Anthony Englert

BROWN
Department of Physics

A LADD OBSERVATORY QUARTERLY PUBLICATION

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INTRODUCTION

Welcome to the summer edition of Clear Skies! With the weather being as hot as it's been, we all hope you are able to find a nice, cool place to read and enjoy these articles.

As ever, we begin with Jim's star maps for August and September. Also, take a look at the image gallery, where several beautiful pictures of celestial objects can be admired.

Other forms of astronomical "viewing" are here: Mahmoud and Ian introduce the work being done at Brown in spectroscopy, and Mike takes us back to the early days of radio astronomy.

For many of us, Anthony's trip to Cerro Tololo in Chile would be a dream come true. Be with him as he talks of his time observing with this incredible instrument.

Francine introduces what at one time was thought to be an important phenomenon for determining distance in the solar system: the transit of Venus, which has one of the most unusual cycles in all of astronomy.

Mike travels into the archives to 1624, where a painting by the artist Vermeer has astronomical significance.

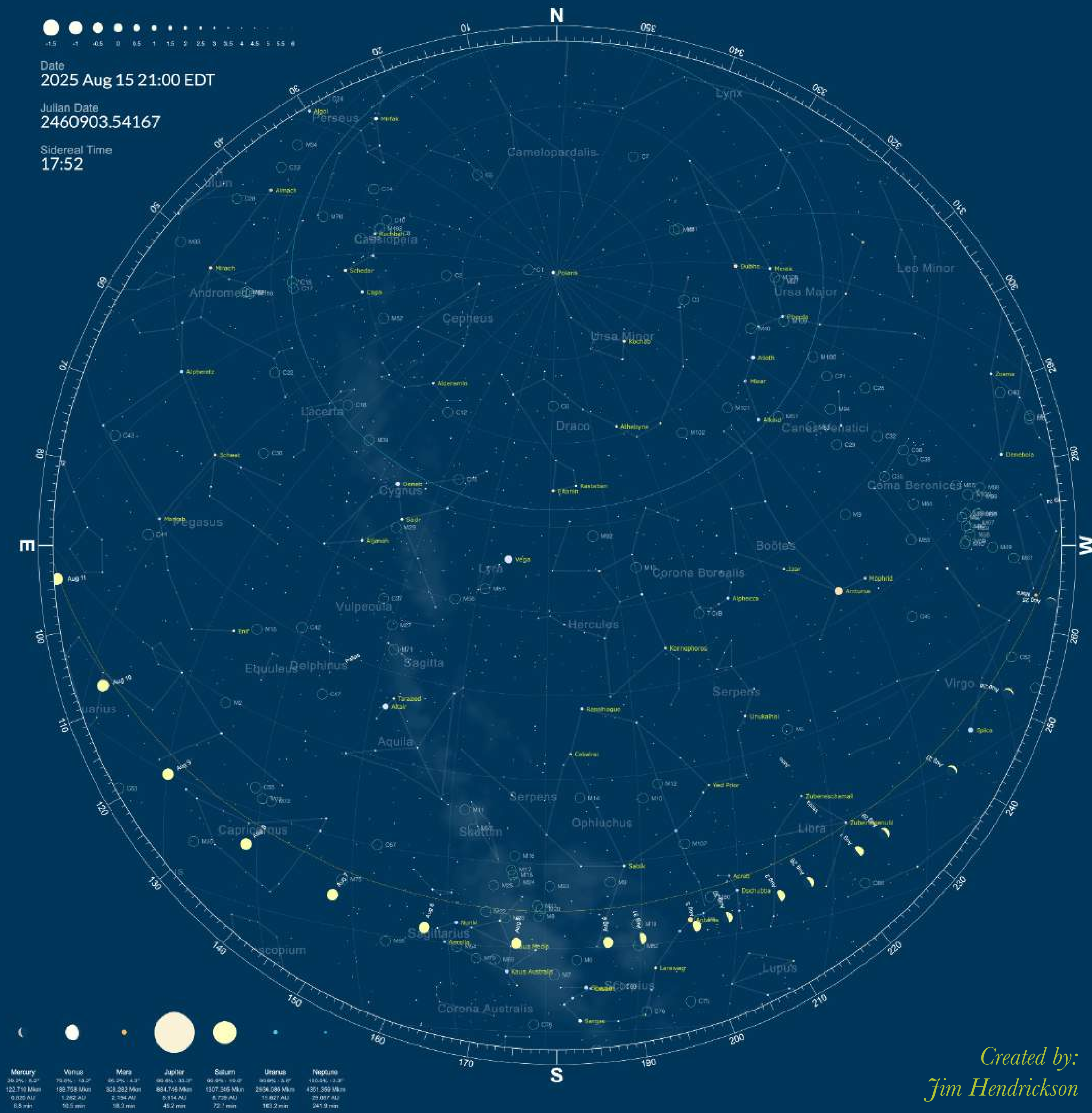
Donny lays out for us both the history of astronomy here at Brown, and the creation of the Brown Astronomy Club.

Rhode Island School of Design staff and students have visited Ladd quite often, sometimes coming up with ideas and concepts for exhibits. RISD student Stephanie Van Riet recently showed one, and, if you missed seeing it on display in the Transit Room, you will enjoy reading about it here.

As ever, Clear Skies wouldn't be the magazine it is without the incredible work by layout and design staff Ina Ma and Shaliz Bazldjoo, and the cover artwork by Mahmoud Hallak.

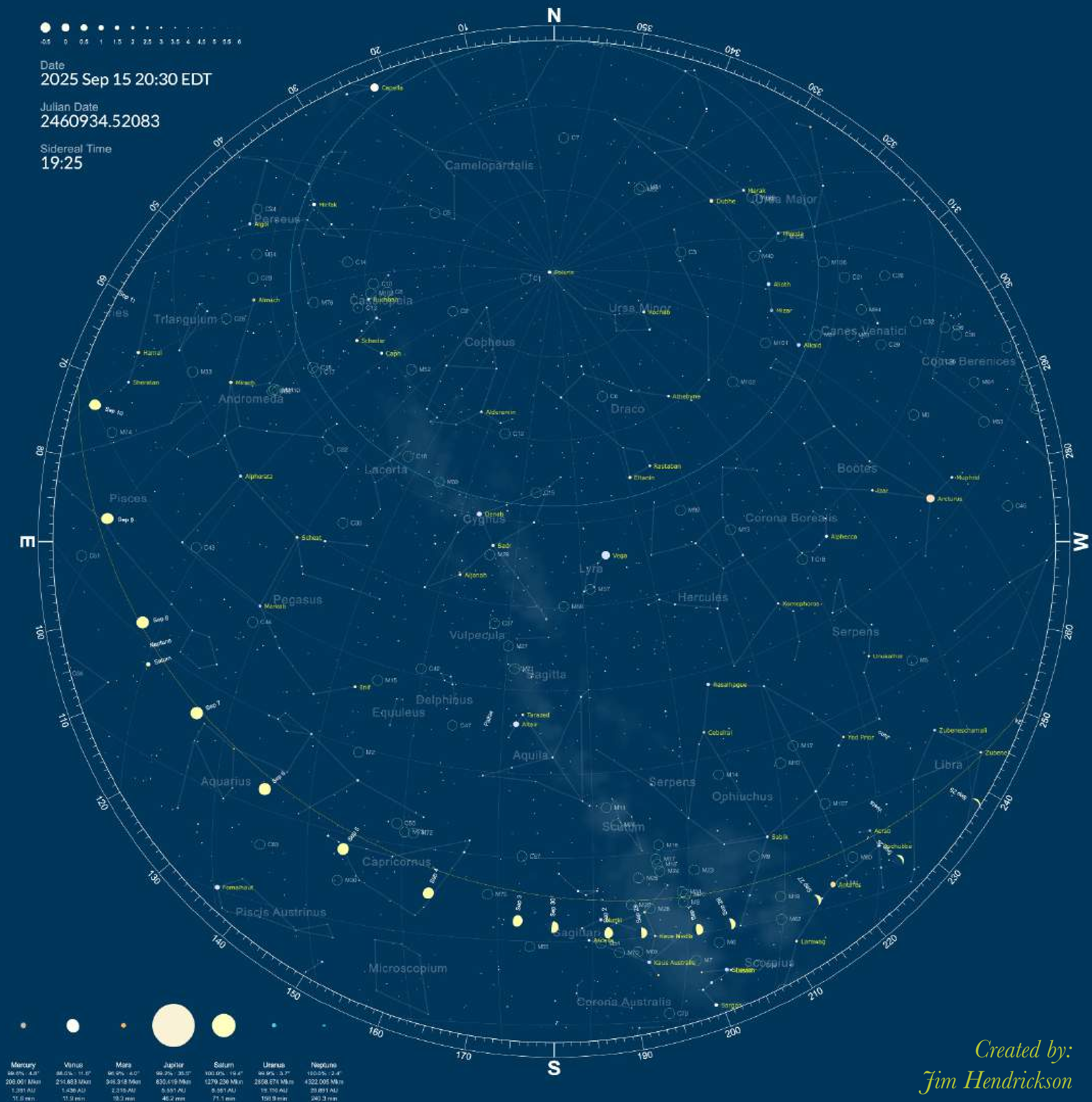
Please enjoy our Clear Skies!

August Sky Chart



Created by:
Jim Hendrickson

September Sky Chart



Created by:
Jim Hendrickson

HOW 260 YEARS OF STUDENT-LED ASTRONOMY AND DEPARTMENTAL COLLABORATION SHAPED BROWN'S ASTRONOMY LEGACY

DONOVAN DAVINO

Beginnings

Brown University, known then as Rhode Island College, was founded in 1764. Within just a year, astronomy made its way into the curriculum when President James Manning, president and faculty at Brown offered the school's first classes on the subject in 1765.

Jump ahead a few years, and in 1769, determined to observe the transit of Venus, Providence merchant-scientist Joseph Brown (one of four Brown brothers, including Nicholas Brown, the university's namesake) imported a precision catadioptric Gregorian telescope from London and set it up on campus. He observed the celestial event and would later become both an astronomer and professor of astronomy at the college. His telescope remains part of Brown University's collection and is available by appointment with the archivist.

After a century of instruction through other departments, Brown formalized a Department of Astronomy in 1883. Eight years later the department gained a crown jewel: Ladd Observatory, a domed facility funded by a $40,000 gift from former Rhode Island governor Herbert W. Ladd. Professor Winslow Upton became the first director of Ladd Observatory in 1891. Under Upton, students and townspeople alike made their way to Hope Street to see Saturn's rings through a 12-inch refractor. In 1891, the newly opened Pembroke Hall offered women's classes in celestial mechanics (from its founding the Pembroke, Women's College Adjunct to Brown University, was separate from Brown which only admitted men. The two were merged in 1971 as a coeducational institution).

A Department in Crisis and Charles Smiley's Timely Rescue

When Winslow Upton suddenly passed away in 1914, Brown University faced uncertainty about the future of its astronomy program. Two paths were considered: merging astronomy with either the physics or mathematics departments. Ultimately, Brown chose to place astronomy under the temporary oversight of the mathematics department. During this transitional period, R.G.D. Richardson (1914–1921) and Clinton H. Currier (1921–1931) served as interim directors of Ladd Observatory. Although the university had no formal chair of astronomy during these years, courses continued to be taught, the instruments remained in use, and student curiosity found new outlets.

In 1930, Charles H. Smiley joined Brown as a professor of mathematics. By 1931, he became director of Ladd Observatory. In 1932, Prof. Smiley, created *Skyscrapers*, an amateur society that began with 15 members and soared to 56 within months. Among its ranks were several members of the Brown University community, and just two years later the group purchased Frank Seagrave's private observatory in North Scituate, where its eight-inch Alvan Clark refractor still welcomes the public.

Among those profoundly influenced by Charles Smiley and the Skyscrapers Astronomical Society was Robert Horton, who today serves as the Manager of Astronomy Labs and Public Outreach at Brown University. Reflecting on his journey, Bob shares, "I discovered the observatory, which is located in my hometown, when I was 12 years old. I joined the group as a junior member when I turned 13 years old, over 50 years ago! I doubt I would have ended up in my career without the inspiration of fellow amateur astronomers. And that brings me full circle to the present - working with a wonderful team of students at Brown, and sharing our love of astronomy with others." This story illustrates how a single moment of inspiration can spark a lifelong passion, one that not only shapes a career but eventually brings that passion full circle, creating opportunities to inspire the next generation.

Smiley's charisma also drew crowds back to the university campus. A 1937 *Alumni Monthly* article noted with amazement that "an average of fifty undergraduates" packed into Ladd's open nights. The administration took notice, and in 1938, after a 24-year hiatus, Brown officially re-established the Astronomy Department, appointing Smiley as both department chair and director of Ladd.

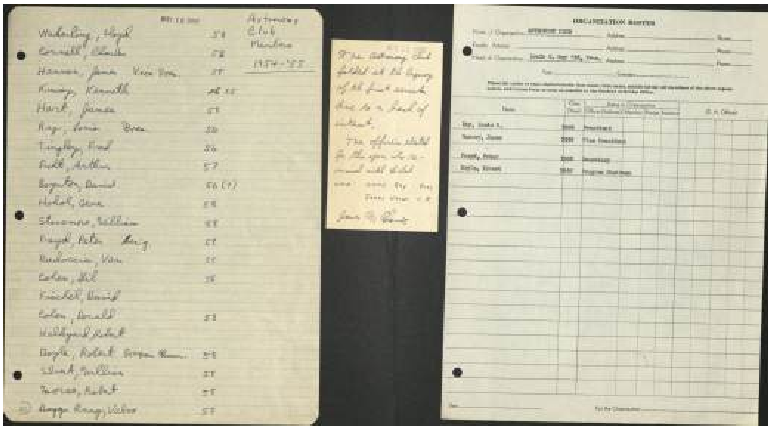
On April 12, 1949, eighty students crowded onto

Ladd's observing deck to witness a partial solar eclipse, while Smiley and three seniors captured what would become iconic photographs of the blacked-out sun. Smiley was also renowned for his eclipse expeditions, which took him to places like Peru, Manitoba, and Thailand. These journeys often provided hands-on learning opportunities for the Brown community. One such trip, the 1955 eclipse expedition to Thailand, included three university students, among them Kenneth Kinsey, a recent Brown graduate who skipped commencement exercises to attend, and Judith Preston from Pembroke College. Smiley held his roles of department chair and director of Ladd until his retirement in 1970. That same year, under new director Philip J. Stiles, the Astronomy Department was formally merged with the Department of Physics.

Astronomy Clubs Beginnings

By the mid-1950s, the momentum was palpable. The Brown University astronomy club was chartered for the 1954–55 academic year with 21 student members (roster below), the Brown University Astronomy Club met weekly to build telescopes and plan stargazing events. Led by President Louis Ray and Vice President James Hanner, the group captured the curiosity of students eager to explore the skies.

But its golden hour was brief. In 1956, a handwritten note



in the archives recorded that the club had formally folded "due to a lack of interest." Yet it seems the spark was not entirely lost. Just a year later, on September 25, 1957, the Cammarian Club, Brown's original student government, reviewed the Astronomy Club's constitution, though approval was delayed pending clarification. That fall, the club returned to the spotlight in *The Brown Daily Herald* with plans including a Sputnik-sighting event, urging students to bring binoculars, as well as many stargazing events, and film nights. Momentum surged: six announcements ran in the 1957 Brown Daily Herald and 16 more followed in 1958, suggesting the constitution was eventually approved. However, by 1959, there was only one Herald announcement, and in 1960, again only a single Herald announcement appeared, suggesting a slowdown in activity. It is possible the club continued meeting quietly or simply stopped publicizing its events.

A Rooftop Renaissance

Modern astrophysics returned in force with the opening of the Barus & Holley Observatory atop Brown's science complex in 1976 (renovated and upgraded in 1997). For the first time, advanced CCD cameras and a control room let undergraduates capture digital data without leaving College Hill. To this day undergraduate labs are held in the observatory.

Although there was no formal astronomy club during this era, students remained a driving force within the department. One standout was David Targan, who would later become a professor at Brown, and Director of the Ladd

FIGURE SEQ FIGURE * ARABIC 3.

TOP PHOTO CAPTION: THE IMAGE OF THE SUN AS IT APPEARS ON THE GLASS PLATE AT THE SHUTTER BEFORE THE FILM IS INSERTED. THIS CAMERA MADE ONE PICTURE EVERY FIVE SECONDS DURING ECLIPSE.

MIDDLE PHOTO CAPTION: MISS JUDITH PRESTON OF HAMPDEN, CONN., A STUDENT AT PEMBROKE, ADJUSTS MIRROR WHICH REFLECTS SUN INTO LENS. BOTTOM PHOTO CAPTION: KINSEY EXPLAINS HOW A 35-MILLIMETER CAMERA WAS TO BE USED TO RECORD VARIOUS PHASES OF THE ECLIPSE.

BOTTOM PHOTO CAPTION: KINSEY EXPLAINS HOW A 35-MILLIMETER CAMERA WAS TO BE USED TO RECORD VARIOUS PHASES OF THE ECLIPSE.


The Image of the Sun as it appears on the glass plate at the shutter before film is inserted. This camera made one picture every five seconds during eclipse.

Miss Judith Preston of Hampton, Conn., a student at Pembroke, adjusts mirror which reflects sun into lens.

Kinsey Explains how a 35-millimeter camera was to be used for recording various phases of the eclipse.

Observatory. His connection to Brown originated in a meaningful engagement with none other than Prof. Smiley. David states "In 1973 I was fortunate to be on the Canberra, a large passenger cruise liner that was going to sail off the coast of Africa to a location within the path of totality. Charles Smiley was the astronomer who gave talks about astronomy and eclipses to the passengers. I talked to him and he told me about Brown."

Inspired by that encounter, and drawn by the cutting-edge equipment in Brown's new observatory, David chose Brown over other options. Once on campus, he threw himself into hands-on astronomy, training undergraduates on the 14" telescope in the University Observatory and the 12" at Ladd, which they began using for introductory courses.
David recalls, "Those undergraduates became TAs

the next year, so we developed a cohort of 6-10 TAs. Some of them were not physics concentrators- for example one student was an undergraduate premed student in the 7 year AB-MD program. They loved the extra time they spent learning the ropes (literally, in the case of Ladd) and we succeeded in developing an observational program associated with the intro courses, run by both undergraduates and graduate students."

According to David, even without a formal astronomy club, student-led activities flourished during these years. "We had a weekly Wednesday night program that featured talks and slide shows so even cloudy night open house events were worthwhile. We had a trip to the frozen far north of North Dakota on Feb 26, 1979 for a total solar eclipse. We also took trips north to find dark skies to observe meteor showers and we set up telescopes on Jerimoth Hill, […] We had events for students such as public observation of the sun. Also views through portable telescopes from the Main Green."

Though unofficial, these efforts reflected the heart of a thriving student-led astronomy community. In many ways, the spirit of the department lived on through students like David, whose journey began with a conversation on a boat and ultimately led him to take on the role of Ladd Observatory Director, continuing the legacy passed down from Smiley. It is a reminder that sometimes, the smallest encounters can shape our future in unexpected ways.

Twenty-First-Century Reboot

The pandemic year of 2021 might have grounded many activities, but it rekindled Brown's stargazing spirit. The current iteration of the Brown University Astronomy Club was born out of one student, Phillip LaDuca's, desire to connect more deeply with the cosmos. In Fall he enrolled in PHYS 270, the introductory astronomy, and astrophysics course, taught online by Professor David Cutts. This experience left a lasting impression. Inspired by the course, he decided to pursue astrophysics when he arrived on campus the following semester. Eager to use the telescopes in person, he became a TA for the course and secured a job at Ladd Observatory, where he built connections with Bob and other professors.

Motivated by the lack of student access to the Barus & Holley Observatory outside of lab hours, he took the initiative to formally re-establish the Astronomy Club. Phillip applied to the Student Activities Office, drafted a constitution, and secured around $1,600 in funding. The club was officially instituted in Spring 2022. In its early days, he initially asked friends to sign on as founding members to meet the official membership requirement, but the club soon expanded in both size and visibility. Today, the Astronomy Club's email list includes nearly 600 members, and thanks to additional funding and grants, the club now owns several telescopes specifically for club use.

When asked about the most memorable moments Philip replied one included organizing a camping trip to New Hampshire's dark skies that blended hiking, community, and night-sky observation. The club went on to host numerous events such as observation

nights open to students and the broader community, and organized a 200-mile caravan to Vermont to witness the 2024 solar eclipse. In doing so, they shared in an intergenerational tradition of eclipse watching, an experience once marked by figures like Smiley and Targan. Other vital club members of the Brown Astronomy club in the years to follow include Mahmoud Hallak, Finnegan Keller, Donovan Davino, Alexis Ortega, and Pei-Jun Huang, amongst many other important members.

A Tradition Still Looking Up

From Joseph Brown's transit-of-Venus telescope in the 18th century to the Astronomy Club's recent acquisition of robotic telescopes controllable by smartphone, Brown University's astronomy story has been one of enduring student initiative and innovation. When formal academic structures faltered, student-led clubs emerged to fill the gap; when departmental budgets tightened, it was dedicated amateurs who kept the spirit of astronomy alive and the passion for exploration burning. This resilient spirit has kept Brown's astronomical legacy vibrant across generations.

As the university looks ahead to the next phase of instrument upgrades and expanded public outreach programs, one message remains clear: at Brown, astronomy is far more than a classroom subject. It is a living dialogue, one that spans centuries, sustained by every student who lingers a moment longer at the eyepiece, captivated by the cosmos and reminded that the universe still welcomes their curiosity.

Transits of Venus

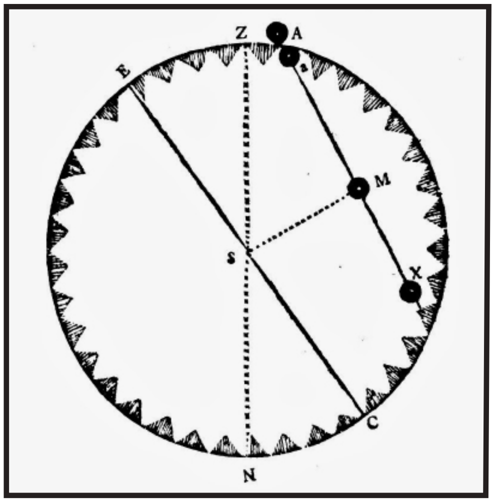
In the 1600s Johannes Kepler, known for his three laws of planetary motion, realized the planet Venus occasionally passes directly in front of the Sun – transits – from our perspective. He noted that one would occur in 1631. No one saw it.

As good as Kepler's calculations were, he missed the fact that another would occur in 1639. An English minister, Jeremiah Horrocks, noted this omission, and he, and a friend of his, William Crabtree, were the only two who witnessed it.

In 1677, Edmond Halley observed the planet Mercury transit the Sun, and realized a planetary transit could in fact be used to determine the distance between the Sun and Earth, the astronomical unit; however, Mercury is really too small to be able to accurately observe the apparent motion of it across the Sun. Therefore, Venus would be a much better planet to observe.

There was a slight problem, though: Venus only undergoes transits four times in over two centuries. The next one after Halley's observation was in 1761, years after his demise. This, and one happening eight years later, resulted in scientists traveling around the world in attempts to determine the elusive Sun/Earth distance. Even in Providence, astronomer Benjamin West observed the 1769 transit from Providence's East Side. Today, Transit and Planet streets are memories of the work West did.

A watercolor silhouette of Benjamin West, Professor of astronomy and natural philosophy. Credit: artist and date unknown



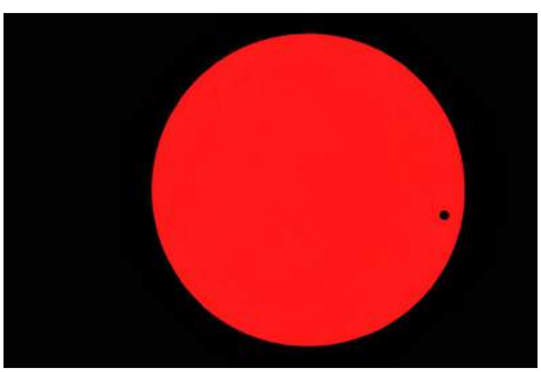
A diagram illustrating the 1769 transit of Venus. Credit: Benjamin West, from: An Account of the Observation of Venus Upon the Sun, the Third Day of June 1769.

With 18th century measurements unsure, the scientific community waited for the next set of Venus transits: 1874 and 1882. Again, there were journeys around the world to try to pinpoint the actual measurement of the astronomical unit. Among those travelers was David Peck Todd, Director of the Amherst College Observatory. He had become fascinated with transits while observing in 1874. An itinerant tinkerer, Todd had invented a way to photograph the event without having the images becoming blurry. Traveling with major American astronomer Simon Newcomb, Todd was charged with reducing all the observations, but he didn't finish doing so until 1881. This enraged Newcomb, who passed Todd over for his 1882 South America expedition. However, this allowed Todd to travel to Mount Hamilton, California, where his photographs were considered the best of that phenomenon.

Today, through better and less infrequent astronomical occurrences, the Earth/Sun distance is listed as 150 million km, or 92.9 million miles. Interestingly, the entire 20th century was "skipped" over from any Venus transit activity, and the previous two, in 2004 and 2012, were more objects of interesting observations. And now, we again have to wait a while to watch Venus seem to pass in front of the Sun, 2117 and 2125.

Mike Umbricht testing a digital camera attached to the Ladd telescope before the 2012 transit. Credit: Ladd Observatory

Observers on the roof of the Barus and Holley physics building during the 2004 transit. Credit: Bob Horton



Hydrogen alpha image of Venus transiting the Sun on June 8, 2004. Credit Bob Horton

Second contact of Venus transiting the Sun on June 5, 2012. Credit: Michael L. Umbricht

FROM THE ARCHIVES:

The book by Adriani Metii in the Vermeer painting of *The Astronomer*.

There are a pair of paintings by the Dutch Golden Age artist Johannes Vermeer that are titled *The Astronomer* and *The Geographer*. Astronomus is the Latin word for the phrase "the astronomer," and geographus is the Latin word for the phrase "the geographer." Astronomy and geography were often paired together in the early 17th century when Vermeer created these paintings. The two disciplines used the same scientific instruments: the astronomer used the instruments to measure the exact positions of the stars and planets; the geographer used them to measure latitude and longitude on Earth.

The astronomer is resting a hand on a celestial globe that shows the positions of the stars and constellation figures. Behind the geographer there is a globe of the continents of Earth. These two types of globes were often sold as a pair. At the base of the astronomer's globe there is a scientific instrument called an astrolabe. It was used to measure the position of the planets relative to the background stars. It was also used by navigators, surveyors, and map makers. The astrolabe was a precursor to the sextant.

Both paintings have the same person at center wearing the same clothing. This is possibly Antonie van Leeuwenhoek. He was a microbiologist who did early work with the recently invented microscope. Vermeer and van Leeuwenhoek were both born in Delft in 1632. The painting on the wall behind the astronomer is called *Finding of Moses*. Moses was seen as "learned in all the wisdom of the Egyptians." He has also been referred to as the "oldest geographer" because of his numerous travels and geographical descriptions. There is a great deal of symbolic detail portrayed within these paintings.

On the table near the astronomer's globe there is a book. Art historians have identified it as the 1621 volume of Adriaan Adriaanszoon's *Institutiones Astronomicæ et Geographicæ*. It is a practical work on using instruments for measurements in astronomy and geography. The page that it is opened to is a section titled "On the Investigation or Observation of the Stars." A translation of a portion of the text is shown here.

> "The first observers and investigators of the situation and course of the stars have been, as history points out, our ancestors the patriarchs who through inspiration from God the Lord and the knowledge of geometry and assistance of mathematical instruments have measured and described for us the firmament and the course of the stars."

The author is often referred to by his adopted name Adriaan Metius. Metius is a Dutch word that means "measurer" or "surveyor." The book in the painting can be identified as the second edition of his 1614 work. Both were printed in the author's native Dutch. The archives at the John Hay Library includes a 1624 version of this work that was printed in Amsterdam. This edition is a Latin translation. The annotations in some of the engravings are in Dutch and/or Latin; the same printing plates were used from the earlier editions. The author's name on the title page is the Latinized version Adriani Metii. The photos of the book shown here are of the Latin volume in the Brown Library special collection. Description of the details in the paintings are based on the work *Vermeer's Astronomer: Observations on an Open Book* by James Welu.

—Michael L. Umbricht

The Astronomer by Johannes Vermeer, 1668.

The Geographer by Johannes Vermeer, 1668 - 1669.

ADRIANI METII
Alcmar. Prof. Matheſ. in Acad. Friſiorum
DE
GENVINO VSV VTRIVSQVE
GLOBI
TRACTATVS.
Adjecta eſt nova Sciatericorum, & artis Navigandi ratio
novis Inſtrumentis, & inventionibus illuſtrata.

FRANEKERÆ,
Excudebat Vldricus Balck, Ordinum Friſiæ Typographus.
Sumptibus Joannis Janſonii, Bibliopolæ Amſtelodamenſ. Anno 1624.

The page of the 1624 Latin edition with the author's name.

gulas, ſuper centro in circumferentia adminiculo plumarum æqualiter circumvolutas, collimatio perficitur: Vnde per 20 pr lib 3 element. Euclidis tota peripheria 180 gr. in ſua diviſione tantum admittit, fiuntque conſequenter gradus iſti duplo majores, quam more conſueto, quo peripheria in 360 gr. diſtinguitur.

Hujus diſtinctionis initium, graduumque numeratio à medio Cylindrorum puncto deorſum procedit, quemadmodum patet ex Iconiſmo, in quo Cylindri ænei duo, per circuli quadrantem à ſe mutuo diſtantes; medio loco anſa interpoſita eſt, à

P 2

A type of astrolabe invented by the author of the book. This is one of the pages that the book is open to in the painting.

16 DE ARTE

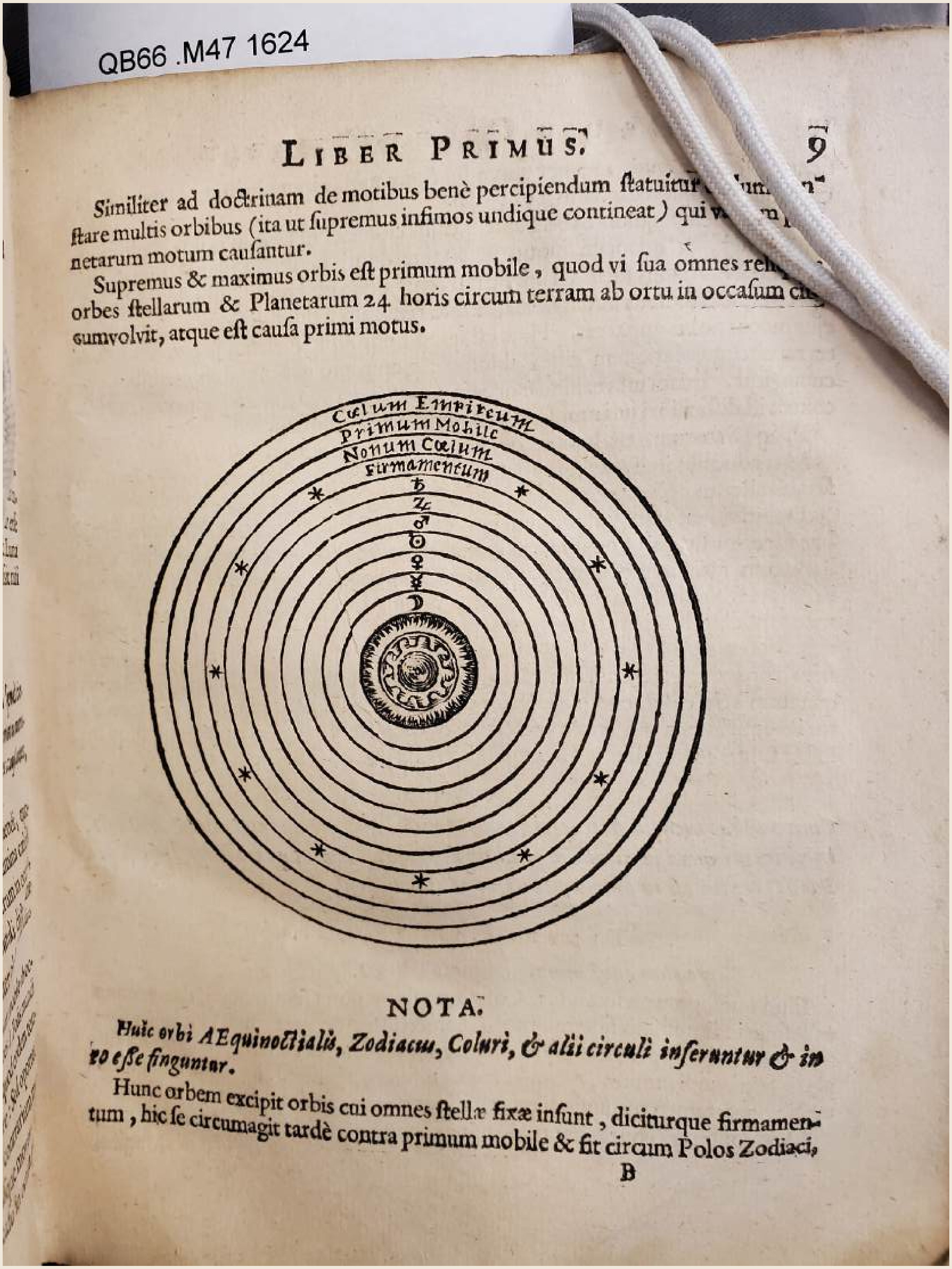
CAPVT II.

1. De inſtrumentis aptiſſimis ad uſum Navigationis, primum de Annulo Marino.

ASTrolabium non rectè inſeruit uſui, ob perpetuum navium motum, niſi pinnulæ in dioptra quam proximè ſibi mutuo collocatæ fuerint, tum enim nautæ nonnunquam utuntur Aſtrolabio, quod in Aſtronomia deſcriptum eſt, & ut his in ſchemate apparet.

Non tamen perfecta habetur obſervatio per ejuſmodi Aſtrolabium, pinnacidia enim in dioptra diſtant tantum 3 aut 4 digitis, & ſi in tam brevi ſpacio error ſit com-

An astronomer using an instrument to measure the position of the Sun above the horizon. The annotation "de kimmen" is Dutch. "Horison" is Latin. Both translate to the English word horizon. The direction overhead is called the zenith. The word is spelled the same in all three languages.



LIBER PRIMUS. 9

Similiter ad doctrinam de motibus benè percipiendum ſtatuitur ... ſtare multis orbibus (ita ut ſupremus infimos undique contineat) qui ... netarum motum cauſantur.

Supremus & maximus orbis eſt primum mobile, quod vi ſua omnes reli... orbes ſtellarum & Planetarum 24 horis circum terram ab ortu in occaſum ci... cumvolvit, atque eſt cauſa primi motus.

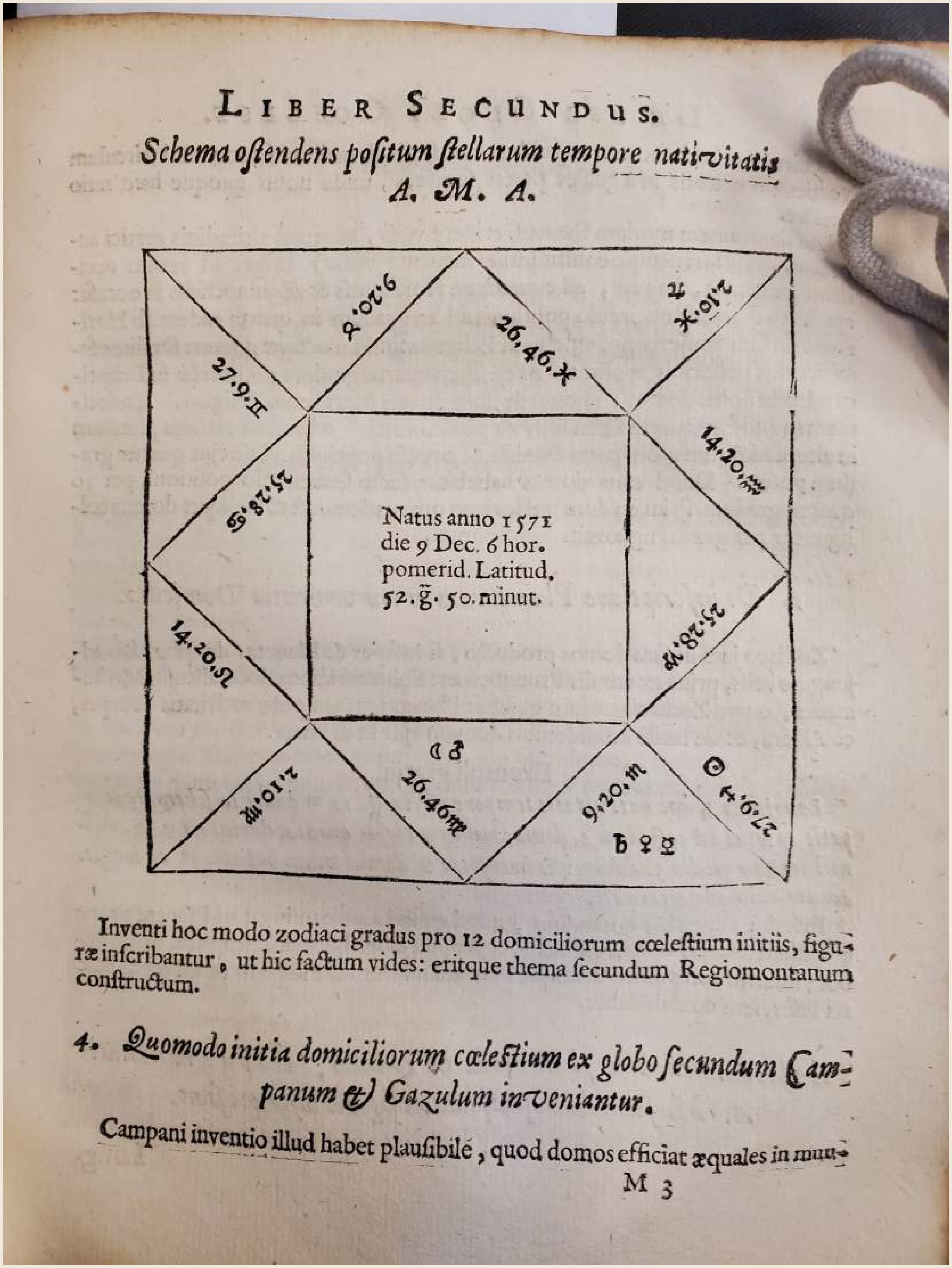
NOTA.

Huic orbi AEquinoctialis, Zodiacus, Coluri, & alii circuli inſeruntur & in eo eſſe finguntur.

Hunc orbem excipit orbis cui omnes ſtellæ fixæ inſunt, diciturque firmamentum, hic ſe circumagit tardè contra primum mobile & fit circum Polos Zodiaci,

B

Cosmological conception of the celestial spheres. The symbols represent the planets. The Sun is at the center; "firmanentum" is the sphere of the fixed stars beyond the planets.


LIBER SECUNDUS.

Schema ostendens positum stellarum tempore nativitatis A. M. A.

Natus anno 1571
die 9 Dec. 6 hor.
pomerid. Latitud.
52. g̃. 50. minut.

Inventi hoc modo zodiaci gradus pro 12 domiciliorum cœlestium initiis, figuræ inscribantur, ut hic factum vides: eritque thema secundum Regiomontanum constructum.

4. *Quomodo initia domiciliorum cœlestium ex globo secundum Campanum & Gazulum inveniantur.*

Campani inventio illud habet plausibile, quod domos efficiat æquales in mun-

M 3

The author scoffed at the practice of astrology. He did, however, include a natal horoscope. The notation at center is the date that the author was born, and the latitude of his birthplace. The 12 triangles represent the constellations of the zodiac. The symbols show the positions of the planets at the time of his birth.

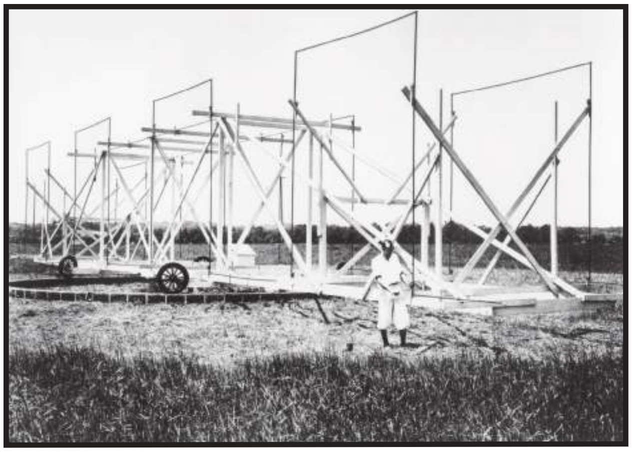
Electrical Disturbances Apparently of Extraterrestrial Origin

Alexander Graham Bell established the Bell Telephone Laboratories in 1925 to advance communications research. Bell Labs has made many important discoveries that led to technological innovations that we take for granted today: the transistor, the basic building block of all computer chips; the photovoltaic solar cell; the CCD imaging camera commonly used in cell phones. The CCD has led to great advances in astronomy imaging and new scientific discoveries.

Many discoveries have led to advances in pure and applied science. Bell Labs performed research in both radio communications technology and radio astronomy at their facility in Holmdel, NJ.

Galactic Center

Karl Guthe Jansky (1905 – 1950) was a radio engineer hired by Bell Labs in 1928. In 1931 he designed an antenna and radio receiver to investigate noise that interfered with shortwave communications at a wavelength of 14.6 meters. (In that era, it was common to report radio waves in terms of wavelength; it is equivalent to a frequency of 20.5 MHz. For comparison, the BBC World Service transmits shortwave broadcasts near this frequency.) These shortwave transmissions were to be used for trans-Atlantic radio telephone. He designed a directional antenna to try to identify the source(s) of the noise. The static, crackling, and hissing sounds were commonly called “atmospherics” in that era. The antenna rested on wheels from a Model T Ford that allowed it to rotate slowly. This led to the antenna’s nickname: “Jansky’s merry-go-round.”



Jansky and his "merry-go-round" antenna.
Credit: National Radio Astronomy Observatory /
Associated Universities Inc.

He identified three sources: the first two were crackling sounds caused by lightning strikes from either local or distant thunderstorms; the lightning generates radio wave noise. The first type of noise preceded storms at his location. The second type coincided with difficulty communicating with South America when there were thunderstorms in the tropics. The third was a steady background hiss of unknown origin. In 1932 he published his initial results. The hiss seemed to be stronger when the antenna was aimed near the Sun. At the time it was believed that solar activity caused radio communication to sometimes be better or poorer. This was thought to be due to the interaction of sunlight with Earth's atmosphere, because it persisted after sunset. Radio waves from beyond the Earth hadn't been detected before.

In 1933 he published a brief note with updated results. After months of further studying these "hiss type atmospherics" he realized that the location was fixed relative to the stars. His first observations were done when the Sun was in front of the constellation Sagittarius. Later, when the Sun was in a different part of the sky, he continued to receive the more intense hiss from a location in Sagittarius that was near the center of the Milky Way galaxy. Later in the year he published a more detailed report titled *"Electrical Disturbances Apparently of Extraterrestrial Origin."* This was the first known confirmed detection of an extraterrestrial radio source. The timing of his observations, during solar minimum, was fortuitous. If he had tried to observe during the solar maximum the frequencies would not have penetrated the upper layers of the atmosphere, the ionosphere.

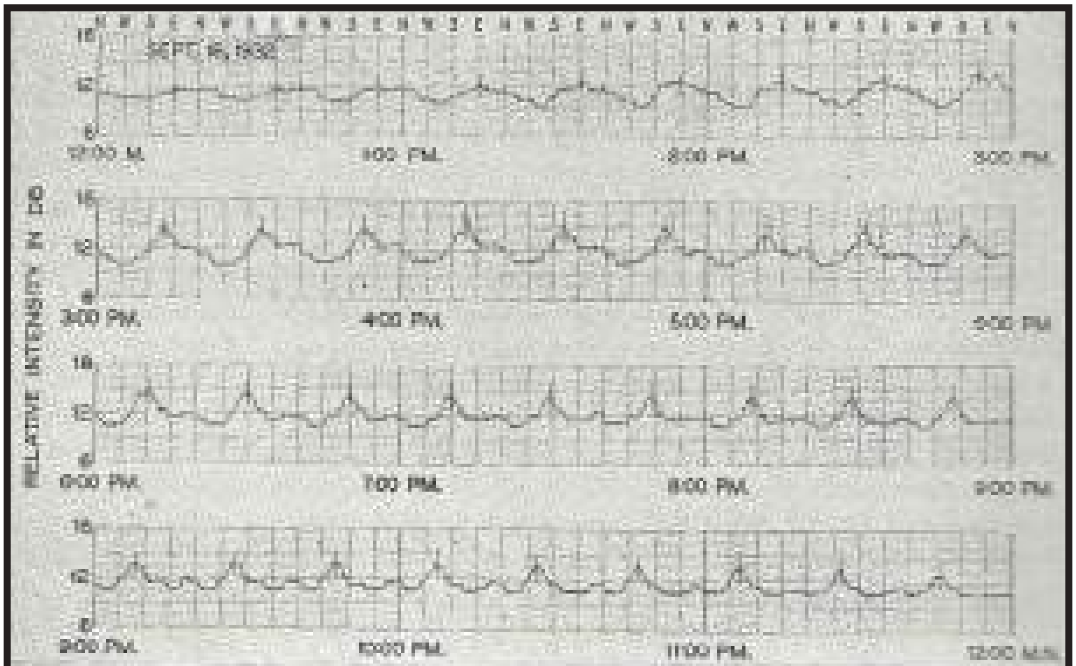


Fig. 1—Sample record of waves of extraterrestrial origin

Astronomers did not, at first, understand what the source in the center of the galaxy could be. It was later determined that there were several overlapping regions of radio emission. Then, in 1974, a more sensitive radio telescope was used to discover that the central, brightest, source was very small in angular diameter. It appeared that it originated from a point-like source, the radio counterpart to how a star appears.

Today, we know that the source of the signal is a region very close to a supermassive black hole (now named Sagittarius A* or abbreviated to Sgr A*) at the center of our galaxy. Studying the motions of ordinary stars near Sgr A* showed very elliptical orbits and high velocities that can only be explained if their motion is influenced by the intense gravity of a black hole that is four million times more massive than our Sun. In 2022 the Event Horizon Telescope consortium published results from an array of radio telescopes. The 1.3-millimeter (231 GHz) observations were used to produce an image of the "shadow" of the black hole.

The Jansky Monument is a sculpture that is a stylized representation of Jansky's radio telescope. It is located at the former site of Bell Labs in Holmdel, NJ. The sculpture is much smaller than the original antenna. The author is shown for scale. Credit: Lindsay Beebe.

Jansky is generally considered the founder of radio astronomy. The cosmic static disturbances that he studied are sometimes referred to as "Jansky noise." The measurement unit that radio astronomers use today to report their measurements is named the "jansky" (the abbreviation is Jy) in his honor.

Cosmic Microwave Background Radiation

The Holmdel Horn Antenna. The open aperture, at left, is 20 feet square and the horn is 50 feet long. The author is shown for scale. Credit: Lindsay Beebe.

Bell Labs began working on a sensitive antenna to detect transmissions that reflected off the NASA Project Echo satellites. These were large metalized balloons that could reflect radio signals back to the ground. The Echo 1 satellite was 100 ft in diameter, and launched in 1960. Echo 2 was even larger, at 135 ft, and launched in 1964. These large and highly reflective balloons were easily seen by the public as they passed overhead after sunset.

The first transmission was sent by the Jet Propulsion Laboratory in Goldstone, CA. They were received using a large horn antenna in Holmdel, NJ. The antenna is mounted on a track, allowing it to rotate 360 degrees. A large ring allows the antenna to change elevation from the horizon to the sky overhead. The antenna was aimed at a point where the satellites were predicted to be. At the narrow end of the horn there is an equipment room housing the radio receiver. The first signal was 2,390 MHz, which is the microwave portion of the radio spectrum. This experiment predated the first communications satellites that could receive a signal and repeat it to a different ground location. Other groups that participated in these early tests were the Collins Radio Company and the Naval Research Laboratory.

The horn antenna was very sensitive, and able to detect the very weak signals reflected from the satellites. The radio receiver was cooled with liquid helium to a temperature of 452 F below zero. The cooling was to reduce background noise from within the equipment.

During these experiments, Arno Penzias and Robert Wilson at Bell Labs discovered a background noise that was 100 times more intense than they expected. Astrophysicists at Princeton University had just predicted that there should be a cosmic microwave background radiation left over from the Big Bang at the start of the universe. The measurements exactly matched the prediction. The signal was detected in all directions in the sky, both day and night. The results were published in 1965 as *"A Measurement of Excess Antenna Temperature at 4800 Mc/s."* Penzias and Wilson were awarded the Nobel Prize in 1978 for this discovery.

Crawford Hill Today

The 7-meter (23 foot) diameter parabolic dish antenna. Credit: Michael L. Umbricht.

The horn antenna is listed on the National Register of Historic Places, and is a National Historic Landmark. Another antenna a short distance from the horn was designed for satellite communications testing in the 1970s. It was also used for radio astronomy to study star formation, aging stars, and external galaxies. Molecules that can be detected include carbon monoxide, silicon monoxide, and ethyl alcohol.

The town of Holmdel acquired 35 acres of land, including the two antennas on Crawford Hill. The site will become a public park and recreation area. It will be named Dr. Robert Wilson Park.

– Michael L. Umbricht

Image of Messier M8, The Lagoon Nebula. Taken with a Celestron Origin by Donny Davino.

Galaxies Messier M81 and M82, imaged using a Celestron Origin 6" RASA telescope. Photo by Donny Davino

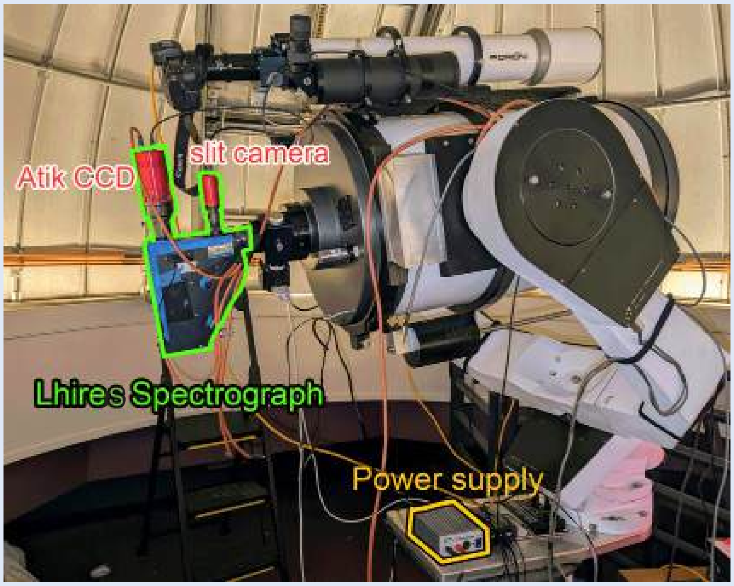
Mars was just above the Crescent Moon on June 29, 2025. I purposely overexposed the image to bring out the Earthshine on the dark portion of the Moon. Taken with a Nikon 1,000mm F11 mirror-lens.

-Bob Horton

Spectroscopy is the technique of breaking light into its component colors or wavelengths, often using a prism or a grating. It's extremely important in astronomy because so much information about distant objects is imprinted in the intensity at different wavelengths of light (called the spectrum). The spectrum of an object can tell you what its temperature is, what atoms it is made of, what the speed of the object towards or away from us is, and even information about the physical properties such as density and pressure of the emitting material. As the light travels from distant stars, nebulae and galaxies to us, it also acquires information about the gas in the space between them and us. Most of this information is encoded in the spectral lines, absorption or emission at specific wavelengths of light that are the "fingerprints" of different elements. The pattern of the lines tells you what elements are present. Because the lines are always created at the same wavelengths, the wavelength at which we detect the lines tells us the relative velocity of the star or galaxy via the Doppler effect (the redshift or blueshift of light).

Brown's physics department uses spectroscopy in laboratories in both the Introduction to Astronomy and Astrophysics and its extragalactic astronomy class, to measure the properties of stars and the redshift of distant galaxies, respectively. This has been one of the most difficult labs of the semester to carry out, because of problems in the design of our spectrograph.

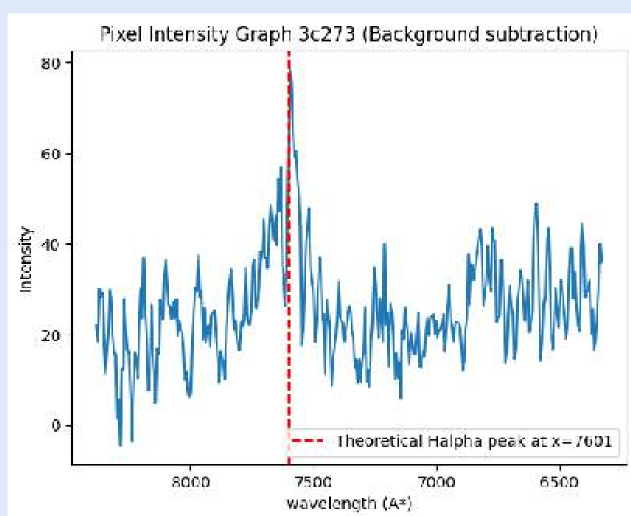
In 2023, the physics department recently purchased a new spectrograph to upgrade our astronomy labs. It's a French-made Lhires III spectrograph featuring interchangeable slits and gratings. This flexibility allows us to adjust the resolution range: we can study low-velocity events, such as binary star motion, and also capture high-resolution data for distant phenomena like galactic redshifts—crucial for investigating the expansion of the universe.



My role involved calibrating the instrument in the astronomy lab. Let's break down the two essential components of a spectrograph, the slit and diffraction grating. First, the slit lets us isolate a specific object in the sky for observation. Then, the diffraction grating disperses the incoming light into its component swavelengths, which are projected onto a CCD camera. A micrometer mechanism allows us to tilt the grating to scan across different parts of the spectrum. Since the position of light on the CCD corresponds directly to its wavelength, there's no need for a color camera. However, calibration is essential—we use a reference element lamp (e.g., a Thorium-Argon lamp) to precisely map pixel positions on the CCD to actual wavelengths.

Since our slit sizes are roughly the width of a human hair, precise guiding of the target object onto the slit is crucial. Although our equatorial telescope mount can track at the sidereal rate, small mechanical errors in the gears can cause the object to drift off the slit over time. Fortunately, the Lhires III spectrograph supports a separate slit-viewing camera, which allows us to monitor the target's position in real time. This setup enables an automated feedback loop to continually recenter the object on the slit, ensuring accurate and consistent data collection without the need for a person monitoring the slit.

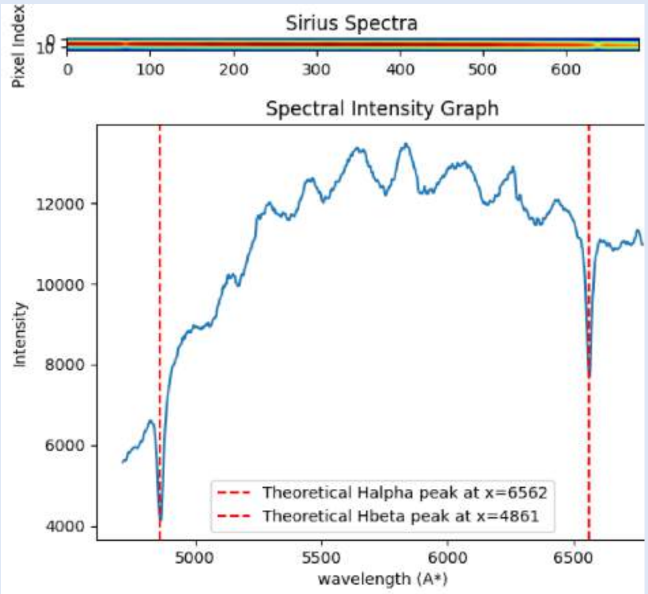
Due to light pollution in Providence, our astronomical targets are limited. To work within those constraints, we tested the spectrograph on some of the brightest objects in the universe: Active Galactic Nuclei (AGN). These incredibly energetic sources are not only luminous enough to overcome urban light pollution, but also distant enough to exhibit noticeable redshifts. One such object is 3C 273, the first



quasar ever discovered. It's moving away from us at approximately 47,400 km/sec and is so bright in optical wavelengths that it outshines its host galaxy.

To collect the spectrum of 3C 273, we centered the quasar on the slit and captured three 10-minute exposures. After calibration, we produced a clean spectrum. The x-axis of the graph shows the wavelengths: shorter (bluer) wavelengths on the left, and longer (redder) wavelengths on the right. Because 3C 273 is receding from us, we observe a redshift; its hydrogen emission lines appear at longer wavelengths than they would in a stationary source. This shift provides direct evidence of its motion away from Earth.

Most stars can be studied by the information encoded in the absorption features of hydrogen and other elements. Astronomers then use those spectral features to classify those stars. Type A stars, for example, have absorption features around the hydrogen lines due to their surrounding hydrogen gas, while smaller stars have more metallic absorption lines. Sirius, a type A blue star, shows a spectrum of the mentioned absorption features; those spiking dips at specific wavelengths indicate that a hydrogen cloud of some sort surrounding the star absorbed the incoming light.



By breaking light down into its component wavelengths, this instrument allows us to study everything from simple stars to the expansion of the cosmos, all from right here in the heart of Providence. Students in our future astronomy courses will have the opportunity to conduct their own investigations firsthand, stepping into the role of astronomers in the making.

– Mahmoud Hallak and Ian Dell'Antonio

A TRIP TO CERRO TOLOLO

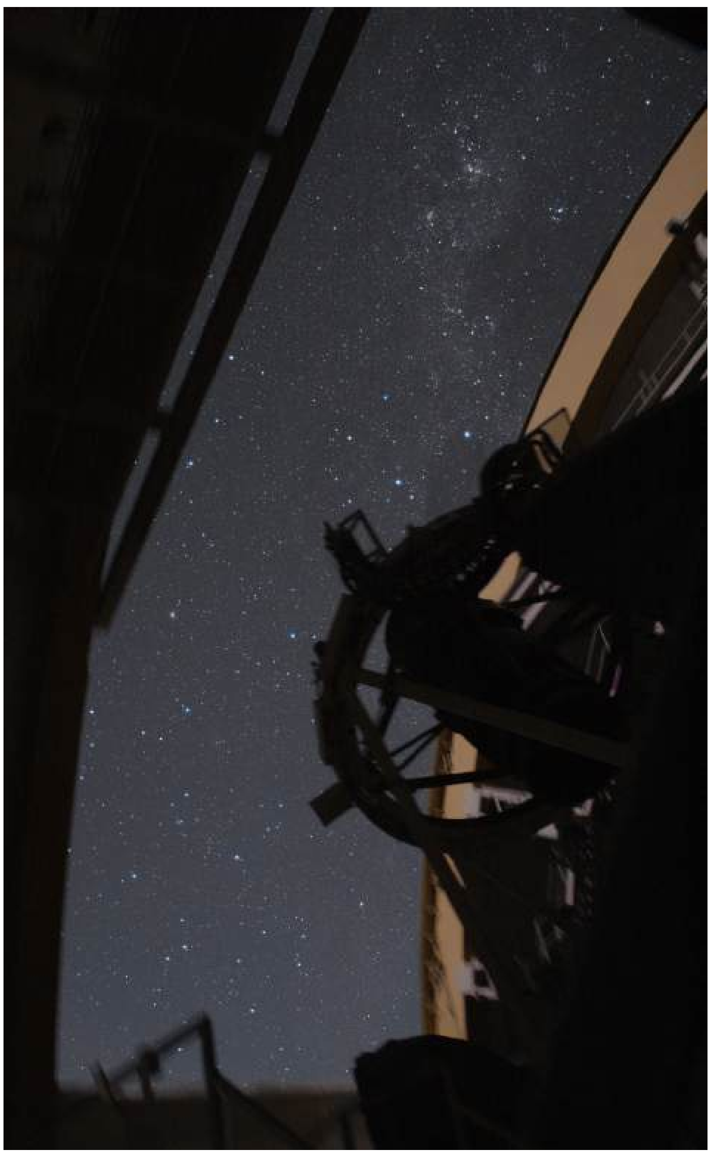
ANTHONY ENGLERT

It is a very exciting time to be an early-career astrophysicist. Some of the largest observatories and boldest projects, such as the Dark Energy Spectroscopic Instrument, the Vera C. Rubin Observatory's Legacy Survey of Space and Time, and a new generation of infrared space telescopes, have begun, ushering in a new era of "big data" in astrophysics. Observatories around the world are spending every night collecting data, often entirely automatically to maximize efficiency. But, this push to streamline observing has made it more difficult to travel and explore observatories to better understand the instruments and staff members who form the backbone of modern astrophysics. Fortunately, this May, I secured funding to carry out observations in support of my thesis using the 4m Victor M. Blanco Telescope, located at the Cerro Tololo Inter-American Observatory (CTIO) in Chile.

Getting to CTIO was just barely possible with a set of connecting flights that carried me across the United States, ending with a red-eye flight from Florida to Santiago and a final short flight to La Serena. After arriving, I was picked up at the airport almost directly off the runway by Guillermo Damke, one of the Assistant Scientists, and we embarked on his regular three-hour commute to CTIO from downtown. The drive was spectacular and full of nothing but clear skies, locals running small farms and other businesses along the road, and a beautiful cliff-side drive reminiscent of my trip last summer to Mt. Wilson. As the observatories occupying Cerro Tololo and the nearby Cerro Pachón

came into view, my breath was swept away: partially out of amazement and partially due to the thinning atmosphere at 2200m above sea level.

At CTIO, there is a team of over a dozen engineers, observational astronomers, and assistant scientists who spend weeks-long shifts living on the mountaintops as they maintain the telescopes. Everyone was housed in a small hotel just below the peak which can only be described as having "the best possible view" in each room, which overlooked the surrounding mountain range. After sleeping until the early afternoon, the staff either hike or drive to the peak to collect data for calibration, before going back to the hotel to grab dinner just before sunset. The food provided at the peak was, to my delight, excellent, mostly local cuisine cooked fresh every day. In fact, when I first arrived at the peak on (the Chilean) Labor Day, I was warmly greeted by staff members hosting a small barbeque to celebrate the day.



As my first night on the peak started, I was given a tour of the array of observatories present at Tololo. This includes the 4m Victor M. Blanco Telescope, whose size dwarfed other telescopes present on the peak. But there is an array of "smaller telescopes" owned by the SMARTS Consortium; of particular note were the 1m and 1.5m telescopes, which were being used to study stars by a pair of graduate students who were only two weeks into their two-month-long observing run. Loca-ted just a few miles away on Cerro Pachón was the newly constructed Vera C. Rubin Observatory, the Gemini South telescope, and the Southern Astrophysical Research telescope.

Several arrays of smaller telescopes were scattered across the peak as well, including the "mushroom farm," which is full of smaller telescopes optimized for finding near-Earth objects.

When sunset began, the observatory came alive as the domes surrounding each instrument opened up and appeared to flicker as stray light was reflected off the rotating domes. As the night grew darker, satellites and shooting stars made the sky come to life, and I had never seen so many visible to the naked eye. Most importantly, constellations and nebulae that were unobservable in the northern hemisphere, including the Southern Cross, the center of the Milky Way, and the Magellanic Clouds, were strewn about the sky. In fact, upon first looking at the sky, I was amazed, but also confused as the Moon and familiar constellations were rotated relative to their positions in Providence. This was made all the more shocking when talking to Guillermo and other astronomers who grew up in La Serena, and argued that Orion was always like that. Guillermo had experienced the same thing when visiting the NOIRLab headquarters in Tucson, AZ. The rotation is due to the positions of constellations, and the orientation of the Moon, being fixed with respect to the Earth. By travelling to the southern hemisphere, I was flipped upside-down relative to those fixed constellations.

On my observing nights, I operated the telescope from the control room with the help of two additional staff members. This included the opportunity to explore the dome and see the telescope first-hand, which was absolutely massive. Seeing my reflection in the 4m-diameter (~13ft) primary mirror was incredible and the dome that hosted the telescope felt even larger on the inside. Strewn about the dome were other instruments, filters, and pieces of equipment such as the (still-functioning) control panel that was installed when the telescope was built in the mid-70's.

On this trip, I happened to have a single free night where I was not booked to operate the telescope. I spent the night hiking across the peak, while imaging the night sky with my DSLR and a small tripod that I had managed to squeeze into my luggage. Unfortunately, I could not pack a star-tracker, but the skies were so dark that short exposure times were more than enough to capture the Milky Way setting over the SMARTS-1.5m telescope and capture the Large Magellanic Cloud next to Blanco. My final piece of astrophotography was taken on my last observing night, and features a snapshot of the Milky Way taken just behind the 4m telescope in Blanco.

One of the joys of academia is being able to travel in support of one's research, and this trip was no exception. Visiting Tololo was an experience I hope to have again with other telescopes in the future. Many of the experiences from this trip cannot be replicated by observing remotely and, particularly when operating a telescope remotely, the contributions of observatory staff are easy to overlook, despite being essential to modern astrophysics. As I continue in my career, I will be making a goal to not only experience this myself once again, but to pass it on to my future students and colleagues so they can understand the bigger picture of just what we do, how we do it, and who makes it possible.

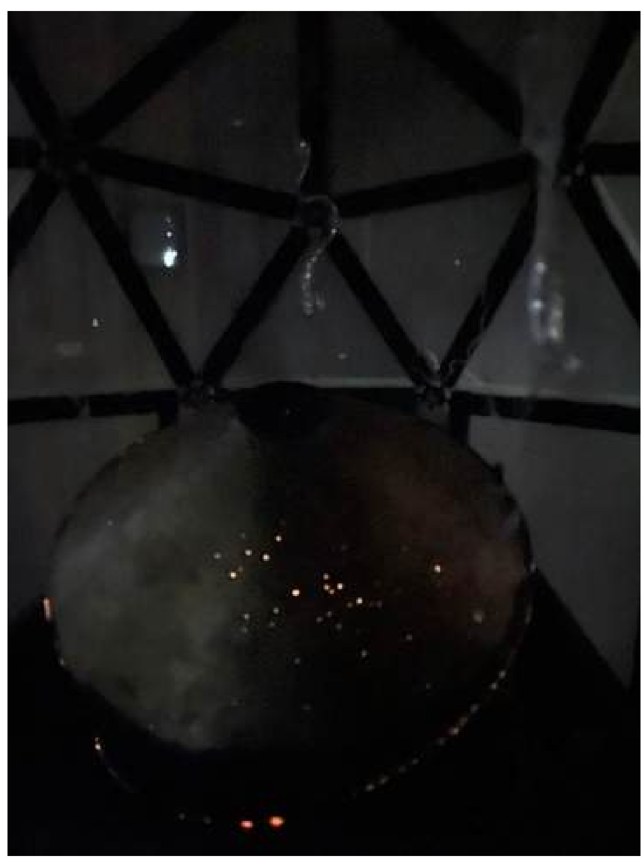
CELESTIAL THEATER

Stephanie Van Riet, *Celestial Theater*, 2025
Cotton mesh, pine, glass, thread, moss, plants, plastic, metal, UV lights, brass star projector, 6.5 ′ x 3.5 ′ x 3.5 ′

Existing within an endless cycle of circuits, we stare out at the sky, which curves around the edges of our eyes and extends behind our heads in a complete circle. By closely observing the world around us, we witness the gradual transformation of one thing into another, and then back again—a continuous spiral we record as history.

Artist Stephanie Van Riet explores her curiosity about deep time through her installation Celestial Theater, exhibited at Brown University's Ladd Observatory this spring 2025. Her constructed wooden dome, covered in sheer mesh and large enough to fit a human (or two!), houses a star map projector on a brick pedestal originally designed to hold a telescope. This projector illuminates a network of suspended glass - each piece a frozen gesture of motion, as the light refracts and dances across the dome's interior.

The shapes and sizes of the glass vary. Van Riet formed each piece by gathering hot glass on a punty rod and drawing with it in space. Her swift movements are recorded in the glass as it cools, capturing about a minute of motion in each form. The installation is viewed with no external light - only the star map projector reveals the glass forms, simulating the experience of patiently looking into the dark night sky, and being rewarded with the occasional meteor.



Celestial Theater also invites exploration under UV light. Ultraviolet lights secured to the top of the dome shine down on microplants and moss growing beneath, creating a luminous undergrowth. In astrophysics, UV light is used to study the formation of young stars, which emit most of their radiation in this wavelength[1]. Here, Van Riet subtly nods to the interdependence of celestial phenomena and earthly life—suggesting a relationship between the stars above and the slow, quiet growth below.

1 https://science.nasa.gov/ems/١٠_ultravioletwaves/

Functioning as a reverse observatory, Celestial Theater encourages viewers to turn their gaze inward, reflecting from within the historic Ladd Observatory—a site long used to look outward at the cosmos. Through her focus on light, motion, and the accumulation of time, Van Riet visualizes the invisible, encouraging new ways of seeing. Her reimagining of the observatory evokes a sense of celestial, temporal, and atmospheric wonder, while simultaneously drawing attention to the limitations of human perception in the face of the universe's immensity.

In her work, Van Riet seeks to understand humanity's fleeting existence within the scope of deep time—a concept that transcends our capacity for full comprehension. Acknowledging that we live for only a fraction of a second, she reflects on the finitude of life, even as we continue to create, to search for meaning and pattern, and to question whether our existence carries weight—or is simply one more flicker in the dark.

Her sincere thanks go to all who work at Ladd, who have graciously helped make this possible. A special thank you to Mike Umbricht and Bob Horton.

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