Highlights of the June Sky...

- - - 1st - - -

AM: Jupiter and Mars are 2° apart above the eastern horizon.

- - - 4th - - -

DAWN: All five naked-eye planets will form a long line starting low in the east to the southern sky. Mercury will be a challenge to spot.

- - - 5th - - -

PM: The Moon is 4½° to the upper right of Regulus and less than ½° below Eta Leonis.

- - - 7th - - -

First Quarter Moon @ 10:48 am EDT

- - - 9th - - -

PM: The Moon moves to within 6° of Spica in the constellation Virgo.

- - - 13th - - -

AM: A nearly full Moon appears less than 6° from Antares in Scorpius.

- - - 14th - - -

Full Moon @ 7:52 am EDT

- - - 18th - - -

DAWN: The Moon hangs 6° below Saturn. Mercury, Venus, and the Pleiades form a triangle.

- - - 20th - - -

Last Quarter Moon @ 11:11 pm EDT

- - - 21st - - -

DAWN: The Moon and Jupiter are about 5° apart.

- - - 22nd - - -

DAWN: A waning crescent Moon is 5½° to Mars' right.

- - - 24th - - -

DAWN: The five planets stretch across the sky from the ESE to the south. This time the Moon is evenly spaced between Venus and Mars.

- - - 26th - - -

DAWN: A thin waning crescent Moon is 2½° from Venus.

- - - 27th - - -

DAWN: The thinnest sliver of the Moon is 3½° left of Mercury.

- - - 28th - - -

New Moon @ 10:52 pm EDT

Prime Focus

A Publication of the Kalamazoo Astronomical Society

★ ★ ★ June 2022 ★ ★ ★

This Months KAS Events

General Meeting: Friday, June 3 @ 7:00 pm

Held on Zoom • Click to Register • See Page 14 for Details

Observing Session: Saturday, June 4 @ 9:30 pm

Kalamazoo Nature Center • Visit Observing Page for Details

Observing Session: Saturday, June 18 @ 9:30 pm

Kalamazoo Nature Center • Visit Observing Page for Details

Observing SIG: Saturday, June 25 @ 9:30 pm

Richland Township Park • Visit Schedule Page for Details

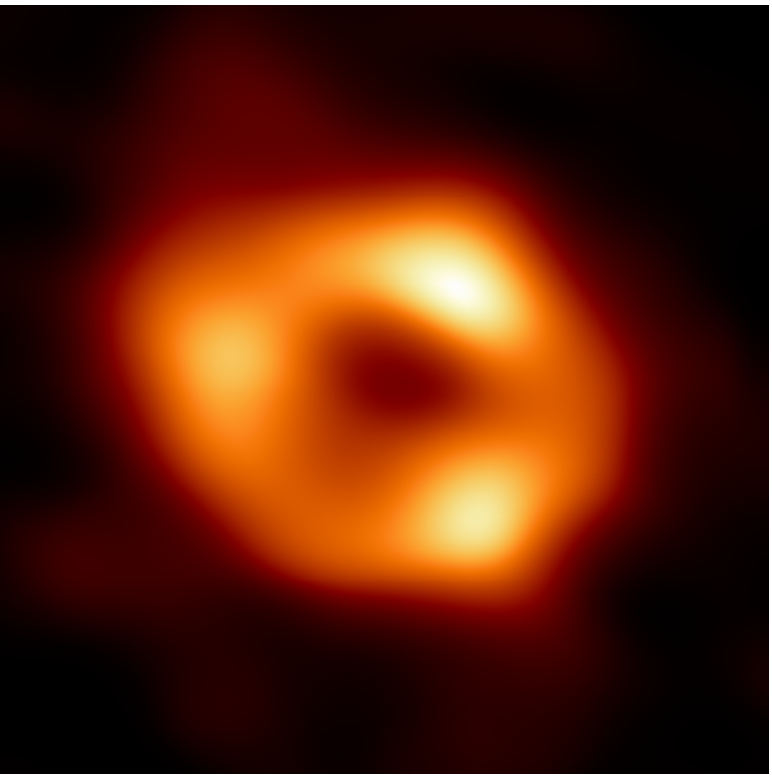
Inside the Newsletter. . .

Observations by Richard S. Bell

The Event Horizon Telescope collaboration revealed a new image of an accretion disk around a black hole on May 12th. This time it's none other than Sagittarius A* (Sgr A*, pronounced "sadge-ay-star"), the supermassive black hole (SMBH) at the heart of our own Milky Way Galaxy.

You might recall that the Event Horizon Telescope released its first image in 2019. This was of M87*, the SMBH within supergiant elliptical galaxy M87 (itself located at the center of the Virgo cluster). What's really amazing though is that radio telescope data for M87* and Sgr A* were both collected in April 2017. So, it took 2 years to process the data from M87*, but 5 long years for Sgr A*. Why the difference?

M87* may be much more distant than Sgr A* (53.5 million vs. 27,000 light-years), but M87* has a much larger event horizon due to its significantly greater mass. The most recent measurement (from the EHT collaboration) for M87* is 6.6 *billion* solar masses ($M_\odot$), while Sgr A* is only(!) 4.1 *million* $M_\odot$.



Gas whirling around both SMBHs move at relativistic speeds, up to 30% the speed of light. However, due to the smaller diameter of Sgr A*, gas completes an orbit in mere minutes. With M87*, it can take days to weeks to complete an orbit.

Nearly all the images of M87* look the same, while sophisticated new tools needed to be developed to account for the rapid gas movement around Sgr A*. One EHT member said it was like trying to take a clear picture of a puppy quickly chasing its tail!

The image at left reveals the *entire* accretion disk surrounding Sgr A* thanks to gravitational lensing. Space is so severely distorted, it permits us to view the disk on the far end of the event horizon. The dark feature in the center isn't the event horizon itself, but its larger shadow.

The resolution is incredibly fine at 52 μas (or 5.2×10^{-5} arcseconds, where 1° = 3600 arcseconds) or about the same size in the sky as a donut on the Moon. This is why the Event Horizon Telescope is needed to take an image like this. The EHT is currently a collection of 11 radio telescope facilities scattered around the world, but eight observatories were part of the collaboration in 2017 when the image above was created. Together, they work as interferometer. They may not have the light gathering capacity of one massive telescope, but together they have the *resolution* of an Earth-sized radio dish.

According to the press release, there's more black hole awesomeness to come. This include movies of material whizzing around black holes. These, along with more images, are supposed to be released in the near future.

May Meeting Minutes

The Kalamazoo Astronomical Society general meeting was brought to order by President Richard Bell on Friday, May 6, 2022 at 7:08 pm EDT. Over 130 members and guests attended via Zoom and the live stream on YouTube.

Our very special guest speaker was Dr. Alex Filippenko from University of California, Berkeley. He may be a world-renowned astrophysicist and professor of astronomy, but as we begin planning for April 8, 2024, it is interesting to note that Dr. Filippenko has witnessed 18 total solar eclipses to date.

Dr. Alex Filippenko's biography notes that he is working to determine the nature of the progenitor stars and the explosion mechanisms of different types of supernovae and gamma-ray bursts. He uses light from supernovae as cosmological distance indicators which provided him an opportunity to be a member of both teams that discovered the accelerating expansion of the Universe in 1998.

He also works on quantifying the physical properties of quasars and active galaxies, and he searches for black holes in both X-ray binary stars and nearby galactic nuclei. His group has developed the 0.76-meter Katzman Automatic Imaging Telescope (KAIT), which has conducted one of the world's most successful searches for relatively nearby supernovae, discovering more than 1000 of them. He is a frequent user of Lick Observatory, Keck telescopes, and the Hubble Space Telescope.

The first half of Dr. Filippenko's presentation, *A New Surprise in the Accelerating Universe*, was dedicated to sharing the history of discovering the Universe and exploring its mechanism of expansion. The story starts with two important discoveries made in 1912.

It wasn't yet known (for certain) that other galaxies lie outside our own. Vesto M. Slipher, from Lowell Observatory, measured the spectra of light from galaxies. He found that they were shifted toward the red end of the spectrum. This redshift was due to expansion of space itself. He was able to also prove that galaxies had rotation. While the rotation was measurable, the total distance to the galaxy was not.

Henrietta Swan Leavitt discovered that Cepheid variable stars have a specific and consistent brightness and periodicity. The cycle of these stars is highly consistent and allows the observer to know the actual luminosity of the star, no matter what distance the star may be. Plotting the light curve of a typical Cepheid shows that it is approximately 5.37 days long.

Edwin Hubble was studying nova (later identified as surface explosion of a white dwarfs). While these stars tend to brighten and fade, sometimes multiple times over many years, they do not have a regular periodicity. In 1924 he was observing a brightening event in M31, then known as the Andromeda Nebula, that he initially mistook as a nova. Hubble later amended the observation after noting the periodicity of the star as actually being a variable.

Using Leavitt's discovery, Hubble was able to determine the absolute magnitude of that star and therefore measure its distance. M31 turned out to be far beyond the confines of the Milky Way Galaxy.

Once the distance was known, Hubble was able to measure the width of the galaxy as well. It was larger and further away than anyone had ever anticipated at 1 or 2 million light years away and over 100,000 light-years wide. This was the first measurement of a galaxy outside of our own.

Subsequent measurements showed that many nebulae were actually galaxies and had distances far greater than that of Andromeda. Not only were galaxies far away from our own, but surprisingly the redshift of those galaxies showed that they were moving away from us. A constant was found correlating galaxy distance and the velocity at which it was moving away from us.

It has to be noted, Hubble obtained the redshift data from Slipher's papers, but he never gave Slipher credit. Additionally, while Hubble often gets credit for the constant, George Lemaître published his findings for the same discovery two years before Hubble. Lemaître also speculated the "beginning of the world" based on this constant. He is credited as the first to propose what would later be known as the Big Bang.

Original plots (of galaxy distance versus the recession velocity that revealed galaxies were moving away from us) were limited to a few thousand parsecs and was quite scattered. The more

recent data obtained from the Hubble Space Telescope shows distances of up to 600 megaparsecs, and is very consistent.

We now know that the Hubble-Lemaître law is $v = H_o d$. Lengthening light wavelengths can only be attributed to expanding space. It is accepted that, while the galaxies appear to be moving away from us (in the center of a visible universe), the reality is that no matter where in the Universe you make your observation it would appear to move away from you from that point of observation.

Seeing a universe behave in a certain way and explaining its motion are not the same thing. Isaac Newton gave us law of universal gravitation and three fundamental laws of motion. The Moon orbiting Earth is maintained in orbit by the same mechanism as an apple falls to the ground. These laws are the same that determine galaxy interactions.

Fritz Zwicky observed galaxy clusters clumping and orbiting each other in 1960's. But problematically, the galaxies visible mass failed to account for their gravitational orbit. Vera Rubin, in the 1970's, studied galaxy rotation and found that they wouldn't maintain their integrity without dark matter.

Later images by the Hubble Space Telescope shows gravitational lensing around galaxy clusters shows the same phenomena everywhere, where the lensing cannot be accounted for by the visible matter. There is dark matter everywhere in the universe that we look.

Is all this extra dark matter really black holes? It is not really possible. Big Bang nucleosynthesis shows that the abundance of dead star material could not have participated in early universe formation. It really can't be dead white dwarf stars or black holes or other dead star material. So, we really don't know what it is. Its nature is largely a mystery. Whatever it is, dark matter out numbers visible matter 5 to 1.

The behavior of the expanding Universe is also unjustified by visible energy alone. In theory you can examine the past history of expansion in order to determine the fate of the Universe. Has expansion been slowing down? Speeding up? By looking to further distances, you are also seeing light from further back in time.

Hubble's Law depends on red shift. But since Cepheids are not bright enough to be seen at billions of light years, a technique is required to be used independent of Hubble's Law. Type Ia supernovae light profiles can be studied at extremely great distances. Supernovae are used for two purposes. They can be used to accurately measure the distance of a galaxy from our own and, by analyzing the redshift of the spectra of the light profile, the red shift can be established which is a direct result of the recession speed of that galaxy due to the expansion of space.

Two teams, one from Australia and the other from UC Berkley set out to independently prove that Hubble's Law was not constant and that the acceleration was changing. What they found was that not only is the Universe expanding, it is accelerating in its expansion. The teams' leaders received a 2011 Nobel Prize in Physics for the 1998 discovery. Dr. Filippenko was fortunate enough to have an expertise in nova and access to the Keck Telescope that allowed him to work with both teams.

The cosmological constant that Einstein considered his greatest blunder, while simple defined as Λ, is the unknown energy that balances the collapse of all matter in the Universe that would otherwise result from gravity. Now, more generally called dark energy, it accounts for the acceleration of the expanding universe and is 70% of $E=mc^2$. On a local scale we may not experience it, but at 10 million light-years or greater, Einstein's cosmological constant is the dominant force.

One aspect of dark energy that we are examining today is whether dark energy density is constant. It may be clumped inconsistently like matter in the Universe. Currently, Dr. Filippenko is taking expansion research through its next phase. Using robotic telescope data (and undergraduate students) to analyze thousands of galaxies a night, he is looking for new nova events. They are refining the results of decades of work and discovering that the Universe is expanding faster than previously thought!

The Hubble Constant (H_0) was estimated by the Plank team by looking back at the earliest visible Universe (a mere 380,000 years old). By extrapolating forward, $H_0=67.4 \pm 0.5$ km/s/Mpc. Direct measurements historically have shown that H_0=(between 70 to 75) ± (4 to 7) km/s/Mpc. With the new data from Dr. Filippenko's research, $H_0=73.04 \pm 1.04$ km/s/Mpc. With a deviation from the Plank estimated constant > 5σ, this is a discovery! Without any idea as to the cause of this discrepancy, this is the biggest new revelation in cosmology. Everyone is talking about the Hubble tension…so stay tuned.

Dr. Filippenko stayed for a half an hour to answer questions, after which Richard thanked our guest and proceeded to give the President's Report.

We are up to 280 memberships. Owl Observatory training sessions are available again for those interested in learning how to use the Leonard James Ashby Telescope. 2024 eclipse travel planning has commenced. Volunteers are needed for an outreach activity at the Pierce Cedar Creek Institute on June 22nd. Astrophotography SIG meeting topics for the 2022-2023 season are needed. Richard made it publicly known that Eric Schreur will be receiving a KAS Lifetime Membership later this year. With Pete Mumbower noting that KPS is ending its mask mandate, we may very well be meeting in person in September.

Eric Schreur shared images taken of the constellation Leo from two of Michigan's dark sky sites, Dr. T. K. Lawless and Headlands. He then shared his calibrated Dark Sky Meter capable of measuring sky quality from 17 to 23 magnitude/arcsec^2. Joe Comiskey reported on our last Observing SIG gathering at Richland Township Park.

Richard concluded the May General Meeting with a very important request. If you have a telescope or binoculars, please bring them out to the Public Observing Sessions. We need to get the event back to our pre-pandemic status. The only way to do that, is to get members and their equipment back in service. Please come out and participate this summer!

The meeting adjourned at 9:08 pm.

Minutes provided by Aaron Roman

This meeting can be viewed in its entirety on our YouTube Channel.

Sky Writer

Part 2 by **Tony Ortega**

The Cosmic Life of *Celestial Handbook* Author Robert Burnham Jr.

Henry Giclas has seen many people come and go in the 56 years he's been associated with Lowell Observatory. Yet the 87-year-old still goes to his office there every weekday, and it's no trouble for him to remember the details of hiring Robert Burnham.

"Anybody that spends a lot of time out looking for comets, first of all he has to have a lot of patience, and he has to want to take the time to do it. And so, I just figured that anyone who would spend that much time would make a pretty good observer for a routine job."

An article without a byline which appeared February 3, 1958, in the *Courier* described how Burnham got the post: "H.L. Giclas, of the Lowell Observatory, passing through Prescott, took Burnham to lunch, and invited him to visit the Flagstaff observatory over the following weekend. Soon after he returned home, he received the offer of the position in the observatory. The camera studies he will make are expected to take a two-year period, Burnham said... He will begin his work on Feb. 10."

Courtney remembers her mother telling Burnham: "If you turn this down, you're crazy." "I'm not going to turn it down," he answered.

He accepted the job at $6,000 a year with the likelihood that it would last only the two years of the project.

Then, Giclas says, the entire deal nearly fell through.

The February 3rd *Courier* article infuriated the astronomers at Lowell. Always sensitive about Lowell's reputation, they did not appreciate that Burnham had spoken about his upcoming job without the observatory's approval.

"We had a bit of trouble about that article in the *Courier*. His mother, you know, was a kind of jackleg reporter for it," Giclas says.

"He damned near didn't get the job. We thought he'd written that article." They changed their minds, says Giclas, after a contrite Burnham convinced them that he hadn't written it.

"It was his mother. When I offered him that job, his mother went bonkers and wrote up a big story about how he was going to do a proper motion program at the Lowell Observatory when the guy didn't even know what a proper motion was."

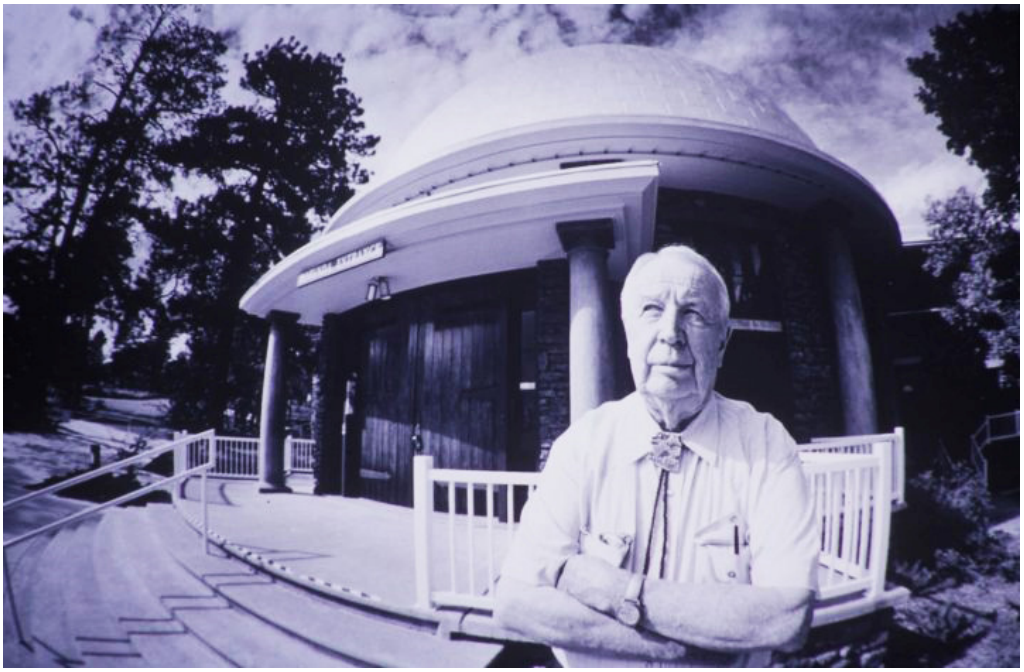
It wasn't the first time the observatory had hired a skilled amateur on the cheap for repetitive work that better-paid professionals might have scorned.

In 1929, a young Kansas farmer sent the observatory detailed drawings of Jupiter and Mars that he'd made with a homemade telescope. Lowell astronomers were sufficiently impressed that they hired the young man, named Clyde Tombaugh, to help with an ambitious, but tedious, project.

The search for Planet X.

The observatory's founder, Percival Lowell, had predicted that a massive ninth planet might be found beyond Neptune. Lowell had died in 1916, but his colleagues were eager to validate his Planet X theory. It might help counter the observatory's association with Lowell's more well- known legacy, his infamous and illusory Martian "canals," and rescue the observatory from a second-class status.

Fortunately, Tombaugh proved to be more than simply a hired hand. On Feb-



In 1958, Henry Giclas hired Robert Burnham, Jr. to work on a proper motion survey at Lowell Observatory. Henry started as a volunteer at Lowell in 1930 and was hired by Director Vesto Slipher in 1931. He retired in 1979, but kept his office (and used it nearly every day) until 2006. He passed away in 2007 at the age of 96.

Clyde Tombaugh is undoubtedly the most famous amateur astronomer Lowell Observatory hired due to his discovery of Pluto in 1930. Tombaugh worked at the observatory from 1929 to 1945.

ruary 18, 1930, Tombaugh brought glory to Lowell Observatory by discovering the only major planet found this century.

It was named Pluto. (But Lowell was not vindicated: Pluto was much too small to be his predicted Planet X.)

Now, in the late 1950s, with Tombaugh no longer associated with the observatory and his planet search long over, Henry Giclas had conceived of a way to make additional use of Tombaugh's labors.

He would take a series of long-exposure photographs of the sky, each on a glass plate corresponding with one taken by Tombaugh 30 years earlier. In that time, some of the stars would show movement. The closer ones would, anyway, just as when motorists see objects that are closer whiz by faster than distant ones.

Identifying that movement - called "proper motion" - was the best way to determine which stars were closest to the Sun, valuable data for scientists who wanted to know what kind of stars a typical portion of the galaxy - namely our own - contains.

Soon after the project got under way, Giclas learned about the Prescott amateur who had discovered a comet, and decided to hire him.

But only, Giclas says, after Burnham's mother apologized to the observatory for writing the unsigned article in the Courier.

"I couldn't hold it against Burnham," he says.

In 1959, with the continuation of his graduate studies in astronomy jeopardized by a lack of funds, Norm Thomas packed up his family of four and left Berkeley, California, for a job at Lowell Observatory.

There he was paired with Robert Burnham Jr., who for the past year had been working on the proper-motion survey with astronomers Giclas and Charles Slaughter.

Day after day, Thomas tried to trip up his taciturn and brilliant partner. Sometimes he succeeded. Other times, Burnham came out on top.

Their competition would produce the most widely cited proper-motion survey in history.

Now that the project was running smoothly, Giclas and Slaughter turned it over to the two young men who lacked advance degrees in the field.

Both Burnham and Thomas were told not to expect the survey to last longer than three years. Instead, it would last another 20.

Mostly, that was because of how well Burnham and Thomas worked together. Their success impressed the National Science Foundation, which continued to fund the project.

"Henry [Giclas] was quite good, but he was a little impatient with it," Thomas says, adding that because Giclas wasn't a "blinker" by nature, he wasn't taking the project to its full potential.

To explain what he means, Thomas descends into the basement of one of Lowell Observatory's oldest buildings where thousands of glass plates in white envelopes line the walls of a cramped room.

Against one wall is a contraption called a "blink comparator." The machine held two glass plates at a time, one dating from the 1930s search for Planet X, the other exposed by Burnham or Thomas themselves. Corresponding postage-stamp-size regions from each plate were projected onto a screen, first from one plate and then the other, back and forth, clickety clack, endlessly.

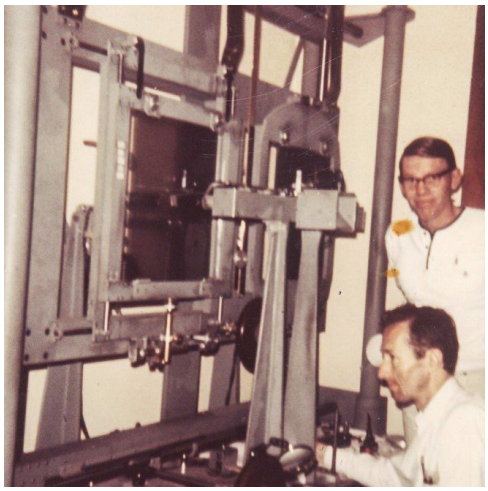
With the plates lined up correctly, the stars in each portion projected on the screen would hold still. Even in the 30 years between exposures, most stars seemed fixed in their positions and showed no movement. But occasionally, in a particular field on the plates, Burnham or Thomas would notice a star make a subtle leap.

Thomas shows how he would mark the star with a dab of India ink, hoping that Burnham had missed it. After Burnham, using another, fresh plate, had made his own search, the two of them would compare notes, tallying up the moving stars, particularly the ones that the other had missed.

"That did provide something fun. Who would miss something really neat? It was a competition," he says.

By the time the program ended in 1979, they would identify 9,000 high-motion stars as well as several comets, 1,500 asteroids and 2,000 new white-dwarf suspects - degenerate stars with incredible densities - as well as thousands of variable stars which they simply had no time to study.

Thomas describes it as a merry-go-round of activities. While one of them blinked during the day, the other would expose new plates at the 13-inch Pluto discovery telescope at night. Plates had to be developed, leaping stars identified



Robert Burnham, Jr. and Norm Thomas at the blink comparator they used for Lowell's Proper Motion Survey. Taken in December 1964.

and tabulated, and finder charts had to be made for the high-motion stars and white dwarfs so other astronomers could recover them in the sky. Both of them were also expected to help out by giving tours to visitors.

Somehow, the two of them found time in that demanding schedule to spend occasional nights simply touring the night sky with a telescope. Thomas says those nights are among his fondest memories.

"Bob was great to be with. I'd be the student. The stuff he had in his memory was just amazing."

Like others, Thomas describes Burnham as exceedingly shy and reclusive. Only a few times, in their close 20-year collaboration, did Burnham make the trip down from Mars Hill to spend an evening at the Thomas home.

Burnham himself lived in a cabin on the observatory's property. He'd moved into the rent-free home in lieu of a raise after his first year of work, and turned the place into a virtual museum.

Viola Courtney's daughter Donna made frequent trips from Prescott and later Phoenix to visit her uncle. Often, she would find him sitting in a rocking chair on pine needles outside his cabin, enjoying silence.

Burnham's display case filled with geologic wonders in his cabin at Lowell Observatory.

Robert Burnham, Jr. immersed in his work at his Home Laboratory in Prescott, Arizona. He no doubt had a similar set up at his cabin on Mars Hill.

Inside, the cabin was a fascinating clutter. There were rocks that glowed under ultraviolet light. Ancient coins and other artifacts of long-dead cultures. Fossils of trilobites and sharks' teeth.

And on nearly every wall, from floor to ceiling, books.

Donna says she was careful to travel alone to see him. With people he knew well, Burnham relaxed and could be quite talkative. If Donna brought someone her uncle didn't know, he'd clam up.

Once, she made a boyfriend wait in the car for a half-hour while she spent time with Burnham.

Burnham overcame his shyness sufficiently to have several girlfriends during his Lowell years. Viola Courtney and Thomas remember one woman in particular who seemed to bring Burnham nearly to the point of sociability.

"I remember that she was blond and curvaceous," says Courtney. "She had visited the observatory on a trip. He would give talks to the tourists, and she was impressed by him. She was so taken, he arranged for her to have a summer job."

Thomas remembers that Burnham was similarly taken, and that one time the shy astronomer gushed: "We're really together on our philosophy." Burnham was so far gone, Thomas says, he didn't mind being seen holding hands with the girl.

The curvaceous blond herself, now Professor Julie Lutz of Washington State University, says she had just graduated from San Diego State University and spent the summer of 1965 at Lowell Observatory as a 20-year-old intern before beginning graduate work at the University of Illinois.

"Bob was very, very, very shy. But he was fascinating. His place was filled with fascinating stuff," she remembers. "He was a pleasant person, but, you know, he didn't talk to too many people at Lowell.

"He was like Tutankhamen's tomb. Once you got to know him, you opened a passageway and then a lot of treasures would appear."

She laughs when she's told of Burnham's comment about his philosophical girlfriend.

"I am a big reader of books. At that time, I think I'd read a lot of philosophy and history. I was probably pretty intellectual for my age. He was probably impressed that he could talk to me."

She lived in a cabin near Burnham's, and remembers walking hand in hand through the woods with the astronomer.

"Yeah, and that was about it," she says with a chuckle. Their fling ended

with the summer.

But by that year, 1965, Burnham's true love - the Celestial Survey he'd started 10 years earlier - was finally near completion.

Donna Courtney remembers walking around and around a long table at Lowell Observatory which was covered with papers.

The year was 1966. She was only 6 years old, but like the rest of the family, as well as Norm Thomas and his children, she had been enlisted by her uncle to circle the table with pages in her hands.

Collating hundreds of copies of the first of what would be an eight-volume, 2,000-page book seemed like an eternal task, and sticks in the memory of everyone who helped.

Burnham had decided to publish his *Celestial Handbook* himself.

He would write later that the idea of self-publication had come to him gradually, particularly after he began working at Lowell Observatory.

His employment there gave him access to the mountains of information in Lowell's library, as well as the images on the thousands of glass plates he worked with every day.

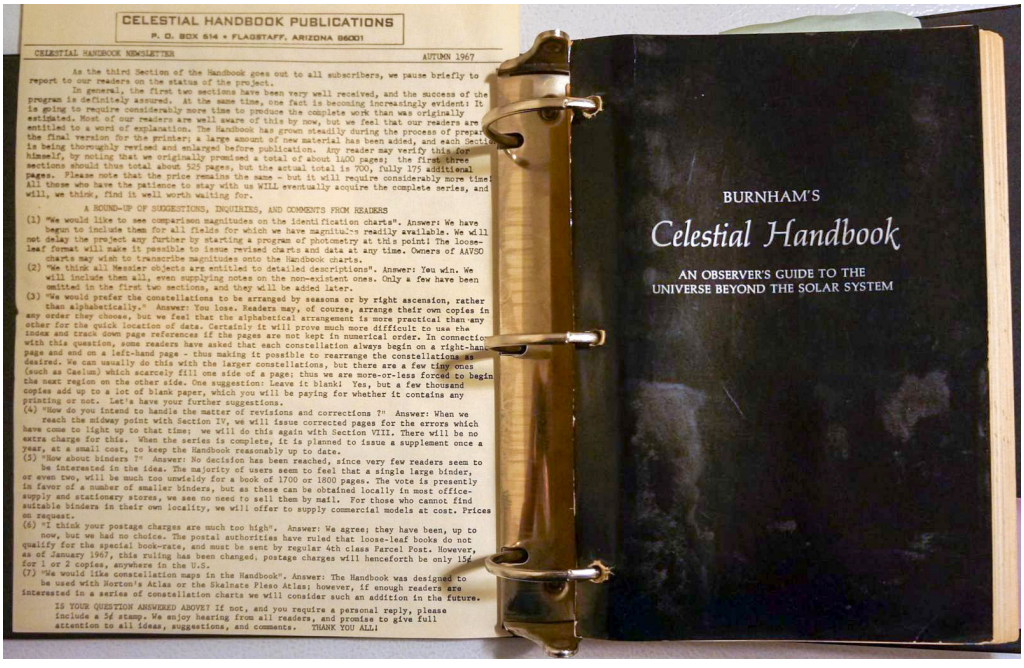
His survey quickly became more than simply the observational notes of an amateur astronomer. Burnham could now include more scientific depth and thousands of intriguing photographs. He also injected material related to his other interests, including photographs of ancient coins that carried astronomical themes, discourses on the lore of constellations, even thousand-year-old Chinese poetry about the sky.

He knew it was becoming a remarkable work.

He'd made inquiries to publishers, Thomas says, but he was most often met with an, "Are you kidding?"

"I tried a few of the larger astronomical publishers," Burnham wrote later. "Some thought that there really wasn't much of a demand for anything like that. Others said that there was no way to finance such a thing. One publisher said that they would have to hire someone full-time for a couple of years just to check and edit the material. That would be a requirement, they said, if they were to publish. At a cost which would make the project impossible, of course."

Thomas says Burnham was also disappointed by Lowell Observatory's official position regarding the Handbook.



Burnham originally self-published his *Celestial Handbook* with loose-leaf pages in a binder notebook after failing to find a publisher. The first issue contained 218 pages and was intended to be an eight volume set with some 1,400 pages. Burnham only self-published the first five sets after Dover decided to publish the Handbook as the three volume classic everyone is familiar with today.

Namely, that there would be no position.

"I think Bob was counting on some promotional help from Lowell on the books, but it never happened," Thomas says. The other astronomers, Thomas says, were concerned about the effect it might have on the observatory's reputation if the books were full of errors.

"I knew him a lot better. I knew how careful he was. Other people didn't know that," Thomas says.

Other Lowell astronomers were also apparently unaware that Burnham had sought outside assistance to check the accuracy of his data.

Giclas, however, saw the books as an irritation.

"The great problem I had with him was his handbooks. I offered to have the observatory personnel here check what he put into them, but he was reluctant and would not do that. And for that reason, I told him he could not make it a Lowell Observatory publication," Giclas says.

"We had a great English amateur that published books and stuff, but the stuff he had in it was wrong. His name was Patrick Moore. In later years, he learned enough to at least try to put the facts down straight. But Burnham quoted Moore as many times as he quoted Henry Norris Russell or some other famous astronomer, you know. And that was the trouble; Burnham didn't know the difference between someone who knew something and someone who didn't."

After Burnham finished collating the loose-leaf, type scripted books, Giclas says he gave them a cursory look. "I pointed out several errors in them. He may have changed some. I don't know whether he did or not."

Thomas says Burnham resented his colleagues' reaction. "They were afraid that it would be full of errors, and then it turned out to be better than 80 percent of the stuff [published about astronomy] that comes out. The good reviews quieted some people down. That, and the fact that it became quite famous because of the lack of errors."

No review carried more weight than that in the June 1966 issue of *Sky & Tel-*

escope, the field's primary popular journal. The reviewer, Robert Neil Stewart, found himself referring to a recent French book with a narrower scope as the only thing he could compare to the *Celestial Handbook*. While somewhat guarded in his praise (he only had the first, 218-page volume), Stewart did seem impressed by the sheer size of the projected work: "Mr. Burnham's manual promises to be about 10 times more inclusive than its strongest competitor."

And it was in English, to boot. "The greatest merit of the *Celestial Handbook* is its up-to-date and detailed physical information... I know of no other place where all this information can be so readily obtained." Yet, as Stewart and later reviewers noted, the Handbook was much more than an assemblage of data. He complimented Burnham for his frequent essays and other written interludes.

Thirteen years later, the same magazine would review the books again, and this time the writer's tone would be less restrained.

Burnham's Celestial Handbook had become a classic.

By 1976, Burnham had secured a deal with Dover Publications, Inc., in New York to republish the Handbook in three paperback volumes. Two years later, the books appeared.

As *Sky & Telescope's* second reviewer, Kenneth Hewitt-White, noted in 1979, wherever people dedicated to exploring the night sky gathered, they would solve riddles about what they saw with a simple question: "What does Burnham say about it?"

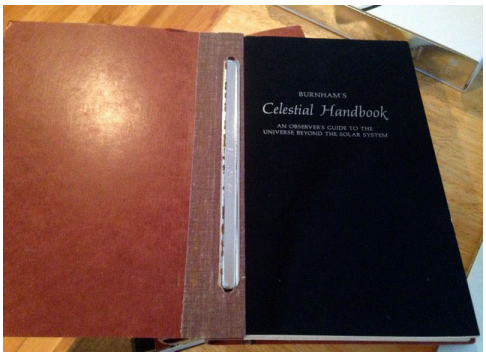
Owners of small telescopes found it difficult to go where Burnham had not gone before.

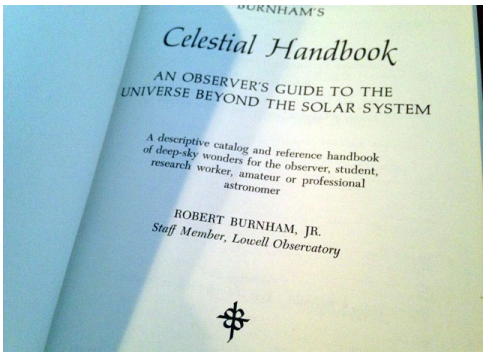
The Handbook could guide the enthusiast from his or her backyard to the far reaches of the galaxy, explaining such concepts as stellar evolution en route.

The Handbook looked different from other books, with its many hand-drawn diagrams and the typescript pages preserved from the self-published edition.

It also contained passages that were pleasantly out of place in a book of science, such as the following statement in a section on cosmology, which tries to explain what our universe is doing here:

"Oriental philosophers speak of the 'Tao,' the all-pervading intelligence of the Universe, never personified or regarded as a 'being' of any sort; such a concept seems vastly more appropriate to the Universe we actually live in than do the grossly anthropomorphic and marvelously tortuous theologies of Western thinkers."





Burnham knew that such passages would draw scorn from astronomers who held more mechanistic views. He would write later that he expected to come in for criticism for including them. But he was determined, he wrote, to make the books more than a dry list of data.

Courtney, who is now executor of her brother's estate, says that the 1966, loose-leaf Handbook edition had eventually paid for itself, but Burnham was happy to be done with publishing the thing on his own.

Burnham wrote in 1982, "The memory of those days still causes me to leap forth from my pillow with a loud cry. I have this nightmare, you see, where I'm trying to publish the Britannica from my kitchen table..."

But even as he began to enjoy the benefits of wider publication - and regular royalty checks - Burnham learned that Lowell Observatory planned to fire him.

ABOVE: Even today, though the science is dated, *Burnham's Celestial Handbook* is a prized possession in the library of amateur and professional astronomers. TOP RIGHT: Another version of the self-published Handbook.

Solstice Shadows

by **David Prosper**

Solstices mark the changing of seasons, occur twice a year, and feature the year's shortest and longest daylight hours - depending on your hemisphere. These extremes in the length of day and night make solstice days more noticeable to many observers than the subtle equality of day and night experienced during equinoxes. Solstices were some of our earliest astronomical observations, celebrated throughout history via many summer and winter celebrations.

Solstices occur twice yearly, and in 2022 they arrive on June 21st at 5:13 am EDT, and December 21st at 4:48 pm EST. The June solstice marks the moment when the Sun is at its northernmost position in relation to Earth's equator, and the December solstice marks its southernmost position. The summer solstice occurs on the day when the Sun reaches its highest point at solar noon for regions outside of the tropics, and those observers experience the longest amount of daylight for the year. Conversely, during the winter solstice, the Sun is at its lowest point at solar noon for the year and observers outside of the tropics experience the least amount of daylight – and the longest night – of the year. The June solstice marks the beginning of summer for folks in the Northern Hemisphere and winter for Southern Hemisphere folks, and in December the opposite is true, as a result of the tilt of Earth's axis of rotation. For example, this means that the Northern Hemisphere receives more direct light from the Sun than the Southern Hemisphere during the June solstice. Earth's tilt is enough that northern polar regions experience 24-hour sunlight during the June solstice, while southern polar regions experience 24-hour night, deep in Earth's shadow. That same tilt means that the Earth's polar regions also experience a reversal of light and shadow half a year later in December, with 24 hours of night in the north and 24 hours of daylight in the south. Depending on how close you are to the poles, these extreme lighting conditions can last for many months, their duration deepening the closer you are to the poles.

A presenter from the San Antonio Astronomy Club in Puerto Rico demonstrating some Earth-Sun geometry to a group during a "Zero Shadow Day" event. As Puerto Rico lies a few degrees south of the Tropic of Cancer, their two zero shadow days arrive just a few weeks before and after the June solstice. Globes are a handy and practical way to help visualize solstices and equinoxes for large outdoor groups, especially outdoors during sunny days!

While solstice days are very noticeable to observers in mid to high latitudes, that's not the case for observers in the tropics - areas of Earth found between the Tropic of Cancer and the Tropic of Capricorn. Instead, individuals experience two "zero shadow" days per year. On these days, with the sun directly overhead at solar noon, objects cast a minimal shadow compared to the rest of the year. If you want to see your own shadow at that moment, you have to jump! The exact date for zero shadow days depends on latitude; observers on the Tropic of Cancer (23.5° north of the equator) experience a zero shadow day on the June solstice, and observers on the Tropic of Capricorn (23.5° south of the equator) get their zero shadow day on December's solstice. Observers on the equator experience two zero shadow days, being exactly in between these two lines of latitude; equatorial zero shadow days fall on the March and September equinoxes.

There is some serious science that can be done by carefully observing solstice shadows. In approximately 200 BC, Eratosthenes is said to have observed sunlight shining straight down the shaft of a well during high noon on the solstice, near the modern-day Egyptian city of Aswan. Inspired, he compared measurements of solstice shadows between that location and measurements taken north, in the city of Alexandria. By calculating the difference in the lengths of these shadows, along with the distance between the two cities, Eratosthenes calculated a rough early estimate for the circumference of Earth – and also provided further evidence that Earth is a sphere!

Are you having difficulty visualizing solstice lighting and geometry? You can build a "Suntrack" model that helps demonstrate the path the Sun takes through the sky during the seasons. You can find more fun activities and resources like this model on NASA Wavelength. And of course, discover the latest NASA science at nasa.gov.

Spiral Galaxy M106

by Pete Mumbower

Messier 106 is an intermediate spiral galaxy located 23.7 million light-years away in the constellation Canes Venatici, the Hunting Dogs. Intermediate indicates the galaxy is neither a barred or unbarred spiral, but a classification between the two. It has a diameter of 135,000 light-years.

It was discovered by Pierre Méchain, Charles Messier's friend and assistant, in July 1781. Neither Messier or Méchain ever officially published this galaxy on their list of comet masqueraders. It was given "honorary" status as a Messier object in 1947.

NGC 4248, seen to M106's lower right, is a 13th magnitude spiral located 36 million light-years from us. Irregular galaxy UGC 7356 is to M106's left. This 16th magnitude galaxy is of similar distance as M106, likely making it a satellite galaxy.

Pete gathered photons from this galaxy in March 2022 from his home observatory in Vicksburg. It is a 13 hour total exposure (L = 48×600s, RGB = 20×300s each). Instruments used includes a 12-inch f/4 Newtonian, equipped with a Tele Vue Paracorr and ATIK 383L+ CCD camera, on an Astro-Physics 1100GTO German equatorial mount.

More details and a larger image can be found on Pete's Astrobin page.

Star Trails Over Yerkes

by Eric Schreur

Yerkes Observatory, in Williams Bay, Wisconsin, was built by the University of Chicago in the late 19th century. George Ellery Hale, the first director of Yerkes, was the driving force behind the project.

The large dome on the left contain Yerkes' crown jewel, the 40" refractor, which today remains the largest telescope of its type in the world.

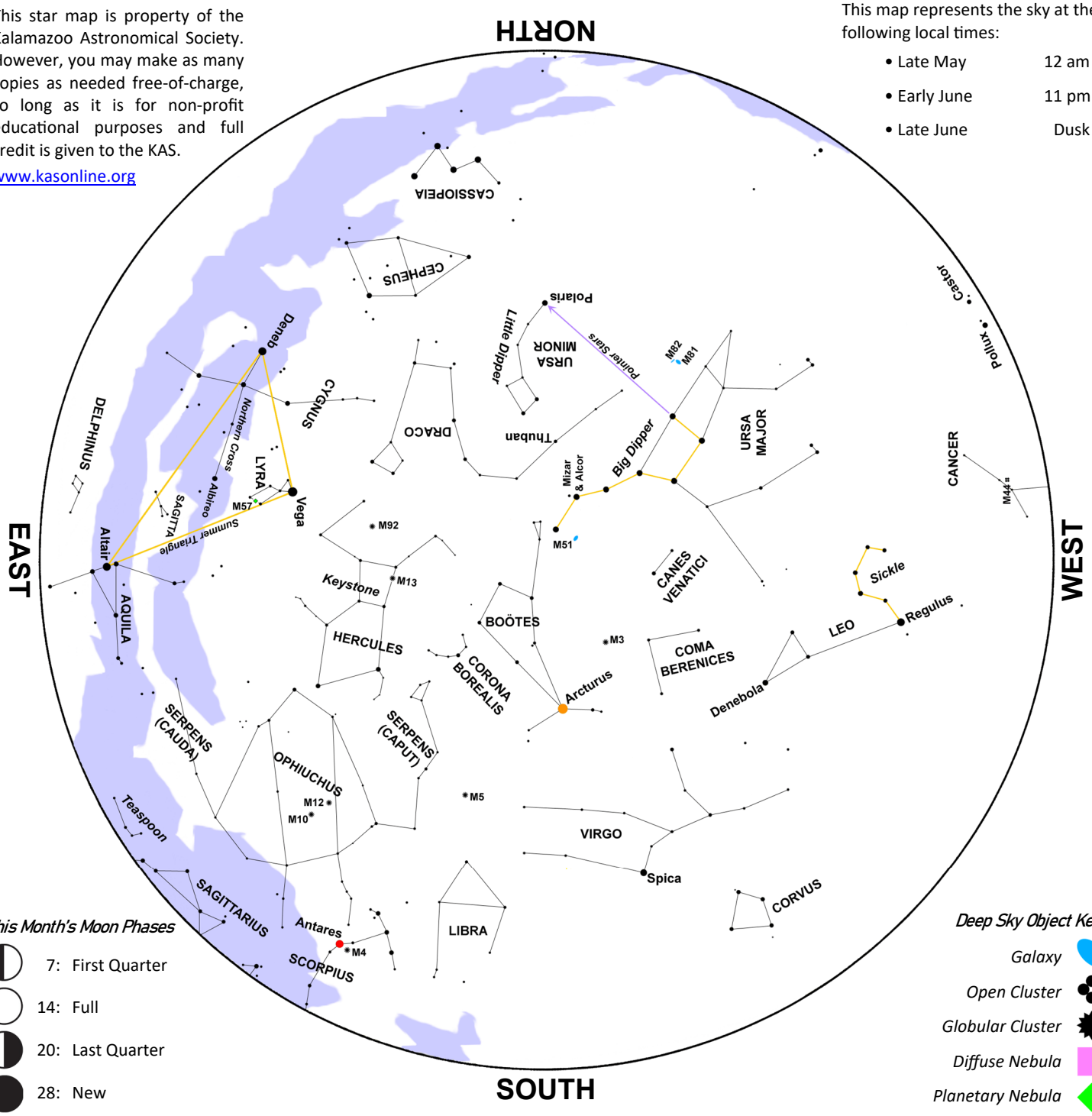
Eric took 332 exposures of 17 seconds each at intervals of 20 seconds on March 20, 2022. He used a Nikon D5500 DSLR camera (at ISO 1600) and Tokina 11-16mm lens set at 11mm (and f/5.6).

Eric recently gave a presentation on creating star trail images, which can be viewed online.

June Night Sky

This map represents the sky at the following local times:

- Late May 12 am
- Early June 11 pm
- Late June Dusk



This Month's Moon Phases

- 7: First Quarter
- 14: Full
- 20: Last Quarter
- 28: New

Deep Sky Object Key

- *Galaxy*
- *Open Cluster*
- *Globular Cluster*
- *Diffuse Nebula*
- *Planetary Nebula*

ALL of the solar system's planets line up in the sky before dawn on June 4th. These include the five classical planets visible with the unaided eye. Starting low in the east-northeast (ENE), their order is Mercury, Uranus, Venus, Mars, Jupiter, Neptune, and Saturn in the south. Earth, of course, is at your feet! Mercury will be a challenge to locate, while Uranus and Neptune require optical aide.

The Moon appears 4½° from Regulus, Leo's brightest star, on the night of June 5th. However, the Moon is even closer (less than ½°) to Eta Leonis, the next star up in the famous Sickle asterism.

A waning crescent Moon joins the planetary lineup on June 24th. Venus and Uranus have switched places, and the Moon is spaced evenly between Venus and Mars.

The Moon, enhanced with Earthshine, appears 2½° to the left of Venus at dawn on June 26th. As always, this is a stunning sight with the unaided eye, but enhanced when viewed through binoculars.

The next morning (June 27th), the thinnest sliver of a crescent Moon, comes within 3½° of Mercury's upper left. An unobstructed view of the ENE horizon is required.

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Public Observing Sessions

at the Kalamazoo Nature Center

June 4th
The Moon & Spring Deep Sky

June 18th
Great Globular Clusters

Gates Open: 9:30 pm | Observing Begins: 10:00 pm

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Bring Astronomy to the People

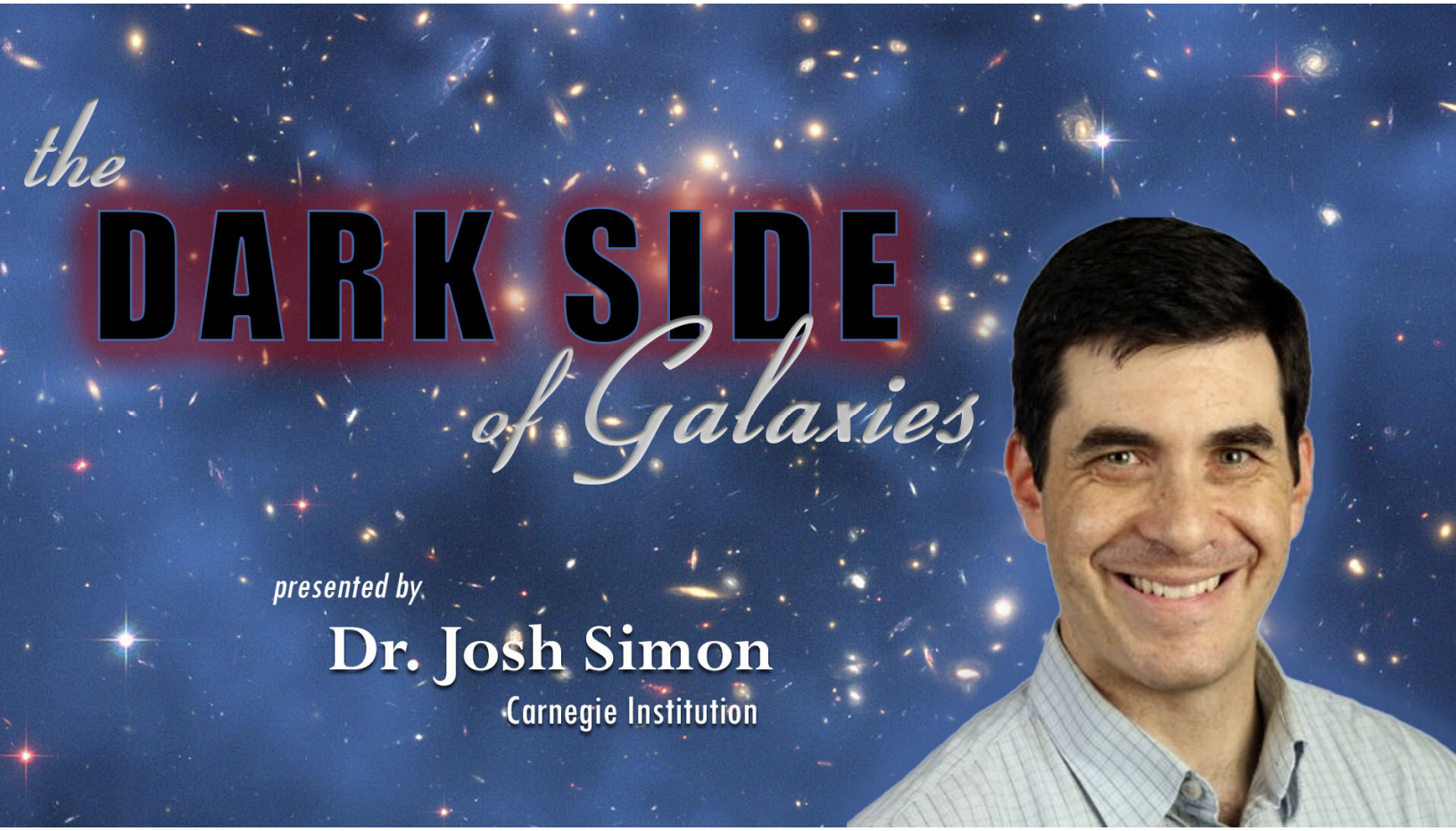
June 20th @ 1:15 pm:
Air Zoo Space Camp
Solar Observing

June 22nd @ 6 - 8 pm:
Pierce Cedar Creek Institute
Hands-On & Solar Viewing

July 9th @ 9am - 3pm:
Kindleberger Festival
Gen. Outreach & Solar Viewing

Contact Us to Learn More or Sign-Up

General Meeting Preview



Dr. Simon will provide an introduction to nearby galaxies, including our own Milky Way, and then focus on the mysterious substance called dark matter that makes up most of the universe. He will then describe how observations with our most advanced telescopes are giving astronomers new clues to exactly what this invisible matter is.

— About the Speaker —

Josh Simon has been a staff astronomer at Carnegie Observatories in Pasadena, CA since 2010. He grew up in Ann Arbor, MI, and earned a B.S. in physics from Stanford and a Ph.D. in astrophysics from UC Berkeley. His research spans all aspects of nearby galaxies (those within 100 million light years of the Earth), including the oldest and youngest stars they contain, supernova explosions, and the production of the chemical elements, but his primary focus is investigating the evasive material that comprises most of the mass of the universe, dark matter. He lives in Sherman Oaks, CA with his wife and two sons.

Friday, June 3rd @ 7:00 pm

Held on Zoom • Click Here to Register