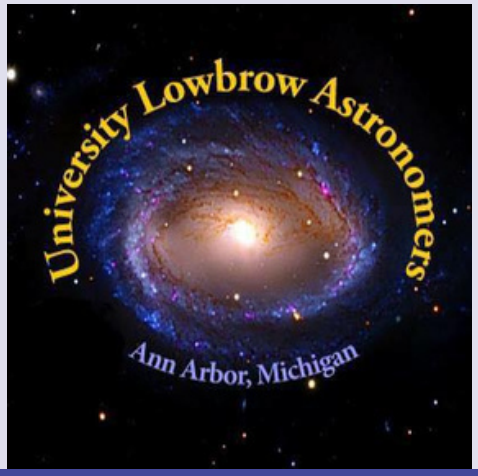
REFLECTIONS / REFRACTIONS

University Lowbrow Astronomers Monthly Newsletter

July 2022, Vol 46, Issue 7

Inside this issue:



MILKY WAY & AURORA

PHOTO BY ADRIAN BRADLEY

This photo taken near Trout Lake in the Upper Peninsula is just one of many stunning Milky Way landscapes by our Club's resident Milky Way photography expert, Adrian Bradley. Adrian recently won first place in an RASC General Assembly photographic competition for the category of images highlighting light pollution and its effects. The winning photo showing a faint Milky Way rising over Lake Huron and a rocky coastline is included in this month's Objective Lens. Adrian also came in as runner-up in a competitive field of landscape astrophotographers doing stacked imaging for photographing the most detailed Milky Way core in a nightscape. (This photograph was featured in last month's Reflections, page 6.) Congratulations, Adrian! ■

Check out many more Milky Way photos by club members in this month's issue of The Objective Lens.

EMERSON SCHOOL'S SPECIAL DAY EVENT, JUNE 6, 2022

BY JEFF KOPMANIS

On June 6, 2022, Emerson Middle School teacher Emily Qwon held a Special Event Day and the morning session theme was Space and Astronomy. Brian Ottum volunteered to do his Tour of the Universe presentation and arranged for two Lowbrows with solar telescopes to view the Sun. Brian was unfortunately called away at the last minute but the Lowbrows rallied and came through to give all 60+ kids a memorable morning. The Lowbrow crew consisted of Adrian Bradley and Jeff Kopmanis doing astrophotography presentations; Dave Snyder and Charlie Neilsen demonstrating the optics bench; and Jim Forrester, Don Fohey, and Mark Ten Brink showing off their telescopes. Rain and clouds were predicted, but only the clouds showed up in the face of the awesomeness of the Lowbrow commitment and the kids' enthusiasm. It was hoped the Sun would be out to show H-alpha and visual solar viewing, which is always something special. Stupid clouds....

Since over 60 middle-schoolers would be a large group to manage, the school separated them into three groups so that everyone had about 50 minutes at each of the three stations. Afterward, we all agreed that the students were very much engaged and came up with great questions at each station. By the last segment, we were getting questions that obviously reflected what they'd picked up in earlier stops, which was pretty satisfying since attention spans beyond 15 minutes can

Jeff Kopmanis - Introduction to Astrophotography

Jim Forrester shows kids how to view distant objects (if not the Sun, then a very far away basketball hoop!) Don Fohey and his rig are in the background as well, "shooting hoops."

Dave Snyder and Charlie Nielsen demonstrating the Optics Bench

be a little spotty for that age group. All of the kids were very courteous and respectful. I can't speak for all stations, but at the end of my presentation, there was always one or two who came up with more specific individual questions. I wouldn't be surprised if we didn't see them out at Peach Mountain this summer when we start doing public outreach again! ■

GENERAL RELATIVITY, PART 3

BY DAVE SNYDER

In parts 1 and 2 of this series, [1] I discussed different aspects of General Relativity. In this article I will discuss the backbone of General Relativity, namely the Einstein Field Equations and the Geodesic Equation. It can be extremely difficult to use these equations to solve real problems. However, solving real problems is not the goal of this article. Instead, I will attempt to present an intuitive understanding of how these equations work.

About 1907, Einstein began to realize that the theory of gravity in Newtonian physics was incompatible with the Special Theory of Relativity he developed two years earlier. I discussed some of his thinking process in parts 1 and 2 of this series. At first, Einstein had only a framework for a new theory of gravity, and many details needed to be fleshed out; he needed to construct equations to specify exactly how the theory worked. This effort would involve not just Einstein but other people including Einstein's classmate Marcel Grossman and the mathematician David Hilbert, among others, and would take eight years.

These equations need to create a theory that is not only compatible with special relativity, they must agree with known observations and be compatible with conservation of energy (the idea that energy can change forms but can never be created or destroyed).

The following is an outline of one way of producing the Field Equations (though not the way Einstein derived them):

1) Consider Earth orbiting the Sun. To make things easier, pretend Earth's orbit is a perfect circle.

If we assume that gravity acts instantly, Newtonian physics allows the force acting on the planet Earth to be calculated. That force has both a magnitude and direction, the magnitude is constant, and it doesn't change over time. The direction continually changes as Earth proceeds in its orbit, it points from where Earth is at that moment to the Sun. When these values are calculated, they can be used to trace out an orbital path, and that matches the observed path of Earth in its orbit.

Now if we assume gravity takes time to act, namely that it travels at the speed of light, the magnitude of the force is the same, but the direction of the force is not. It points from where the Earth is now to where the Sun was eight minutes earlier. Eight minutes, because that's how long it takes light (and gravity) to travel from the Sun to Earth. That difference in direction produces a prediction that is simply wrong.

To fix this we need a theory where gravity travels at the speed of light AND has an additional term that is dependent on the velocity of Earth. Why? Because the discrepancy is proportional to the speed Earth travels. If it travels faster, the distance moved in 8 minutes is greater and the discrepancy is bigger. If it travels slower, the discrepancy is smaller. And there needs to be a term that needs to undo the discrepancy, a term dependent on velocity.

Hold that thought.

2) Newtonian gravity is based on mass. The more mass, the stronger the gravitational force. However, special relativity tells us that mass and energy are in a sense equivalent. With that in mind, the field equations use energy not mass. The more energy, the stronger the gravitational effect.

Energy comes in different forms, and we can group energy into the following categories:

A) Energy that is moving (Earth in our example). This will be called "momentum."
B) Energy that's not moving but exerts a force (there isn't a parallel in our Earth/Sun system, but the air pressure in a tire is an example). This will be called "stress."
C) Energy that's not moving and does not exert a force (for example the Sun, here gravity does not count as a force). This will be called "relativistic mass" (though it can be associated with entities we don't think of as mass).

For each category, we obtain a value for energy per unit volume. [2]

GENERAL RELATIVITY, PART 3 continues, p. 4.

Note that momentum has both a magnitude and direction. (This is the velocity-dependent term mentioned earlier). You might think "moving energy" means kinetic energy. This is not correct; energy in this category is evaluated as momentum, not kinetic energy.[3]

Stress is represented by a 3x3 tensor (called the stress tensor). This is generally zero (or close to zero) unless there are extreme conditions. [4]

3) The different forms of energy can be combined to form a 4x4 tensor. One component for relativistic mass, 9 components for stress, and 6 for momentum. That makes 16, the number of components in a 4x4 tensor. This tensor is called the energy-momentum tensor and is denoted by the letter "T". [5]

Note that in most normal situations, relativistic mass is the most important, followed in order by momentum then stress. [6]

Einstein assumed that the distortion of space was proportional to T, or the energy density (energy per unit volume) present at a specific location.[7] If we assume this is some function of the tensors I discussed in Part 2 [8], and we assume that energy is conserved, there are two possible solutions:

$R - \frac{1}{2}R^*g$

$R - \frac{1}{2}R^*g + \Lambda g$

(R is the Ricci tensor, R* is the curvature scalar, g is the metric and Λ is the cosmological constant. I'll explain the cosmological constant in a subsequent article).

Einstein initially used the first solution, the one without the cosmological constant.

Using an appropriate constant of proportionality produces this equation:

$R - \frac{1}{2}R^*g = 8\pi G/c4\ T$
(where G is the gravitational constant from Newtonian physics). [9]

Since R, g and T are all 4x4 tensors, this is really shorthand for 16 equations, and they are called the Einstein field equations.

I need to examine some of the complexities of the field equations.

1) Consider a planet with no atmosphere. If we release an apple a few feet above the planet, for a brief moment the apple is motionless. We will observe the apple fall toward the surface of the planet. Newton explained how this works, but if we think about this from the point of view of General Relativity, we see a stationary apple sitting in distorted space. I could argue that the apple should remain stationary. After all, Newton told us that an object at rest stays at rest unless acted on by a force. And I've already established that gravity in General Relativity is not a force. Why does the apple fall?
The answer is as follows: The distortion is not just of space but of space-time. The apple might be stationary in space, but it is not stationary in space-time. It is moving through time.[10] The distorted space-time causes some of the motion through time to be converted into motion through space. Specifically, it causes the apple to fall toward the surface of the planet. And the corresponding change in motion through time has been detected by careful measurements.

2) Newton showed the motion of Earth is dependent on the mass of the Sun and distance from the Sun to Earth. The field equations have a dependency on energy, which means that it has a dependency on the mass of the Sun. If they are to agree with observations, the field equations must also have a dependency on distance. However, no such dependency seems to be present. But there is a dependency, it is just hidden. Note that curvature can be defined as how direction changes with respect to change in distance. And since the field equations are dependent on curvature, they have an implicit dependence on distance as well.

Now that we have the field equations, what do we do with them? With the field equations, we can calculate the metric (a surrogate for the distortion of space-time). However, we usually aren't directly interested in the distortion. Rather we are usually interested in how the distortion causes objects to move.

An additional equation, the geodesic equation, is used to determine this. We assume that objects take the shortest path through space-time when they move. This shortest path will be a straight line in

GENERAL RELATIVITY, PART 3 continues, p. 5.

normal space. But that isn't necessarily true in distorted space. The geodesic equation will allow us to determine this shortest path. This will tell us both where an object will be, as well how fast it moves, at various times in its trajectory through a gravitational field.

In part 4 of this series, I will explore specific examples on how this is done. ■

NOTES

1. Part 1 (Snyder, Dave. 2021a, November) and Part 2 (Snyder, Dave. 2021b, December).
2. To convert mass to energy density, we take mass, multiply by the speed of light squared and divide by the volume of the mass.
3. Momentum is defined as mass times velocity, whereas kinetic energy is defined as one-half mass times velocity squared. Only kinetic energy would seem to have the correct units for energy. But that is easily fixed. If we use momentum times the speed of light, we get the units for energy. If we then divide by volume, we get the correct units for energy per unit volume.
4. The stress tensor is composed of both stress and pressure, both already have units of energy per unit volume.
5. You may see other terms used such as "stress-energy tensor."
6. Relativistic mass must be multiplied by the speed of light squared, whereas the momentum is multiplied by the speed of light and stress is not multiplied by anything. That suggests which factors are the most important. However, this is not necessarily true in extreme conditions such as close to a black hole or within the first few seconds after the big bang.
7. The energy density at that point.
8. Part 2 (Snyder, Dave. 2021b, December).
9. These equations are usually written in Einstein notation, and look like this:

Rμν- 12Rgμν= 8πGC4Tμν

where the symbols with Greek letters are tensors, Rμν gμν Tμν (the Ricci tensor, the metric and the energy-momentum tensor respectively). R without Greek letters is the curvature scalar.

10. See part 1 (Snyder, Dave. 2021a, November).

FURTHER READING

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D'Inverno, Ray. 1992. *Introducing Einstein's Relativity*. Oxford: Clarendon Press.

Misner, Charles W., Kip S. Thorne and John Archibald Wheeler. 1973. *Gravitation*. San Francisco: W. H. Freeman.

Snyder, Dave. 2021a. *Reflections/Refractions*, Newsletter of the University Lowbrow Astronomers. "General Relativity, Part 1." November 2021, Volume 45, Issue 11.

Snyder, Dave. 2021b. *Reflections/Refractions*, Newsletter of the University Lowbrow Astronomers. "General Relativity, Part 2." December 2021, Volume 45, Issue 12.

Susskind, Leonard. 2012. Stanford University. "General Relativity," Lectures 1 through 10. https://www.youtube.com/watch?v=JRZgW1YjCKk&list=PLXLSbKIMm0kh6XsMSCEMnM02kEoW_8x-f (Accessed April 18, 2021).

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You Tube Channel "Trin Tragula General Relativity." https://www.youtube.com/watch?v=LEg5nhdjrx8 "Stress-Momentum-Mass Tensor, Part 1 of 3." (Accessed November 12, 2021).

You Tube Channel "Trin Tragula General Relativity." https://www.youtube.com/watch?v=H0lWKHhle6k "Stress-Momentum-Mass Tensor, Part 2 of 3." (Accessed November 12, 2021).

You Tube Channel "Trin Tragula General Relativity." https://www.youtube.com/watch?v=0OVMhyQvJGE "Stress-Momentum-Mass Tensor, Part 3 of 3." (Accessed November 13, 2021).

OBSERVING NIGHTS AT PEACH MOUNTAIN

BY JIM FORRESTER

An ambitious members' observing schedule on Peach Mountain saw about 15 Lowbrows, many more than once, take advantage of 10 open nights on the Hill in May and June. A couple of the evenings offered very good transparency with 12th, approaching 13th magnitude galaxies visible in some instruments.

Don Fohey with his Big Blue Dob. Photo by Jim Forrester.

The McMath in silhouette. Photo by Christopher Collins.

A highlight over these last two weeks has been a bright comet C/2017 K2 (Panstarrs) as it has made its way through the constellation Ophiuchus. Visible in most any telescope, it was spectacular in the 24-inch McMath Telescope. Thanks to Observatory Director Jack Brisbin for the terrific views. Jack has been generous with his time, opening the Observatory for many of these evenings.

Beyond the traditional safety and etiquette rules, those attending enthusiastically embraced the Covid protocols established by the membership at the April membership meeting. This is important, not only to the continuance of the member night dark of the moon observing schedule, but has positive implications for our ability to offer limited observing and educational opportunities to the wider public.

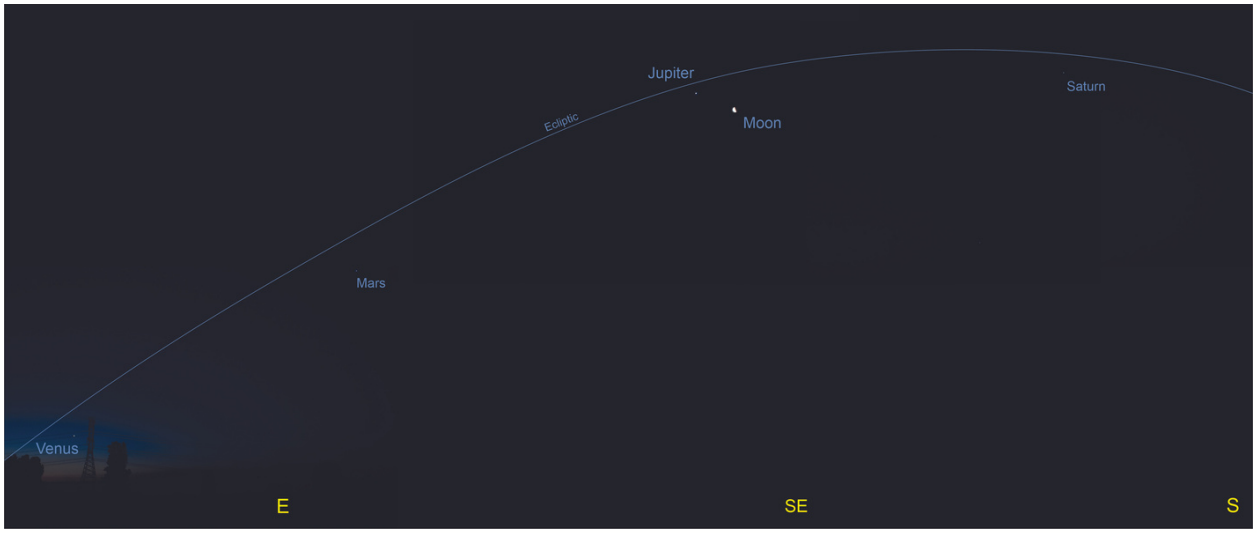
Similar organizations to the Lowbrows, with similar Covid arrangements, also having an interest in the night sky wish to attend events on Peach Mountain. Given how smoothly member nights have gone, we've arranged for the Ann Arbor Photo Club to come to the Hill—the first clear night of the following: July 23, 29 and 30.

The exact program for the Photo Club is still being discussed, but views through the McMath Telescope and members' instruments will be part of the night's activities. We're hoping many of you can attend. ■

Club members Alex Swartzinski, left, and Doran Jurgle on the hill. Photos by Jim Forrester.

JOIN US ON THE HILL
with the Ann Arbor Photo Club,
the first clear night of the
following: July 23, 29 and 30.

JUNE'S PARADE OF PLANETS



From Charles Steele. "I set the alarm clock for 4 AM to look at the planet alignment. I took my Nikon D3400 with a 28mm Nikkor Lens attached. I took 40 pictures. I could not get all planets in one frame so had to stitch 7 frames together for this picture."

Photos above and below by Adrian Bradley.

NGC 6946 and NGC 6939

DOUG BOCK

Taken June 27-28
Details: 49 x 300-second light frame
William Optics 105mm f/7 APO refractor
ZWO asi2600MC PRO camera, gain 100, temp 0C
Losmandy G11 mount.

EARTHSHINE

DOUG SCOBEL

From July 1. "The setting moon showed some really strong Earthshine tonight, as strong as I've ever seen it. This matches pretty closely the unaided-eye view - I could see some of the mare regions. Admittedly this image looks a little exaggerated and artificial, but I actually tried to reduce the effect during post-processing, not strengthen it.

Taken from my front porch. Canon 5D Mark IV DSLR, Canon 100-400mm lens set to 214mm. One second at f/6.3, ISO 1600."

UPCOMING MEETING SPEAKER SCHEDULE

JULY 15: Norb Vance, EMU Observatory Director. Topic: **Pending**

AUGUST 19: Professor Karim Jaffer, John Abbott College. Topic: **Pending**

SEPTEMBER 16: Note: Meeting Cancelled: Professor Nicolle Zellner, Albion Physics Dept, will be at Astronomy at the Beach

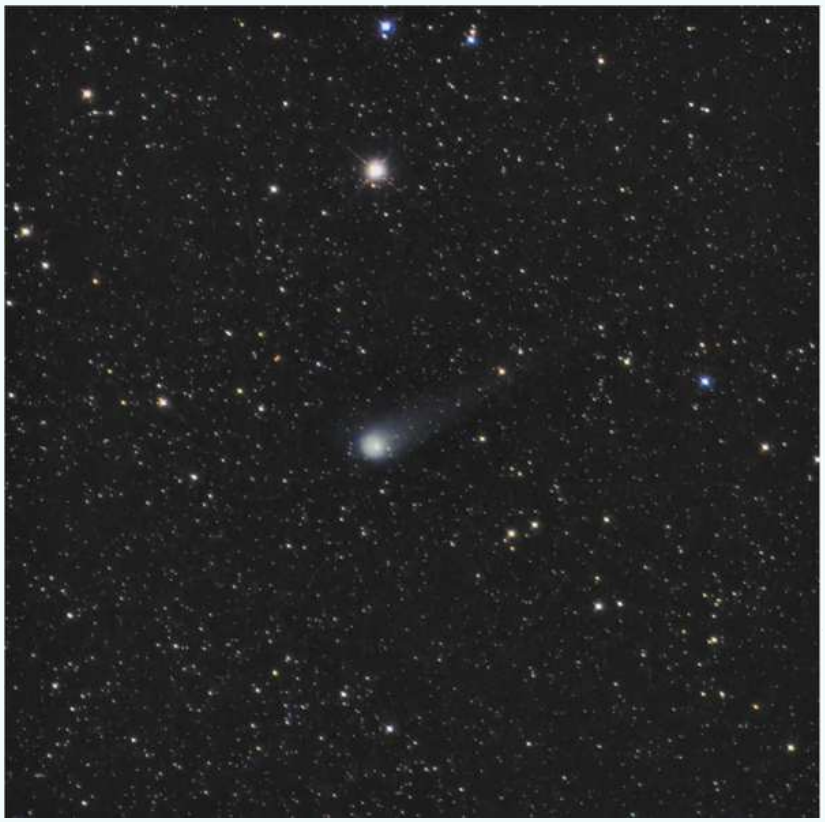
OCTOBER 21: Associate Professor Elena Gallo, U of M Dept of Astronomy. Topic: ***Seeing and Hearing Black Holes, (big and small)***

NOVEMBER 18: Professor Neil Cornish, Montana State University. Topic: **Pending**, but about ***Gravitational Waves***

DECEMBER 16: Fred Schebor. Topic: ***The Artsy-Meaningless Slide Show***

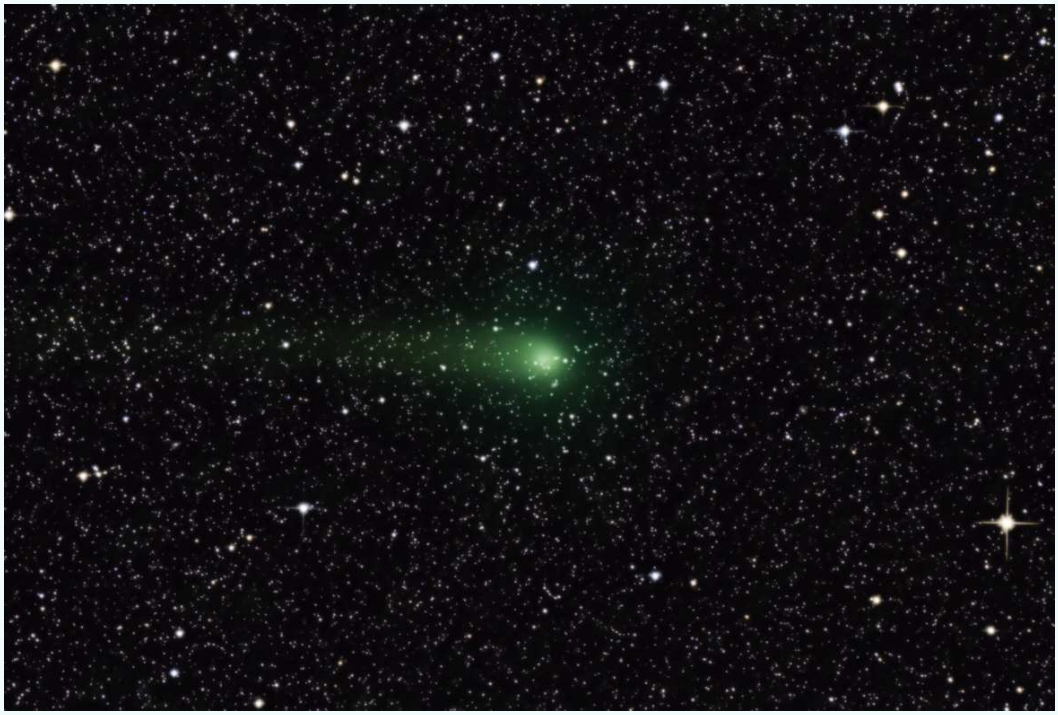
JANUARY 20: Dr. Guy Consolmagno, Director of the Vatican Observatory. Topic: **Pending**.

TWO VIEWS OF COMET C/2017 K2 PANSTARRS



"Comet C/2017 K2 is heading towards the sun and close to earth. What makes this comet fascinating is its size. The "snow-covered-rock" nucleus is HUGE, twice as big as Mt. Everest! As it flies closer to the sun, it warms up and the ice evaporates, forming an even bigger fog shroud. That fog you see in this picture is 10X the size of earth! The tail is millions of miles long. You can see this comet with binoculars, in the south after dark. However, it is best to get out, away from city lights."

Photo by Brian Ottum

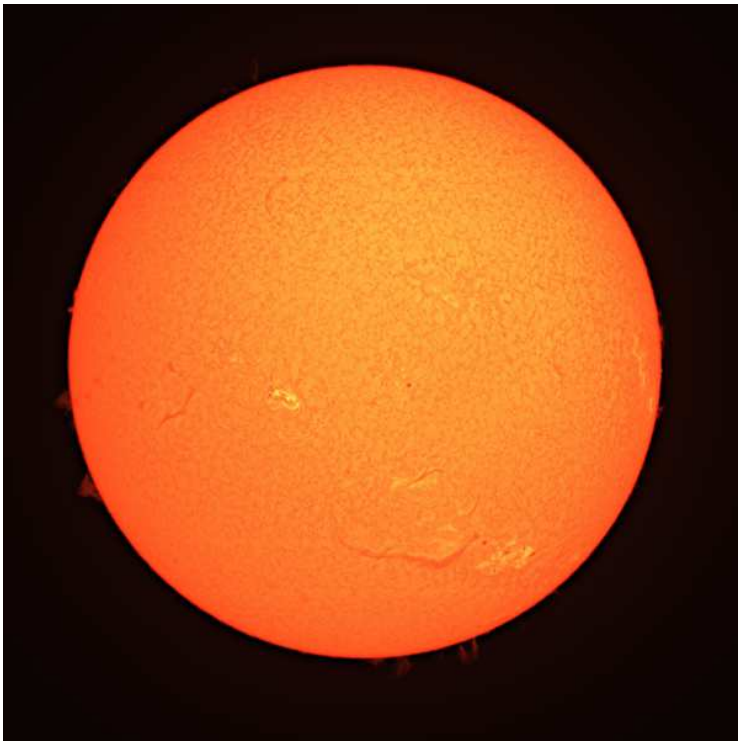


"Comet C/2017 K2 PanSTARRS. Just over two hours of integration time. Its closest approach will be July 14th, 2022 at a distance of 1.8 AU. Currently in the constellation Ophiucus. "

Photo by Donovan Drew

H-ALPHA SOLAR PHOTO

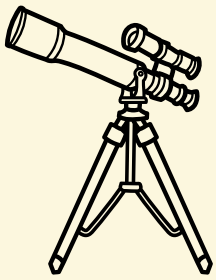
BY JEFF KOPMANIS



"This is my best H-alpha solar photo to date, as I was very pleased with the detail and content. I'm sure the focus could be better, but this was all done with a manual 2-speed Crayford focuser, standard on the Lunt scopes. They're nice focusers, but they're such that there aren't any places to mount a motorized, remote-control focuser. Note that this image is upside-down and flipped compared to the NSO GONG H-alpha images."

Taken in Ypsilanti, Michigan, 6/19/2022 14:17
Lunt 60MT (without double-stack)
iOptron ZEQ-25GT
ZWO ASI183MC camera
1500 frames each at gain=50, exposure=14.622ms
Stacked with Autostackert!3
Wavelets applied with Registax 6
Cropped with FastStone Image Viewer"

UPCOMING TOPICS FOR THE OBJECTIVE LENS



BY JACK SPRAGUE

We'd like to remind everyone that all images are welcome and while we have a monthly theme, we love candid shots of members in action.

Images submitted will be included in 'The Objective Lens" and in the annual Backfocus compilation without any rights transfer beyond your permission to allow The University Lowbrow Astronomers use of your image for inclusion in these two documents.

August – Cluster Month! Globular clusters, open clusters, galaxy clusters, and even planetary clusters if the conjunctions allow will all be perfect on-theme topics.

September – Lunar Photos! Craters, phases, the terminator, the whole moon, conjunctions with other bodies, nightscapes, reflections, moons other than Earth's own – the works! Astrophotographers spend a fair effort planning "around" our moon to acquire specific images. Let's celebrate the moon this September.

October – Planets, planets, planets! 2022 has been an especially good year for planetary observation, near occultations, conjunctions, and multiple planets simultaneously visible. Looking to September, there are close approaches of the Moon and both Saturn and Jupiter. (both under 4˚ of arc at the closest approach).

University Lowbrow Astronomers:

Monthly Meeting Minutes, June 17, 2022
7:35 PM: Meeting called to order by President Charlie Nielsen

- **Charlie introduced guest speaker, Dr. Zachery Constan of Michigan State University's *Facility for Rare Isotope Beams.* His well received talk, "(Almost) 14 Billion Years of Nuclei," inspired members to inquire about touring the East Lansing laboratory.**

Business Meeting

President Charlie Nielsen: Westland Library has inquired about a public observing event later this summer or early fall when the planets are observable in the evening.
Also: A Chinese Studies group wants us to participate in a moon festival event in September. The timing is unfortunate as the September full moon is a week before Astronomy At The Beach. The concern is we won't have enough members to do justice to two major events a week apart. The group did express interest in AATB.

Vice President Dave Snyder: A few weeks ago Dave had a discussion with Buddy Stark, the new Planetarium Director at the University's Museum of Natural History.
Buddy Stark was present in the Zoom meeting, Dave asked him to introduce himself to the club. He is the past director of the Longway Planetarium in Flint and is working toward a PhD in science education.

Online Coordinator Jeff Kopmanis: Our attendance on Zoom was 29. The University could soon steeply increase its web hosting charges. A reasonably priced alternative is "Host Gator." As many organizations (including the University) are hosting on Google or Amazon servers, there is no advantage to archiving our content with the University. Host Gator, with one basic charge, will host our "Welcome to the University Lowbrow Astronomers" and "Young Astronomer" websites, as well as, for example, our new "Objective Lens" publication. These links provide analysis and detail on the web hosting research:
https://docs.google.com/spreadsheets/d/1wdYraGFAxBSPs2h7p6P4EWJu56gF7-2kNp7zVu43O4M/edit?usp=drive_web
https://docs.google.com/document/d/1DBj9DnziFFteSxzfzw-zLEw0K8pCjwd6pkNph4tZBKY/edit?usp=drive_web

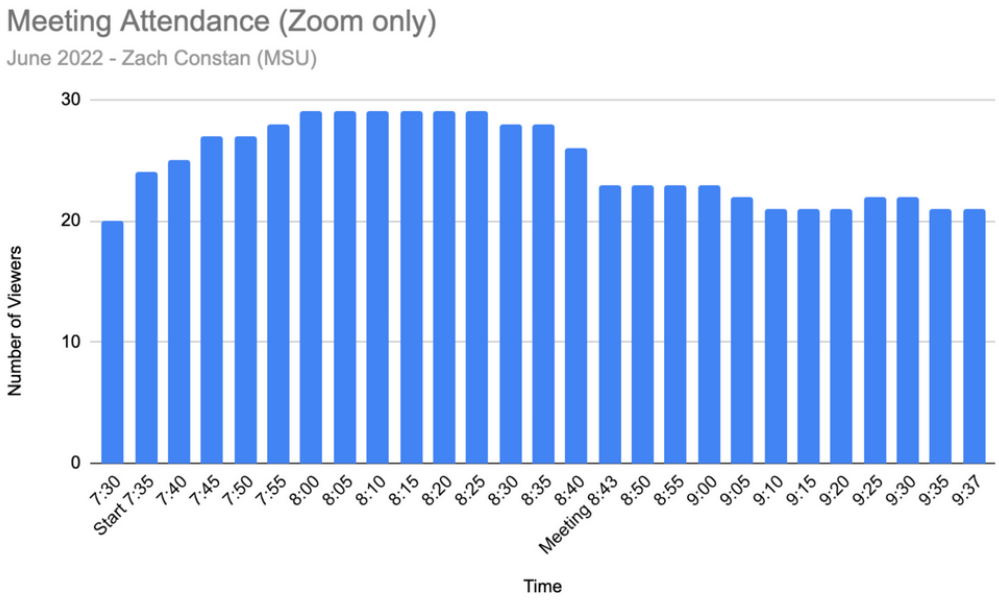
Vice President Jim Forrester: Three member observing nights, attended by 18 members, have been conducted this past month at Peach Mountain. Two of those nights included the opening of the Observatory and sky tours of the night sky for some of our newer members by Observatory Director Jack Brisbin. Distancing and masking was observed and all attending had been vaccinated against Covid-19. Jim believes a public event might be attempted, but an Open House would require 6 or more members dedicated to conducting the event.

Several members have been shaking down the 17.5 inch Dobsonian as it hasn't been under the stars since last fall. The Sky Commander digital setting circles computer was found to be faulty. Some suggestions were made by members present for maintenance that might solve its problems. Sky Commander is no longer manufactured. An alternative unit for replacement would cost $400-$600.

Peach Mountain may be opened to the members the evening of Saturday, June 18. A confirming notice will be emailed by 4:00 PM Saturday.
Newsletter Editor Amy Cantu: Amy is seeking reports on observing and public outreach events. Jeff Kopmanis offered to write up our recent presentation to Emerson Middle School students.
Observatory Director Jack Brisbin: Jack has been talking to Professor Jamie Cutler of the Engineering College about the radio telescope floodlights that also light up our observing field. The one pointed directly at the field has been turned off. Jack and Prof. Cutler are working on a solution for the other. The Argo Navis digital setting circle computer on the McMath telescope is showing its age and may need to be replaced. A new unit sells for about $600.
Treasurer Doug Scobel: Doug submitted the following:

- **We have 189 memberships. That's seven new members since the April meeting! This count also includes 14 memberships that would have expired but for grace extended due to COVID-19 pandemic considerations.**
- **We have $13,463.02 in the treasury. $352.50 of that is pending for our 2022-23 Astronomical League memberships.**
- **Since our April meeting we spent:**
  - **$9.10 to mail a Lowbrow cap to our May speaker and member Dr. Rudi Lindner.**
  - **$26.45 for printing and mailing paper copies of the June newsletter.**
  - **$15.85 for our AT&T open house "hotline" for May.**
- **I filed our Federal "ePostcard" - our annual statement to the Feds that we are still "in business" and that our annual revenue is under $50,000.00.**
- **Coming up:**
  - **Send a size large T-shirt to June guest speaker Dr. Z. Constan of MSU.**
  - **Come up with six worthy recipients of gift memberships in the Astronomical League (one of our members donated $45.00 for that purpose).**
  - **Finish collection of memberships/renewals in the Astronomical League, and send membership form, roster, and collected dues to the A.L. office before the end of June.**
  - **Send $500.00 to GLAAC in support of the 2022 edition of Astronomy at the Beach.**

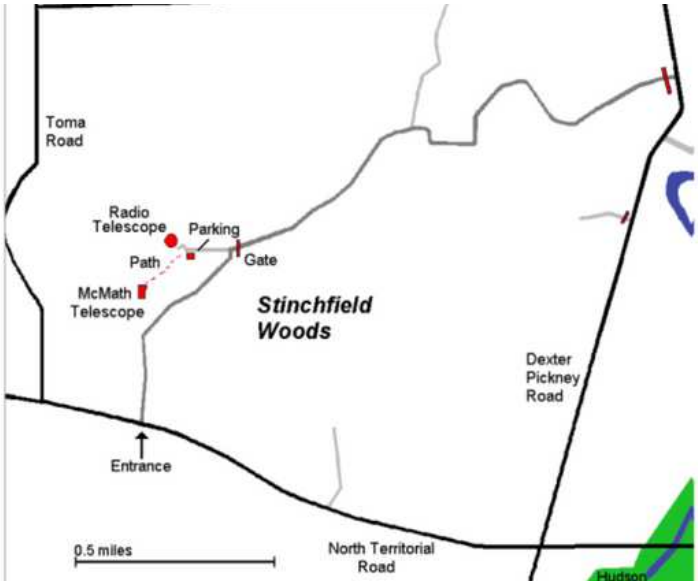
Submitted June 17, 2022
Jim Forrester
Vice President



PLACES & TIMES

Monthly meetings of the University Lowbrow Astronomers are held the third Friday of each month at 7:30 p.m. The location is usually Angell Hall, ground floor, Room G115. Angell Hall is located on State Street on the University of Michigan Central Campus between North University and South University Streets. The building entrance nearest Room G115 is the east-facing door at the south end of Angell Hall.

Peach Mountain Observatory is the home of the University of Michigan's 25-meter radio telescope and McMath 24" telescope, which is maintained and operated by the Lowbrows. The entrance is addressed at 10280 North Territorial Road, Dexter MI, which is 1.1 miles west of Dexter-Pinckney Rd. A maize and blue sign marks the gate. Follow the gravel road to the top of the hill to a parking area south of the radiotelescope, then walk about 100 yards along the path west of the fence to reach the McMath Observatory.



PUBLIC OPEN HOUSE / STAR PARTIES

Public Open Houses / Star Parties are generally held on the Saturdays before and after the New Moon at the Peach Mt. Observatory but are usually canceled if the forecast is for clouds or temperatures below 10 degrees F. For the most up-to-date info on the Open House / Star Party status call: (734) 975-3248 after 4 pm. Many members bring their telescope to share with the public and visitors are welcome to do the same. Mosquitoes can be numerous, so be prepared with bug repellent. Evenings can be cold so dress accordingly.

MEMBERSHIP

Annual dues are $30 for individuals and families, or $20 for full time tudents and seniors age 55+. If you live outside of Michigan's Lower Peninsula then dues are just $5.00. Membership lets you access our monthly newsletter online and use the 24" McMath telescope (after some training). Dues can be paid by PayPal or by mailing a check. For details about joining the Lowbrows, contact the club treasurer at: lowbrowdoug@gmail.com

Lowbrow members can obtain a discount on these magazine subscriptions:

Sky & Telescope - $43.95/year

Astronomy - $34.00/year, $60.00/2 years or $83.00/3 years

Newsletter Contributions:
Members and non-members are encouraged to write about any astronomy-related topic. Contact the Newsletter Editor: Amy Cantu cantu.amy@gmail.com to discuss format. Announcements, article, and images are due by the 1st day of the month as publication is the 7th.

Telephone Numbers:

President:	Charlie Nielsen (734) 747-6585
Vice President:	Adrian Bradley (313) 354-5346
	Jim Forrester
	Brian Ottum
	Dave Snyder
Treasurer:	Doug Scobel (734) 277-7908
Observatory Director:	Jack Brisbin
Newsletter Editor:	Amy Cantu
Key-holders:	Jim Forrester
	Jack Brisbin
	Charlie Nielsen
Webmaster:	Krishna Rao
Online Coordinator	Jeff Kopmanis

A NOTE ON KEYS: The Club currently has three keys to the Observatory and the North Territorial Road gate to Peach Mountain. University policy limits possession of keys to those whom they are issued. If you desire access to the property at an unscheduled time, contact one of the key-holders. Lowbrow policy is to provide as much member access as possible.

Lowbrow's Home Page
http://www.umich.edu/~lowbrows/

Email to all members
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