REFLECTIONS / REFRACTIONS

REFLECTIONS \ REFRACTIONS

University Lowbrow Astronomers Monthly Newsletter

December 2021, Vol 45, Issue 12

Inside this issue:

University Lowbrow Astronomers
Ann Arbor, Michigan

Equipment used:
Celestron 9.25" with 0.7x reducer
ZWO ASI533MC Camera
Astronomik L2 filter
iOptron CEM60 mount

NGC7814
SUPERNOVA

BY AWNI HAFEDH

One of the targets I captured during the Great Lakes Star Gaze 2021 is NGC7814. Unfortunately, I did not capture a lot of subs because the weather that night did not cooperate and I ended up with only 8x3-min subs. I wasn't very interested in stacking them but later realized a supernova was discovered in that galaxy during the same time period. So, I went back to my subs, and there it was! This made me excited to stack my subs and although the final image is not that impressive, the supernova is very visible and I'm glad to share it with everyone.

Some information on that supernova: (2021rhu (= ZTF21abiuvdk), TNS discovered 2021/07/01.405 by Zwicky Transient Facility (ZTF) ▪

GENERAL RELATIVITY - PART II

BY DAVE SNYDER

In Part 1 of this series, I introduced the topic of general relativity, Einstein's theory of gravity. I explained why Einstein felt the need to construct a new theory of gravity in spite of the fact Newton developed a theory of gravity over two hundred years earlier.

In this article, I will explore some of the foundations of general relativity: the equivalence principle, tensors, and non-standard geometry.

Equivalence Principle

Imagine earth in orbit around the sun. Earth is 93 million miles from the sun. With that distance, the mass of earth and the mass of the sun, the acceleration can be calculated.

Now replace the earth with something more massive, say Jupiter, and place it the same distance from the sun. The calculated acceleration is the same. Replace Jupiter with a tennis ball. Again, the calculated acceleration is the same. If the initial velocity is the same in each case, then the trajectory will be the same in each case.

This can be generalized to other systems of two objects when one is much more massive than the other. We can call the heavy object the "primary mass" and the other object a "test mass," the equivalence principle tells us the following: if we know the mass of the primary mass, the location of a test mass relative to the primary mass, and the initial velocity of the test mass, we can determine the trajectory of the test mass. [1] The mass of the test mass is irrelevant. That fact is key to understanding general relativity.

Tensors

A tensor is a collection of components. The components may be simple numbers, but usually they are algebraic expressions.

Tensors come in different shapes and sizes. General relativity uses two sizes of tensors: 4x4 with 16 components and 4x4x4x4 with 256. [2]

-1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Example 4x4 tensor

Many of the tensors used in general relativity have symmetries. A symmetry means one or more values appear in two different components. More about that in a moment.

Many of the equations of general relativity come in sets of 16, if there are appropriate patterns to the set of 16, they can be expressed with a single equation using tensors. For example, if there is a set of 16 equations, each of the form a+b = c, then an equation can be constructed with three 4x4 tensors, call them A, B, and C. If these tensors are appropriately defined then

$$A + B = C$$

is equivalent to the 16 original equations.

The 4x4 tensors that appear in general relativity are symmetric, this means that 4 components appear once and 6 appear twice, which means 10 unique values.

Geometry

The angles of a triangle add up to 180 degrees. The area of a circle is πr^2. Parallel lines do not intersect. These are statements that are true in normal space (also known as Euclidean space). But perhaps not always.

Imagine an alternate reality where angles of triangles are more than 180 degrees, the area of a circle is greater than πr^2. Parallel lines always intersect. [3] In a word, this reality is "distorted" when compared to normal space.

This is an example of a "manifold." [4] (For our purposes a manifold is a collection of points that may be infinite in extent). As I explained in part 1, special relativity is based on the concept of space-time, a manifold that includes the three dimensions of space along with time. This is true of general relativity as well.

General Relativity - Part II continues, pg. 3

General Relativity - Part II, continued ...

We need a better definition of the word "distortion." There are five different ways of defining distortion:

1. Curvature scalar – single number.
2. Ricci tensor – 4x4 tensor (symmetry reduces this to 10 components).
3. Weyl tensor – 4x4 tensor (symmetry reduces this to 10 components).
4. Riemann tensor – 4x4x4x4 tensor (symmetries reduce this to 20 components).
5. The metric – 4x4 tensor (symmetry reduces this to 10 components).

In most cases, each of these will have different values at different points in the manifold.

Curvature is a word used in the literature, roughly equivalent to what I've called distortion. The first 4 of these are different ways to measure curvature. The 20 components of the Riemann tensor completely describe the curvature found in the manifold. This can be divided into two parts, curvature that changes the volume of space and curvature that changes the shape of space. The former is described by the Ricci tensor, the latter is described by the Weyl tensor. [5], [6], [7], [8].

The curvature scalar describes curvature as a single number. It is zero for undistorted space and a positive number for distorted space. The more distorted the space, the larger the number.

The metric is a description or recipe for computing distance in the distorted space. How distance is computed is not obvious in non-Euclidean spaces, the metric tells us how to compute distances. [9]

Each of these measures of distortion are "smooth," there are no abrupt changes from point to point. [10]

What I've described forms the basis of general relativity. It's known as a "four-dimensional pseudo-Riemannian manifold." [11], [12] (It's four dimensions since this is space-time and space-time has three dimensions of space and one of time). When objects move through such a manifold, they might follow a straight line, but they might follow other trajectories including orbits around a primary mass. All the motion explained by gravitational forces in Newtonian physics can be explained by motion through distorted space in general relativity.

Einstein Field Equations

Using these ideas, Einstein constructed a set of equations now called the Einstein Field Equations. The field equations allow one to calculate the metric given the density of mass or energy at a given point. From the metric, another equation, known as the geodesic equation, allows one to determine the trajectory of objects moving through the gravitational field generated by the mass or energy. For some calculations, such as calculations involving gravitational waves, it is useful to calculate the curvature scalar and associated tensors. They can be calculated from the metric.

It took eight years to develop these equations. I will explore this in the next article. ▪

BIBLIOGRAPHY

Fleisch, Dan. 2011. "What's a Tensor?" Nov 21, 2011. https://www.youtube.com/watch?v=f5liqUk0ZTw [Accessed October 16, 2021]

Green, Brian. 2020. "Your Daily Equation #26: Einstein's General Theory of Relativity: The Essential Idea." (May 12, 2020). https://www.youtube.com/watch?v=2cO8Qq-fthQ [Accessed October 15, 2021]

_______. 2020. "Your Daily Equation #27: Curvature and Parallel Motion." (May 13, 2020). https://www.youtube.com/watch?v=2qP0TD2rjX0 [Accessed October 15, 2021]

Hartel, James B. 2003. Gravity: An Introduction to Einstein's General Relativity. San Francisco: Addison-Wesley.

Lieber, Lillian R. 2008. The Einstein Theory of Relativity: A Trip to the Fourth Dimension. Illustrations by Hugh Gray Lieber. Edited by David Derbes and Robert Jantzen. Philadelphia: Paul Dry Books.

General Relativity - Part II continues, pg. 4

Snyder, Dave. 2021. “General Relativity - Part 1.” Reflections of the University Lowbrow Astronomers. (November 2021).

Taylor, Edwin F. and John Archibald Wheeler. 1966. Spacetime Physics. San Francisco: W. H. Freeman and Company.

FOOTNOTES

1 This assumes that the two objects are sufficiently isolated from any other objects.

2 Technically, tensors are described by dimension and order. In other branches of science and engineering tensors have a dimension of 3 (as should be expected as there are 3 spatial dimensions). In general relativity, the dimension is 4, 3 spatial dimensions plus 1 time dimension. What I called a 4x4 tensor, is formally known as a 2nd order tensor of dimension 4. A 4x4x4x4 tensor is known as a 4th order tensor of dimension 4. The word “rank” is often used instead of the word “order.” Both words mean the same thing in this context.

3 There is another possibility, triangles with angles totaling less than 180 degrees, the area of a circle is less than πr^2, parallel lines never intersect. These things happen when the curvature scalar is negative (the curvature scalar is described below). Negative curvature scalars do not occur under normal conditions but are possible.

4 I use the terms “distorted” or “distortion.” These words are rarely used in books on general relativity. You will see the term curvature used a lot instead.

5 Calculating the Ricci tensor requires a sequence of additions, straightforward but tedious. Calculating the Weyl tensor is more complicated and also tedious.

6 Given the Riemann tensor, the Ricci tensor and Weyl tensors can be computed. Conversely given the Ricci and Weyl tensors, the Riemann tensor can be computed.

7 Given the Ricci tensor, the curvature scalar can be computed. The curvature scalar is zero for locally flat or Euclidean space, positive when the angles of a triangle add to more than 180 degrees, and negative when the angles of a triangle add to less than 180 degrees.

8 The Riemann, Ricci, and Weyl tensors are tensors instead of simple numbers because distortion can be different in different directions. Formally a process called parallel transport can be used to transport any of 4 different unit vectors in 16 different ways to give 64 possibilities. Four numbers need to be given for each of the 64 possibilities to give 256 numbers. If this is done to completion, this captures all the distortion present in a Riemannian or pseudo-Riemannian manifold. This allows us to create a tensor with 256 numbers, namely the Riemann tensor. A more careful analysis shows many of these 256 values are duplicates, and only 20 unique values are needed to completely represent the Riemann tensor.

9 If you are familiar with calculus, given the metric and the first derivative of the metric, the Riemann tensor can be computed.

10 If you are familiar with calculus, this means the values are differentiable at all points.

11 In a pseudo-Riemannian manifold (sometimes called a semi-Riemannian manifold), the distance between two different points might be negative, zero, or positive. In a Riemannian manifold, the distance between two different points is always a positive number (greater than zero).

12 A number of mathematicians developed these ideas in the 19th century. ▪

COMET A1 LEONARD

BY BRIAN OTTUM

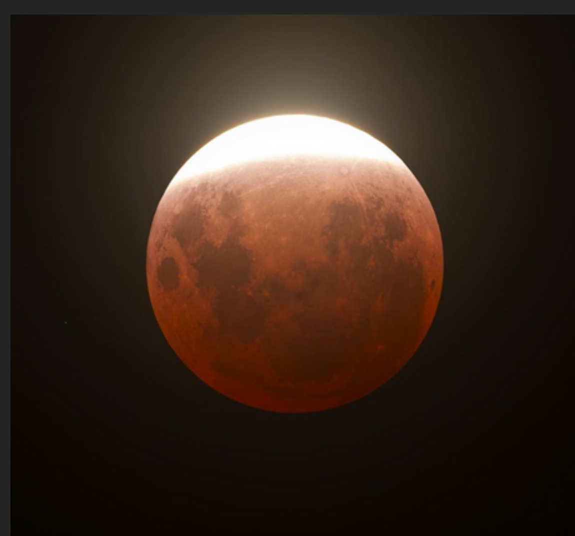
Comet A1 Leonard is getting brighter! It passes Earth on December 12 and goes around the sun January 3, then heads back out into deep space. This is definitely a great binocular object in the eastern predawn sky, but it moves into the evening sky after December 12. ▪

FOUR VIEWS OF THE NOVEMBER 19 PARTIAL LUNAR ECLIPSE

<< Photo by Adrian Bradley, taken in Clyde, Michigan, near Port Huron.

>> Photo by Karim Jaffer, taken in Montreal. First Part of Umbral Shadow.

<< Photo by Karim Jaffer, taken in Montreal. Second Part of Umbral Shadow.



>> Photo by Brian Ottum, taken remotely from his telescope in New Mexico.

M31 AND IC1805

BY GLENN KAATZ

M31 (ANDROMEDA GALAXY)

I decided to try my luck on an "easy" target that I had only imaged previously using a DSLR. However, I have only a small gap between the trees in my backyard to work with so I gathered data over two nights (November 5-6).

IMAGING INFORMATION

Williams Optics Z61 refractor
CGX Mount
ASIAir Pro controlling all electronics
ASI294MC Pro one-shot color camera
Guiding using an ASI120MM mini camera
ZWO mini electronic filter wheel
5 hrs of 3 min images through an Optolong LPRO filter
3.1 hrs of 3 min images using a Optolong LExtreme filter

Total integration time: 8.1 hrs

Processing in Pixinsight and Photoshop, blending together the H-alpha and OIII data from the LExtreme filter with the broadband data from the LPRO.

IC1805 (HEART NEBULA)

I recently obtained an ASI1600MM Pro monochrome camera and gave it first light on the Heart Nebula in Cassiopeia. I imaged over two nights to collect sufficient data (Nov 22-23).

IMAGING INFORMATION

Williams Optics Z61 refractor
CGX mount
ASIAir Pro controlling everything
ASI1600MM Pro camera
ASI120MM for guiding
ZWO electronic filter wheel

20 X 5 min Ha
21 X 5 min OIII
20 X 5 min SII

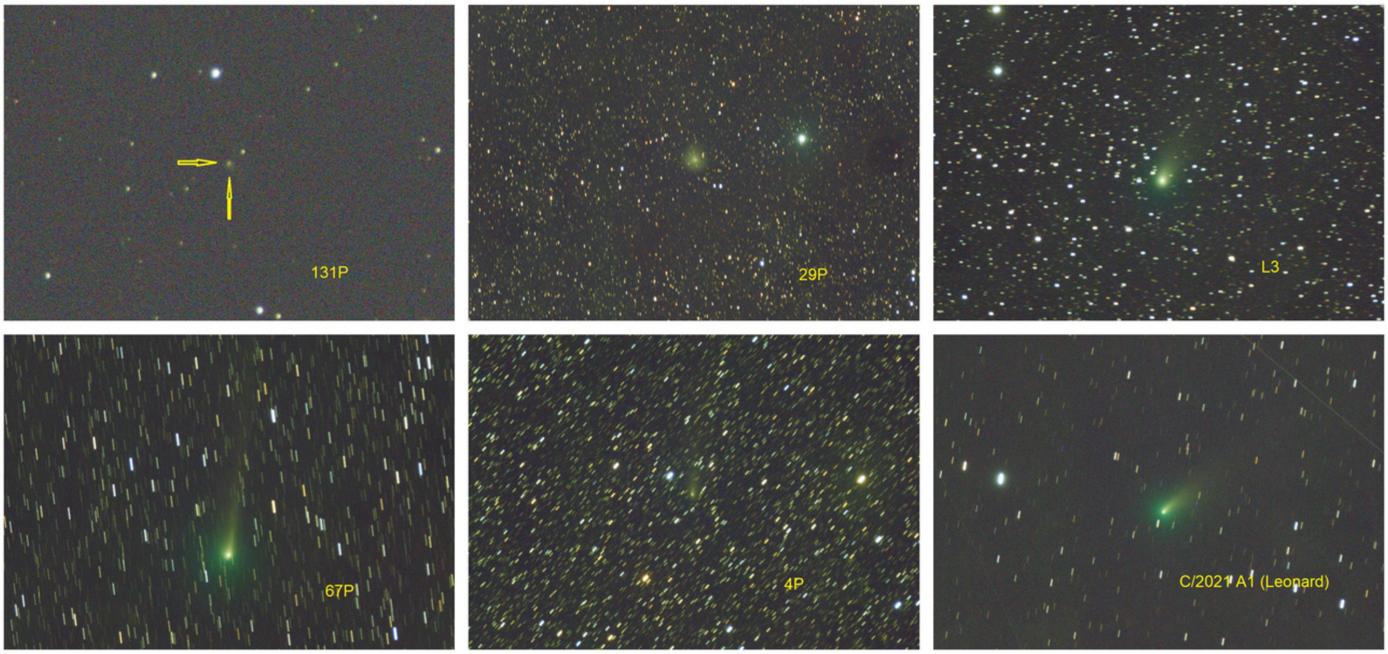
Total integration time: 5 hrs

Processing in Pixinsight and Photoshop. I was fairly pleased with my first attempt at monochrome imaging. ■

COMET RUN

PHOTOS BY DOUG BOCK

Doug Bock imaged all the comets shown here on the night of November 6-7 using the William Optics 105mm APO refractor and the ZWO asi2600MC PRO camera at Gain 100 and temp 0C. All subframes were 5 minutes each for each object, with numbers varying from 12 to 24. ▪



ASTROPHOTOGRAPHY TIP OF THE MONTH

Ahh, December. Michigan isn't known for its abundant clear skies during this last month of the year, but if it turns out you're lucky enough to hit a cloud-free night here or there, the chart at right will help you make the most of it.

Many thanks to **AWNI HAFEDH** for compiling this handy list of choice targets for this time or year, with all the Go-To info you need to get in some quality imaging time between snow squalls. ▪

Name	Code	H-Alpha	Position RA/DEC
Heart Nebula	IC 1805	H	02h 32m 42s / +61d 27' 00"
Soul Nebula	IC 1848	H	02h 51m 06s / +60d 24' 36"
Pleiades	M45		03h 47m 00s / +24d 07' 00"
California Nebula	NGC 1499	H	04h 00m 42s / +36d 39' 37"
Witch Head Nebula	LBN 959 / IC 2118		05h 02m 24s / -07d 55' 45"
Flaming Star Nebula	IC 405 / IC 410	H	05h 16m 12s / +34d 16' 00"
The Tadpoles	IC 410	H	05h 22m 36s / +33d 31' 00"
Crab Nebula	M1	H	05h 34m 31s / +22d 00' 52"
Orion Nebula	M42	H	05h 35m 24s / -05d 27' 00"
Horsehead Nebula	IC 434	H	05h 41m 00s / -02d 24' 00"
Spaghetti Nebula (Simeis 147)	SH2-240	H	05h 41m 06s / +28d 04' 58"
Messier 78	M78		05h 46m 45s / +00d 04' 45"
Boogie Man Nebula	LDN 1622	H	05h 54m 28s / +01d 48' 12"
Monkey Head Nebula	NGC 2174	H	06h 09m 42s / +20d 30' 00"
Jellyfish Nebula	IC 443 / LBN 844	H	06h 17m 01s / +22d 28' 52"
Rosette Nebula	NGC 2244	H	06h 31m 43s / +04d 55' 46"
Cone Nebula	NGC 2264	H	06h 40m 58s / +09d 53' 42"

University Lowbrow Astronomers

19 November 2021, 7:33 pm, Room G115 Angell Hall & Individual Live Connections via Zoom/YouTube

After some chatter to allow for late arrivals, President Charlie Nielsen called the meeting to order and then introduced our speaker.

Speaker

Who

Fred Adams of the University of Michigan Physics Department

Subject

Constraints on the Future of Computation

A Q&A session on spectroscopy occurred afterward. Charlie thanked our speaker for the presentation.

Business Meeting

Name	Topic
Charlie Nielsen, President	U of Michigan Retirees emailed about a possible tour of Peach Mountain. We informed them that we cannot do a tour at this time.
Doug Scobel, Treasurer	From Email: – We have 173 memberships, including a new member from Quebec - our first international member! This count also includes about a dozen memberships that would have expired but for grace extended due to COVID-19 pandemic considerations. – We have $11,581.57 in the treasury. About $400.00 of that amount is money owed to the RASC for the 2022 observer's handbooks. – RASC 2022 observer's calendars and handbooks have been ordered. We have paid for the calendars, but we are still awaiting their arrival. The handbooks have arrived, but we are still waiting for the invoice from RASC so we can pay for them. VP Liz Calhoun has graciously accepted responsibility for distributing the items. – Since our October meeting our expenses consisted of payments for our usual monthly newsletter printing/mailing costs, our monthly fee for maintaining our open house telephone "hotline", and reimbursement to observatory director Jack Brisbin for observatory expenses.
Joy Poling, V.P.	Updated online calendars to show that our club meetings are now both in person and online.

Elizabeth Calhoun, V.P.	– Still has the Peach Mountain Keys – Also has all of the RASC Handbooks, but still no calendars as of yet – Has contacted a past Lowbrow, Professor Dan Crane, who might be willing to network and find someone who would be interested in giving a talk to us on Space Law.

Jeff Kopmanis, Communications	Will continue to work on showing the screen properly for in person members.
Krishna Rao, Webmaster	From email: – Website has been updated with the minutes, newsletters, and youngastronomer's observing calendars. I don't think I've missed anything I've been sent but please let me know if so – Website now with updated officer's information (previously some phone numbers were missing). Go to the member's only section and click on the link for information about the officers. – I haven't posted the communication committee minutes and I'm not sure I have all of them. Probably worth creating a separate section on our page for minutes. If Jeff Kopmanis or another committee member has them and can forward along, I'll add those to the website as well – As for the website transition plans, still in the exploratory phase. I haven't had time yet to play around with the UM free offerings yet but the hope is to move over to one that allows for better content curation (i.e. you don't need to know HTML to make website changes). – I am looking into adding a weather widget to our website, possibly the clear sky clock for Peach Mountain on the observing and calendar of events page. I received one request about this from the membership. What do the members think? – COVID update: numbers are going up but vaccination and masking work well to protect us, as do the outdoors, which are still quite safe despite the delta variant. Hope everyone is staying vigilant!
Jack Brisbin, Observatory	Did tests out at the Observatory to make sure the drives on the McMath were still working. Also, Jack attended the "Reducing Light Pollution for Night Sky Viewing" at Oceola TWP Hall, Howell Mi. He talked with Robert Parrish a delegate to the International Dark association and very active in getting the Dr. Lawless Park in Cass county, recognized as an International Dark Sky Park and Michigan Dark Sky Preserve.

All Lowbrow Officers and members in attendance	A discussion, led by Harry Anderson III, on changing our Any Clear Nights Observation (ACNO) to include something in honor of the late John Causland. After a lot of good debate, it was narrowed down to 4 options: 1. Keep the ACNO title as is 2. ACCNO (Any Causland Clear Nights Observation) 3. JACNO (John's Any Clear Nights Observation) 4. Change to 'Causland Nights' A vote by email will be held to determine whether ACNO nights change or remain the same.

Addendum

Attendance for tonight's virtual meeting: 28 via Zoom/YouTube, 11 in person.

Adjourned
09:18:00 PM

Minutes were taken and transcribed by
Adjourned
Adrian Bradley

UPCOMING MEETING SPEAKER SCHEDULE

DECEMBER 17: Don Fohey, Lowbrow member. Topic: ***The New Horizon Mission to Pluto***

JANUARY 21, 2022: Dan Durda, Southwest Research Institute, Boulder, CO. Topic: ***The Southwest Research Institute's Suborbital Research Initiative: First Flights with Virgin Galactic and Blue Origin***

FEBRUARY 18: Professor Claude Pruneau, WSU Physics Dept. Topic: ***What the LHC mini-bangs tell us about the Big Bang***

MARCH 18: Tentative Professor Michael Meyer, U-M Astronomy. Topic: ***The NASA/ESA/CSA James Webb Space Telescope: Discovery Space***

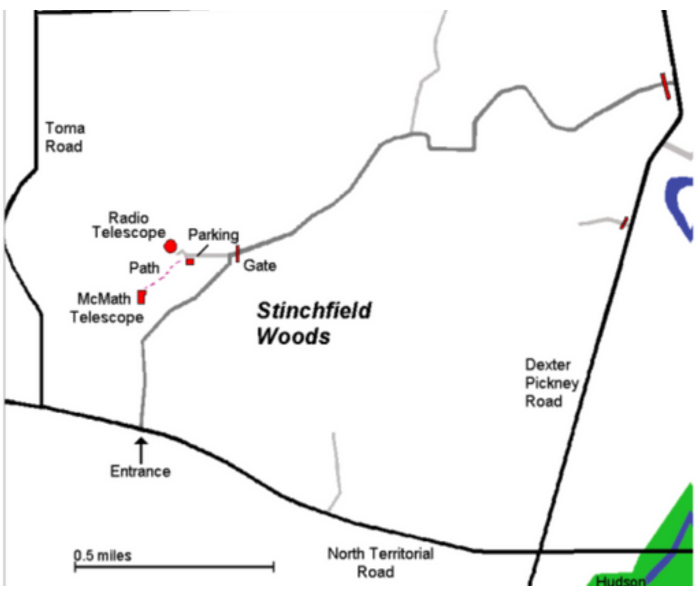
APRIL 15: Adrian Bradley, Lowbrow VP. Topic: ***The Dark Skies of Michigan***

MAY 20: Professor Rudi Lindner, U-M History. Topic: ***The Michigan-California Axis in Astronomy***

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). You can have the newsletter mailed to you with an additional $18 annual fee to cover printing and postage. Dues can be paid by Venmo, 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 - $32.95/year
or $65.90/2 years
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
	Joy Poling
	Liz Calhoun
	Dave Jorgensen
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
Lowbrow-members@umich.edu

University Lowbrow Astronomers

Night Sky Network

University Lowbrow Astronomers
P.O. Box 131446
Ann Arbor, MI 48113

STAMP