REFLECTIONS / REFRACTIONS
University Lowbrow Astronomers
July 2012
Volume 36 Issue 7

A Solution to the Guiding Problem

by
Tom Ryan

> It was twenty years ago today,
> Sgt. Pepper taught the band to play.
> They've been going in and out of style
> But they're guaranteed to raise a smile.
> So may I introduce to you
> The act you've known for all these years,
> Sgt. Pepper's Lonely Hearts Club Band.
> (Lennon/McCartney)

Some time around 1992, Roger Tanner was messing around with his telescopes, trying and failing to take good pictures of the Messier objects in the sky. Since Roger is basically an Engineer's Engineer, he approached the problem from an engineer's perspective. (If he'd been a bean counter, he'd have just bought the top-of-the-line equipment he needed.) Roger investigated the mechanical design of his mounts, calculated the bending moments, masses, deflections and resonant frequencies of the mount's individual components, revised the mechanics as best he could to compensate for the shaky mounts and the uncertain machining, and undertook to guide his CCD cameras by using one of two methods.

The first method involved guiding off a star in the field of view of the camera. This meant he positioned a small pick-off mirror near the camera itself, just inside the beam coming from the main mirror, but outside the part of the beam that entered the camera. This area is relatively small, and Roger found that the likelihood of finding a star which was bright enough to guide on was also relatively small. Roger's guiding focuser had a pick-off mirror which could be rotated about the field, and moved toward or away from the field, in order to pick up that rare star that was near to, but not in, the field of view, but most of the time, that convenient guide star simply didn't exist.

This led to some frustration on his part, and an attempt to guide by a different, second method.

This second method used a guiding telescope. This guiding scope rode piggy-back on the main scope, and could be offset by some given angle from the main scope, in order to find and track that bright star which was near, but not near enough for method #1 to work, to the object to be imaged.

Guiding scopes have problems of their own. For one thing, they're looking at a different part of the sky than the object to be imaged, and this means that slightly misaligned mounts and atmospheric refraction will cause the two points to drift apart, with disastrous effects on the image. Roger carefully assesed these errors (engineers believe that math can be used to make real predictions about the world, thereby separating both the ignorant and the maliciously persuasive arguments from the truth, and for the most part, they're right) and concluded that he could compensate for these problems. He designed a mount for his guide scope which was so good that I recently copied it to adjust the coherent output beams of what is euphemistically called a directed energy weapon, but which we will simply call a death ray from outer space, because that is what it is. (When you observe a Master at work, you should pay attention and learn.)

Roger's mount had one design flaw. It attached to the main telescope, which he did not design. The result was differential flexture between the two optical systems, with disastrous effects on the image.

And there matter stood, for a long time.

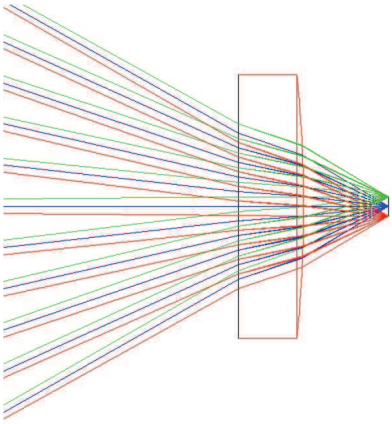
REFLECTIONS / REFRACTIONS

About ten years went by, and I gradually learned more and more about optical systems and impressed my bosses with mechanical designs which were largely cribbed from Roger's throw-away ideas. But during this time, I kept thinking about the guiding problem, and one day, while designing a beamsplitter for an interferometer, I solved it.

The interferometer I was designing needed to have a high quality light beam expand out from the laser, travel through a beamsplitter, and return from the object being tested to the beamsplitter, where it was reflected and then imaged by a CCD camera, and both the output and return beams needed to be very good; that is, free of aberrations. Now, anyone who knows a little bit about optics knows that sending an expanding beam through a tilted plate beamsplitter results in quite a bit of aberration being added to the beam, and pellicle beamsplitters are out because they are fragile and uncleanable, and cube beamsplitters are out because they have spurious reflections from their squared-on faces, and spurious reflections in a laser-based optical system are double plus ungood.

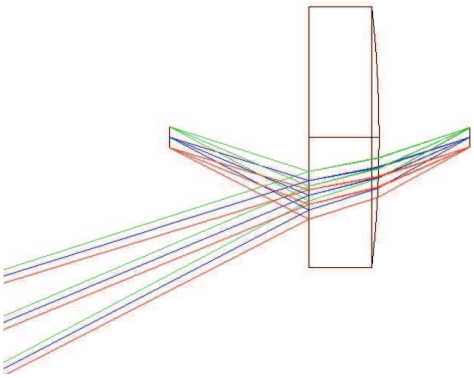
But, there exists a little-known type of beamsplitter that adds almost no aberration to either the reflected or the transmitted beams, and that was what I used.

The beamsplitter was invented by two geniuses, whose names I unfortunately do not remember but would look up if you were reading a scientific report, but since you are not, I won't. I do, however, remember their design. The basic question was, given a rapidly converging beam, could you insert a lens somewhat before focus which would not add too much aberration to the final image field, and the answer is, of course, yes. Then, they had a flash of insight. What if the front side of the lens were flat and semi-reflective, and then you only used the below-axis half of the rapidly converging beam in your beamsplitting system? The light which went through the bottom half of the lens would focus just as well as had the light going through the entire lens (better, actually), and the light which reflected off the planar side of the lens would focus as well as the light would have focused had there been no lens there at all. Of course, the optical axis changes in this transformation, but that hardly matters to the optics.

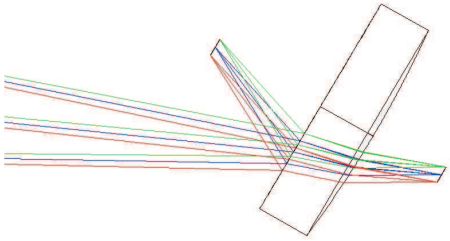


Converging Light With Corrector Lens

Here is how the design evolved.



Converging Light With Correcting Beamsplitter



Converging Light With Correcting Beamsplitter, Rotated.

Admittedly, the light reflecting off the flat surface of the lens in the accompanying figures is not at a 90 degree angle to the incoming light, and the transmitted and reflected focal planes are perhaps not exactly square to the incoming light, but if you insist on making those things perfect, then you have to change the radius of curvature on the back side of the lens. But that's all that is required. Brilliant, eh?

At this point, I suddenly realized that I had a solution to Roger's guiding problem. This beamsplitter design has a fairly large field of view, and if a person were to place it in front of the camera, most of the light from the main mirror would reflect off its face into the camera, but some light would pass through the beamsplitter to focus onto a wide field of view, where the field and therefore the likelihood of finding a guide star is greatly increased. Furthermore, since CCD cameras are typically sensitive to the infrared, the coating on the beamsplitter could be a long-pass edge filter which reflects 100% of the visible, and passes 100% of the infrared. Sending 100% of the visible light to the camera and 100% of the infrared light to the guiding mechanism would greatly improve the efficiency of the system. So, I designed (but did not build) this guiding device (I did build the interferometer with this device incorporated in it, and it works very, very well), and the following figures show how it performs, compared to existing designs:

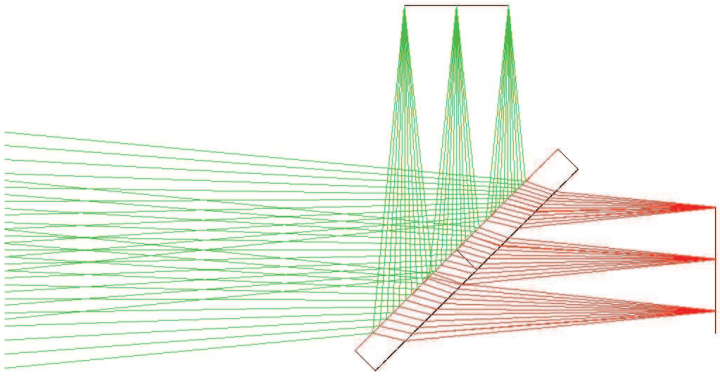
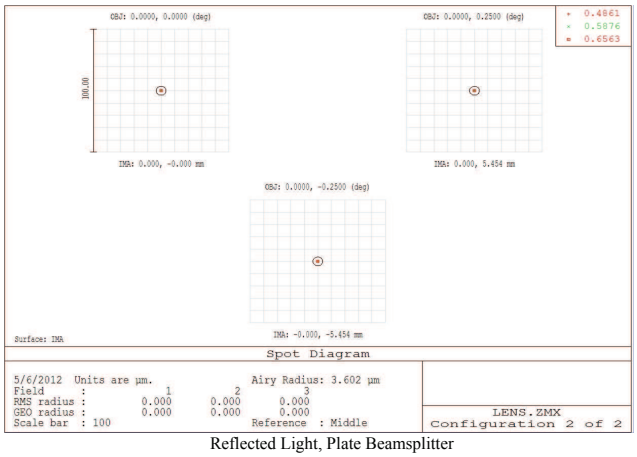


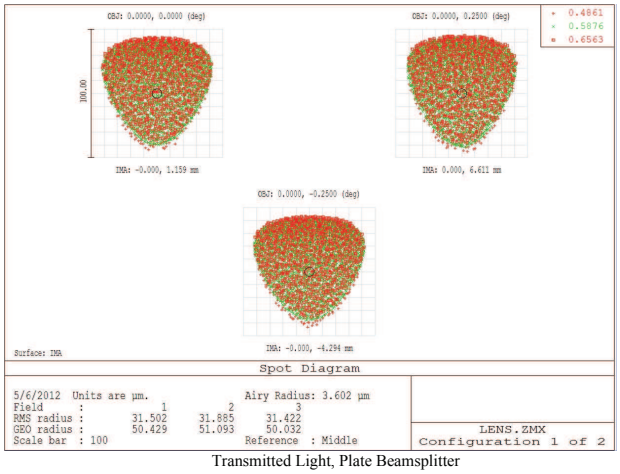
Plate Beamsplitter

First, let's look at the performance of a typical parallel plate beamsplitter, and let's coat the front side with an edge-pass coating and the back side with a good anti-reflection coating.

The (red) infra-red light goes through the plate beamsplitter, and the (green) visible light reflects off the front face. When coming from a 10" diameter f/5 perfect objective (a reflector with a coma corrector, for example, or a nice refractor objective), and falling upon a CCD with 10 micron pixels, the reflected light looks pretty good, as shown in the figure. It is as good, in fact, as the light from the objective itself. Unfortunately, the same cannot be said for the transmitted light. The figure with the transmitted spots shows them at their best focus, believe it or not. All images are shown at the same plate scale of ten microns per small square, 100 microns per large square.

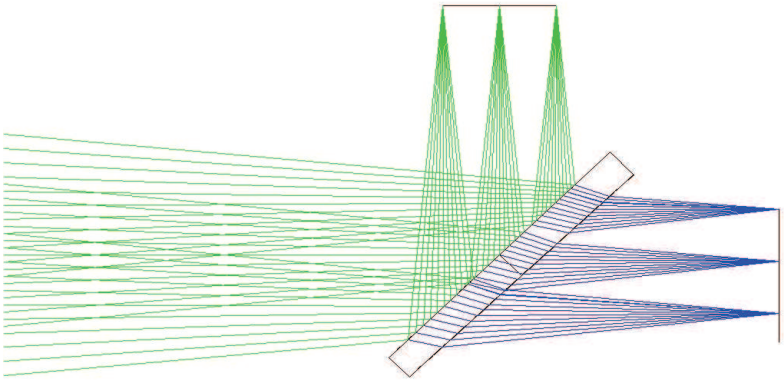


Reflected Light, Plate Beamsplitter



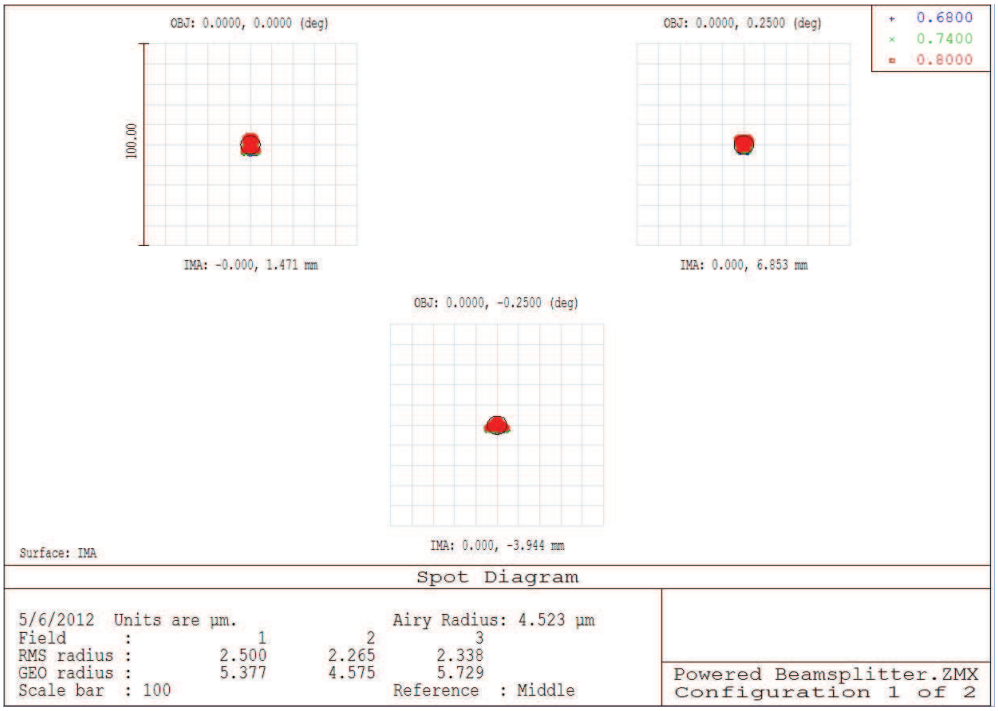
Transmitted Light, Plate Beamsplitter

However, using the modified beamslitter, which has a flat front, a spherical back of appropriate radius of curvature, and an appropriate amount of wedge, which looks like this,:



New Beamsplitter (See the difference? No? It is subtle but important).

the transmitted IR spots now can be used for critical guiding, because they look like this:



In all of the figures, the black circles are the Airy disk, which represents perfect imaging.

In the case of a 10” f/5 objective, the beamsplitter is made from a plano-concave lens which has a negative focal length of 6.25 meters, and is wedged by being a 30 mm diameter lens cut eccentrically from a 90 mm diameter lens. The details of the lens are easily calculated once the method is known, and if you are serious about making one of these, you should either have someone calculate the parameters for you, or let me know and I'll do it for you.

The advantages of this design are that you can guide on anything in the field of view (and a bit beyond it) and there is almost no (I won't say none, but very, very little) differential motion between the guide stars and the imaged stars. The registration between the two fields stays as tight as you can make a solid block of metal, and atmospheric distortion and instrument flexure affects both fields equally. Truly, what you guide on is what you image.

I told a few people about this method of guiding, and they suggested that I patent it. However, I

have a love-hate relationship with patents. I have a few patents already, having worked for companies which routinely patent everything that comes within their grasp, and I have patented one of my potentially more profitable ideas, and I'm proud of these pieces of paper, but most of the patentable things I've thought of have gone unpatented.

Basically, I believe that one should make money by being “firstest with the mostest”, as one of our more successful generals was claimed to have said. Get the device to market quickly, make money from it, improve it if you feel like it and if there is enough interest in it, or abandon it if there is insufficient interest and move on to the next thing. I've used this method before, relying on keeping the method a trade secret, and have even started a company based on one of these ideas, but eventually, someone else will independently figure out how to do the same thing, and may or may not patent it, and may or may not be more successful with it, but that's the way it goes when you are morally opposed to the rent-seeking behavior that the patent system encourages. To say nothing of the fact that defending marginally profitable patents is not the way I wish to spend the remaining days of my life. So, in the spirit of Dean Baker, who puts his money where his mouth is, I'm officially making a public disclosure of this powered-beamsplitter-used-in-a-guider idea, and I hope you will benefit from it.

For the past ten years, I've been sailing along, always working immediately on better methods to destroy the world, but with this guiding device always in the back of my mind. (In truth, it resides there along with quite a few other ideas for making the world a better place, but which no one wants to pay me for right now, and most of who's profitability I frankly doubt.)

So, given the ten years between the expression of the need and its solution, and an additional ten years lapse factor, it was no real surprise when I opened the March-April 2012 issue of Astronomy Technology Today and found that Innovations Foresight was selling a guiding device called the ONAG that looks a lot like the one I imagined so long ago. You can check it out on the web at www.innovationsforesight.com. Assuming that an engineer's technical prowess is inversely related to his marketing skills, this ONAG device should work very well.

The company's illustrations don't give much in the way of technical details about it (and I confess I haven't actually read the article; I've just looked at the pictures), other than to say that patents are pending. They clearly believe in the power of patents.

In any case, it looks like they are making a product that is needed, and I am not, so I say, more power to them. It would be nice for their customers if they were also using the beamsplitter I described above, but really, they probably aren't.

But they could. It's not patented.

Your editor did indeed discover the identity of the Death-Ray patent holder.

The Transit of Venus: Lowbrows and the 2012 Event

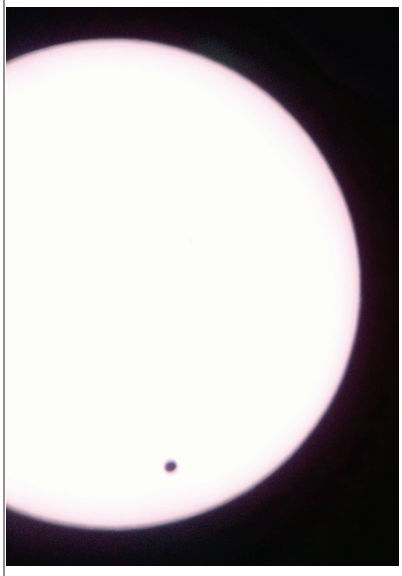
Editors note: Lowbrows far and wide, at numerous venues, brought the 2012 Venus transit to hundreds of individuals making the club a focus of a major cultural event. Reporting on these efforts will be spread over the next several issues of Reflections.

A Medley of Lowbrows Venus 2012 Observing Reports

Collected by Chris Sarnecki

*A big **THANKS again** to all who contributed in the second ever combined Lowbrow Venus Transit report. (See the first Lowbrows' 2004 Venus Transit report at - http://joinww.umich.edu/~lowbrows/reflections/2004/venus.html). How often does one get to see two Venus transits in a lifetime? The second time around I decided to observe at Leslie Park, same as in 2004. The weather cooperated back then, so I hoped it would cooperate again. Well, it did. The weather for the June 5th Venus transit was touch-and-go at first contact, but by second contact the sky did clear up and remained clear for most of the evening. What an event this was. Our Lowbrows at Leslie Park hosted a steady stream of local residents and others that traveled to the park for a chance to see Venus dance across the disk of old Sol. It was a little strange having a 'star' party during daylight. Like most of you that saw this, we observed the Sun until it dived below the horizon. Sweeeet!*

This report is a little different than the 2004 report in that it is laced with lots of hyperlinks of photo collections by our assembled membership. So grab your mouse, and be prepared to 'click' and read through these observation reports. - Chris Sarnecki



Ok, so I have to get this picture out of the way fiirst. A handheld i-phone picture through an 8-inch dob stepped down to 3-inch-es. Pretty nice pic if I say so myself.

Basking in the Venus 2012 after glow, Lowbrow Liz Calhoun files her report. Good morning, Lowbrows! We set up our 8" Dob with the solar filter at Leslie Science Center, just up from the "Raptor Roost." We had a steady stream of viewers from 6:15 to when we finally lost the last decent clear FOV at about 9pm -- about 60-70 all told. We were wearing our Lowbrow shirts and we hope we've sent a few new recruits to the Club. People from Northside School came by and it sounded as if they'd be in touch to schedule a school demo at some point.

One gentleman took photos through the eyepiece we were using ... not great photos, but it was what it was: for most of us, a last-chance viewing opportunity.

Dave Snyder, Lowbrow Webmaster extraordinaire writes…
(Dave sent out an e-mail on June 1st in preparation for the big day.)
Reminder: we have several Venus Transit venues in the immediate area, so not everyone needs to go to the same place...

Angell Hall
Ashley Street
The Detroit Observatory
Ann Arbor District Library, Traverwood Branch
Leslie Park
Sherzer Observatory

(A gaggle of Lowbrows also 'observated' at Kensington Metro Park)

Dave collected and organized our Lowbrow photos at:
http://www.umich.edu/~lowbrows/album/venus-2012/

I first got interested in Venus transits 12 years ago (in the year 2000) when I got this email...

Greetings from Princeton -- I just wnated to let you know that Eli Maor who id the author of a new book on the transits of venus will be speaking at Borders Books on Liberty Street this coming wiik July 13th at 7:00 PM.

I went to Boders, met Dr. Maor and bought a copy of his book (which I still own). However I had to wait four years to actually see a transit (which was a memorable experience, more so than I would have expected).

After another eight years, we had another memorable experience. The afternoon of June 5, 2012 was cloudy, but the weather gods cooperated and the clouds parted before the start of the transit. We planned this Venus Transit better than the last one, having set aside several sites for viewing.

I joined a group of Lowbrows who set up on Ashley Street. We had lots of visitors, and I lost track of how many people I talked with, how many questions I answered. Other Lowbrows has mentioned that "gigs lik yeesterday renew ones' enthusiasm for public events". At the risk of sounding like a broken record, I agree For me the best part of this was helping to share a unique experience with so manny different people. My favorite experience was a young girl who was looking through Mike Radwick's telescope. I took a photograph of her. I had remarked that she might just be able to live long enough to see the next transit; she responded that she'd like to live a hundred years

The Lowbrow observing crew from Ashley Street -- Doug Scobel, Mike Radwick, Amy Cantu, Jack Brisbin, John Wallbank, Paul Juska, Dave Snyder and John Causland.

Antique Spyglass Confirms Transit of Venus

By Jack Brisbin

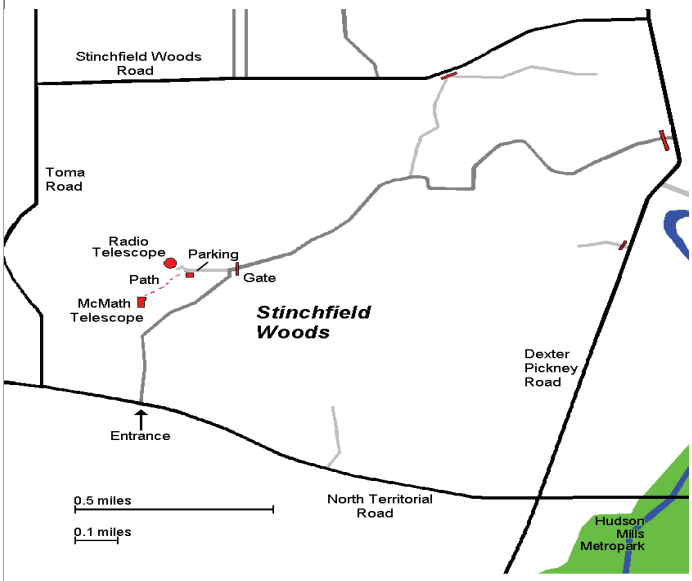
The spyglass was imported from France and sold in the U.S in 1889. I acquired the spyglass at an astronomy conference and have had it for many years. I built an observing frame so the spyglass could be used by the public with some restrictions. I attached one of my binocular solar filters to the front of the frame. The spyglass is about 120+ years old……. *The public loved it!*

As people strolled up and down Ashley Street the antique spyglass captured their attention and interest. Once they looked, they were hooked. How surprised they were to view Venus and the Sunspots. Not to mention the return requests to see how far Venus had moved across the sun. Even the kids returned to look and see if it was “still there”. Some of the local antique buffs where impressed with the image quality and continued to stay and observe. When you explain it to the public, that you won’t see this again until 2117, they realize they are part of a once in a lifetime event.

Places & Times

Dennison Hall, also known as The University of Michigan's Physics & Astronomy building, is the site of the monthly meeting of the University Lowbrow Astronomers. Dennison Hall can be found on Church Street about one block north of South University Avenue in Ann Arbor, MI. The meetings are usually held in room 130, and on the 3rd Friday of each month at 7:30 pm. During the summer months and when weather permits, a club observing session at the Peach Mountain Observatory will follow the meeting.

Peach Mountain Observatory is the home of the University of Michigan's 25 meter radio telescope as well as the University's McMath 24" telescope which is maintained and operated by the Lowbrows. The observatory is located northwest of Dexter, MI; the entrance is on North Territorial Rd. 1.1 miles west of Dexter-Pinckney Rd. A small maize & blue sign on the north side of the road marks the gate. Follow the gravel road to the top of the hill and a parking area near the radio telescopes, then walk along the path between the two fenced in areas (about 300 feet) to reach the McMath telescope building.



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 Mountain observatory, but are usually cancelled if the sky is cloudy at sunset or the temperature is below 10 degrees F. For the most up to date info on the Open House / Star Party status call: (734)332-9132. Many members bring their telescope to share with the public and visitors are welcome to do the same. Peach Mountain is home to millions of hungry mosquitoes, so apply bug repellent, and it can get rather cold at night, please dress accordingly.

Membership

Membership dues in the University Lowbrow Astronomers are $20 per year for individuals or families, $12 per year for students and seniors (age 55+) and $5 if you live outside of the Lower Peninsula of Michigan.

This entitles you to the access to our monthly Newsletters on-line at our website and use of the 24" McMath telescope (after some training).

A hard copy of the Newsletter can be obtained with an additional $12 annual fee to cover printing and postage. Dues can be paid at the monthly meetings or by check made out to University Lowbrow Astronomers and mailed to:

The University Lowbrow Astronomers

P.O. 131446

Ann Arbor, MI 48113

Membership in the Lowbrows can also get you a discount on these magazine subscriptions:

Sky & Telescope - $32.95 / year

Astronomy - $34.00 / year or $60.00 for 2 years

For more information contact the club Treasurer at:

lowbrowdoug@gmail.com

Newsletter Contributions

Members and (non-members) are encouraged to write about any astronomy related topic of interest.

Call or Email the Newsletter Editor: **Jim Forrester (734) 663-1638 or** jim_forrester@hotmail.com to discuss length and format. Announcements, articles and images are due by the 1st day of the month as publication is the 7th.

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Lowbrow's Home Page

http://www.umich.edu/~lowbrows/

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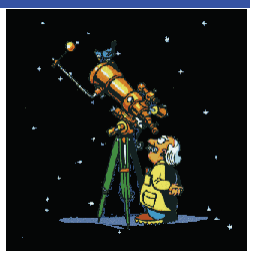
Reflections & Refractions



Website
www.umich.edu/~lowbrows/

My Backpacker/ sunfunnel combo worked splendidly! Besides letting more than one person look at one time, dozens of folks snapped pictures of the transit using their cell phones. The larger black dot at the lower left, just inside the sun's disk, is Venus's silhouette. The smaller, less distinct spots on the sun are sunspots.

--Doug Scobel

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