REFLECTIONS / REFRACTIONS

REFLECTIONS \ REFRACTIONS

University Lowbrow Astronomers

FEBRUARY 2013

Volume 37, Issue 2

*Don't Forget Your Towel!*

# The Sky is Falling!!!

by Mike Radwick

## ...or is it?

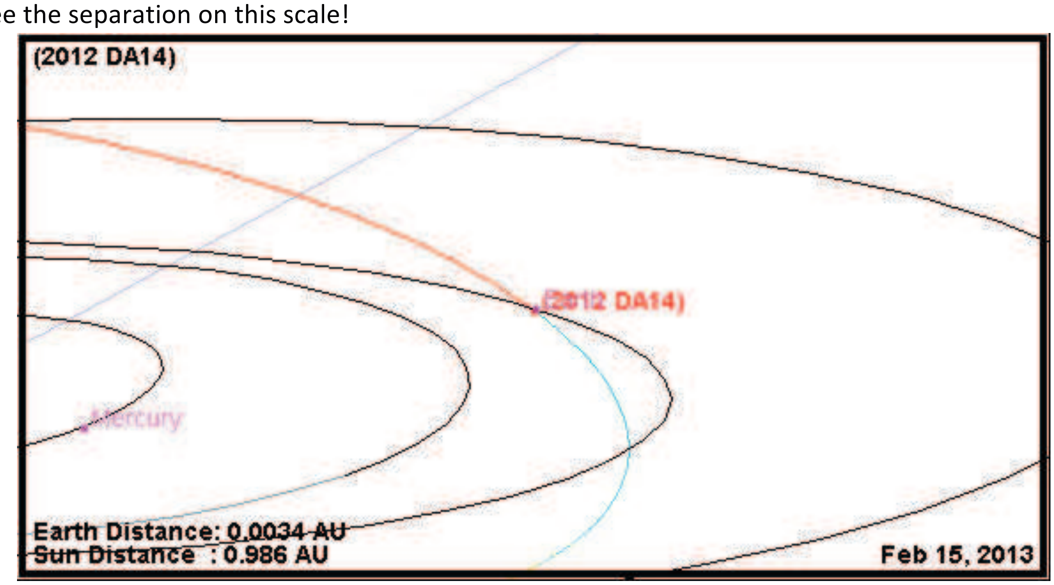
***Are the Vogons clearing the way for a hyper-space bypass? Your intrepid Observatory Director fills us in on the latest and tells how you can see for yourself. And if you mislay your towel, at least remember to duck.--ed.***

Well, Chicken-Little may have something to fear, but while tons of material fall to Earth from the heavens each year we rarely have much to worry about. Most of the stuff that intersects Earth's orbit is very small and burns up in our atmosphere long before reaching the surface. Before Shoemaker-Levy 9 impacted Jupiter in 1994, few astronomers considered planetary impacts by a large object a serious modern concern. However, the event drew attention to the possibility that we might get in the way of leftover debris from the Solar System Construction Project. In response, NASA and other organizations established programs such as the Lincoln Near-Earth Asteroid Research (LINEAR) project to survey the sky and try to discover any threats ahead of time. These programs (see http://neo.jpl.nasa.gov/programs) have made many discoveries.

The Space-Weather web site (http://www.spaceweather.com) digests reports from the survey programs and provides a list of objects that will come close to Earth in the near future. One object that recently grabbed my attention is asteroid 2012 DA14.

2012 DA14 was discovered on February 23, 2012 by the Observatorio Astronómico de Mallorca near the Spainish city of La Sagra. Orbital calculation estimated a period of about a year (366 days), and that a very close approach had occurred only 7 days earlier. The asteroid is estimated to about 45 meters (145 ft) in diameter and weigh in at about 130,000 metric tons. While not especially large, this guy is not small either and is considered a medium size object. It is thought that an object of about this size created Meteor Crater in Arizona.

As shown below, DA14 will make another very close pass of Earth on Feb 15, 2013. In fact the distance is so close that you cannot see the separation on this scale!



Calculations have shown that this will be a very near miss. The asteroid will miss Earth by 25,000 to 35,000 miles. This is so close that the asteroid will pass *inside* the orbit of our geosynchronous satellites (about 26,199 miles from center of Earth)!

Estimates suggest that when at perigee (closest point to Earth), DA14 may be as bright as $7^{th}$ magnitude for a short time (maybe only seconds). An easy observing target, right?

The bad news (for those of us in the U.S.) is that perigee occurs at about 19:26 UTC; Eastern Standard Time is -5 hours, so closest approach is at 2:36pm EST.

This might be just as well for us, as the asteroid at that time will be moving very fast in the sky and thus hard to catch in most telescopes. If I were in Europe (or further East), I'd consider using binoculars on a mount and a camera with a moderately wide field of view and high sensitivity.

Sunset occurs in Michigan at 6:02pm EST, Nautical Twilight at 7:09pm EST (00:09 UTC). By this time (7pm) the asteroid will have dimmed to about $11^{th}$ magnitude and will still be moving rather fast against the background stars. So a telescope and high-precision star-charts will be needed to observe. Such charts are needed as most programs calculate the position relative Earth's center but the asteroid is so close that our position on Earth's surface introduces a significant angle (parallax) when projected against the sky.

Thanks to the NASA HORIZONS Web-Interface (http://ssd.jpl.nasa.gov/horizons) we can obtain high-accuracy position data for DA14. The following table shows the position every 15 minutes as seen from Ann Arbor, MI for several hours following the point of closest approach:

| Date/Time (UTC) | RA | DEC |
|---|---|---|
| 2013-Feb-15 22:45 | 12 41 35.22 | +66 39 19.8 |
| Local Sunset | | |
| 2013-Feb-15 23:00 | 12 47 13.07 | +68 34 21.4 |
| 2013-Feb-15 23:15 | 12 53 01.38 | +70 16 27.3 |
| 2013-Feb-15 23:30 | 12 59 00.65 | +71 47 31.9 |
| 2013-Feb-15 23:45 | 13 05 11.39 | +73 09 08.8 |
| 2013-Feb-16 00:00 | 13 11 34.08 | +74 22 35.0 |
| 2013-Feb-16 00:15 | 13 18 09.25 | +75 28 54.4 |
| 2013-Feb-16 00:30 | 13 24 57.38 | +76 28 59.9 |
| 2013-Feb-16 00:45 | 13 31 58.97 | +77 23 36.0 |
| 2013-Feb-16 01:00 | 13 39 14.50 | +78 13 20.1 |
| 2013-Feb-16 01:15 | 13 46 44.40 | +78 58 44.0 |
| 2013-Feb-16 01:30 | 13 54 29.08 | +79 40 14.7 |
| 2013-Feb-16 01:45 | 14 02 28.87 | +80 18 15.2 |
| 2013-Feb-16 02:00 | 14 10 44.05 | +80 53 05.6 |
| 2013-Feb-16 02:15 | 14 19 14.78 | +81 25 03.1 |
| 2013-Feb-16 02:30 | 14 28 01.12 | +81 54 22.6 |
| 2013-Feb-16 02:45 | 14 37 02.99 | +82 21 17.4 |
| 2013-Feb-16 03:00 | 14 46 20.11 | +82 45 59.0 |

Even if our skies are clear, this won't be easy to catch as it will still be moving fast against our sky. For example, between 23:00 and 23:15 (6:00pm and 6:15pm), the asteroid will have moved about 1d, 46m, 34s. The motion is down to only 1d, 11m, 6s between 00:00 and 00:15.

The moon will be up, about 30% illuminated. At 7pm, it will be about 52 degrees high in the South-West (230 degrees). DA14 will be about 30 degrees high in the North (12 degrees). Hopefully this won't present too much trouble.

If the skies are clear I hope try observing this asteroid. Please think about joining me (location to be announced).

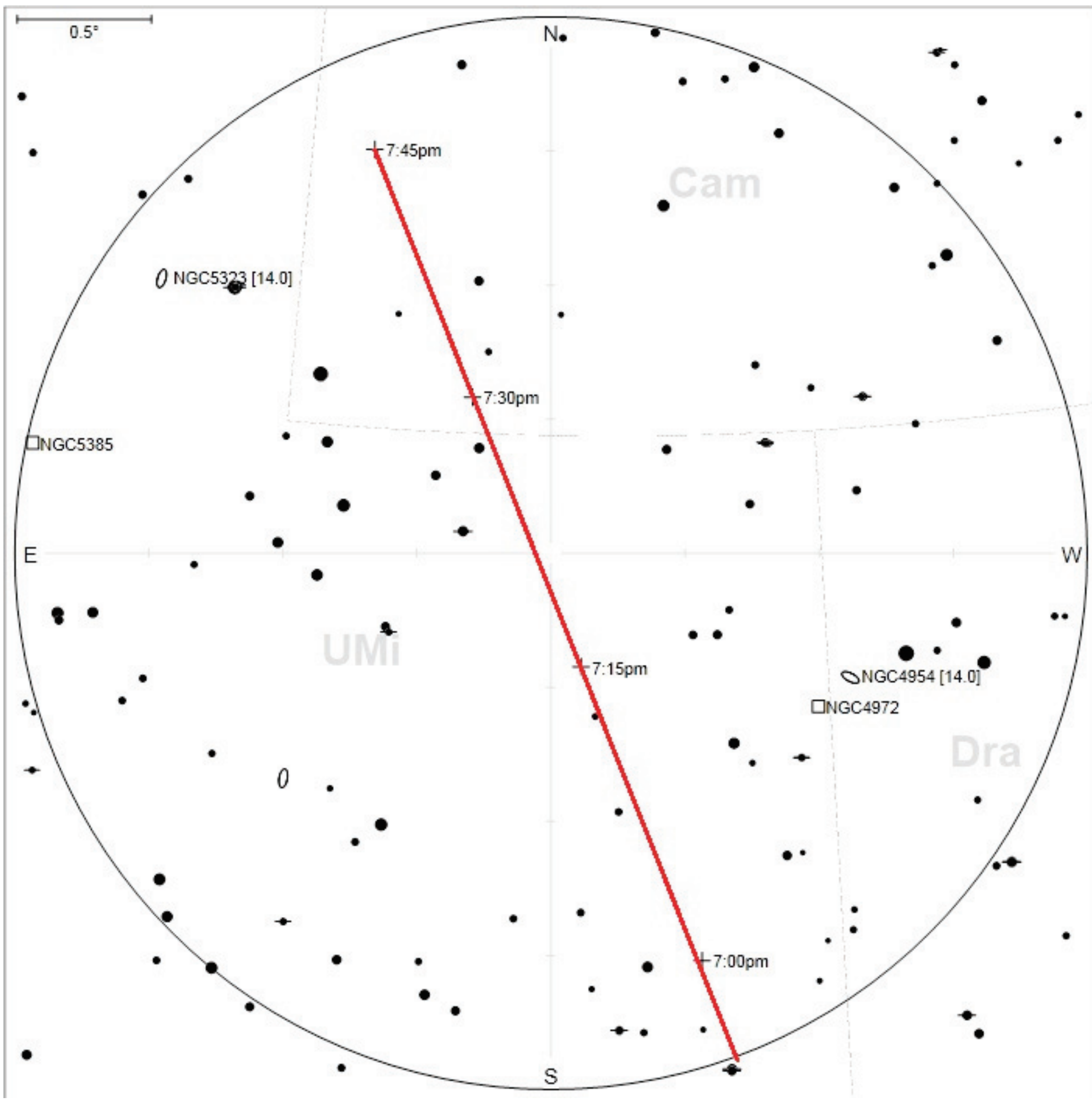



*Illustration 1: 4-degree wide field tracking 2012 DA14 at 7pm EST from Ann Arbor, MI*

# Lowbrow Calendar

**Saturday, February 9, 2013.** (5:00-9:00 PM) Yankee Air Museum, Willow Run, MI NASA hardware exhibit with Astronaut Jack Lousma. Bring your scope, we'll be showing people the night sky. May be cancelled if cloudy.

**Friday, February 15, 2013.** (7:30PM). Monthly Club Meeting.

# Making and Testing a Long Focus Mirror

by
Tom Ryan

Long focus mirrors are not that common nowadays. In the early days of telescope making, refractors were made with extremely long focal lengths in order to minimize the color error in the images. When color-free reflecting telescopes were invented by Isaac Newton, they initially tended have shorter focal lengths, but these grew longer over time. The reasons for this growth were a lack of optical tests for fast paraboloids and the difficulty in making accurately flat mirrors for large diagonals. Hershel, in fact, abandoned the idea of using a diagonal mirror in his large reflector, and simply tilted the mirror until the focus reached the side of the tube, where it could be directly examined by an eyepiece.

Simply tilting a mirror so that it can be used off-axis has several consequences. First, there is no extra diffraction added to the image by a diagonal mirror or from the diagonal mirror's support vanes, and this is very good for high definition observing. The second effect is the appearance of massive amounts of coma and astigmatism, and this is not so good for high definition imaging. However, if the focal length of the mirror can be made to be very long, then the blur diameters from coma and astigmatism shrink to below the Airy disk diameter and consequently cannot be seen. The focal length at which this happens grows faster than the mirror's diameter, so good-performing Hershelian telescopes tend to be small in diameter and long in focal length. This combination is also the realm in which a mirror's parabolic surface is so close to a sphere that it can be left spherical with no effect on the image, which is an advantage when you don't have a good optical test for measuring paraboloids.

Most observers today prefer to go in the other direction; that is, to larger diameter mirrors and to shorter focal lengths. They like to observe fainter fuzzies and have both feet on the ground while doing so, and who can blame them? In all the years that Astrofest ran, only one Hershelian telescope was ever set up and shown, and since it was about 8” in diameter and about 25 feet long, it was generally ridiculed as something that you'd never wish either to use or to own. Indeed, after Hershel built his own telescope and published his observations, astronomers were careful to never build anything like it again.

And so, long focus Hershelian telescopes are not that popular today. On the other hand, remember the part about the lack of additional diffraction? It turns out that this feature can be very useful, if you need to examine and control the finer details in an image.

Researchers who are trying to build devices that compensate for atmospheric turbulence need detailed information about the slope of the rays which form the image of a point source, like a star or a very high energy laser beam. With information about how the rays are being bent by the air, a deformable mirror inside the telescope can be reverse-deformed to correct for turbulence.

It is helpful to the calculations to be able to analyze small parts of the image using pixelated sensors. The light from the object should be spread out over a large area on the detector, so that small errors in the image can easily be seen and can be corrected. Since turbulence tends to shift light all around the focal plane, reconstructing the image, that is, putting the parts of the image back where they should be, is easier if the mathematics don't have to correct for additional diffraction. Thus, a large-scale turbulence analyzer needs to have a high magnification (a long focal length) and minimal diffraction. This is the recipe for a Hershelian telescope.

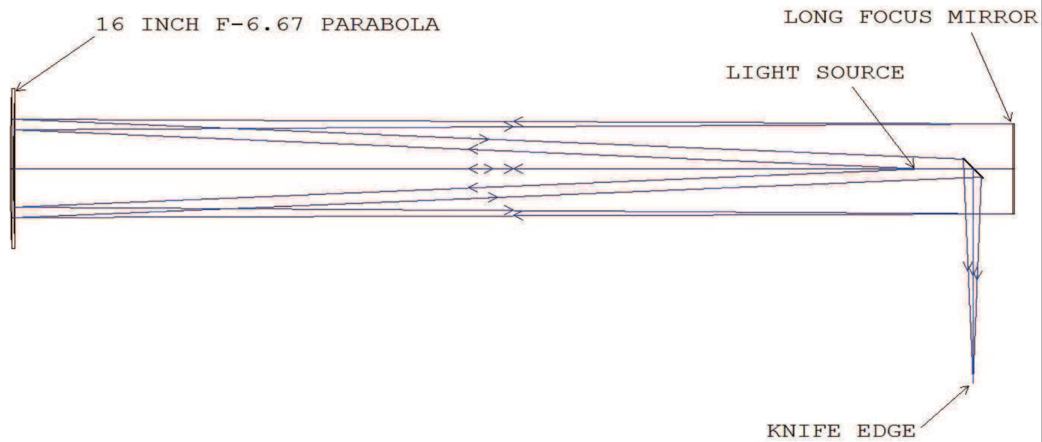
An atmospheric research lab recently asked me to make a long focus mirror, and this is how I did it.

The mirror in question was required to be a little over 9” in diameter, and to have a focal length of 50 meters. That works out to a focal ratio of approximately f/200. The central depth of the curve of this mirror would be 0.002,6”, or thinner than a sheet of paper. The mirror would very nearly be an optical flat, but could not be tested like an optical flat, because its curvature would be too great for fringe testing against another flat. Thus, the first thing to do was to devise a method of testing the mirror.

When Lowbrow Brian Close decided to make a Tri-Shiefspiegler, one of his telescope's three mirrors had a focal length of almost 17 meters. That meant we needed a straight hallway that had steady air over a span of 109 feet. Fortunately, Brian lived in an apartment building that had just such a hallway, although testing had to be done late at night and we had to use a telescope just to see the mirror we were testing. The present mirror would need a space three times longer. That, and testing only at night, was completely impractical.

Instead, I devised a test using a folded light path and a large parabolic mirror. The arrangement appears in figure 1.

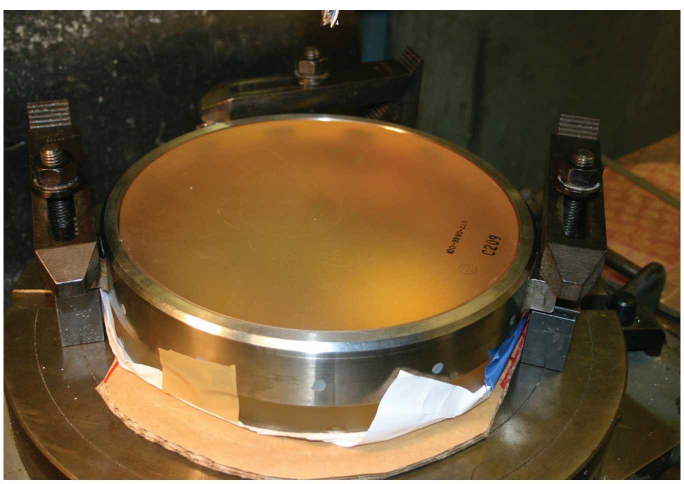
Figure 1

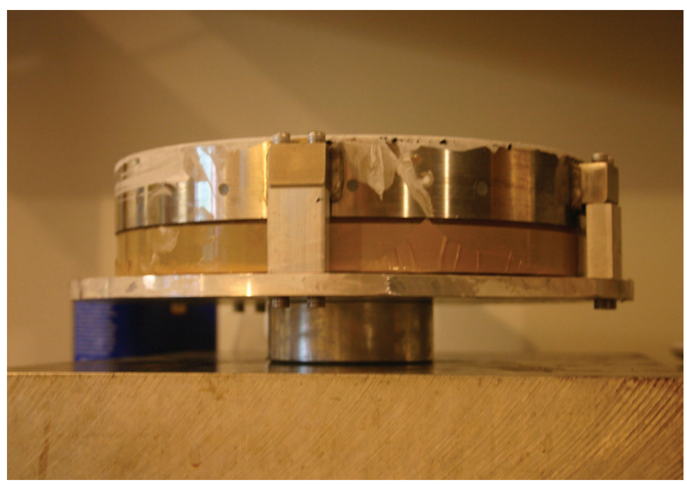



The light starts from the light source and travels to the left, bounces off the 16" mirror to travel to the long focus mirror, which reflects the light back to the 16" mirror again, and after reflecting once again, is focused down to the knife edge. The optical design program Zemax optimized the spacings so that the test's residual errors are less than 1/500 wave. Obviously, the test's accuracy is actually limited by the surface accuracies of the 16" mirror and the diagonal mirror, but both were better than 1/10 wave. Best of all, the mirror separation was specified to be 100 inches, so everything fit onto a 10-foot long optical bench.

With the test method determined, the next step was to choose a mirror blank. There are many types of glass which will make good optical flats. They include fused quartz, Pyrex, Zerodur, and even plate glass. These materials have prices that are inversely proportional to their thermal coefficients of expansion. People have made good flats out of all of these materials, but a mirror maker who uses a glass that expands from the frictional heat of polishing is going to spend a lot of time waiting for the mirror to cool down before he can make an accurate test of the surface. By "a long time", I mean five minutes of polishing followed by 8 hours of waiting. The decision as to which glass to use has a lot to do with the cost of the optician's time, and since I was charging on the AFSOP (sometimes known as A Fairly large Share Of the Plunder) schedule, I chose a Zerodur blank to minimize the time I'd have to wait between polishing and testing sessions. Believe it or not, even at Zerodur's price of $12-$15/cubic inch, using Zerodur reduced the buyer's overall costs because it eliminated hours and hours of unproductive waiting between polishing sessions and shortened the overall delivery time.

The 2.5" thick Zerodur blank arrived with faces rough ground and set in a ring of stainless steel, supported around the edge by pads of silicone between the blank and the ring. This is the best way to support a mirror when its axis is horizontal, because the silicone pads on the underside push the mirror up, and the the silicone pads around the top pull the mirror up. FEA analysis indicates that this method supports the mirror about 95% as well as a theoretically perfect (and realistically nonexistent) method. I'm also in favor of figuring a mirror in its support cell, even though that requires some extra work.



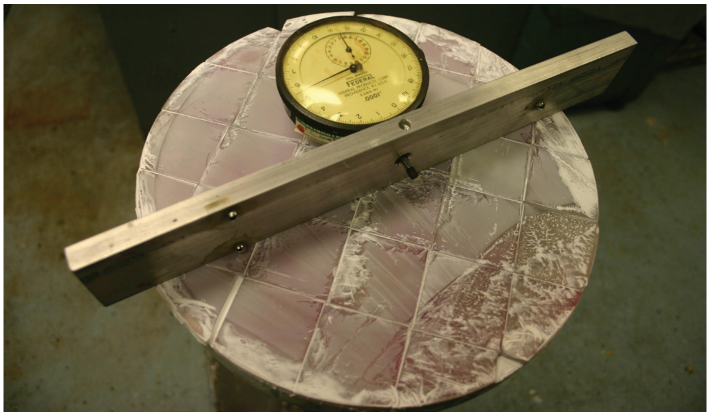
All photos by the author

*Mirror blank with Support Ring, before and after fitting the polishing pin drive plate.*

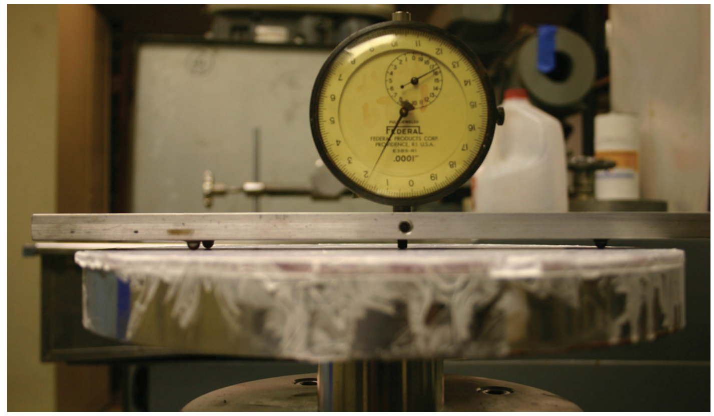
A grinding tool was made by cementing beveled window glass squares to an aluminum blank. This tool was pre-ground against a grinding flat to remove any irregularities, and then the curve in the long focus mirror was generated by hand using 30 micron alumina abrasive. The curve depth was checked using a depth gauge which read in increments of 0.0001" and was frequently zeroed against an optical flat.

Note that the three ball bearings on the underside of the depth gauge are glued onto a rough aluminum bar with sticky wax. The three points define a plane, and if the dial indicator is zeroed against a true flat, the accuracy of this simple gauge is quite high.

Grinding the curve to depth took about 15 minutes. Fine grinding with 9 micron took another 20 minutes.

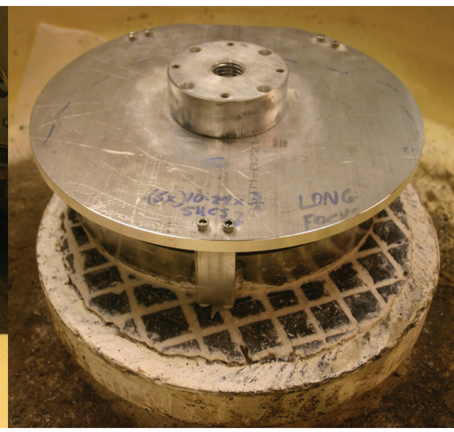


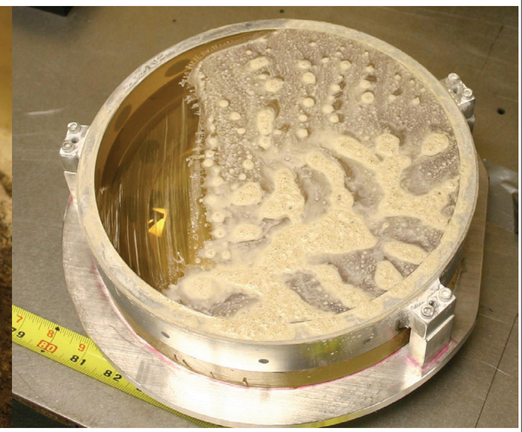
*Glass squares glued to aluminium disc*




*Depth measuring the rough curve at 0.0019*

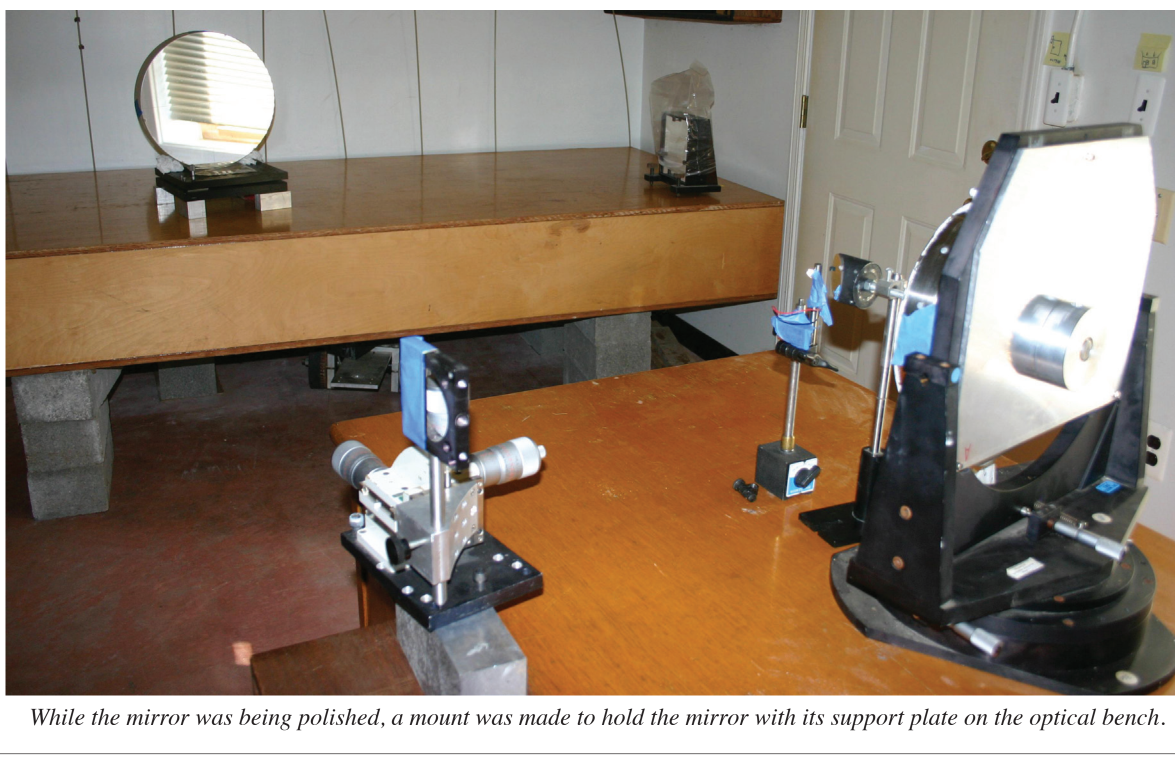
The next step was to make a pitch lap and polish the surface. The lap was cast and cut on a circular aluminum blank whose back was machined to mount onto a grinding spindle. The lap's diameter was 6/5ths the mirror's diameter. Zerodur is an extremely hard glass, and polishing it out with zirconia polishing compound (cerium oxide is not hard enough) took two and a half days.



*Cutting facets in the lap.*

*Mirror being polished out for the first time*



*While the mirror was being polished, a mount was made to hold the mirror with its support plate on the optical bench.*

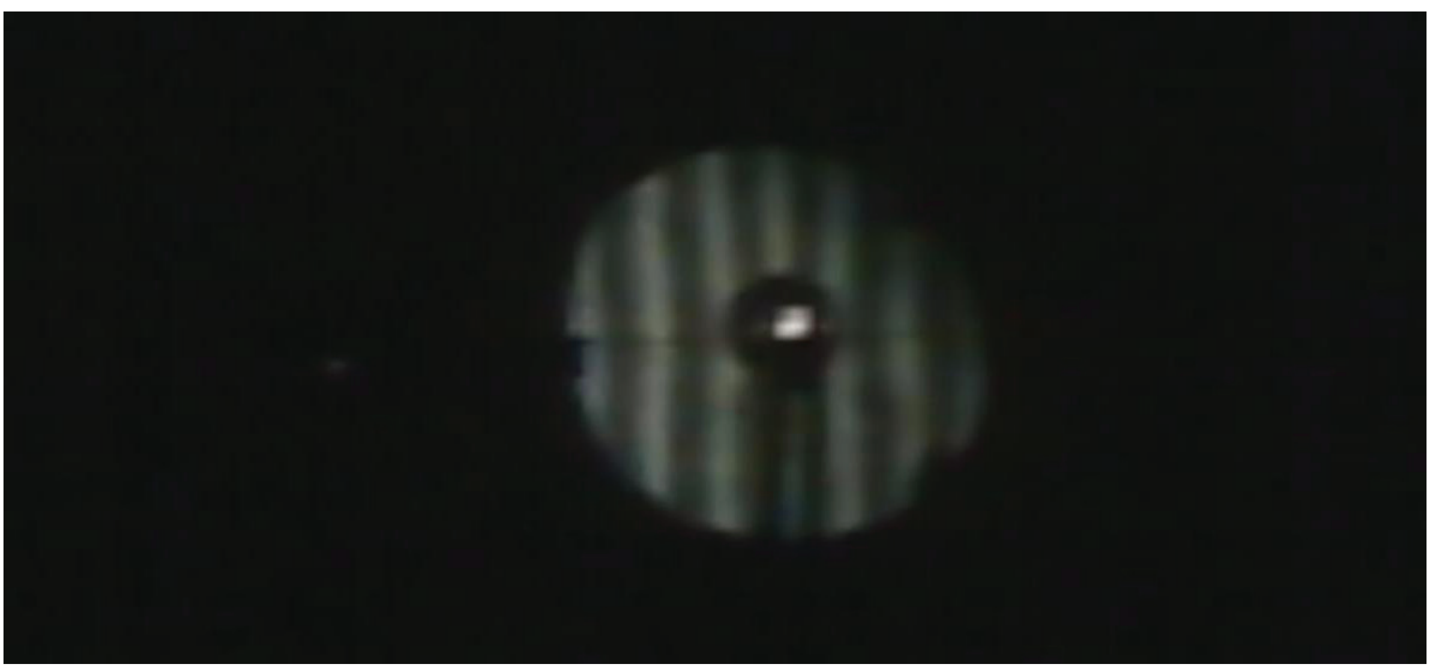
Initial testing showed that the mirror had a relatively flat center, but the surface sloped down about eight waves to the edge. Correcting eight waves of error in Zerodur is forever in polishing, so the mirror had to go back to fine grinding. It was supposed that the edge polished down so far because the lap was too large, so the polishing lap's outer diameter was reduced.

*Ronchi test of a mirror with a severely turned down outer zone*

Faced with another two and a half days of polishing and not liking the prospect, it was decided to try using a finer grinding compound prior to polishing in order to shorten the polishing time. This can be extremely dangerous, because the mirror can weld itself to the tool in an instant without warning. A call to Universal Photonics techincal support resulted in the purchase of a special grinding fluid, at $67/gallon, that was supposed to prevent sticking. It was tried and it worked, and fine grinding proceeded through 3 micron alumina. (By comparison, polishing compound particles are 1 micron.) The mirror subsequently polished out in four hours, even though the machine's speed was slowed by half to improve the edge. About $1 worth of fluid was used, and it saved over two days of polishing.

But when tested again, the edge was again turned down hard, so back it went to grinding.

This time, it was clear that the edge was plowing into the lap as a result of the high drive pin height. The mirror was 9 inches across and 2.5 inches thick, with an additional inch and a half of height from the backing plate and the drive pin socket. It was being pushed across the lap the way a semi-truck is blown sideways off the road. The only reasonable solution was to align the driving force with the level surface of the mirror. This was approximated by making a sub-diameter lap with the drive pin socket recessed almost to the lap surface itself, and polishing proceeded with the mirror face-up. When the mirror was polished out a third time, using a stroke recommended by the late Karl Mueller but not by the machine manufacturer, it tested out as a smooth sphere all the way to the edge.



Actually, the mirror was not perfectly spherical, as you can see from the lines on the last test image. However, because the customer will effectively divide the mirror into 30mm squares using sub-aperture adaptive correctors and because the mirror only has to be above Strehl .99 over each of these sub-apertures, it is believed that it will perform adequately even with these small errors, because the mirror's errors are both very small and very smooth.

Just for fun, the mirror was taken outside to the side yard, and an image of the sun was formed at its prime focus on a highway sign, 58 meters away across the street. (All that polishing flattened the edge and lengthened the focus by 8 meters, but the customer was actually happy about that.)

*A passer-by, whose thoughts inexplicably turn to ants and magnifying glasses*



Gratifyingly enough, the image of the sun was generally circular, so the mirror was sent to Spectrum Coatings for aluminizing, and from there on to the customer, who will use it to find better ways to compensate for atmospheric turbulence. And that should benefit all of us who live under this ocean of air.

Mark Deprest's

# *Bright Comets for 2013*

This is a compilation of the Bright Comets for 2013. It is based on Seiichi Yoshida's Comet page. It is for comets visible in the northern hemisphere. For purposes of making this list pertinent for persons with scopes of 102mm and larger I only included comets brighter than 12th magnitude.

The Column headings should be self-explaining, but for the great un-washed, here is a brief explanation of each.

***Month*** – if you need an explanation of this, stop reading this right now! (Because you won't understand anything else)

***Comet*** – This is the full, official name of the comet … please use this in my presence as these include the names of the discoverers and they deserve our respect and recognition!

***Mag. (m1)*** – This is the overall magnitude of the comet or intrinsic brightness. These are ESTIMATES based on current "Light Curves", please use as reference only!

***Alt.*** – This is the projected highest point above the horizon for the listed time.

***Time*** – This is the best time period to see the comet. Early Evening = from Dusk to 23:00; Midnight = 23:00 to 02:00; Morning = 02:00 to Dawn

As you can see there are possibly some very bright comets coming our way. However, keep in mind the comets are very unpredictable when it comes to how bright they will appear in our night skies. Think in terms of a galaxy's magnitude; M-31 is 3.4 magnitude and from Peach Mt. that's about the limit on most nights for un-aided eyes and extended objects.

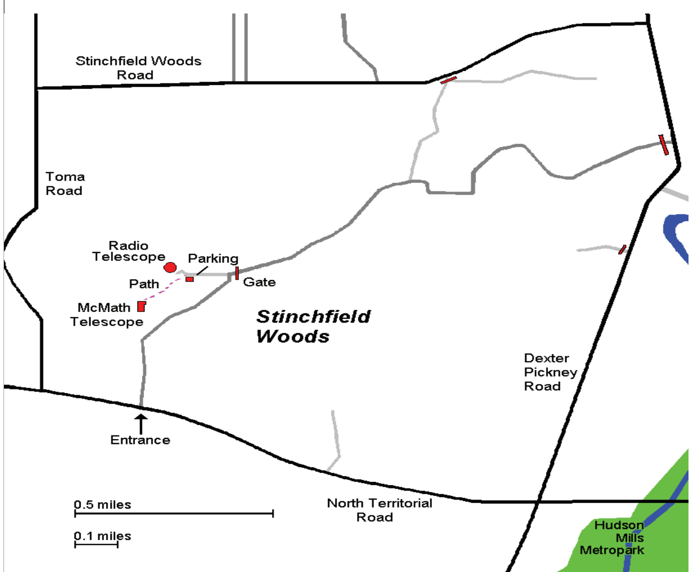
| Month | Comet | Mag. (m1) | Alt. | Time |
|---|---|---|---|---|
| January | C/2012 K5 (Linear) | 8th | 75d | Early Evening |
| January | C/2012 F6 (Lemmon) | 7th | 19d | Morning |
| January | 273P/2012 V4 (Pons-Gambart) | 8th | 23d | Morning |
| January | C/2012 T5 (Bressi) | 11th | 36d | Early Evening |
| January | 262P/2012 K7 (McNaught-Russell) | 11th | 46d | Early Evening |
| February | C/2012 T5 (Bressi) | 10th | 5d | Early Evening |
| February | 273P/2012 V4 (Pons-Gambart) | 9th | 57d | Morning |
| March | C/2011 L4 (PanSTARRS) | 3rd | 5d | Early Evening |
| March | 273P/2012 V4 (Pons-Gambart) | 10th | 52d | Midnight |
| March | C/2012 T5 (Bressi) | 9th | 28d | Morning |
| April | C/2011 L4 (PanSTARRS) | 5th | 30d | Morning |
| May | C/2011 L4 (PanSTARRS) | 7th | 40d | Midnight |
| May | C/2012 F6 (Lemmon) | 5th | 32d | Morning |
| June | C/2011 L4 (PanSTARRS) | 8th | 56d | Early Evening |
| June | C/2012 F6 (Lemmon) | 8th | 58d | Morning |
| July | C/2011 L4 (PanSTARRS) | 9th | 59d | Early Evening |

| Month | Comet | Mag. (m1) | Alt. | Time |
|---|---|---|---|---|
| July | C/2012 F6 (Lemmon) | 10th | 56d | Midnight |
| August | C/2011 L4 (PanSTARRS) | 10th | 57d | Early Evening |
| August | C/2012 S1 (ISON) | 11th | 11d | Morning |
| September | C/2011 L4 (PanSTARRS) | 11th | 48 | Early Evening |
| September | C/2012 S1 (ISON) | 9th | 28d | Morning |
| September | 2P/Encke | 10th | 77d | Morning |
| October | 154P/Brewington | 11th | 56d | Early Evening |
| October | C/2012 S1 (ISON) | 6th | 35d | Morning |
| October | 2P/Encke | 7th | 69d | Morning |
| November | 154P/Brewington | 10th | 64d | Early Evening |
| November | P/1998 U3 (Jager) | 11th | 63d | Midnight |
| November | C/2012 S1 (ISON) | (-)3rd | 32d | Morning |
| November | 2P/Encke | 7th | 16d | Morning |
| December | 154P/Brewington | 10th | 67d | Early Evening |
| December | P/1998 U3 (Jager) | 10th | 86d | Midnight |
| December | C/2012 S1 (ISON) | (-)1st | 42d | Morning |

## 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 $62.95/2 years

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.

## Telephone Numbers

| | | |
|---|---|---|
| President: | Charlie Nielsen | (734) 747-6585 |
| Vice Presidents: | Sirini Sundararajan | |
| | Jason Maguran | |
| | Jack Brisbin | |
| | Belinda Lee | (313)600-9210 |
| Treasurer: | Doug Scobel | (734)277-7908 |
| Observatory Director: | Mike Radwick | |
| Newsletter Editor: | Jim Forrester | (734) 663-1638 |
| Key-holders: | | |
| | Fred Schebor | (734) 426-2363 |
| | Charlie Nielsen | (734) 747-6585 |
| Webmaster | Dave Snyder | (734) 747-6537 |

## Lowbrow's Home Page

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

## Email at:

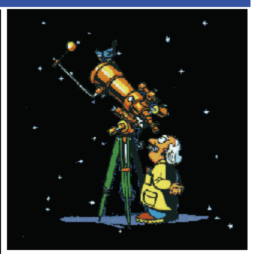
Lowbrow-members@umich.edu

**University Lowbrow Astronomers**

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

lowbrowdoug@gmail.com

Reflections & Refractions



**Website**
**www.umich.edu/~lowbrows/**

*Tom Ryan and his f/200 mirror*

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