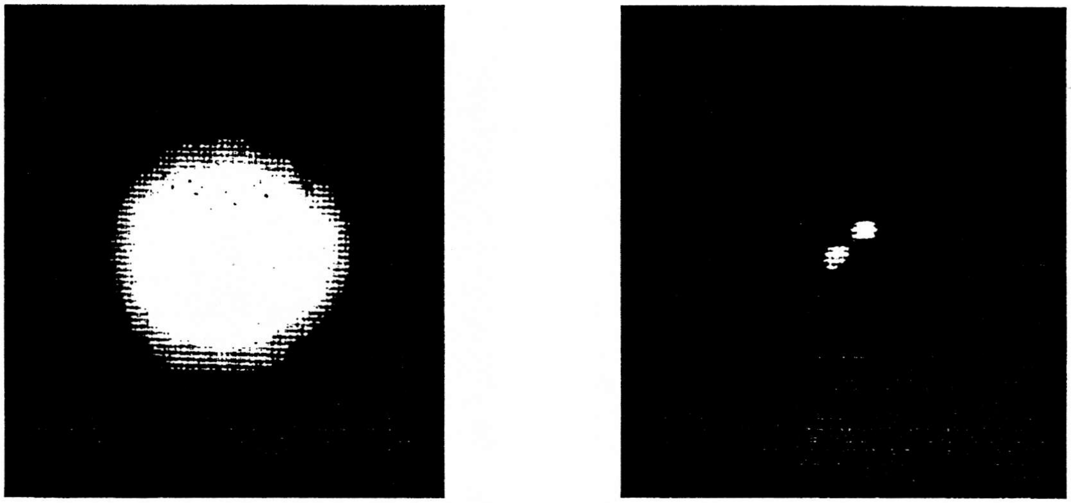
REFLECTIONS

December 1992

Kurt Hillig
Editor



The double star ADS 11640A, having an angular separation of 1/7 arc seconds, is resolved by the use of speckle interferometry.

University Lowbrow Astronomers

The University Lowbrow Astronomers is a club of astronomy enthusiasts which meets on the third Friday of each month in the University of Michigan's Detroit Observatory at the corner of Observatory and Ann Streets in Ann Arbor. Meetings begin at 7:30 PM and are open to the public. For further information, call Stuart Cohen at 665-0131.

This Month:

December 18 - Meeting at the **Detroit Observatory** in **Ann Arbor**. Our own Fred Schebor will host the traditional "artsy meaningless" slide show – all members and guests are invited to bring their favorite slides and pictures to amaze and astound the crowd. Also on the agenda: Contrary to popular misconception, the date and place of the next computer subgroup meeting have NOT been determined – come or be appointed host in absentia!

December 19 - Public Open House at the **Peach Mountain Observatory** (on North Territorial Road, 1.1 miles west of Dexter-Pinkney Road). This is the last one this year – let's hope it's not too cloudy (of course then we'd have to miss the big party at the boss's house....).

Next Month:

January ? - Computer Subgroup Meeting. Come to the December club meeting to find out where and when, or call Roger Tanner at 981-0134.

January 15 - Meeting at the **Detroit Observatory** in **Ann Arbor**. Our speaker will be Tom Ryan, on "Back to the `ame Old Grind: How to Make a Mirror".

January 16 - Public Open House at the **Peach Mountain Observatory** Who cares if it's cold and cloudy? the mosquitos are gone! What more reason do you need?

January 23 - Public Open House at **Peach Mountain**

30 Years Ago

Thirty years ago, Dec. 14, 1962, the first successful interplanetary traveler reached Venus after a 108-day journey from Earth. Named Mariner 2, it was a 200-kilogram (450-pound) machine carrying six scientific instruments, a two-way radio, a solar power system and assorted electronic and mechanical devices. Its crew, numbering roughly 75, stayed behind at NASA's Jet Propulsion Laboratory.

The Mariner planetary spacecraft series began in 1960 as a group of mission studies at JPL. The first launch, Mariner 1, was aborted when its launch vehicle strayed from the safe flight corridor and was destroyed by the Range Safety Officer. During Mariner 2's three-and-a-half-month odyssey of some 290 million kilometers, it transmitted coded signals continuously to the Earth, mixing scientific measurements of interplanetary dust, magnetism, cosmic rays and solar plasma with engineering data on the health and performance of the spacecraft.

On Dec. 14, 1962, Mariner's infrared and microwave radiometers scanned back and forth across the planet, capturing data that would prove Venus's surface to be fire-hot -- about 425 degrees Celsius or 800 Fahrenheit -- warmed in part by a runaway greenhouse effect in the thick carbon dioxide atmosphere. Aboutthree weeks after its historic Venus flyby, Mariner 2 went off the air. Its signal was last received on Jan. 3, 1963.

Refractors vs. Reflectors: A Brief Optical Analysis

by Tom Ryan

Have you ever critically compared the images seen in both refractors and reflectors? I have, and for years one thing has puzzled me. A good, well made refractor of 6"-8" aperture just blows the doors off any reflector of equal size. In refractors, the stars are points, with Airy disks and no diffraction spikes, and the sky is a deep, dark black (see Figure 1A); planetary views are crisp and almost three-dimensional. On the other hand, reflectors often transform star images into small sparkler displays projected onto a distinctly blue background (see Figure 1B). Why, why?

Part of the reason for the brighter background in reflectors is the light scattered by diffraction from the secondary mirror and its support vanes. The amount of light scattered by diffraction increases linearly with every inch of edge (two edges for every vane – the vane's thickness matters not at all). Diffraction scatters light into lines which parallel the vanes and intersect the stars. An unobstructed reflector, such as a Herschelian or a Schiefspiegler would get rid of those lines. But where do the rest of those sparkles come from? And why is the sky so much brighter in reflectors?

F-ratios can account for some of the background differences. Shorter f-ratios make extended objects (like the sky background) appear brighter. I know, that's why you bought an f/4.5 scope in the first place – to look at nebulae. But even at the same f-ratio, backgrounds are still brighter in reflectors than refractors.

Many people, including Roland Christian of Astro-Physics, think that the superior baffling in refractors is responsible for the darker–appearing skies. The baffles are what keep stray light, either coming in from outside (like the moon 20° away from whatn you're observing) or scattered inside the telescope (perhaps from dust on the optics), from reaching the eyepiece My own 8" f/4.5 reflector is not baffled, and the sky background looks like Detroit Edison's version of heaven. I can tell when the scope is pointed near a bright star even when the star is not in the field, just by the light it scatters into the eyepiece. For a comparison of baffling methods for a refractor and a Newtonian reflector, refer to figures 2 and 3.

However, there's another significant contributor to image degradation in reflectors – surface roughness. Fast polishing of an optical surface by a quick polishing agent like cerium oxide can leave the surface lumpy, sort of like a microscopic orange peel. These bumps are very hard to see when testing a short F-ratio surface, especially if the source and slit of the Foucault tester are more than 1/8" apart. It is also very difficult to get the zones at varying radii of a paraboloid perfect when testing with a non-null set up like this. Nevertheless, these zonal errors and bumps contribute to image degradation.

I didn't realize how much they contributed until I learned about the Strehl ratio in ATMJ #1. It is a measure of how much light is lost to the central Airy disk peak (to reappear elsewhere), compared to a perfect image. It is only valid for small amounts of aberration, but that's what we're talking about here. The Strehl ratio is given by the formula:

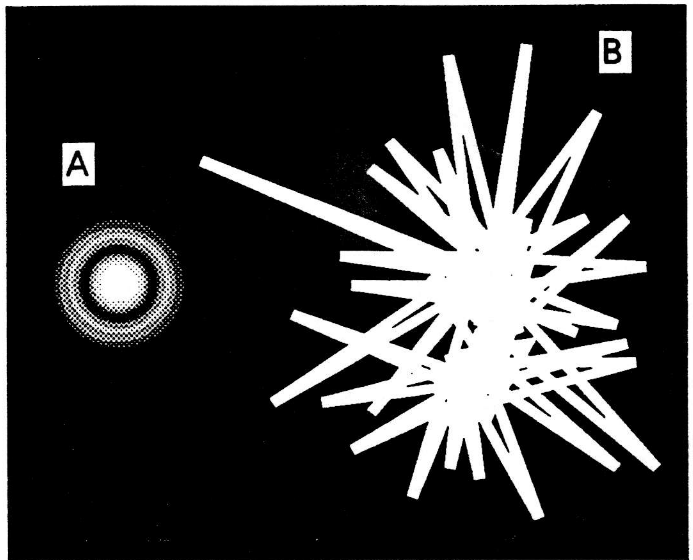


Figure 1. A sketch of typical star images as produced by (A) a refractor, and (B) a reflector.

$$SR = 1 - (2\pi\sigma/\lambda)^2$$

where $\pi = 3.14159...$, σ is the root-mean-square error in the wavefront, and λ is the wavelength of the light you're using (with σ in units of wavelength, this ratio is just $[1 - 4\pi^2\sigma^2]$). For a perfect system the SR is 1; for a 1/8-wave RMS error the SR is 0.38, i.e. almost two thirds of the light is outside the Airy disk!

Now, manufacturing errors in the surfaces of optics contribute differing amounts of wavefront errors to the focussing of the light, depending upon the index of refraction change at the surface. A polishing error that is one wavelength high on the surface of a glass lens (index of refraction N = 1.517; for air N = 1.000) changes the wavefront by an amount equal to $[\sigma \times (N1 - N2)] = [1 \times (1.517 - 1.000)] \approx 1/2$ wave.

On the other hand, at a reflecting surface, a one wave surface error becomes $[1 \times (1 - (-1))] = 2$ waves, or four times worse. Since the RMS wavefront error is squared in the formula for the Strehl ratio, figuring errors on a reflector degrade the star images by a factor 16 times greater than the same errors on a refractor. The optical designer James G. Baker has said that reflecting surfaces scatter 15 times more light than refracting surfaces, and now we see why!

The overall effect can be illustrated by two examples. Roland Christen made a Houghten-Cassegrain that just didn't perform like his refractors. When asked why he thought the images weren't good, when ray tracing suggested that they should be nearly perfect, he replied "too many surfaces." This scope had four refracting surfaces, just as in his refractors, but added two additional reflecting surfaces.

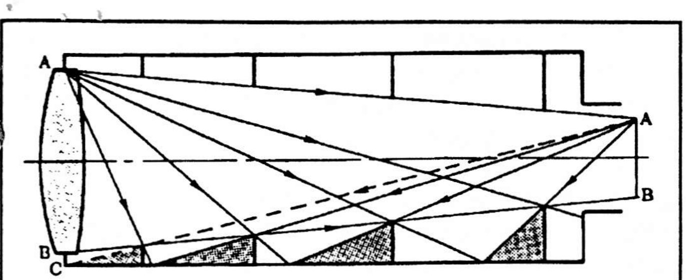


Figure 2. Baffling in a refracting telescope.

Al Woods, maker of the best imaging reflector I have ever seen, talked about making the mirrors in his tri-schiefspiegler. All of the mirrors are very long focus spheres, and can easily be tested to smooth nulls, except for the primary. This required partial parabolization, according to his ray trace calculations. But partial parabolization is difficult to measure accurately using Foucault zonal testing, and he soon replaced his partially parabolized primary with a spherical one, saying the images were better.

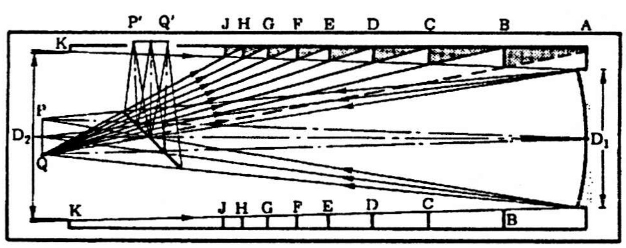


Figure 3. Baffling in a newtonian telescope

So which is better, a refractor or a reflector? If both are well made, well baffled and unobstructed, then neither one is better. But in the real world – where toast falls butter side down and we compromise on the jobs we have because, well, a compromise is better than nothing – for perfect images you choose a refractor or you spend a LOT of time making your mirrors perfect.

At the 1992 Astrofest, I was looking through the Astro-Physics refractors, as usual, and admiring the perfect images. Using one of the new 6" models, I examined the area around the double-double star in Lyra. The doubles themselves were clearly separated. Airy disks surrounded all the stars, the sky was as black as soot, and faint points of light rose out of the darkness, clear and sharp as pinpoints. I was sure that those points would be invisible in my 8" reflector. I memorized the star pattern, and then wandered over to an idle 17" reflector, mentally calculating how many years of saving would be required before one of those refractors was mine. I swung the 17 over to the double-double, and reexamined the star field. The sky was blue, the stars were sparklers, but I could drive a truck between the doubles, and the stars formerly on the edge of perception now blazed out brightly, surrounded by even fainter stars. What's more, I could afford the 17" now. So, in the real world....

Could the Moon be Always Full? A Brief Look at Lagrange Points

by Kurt Hillig

Someone on the net recently posted a question on whether it was possible to have the moon in an orbit such that it was always full – to be the basis for a proposed sci-fi story. There were a number of replies which mentioned the Lagrange points as stable orbital positions, but people seemed to be confused about just what a Lagrange point was. The discussion which follows is based in part on the reply posted by Jim Batka of Wright State University, Dayton OH.

The Lagrange points are five points in space – called L1 through L5, oddly enough – at which a small body can have a stable (or metastable) orbit around a two-body system such as the sun and earth. You can think of a Lagrange point as a point of gravitational neutrality – at each Lagrange point the forces acting on a body are exactly equal. Two of the Lagrange points are stable; an object which is pushed out of it will tend to drift back. However, the other three are "metastable", and if an object is nudged from one it will keep on going.

Could the moon actually sit in one of the Lagrange points? Well, the math is really only valid when there are only two large masses involved; on the one hand, the moon is too heavy for this, and on the other the perturbations from the other planets would mess things up. Still, let's ignore these problems for the time being and see where we get.

Where are the Lagrange points? The three metastable ones (L1, L2 and L3) all lie on the line connecting the earth and the sun; one lies on the far side of the sun, but the other two are both about 0.01 AU away (about four times the actual earth-moon distance) on either side of the earth. The two stable ones (maybe you can guess how the *L5 Society* got its name?) are also known as Trojan points – 60° ahead and behind earth in its orbit.

What determines whether they're stable or not? The reason some Lagrange points are stable and some are not is because of how the forces on them are acting. Imagine space as a flat plane, and think of each planet lying at the bottom of a well which slopes gradually near the edges and more steeply near the center (the classic "rubber-sheet" model of gravity). The greater the mass, the deeper the well. Now imagine the earth's small well superimposed upon the sun's much larger well. Near the earth, the attraction of the earth's well is stronger; farther away the attraction of the sun's is stronger. Somewhere in between the attraction is exactly balanced – the L1 point. Unfortunately, this point is like sitting on the top of a ridge between two valleys. It's stable as long as nothing disturbs it, but one small push in either direction and you go rolling off into one of the valleys. This is what metastable means – like balancing a feather on your nose, it's fine until you sneeze.

This static image only works well for the Lagrange point between the earth and sun. For the others, you have to take into account dynamic effects – mainly conservation of angular momentum – and these are a bit harder to visual-

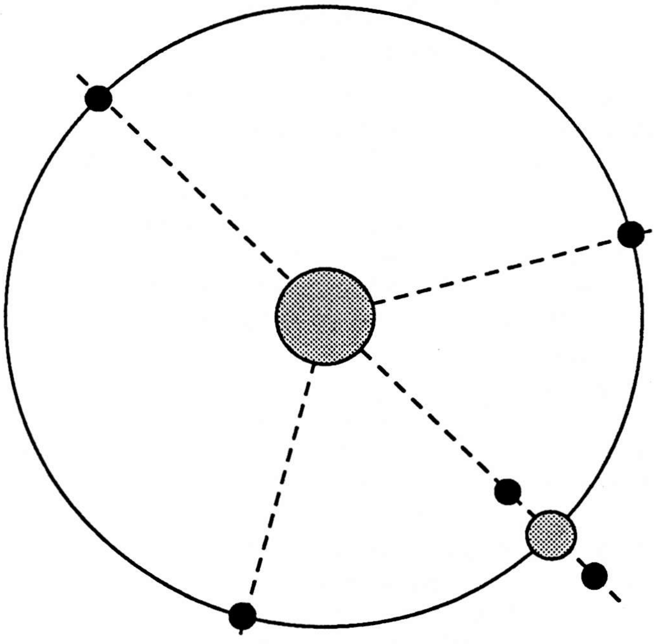


Figure 1. The five Lagrange points around a two-body system.

ize. For example the one beyond the earth is a bit farther from the sun, so an object there should tend to orbit more slowly than the earth; but since the earth is nearby, it feels a slightly stronger inward pull – as though the sun were a bit heavier – so its orbital velocity increases to keep it in lock-step with the Earth. (This would satisfy the author's condition of a permanently full moon – but it would also be in permanent eclipse!) Again this is metastable; if it got pushed forward, the increase in angular momentum would move it to a higher orbit, which would lessen the attraction from the earth, making it move still farther out, etc.

Although these two positions are not stable, they are not terribly unstable either; nor is the third, on the far side of the sun, although the effect of the presence of the earth on this one is pretty small. Therefore if you did find a way to put the moon in any of these, while it would not stay forever, it also wouldn't go screaming off into deep space two weeks later.

The two stable Lagrange points are on the ellipse described by earth's orbit, just 60 degrees (1/6 of an orbit) ahead and behind the earth; the earth, sun and L4 and L5 points form two equilateral triangles. Consider the one ahead of the earth; any force pushing the mass forward increases its momentum, causing it to move into a larger orbit. The larger orbit is a slower orbit, so the mass gets closer to the Earth. This increases the pull by the earth, which decreases its momentum. The decreased momentum causes the object to move into a lower orbit, which speeds it up, etc. The Trojan asteroids are concentrated in the L4 and L5 points of Jupiter's orbit, although perturbations from the other planets make them wander a bit.

As it turns out, there are a (very) few other stable many-body orbits as well. The L4 and L5 positions are a special case of the *Lagrange triple*. Any three bodies of any mass (where the total mass is *M*), will form stable orbits around their center of mass if they lie at the corners of an equilateral triangle (with a side of length *r*) which rotates at an angular velocity ω given by Kepler's law: $\omega^2 = M / r^3$. And, if you really like big engineering projects, you can form a Kemplerer rosette by putting six equal-mass planets in the same orbit around a star at the corners of a hexagon. Of course, first you have to find six equal-mass planets....

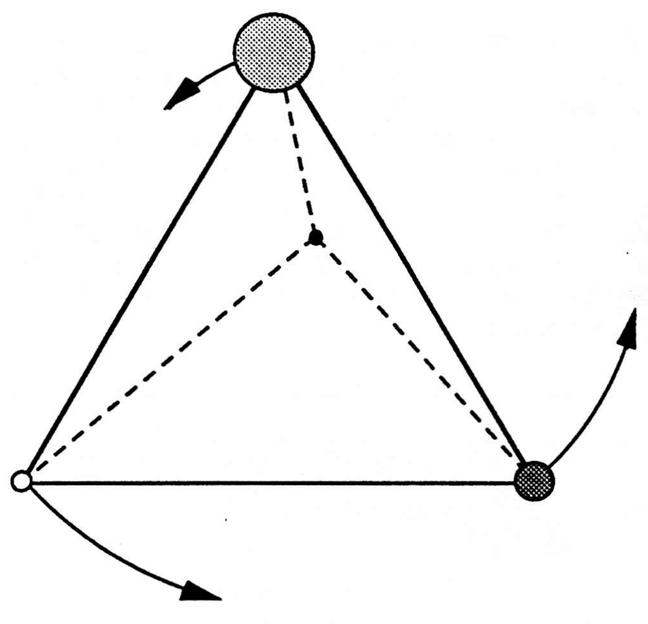


Figure 2. The three members of a Lagrange triple orbit around their common center of mass.

Computers in Astronomy Subgroup Meeting Report

by Roger Tanner

The December meeting discussion ranged over several topics; a new astronomy program called MEGASTAR, the astronomy information available on CompuServe, the QuickPix program for batch processing CCD images, and some programming challenges concocted by Stuart Cohen.

Astronomy Programming Challenges Stuart started the meeting by issuing a offer of $25 to anyone who can supply the source code for IBM PC or Mac programs which perform any one of the following:

1. Graphically display the 27 members of the Local Group in a 3-D coordinate system, viewable from any location within a cube 4 million light years on a side. The galaxies must be scaled relative to each other but must be enlarged enough to show some galactic planes, (extra points for a blue-red display for use with 3-D glasses).

2. Graphically show the earth poles, longitude–latitude

lines, RA–Dec lines, and galactic longitude–atitude lines superimposed on the track of the earth, sun and galactic center orbit paths. A selectable point on the earth must be able to be extended to infinity, with the corresponding terrestrial longitude–latitude, RA–DEC, and galactic longitude–latitude shown.

3. A realistic view of the Milky Way from any point, with steady rotation, and position of the solar system and 4 other objects of choice shown.

4. Demonstrate graphically the effect of a gravitational lens on objects of various size and colors.

5. Identify any object of magnitude 8 or brighter on a H–R diagram, when requested.

6. Graphically animate the process of a nova or supernova, in time or size as requested, showing a section through the star to demonstrate the internal processes.

Really interesting programs, everyone was excited about the ideas. We discussed how these programs would work. Sounds like a good programming challenge, we will continue the discussion at the next meeting.

MEGASTAR A flyer for the MEGASTAR star chart program prompted a short discussion. MEGASTAR, by ELB Software, was demonstrated at the Texas Star Party this year. The flyer listed several unique features, such as a database of 15 million stars derived from the Hubble Guide Star Catalog with many areas down to 15th magnitude; 80,000 nonstellar objects; and a utility to add objects r modify the existing data. Another interesting feature is that it plots nonstellar objects to scale with proper orientation. After entering information on your telescope and eyepieces you can click on an eyepiece and it will plot the circular eyepiece view with the correct field. The program costs $149 until March 31, 1993. On the down side, you need 54 megabytes of disk space to use it. The programmer has done an incredible compression job as the HGSC takes up 2 CD- ROM's of 600 MBytes each.

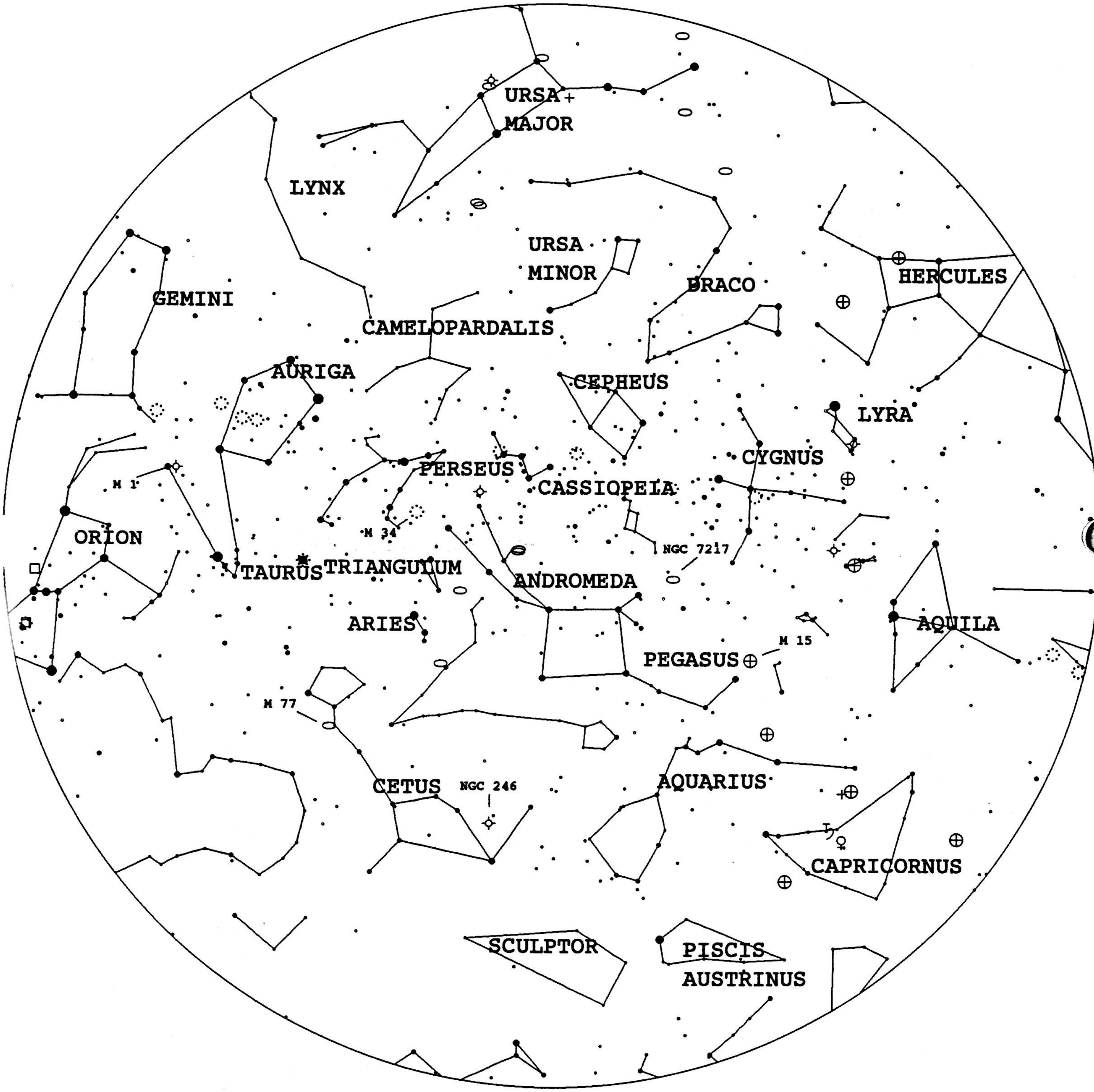
QuikPix The next topic was the demonstration of the batch processing program for CCD images, QuikPIX, which comes with Richard Berry's book "Choosing and Using a CCD Camera". The software gives a handy way to batch process a number of images taken during a night of imaging with the popular CCD cameras which use the TI 211 chip, (Lynxx PC, SBIG ST-4). The software comes with some sample images to demonstrate the features of the program. These images were used to demonstrate the value of averaging several dark frames together to reduce the noise in the dark frame. This gives the best estimation of the dark frame and will then not add noise to the image when it is subtracted from the raw data. This averaging also applies to the flat field frames which are used to compensate for the sensitivity differences between the pixels. The other demonstration was of the image processing algorithms which are used to provide a rough first pass processing for deep sky and planetary images. The algorithms are a combination of contrast enhancement, noise filtering, and for the planetary images, a little unsharp masking. This greatly enhanced the various images provided. The book makes a good point that the Lynxx PC may be the best CCD camera available for planetary imaging, and does a fair job with deep sky. The ST-6 is an excellent deep sky camera but not very good for planetary imaging. The ST-4 is not as good as either of these.

Astronomy on CompuServe We then took a tour of the CompuServe a computer information service. CompuServe is a massive computer system which serves several Special Interest Groups on every imaginable subject. We logged on to the system and navigated through the various areas in the Astronomy SIG. We reviewed several bulletins on current events on the Sky and Telescope area and downloaded the latest coordinates for comet Swift-Tuttle. We then browsed through the library section and downloaded some interesting files including a CCD image of the comet taken with a SBIG ST-6 CCD camera (see below) and several interesting astronomical programs. One was a Visual Basic galaxy display program (which would not run with my version of Visual Basic). Another was a Quick Basic program from Sky and Telescopes astronomical computing column which produces various arm shapes of spiral galaxies.

Another file was a description of a computerized setting circle/database device you can build which essentially gives you a Astromaster. The device was submitted to Telescope Making but didn't get printed before it ceased publishing. The designer (David Lane) has PCB boards and EPROM's for sale. The design has a 16 button keypad, a 2x20 column LCD display, uses HP encoders, a serial port, a real time clock. Most of the parts appear to be available from Jameco. The database has alignment stars, the Messier and NGC catalogs and planetary data. This device may be the best and fastest way to get accurate setting circles for the 24".

Next Meeting The next meeting was not scheduled, due to uncertainties in vacation plans etc. Come to the Club meeting on Dec. 18 to find out where it will be! Topics will be further discussion of the Programming Challenges Stuart has concocted, and the CompuServe astronomy forum. We may even log on to see what the latest news is. We also can talk about the possibility of using the David Lane version of the Astromaster for the 24".

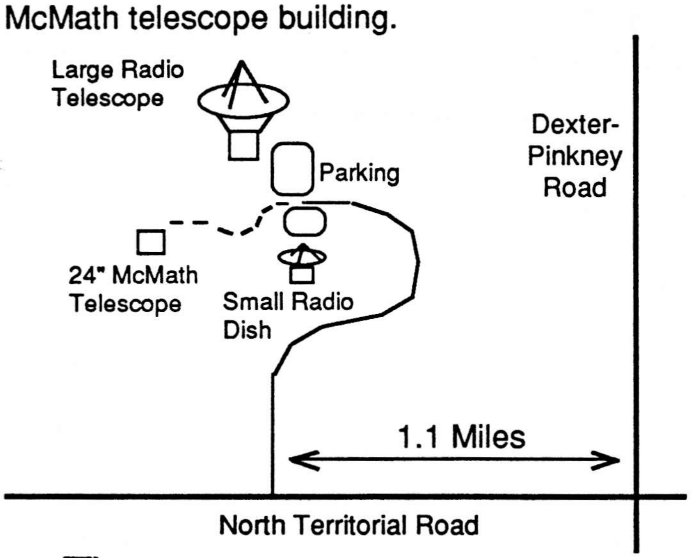
12/19/92 7:46pm EDT stars to 5th mag



☞ Places:

The Detroit Observatory is in Ann Arbor, at the corner of Observatory and Ann Streets, across from the old University of Michigan hospital and between the Alice Lloyd and Couzens dormitories. The Detroit Observatory is an historic building which houses a 19th century 12-inch refractor and a 6-inch transit telescope.

The Peach Mountain Observatory is the home of the University of Michigan's 20-meter radio telescope, and the McMath 24-inch telescope maintained and used by the Lowbrows. The observatory is located northwest of Dexter; the entrance is on North Territorial Road, 1.1 miles west of Dexter-Pinkney Road. A small maize and blue sign marks the gate. Follow the gravel road one mile to a parking area near the radio telescopes. Walk along the path southwest (between the two fenced-in areas) about 300 feet to reach the McMath telescope building.



☞ Times:

The monthly meetings are held on the third Friday of each month at 7:30 PM at the Detroit Observatory. During the summer months, and when weather permits, a club observing session at Peach Mountain will follow the meeting.

Public Open House / Star Parties are held on the Saturdays before and after each new moon at the Peach Mountain Observatory. Star Parties are cancelled if the sky is cloudy at sunset – call 426-2363 to check on the status. Many members bring their telescopes; visitors are welcome to do likewise. Peach Mountain is home to millions of hungry mosquitos – bring insect repellant, and wear warm clothes, as it gets cold at night!

☞ Dues:

Membership dues in the Lowbrow Astronomers are $20 per year for individuals or families, and $12 per year for students. This entitles you to use the 24" McMath telescope (after some training). Dues can be paid to the club treasurer, Ron Avers, at a meeting or by mail at this address:

9394 Anne
Pinckney, MI 48169-8912

☞ Magazines:

Members of the Lowbrow Astronomers can get a discount on these magazine subscriptions:

Sky and Telescope: $20/yr
Astronomy: $16/yr
Odyssey: $10/yr

For more information, contact the treasurer.

❒ Sky Map:

The sky map in this issue of *REFLECTIONS* was produced by Doug Nelle using *Deep Space 3D*.

✎ Newsletter Contributions:

Members (and non-members) are encouraged to write about any astronomy-related area in which they are interested. Please call the newsletter editor (Kurt Hillig, 663-8699) to discuss length, format, etc. Announcements and articles are due 14 days before each monthly meeting. Contributions should be mailed to Kurt Hillig, 1718 Longshore Dr., Ann Arbor, MI 48105.

☎ Telephone Numbers:

President:	Stuart Cohen	665-0131
Vice Pres:	Doug Nelle	996-8784
	Paul Etzler	426-2244
	Fred Schebor	426-2363
	Tom Ryan	662-4188
Treasurer:	Ron Avers	426-0375
Observatory:	D. C. Moons	254-9439
Newsletter:	Kurt Hillig	663-8699
Membership:	Steve Musko	426-4547

Peach Mountain Keyholder:

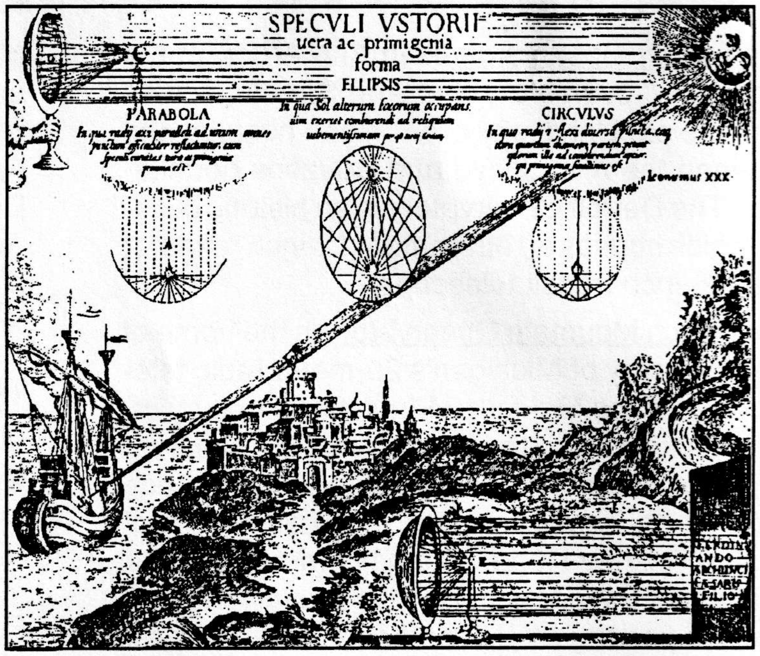
Fred Schebor 426-2363

Monthly Meeting:

Dr. Fred Schebor will host the Christmas Special Slide Show

Dec. 18, 1992 at 7:30 PM

At the
Detroit Observatory in
Ann Arbor



A seventeenth-century engraving illustrating the invention by Archimedes of a system of mirrors to focus the Sun's rays on a hostile ship, setting it afire.

University Lowbrow Astronomers
840 Starwick
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