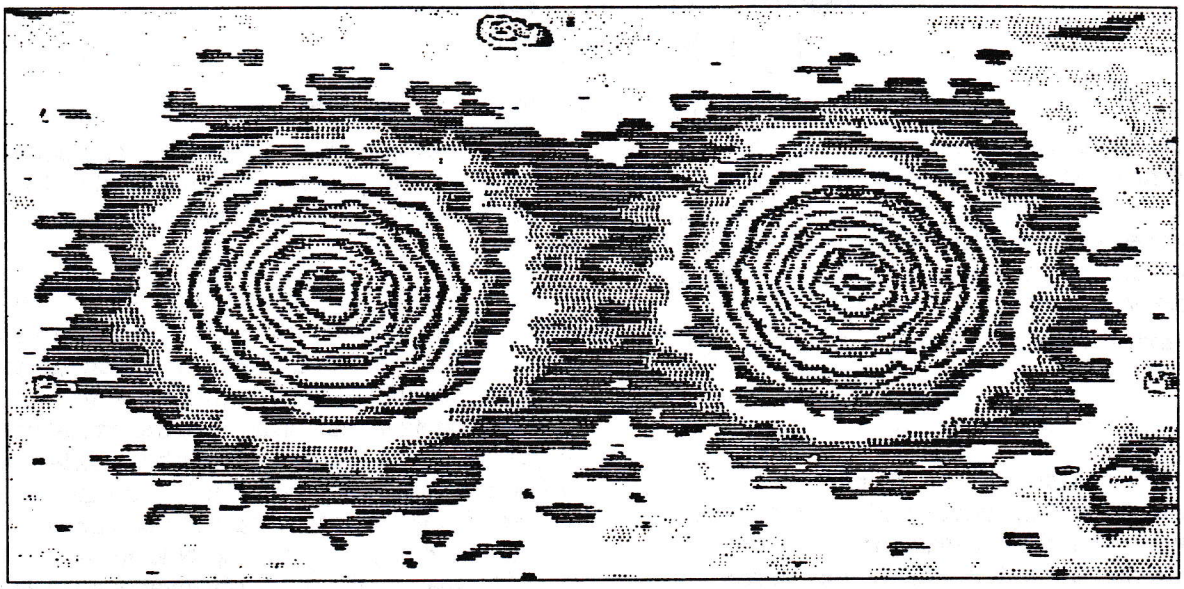
REFLECTIONS



REFLECTIONS

January 1993

A visible-light intensity map of the quasar 0957+561, split into two components by gravitational lensing from a closer galaxy too faint to be seen. CCD photo from the Canada-France-Hawaii 3.6 meter telescope on Mauna Kea.

Kurt Hillig
Editor

of the 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. Public star parties are also held twice monthly, at the Peach Mountain Observatory on North Territorial Road (1.1 miles west of Dexter-Pinkney Road; map on page 7) on the Saturdays before and after the new moon (cancelled if it's cloudy at sunset). For further information, call Stuart Cohen at 665-0131.

This Month:

January 15 - Meeting at the **Detroit Observatory** in **Ann Arbor**. Our own Tom Ryan will discuss and demonstrate the theory and practice of mirror grinding. Learn how to turn hours of tedium into a precision optical instrument! (But come prepared to get your hands dirty.)

January 16 - Public Open House at the **Peach Mountain Observatory**. It's been a pretty cloudy year so far, but Mars is just past opposition (only 94 million km away!) and won't be higher in the sky for several years. Wear long johns!

January 23 - Public Open House at the **Peach Mountain Observatory**. Even if we don't get clouded out on the 16th, come on back and see what you missed the first time. A new moon means dark skies....

Frustration!

An Editorial Comment

Once again, it's been too cloudy to see diddley-squat for weeks on end. The one night I did get up to Peach Mountain was clear, but too turbulent for good viewing. At least the computer group is dealing these problems (see inside).... More frustrating is trying to edit a newsletter for which the members don't want to write! C'mon, folks! Most of you have been in the star-gazing game a lot longer than I have. Every one of you knows more about something than the rest of us – share your experience (and experiences)!

Next Month and Beyond:

February 1 - Computer Subgroup Meeting at **Kurt Hillig's** house (a Monday). The computer subgroup will continue discussions on the project to computerize the 24" McMath scope (along with several others), CCD imaging, etc. With luck a copy of the latest release of Voyager (one of the few Mac-based star-chart programs) will have arrived and be on display. Call Kurt at 663-8699 for directions.

February 13 - Public Open House at the **Peach Mountain Observatory**. The Moon is in the Seventh House, and Jupiter's aligned with Mars. No, sorry, just kidding....

February 19 - Meeting at the **Detroit Observatory**. Come help us celebrate Copernicus' 520th birthday, as Paul Etzler gives a presentation on the Dark Sky Association.

February 20 - Public Open House at **Peach Mountain**. Mercury is near it's greatest elongation – maybe the skies will be clear enough for us to spot it!

March 1 - Computer Subgroup Meeting at **Tom Ryan's**

TSP '93 is coming up!

The 1993 Texas Star Party will be held this year from May 16 through May 22 (Sunday through Saturday) at the Prude Ranch in southwest Texas. It's not too soon to start making plans! The TSP Registrar is

Bobby Brailey P.O. Box 386 Wylie, TX 75098

Cold Dark Matter

by Chris Metzler

University of Michigan Department of Physics

[Once again I find myself borrowing an article from the sci.astro network news group. This time it's on the distribution of matter in the universe, in response to a recent investigation whose results are surprisingly different from earlier work. The net's a great place to see what's the latest word – this article was posted to the net last week.

You may notice that several other items in this issue were taken from UseNet news. Blame it on writer's block.... - Ed.]

In an earlier posting, Eli Hawkins wrote:

|> I saw a brief item last night on an overnight news
|> show. It was something about dark matter having
|> been observed with X-ray astronomy and that it is
|> supposed to be enough to close the universe.
|> I imagine that someone on the net knows more
|> about this. Has this been published (if so, where)
|> or just announced? What's the deal?
|> —
|> Eli Hawkins : mrmuon@wam.umd.edu

Here's the deal. What Rick Mushotzky and collaborators did is use ROSAT (a German X-ray astronomy satellite) to measure carefully the gas mass and total mass of a small group of galaxies. This let them calculate a value for Ω (Omega) which turns out to be much higher than previous efforts in this regard.

That's the short answer. Here comes the long answer. (From here on out, I'm assuming the cosmological constant $\Lambda = 0$.) We'll do this in three steps.

1. How Heavy Is the Universe? Mass estimates for groups and clusters of galaxies are important because they give you a way to get at Ω_0, the ratio of the mean mass density of the universe to the critical value. If $\Omega_0 > 1$, the universe is closed, the Hubble expansion should slow down, stop and reverse, and everything should eventually collapse back upon itself. If $\Omega_0 < 1$, the universe is open and should continue in free expansion forever. If $\Omega_0 = 1$, the universe is flat and should expand forever but asymptotically approach no-expansion. So cosmologically speaking, Ω_0 is the quantity of interest.

Now, how do cluster masses let us get at Ω_0? Assume for a second that we know the total mass of a cluster of galaxies, as well as the total mass in normal, baryonic-type matter. In the absence of any significant dissipation (and dissipation should not be important on these huge scales), all the matter in the cluster should have fallen in from the same volume. Then the ratio of the mass in baryons to the total mass (the baryon fraction of the cluster) should equal the ratio of the average baryon density in that original volume to the average total density in that original volume,

$$M_{baryon} / M_{total} = \rho_{baryon} / \rho_{total}$$

Now, overdensities that result in clusters of galaxies are not that huge (~0.001). So, we introduce only a very small error by considering these average densities to be representative of the universe as a whole. Then dividing the numerator and the denominator by the critical density, we get

$$M_{baryon} / M_{total} = \Omega_{baryon} / \Omega_{total}$$

where Ω_{baryon} is the ratio of the mean baryon (normal matter) density of the universe to the critical value, and Ω_{total} is the ratio of the average total density (considering all components in the universe) to the critical value. Note that Ω_{total} is what we above described as Ω_0, the quantity of interest. We thus have that Ω_0 is equal to Ω_{baryon} divided by the baryon fraction of the cluster. The very-successful theory of Big Bang Nucleosynthesis tells us what Ω_{baryon} is; the X-ray observations tell us what the baryon fraction of clusters are by measuring the two masses.

Up to this point, efforts to do this keep coming up over and over with values for Ω_0 of 0.1 - 0.3.

2. How Do You Find What You Can't See? How do you get the total mass of the cluster when you can't see the dark matter? One way is to use gravitational binding arguments on the group or cluster galaxies. If you know how far they are from the center of the cluster, and you know how fast they're going, and you assume that either the galaxy orbits are circular, or that their trajectories ("velocity dispersions") are isotropically distributed, then it's simple physics to calculate the mass of the group or cluster within a certain radius. The problem with this, however, is that there's a lot of reason to believe that the galaxy orbits AREN'T isotropically distributed — both "experimental" (i.e. through simulations) and observational. In particular, anisotropies in the velocity dispersions tend to result in underestimates of the binding mass.

A believed-to-be-more-reliable method is to get the binding mass (total mass within a certain radius) by X-ray observations. Cluster gas is hot — from 10^6 K for small groups to 10^7 - 10^8 K for rich clusters. If you assume that the gas is in hydrostatic equilibrium (that is, that the gravitational force pulling a parcel of gas down is exactly equal to its pressure support), and also assume the ideal gas law applies, then you can get a simple formula for the binding mass within a certain radius. The observables in the formula are the radius, the temperature at that radius, and the temperature and density slope (vs. radius) at that radius. This is believed to be fairly reliable. The same N-body plus hydrodynamic simulations which give underestimated optical mass estimates (using cluster galaxy velocity dispersions — see paragraph above) give X-ray mass estimates that are bang on.

3. Lies, Damn Lies, and Statistics? Mushotzky's group measured an X-ray binding mass for this small group of galaxies and found a very large mass, and thus a very small baryonic fraction, and thus a large Ω_0.

This result is in direct contrast with small Ω_0 values (0.1-0.3) obtained by following the exact same procedure on rich clusters of galaxies rather than small groups.

There are four ways to interpret this:

a) This newly announced result is wrong. I don't know much about the group they observed, but it's hard for me to see how they were able to get both a gas temperature, and a temperature slope, at large radii from the center of the group (~400 kpc or so). The reason that this technique has been applied primarily to nearby rich clusters is because they occupy a large solid angle on the sky, and thus are easier to observe at several points radially. And even then, we don't have reliable measurements of temperatures out very far in the cluster (~2 Mpc or so); that's the equivalent of what they've done here. So I'm not sure how seriously to take this result.

b) The rich cluster observations which predict Ω_0 is low are wrong. This is possible, but not very probable. This is what theorists would like to be true, and accordingly theorists have worked very hard to show how this might be true. What the critiques boil down to is assailing the assumptions of hydrostatic equilibrium or of ideal gas-ness. Certainly the degree of substructure we see in X-ray surface brightness profiles tells us that in many (perhaps even most) clusters, the gas hasn't relaxed yet. And the work I'm doing suggests that clusters can be out of hydrostatic equilibrium, have significant substructure, and yet look very relaxed and in hydrostatic equilibrium if you're looking in the right direction (this is happening about 15% of the time). But if the gas isn't in hydrostatic equilibrium, then the total binding mass estimates ought to be off, and there's no reason to believe that they'd consistently be off the same way, getting larger as you go to larger clusters with larger gas masses. In other words, the fact that when we do this with different rich clusters, we keep getting about the same value, tells us that there's probably no problem.

c) Neither set of observations are wrong, but this group of galaxies is not a representative object; it's an oddity. Then while the structure of this group may be interesting, it doesn't tell us anything about Ω_0 per se.

d) Neither set of observations are wrong, and this group of galaxies is representative. If this very exciting possibility is true, then Ω_0 is probably high, because small groups are more representative of the universe than rich clusters are. But then we are faced with explaining why dark matter is more concentrated in small groups than in rich clusters. Very strange.

I should point out in closing that the statement I read in the newspapers to the effect that this is the first observational evidence that Ω_0 might be high (~1) is false. Observations of substructure in clusters suggests a value greater than 0.5, as do various observations of the galaxy peculiar velocity field.

So, in summary, this is a very interesting observation, but just how excited we should get is going to take some time to tell.

HUBBLE DISCOVERS A DOUBLE NUCLEUS IN THE CORE OF AN ACTIVE GALAXY

NASA Press Release 93-006 Jan. 7, 1993

Astronomers, using the Hubble Space Telescope, now believe that a galaxy they have observed for a decade actually is composed of two merged galaxies and that the collision has provided new fuel for a massive black hole which is spewing out a jet of gas and other matter 240,000 light-years long.

The galaxy is Markarian 315, located about 500 million light-years from Earth. The collision and refueling theory emerged after the Hubble Telescope revealed that the galaxy has a double nucleus or two core-like regions.

The brighter core-like region is believed to harbor the massive black hole which accounts for the tremendous amounts of energy produced by the galaxy. The fainter nucleus is considered to be the surviving core of a galaxy that recently merged into Markarian 315.

"The galaxy's active core presumably harbors a black hole which has been re-fueled by the galactic collision," said Dr. Jack MacKenty, Assistant Scientist at the Space Telescope Science Institute in Baltimore.

"The Hubble images provide support for the theory that the jet-like feature may be a 'tail' of gas stretched out by tidal forces between the two galaxies as they interacted," explained Dr. MacKenty, Assistant Scientist at the Space Telescope Science Institute.

"The jet feature is most likely a remnant of a merger between Markarian 315 and a smaller galaxy," said MacKenty. This observation best explains the extraordinary 240,000-light-year long jet-like feature of Markarian 315. An image of the core of Markarian 315, taken with the Hubble Space Telescope's Wide Field and Planetary Camera shows a second, fainter nucleus located approximately 6,000 light-years (or 2 arc seconds in angular separation) from the galaxy's bright central nucleus.

Galaxy mergers may be one mechanism for driving gas deep into the heart of a galaxy, astronomers believe. This raw material fuels massive black holes, theorized to be the "central engines" in Seyfert galaxies and other active galaxies.

The Hubble Space Telescope's high spatial resolution allows astronomers to probe the cores of Seyfert galaxies in unprecedented detail. In exposures taken with ground-based telescopes, the companion nucleus is drowned out by the brighter Seyfert nucleus.

The report on this discovery is by Drs. John MacKenty and Andrew Wilson of the Space Telescope Science Institute, Baltimore; Richard Griffiths of The Johns Hopkins University, Baltimore; and Susan Simkin of Michigan State University, East Lansing. The report was delivered at the 181st Meeting of the American Astronomical Society meeting in Phoenix, Ariz.

The Hubble Space Telescope is a project of international cooperation between NASA and the European Space Agency.

When is Easter, anyway?

ARLIN B COLLINS
University of Texas at Dallas

[More good stuff from the UseNet! It's getting close to that time of year, so if you don't have a calendar.... - Ed.]

> What is the Gauss (I think that's him) formula to
> compute Easter date (month and day of month)
> fromthe year? Thanks, and best regards,
> Jacques C. Wenger, University of Lausanne
> jwenger@ulys.unil.ch

Note: this is NOT the Gauss formula – if you're looking for THAT formula in particular, then: oops! This is from "Astronomical Formulae for Calculators" (Jean Meeus, 4th ed., Willmann-Bell. Chapter 4) and is valid for all years in the Gregorian Calendar (from 1583 on).

DIVIDE	by	Quotient	Remainder
the year **X**	19	–	**A**
the year **X**	100	**B**	**C**
B	4	**D**	**E**
B + 8	25	**F**	–
B - **F** + 1	3	**G**	–
19**A** + **B** - **D** - **G** + 15	30	–	**H**
C	4	**I**	**K**
32 + 2**E** + 2**I** - **H** - **K**	7	–	**L**
A + 11**H** + 22**L**	451	**M**	–
H + **L** - 7**M** + 114	31	**N**	**P**

N is the number of the month (3 = March, 4 = April) and (**P**+1) is the day of the month upon which Easter Sunday will fall in the year **X**. The extreme dates of Easter are March 22 (as in 1818 and 2285) and April 25 (as in 1886, 1943 and 2038)

What's Happening?

While an intereast in astronomy doesn't guarantee a corresponding interest in the space program, here are some highlights from the latest Space Calendar from NASA (courtesy of Ron Baalke –baalke@kelvin.jpl.nasa.gov – at NASA's Jet Propulsion Lab, Pasadena CA). Note that launch dates are subject to change.

January 1993
- 06 Galileo, Dual Drive Actuator hammer test #2
- 07 25th Anniversary, Surveyor 7 launch (Moon soft lander)
- 10 Geotail, 4th Lunar flyby
- 11 Galileo, Dual Drive Actuator hammer test #3
- 15 Galileo, Dual Drive Actuator hammer test #4

February 1993
- 01 35th Anniversary, Explorer 1 launch (1st US satellite)
- 08 Mars Observer, 2nd Trajectory Correction Maneuver (TCM)
- 18 Jules Verne's 165th Birthday
- 19 Copernicus' 520th Birthday
- 25 STS-55, Columbia, Spacelab Germany (SL-D2)

March 1993
- ?? Galileo, 10 RPM Spinup test
- 01 Ulysses, 3rd Opposition
- 18 Mars Observer, 3rd TCM
- 23 STS-56, Discovery, Atmospheric Lab for Applications and Science (ATLAS-2)

April 1993
- 06 20th Anniversary, Pioneer 11 launch (Jupiter & Saturn flyby)
- 19 Venus/Moon Occultation, visible from N.A.
- 22 Lyrid meteor shower (maximum: 02:00 UT)
- 23 Pi-Puppid meteor shower
- 29 STS-57, Endeavour, European Retrievable Carrier (EURECA-1R)

May 1993
- 04 Galileo enters asteroid belt again
- 05 Eta Aquarid Meteor Shower
- 21 Partial Solar Eclipse, visible from N.A.
- 25 Magellan, end of mission?

June 1993
- 04 Lunar Eclipse, visible from North America
- 14 Sakigake, 2nd Earth flyby (Japan)
- 22 15th Anniversary of Charon discovery

July 1993
- 28 S. Delta Aquarid meteor shower
- 29 NASA's 35th Birthday

August 1993
- 08 15th Anniv., Pioneer Venus Orbiter 2 launch
- 09 Mars Observer, 4th TCM
- 12 Perseid Meteor shower
- 24 Mars Observer, Mars orbit insertion
- 28 Galileo, Asteroid Ida flyby

October 1993
- 21 Orionid Meteor shower

November 1993
- 03 20th Anniversary, Mariner 10 launch (Mercury & Venus flyby)
- 03 S. Taurid Meteor shower
- 04 Galileo exits Asteroid Belt
- 06 Mercury Transits Across the Sun, visible from Asia, Australia, and the South Pacific
- 13 Partial Solar Eclipse, visible from southern hemisphere
- 16 STS-60, Discovery, SPACEHAB-2
- 28-29 Total Lunar Eclipse, visible from North and South America

December 1993
- ?? TOMS Pegasus launch
- 01 Mars Observer, Mapping orbit established
- 05 20 Anniversary, Pioneer 10 launch (Jupiter flyby)
- 07 STS-61, Endeavour, Hubble Space Telescope repair
- 08 Mars Observer, Mars equinox
- 13 Geminids Meteor Shower
- 20 Mars Observer, Solar conjunction
- 25 Mars Observer, Mapping phase begins

The Computer Subgroup Report
or
The Computer Subgroup Makes Five Proposals to the Club, and Other Items of Interest
by Stuart Cohen

The computer subgroup was especially creative in the January session. A wide-ranging discussion generated five new proposals for the Lowbrows to consider. First, though, the news:

Roger Tanner reported on his efforts to fix bugs in the program that points his 17" scope automatically (like the system John Lafitte showed at the club meeting last year). Roger's program uses coordinates for the year 2000.0 for all calculations, but does not use them for the initialization routine. Of the 15 pages of BASIC code for his Atari computer (which runs the whole thing) 3/4 is for calibration and only 1/4 is for the control system that moves the scope.

Guiding is a separate problem. Roger uses an IBM PC for data collection from his ST-4 CCD camera and for color image processing. Off-axis guiders are less useful than expected, because the human eye adjusts to small focusing errors where the CCD camera will not. It was noted that clearer skies and better seeing would help.

This last observation prompted a discussion on how to find better atmospheric conditions. After various considerations, the subgroup made its first proposal: that we begin a long term fund-raising program to purchase 5 square miles outside Dexter and establish a 5,000 foot mountain to be above the clouds. [At least 12,000 feet is necessary to avoid Ann Arbor's typical stratified cumulus clouds. Also, I think a five-mile square – i.e. 25 square miles – might be more appropriate; since township in Michigan are standardized at six miles on a side, perhaps we could just buy Dexter township. - Ed.] Area municipalities would be encouraged to use the area as a landfill, thereby increasing revenues along with elevation. Methane from vent wells could be used to power heaters in the winter for the cold night star parties. The suggested name would be the Lowbrow Landfill Observation Outpost. The subgroup is looking into getting the necessary permits.

An alternative second proposal was made: Since the weather is consistently bad in Ann Arbor, why not accept the conditions as they are and simply replace the 24" scope with a radio telescope that can be used in any weather? The subgroup is considering the small radio dish stored at Peach Mountain, and will begin removal of the optical scope as soon as the weather warms up. Anyone with a 70 Megahertz receiver is encouraged to donate surplus equipment to the Club.

The next news item came from Tom Ryan who discussed the NGC-max star finder emulator kit available by mail order from David Lane. For $35 you get a P.C. board, program, EPROM, source code and instructions to build the star finder. The total project, including encoders, is expected to be about $300. The subgroup's third proposal is to expend the $35 to see what Tom can do with the kit.

Tom also reported that the Universe is closed [see lead article in this issue of *Reflections* - Ed.]. Since every electron has a wave function that extends to infinity, the whole Universe is filled up with wavefunctions and there's no more room for anything else, therefore it must be closed. Thanks, Tom, for finally settling that vexing problem.

There was a spirited discussion of how to focus CCD cameras, since you can't see the image until the integration is over. There are two methods which work with video cameras. One is to look at the readout streak of an overexposed star and minimize its width (not length). The second is to look at the statistical fluctuations of the brightest pixel; when the variations are high for 1 pixel but not for other ones nearby, the star image is focussed on just that one pixel. On the other hand, electronic photography is not amenable to these solutions, which require continuous readout of the image. Since most video cameras cannot be clocked statically, only electronic cameras can provide the integration times needed for astronomy. [How come nobody makes a CCD camera with a built-in T-adapter? This way you'd be able to use, for example, the Celestron MFFT focal tester or even a 35mm camera to set the focus. - Ed.] The fourth proposal is that the club purchase an electronic camera which could automatically download to the club's computer. Steve Musko is in charge of the project to permanently install a computer at Peach Mountain.

Roger noted that he has begun some work on the computer challenge issued last month . To reiterate, the Lowbrows now offer a joint prize of $50 to any member of any astronomy club who provides the software for the challenge programs. The final proposal of the subgroup was that more individuals should be encouraged to contribute to an increased prize, to bring the total up to $200.

The next meeting will be on Monday, February 1, 1993 at Kurt Hillig's house (1718 Longshore Drive in Ann Arbor – call 663-8699 for directions), and the following meeting will be March 1, 1993 at Tom Ryan's house.

For Sale: 30" F-4 Newtonian

Steve Huss
Tektronix Inc., Beaverton OR

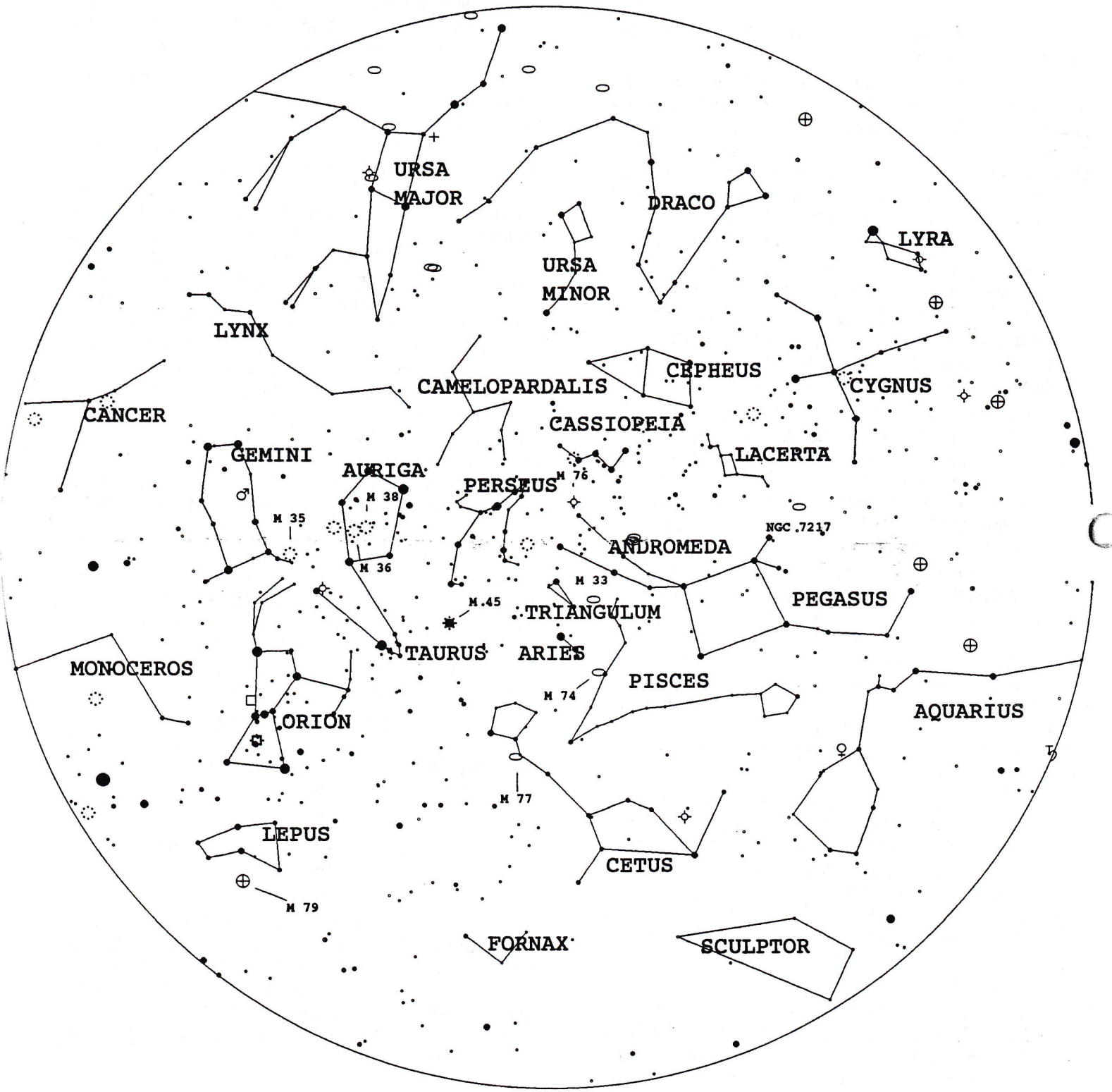
A beautiful Dobsonain made out of Maple and Walnut, it is a truss design that travels in a very compact package, with comercial optics that really pull in the faint fuzzies.

A friend of mine is selling this but if you have questions you can E-mail me at steveh@amadeus.wr.tek.com. You can also contact him directly (I know h's prepared a video):

Steve Swaze
700 N.E. 101st #31
Portland OR 97220
Phone: (503) 274-6016

Reason for sale: Optics too small – Steve figures he needs 40" now. I do not have a firm asking price but I expect it to be in the $7K to $8K range.

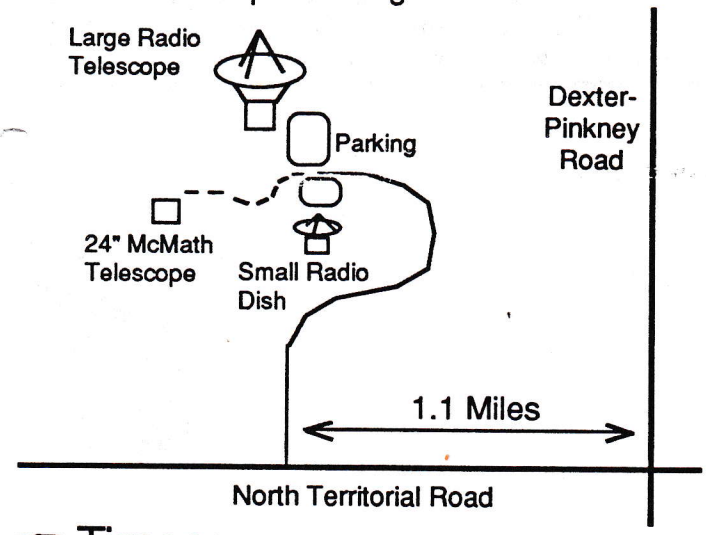
1/16/93 8:Ø8pm Stars to 5th mag



☞ 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:

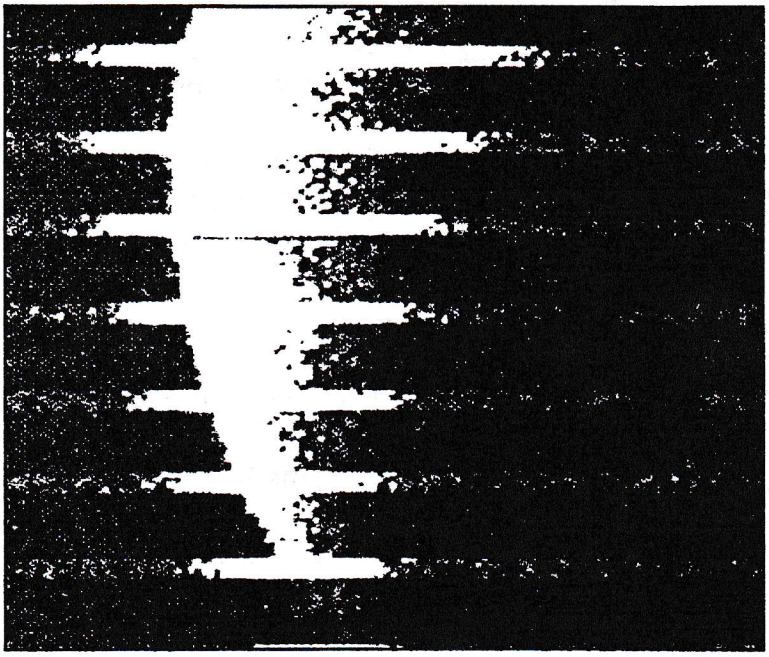
Fred Schebor 426-2363

Monthly Meeting:

Tom Ryan
on
"Mirror Grinding: Theory and Practice"

Jan. 15, 1993 at 7:30 PM

At the
Detroit Observatory in
Ann Arbor



A computer-generated view of Venus from ultraviolet spectrometer measurements by the Pioneer Venus 1 spacecraft. The narrow bars show atomic hydrogen emission, while the broader ones map the oxygen atoms. The oxygen is clearly confined to the lower portion of the atmosphere.

University Lowbrow Astronomers
840 Starwick
Ann Arbor, MI 48105