University Lowbrow Astronomers
Ann Arbor, Michigan

REFLECTIONS / REFRACTIONS

University Lowbrow Astronomers

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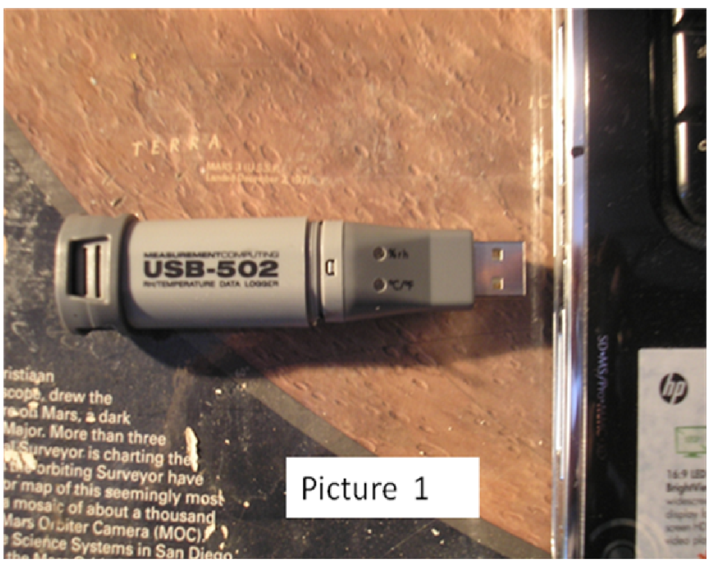
ADVENTURES IN DATA LOGGING BY JACK BRISBIN

What is a data logger and why are we using one, this all goes back to the discussion we had about water on the 24 inch McMath mirror and how it destroys the protective surface coating used on top of the enhanced aluminum coating. Read the article; "Journey to Flabeg" September 2010 Newsletter by Tom Ryan. The other issue is observing conditions relating to turbulence and air boiling that cause soft images or images that appear out of focus. Some of these observing conditions are due to sky conditions but the observatories environmental conditions can impact the 24" McMath telescopes optics (main mirror and secondary mirror) and cause these conditions. Many club members have witnessed these observing conditions. High humidity conditions also contribute to rust and mildew. Enter the data logger. The data logger is a small device that is USB enabled for data downloads of; temperature, humidity and dew point measurements. Our data logger is set to take measurements every half hour of all three data points.

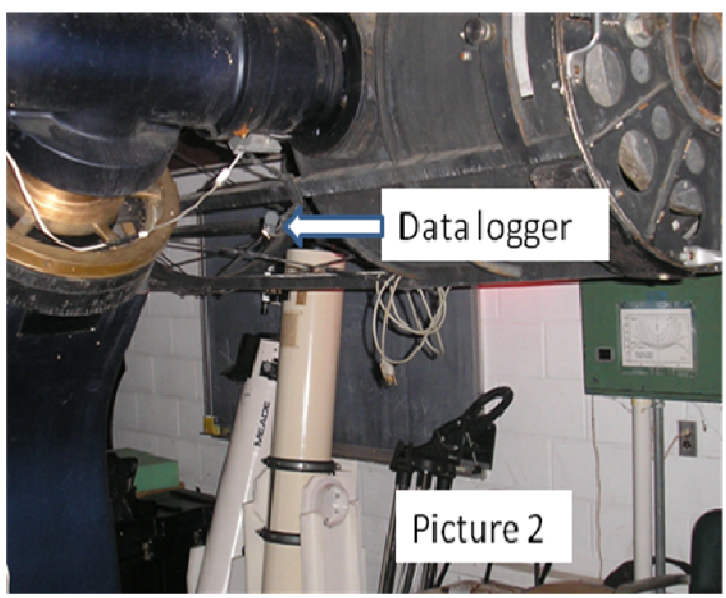


Picture 1

In picture 1 you see the data logger with USB connector being inserted into the laptop.

Picture 2 shows the data logger clamped to the telescopes frame, in front of the mirror cell. On April 19,(mirror installation) the data logger was moved to the eyelet ring on top of the polar axis casting, so it will not interfere with the mirror cover.

We started to monitor the observatory building environment in January 2011, as of this writing we have 96 days of data. We plan on monitoring the observatory for the rest of the year to get a more accurate description of the environment. Jim Forrester our Open House Coordinator has been going with me to Peach Mountain and unlocking the observatory so I can do the data download. Picture 3 describes the adventure at best . On February 20 we started to drive to Peach Mountain and a severe storm warning was issued. So we figured they might be right or they might be wrong. Well we got there just as the storm hit and you can see Jim opening up the gate to Peach Mountain. By the time we got the data download and drove to the I-94 Baker road entrance, two freight trucks where jack knifed at the intersection, so we just drove back on Jackson road. Thanks Jim! Back to the data. We take the data and chart it and overlay the outside high and low temperature and humidity using



Picture 2

the Weather Underground Portage Pinckney station as our official station. You might remember our January 2011 lecture by Jeff Masters from Weather Underground.

Based on the preliminary data, we know that when the outside temperature is at -2 degrees F, the temperature inside the observatory is in the low twenties and that's because the switch for the heat lamps is working. We also know the Humidity inside the building gets as high as 90 degrees. We have a long way to go to get an accurate picture of the seasonal changes and how they impact; the coatings on the 24" McMath mirror and other telescopes stored in the building, observing conditions, rust and other types of corrosion on the observatory equipment.

Finally, we know there are insects and other little critters that like the observatory. Maybe the data will show us a way to persuade the insects and little critters to find a new home.

Latitude and Longitude from the Stars

Jim Abshier

9 May 2011

There was a time in the not too distant past when the Sun and stars were used extensively for navigation and geodetic surveying. Celestial navigation was, at one time, the primary method of determining one's position at sea. The stars were also routinely used in determining latitude and longitude of control points to establish absolute positions of geodetic triangulation networks. With the advent of GPS though, navigation and surveying have experienced dramatic changes. Still, there are applications where the Sun and stars are used. In surveying, the Sun and Polaris are used to determine absolute azimuth. Stars are also used to determine attitude of spacecraft. The use of the stars to determine latitude and longitude, however, has been mostly supplanted by GPS. In spite of this, there are people who practice celestial navigation just for the fun of it, or as a back-up in case other navigation systems fail.

I became interested in the use of stars to determine latitude and longitude by reading accounts of geodetic surveys of India and France, and books on surveying and celestial navigation. It seemed like an interesting thing to do, so I decided to try it myself. To do this, however, I would need a sextant or theodolite. These instruments are rather expensive to buy just to play with, so I decided to make my own theodolite. The measurements that I would need to make were elevation angles or their complement zenith angles. Theodolites usually measure both vertical and horizontal angles. I only needed to measure vertical angles, so my theodolite does not measure horizontal angles. It is not really a theodolite with full measurement capabilities. My theodolite was built mostly from materials lying around in my basement that had been collected over the years. I purchased a 360 degree protractor that had markings every half degree to measure the angles. With a full 360 degree measurement capability, redundant measurements of star zenith angles can be made that cancel certain errors. The other item I purchased was a surveyors tripod to support the instrument in the field.

Figure 1 Zenith Angle Measuring Theodolite

A photo of the theodolite is shown in Figure 1. It consists of a small telescope mounted on a common ½ inch shaft with the protractor. I had a supply of fiber gears from old teletype machines that a friend had given me years ago. These

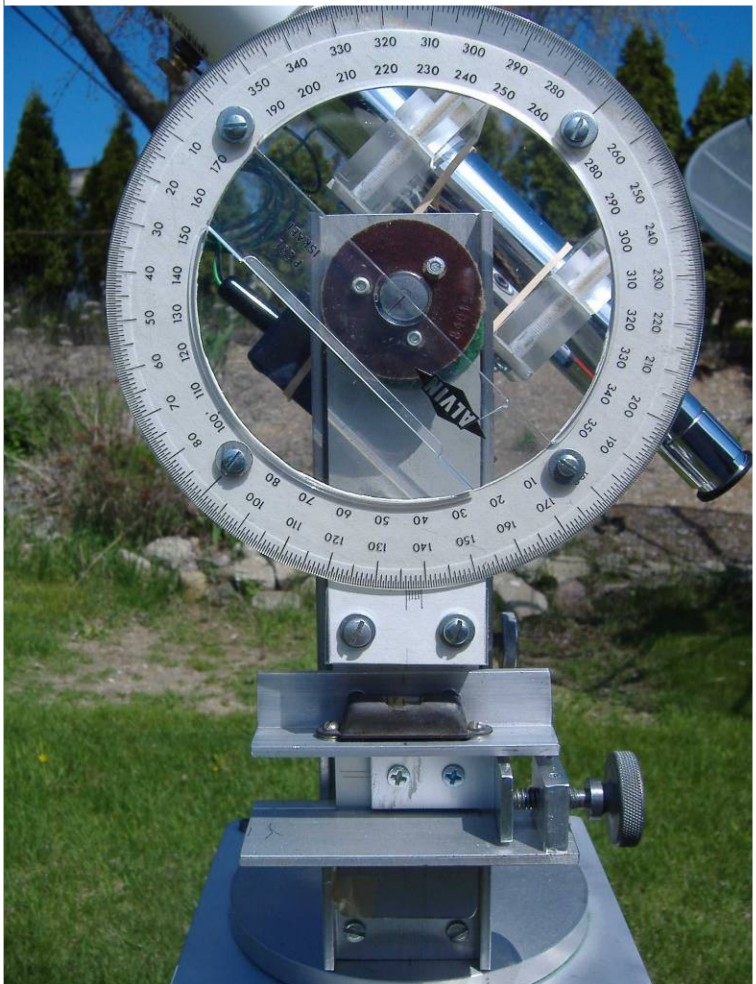


Figure 2 Close-Up Showing Vernier Dial and Spirit Level

gears were used as both bearings and bushings on the shaft. In addition to the protractor, an adjustable vernier arm was fabricated that held the vernier dial and a spirit level for measuring zenith angle with respect to the local gravity gradient. Tangent arms for fine adjustment of both the telescope and the spirit level were incorporated in the instrument. A close-up photo of the vernier dial and spirit level is shown in Figure 2. Since the instrument did not have an illuminated reticle, I mounted a small LED directly in front of the objective lens of the telescope. The light from the LED produces an out-of-focus blob of red light which back-lights the cross wire reticle. The LED current is adjusted so that a faint background light illuminates the cross wire reticle but does not overpower the light from the star. The LED attachment is shown in Figure 3.

The procedure for measuring star zenith angles with my theodolite is to first set up and level the tripod. This is done with a small circular spirit level. The instrument is then placed on the tripod and secured with a hand nut. The telescope is centered on a star using first coarse motion and then fine adjustment with the tangent screw. When the star is centered on the horizontal cross wire, the time is immediately recorded. It is important that time be recorded to within a second or two because the point on the Earth for which latitude and longitude are to be determined is moving rapidly. On the Equator, points are moving at a speed of about 460 meters per second in an easterly direction. At my latitude (about 42.5 degrees north), this motion is only about 340 meters per second, but this is still rather fast. This motion can be sensed easily by observing stars that are rising or setting. Within a few seconds, they can be seen to move away from the horizontal cross wire of the telescope a significant distance. When the time is recorded, the vernier tangent arm is adjusted so as to center the bubble of the spirit level. This establishes the angular orientation of the vernier with respect to the local gravity gradient or plumb line. The zenith angle is then read on the protractor using the vernier to estimate the angle to the nearest 0.1 degrees. A second measurement of the same star is then made by reversing the direction of the telescope and rotating the instrument horizontally 180 degrees. The zenith angle measured using the telescope reversed is 360 degrees minus the value indicated on the protractor. For example, if the zenith angle read in the forward direction is 30 degrees, the angle read in the reverse direction would be 330 degrees (plus errors). The reason for making these two measurements is that any error in the alignment of the telescope with respect to the protractor (collimation error) will be canceled when the two zenith angles are averaged.

Figure 3 LED Background Illumination Attachment

To determine both latitude and longitude, at least two star measurements are required. To improve accuracy, I usually measure about 10 stars and use the weighted least squares technique to solve for latitude and longitude. The solution for latitude and longitude is based on the following relationship between zenith angle, latitude, longitude, star right ascension and declination, and time.

$$\cos(ZA) = \sin(lat)\sin(dec) + \cos(lat)\cos(dec)\cos(GHA + lon)$$

where:

ZA = Zenith Angle; lat = Latitude; dec = Star Declination; GHA = Greenwich Hour Angle of the Star; lon = Longitude

Greenwich Hour Angle is determined from Greenwich Mean Sidereal Time (GMST) and right ascension of the star. GMST is determined from the date and UTC or Greenwich Mean Time. Algorithms are available for finding GMST from UTC. To ensure that my watch is correct within a second, I listen to the National Institute of Standards and Technology (NIST) broadcasts from station WWV on one of the standard frequencies of 5, 10, 15, or 20 MHz. Right ascension and declination of the stars are obtained from the Bright Star Catalog published yearly by the US Naval Observatory.

The weighted least squares observation equations used to determine latitude and longitude are of the form:

$$F = \text{arc-cos}(\ \sin(lat)\sin(dec) + \cos(lat)\cos(dec)\cos(GHA + lon)\ ) - ZA$$

These equations are used to relate measured zenith angles ZA to latitude, longitude and other parameters. There will be one such equation for each star measurement. Multiple star measurements provide a system of equations that is over-determined when the number of measurements is greater than two. In other words, if the number of measurements is greater than two, there are more equations than are needed to uniquely determine latitude and longitude. The weighted least squares process determines values for latitude and longitude that best fit the system of equations in a least squares sense. Since the observation equations are non linear, linearized forms of the equations are generated by Taylor series expansion of the observation equations, and the solution is obtained by iterative application of linear least squares. A detailed explanation of this process is beyond the scope of this article.

I have used my home-made theodolite and the least squares analysis technique to determine latitude and longitude of my house to an accuracy of about 1 nautical mile. The theodolite accuracy of 0.1 degree implies an accuracy of roughly 6 nautical miles for a single pair of star measurements. By including 10 measurements, the error is substantially improved. This accuracy is, of course, nowhere near what can be achieved with a low cost GPS receiver. I have, in fact, used the coordinates of my house measured with a GPS receiver to determine the accuracy of my star-based positions. I find the measurement of stars an interesting hobby. Some people like to just look at stars in the night sky. I like to measure star positions and use the measurements to do other interesting things. In addition to determining latitude and longitude from the stars, I have used the Sun and Polaris to determine azimuth for laying out the baseline of a radio telescope interferometrer and used star field images to calibrate the radial lens distortion of a 35 mm camera. Measuring bright stars does not require really dark skies. The stars traditionally used for navigation can usually be seen from within cities. It is a good hobby for someone like me who lives in a city with large shopping malls.

Mike Radwick's

IC-2233 & NGC 2537 (Bear Claw)

Galaxies

Taken April 30th at Lake Hudson S.R.

20 x 100 seconds (33.3 minutes)

Zooming in you will notice 2 smaller galaxies just above the Bear Claw they are NGC 2537a and PGC 23096 both are 16th magnitude!

The Problem With Assumptions

By Tom Ryan

One of the professors in the University of Michigan's Aerospace Engineering department asked me to give a few lectures to his graduate level class on how to use the optical design program, Zemax, so his students would have a better understanding of how some of the optical payloads in their future space or aeronautical vehicles were designed. I was happy to comply. It was a lot of fun working with the students, because every single one of them is a lot smarter than I am. Also, I found that they are much harder workers than I was back when I was about to graduate and jobs were plentiful, and it's a pleasure to work with smart, hard-working people. But there was one thing that surprised me, even beyond how fast they learned optical design, which is a relatively arcane subject.

I had already given several lectures, so the students had a general feel for how the program works (the U of M had bought $4k Zemax licenses for everyone in the class, which is why tuition is out of sight and why every single one of these students got several firm job offers upon graduation), and I was working through the class on a one-on-one basis to see if they were able to create optical systems on their own. Zemax has a lot of features and can be configured to create many different optical systems. Unfortunately, this causes it to give nonsensical results if you don't set every relevant parameter correctly. I assumed their programs would be in the default mode and gave them some problems to solve. Some of the students zoomed through the board exercises, some were texting, and some were struggling. I walked over to a group that seemed to need help and asked how they were doing.

"This is weird," one said. "Look. Can you give us an example problem, so we can see if we get this?"

I thought about all the ways the program will screw up if the operator doesn't keep it under control. "You mean, a problem with a flaw in it, so it won't find a solution? Yes, I can do that."

"No no no! We just want a problem, a slightly different problem than the one on the board. One that will work."

And I realized that I had made a mistake. At this early point in their learning process, they were still struggling to learn the One True Way, and weren't yet ready to declare a problem to be Bad just because they couldn't get it to work. They were still at the stage of blaming themselves when things didn't work.

I, on the other hand, seem to be forced to declare some problems Bad with every other job I take. You wouldn't believe how many project managers are convinced they can violate the laws of Physics. Their wants usually include something that will violate the second law of Thermodynamics, or create light out of nothing because their photon budget was itself created out of thin air, or which will generally warp the space-time continuum and send us all back to 1957.

My only defense against these time-wasting, budget busting wishes is to immediately examine every project for violations of the above-mentioned kind, as the first thing I do. If I find one (or more) problems, I can immediately point them out, and then the manager can can save both my time and his money by either canceling the project or scaling back his wants to a place that actually exists in this Universe.

I do this because I've been doing this for a long time, and I've made lots and lots of mistakes and wasted lots and lots of time trying to make the optical equivalent of perpetual motion machines. To defend against this, I have found several rules that I use to check the sanity of the proposed optical system. First, I check the system's Lagrangian function, then check to see if it is diffraction-limited, and if so, over what field, then check the photon budget, and then the wavelength and temperature range to see if it has to be made of Unobtainium, and then the space constraints, etc., etc., etc, until I eventually get some idea as to whether this can be built in the real world. If all of these first checks turn out good, then I can say it is not impossible to build the system. Difficult, maybe, but not impossible. It may even be possible to build something that's never existed before, which is what I really like (as do the customer's patent attorneys), and is why unrealistic wishes aren't all bad.

Still, I have to be careful in my initial assessment. Some of my sanity tests are more strict than others. The strictest tests seem to correspond to information-conservation laws. After that come the laws of Physics, and after them come the laws of Engineering. The information-conservations laws are never violated, the engineering laws can sometimes be gotten around, but the laws of Physics are the most difficult to deal with, because sometimes they're true, and sometimes they're not.

For example, I can't focus the Sun's rays to a point that will be hotter than the surface of the Sun. Never could, can't now, and never will be able to. That's an information-conservation law. On the other hand, the 4% reflection that occurs at an air-glass interface can be reduced to less than half a percent over a limited wavelength range by the use of anti-reflection coatings, and there is new research that indicates a surface can be built with a graduated density increase, which will lower the reflection from it to zero. Actually zero. Engineers are clever beasts.

Then there is diffraction, which is based on the Heisenberg Uncertainty Principle, which is a pretty firm law of Physics. Because it is such, I usually assume that ninety-nine times out of a hundred, I can apply it to an optical system's resolution and be pretty sure it'll give me the correct answer. After all, you know that if you want to improve your telescope's resolution, you need to buy a bigger lens (or mirror). That's just the way it is. There's even a simple formula for calculating an optical system's resolution, which I won't write here. But despite the formula, the diffraction limit is not actually always a limit.

It turns out that a system is diffraction-limited only over a short time period. No, that doesn't mean that old telescopes will out-resolve newer ones. It means that information gathered over several time periods can be combined to increase the resolution of a system to a point far past the system's diffraction limit. Anyone who has seen John Kirchhoff's Jupiter pictures should know that. Take a look at his Jupiter pictures, estimate the smallest details clearly resolved in the images, ask him how big the telescope was that he used to take the images, and then do the math. The Heisenberg Uncertainty Principle, a Law of Physics, can be beaten, if your information has memory.

Another method of improving on the diffraction limit is called Maximum Entropy Deconvolution. About the time I graduated from college, radio astronomers were just starting to take pictures of distant radio sources. Because radio waves are big and the diffraction limit depends on wavelength, their pictures weren't too detailed. However, some clever mathematicians invented a method for improving their resolution. It involved taking a picture of the object (only one picture), and then guessing what the object would look like if it weren't hopelessly blurred by a relatively small-aperture radio telescope. Their algorithm would take light from one part of the picture and patch it into another part by assuming it had come from there originally. This involved considerable guesswork as to what was blur and what was object. (This is the Deconvolution part.) But it turned out that if you guessed many, many times, and made many, many pictures of a reconstructed object (this is the Entropy part), you would get some pictures that looked like an egg beater, some that looked like Ronald Reagan, and a whole bunch that looked like a sharpened radio source, and that's the one they'd give to the press (that's the Maximum part). And as much as this sounds like Magic, when long baseline interferometry became possible through the coherent phase-matching of independent radio telescopes, the new pictures of the source looked just like what the math predicted. (This method was used to read license plates from orbit, something Mr. Reagan was all in favor of.)

Recently, astronomers have seen the scattering effects of bad atmospheric seeing being compensated for by artificial stars, which are created by projecting lasers into the sky to make a reference point source, and adaptive optics, which warp the wavefront inside the telescope to exactly compensate for the warped atmospheric air path until the artificial star sharpens to a point, at which time, all the real stars in the field sharpen, too.

However, the most amazing thing I've seen is that it is now possible to form ultra-sharp (as in, much better than diffraction limited) images of objects completely obscured by scattering surfaces, like dense, impenetrable fog, or a painted-over window. All that is required is a coherent light source on the far side of the scatterer, like a lit laser pointer inside a room. The laser pointer can be obscured by the window, too, to the point where it, unlike the astronomer's artificial star, can't be seen. The point of the laser source can be reconstructed by sampling the light from the scattering medium, which turns the window or the fog into a giant lens, with resolving power commensurate with the size of the window. Astronomical applications would include being able to resolve details on the surfaces of distant planets, if there were a coherent source (see, for example, The Lasers Around Mars) there, and a large scattering medium between us. The scattering medium would act like a telescope's lens, and could be light-years across, which would be a pretty big telescope lens.

Come to think of it, this could explain why aliens have never visited us. They've probably already seen downtown Detroit, given the number of laser pointers there aimed at the sky on any given night, and they consequently booked their flights to nicer vacation spots, where the natives actually believe in maintaining the roads.

So almost every rule of thumb that I learned in the school of hard knocks has been superseded, and it has left me wondering how much of the rest of what I think I know is wrong. (Now, we're just talking physical law here, in case any of you think I'm starting to doubt the merits of high tax rates and a more equal society, which I'm not.)

One of the things I like to do is to try to keep up with current developments in physics and the latest theories on the nature of the Universe. My personal belief is that we haven't yet scratched the surface of understanding it. Unfortunately, it is getting harder and harder for me to understand a lot of the theories that are proposed every year, and harder and harder to separate the crazy theories from the merely baffling. To judge their craziness factors, I find myself falling back on the same methods I use in my work, which is to apply a few laws which seem to have universal applicability (information laws, mostly), and then ask myself if the theory makes sense in that context, given the experimental evidence. It's probably a pretty bad method, and almost certainly misses some of the more obscure things that can derail a theory, but like those graduate students and program managers, I lack perfect knowledge, and therefore it's the best method that I've got.

TEXT-BOOK OF PHYSICS

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1911

One of the most recent theories, and one which very powerfully appeals to the imagination, is Lord Kelvin's vortex atom theory. By vortex motion is meant a form of motion such as occurs in a smoke-ring. The path of the particles of air in such a smoke-ring is indicated by the arrows in Fig. 95, where the curved arrows show the direction in which the air particles, which are simply rendered visible by the smoke, rotate, while the straight arrow shows the direction in which the ring, as a whole, moves. There is a very important difference between this form of motion and a wave motion. In the latter, although the waves travel onwards, the individual particles of the medium in which the wave is being propagated only move through a comparatively small distance from their original position, the motion being handed on from one particle to the next. In vortex motion, however, the particles of the medium themselves move forward, so that in a smoke-ring the particles of air originally forming the ring move on with the ring.

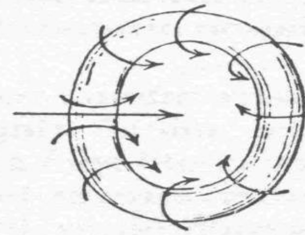


FIG. 95.

The properties of vortex motion were first examined by rigid mathematical methods by von Helmholtz, who found that if the fluid in which this form of motion exists is frictionless, incompressible, and homogeneous, then : (1) A vortex can never be produced, nor if one exists can it be destroyed, so that the number of vortices existing is fixed. This corresponds to the property of indestructibility of matter. (2) The rotating portions of the fluid forming the vortex maintain their identity, and are permanently differentiated from the non-rotating portions of the fluid. (3) These vortex motions must consist of an endless filament in which the fluid is everywhere rotating at right angles to the axis of the filament, unless the filament stretches to the bounding surface of the fluid. (4) A vortex behaves as a perfectly elastic substance. (5) Two vortices cannot intersect each other, neither can a vortex intersect itself.

On the basis of these results of von Helmholtz, Lord Kelvin has founded a theory as to the constitution of matter. He supposes that all space is filled with a frictionless, incompressible, and homogeneous fluid (the ether), and that an atom is simply a vortex in this medium. The existence of different kinds of atoms may be accounted for by the fact that a vortex need not necessarily be a simple ring, as shown in Fig. 95, but might have such a form as that shown in Fig. 96. Since a vortex can never intersect itself, it follows that the number of times such a vortex is linked with itself must always remain the same. Hence we may suppose that the atoms of the different elements are distinguished from one another by the number of times they are linked.

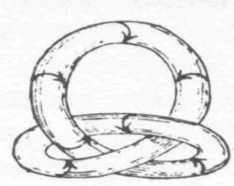


FIG. 96.

The Vortex Theory of Atoms, 1911. Now, before you start feeling superior, give a thought to vibrating string theory, and you should also know that most physicists now believe in the Ether. Einstein, too.

LOWBROWS ON TOUR, PART 3

By Charlie Nielsen, May 11, 2011

Last Winter I promised (or threatened) to write part 3 of "Lowbrows on Tour" this Spring. It is definitely Spring at last, and here is the article.

For this edition, we open up with our presentation at the University of Michigan Exhibit Museum of Natural History. We have made several appearances here and we have enjoyed them all. This time we were talking about water in the solar system, and beyond. On Saturday, March 26 the crew of Dave Snyder, Jack Brisbin, Sandy Dugan, and Jim Forrester convened on the Museum at 8 AM to begin setup. Dave, Jim, Jack and I went to the demo lab to pick up the equipment we needed for 2 demos that we would be continuously running. Sandy went directly to the Museum to set up a large poster that Sandy and Betsy Dugan produced, which showed where and in what form we may (or have) found water in our solar system. There was a section of the poster that did a very nice job of showing how a star's habitable zone varies with the size and temperature of the star. We found that the poster drew even more attention than we expected and caused visitors to ask questions, which of course is exactly what we hoped for. We also had a variety of other graphics available, including one that showed how we think Mars looked when it had liquid water on its surface and how it disappeared over millions of years. Alongside that picture was one of our demos. We had a small sealed container in which we could place a small amount of water. Attached to the container was a vacuum pump which would suck the air out of the container rapidly. We had visitors touch the water to verify it was room temperature, if not a little cooler. Then we put the lid on the container and started the pump. Within seconds the water began to boil. While they were fascinated by this we explained how water cannot stay in a liquid state without sufficient atmospheric pressure, despite the temperature. What I really enjoyed is when I had the younger people touch the water right after they saw it boil, and it was not hot. The expressions on their faces were priceless. If that was not enough to blow their minds, then I explained that Mars is also very cold, so that same water placed on the surface of Mars would try to freeze and boil at the same time! How weird! For our other demo we had my Astro Tech 66 mm APO refractor set up, but without an eyepiece. In place of the eyepiece was a plastic plug with a small hole in its center. In the hole was the end of a fiber optic cable that went to a spectroscope "black box" that connected to a laptop computer via USB. The laptop was running software that took the signal from the spectroscope and displayed the emission lines of whatever we were focused on in graphical form. The scope was focused on one of several light sources, an incandescent light bulb, a bulb with water vapor, and a bulb with deuterium. This way we could show our guests how we can detect hydrogen and oxygen just by analyzing the light from a star, or a planet. With the right conditions, this detection would most likely indicate the presence of water. We ran our presentation from 9 AM till 5 PM and we were visited by hundreds of guests, at least half of which were children. In the early afternoon we were visited b Warren Smith, manager of the Physics Demo Lab. He wanted to stop by to see how we were doing and what the setup looked like. His visit was most fortuitous and timely since our water vapor bulb had burned out. Warren and I went back to the demo lab to grab a new one, and we rolled on.

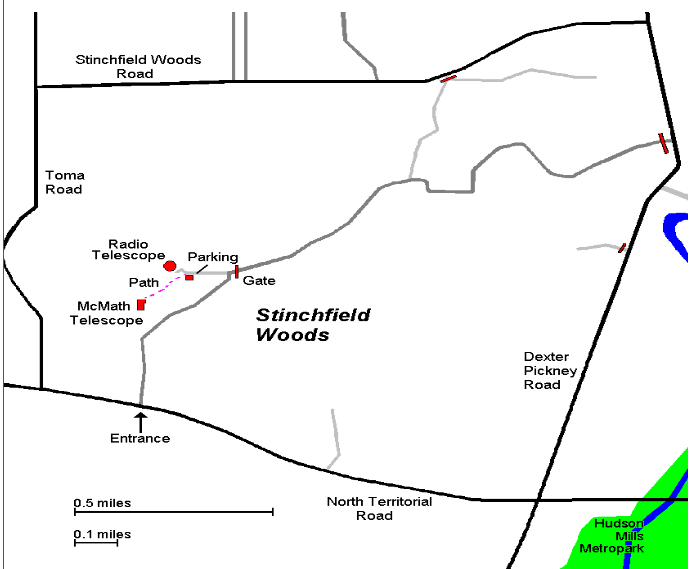
Now we continue on with our Ann Arbor Public Schools tour. Our first event this year was on March 3 at Bach Elementary. That was followed by Haisley on March 14, Wines on March 29, and Eberwhite on May 5. The students were a mixture of 3rd, 4th, and 5th grades, and ranged in size from 50 to70+ students. We did our usual presentation which consists of breaking the group into 2 sections. One of them watches a slide show about telescopes and then gets their chance to handle, aim, and focus them. The other section makes planispheres and they are showed how they work, while getting instruction about how to find North, distance and size scales, and sky movement. After about 45 minutes the 2 groups reverse and we start over again. Just like last year the students and the teachers really liked our program and we received many compliments and thanks. The presenters really enjoyed it too, as we always do. Crew members for at least one or more of these events were Amy Cantu, Raya Cooper, Betsy Dugan, Sandy Dugan, Belinda Lee, Dave Snyder, Jim Forrester, Jack Brisbin, Yumi Inugi, Yasu Inugi, David Jorgensen, and of course the author of this article. But, as of this writing we are not done! Upcoming is Lakewood School on May 19, and on an undetermined date just me and our main contact for the schools are doing a small follow up at Wines. At our Eberwhite event we started a slightly different format, that being that the students assembled their planisphere in advance, which means all the time for that section can be spent with our astronomy program running on our laptop and using it to describe more constellations, types of starts, etc. Next year all our presentations will be this new format, and we will be instruction 5th grade exclusively. We all agreed that 5th grade is a better target for what we are doing. Having stated that, I was very impressed with the 3rd grade at Eberwhite. They were the most engaged and well behaved of any of the 3rd grades, in my opinion.

Being that I could file a brief report on the last 2 schools for this year (but they have not happened yet), and that we have 2 events that are observing, education, and possibly demos for Hazel Park Schools (at Camp Hazelwood) on May 17 and 24…well, it looks like a "Lowbrows on Tour, Part 4" may be coming. That would cover the end of the AA Schools season, the Hazelwood events, and if I wait until the end of July, the two upcoming events at Leslie Park Science and Nature Center. So please stay tuned.

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

c/o Doug Scobel

P.O. 131446

Ann Arbor, MI 48105

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. Members renewing their subscriptions are reminded to provide the renewal notice along with your check to the club Treasurer. Please make your check out to: "University Lowbrow Astronomers"

Newsletter Contributions

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

Call or Email the Newsletter Editor: **Mark S Deprest (734)223-0262 or msdeprest@comcast.net** 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
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Lowbrows on Tour

From left to right: Jim Forrester, Dave Snyder, Amy Cantu, Jack Brisbin, Charlie Nielsen, David Jorgensen, Raya Cooper, & Sandy Dugan.

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Check your membership expiration date on the mailing label