ReFlections / ReFRactions

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University Lowbrow Astronomers

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Mercury Vapor Lights

By Tom Ryan

Before I got my driver's license, back in the '60's, a guy by the name of Jim Thomas gave me a ride once a week into a suburb of Cleveland so I could attend a telescope making class. Jim had already made two 16" f/4.5 mirrors, the first of which he sold to finance the second, so he was already an old hand at telescope making at the ripe old age of nineteen. He was volunteering his time as an instructor in the class that Norm Oberle had organized at the Lake Erie Nature and Science Center, and I was there as a student. We'd pile into Jim's old Corvair at about 6:15 PM every Wednesday after dinner for the ride into Lakewood.

The drive in to the class took about forty minutes over an old two-lane asphalt road. The road ran between cities, so the scenery was mostly Ohio farms and very small towns. The drive back through the dark, after a core group of us shot the breeze over a pizza at a local Pizza Parlor, seemed to take much longer. Both Jim and I were usually tired, and since I couldn't drive, he had to stay awake and alert, no matter how tired he was. I still remember how, in the dead of winter, he would turn the car's heater on full blast and open the windows as we flew through the dark, on the theory that the alternating waves of hot and cold air would keep us awake. It must have worked, because we never crashed.

Jim and I went to that telescope making class for about three years, so we spent a lot of time talking and traveling in that Corvair. He and I got along pretty well; he hadn't had much education but had done a lot of stuff, and I had all the education I could get but hadn't done anything. That pretty much set the tone of our relationship.

On the drive back from the class, we would talk about anything that came into our heads, just to stay awake. He would talk about variable star observing, a subject about which he was passionate. I, on the other hand, thought variable star observing was boring and pointless. I mean, where would it lead? Jim felt that it was one way that amateurs could make a real contribution to astronomy. I thought that variable stars were soon going to be completely explained by the theoretical physicists, if they hadn't been already, and that observing them was about as useful as phrenology. However, since he was doing the driving and had once threatened to let me walk home, I kept my opinion about this to myself.

I remember we once talked about street lights. I said that the new mercury vapor lights that the cities were putting up looked great. I particularly liked the pure white core of light, surrounded by a blue-violet halo. Jim immediately took issue and said they were the worst thing that he had ever seen. They lit up the night sky and were ruining observing.

At that time, I was pretty sure I would become a professional astronomer who did his observing from really remote locations with truly dark skies, so I just couldn't get as worked up about the loss of small-town dark skies as he did. Instead, I liked the lights for their pure, intrinsic beauty. As with so many of our discussions, Jim expressed his opinion, and I reserved mine. Not being able to drive taught me a few things.

A few years back, I heard that Jim had frozen to death in an open field after an all-night observing session. I don't know if that's true, I haven't been able to confirm it, but it would be in keeping with his gung-ho nature.

I still like mercury vapor lights, and for the same reasons as old. However, the other day I was looking at a group of them, and I suddenly wondered why I could see a blue-violet halo around them at all. I mean, the violet light from the bulb doesn't separate from the white light, travel a little way off to one side from the bulb, and then turn ninety degrees and speed to my eyes. Why was there a blue-violet ring around these lights, and no others?

It gradually dawned on me that the blue-violet halo was an artifact of my eyes' poor color correction. The human eye has terrible (that is, almost no) color correction. If you placed a piece of film or a CCD camera at the retina, you'd find that every light, everything you see, in fact, has a violet halo around it. It's usually removed in real-time by an incredible amount of brain processing. Mercury vapor lights appear to have blue-violet halos because their spectra have an excess of ultraviolet light compared to sunlight. Since the brain removes the solar-spectrum-correct amount of violet halo from everything, some still is left over after processing the mercury vapor lights.

The same holds true for images in refractors with poor color correction. Blue halos are the norm, even though the color correction of even bad refractors is about a hundred times better than the color correction of the eyes. We're just seeing the leftovers.

The brain is a remarkably adaptive device, though. It can learn. If you stare at the stars through a bad refractor long enough, the purple halos will disappear.

Like many things from my youth, I've looked at these lights all my life, but I've never seen what is really there.

Glass Choices for Refractors Part I

By Tom Ryan

The great physicist Richard Feynman said that if civilization collapsed and all scientific knowledge was lost (sort of like 1:45 AM at the Brown Jug), he would want one idea to be transmitted to the new society. That idea is that all matter is made of little bits called atoms. Apparently, he felt that everything could be reconstructed if you knew that one thing. Therefore, we'll start our analysis of the best glass types to use in refractors with that thought.

When a light wave hits a substance, it encounters a regular or an irregular arrangement of atoms. If that substance is optical glass (it could equally well be a crystal, a gas, or a liquid, but for now, we're talking about optical glass), it is made of approximately evenly spaced atoms. The atoms have tiny electron clouds around them, and the light wave's electromagnetic field causes the electron clouds to bob up and down, like corks on a stormy sea. Depending upon how strongly they are attracted to their nuclei, these electron clouds may bounce a little or a lot, but in doing so, they, being moving charges themselves, create secondary electromagnetic waves, which add to and interfere with the original wave.

This is the same thing that happens in my car's antenna when I tune in to NPR, or when someone uses their cell phone to make a call. It actually happens to everything you see. The electrons are very small compared to the wavelength of the exciting light, so when they bob up and down in response to the incoming plane wave, they generate outgoing spherical waves. The bobbing happens at the same frequency as the incoming wave, but is usually slightly out of phase with it, because the light is usually not bouncing the electrons at their natural frequency of vibration. These rows of bobbing, individually emitting atoms act like phased array antennas (you can Google this, if you're curious), and all the individual outgoing waves add and interfere with each other and with the incoming wave.

In the simplest case, you get a reflection off the surface of a block of these emitters. Amazingly enough, the interfering waves (and energy conservation laws) ensure that light seems to "bounce off" a surface at an angle equal to its incident angle. But, of course, it doesn't really bounce. (How would an individual photon be able to determine the angle of the surface, far from the individual atom it hits? Moreover, why would it care at all about the angle of the surface? The universe is smart, but its parts are not.) Each individual wave from each atom is rebroadcast spherically and it interferes with other phased emitter-atoms on down the surface. Far from the surface, out in space (at least a few wavelengths away), all of the phase-shifted, spherically broadcast fields cancel each other, with the exception of those oriented in one direction, where the emitter spacing and phase delays are just right – the "equal angle" direction. Thus, the emitted spherical waves are transformed into a single plane wave obeying the "law of equal angle reflection".

If you think this is just an abstract mathematical exercise to make a complicated explanation of what should be as simple as a photon's billiard-ball bounce, think about what happens when you take a sharp diamond and scratch up the flat surface in a series of parallel lines. If the parallel scratches remove the surface emitters that are a fixed distance apart, you remove emitters with a fixed phase relationship to each other. They can't make their usual contribution to canceling out the spherical waves, and suddenly you get light "bouncing off" the surface in directions which don't obey the equal angle reflection law. You've created a diffraction grating, which broadcasts light into what are called "orders", and there's nothing equal-angle about them.

In the more complex case, the waves are broadcast into the material, along with the original wave, and the rebroadcast spherical waves once again experiences phase delays and interfere with each other. Once again, random interference between waves cancels the light in every direction but one (Snell's Law!), and the continuous phase delays cause the phase amplitude to slow down (the actual speed of light is still *c* between the atoms) creating a bulk "index of refraction" *n* for the material. The index *n* is an inverse measure of the speed of the phase amplitude of light in a material. Knowing that *n* combines into one number the oscillator restoring force and emitter spacing, it probably wouldn't surprise you to know that in general, the denser a material, the slower the phase velocity of light through it, and thus the higher the index. The index of refraction of the vacuum is 1, air is 1.0003, quartz (an oxide of the light semi-conductor silicon) is 1.5, and flint glass (containing a high percentage of lead oxide) is 1.75.

Many different oxides are combined to make optical glass, and each element's atom's electron cloud has its own natural frequency. If you apply more math than I remember to solve an equation for the inverse phase velocity (*n*) of a wave passing through a medium of phase-delayed oscillators with different natural frequencies (λ), you get the following curves:

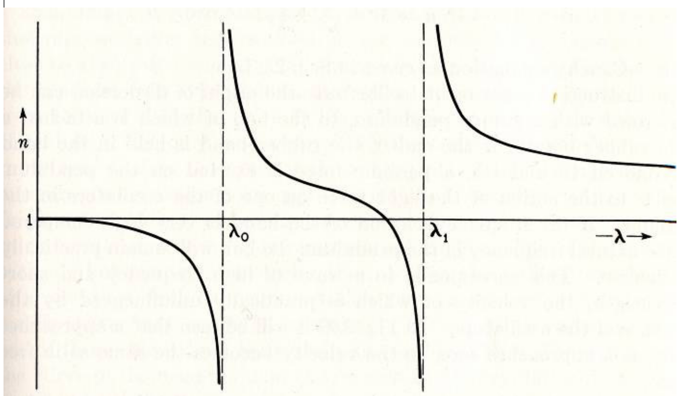


Figure 1. *Fundamentals of Optics,* Jenkins & White, pg. 473. Theoretical dispersion curves for a medium having two natural frequencies, λ_0 and λ_1.

If you insert into this equation numbers which correspond to typical optical glasses, you get a description of the index of refraction (n) as a function of the incoming wave's wavelength that looks like this:

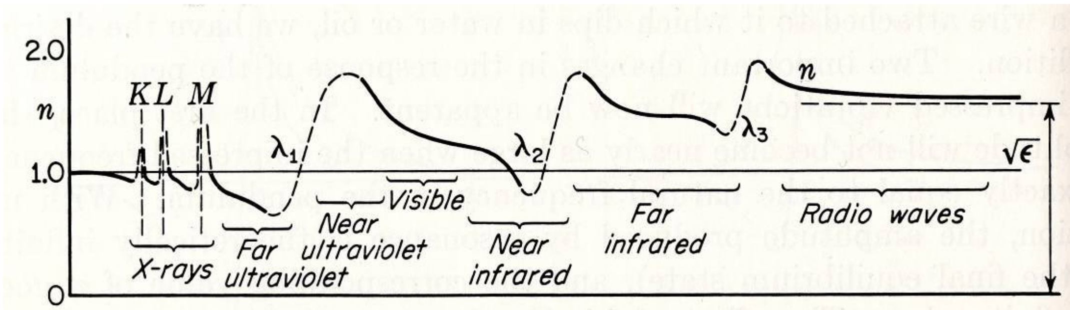


Figure 2. *Fundamentals of Optics,* Jenkins & White pg. 478. Full dispersion curve for a substance that is transparent to visible radiation.

Finally, if you zoom in on the visible region of the graph and plot the curves for different oxide mixtures (for different optical glasses, that is), you get this:

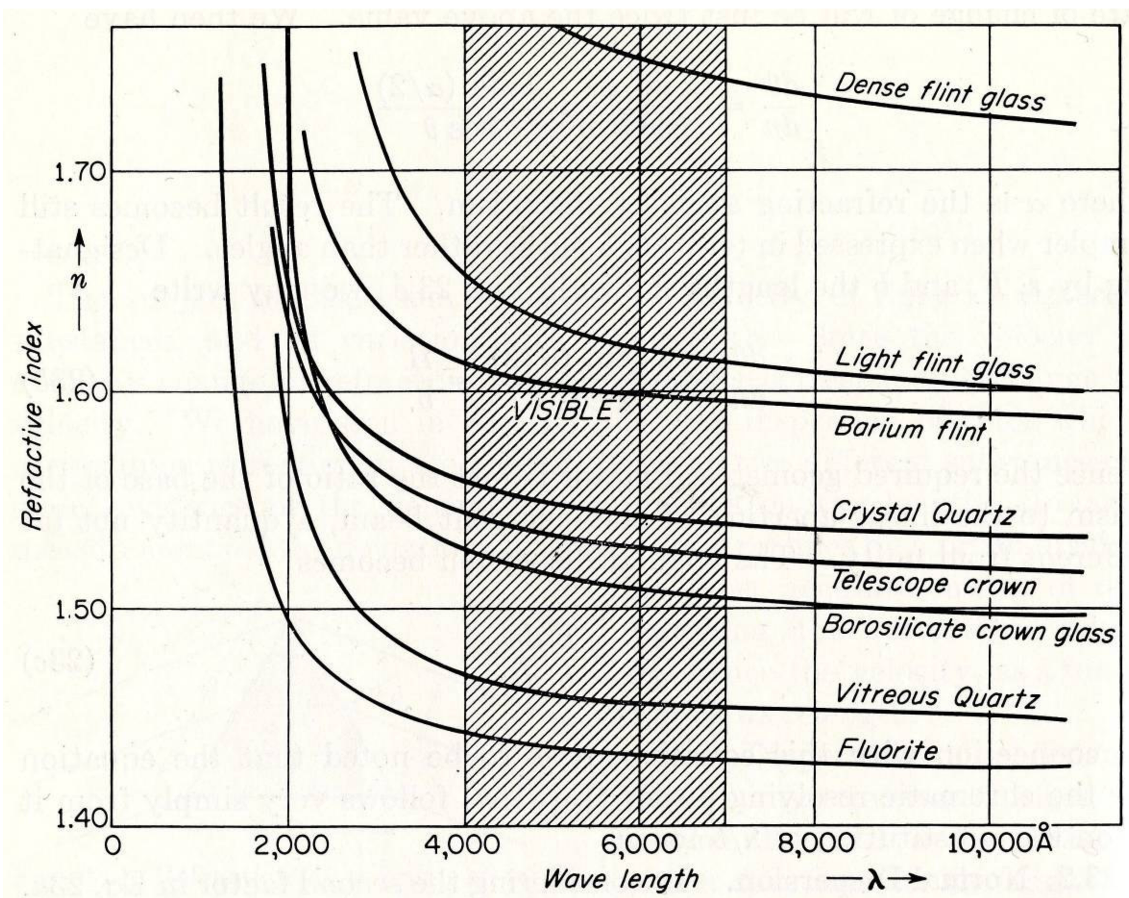


Figure 3. *Fundamentals of Optics,* Jenkins & White pg. 466. Dispersion curves for materials commonly used for lenses and prisms.

What does all this have to do with telescopes? The focal length of a lens depends on the lens' index of refraction. The index of refraction, and its variation with wavelength, depends on the material's exact composition. If you turn Figure 3 ninety degrees counter clockwise, you get the change in focal length with wavelength of a lens made of that material. The short blue wavelengths are focused closer to the lens, and the longer red wavelengths are focused farther away. Intermediate wavelengths trace a curve between blue at 4000 angstroms wavelength and red at 7000 angstroms.

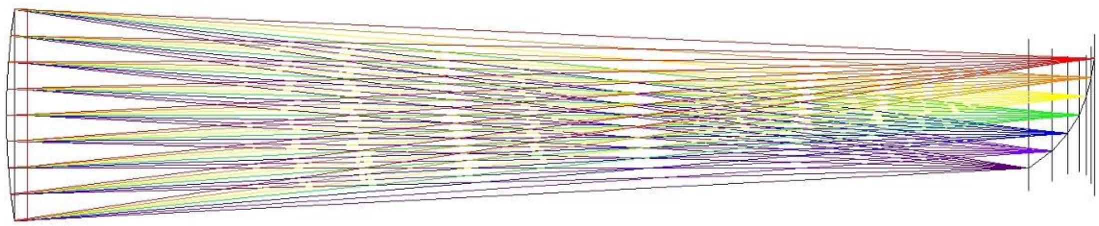


Figure 4. Longitudinal chromatic aberration of a single lens of Calcium Fluorite.

If you were making a refractor lens out of a single material, you'd choose the material with the shortest distance between the red and the blue foci to minimize the red and blue halos around stars. Of all the illustrated materials, that would be Fluorite, or Calcium Fluoride, although "Telescope Crown" works just about as well, which is to say, badly.

Newton looked at these curves, decided it was impossible to make a color-free telescope using optical glass because none of the curves were flat, and invented the reflecting telescope.

However, in 1729, a lawyer and amateur optical instrument maker named Chester Moor Hall succeeded where Newton had failed, and invented the achromatic refractor. Not being a lens grinder himself and wishing to preserve the secret of using two lenses of different glass types to make an achromat, he placed an order for the first lens with one Edward Scarlett of Soho and an order for the second lens with a certain James Mann of Ludgate Street. Both men then subcontracted the work to a gentleman named George Bass who, upon learning that both orders were ultimately from the same individual, put the lenses together, looked through them, and discovered the secret to achromatic refractors.

This is one argument for not subcontracting work that your livelihood depends upon.

For any one material, the distance between the red and blue focus points of a lens (which is called the dispersion) is directly proportional to the lens' focal length. If the focal length of the lens were zero, the dispersion curve would be compressed to zero. If you make the focal length negative, as it is in a negative lens, then the dispersion curve flips through zero, close to far. You might imagine that if you added a negative lens with a lot of color error (dispersion) to a positive lens with a little color error, the positive and negative dispersion curves might add to almost zero, while still allowing the positive element's focusing power to predominate and focus the light to a point. This is exactly what Chester Hall discovered and lost to outsourcing.

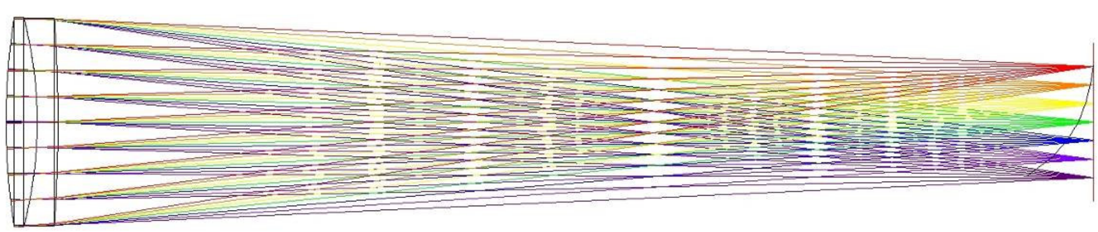


Figure 5. Longitudinal chromatic aberration of two lenses with different dispersions.

This is the end of Part I , Tom Ryan has promised to write 3 more parts and these will appear in your University Lowbrow Astronomers newsletter in the upcoming months.

2008 University Lowbrow Astonomers' Meeting Schedule

- **Friday, May 16, 2008.** Matthew Linke (University of Michigan Exhibit Museum of Natural History): Visit to the Planetarium at the University of Michigan Exhibit Museum of Natural History (weather conditions prevented some people from attending the March meeting, so we are trying this again). We will meet at the front of the museum (instead of at the Dennison Building). The museum is normally locked at night. However the door will be open about 7:15PM for our meeting and the meeting starts at 7:30PM. If you are a little bit late, you should be able to enter the building. If you are really late, you might not be able to enter.
- **Friday, June 20, 2008.** D.C. Moons (University Lowbrow Astronomers): "Welcome to the Moon, Part 1."
- **Friday, July 18, 2008.** John Kirchhoff (Rider's Hobby Shops): "New Equipment Show and Demo." This meeting will take place in room 402 of Sherzer Observatory. Sherzer Observatory is located on the campus of Eastern Michigan University.
- **Friday, August 15, 2008.** To be announced.
- **Friday, September 19, 2008.** D.C. Moons (University Lowbrow Astronomers): "Welcome to the Moon, Part 2."
- **Friday, October 17, 2008.** Mark Deprest (University Lowbrow Astronomers): "SLOOHing."

2008 University Lowbrow Astronomers' Open House Schedule

- **Saturday May 10, 2008.** *Cancelled if it's cloudy.* (Starting at Sunset). Open House at Peach Mountain.
- **Saturday May 31, 2008.** *Cancelled if it's cloudy.* (Starting at Sunset). Open House at Peach Mountain.
- **Saturday June 7, 2008.** *Cancelled if it's cloudy.* (Starting at Sunset). Open House at Peach Mountain.
- **Saturday June 28, 2008.** *Cancelled if it's cloudy.* (Starting at Sunset). Open House at Peach Mountain.
- **Friday, September 5 and Saturday, September 6, 2008.** (6:00 PM to Midnight). The 12th Annual "Astronomy at the Beach" at Kensington Metropark. Hosted by GLAAC (the Great Lakes Association of Astronomy Clubs).
- NEW **Sunday September 21, 2008.** (2:00-4:30PM). Open house at the Radio Telescope at Peach Mountain (hosted by the University of Michigan Astronomy Department).

2008 Other Events

- **July 2—5 Green Bank Star Quest V—**A (4) day/night Star Party in Green Bank, WV held at the (NRAO) National Radio Astronomy Observatory. Registration is required, for more information: www.greenbankstarquest.org
- **September 5—7 Black Forest Star Party**—A weekend Star Party in Potter County, PA held at Chrry Springs State Park (A Dark Sky Preserve) Registration is required and limited to the first 475. For more information: www.bfsp.org/starparty/index.htm
- **September 25—28 Great Lakes Star Gaze 6**— An extended weekend Star Party Near Gladwin, MI held at River Valley RV park. Registration is required, for more information: www.greatlakesstargaze.com

There are many other star parties being held in 2008, for a more complete list check:

http://www.skyandtelescope.com/news/3306276.html

Tolerance Limits

By Tom Ryan

Every other Sunday I get a visit from two men who are trying to infect me with a brain virus. It is what the Greeks called a *meme,* a thought pattern that takes over the operating system of your brain, make copies of itself, and causes you to infect others with those copies. As a virus, its actions are not unusual. It is an old virus, so it's virulent stage, in which it kills many or most of its hosts in its efforts to spread, is pretty much in the past. These men are already infected, and they say that their lives are better, now that they know One True.

I enjoy their visits for two reasons. One, I'm testing the limits of my immune system. (I almost never get sick) Two, I genuinely like and respect these guys, especially one of the men, Nate. He is, in my opinion, a truly Good Man. I want to know how he got that way, and whether I can copy it without accepting One True, which is my name for the virus. (He calls it something else.) Nate and I have been talking for a couple of years (that's one way the virus is spread), and I think he's getting discouraged at my resistance.

The last time Nate visited, he brought a different friend along to see if a slightly mutated copy of One True would be more effective at infection. His friend wore a suit that said he was conservative, reliable, law-abiding, and an upholder of society's rules. At least, the ones which don't conflict with One True. I immediately recognized him as a Guardian.

Let me explain. I have been reading a book called "Please Understand Me II", which I find very useful. Its author, Keirsey, classifies people into four broad categories, depending on how they can be expected to behave. The categories are Idealists (ten percent of the population), Artisans (40%), Guardians (40%) and Rationals (10%). I'm a Rational, who is a person who invents, discards the rules if they don't make sense, and tests everything for effectiveness. He was a Guardian, who never steps out of line, upholds convention, and is super-reliable. My wife is a Guardian. When she and I are together in the car and I come to a stop light that says "No Turn On Red", I'll sometimes turn on red. She hates that. I see it as a way to improve my life by saving a few seconds, and I'm willing to risk the consequences of my actions. She sees it as dangerous law-breaking. Both views are valid.

Guardians give society its rules and conventions. They tend to see things in Black and White, Good and Evil. Rationals see possibilities everywhere. They give society its hydrogen bombs, orbiting beam weapons, indoor plumbing and the Salk vaccine. Everything, in fact, that the Neanderthal didn't have. You can see how a stable society might end up with four times the number of Guardians as Rationals.

I explained this to my Guardian friend. He said that he didn't think there were shades of gray, there was only Black and White, and society would be better off if it were made up exclusively of Guardians. I asked him what he thought would happen to a group that lacked the capacity to change the rules, or evolve to adapt to changes in the environment? He said that there was no need to adapt, and evolution was a myth.

Bang! This triggered my immune response. I decided I'm safe against infection by One True.

This man was demonstrating no capacity for tolerance. In his eyes, the quality of his world would be ruined by allowing any thought deviance from that of One True. His copy of the virus was definitely an older, more virulent one. I, on the other hand, look at other *memes* as a potential source of code that can be incorporated into my own, so I can become stronger and can better cope with changing circumstance. Clearly, my *meme* is at a different stage of evolution than his. Maybe my *meme* is the Borg. I don't know. I do know that Lucifer means "Bringer of Light", and he is said to have definitely upset what was purportedly a previously stable system.

As a Rational, I value autonomy and tend to look at people as resources. I ask myself, "What is it about this person that I respect?" It seems clear to me that everyone has valuable characteristics, usually unique to that person, and to get those resources, you have to incorporate as many people, with as much variation as possible, into your *clade* (another Greek term – they knew their onions) to ensure success in whatever you are trying to do. Variation in thought and action is very, very good. Teams that don't have variety and depth usually fail for some silly reason.

However, in a system which does not have to adapt to a changing environment, variation is very, very bad. It almost always degrades performance if the system originally performed well. Genetic mutations usually kill their hosts, but are necessary to the continuance of life when the environment changes. As an optical engineer, I recognize that optical systems obey those rules.

Because all optical systems have design goals which are almost always made worse by variations in the way they are built, there is a whole sub-field of optical design called tolerancing. Performing a Tolerance Analysis on an optical system is intended to identify and set limits on variations to the point where they don't affect performance. It is the Nazi Germany part of the field.

Tolerancing determines how much variation is allowed. It examines the effect on system performance of component manufacturing errors, spacing errors, the effects of temperature, stress, vibration, and stray light. If you are building just one system, a tolerance analysis may not be so important. To some extent, you can build a system and adjust things until they work (unless your brain child is in space at the time the problem is discovered). How many amateur-built telescopes have you seen with two pairs of mirror cell mounting holes drilled in the tube, only one of which is being used to hold the mirror cell?

If a system is either expensive to build, or if it is to be built in quantity, then tolerancing becomes much more important. When you make large numbers of anything, manufacturing variances occur. When something is used by many people, they use it differently and under different circumstances. Tolerancing anticipates that, and accommodates it.

I've done tolerancing analysis for production systems, and it is a lot harder to make a successful design work correctly under varying circumstances than it is to design a single-use device. The great Jaguar V-12 engine designer Walter Hassan said that the requirements for powering a production vehicle were "more sophisticated and demanding" than those of a racing car, and in many ways, a $100 Canon camera lens is much more sophisticated than the Hubble telescope mirrors. If I had to put numbers on it, I would say that tolerancing a system is about four times more involved than designing the system in the first place.

Successful tolerancing usually feeds back into the design and changes it. It may be that a system which focuses light perfectly becomes terribly defocused when the temperature changes a little, but that same system can be redesigned to be much less affected by temperature if it doesn't focus quite so perfectly in the first place. There can be many trade-offs, many things affected, and designing a system which works under all circumstances requires a very complete and sophisticated understanding of that system.

It may be that someday, Rationals will design an optical system which can adapt to its environment. I think that would be nice. If the temperature changes, the system might change the curvature of its lens surfaces to accommodate that. This would be better than a zoom system. If you drop it, it would sense the fall and extend bumpers as protection against shock. A Rational would say, "If you can imagine it, it can probably, eventually be built". A Guardian might answer, "If it can fully adapt to changing circumstances, might it eventually eat the kids?"

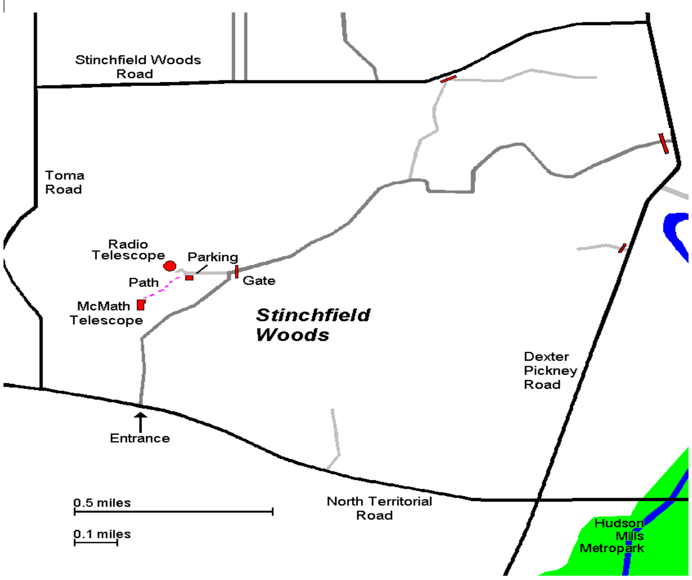
I don't know the answer to that. I'm tempted to say that it might eat some kids, as One True has, but its benefits should eventually outweigh its drawbacks. But I might be wrong. Finding the tolerance limits of a system is hard work.


GREEN BANK STAR QUEST V
THE QUEST CONTINUES
JULY 2,3,4,5, 2008
Join Us at the Largest Optical and Radio Astronomy Star Party in the Nation
4 Days Jammed Full of the Best Astronomical Speakers in America
2008 Star Quest Featured Speakers:
Scott Lever - JPL, Mars Exploration Rover Project • Dr. Amy Lovell - Comets and Dark Matter
Marni Berendsen - Night Sky Network • Dr. Jim Thieman - Radio Jove
Jimmy O'Dell Carol - Original Rocket Boy, Children Activities
Other Scheduled Presenters and Activities:
Tom Crowley, Sue Ann Heatherly, Mark "Indy" Kochte, Dr. Jack Littleton, Dr. Michell Shinn, Dr. Duncan Lorimer, Brent Maynard, Robert Royce, Dr Andrew Clegg
• Optical & Radio Astronomy Presentations
• Free shower accommodations available
• Bunk house available for rent
• Dark West Virginia skies in the radio-quiet zone
• Kids Activities, Great Vendors, Gift Shop
• Movies, Large Raffle, and First Class Presenters
• Nearby West Virginia tourist attractions
• Meet Green Bank Staff Radio Astronomers
• Learn to operate a 40ft radio telescope
• Radio Jove operation instruction
• High-Tech Tours of Green Bank NRAO
• NASA Multimedia Bus
• Swap Meet Saturday
• Rain – No Problem. All events are held indoors
4-day registration is $75 per participant, includes campsite!
For other registration options, and details visit our web-site www.greenbankstarquest.org
Green Bank Star Quest, PO Box 1862, Clarksburg, WV, 26301
Sponsored by: Central Appalachian Astronomy Club, Kanawha Valley Astronomical Society and National Radio Astronomy Observatory

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 Astronomer c/o Yasuharu Inugi

2981 W. Clark Rd
Ypsilanti, MI 48197

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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Reflections & Refractions

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NGC 2537 or Arp 6 one of the many peculiar galaxies visible in the night sky right now. This galaxy is 11.7 magnitude and also called the Bear Claw Galaxy, the challenge is to see the horseshoe shape and the mottled areas, dark steady skies and lots of power will help.

This image was taken by Mark S Deprest using SLOOH.

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Check your membership expiration date on the mailing label