# The ASTERISM

**Volume XVII No. 5** **February *2006***

## *From Chaos…* Order

by Bonnie B. Witzgall

On February 2nd, AAI sponsored a Science Night at the Amos W. Harrison Elementary School in Livingston, NJ. Spearheaded by AAI Research Committee Chair Ed Carlos, about ten club members agreed to produce an astronomy evening geared toward these young students and their parents. The two-hour whirlwind event was complete with live lectures, astro-displays, a Night Sky Network demo of gravity and black holes, examples of different meteorites and hands-on activities for the youngsters. There were also full models of different telescopes, free posters for all attendees and much AAI promotional material. After the show, the school's parental volunteers aided us in repacking our cars and thanked us for delivering such a dynamic experience. The Amos W. Harrison School PTA president Jo Ann Orsini also thanked us by donating $400 to AAI for our evening's labor.

Now - let me tell you the heartfelt story. It was a very emotional experience right from the start! Months ago, AAI Research Committee Chair Ed Carlos had this dramatic idea. He explained that the Harrison Elementary School always had an outside group sponsor a science night for their students and the school would pay said group for their efforts. He thought AAI could do this job by promoting an astronomical road show, presenting basic astronomy items and talks to the kids. The Club would then get some money, hopefully to help pay for the CCD equipment purchased by the Research Committee of AAI. To his credit, Ed warned us that in prior years, Harrison School Science Nights confronted audiences of over four hundred people and sometimes the young children became rowdy. However, in the interest of education and love for astronomy, the club agreed to partake in this new venture. After getting AAI's OK, Ed discussed this plan with the school's Science Night Coordinator Debbie Kane and made final arrangements.

Many AAI members helped set up several programs and exhibits targeted toward younger students and their interested parents. AAI was represented by Kim S. & Elvira P., Steve C., Al Z., Steve L., Nancy T., Anita G. and myself. Ed Carlos, leader of the AAI faction, brought several types of telescopes for display. Ray S. did a demo on black holes and Al W. spoke about space telescopes. They did their presentations simultaneously in different auditoriums so the overflow audience could split into two separate tsunamis. Both Ray and Al did a gallant effort to present their topics amid a noisy standing-room only crowd. Once their lectures were complete, an infinite barrage of youngsters and parents descended into the gym where AAI had its displays. The room was a cacophony of sounds, screams, tramping feet and challenging science questions. It was thick with visitors of all ages, sizes and different levels of astronomical interest. Steve C. and Al W. were constantly re-collecting their meteorite pieces from eager hands and answering so many questions. I was also behind the meteorite sample table, watching for pilfering fingers. In the middle of this noisy commotion, Ed's son Eddie took photos of the event. The teeming crowd made it impossible to see the other AAI members operating their own stations on each side of the room. I'm sure they too were besieged by the human flood, but they were sincere AAI members and so preformed admirably.

After what seemed like eons of congestion, the vast crowd finally began to disassemble. Once again, empty space appeared between the clusters of AAI members. Even at the last moment, parents lingered by our displays, asking admirable questions and gathering astronomical news. Our members were a bit shell-shocked by the new experience, but every AAI'er was glad to help Ed Carlos, his family's school and to promote astronomy. As we packed up our displays, we had our own tough science questions, like, Did any of us make contact with any of the attendees? Amid all that swarming chaos, did AAI actually pass along the flame of astronomy and spark a new interest in anyone's soul? Friedrich Nietzsche once said, "You must have chaos in your heart to give birth to a dancing star." I'm glad the Amos W. Harrison Elementary School officials were pleased with us. Yet, it would please AAI even more if we bestowed a little science and stability to the turbulent crowd. That would make such an emotional night worthwhile. Ω

The ASTERISM

**can be reached at editor@asterism.org**

Monthly Meeting

**Friday, February 17th at 8:00 PM**

in the **Main Lecture Hall**

This month our speaker will be

**Dr. B. Ivan Strom**

***Union County College and AAI Member***

*who will talk about*

★★★ **Light** ★★★

## *AAI Astronomy Day*

Saturday, April 29, 2006

*AAI will be holding its annual Astronomy Day at Sperry Observatory!*

*There will be talks, presentations, and weather permitting, solar observing and nighttime observing.*

Keep the date open!

## *Membership Dues*

| | |
|---|---|
| *Regular Membership:* | *$21* |
| *Sustaining Membership:* | *$31* |
| *Sponsoring Membership:* | *$46* |
| *Family Membership:* | *$5* |

*Sky & Telescope subscription: $32.95*

*Astronomy subscription: $34.00*

*First Time Application Fee: $3*

*Dues can be paid to the Club Treasurer or Membership Chairperson at the Observatory.*

# THEATER IN THE SKY

***by Ron Ruemmler***

March 2006 presents us with a very busy Moon. Every 18.6 years the inclination of the Moon's orbit combines with that of the Earth's axis to produce what is known as The Year of the Wild Moon. Every month this year has two weeks of extremely high Moon alternating with two weeks of a Moon that barely clears the southern horizon. This month the transitions of these two periods falls on the Full Moon and New Moon, producing two interesting eclipses, while the midpoints of these periods give us a very high First Quarter Moon and a spectacularly low Last Quarter Moon.

The First Quarter Moon comes first, just south of the overhead point around sunset. My sources disagree as to whether this is higher than the Last Quarter Moon this September, but both are impressive. Folks in southern Florida and Texas will actually have to look slightly north of straight up to see them.

Then comes one of the rarest and strangest of all eclipses. In a total or partial lunar eclipse, the Full Moon first enters the Earth's partial shadow, or penumbra, and then starts to enter the total shadow, or umbra. Since the penumbra is usually too narrow to enclose the entire Moon, part of the Moon hangs outside, in full sunlight, when the inner edge first enters the total shadow.

This month, however, the penumbra is unusually large and the umbra is exceptionally small since the eclipse occurs just after the Moon's attains its greatest distance from the Earth (apogee). Therefore, the Moon can just fit completely within the Earth's partial shadow. Furthermore, the Moon never enters the Earth's total shadow at all. So we have what I am calling a "Totally Penumbral Lunar Eclipse."

In a sense this is really nothing to get excited about. The penumbra is so hard to detect that only the part of the Moon nearest the umbra will show any visible darkening at all. Also this happens so soon after moonrise it may just look like ordinary horizon haze. Still, it's neat to think that you are looking at something that will not happen again until August 29, 2053!

The third lunar event is the exceptionally low Last Quarter Moon around sunset just after the beginning of spring. This is the southernmost Moon between 1987 and 2025. At 28.72 degrees south latitude, the Moon passes directly overhead around the center of South Africa. Seeing the Moon just 20 degrees above our horizon may not seem unusual until you realize that this is the highest point of its path.

Then comes the Total Solar Eclipse, running through Africa and central Asia. No part of this eclipse is visible from the western hemisphere except its very beginning at the eastern tip of Brazil. Ω

## *MARCH SKY CALENDAR*

| | | | |
|---|---|---|---|
| 1 | WED | 6:00 AM | Uranus passes beyond the sun into the morning sky |
| 1 | WED | 6:00 PM | Mercury far lower right of thin crescent Moon |
| 5 | SUN | 7:00 PM | Fat crescent Moon lower right of Mars and upper left of Pleiades |
| 6 | MON | 3:15 PM | First Quarter Moon |
| 6 | MON | 6:00 PM | Best time to see extremely high Moon from NJ |
| 10 | FRI | 7:00 PM | Saturn to right of Moon |
| 12 | SUN | 7:30 PM | Regulus upper right of Moon |
| 12 | SUN | 9:00 PM | Moon at apogee; maximum distance from the Earth |
| 14 | TUE | 5:51 PM | Moonrise (see next two events) |
| 14 | TUE | 6:35 PM | Full Moon |
| 14 | TUE | 6:47 PM | Center of Penumbral Lunar Eclipse |
| 17 | FRI | 5:00 AM | Spica just above Moon; occultation visible from Hawaii |
| 19 | SUN | 5:00 AM | Jupiter directly above Moon |
| 20 | MON | 1:26 PM | Spring Equinox; Sun crosses equator into northern hemisphere |
| 22 | WED | 6:00 AM | Best time to see low southern Moon from NJ |
| 22 | WED | NOON | Southernmost Moon possible; overhead from S. Pacific |
| 22 | WED | 2:10 PM | Last Quarter Moon |
| 25 | SAT | 2:00 AM | Venus at greatest elongation from the Sun in morning sky |
| 26 | SUN | 5:00 AM | Venus upper right of thin crescent Moon |
| 27 | MON | 5:00 AM | Mercury upper left of extremely thin cres cent Moon |
| 29 | WED | 5:17 AM | New Moon; Total Solar Eclipse visible from Africa and Asia |

# Stewart's Skybox

by Stewart Meyers

February is generally considered a boring month. And there has not been a whole lot of astronomical news lately that I haven't already touched on in previous columns. So, in an effort to literally broaden the scope of this column, this month will cover something outside the solar system.

Recently, the ESA's Integral mission answered a major question in astronomy. By measuring the abundance of a radioactive isotope of aluminum known as aluminum-26, it was possible to estimate how often supernovae occur in our galaxy. This is because aluminum-26 is produced in a roughly known quantity in supernova explosions and it has a short half-life. If the current amount of aluminum-26 can be calculated for the galaxy, it is possible to determine how often supernovae happen. The answer from these observations is about once every 50 years. Since the last supernova in our galaxy that was definitely seen from Earth was in 1604 (the supernova that formed the Cassiopeia A x-ray source might have been seen as a third magnitude star in 1680 by John Flamsteed, but this is very uncertain) either we have been missing them or we are way overdue. Instead of waiting for the next supernova, I thought I would discuss supernovae and novae in this article.

**Ancient Days and Confused**

Supernovae and novae have been going off as long as there have been stars in the universe. But, for most of human history, there has been no distinction made between the two. This is natural, since they look similar to the unaided eye. A star appears where no one has seen a star before and it quickly brightens. After a time, it gradually fades and disappears from view. For the ancients, this was somewhat frightening or at least puzzling. The earliest written accounts of these come from the Chinese. They, as well as the later Korean and Japanese observers, thought these were omens and interpreted them astrologically. The ancient civilizations of the West (Babylonian, Greek, and Roman) also noted supernovae and novae, but seemed to pay less attention to them.

Centuries later, the Asian astrologers were observing supernovae and novae, still interpreting them in the same fashion their predecessors did. But, in what was once the Roman Empire (Europe), things changed. Due to the decline of culture and the influence of Christianity with its acceptance of an Aristotelian cosmology with the heavens being eternal and unchanging, people were no longer interested in sudden, changing phenomena in the night sky. In fact, the main purpose of astronomy in Dark Ages Europe was to keep track of time and to set the date of Easter. However, Islamic culture was at its height during this time and Arab astronomers did make some observations. In fact, many of the older terms in astronomy as well as most of the star names are from the Arabic and date to this time. However, Arab accounts of novae and such concern themselves more with the impression the events made on the public rather than astronomical details.

**…Yond Same Star…**

Eventually Europe got out of the Dark Ages and people started to get interested in the natural world again. In 1572, there was a supernova in Cassiopeia and, this time, Europe noticed. Danish astronomer Tycho Brahe became famous when he wrote a paper describing the event in detail. The supernova of 1572 also influenced another historical figure. William Shakespeare apparently saw Tycho's book on the supernova. A reference to the star itself appears in the opening lines of *Hamlet*, and the names of some of Tycho's ancestors, Rosenkrans and Guildsteren, appear to have inspired the characters Rosencrantz and Guildenstern. Another supernova was seen in 1604 and was described by Johannes Kepler.

Even though astronomy was paying attention to things that go flash in the night sky, people still had no idea as to what these actually were. John Dee, court mathematician to Queen Elizabeth I, claimed that novae were stars that fell from their usual sphere. After a time, these fallen stars would rise back up to their proper sphere.

**Making a Distinction**

As astronomy matured, astronomers thought that all these "new" stars were just stars exploding like bombs. And this view persisted a very long time. However, it gradually became apparent that not all of these events were created equal. In the early part of the 20th century, it was noticed that some novae appeared in exactly the same spots as ones years before. Obviously, the process did not involve the destruction of the star. And in 1934, astronomers Fritz Zwicky and Walter Baade figured out that a supernova was the result of the collapse of the core of a star, which started to explain why supernovae were so bright and could even be seen in other galaxies.

As knowledge of stellar evolution and nuclear physics improved, astronomers made progress towards understanding novae, supernovae, and what kinds of stars were involved. But, this knowledge was very slow to spread. Many science fiction stories have been written where either the Sun or a sun-like star explodes in a supernova or nova. Even greats like Isaac Asimov (*The End of Eternity*) and Sir Arthur C. Clarke (*The Star*) were guilty of this. And as late as the 1960's, the *Star Trek* episode *All Our Yesterdays* featured a sun-like star that was about to explode as a supernova. But the truth was far more interesting.

**It Takes Two to Nova**

Contrary to what the above stories said, stars like our Sun do not go nova. That fate is reserved for certain binaries. In those systems, there is a white dwarf star in close orbit around a red giant. The gravity of the white dwarf pulls gas out of the red giant's extended atmosphere. This gas, mostly hydrogen, forms a disk around the white dwarf. When the gas reaches a critical density and temperature, it undergoes thermonuclear fusion. This is what we see during a nova. The disk is destroyed, but the involved stars are almost unscathed, though the red giant loses mass and the white dwarf gains a little mass, which may affect it later. The process then begins anew.

**Somewhat Big Bangs**

Supernovae come in two basic varieties, none of which involve stars like the Sun. The first type, Type I, results when a white dwarf star gains too much mass. As shown by Subrahmanyan Chandrasekhar, the maximum amount of mass a white dwarf can have is 1.4 times that of the Sun. If a white dwarf winds up with a mass over this limit, it explodes and is completely destroyed. These supernovae are of great astronomical interest because they seem to all have the same brightness, which would allow a means to determine distances to galaxies.

The other type, Type II, is different. When a star like the Sun runs out of hydrogen in its core, it contracts till the core gets hot enough to fuse helium. Once the helium is exhausted, the star will shed its outer layers and become a white dwarf. But, stars much more massive than the Sun have a different future. In such a star, fusion has to proceed at a fast rate to generate enough radiation to balance the gravity of the mass. When these stars run out of hydrogen, they too switch to helium. But, when the helium is exhausted, they switch to carbon fusion. A very massive star can work its way up the fusion sequence until it winds up with an iron core. Iron fusion does not emit energy. So, without the radiation pressure, the star and core collapse. At some point, the core either becomes a neutron star or black hole (it all depends on the mass – anything below 3.2 times the Sun's mass is a neutron star, above that is a black hole). When this happens, the outer layers of the star falling onto the new object cause jets to shoot out along the rotational axis. These, along with neutrinos and shock waves, shatter the star. This explosion is the supernova. The energy released is sufficient to form heavier elements from the iron, which are eventually scattered into space.

Supernova 1987a was a Type II. And since it was studied extensively with modern equipment, we see that the above description is essentially correct.

So, supernovae play a very important role in the universe, forming most of the heavier elements that we see around us.

**The Babylon Protest**

Even though science has had a fairly accurate picture of novae and supernovae, there are still some folks who should know better but just don't get it.

In the final broadcast TV episode of *Babylon 5*, it is implied that the Sun goes nova in about a million years and wipes out the solar system. However, something very rare happened. J. Michael Straczynski, the man who created the show and wrote most of the episodes, reported that he was bombarded with angry letters and E-mails from fans telling him that he screwed up and that the Sun could not go nova. As a result, Straczynski was frantically backpedaling and tried to claim that it wasn't a nova, just a nova-like phenomenon.

Nice to see the astronomers win one for a change. Ω

## Club Email Addresses:

*editor@asterism.org*
*Editor of* The Asterism
*membership@asterism.org*
*AAI Membership Chair*
*trustees@asterism.org*
*All three Trustees of AAI*
*exec@asterism.org*
*Executive Committee*
*ray@asterism.org*
*Ray Shapp for website matters*

## *Friday Night Talks at Sperry*

February 24. 2006
*Night Sky Network "Telescopes" Toolkit*
**--Ray Shapp**

March 3, 2006
*How Did We Get Our Crazy Time Scales?* **--Dr. Lew Thomas**

March 10, 2006
*Astronomical Themes in Currency*
**--Gordon Bond**

March 17, 2006
General Meeting: ***Clif Ashcraft,*** *The Tuthill Telescope*
--Gordon Bond

# *Sperry's 10-inch Refractor*: Good As New!

by Clif Ashcraft

You have a treat in store for you the next clear night you are at Sperry. We have a NEW telescope. Well, not exactly, but it works like new. What I am writing about is the 10" refractor. We have fixed the lens alignment problem that was causing a severe prismatic color in the image and now the image is truly just like it was when the telescope was installed 35 years ago.

I believe the problem has existed for at least 15 years. I first became aware of it when George Chaplenko called me after the lens had been taken apart for cleaning back in 1992, and then put back in service. He told me that something was seriously wrong with the telescope and thought that maybe the lens had been put back in with one of the elements reversed. Since I have become active in AAI again I have had a couple of chances to look at the image produced by the refractor and sadly, I found that I had to agree with our departed buddy George: something was BADLY wrong with the lens.

I gave the problem some thought and finally concluded that just putting an element in backwards could not account for the prismatic effect that I had seen. Similarly, rotation of one component relative to the other was unlikely to be the cause. There was no astigmatism in either of the components when they were made, and Dick Ulmes did not have to resort to the type of local retouching that Alvin Clark used to compensate for variations in refractive power in the glass available in his day: our blanks were quite uniform. I believe that as long as they were centered with respect to one another, our crown and flint elements should work together at any relative rotation. Something in the system HAD to be tilted.

The original collimation of the lens was done using a homemade Cheshire eyepiece. This is a simple tool: a 45 degree tilted white cardboard ellipse with a central viewing hole mounted inside a 1.25" tube with a side hole for shining a light on the ellipse. When you put this device in the focuser of a refractor and look along the axis of the tube through the hole in the ellipse, you see reflections of the white illuminated ellipse in each of the four surfaces of the achromat. If the lens is centered and properly collimated you see just one reflection, exactly in the center of the lens. If not properly collimated you see the reflections individually, spread out on a straight line. The direction of the line tells you which push-pull screws on the cell to adjust to make it right. That is what we did when we installed the telescope 35 years ago. I looked through the eyepiece while Dick Ulmes adjusted the screws. When we got it right, the image was excellent. There was secondary color, of course, but no lateral color and no prismatic effect.

A couple of weeks ago, I put together a Cheshire eyepiece like the one Dick and I originally used and Ed Carlos and I took a good look at the 10" refractor. Instead of the single reflection in the center of the objective, we saw four widely separated reflections spread across the whole aperture, indicating that the lens was badly out of collimation. We then pulled the objective end down to where we could reach it (pulling on the dew shield with the hook as usual), removed the dew shield and proceeded to make some adjustments. After making the adjustments to move the cell more nearly perpendicular to the tube (that's the way it used to be) we had another look through the Cheshire. Instead of being spread out nearly across the width of the lens, the spots were now much closer together, however, we could now see that they were not in a straight line with one another. This was much more serious. The only way it could possibly occur is if one of the lens elements were tilted with respect to the other. This is not something that can be easily fixed by adjusting the collimation screws.

How did the lens get this way? The only way I could imagine was that when the lens was put back together after the cleaning that had been done in 1992, one of the elements was jammed in the cell with a tilt. Then I noticed the real problem: there was a crack in the cell, perpendicular to the optical axis, extending all the way around. It was about 2 mm wide on one side and barely a hairline on the other. The cell was effectively bent about the optical axis, tilting the crown element in the front part of the cell with respect to the flint element in the back part of the cell by an angle of around 0.3 degrees. This was undoubtedly the source of the prismatic color and what was causing the reflective spots from the collimating eyepiece not to lie on a straight line.

When we built the telescope, we machined the cell from a 3" thick plate of aluminum alloy which we made up by taking two 1-1/2" plates and gluing them together "Metal Set" epoxy between them. The plate behaved like a monolithic plate, and we assumed it would always be that way. Evidently not: sometime during the first 20 years of service, the epoxy bond failed. I suspected that the practice of using "the hook" to pull down the objective end by the dew shield to remove the lens cap is the reason for the separation. It probably happened some cold night when the epoxy bond was brittle and someone yanked on the hook a bit harder than needed.

After the club meeting on January 27, several club members formed an *ad hoc* work

crew for the purpose of safely removing the cell from the telescope and scoping out the problem. We removed the dew shield, placed the telescope so the tube was pointing straight down, and lashed it to the pier. Then we placed the three-legged wooden mirror grinding table under the objective to provide a convenient safe support and, with about four sets of hands holding the cell to prevent it from falling, we loosened the screws holding the cell onto the flange at the front of the tube until they were no longer threaded into the cell and carefully lowered the cell to the table and carried it into the shop for study. We removed the retaining ring at the back of the cell and placed the front element of the objective over a small paper towel padded plastic pail and allowed the weight of the cell to pull it down from the lens components. We then lifted off the lens and spacers. Inside the cell we found a recessed bolt circle with positions for twelve holes, three of which (120 degrees apart) were drilled out and tapped for one inch long 1/4-20 Allen cap screws. Two of the screws were loose, and one was tight. The crack was open on the side of the loose screws. Our objective had been hanging together by the threads of one screw! We removed all three screws and the cell separated cleanly along the former epoxy bond line. I am not sure why we only used three screws rather than the full twelve that the bolt circle was obviously intended to contain. I suspect that Dick Ulmes installed three of them so he could use the cell to hold the optical components for testing during the final stage of figuring, intending to add the remaining nine screws before putting the cell on the scope, and somehow that job got overlooked, after all, the two halves of the cell were epoxied together and that should hold forever....

After looking the situation over and discussing it among ourselves, we decided to pull the cell back together from the inside using a ring of twelve larger stainless steel screws to replace the three small screws using all of the remaining positions in the bolt circle.

It took four work sessions to get the job done. In the first session Tom Koscica used the milling machine in the observatory shop to drill and tap the twelve holes in the bolt circle inside the cell to receive two inch long 1/4-20 stainless steel Allen cap screws. After installing the twelve screws and tightening them, the cell came back together with no visible crack at the former epoxy bond. While the lens was out of the cell we took the opportunity to clean the lens.

In the second work session, Tom and I drilled and tapped two holes in the upper end of the telescope tube for attaching eyebolts for QO's to grab with "the hook" instead of using the dew shield as a handle. Hopefully this will avoid breaking the new screws or putting further dents in the dew shield.

In the third work session, Ray Shapp and I reassembled the lens in the repaired cell and verified that the lens was correctly centered using an optical test with the Cheshire eyepiece. We viewed reflections in the optical surfaces from the apparent centers of curvature of each of the concave surfaces as seen from the front of the lens through the collimating eyepiece. In all cases the other three reflections were on the optical axis and superimposed upon each other in the center of the aperture. This is only possible if the lens is centered on the optical axis.

Finally, on Friday evening February 10, after the weekly meeting our group of volunteers carefully reattached the cell on the telescope and collimated it using the Cheshire eyepiece. To our great satisfaction we were able to easily center and superimpose all of the reflections from the optical surfaces. Several club members had the opportunity to observe how the objective is collimated and looked through the Cheshire to see the reflections before and after collimation. Although it was completely overcast when we finished, there were occasional sucker holes in the overcast through which we could get glimpses of the moon, so we quickly opened up the dome and took turns waiting for a chance to view of the now colorless image of the moon for a few seconds. NO MORE PRISMATIC COLOR!

Thanks to all the AAI members who participated in the project, particularly Tom Koscica who did the precision drilling and tapping for the bolt circle inside the cell. Thanks also to Phil Salimbene, Ray Shapp, Ed Carlos and Al Witzgall who participated in the testing, repair, cleaning or collimation, and also to Alan Zuckerman who rounded up the screws at Home Depot. Further thanks to all the hands-on volunteers (Kim, Elvira, Steve and Carl) who helped the effort by supporting the heavy cell during the ticklish removal and reattachment steps. You never dropped it even once!

We believe the defect in the cell has been present for at least 15 years, so if you are a relatively new member of AAI, you may have never seen our telescope working as it should. I recommend you make the effort to look through the telescope at the first opportunity. I believe you will be pleased. Ω

*Please see the next page for some photos of the reconstruction! The Asterism would like to thank, on behalf of AAI, Clif and the entire team who worked to resurrect the 10-inch to its former, and rightful glory. –Editor*

# Deflecting an Incoming Asteroid

## by Dr. Lew Thomas

I read with interest Stewart Meyers' well written article on incoming asteroids and how to get rid of them when needed. May I suggest an alternative method.

Attaching a space craft, even an ion propelled one, to a asteroid is fraught with many difficulties. Even if you do not break up the body upon landing, the slight gravity of the asteroid may not keep you there. In addition, most asteroids that have been measured are rotating, adding difficulty to the landing. Even if successful, the propulsion engine would have to be repeatedly turned on and off in order to defect in a given direction.

If we approach an asteroid without landing and position the spacecraft like a pendulum with the most massive portion nearest the asteroid, the craft will remain stable in orientation. With only very slight thrust the spacecraft can tow the asteroid in a desired direction using the gravity field of the asteroid itself. With such a gravity tow, we could alter the orbital course of the asteroid so as to miss the earth.

As an example, an asteroid 200 meters in diameter and having a density of 2000 kilograms per cubic meter could be towed with a thrust of just 1 Newton. The change in orbit for the asteroid would be slow but the beauty of this method is that it avoids landing problems and is completely independent of the material or structure of the asteroid.

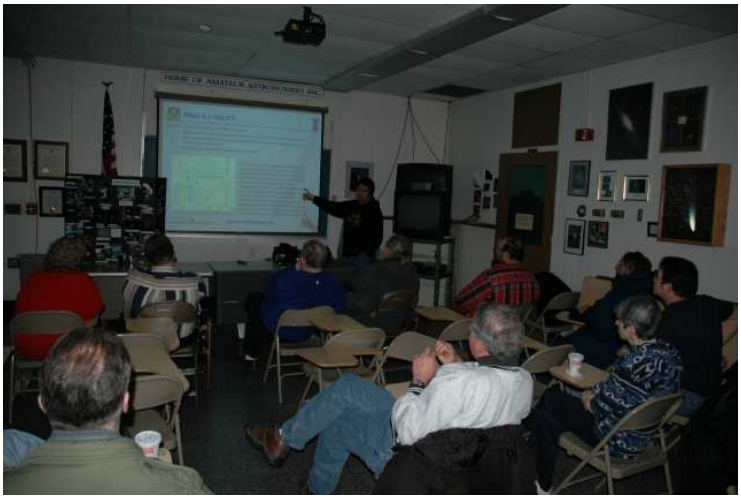
Now this is not just my idea. If you want to look at some equations for this venture, consult November's *Nature* page 177.

Ω

*As with dealing with most problems of such a large scale, the key to avoiding inevitable impact with an asteroid is to take care of it well ahead of time. A small effort now can meet or exceed the results of a much larger (if even technically feasible) effort later. This all indicates the strong need for asteroid detection and tracking, with an eye to earth-crossing asteroids which may someday become a threat. --Editor*

## Dome Duty Schedule

| | |
|---|---|
| **Feb. 24** | **Team A** |
| **Mar. 3** | **Team B** |
| **Mar. 10** | **Team C** |
| **Mar. 17** | **Team D** |
| **Mar. 24** | **Team E** |
| **Mar. 31** | **Team A** |
| **Apr. 7** | **Team B** |



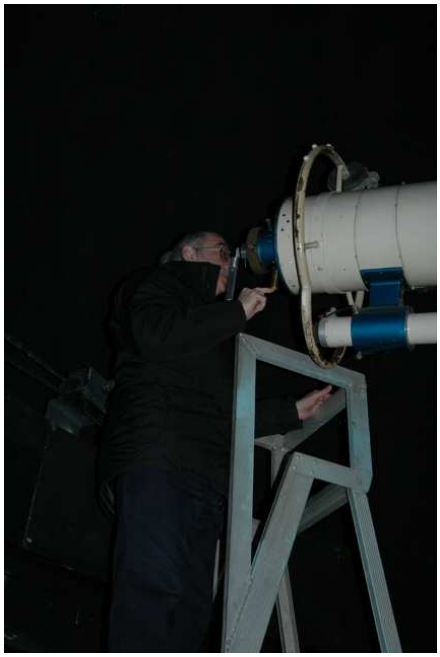
The assembled crowd gathers to discuss repairs to the 10-inch scope.

Clif Ashcraft peers through the eyepiece of the 10” scope.

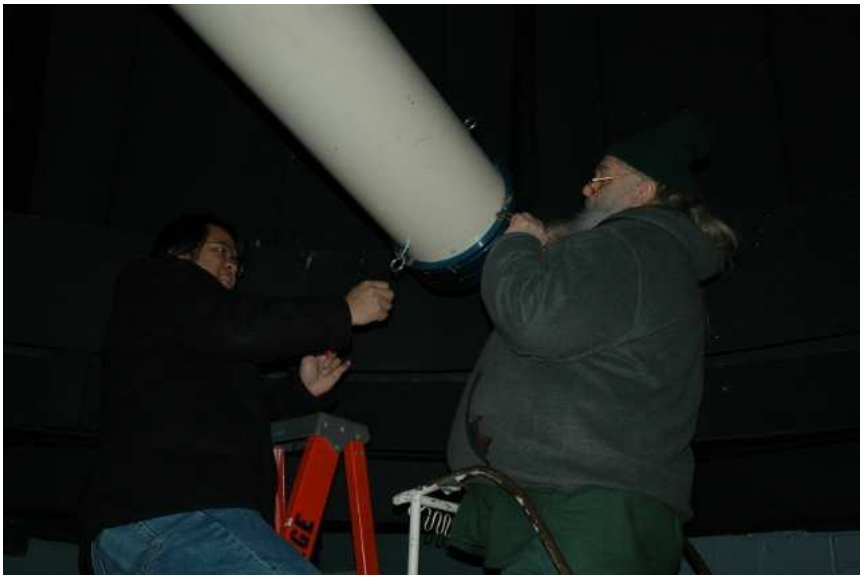
# Repairing the Ten Inch Scope:

## A Gallery

Special thanks to Kim Schoenholtz for these photos.



Al Witzgall, Qualified Observer Chairman, inspects the instrument.



Ray Shapp and Ed Carlos use some elbow grease to work on the scope.