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This Issue: *The New Inside Orbit*

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50 Years 1955 - 2005

The ***Inside Orbit*** is mailed quarterly to all members of the Grand Rapids Amateur Astronomical Association. Individual copies are available at the James C. Veen Observatory during Visitors' Nights. Non-member subscriptions are $5.00 annually.

The **Grand Rapids Amateur Astronomical Association** consists of over 200 members of all ages and levels on interest. The Association owns and operated the James C. Veen Observatory, an extensive observation and educational center. 2005 marks the 50th Anniversary of the GRAAA.

For further information, contact any of the people listed below; the GRAAA Starwatch number (897-7065), or the Association's website. Association brochures and applications are available upon request, or via the website.

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Crescent Earth as viewed from Apollo 11.
Image: NASA Archives

Clyde Tombaugh at work on the blink comparator at the Lowell Observatory, ca. 1938.
Image: Lowell Observatory Archives

The New *Inside Orbit*

The Future is not yet written

by Kevin Jung & Will Millar

As you are no doubt aware, since you are reading this, there have been some changes to the ***Inside Orbit.*** It's now electronic, with a new version being uploaded to the website with the same regularity as the printed version of the ***Orbit*** that you have been familiar with for many years. You will also notice that there is a format change as well. This is to better utilize the regular magazine/journal format that most publications use as a standard.

Like the changes that have happened to the observatory over the years (the new equipment), and the changes to the way the club is operated (updated By-Laws, new committee structures), there comes a time when even more changes are needed.

This is not the first time there have been major changes to the publication. The first ***Inside Orbit*** was printed over forty years ago, mainly by the juniors in the association. It was a few mimeographed pages mailed out to the members. It's been through many variations, from 8x10 pages collated and stapled by the juniors at the museum, to a small "booklet" in the 1990's (still mainly put together by the juniors), to what you see now. Through all that time, the main source of articles and information came from you, the members. There have been technical articles, basic articles, how-to articles, and just plain fun articles. Some have been hard to read or comprehend, while others give us a laugh. That, you can be assured, will continue.

If you remember, there were changes to the monthly newsletter back in January 2003. That month we started emailing the newsletter to the membership. The same reasons apply:

Convenience. It is easier for the editor(s) to put the ***Orbit*** together and then send it off right away to the members. The editor does not have to drive to various places to get the ***Orbit*** copied, folded, and then to the Bulk Mail Unit of the Post Office (on 33rd St off Patterson SE) to mail it with the Non-Profit Bulk Mail permit. Instead, this is all done at the computer.

Monetary Savings. To mail the ***Inside Orbit*** costs (each time) approximately $425.00. This includes the printing and mailing costs, and does not include any costs incurred by the editor in getting it ready for mailing (gas, etc.). By sending out the ***Orbit*** via e-mail, we save nearly $1700 per year in costs.

Time Savings. In order to get the ***Orbit*** out in time for the meetings (with our Bulk Mail permit), it is necessary to get the it mailed over 2 weeks early, due to the fact that Bulk Mail is not handled first – or expediently – by the USPS. It, in essence, gets delivered after all the rest of the mail is delivered. Hence the extra-long lead time. By using email, the ***Orbit*** can be sent at a time convenient to all, and to impart the most information in a timely manner.

Functionality. By sending the ***Orbit*** electronically, it is much easier to include references to any material that may be available online, by way of hyperlinks, thus giving members the opportunity to read further on a subject.

It's taken a few months to get everything in order for this change. New ways of editing, new computer programs to learn, etc. Since the new "Volumes" of the ***Orbit*** begin with the Spring Equinox edition, it was decided to make the switch with the Spring 2005 edition. And even thought we have made these changes after a great deal of thought, we would still appreciate any comments you might have on this change. Please feel free to contact anyone on the editorial staff if you have anything to contribute. Of course, we might always draft you for help in the future.☺

In a way it's fitting that we make this change now. This year marks 50 years that the GRAAA has been in existence, and we will be having some events during the year, culminating in the big get-together at the July Star-B-Que. We hope you like these changes, and will continue to support the club in whatever way you can in the future. It's the members that make the GRAAA work, and it's that dedication that will take us into the next fifty years.

Shedding Light on the Dark Side of the Universe

by Jacob Bourjaily

In 1933 the astronomer Fritz Zwicky discovered that galaxies on the outskirts of the Coma galactic cluster orbited substantially faster than could be accounted for by the gravitational attraction of all the stars in all the galaxies in the cluster combined. To account for the observed dynamics without overturning Newtonian gravity, he boldly proposed that the cluster posses an enormous abundance of non-luminous matter (roughly ten times more than the observed, stellar matter). To produce the cluster's rotation, however, this dark matter needed to be different from stellar matter in more ways than its brightness. In particular, the data is best accounted for if the dark matter behaves like an ideal gas, distributed evenly throughout the cluster, forming a halo-like cloud. The few astronomers perplexed by the situation must have hoped the problem would disappear: Zwicky's observations went largely ignored until the 1970s, when the rotation curves of thousands of other galaxies and clusters were studied only to show the problem is universal.

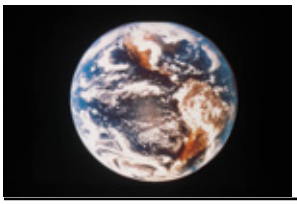
Today, evidence for the existence of dark matter is comprehensive and overwhelming: studies of the dynamics of galaxies and clusters, gravitational lensing, large scale structure formation, the cosmic microwave background radiation, and Big Bang nucleosynthesis all suggest that some 83% of all the matter in our visible universe is non-luminous. Furthermore, all of the data suggests that least a majority of dark matter must be composed of particles different from those that make up stars, planets, and people. Despite the magnitude of these observations, there is still no experimentally confirmed 'observation' of dark matter: if it is 'matter' at all, it is matter that has never been seen in any laboratory on earth. Yet there is hope.

The most widely accepted theoretical explanation for dark matter is that it is composed of weakly interacting massive particles (WIMPs). The popularity of this hypothesis is the result of a complicated mixture of circumstantial evidence, intuition, hope, and the impressive ease by which one can theorize the existence of new WIMP particles. Luckily, however, if dark matter is made of WIMPs, then there exist concrete ways by which they may be observed in the near future; so WIMP dark matter is a verifiable hypothesis. There are at least two ways to obtain concrete evidence for the existence of WIMPs: directly producing them at particle accelerators or by interacting with those already abundant in the Milky Way's galactic halo.

Like many of the universe's elusive particles, WIMPs could be produced at tomorrow's particle accelerator. Today, roughly nine thousand particle physicists are working hard to build what will be the world's most powerful collider at the Center for European Nuclear Research (CERN) in Genève, Switzerland. Called the 'Large Hadron Collider' (LHC), it will boast twenty-seven kilometers of superconducting magnets designed to propel two beams of protons into one another, with up to fourteen trillion electron volts of energy (about seven times the energy of today's most powerful accelerator at Fermilab near Chicago). These collisions will reproduce the extreme environment that would have existed seconds after the Big Bang. There are many reasons to hope (and some reasons to suspect) that if dark matter is made of WIMPs which were produced in the early universe, then the LHC will produce them too.

An alternative way to establish the existence of WIMPs is to directly interact with those in the Milky Way's galactic halo. Although they interact only weakly—being 'weakly interacting' massive particles—they may occasionally scatter off ordinary matter, leaving very small amounts of recoil energy. Today, dozens of experimental groups throughout the world hope to witness WIMPs in the halo interact with their extremely sensitive detectors, usually located deep underground to minimize the background radiation. One experiment has even claimed discovery (although the community remains quite skeptical). In a wide range of explicit WIMP models, these experiments will be able to observe dark matter soon..

Therefore, if dark matter is composed of WIMPs we may have experimental evidence for their existence in the coming years. In the meantime, however, some scientists have suggested many alternative explanations for (some of) the experimental data for dark matter. For example, perhaps Newtonian gravity is simply wrong at galactic scales. But explicit theories of modified Newtonian dynamics (MOND) remain somewhat unconvincing: because we understand Newtonian gravity as a weak-field limit of general relativity, modifying the derived equations of Newtonian dynamics seems terribly unjustified without an underlying replacement for general relativity. Some researchers have managed to modify Newtonian dynamics without disturbing general relativity, for example in theories with large extra dimensions. But these theories of course require the existence of large extra dimensions.



To the Humble of the Earth (and means)

by G.M. Ross

"Solid answers" from G. M. Ross, second greatest observer in Michigan, in the style of Dr James Dobson... only better.

As a boy, I suffered from a prejudice of my era and class which impeded progress in astronomy. The handicap exists to-day in others, and has become immeasurably worse, which I noted as long ago as the 1970s.

Hypothesis: To be in the swim of astronomy one needs a Really Dark Sky, or more erroneously, a Really Big Telescope. One remembers the sainted Ed Sullivan with his "really big shew." For example, my family owned a fine pair of 6X30 French binoculars since the 1940s, and I still have them much the worse for wear from carelessness bordering upon stupidity. With those binoculars I made my still treasured first drawings of the Sun and Moon. My father was intellectually curious and certainly technically adept, but did not know a whit about astronomy. It is not his fault, however, that with binoculars properly mounted and a half decent sky chart -- we owned Herbert S. Zim's ***The Stars*** -- one could have discovered wonders. We even enjoyed that Really Dark Sky at a family cottage. I, however, was a child of the Space Age who wanted "to go [boldly] where no man had gone before," in short to hit the big time like precocious cousin Mike. The result was a trip down that part of the management algorithm which my former friend Gary Michael Morin in his Ex-Cell-O days called "sit on ass."

This is not the place to examine my past errors. That may come as time and self-abasement allows. Returning to the opening paragraph, inaction excused by consumerism (one of North America's three secular religions) is errant rubbish. Last summer at the U. of M. Biological Station the great parasitologist Harvey Blankespoor (Hope Col.) glanced at the 1920s student microscope I had brought. Yes he said, primitive, without even a sub-stage illuminator, but in the old days researchers did "good science" with about the same tools. The following exploit refutes the opening hypothesis and should be read aloud to "junior" or "young" astronomers everywhere as well as the Riverside (Calif.) telescope meeting.

The 27th of January was yet another bitter spasm in this southern Michigan winter. I was in Royal Oak. On the finest summer nights from the stairwell window, one can see all of the "teapot" stars when Sagittarius is on meridian. *Nada mas.* To say the inner suburbs of Detroit are "light polluted" is gentle understatement, but inspired by Mark John Christensen (St. Charles, Ill.), the "Best in the Midwest," and lesser lights, duty called: I had to observe Comet Machholz, sorely neglected of late. The gibbous Moon had not yet risen, but there was also another time constraint. The Pleasant Ridge meeting of Warren Astronomical Society had already started, with its all-you-can-consume soda pop and dough-nuts policy. I had not eaten since afternoon at a McDonalds, so the junk food group quotient was running on empty.

My Royal Oak arsenal is *de minimis*, a home-made 55mm refractor with a (Korean?) war surplus Kellner eyepiece force fitted into the focusing tube. I make no apology for this Precambrian lash-up, but never carry the telescope eyepiece down against the... remote... possibility it will fall out. The telescope was assembled on a summer evening in 1973 in Dr Christensen's basement for the eclipse expedition to West Africa, but the tube of high quality aluminum still shines! It is mounted on an old Star-D camera tripod which I once backed over with my Renault 16. The fine tripod suffered as a result, but the she is a classic -- the best of the amateur rigs in the Heroic Era -- which I refuse to heave out.

Comet Machholz was high and practically due north at that part of its diurnal travel in early evening, very roughly between Polaris and the highly luminous Epsilon Cassiopeiae, 3.4 mag. in Earth's sky. (The constellation was an "M" at that hour.) "Very roughly" was apt because I was not quite sure where Machholz was, and sighting up the telescope impossible. Still in place up the tube was a square solar shield cut from a corru-

gated cardboard box for June's transit, and I was loath to make another one. In short, this was flying blind. An additional challenge was my refusal to use a diagonal with the eyepiece, a prejudice which began in the second Johnson administration, so I positioned the kitchen chair beneath the telescope which pointed very high up -- a strategy which might eventually require an orthopaedic surgeon.

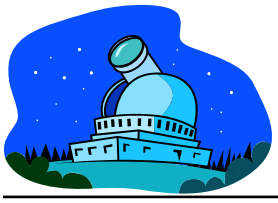
What horror! What do I *not* do for fun? Not fun, enlightenment. It was very cold. I had to dig out a place in the deep snow, and was required to position myself between houses to avoid the streetlight in front of the neighbour's as well as the bright porch light on the house across the street, an establishment rumoured to be engaged in criminal activity one must not repeat in print with a prudent eye on the tort of defamation. My cheap gloves were little better than rice paper when manipulating the metal of my "lighthouse to the sky."

Oh yes, I saw Comet Machholz. It was a... bear... but I saw it, and well. What a beautiful little thing at 22X. There was no tail visible, no surprise. It was perfectly round like many planetary nebulae, precisely studded at centre with a surprisingly bright coma/nucleus which heightened the effect. The object looked robin's egg blue, which might have been from the tinted/washed out sky or previous views sent over the wire by Dr Christensen or "Handsome Joe" McBride. Not to put too fine a point on it, the interplanetary traveler was a gem which anyone with a "modest" telescope could observe.

Like mediaeval drama, this discourse ends with a moral for the *Jacques Bonhommes.* Just go out and observe. Beginners in astronomy can do much armed with the right, if humble, reference materials. One does not need the Veen Observatory or the mythic dark sky of Newaygo County to observe this comet or any other. My old drinking buddy and formerly great amateur astronomer "Raimondo" a.k.a. Dr Rea *failed* to find Machholz from the West Indies with good binoculars a week before. Living in German Village and Ohio City associating with the great and near-great in government has damaged his skills. One does not need the buffet of high priced telescopes routinely seen in colour ads in ***Astronomy*** and ***Sky & Telescope***, neither necessary nor sufficient. Required is the initiative to use what is reasonably at hand. (Not having "cable" is a powerful spiritual boost.) To repeat, part of my incentive to get cracking before moonrise was the Pleasant Ridge meeting which was made, albeit late. I attacked the box of filled dough-nuts generously supplied by host Gary W. Gathen, having bloody well earned them whilst the *cognoscenti* had been inside discussing computers.

"...and for a time day and moonlight were mere blank interruptions to the one satisfactory reality of his life -- star-gazing. It was the deeps that had seized him, the immensities, and the mysterious possibilities that might float unlit in that unplumbed abyss. With infinite labour and the help of a very precise article in The Heavens, a little monthly magazine that catered for those who were under this obsession, he had at last got his opera-glass upon the new visitor to our system from the outer space. He gazed in a sort of rapture upon that quivering little smudge of light among the shining pin-points -- and gazed."

-- H.G. Wells, *In the Days of the Comet*



Remembering the Discovery of Pluto - 75 Years Later

by David L. DeBruyn

No, contrary to popular belief, I am not old enough to have "been there" for this historic find, but I can write about it from a personal perspective. While visiting the noted Lowell Observatory at Flagstaff, Arizona a few years ago, I actually stood under the "Pluto Dome," where I had my picture taken with the beautifully restored 13 inch astrograph telescope which captured the first unambiguous images of the ninth planet in 1930. Meanwhile, the informative Lowell guide related several "legends" about how it happened. The occasion brought back memories of an opportunity I had had back in the 1980's to hear the planet's discoverer, Clyde Tombaugh, personally tell his story.

It was on February 18th, 1930, that the young assistant at Lowell walked into the office of observatory director VM Slipher, and nonchalantly announced: "I think I have found your planet X" While suspicions persist that a tenth planet might still be out there, and many smaller Pluto-like bodies (The Kuiper Belt objects) have subsequently been found floating along the outer fringes of the Solar System, no other qualifying body has turned up in the past three quarters of a century.

At the time of my visit to Lowell Observatory, the media was abuzz with stories questioning whether Pluto legitimately qualified as a true planet. It has an oddly tipped and eccentric orbit, it is a dwarf with solid icy composition lying beyond the gas giants, and seems more closely akin to a huge comet nucleus or the largest member of the Kuiper Belt.

One of the foremost Pluto experts, resident Lowell Observatory astronomer Marc Buie, set me straight. He noted that the object is round, that it is larger than any of the Kuiper Belt objects in the region, that it orbits the sun, and that it has both a satellite and tenuous atmosphere. In Dr. Buie's opinion, Pluto clearly qualifies as Solar System's ninth planet.

Pluto first revealed itself as a faint object that jumped back and forth when two photographic plates of the same part of the sky taken a week or so apart were aligned and then examined in rapid succession. When plucked out of the starry background, it was the first new planet discovered in nearly a century, since Neptune in 1846. Will it remain the last discovered planet? With all the high tech equipment that now allows astronomers to probe ever deeper into space, its designation is far from secure.

We now know that Pluto is by far the smallest of the planets -- only two thirds the size of our own moon. Its size was determined with certainty only after the discovery of its single satellite, Charon, in 1978. Charon is almost half the size of Pluto itself, exerting a considerable gravitational influence which, when analyzed, reveals the mass and size of the parent planet.

Pluto creeps along its vast orbit in perpetual darkness and unbelievable cold. It has traversed only one fourth of its 248 year orbit since discovery in 1930.

Its core is thought to be a mixture of rock and ice, while its surface is an exotic veneer of mostly methane ice, with traces of nitrogen and carbon monoxide. While solar radiation at the distance of Pluto is exceedingly feeble and temperatures therefore extremely cold, some of this material is volatile enough to sublimate, forming a sparse atmosphere.

The search for what was dubbed the "Trans-Neptunian Planet" or "Planet X" began on two fronts early in the 20th century. While astronomer William Pickering and associates were searching out East, the ultimately successful quest got underway at Flagstaff under the direction of a somewhat eccentric Boston aristocrat turned astronomer named Percival Lowell. He had used part of his considerable wealth to build and endow in 1894 a private observatory under the extraordinarily stable air of northern Arizona. His primary purpose was to further his controversial theory that Mars was inhabited by intelligent beings. Lowell fancied that an advanced civilization had built artificial waterways -- the fabled Martian canals -- to carry water from the polar caps to more habitable regions near the equator.

In 1905, he also committed the observatory's resources to a search for Planet X, which he was convinced was "out there." Lowell noted that even when gravitational effects of Neptune are accounted for, the orbital motion of Uranus still departs slightly from prediction. Lowell ascribed this to the gravitational tug of a still more distant planet, and assigned to it a mass 6.6 times that of the earth. He presumed that it should be large enough to be visible in observatory telescopes if its approximate position could be determined. Lowell and his staff crunched the numbers and identified parts of the sky where the suspect planet was most likely to turn up. In 1905, they began a systematic and tedious search of suspect regions along the ecliptic, using a 40 inch reflecting telescope and other instruments.

Years passed and nothing was found. With staff interest and motivation waning despite Lowell's urging to press on with vigor, the search ended early in 1916, just months before Lowell's death. He was entombed on the grounds of his beloved observatory, unaware that the prized planet had actually been recorded as a tiny blip on some of the hundreds of photographic plates laboriously compared to one another. It escaped detection against the rich stellar backdrop because it was smaller, and therefore considerably dimmer, than expected from the calculations.

After Lowell's death, the search remained suspended, but not forgotten, for more than a decade. Late in the 1920's, then Lowell Observatory director Vesto M. Slipher initiated construction of what he considered a more suitable instrument for the quest. It was a thirteen inch "astrograph," a telescope capable of taking in a relatively large area of sky with a shorter exposure than had been possible previously, making for a more efficient search procedure. By late in 1928, the new telescope, set up in a small circular stone structure surmounted by a cylindrical wooden dome, was ready to go, but who would get the assignment to carry out another tedious search? Regular Lowell staff were unenthusiastic about volunteering for the proverbial search for a "needle in a haystack."

Slipher thought of a farm boy from Illinois who had sent him some sketches of the major planets taken through one of his home built telescopes. Impressed with the young amateur astronomer's enthusiasm, Slipher invited twenty-two year old Clyde Tombaugh to come to Flagstaff for a three month "tryout" as an observatory assistant. He stayed for the next thirteen years, becoming quite famous in the process.

Tombaugh was self taught. After being shone the routine, he was pretty much on his own, with other researchers too wrapped up in their own projects to be of much help. Beginning in April of 1929, Tombaugh kept doggedly to the task, using every clear night to methodically photograph suspect regions along the ecliptic. Then, during daylight hours came the tedium of squinting at pairs of images taken a week or so apart. They were first carefully aligned and then switched rapidly back and forth into view by way of a mirrored device called a blink comparator.

Ten months into his search, Tombaugh's "aha" moment finally came. In a region near the star Delta in the constellation Gemini, a faint star-like object was unmistakably "jumping" back and forth against the background of stationary stars when "blinked" with the comparator, clear evidence that it was orbiting the sun.

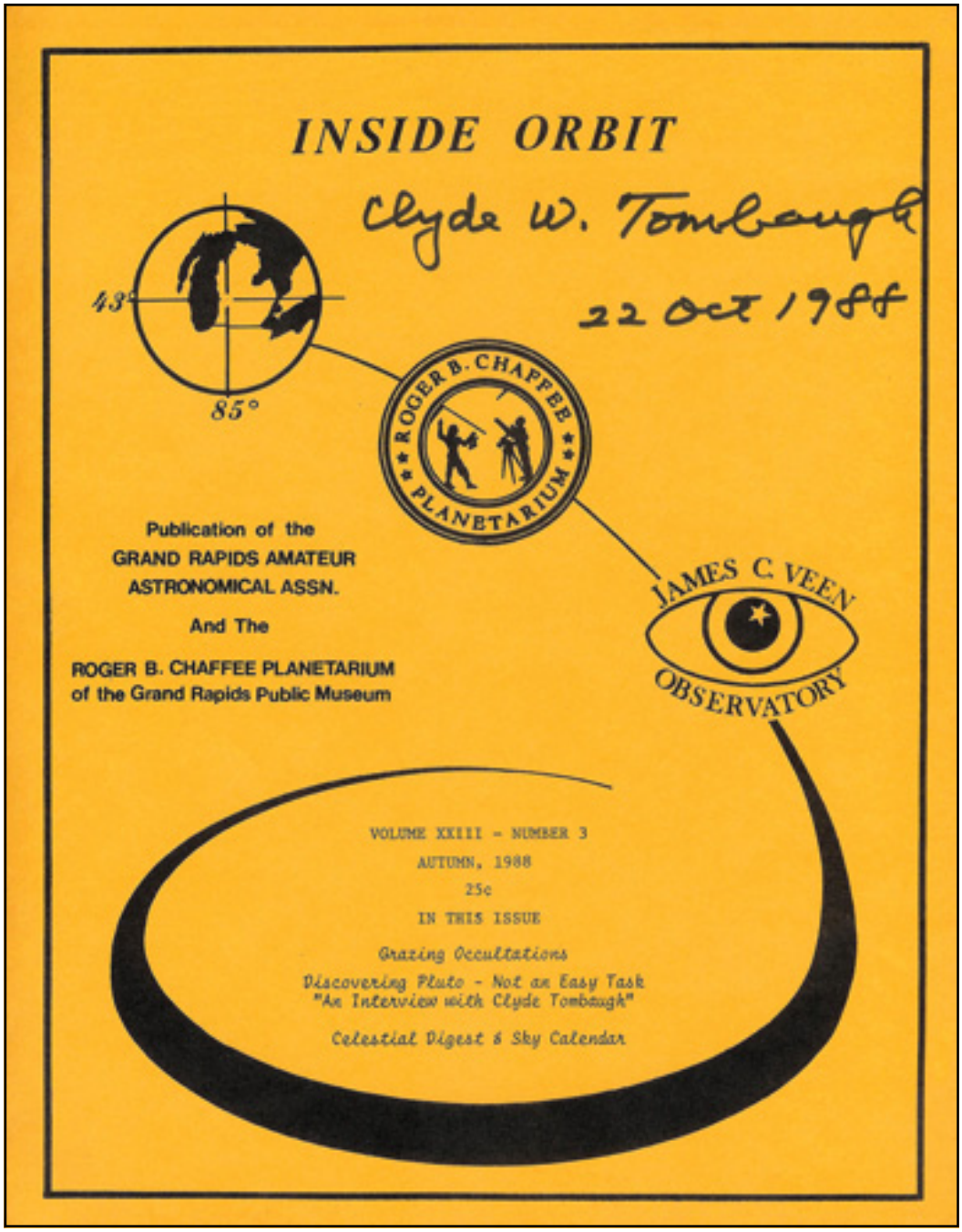
I remember well the octogenarian Clyde Tombaugh's humorous recollection of what happened next. The occasion was his banquet speech before a gathering of the Astronomical League in Peoria in the early 1980's. He recounted how he tried to be blasé as he walked into Slipher's office to report what he found, all the while his heart pounding and hands wringing wet with excitement. He had checked things out enough to be pretty certain that the 15th magnitude object was not a wayward asteroid or a photographic artifact.

Slipher and his associates were delighted and trotted right down the hall to have a look at the plates. While the images looked promising, they cautioned that careful follow up observations would be necessary before discovery of a new planet could be announced to the world. While Lowell's original calculations of where "Planet X" should be located had long been questioned by other astronomers, and did indeed eventually prove to be erroneous, the long sought object -- by coincidence perhaps -- turned up within six degrees of where Lowell predicted it should be.

Tombaugh recounted how difficult the period immediately following the discovery was for him

personally. He was anxious to make confirming observations, but a rash of cloudy weather and other misfortunes impeded him. The senior staff insisted that the new object be followed for awhile to be sure that it was a planet. Finally, on March 10th, 1930, Percival Lowell's birthday, discovery of the Solar System's 9th planet made front page news.

There followed a minor tempest surrounding the naming of the new object. Lowell's widow felt that "Percival" would be fitting, though the observatory staff, noting the names of the other planets, leaned toward something from mythology. "Zeus" was considered and rejected. Then, an eleven year old girl in England suggested "Pluto" the ancient God of the Underworld. The new planet is, after all, a dead ball of rock and ice that moves in its own domain of eternal darkness and cold. Its first two letters commemorate the initials of the astronomical visionary who, convinced that it was out there, initiated the search. Fitting indeed!



Left: Clyde Tombaugh was gracious enough to sign Ed Graff's copy of the Inside Orbit from the fall of 1988.

Image courtesy Ed Graff.

*Note: These articles are courtesy **NASA Space Place Program** at the Jet Propulsion Laboratory.*

A Different Angle on Climate Change

by Patrick L. Barry

Look toward the horizon in almost any major city, and you'll clearly see the gray-brown layer of smog and air pollution. Yet when you look straight up, the sky can appear perfectly blue; you might think there's no smog at all!

The smog is overhead as well, but it's much harder to see. Why is there such a difference?

It comes down to viewing angles: A vertical line straight up through the atmosphere crosses much less air than a line angled toward the horizon. Less air means less smog, so the sky overhead looks blue. On the other hand, when you look toward the horizon, you're looking through a lot more air. The smog is easier to see.

A one-of-a-kind sensor aboard NASA's Terra satellite capitalizes on this angle effect to get a better view of how clouds and air pollutants scatter and absorb sunlight. By doing so, this sensor—called the Multi-angle Imaging SpectroRadiometer (MISR for short)—is helping scientists fill in a major piece of the climate change puzzle.

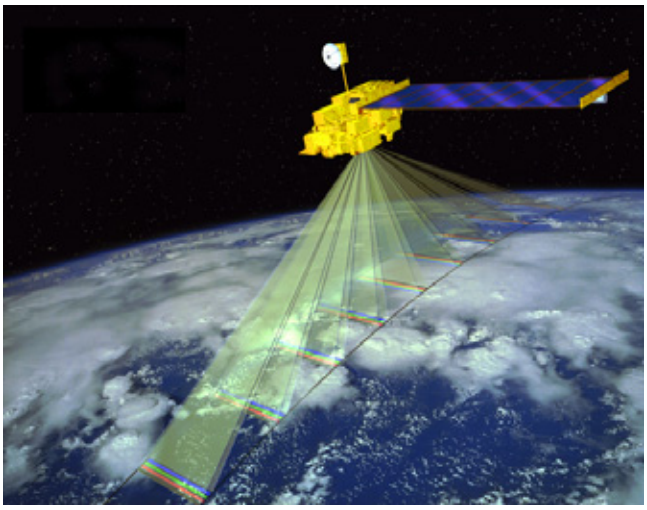
Most satellite instruments look only straight down at the Earth. Layers of airborne particles (called aerosols) and smog are harder to see with this vertical view, and clouds often appear only as two-dimensional sheets of white. Clouds and aerosols both can reflect incoming sunlight back out to space, thus cooling the planet. But they can also absorb sunlight and trap heat rising from below, thus helping warm the planet.

What is the net effect? MISR helps scientists figure this out by looking at the atmosphere at several angles—nine to be exact. Its nine cameras fan out across a range of angles from steeply looking forward (70.5 degrees from vertical), to straight down, to the same steep angle backwards. As the Terra satellite passes over a region, the cameras successively view the region at nine different angles.

From these data, scientists can construct a three-dimensional picture of the cloud cover, revealing much more about cloud dynamics than a flat image alone. They can also see light bouncing off aerosol pollution from nine different directions, thus getting a fuller picture of how aerosols scatter sunlight. And they can even spot thin layers of heat-trapping air pollutants that might go unnoticed by other satellites.

All this information comes just from looking at the atmosphere from a different angle.

For more information, see http://www-misr.jpl.nasa.gov. Kids can learn about MISR, see MISR images, and do an online MISR crossword at http://spaceplace.nasa.gov/en/kids/misr_xword/misr_xword2.shtml.



Caption: The MISR instrument on the Terra satellite views the atmosphere and Earth's surface from nine different angles.

Stardust Up Close

by Patrick L. Barry and Dr. Tony Phillips

Like discarded lumber and broken bricks around a construction site, comets scattered at the edge of our solar system are left-over bits from the "construction" of our solar system.

Studying comets, then, can help scientists understand how our solar system formed, and how it gave rise to a life-bearing planet like Earth.

But comets have long been frustratingly out of reach -- until recently. In January 2004 NASA's Stardust probe made a fly-by of the comet Wild 2 (pronounced "vilt"). This fly-by captured some of the best images and data on comets yet ... and the most surprising.

Scientists had thought that comets were basically "rubble piles" of ice and dust -- leftover "construction materials" held together by the comet's feeble gravity. But that's not what Stardust found. Photos of Wild 2 reveal a bizarre landscape of odd-shaped craters, tall cliffs, and overhangs. The comet looks like an alien world in miniature, not construction debris. To support these shapes against the pull of gravity, the comet must have a different consistency than scientists thought:

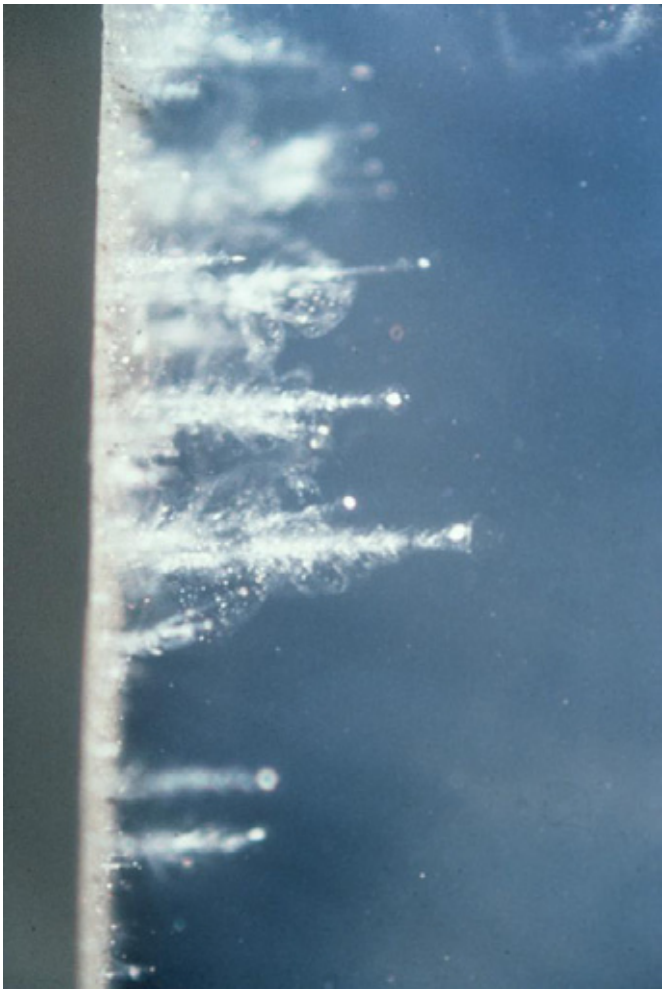
"Now we think the comet's surface might have a texture like freeze-dried ice cream, so-called 'astronaut ice cream': It's solid and can assume odd, gravity-defying shapes, but it's basically soft and crumbles easily," says Donald Brownlee of the University of Washington, principal investigator for Stardust.

Scientists are currently assembling a 3-D computer model of this surface from the photos that Stardust took. Those photos show the sunlit side of the comet from many angles, so its 3-dimensional shape can be inferred by analyzing the images. The result will be a "virtual comet" that scientists can examine from any angle. They can even perform a virtual fly-by. Using this 3-D model to study the comet's shape in detail, the scientists will learn a lot about the material from which the comet is made: how strong or dense or brittle it is, for example.

Soon, the Stardust team will get their hands on some of that material. In January 2006, a capsule from Stardust will parachute down to Earth carrying samples of comet dust captured during the flyby. Once scientists get these tiny grains under their microscopes, they'll get their first glimpse at the primordial makings of the solar system.

It's heading our way: ancient, hard-won, possibly surprising and definitely precious dust from the construction zone.

Find out more about the Stardust mission at stardust.jpl.nasa.gov. Kids can read about comets, play the "Tails of Wonder" game about comets, and hear a rhyming story about aerogel at http://spaceplace.nasa.gov/en/kids/stardust/.



The Stardust spacecraft used a grid holding aerogel to capture dust particles from comet Wild 2. In this test, high velocity dust particles are stopped unharmed at the end of cone shaped tracks in a sample of aerogel

The Alpha Stars

by Fritz Lowe

Alpha Cygni

Alpha Cygni is a massive star. Known to us by the Arabic name 'Deneb', meaning "tail", it is the "brightest" star in the night sky – 500 times brighter than Sirius. OK, I should not use the word "brightest"; but it did get your attention. Alpha Cygni is the most "luminous" star visible to us as we look up at the summer sky. It is over 100,000 times more luminous than the sun. If it were as close as Vega (25 light years), it would be as bright as the crescent moon. It would even be visible in the daytime and would have been a significant aid to early navigators.

The light we see from Deneb left the star 3200 years ago while Moses was talking to God on Mount Horeb. It is the most distant of the 400 brightest stars in the sky. It is a younger star than our Sun, yet it is burning so hot that it will burn out and die long before the Sun. Deneb is so large and hot that the Earth would have to orbit it in an orbit 6 times more distant than Pluto in order for life to survive the intense radiation emitted by this star. Its stellar wind is over 1000 times more intense than our star, and in 8 minutes, Deneb emits more radiation than the sun produces in a year. Alpha Cygni has already consumed most of its hydrogen and is now fusing helium into carbon and oxygen. In another million years it will expand into a red supergiant and appear a lot like Arcturus in the summer sky.

There are several myths in Greek and Roman literature that explain the flying swan in the northern sky. The most popular is the story of Leda and the Swan. But the legend that I wish to tell is Ovid's story of the young and reckless Phaeton and his friend Cycnus. The following is condensed from Thomas Bulfinch's wonderfully told version of Ovid's fable (bulfinch.org), and other internet sources.

The sun god, Helios, has an affair with the beautiful sea nymph Clymene, which results in the birth of her mortal son Phaeton. As a youth his mother confides to him that his father is the famous god who drives his solar chariot across the sky each day. When Phaeton brags of this to his friends, they mock him and call him a liar. He comes home crying to his mother and asks her why he has never met his father. Failing to answer his questions, she suggests that Phaeton make a journey to his father's great palace in the East and that he ask him in person if he will own him as a son.

So Phaeton sets out on his journey with his best friend Cycnus, traveling east to India. There they find the magnificent and radiant palace of Helios, glittering with gold and precious stones. The doors are silver and the columns and ceilings are polished ivory. There are beautiful murals depicting the Earth and its animal inhabitants. And in the lake surrounding and within the palace there are beautiful nymphs riding on the backs of fishes.

Phaeton enters the great hall and attempts to approach the throne of his father, but the light shining forth is more than his eyes can bear. He stops and speaks out "O light of the boundless world, I beseech you, my father, to acknowledge me as your son." Helios replies, "My son, you deserve not to be disowned. I confirm what your mother has told you. To end your doubts, ask what you will and the gift shall be yours." After little thought, Phaeton asks that he be allowed to drive his father's sun chariot across the sky for a day. His father at once repents his promise and tries to convince his son that this is a foolish and unsafe idea. "You are mortal, and what you ask is beyond a mortal's power. Only I have the skill to drive the fiery chariot on its treacherous journey each day. The road rises steeply and descends rapidly. It passes through the midst of frightful monsters, so I have to be perpetually on my guard. The road passes by the horns of the Bull, the jaws of the Lion, and between the pincers of the Scorpion and the Crab. This, my son, is a fatal request." But Phaeton rejects all of his father's warnings and holds to his request.

Needless to say, at dawn the next day when the chariot sets out with Phaeton at the reins, the

(Continued on page 12)

Beginning the Adventure
(or, how I got interested in Astronomy)

by Jeff Kozarski

A Recollection of my early astronomical observations

The following is an account of how I got started in astronomy. I'd say I got bit by the astronomy bug while in the 3rd grade. I received a couple of books in the Christmas of 1979. One book was simply called "Stars & Planets" by Keith Wicks. The other book was from the classic Golden Guide series: "Stars". I remember cutting out newspaper articles about astronomy and putting them in a scrapbook, which I still have. I brought an article from the paper to school about the Voyage spacecraft at Jupiter as part of show & tell in the 4th grade.

My parents could see I had stars in my eyes and got me a telescope for Christmas in 1980. It was a 3" reflector made from a cheap plastic tube on a metal tripod. The eyepieces were plastic too. It even came with a Barlow lens. As cheap as it was, this telescope provided me with some pretty respectable views. The optics weren't all that bad. I was limited to the moon and planets. I didn't have the foggiest idea how to find deep sky objects though I could identify most of the major constellations thanks to books like H.A. Rey's "The Stars". That book also helped me better understand some basic celestial mechanics.

My first good memory of using this scope came from observations of Venus during 1981. I had received my first copy of "Astronomy" magazine that month, the December issue. I was in the 6th grade and our class was selling magazines. Curious about this "Astronomy" magazine, I saved up $9.99 for a six-month trial period and subscribed. Now I could follow the planets every month! I already knew the bright "star" in the evening sky was Venus. I was watching it during the fall. Venus was approaching inferior conjunction in January 1982 so it was getting larger and more of a crescent phase. I remember dragging out the scope every clear and semi-clear night in December gazing at Venus. Also during December every Sunday night PBS was re-airing Carl Sagan's "Cosmos" series. I remember setting up a tape recorder next to the T.V. to record the audio.

Now before the whole Venus thing happened I was also observing the great Jupiter-Saturn triple conjunction. This was a series of three close conjunctions of Jupiter and Saturn throughout 1981. The events occurred while the two planets were in Virgo the Maiden.

1981 was the banner year of astronomical observing for me with Jupiter, Saturn, and Venus looming. I also recall visiting another place that deals with observing stars & planets. In fact I begged my parents to take me there. I read the articles in the newspaper (written by some planetarium curator guy that I would later meet 4 years later) about it. Finally during the last week of August; during one of their annual open house weeks, my parents took my brother & me to the James C. Veen Observatory. It seemed really far from Grand Rapids, out near Cascade & Lowell somewhere, wherever those places were. At the time I was just a young lad of 11 years. There I got to look through the massive 12½" Borr Reflector.

1982 was another memorable year of observing. This year Mars, Saturn & Jupiter were all strewn about Virgo. Mars was near the western end; Saturn lay near Spica & Jupiter was actually just barely in Libra. Venus had swung around into the morning sky and I would occasionally notice it before school. I don't remember observing Mars, mostly because it probably didn't look like much in my telescope.

I do remember observing Jupiter & Saturn, however. I especially remember observing Jupiter in the spring & summer of 1983. Now Jupiter had moved into Scorpius the Scorpion. I was awed at the sight of the massive disc of Jupiter & its colorful cloud bands striping across the planet. I used my astronomy magazine to determine what Galilean moon I was looking at. I remember observing Jupiter in June of '83 only because it was during exams at school. I guess I was studying all right! (I did pass in case you were wondering).

In May of 1984 there was an annular eclipse of the Sun. I can remember viewing it with everybody at school.

The next year (1985) was another milestone for me, the next step to further pursue my passion for astronomy. I read yet another of the "West Michigan Skies" articles in the paper. It said there was an astronomy class at the Chaffee planetarium on Jefferson Street that would meet Saturday mornings in the spring. I signed up & my mom would take me there every week. The curator told us about an observatory (which I remember visiting several years ago) that the class would go to as a field trip. He also told us about an astronomy club, the "Grand Rapids….something, something Astronomers?" It was a long name but was simply called the "GRAAA". I guess I convinced my mom that I should join this group of astronomers. They had a junior section just for young people like me. I was 15 years old and that was 1985. I joined the GRAAA in the summer of that year. So I guess just as the GRAAA celebrates 50 years as an organization this summer, I will be personally celebrating 20 years as a member of this wonderful association.

Dave DeBruyn was the curator of the planetarium (as you may have guessed) back then and was the first person in the GRAAA I met. I also have some good memories of my first observations at the Veen Observatory. One of the nice things Dave did was to personally take the young junior members out to the observatory on a one on one basis. He would show us how to use the 12" Borr telescope. There was one memorable August evening in 1986 that Dave & I observed Mars, which was about a month past opposition. "It's really bright" I would tell him. Though I understood what opposition was & that Mars was relatively closer at some oppositions than others, I had a hard time observing Mars telescopically. "That's Sinus Meridiani & there's Syrtis Major" he told me. Observing Mars is difficult as I soon realized that Dave had many Mars oppositions over me going all the way back to 1956.

All in all I've had a memorable past in astronomy. Starting alone and meeting people along the way was how it went for me.

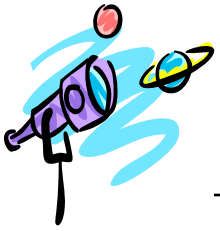
The Alpha Stars...
(Continued from page 10)

journey across the sky is a disaster. The horses do not respect Phaeton's attempts to control them, and soon the chariot leaves the celestial road and goes wildly across the sky, reeking havoc in the heavens and setting the Earth on fire. At last Earth, herself, cries out for the destruction to be stopped. She beseeches the gods not to let heaven and earth be destroyed by fire. For if this happens, all creation will return to chaos. Hearing her plea, mighty Jupiter climbs to the top of his lofty tower and hurls a lightening bolt at the chariot, striking Phaeton and sending him ablaze falling from the sky into the river Eridanus. Here his body is shattered and broken.

Seeing his friend fall in flames from the sky, Cycnus' heart is broken and he weeps at his loss. In order for Phaeton's soul to travel to the afterworld, Cycnus must give his body a proper burial. He goes to the river and dives in repeatedly in order to retrieve all of Phaeton's body and bones. Watching from Mount Olympus, the gods are deeply touched by Cycnus' loyalty to his friend. As he swims under water looking for Phaeton, he appears to the gods like a swan looking for fish.

After he succeeds in giving his friend a proper burial, Cycnus remains outside the palace of Helios and continues to mourn and sing the agony of his loss. Taking pity on him and to immortalize his devotion, Jupiter transforms Cycnus into a swan and sends him to his immortal place in the heavens.

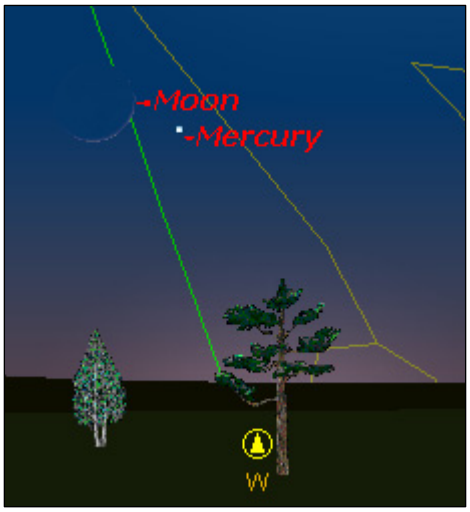
For many cultures, Cygnus has represented a bird in flight or a bird swimming in the river of the Milky Way, which in earlier times was known as the river of Eridanus. But it is not always seen as a swan in every culture In Arabian lore, the bird is the now extinct Roc, a huge and powerful bird that rescues Sinbad from a shipwreck. Later, the Arabs referred to the constellation as "the hen" from which we have the full name for Alpha Cygni "Al Dhanab al Dajajah" (the tail of the hen) which through translation has become the more current "Deneb el Adige", to distinguish it from the other seven stars which in their Arabic name contain the word Deneb.



The Solar System: Spring, 2005

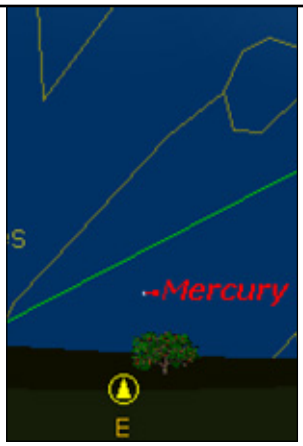
By Jeff Kozarski

Mercury will put on a fine appearance in the evening sky during the first half of March, and be the best evening apparition this year. Greatest elongation occurs March 12, but don't wait until then to start looking for it. On the evening of March 11th, Mercury pairs up with a young crescent moon. Look west a half-hour after sunset.

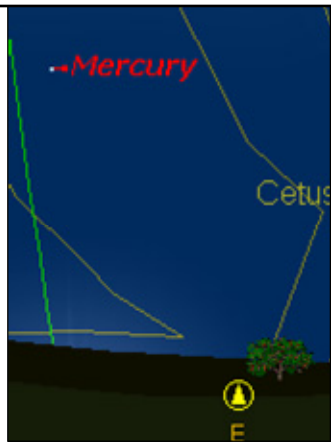


Mercury is brightest as it emerges from the Sun's glare in early March. It is about 11º high and shines yellowish at –0.3 magnitude. You can watch Mercury climb higher each evening during the first days of March, being highest on the 12th then steadily dropping each evening as it dives for inferior conjunction on the 29th. A week after inferior conjunction it has already dimmed to +1.5, making naked eye observations somewhat difficult to see in the bright twilight.

Mercury will move into the morning sky during April where it will be quite low in the twilight and nearly impossible to view. Even ½ hour before sunrise on the date of greatest elongation (*April 26th)* it is about 3º high. Lucky observers from -30ºS will see Mercury about 20º high a half-hour before sunrise. Compare the two views of Mercury. Left is 40ºN and right is 30ºS latitude at ½ hour before sunrise on April 26th.



40ºN Latitude



30ºS latitude

Venus is lost in the solar glare most of this spring. It reaches superior conjunction on March 31, where it will be on the opposite side of the Sun from us. Therefore it will take some time for Venus to slowly emerge from the solar glare. You might notice it low in the WNW by May 1st when it sets only 40 minutes after sunset and only 6º high *at* sunset. Binoculars will help spot the –3.9 magnitude planet. By the end of May Venus is setting 1 hour and 20 minutes after sunset and has doubled its elevation to 12º at sunset.

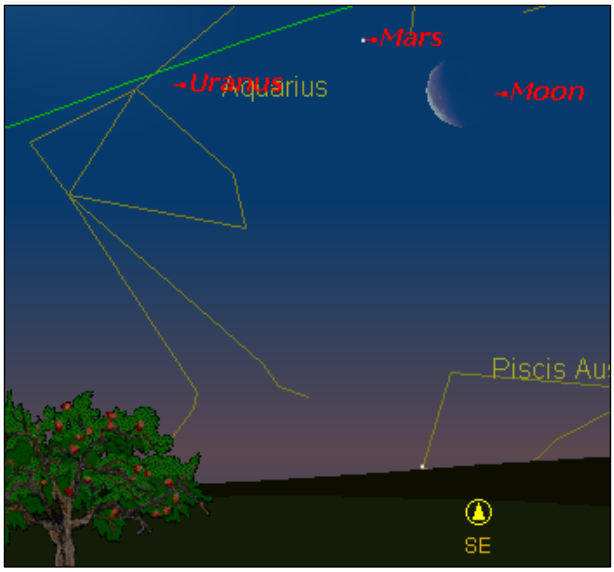
∗Vernal Equinox occurs March 20th at 7:33 am EST
∗New Moon occurs March 10, April 8, and May 8.
∗Full Moon occurs March 25, April 24, and May 23.

Mars is a morning object rising around 4:30 am. in mid-March. It will continue to brighten throughout the spring, rising noticeably earlier each week. Mars is also moving northward along the ecliptic, having reached its lowest declination back in February, which is good news for northern hemisphere viewers. Mars will reach opposition this year in early November where it'll be about 15º north of the celestial equator as opposed to 15º south as it was during the August 2003 opposition. In that respect, this year's opposition will be more favorable than the past one. It crosses into Capricornus on the first day of Spring and moves into Aquarius by the end of April. From then on, Mars will have a higher dec-

lination then when it was last closest to us.

Although Mars brightens from magnitude +1.1 to +0.3 this spring, it is still a little bit too small to see any surface detail. Large telescopes may notice some markings on the planet by the end of May as the disc grows to nearly 8” of arc. By summer the views improve as the Red Planet moves into higher declinations crossing the celestial equator on the first day of summer. A steady brightening trend and slow increase in arc seconds are in order as Mars gets ready to invade backyard telescopes this autumn.

Below is a view of Mars and the moon on the morning of May 2nd before sunrise.



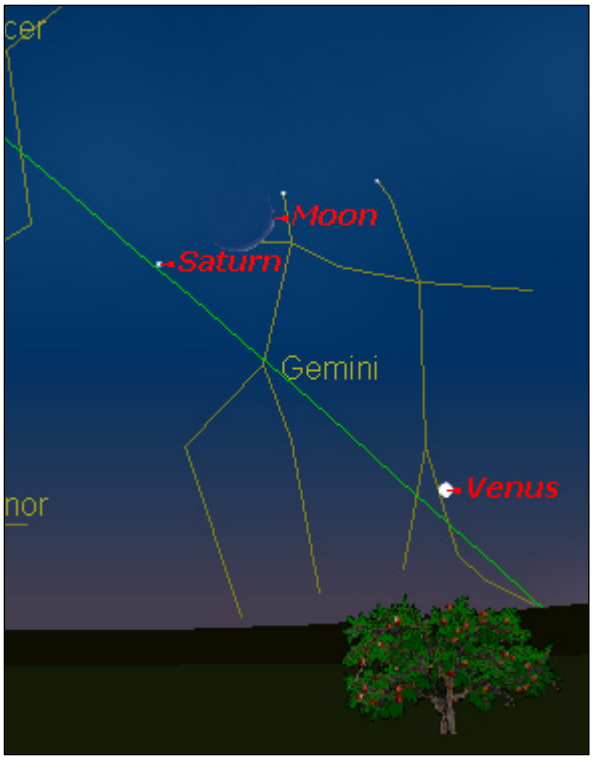
Jupiter reaches opposition this spring on April 3rd in Virgo, rising at sunset. Ten days later on the 13th, Jupiter is at the *aphelion* point in its orbit (farthest from the sun). That also places Jupiter farther from Earth at opposition than it has been in the past 12 years. Such is the case with an “aphelic” opposition. Jupiter will be no larger than 44” of arc this year. Six years from now Jupiter will be at perihelion near the time of opposition for that year and will present us with the largest disc possible (50”).

Regardless, Jupiter is still plenty large enough for even small telescopes to view it. It will be the brightest object on moonless nights shining at an impressive –2.4 magnitude at opposition. As usual Jupiter will present us with colorful striping cloud bands and its four big moons; Io, Europa, Ganymede and Callisto. The moons are always fun to watch each night as they are in different spots near Jupiter than the previous evening.

Throughout May evenings, Jupiter is in the SE after sunset crossing the meridian before midnight EDT. It will remain a prominent object for viewing well into the summer.

Saturn is transiting the local meridian an hour after sunset in mid March and shines at 0 magnitude in Gemini, high in the SW during April evenings. Saturn is still easily observable even though it was at opposition in January. It is over 30º high in the west during May, and drops closer to the glare of the Sun as June approaches. Saturn will be hard to locate after dark by the middle of June.

The graphic below shows Saturn, the moon and Venus ½ hour after sunset on the evening of June 9th, looking northwest. On what date can you last spot Saturn in the twilight?



Uranus & Neptune will slowly creep out of the Sun’s glare this spring. By the end of May they should be high enough to observe in the SE before astronomical twilight begins.

Pluto be best visible in a telescope 8” or larger by early June. Opposition is on June 13th in Serpens Cauda located just east of Ophiuchus. Pluto is at magnitude +13.8.

Calendar of Events

March

March 9 - Special Event at Grand Valley State University beginning at 7:00pm. There will be a public lecture on **"Chandra's High Energy Vision"** presented by Donna Young from Wright Center for Science Education at Tufts University. This is open to the general public, and there is no admission charge for this lecture. A PDF about the lecture is available. More about the presenter can be found online.

March 19 - General meeting of the GRAAA at the James C. Veen Observatory, starting at 7:30pm. The program will begin at 8:00pm with our featured speaker Jerry Persha, President and owner/founder of Optec, Inc. Jerry will speak on **"Astronomical Photometry - You can do it!"** Jerry has been working on a data reduction program for doing photometry which will revolutionize the field. As usual, all members are welcome to attend, and there will be observing afterwards if clear.

March 20 - Training class one for the East Dome Paramount system at 7.00pm. See the information on the next page about signing up for training, and what's required to attend.

April

April 16 - Visitors' Night at the James C. Veen Observatory from 8.30pm until 11.30pm provided the sky is clear.

April 23 - General meeting of the GRAAA at the Grand Rapids Public Museum's Meijer Theater, starting at 7:30pm. The program will begin at 8:0pm. Our guest speaker is aerospace engineer Adam Thodey, who will be speaking on the **Deep Impact Mission** to Comet Temple 1. As usual, all members are welcome to attend.

April 22-23 - NIAGfest - North Webster, Indiana.

April 28 - Visitors' Night at the James C. Veen Observatory from 8.30pm until 11.30pm provided the sky is clear.

May

May 14 - Visitors' Night at the James C. Veen Observatory from 9.00pm until 12:00am provided the sky is clear.

May 21 - General meeting of the GRAAA at the James C. Veen Observatory, starting at 7:30pm. The program, which begins at 8:00pm, will feature Jacob Bourjaily who will speak on **"Shedding Light on the Dark Side of the Universe."** Jacob will graduate this year from the University of Michigan with degrees in mathematics and physics before heading off to Cambridge to study maths and physics as a Marshall Scholar (the first from Michigan in eight years). His research on dark matter cosmology in collaboration with Gordon Kane has been published and Jacob has given invited lectures in Edinburgh, Sicily, and Chicago. He is a former Board Member of the GRAAA and Thomas Strach award recipient.

More about Jake can be found on his website. As usual, all members are welcome to attend, and there will be observing afterwards if clear.

May 28 - Visitors' Night at the James C. Veen Observatory from 9.00pm until 12:00am provided the sky is clear.

News Notes From the GRAAA

The Stephen F. Wessling Observatory at the Kropscott Environmental Center north of Fremont is essentially completed and awaiting the arrival of telescopes. While plans and a fundraising effort are underway for a fully equipped high tech telescope, the first instrument to be installed will likely be the "workhorse" twelve and one half inch reflector which for close to three decades was one of the principal instruments at the Veen Observatory. The instrument is in safekeeping at Van Andel Museum Center where right now a team of members of the GRAAA are in the midst of a restoration effort. The goal is to have the telescope all spiffed up, its optics installed and collimated, and transferred to the Wessling Observatory by mid-April. Hopefully, a "first light" party, to which GRAAA members will be invited, can be held shortly after the full moon of late April. Watch your E-mail and newsletter for details.

In the meantime, if you have metal working experience or expertise in things mechanical or optical (no electronics on this "brute force" telescope) and would like to help out, please contact restoration group leader Dave DeBruyn at 456-3525, or email him at ddebruyn@ci.grand-rapids.mi.us as soon as possible. By the time you read this, the restoration work will be underway and perhaps in critical need of additional help.

The East Dome at the observatory, which holds the Paramount system, is nearly ready to be put into general operation. The first in a series (series, because the training will be rather extensive) of training classes will be held on Sunday, March 20, 2005 at the Observatory, starting at 7:00pm. This is the last part of the training system for the full use of the observatory, and only members who have gone through the individual tiers will be attending the first seminars. For more information, or if you want to sign up to attend, contact Ron Vander Werff at 897-9351 ext. 106 or email at ron@optecinc.com.

There are many things needed to be accomplished the observatory this spring. There is some vital work to be done on the building before Visitors' Nights start in April. The observatory committee will be meeting soon, and will have a detailed list of things to accomplish, which will be posted on the website. If you would like to help out in any way, please contact the Committee Chair, Ron Vander Werff (his phone number is in the front of this publication, and also on the website).

The new season of Visitors' Nights start April 16th, and the first round of solicitations for help have gone out via email last week. Please take the time to fill out the form and send it in. We will need all the help we can get this year. There will be a few more email reminders, and then the committee will start phoning members to sign them up. If you want to avoid a phone call, please send in your signups soon. We must have the list out by the first week of April.

In another item of interest, May is renewal time for memberships. With the exception of those who have joined in the past few months, dues are payable by the end of May. If you want to get a head start, you ca find the renewal forms on the website in the Members' Section (the "downloads" page). We will send out renewal notices by the end of March.

A small reminder to use caution when driving up to the observatory during the early spring. It's quite possible that the upper parking lot will be extremely soft, and a good chance you could get stuck. When you get to the top of the drive, take a look to see what the conditions are before driving the rest of the way. Your best bet is to park near the top along the road. The upper lot is usually back to its normal condition by the middle of April.

Remember you can always get the latest club and astronomy news on the GRAAA website.

ROGER B. CHAFFEE PLANETARIUM

Public Museum of Grand Rapids

Spring 2005 Show Schedule
Continuing through May 8

For children and family audiences

THE GREAT SPACE CHASE - Education/Entertainment Feature

The many audio-visual capabilities of the unique planetarium facility are employed to present a delightful celestial treasure hunt. The multicolored laser system, the Digistar all sky multiple image projector, and dramatic special effects accompany the powerful sound system in bringing this unique story to life.

SHOWTIMES: **Saturday at 11:30 and 1:30 p.m.**
Sunday at 1:30 p.m.

For general audiences

VOYAGE TO INFINITY - Explore the depths of the universe as participants in an imaginary space voyage. Visitors drift among star clusters, nebulas and galaxies, probing deep into space and far back in cosmic time. The voyage is dramatically illustrated with full dome Digistar images, wide angle video and multiple special effects. Latest concepts about the nature of the universe are vividly illustrated, accompanied by a stirring soundtrack. **40 minutes**

SHOWTIMES: **Daily at 2.30 p.m.**

UNDER STARLIT SKIES This informal presentation with live narration identifies the brightest stars, planets and constellations currently visible, using the realistic sky dome. The planets Jupiter and Saturn, visible during this period, are also featured. **40 minutes**

SHOWTIMES: **Saturday & Sunday at 3:30 p.m.**

Added Value: This show is free with paid Museum admission; or arrive after 3:00 p.m. for the planetarium show only and pay only $3.00/ person.

SPECTACULAR LASER LIGHT SHOWS

The most popular music of famous rock bands is drawn from their legendary albums. High power sound is accompanied by ever changing patterns of laser and incandescent light on the planetarium's sky dome. Separate $6.50 admission each show. **45 minutes**

SHOWTIMES: Fridays and Saturdays:
Pink Floyd - *Dark Side of the Moon* at 8:30
Laser Metallica at 9:30 p.m.

Telescopes are in some ways like time machines. They reveal galaxies so far away that their light has taken billions of years to reach us. We in astronomy have an advantage in studying the universe, in that we can actually see the past.

We owe our existence to stars, because they make the atoms of which we are formed. So if you are romantic you can say we are literally starstuff. If you're less romantic you can say we're the nuclear waste from the fuel that makes stars shine.

We've made so many advances in our understanding. A few centuries ago, the pioneer navigators learnt the size and shape of our Earth, and the layout of the continents. We are now just learning the dimensions and ingredients of our entire cosmic, and can at last make some sense of our cosmic habitat.

-- Sir Martin Rees, Astronomer Royal of Great Britain

Grand Rapids Amateur Astronomical Association
Membership Application or Renewal Form

DATE:_____

❑ **New Membership** ❑ **Renewal**

Please fill out the information below as completely as possible.
For Family memberships, please include all persons for whom membership is desired.

Please Print

Name: _____Birthdate: _____

Name: _____Birthdate: _____

Name: _____Birthdate: _____

Name: _____Birthdate: _____

Name: _____Birthdate: _____

Name: _____Birthdate: _____

Address:_____

City: _____ State: _____ Zip: _____

Home Phone: _____ Cell Phone: _____

E-Mail: _____
(Note: For Family members, if more than one e-mail address, please list others on back of application)

❑ **Adult** (18 or older, a Minimum of $35.00) . . . . . $_____
❑ **Student** (through 17 yrs old, a Minimum of $20.00) . . . . . $_____
❑ **Family** (all members of one family, a Minimum of $45.00) . . . . . $_____
(Note: Contributions greater than the minimum dues are considered a donation and are tax-deductible)

❑ **Observatory Endowment Fund** . . . . . $_____
❑ **Miscellaneous Donations** . . . . . $_____
(Note: Contributions to these funds are tax-deductible. Indicate amount of donation)

❑ **OBSERVATORY USER FEE:** (a Minimum of $20.00 per user)..... $_____
(Contributions of more than $20 will help meet repairs and upgrade of equipment costs.)
If you are a qualified user of the Veen Observatory, and wish to remain so, check the box for ***"User Fee."***

TOTAL ENCLOSED (From all categories above) . . . . . $_____

Make Check or Money Order to:
GRAND RAPIDS AMATEUR ASTRONOMICAL ASSOCIATION (or GRAAA)

Mail to: Jerry Persha, GRAAA Treasurer
199 Smith St.
Lowell, MI 49331

Grand Rapids Amateur Astronomical Association
3308 Kissing Rock Ave. SE
Lowell, MI 49331-8918