AD ASTRA

Vol. II, No. VII | *The Newsletter of the Atlanta Astronomy Club* | March 1988

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CLUB CALENDAR

Next Meeting: March 18, 7:00 p.m. at the Fernbank Science Center Planetarium.
Monthly Program: David Dundee, an astronomer at Fernbank Science Center, will present a program on the Zeiss planetarium. A tour of the observatory 36", and open house observing will be conducted later if the weather is favorable.

AD ASTRA is published monthly during the academic year by the Atlanta Astronomy Club, Inc. The AAC, a non-profit organization, is dedicated to the advancement of amateur astronomy, and fostering the social, literary, and educational needs of its members. Meetings are held on the third Friday of each month (second Friday of December) unless otherwise announced in this publication. Membership dues are $25 annually and include a subscription to *Sky & Telescope* magazine and use of club observatory facilities.

Editor in Chief: ..... John Marsh
Managing Editor: ..... Don Barry
Technical Editors: ..... Sharone Franklin, David Roberts, Rick Clark, Richard Jakiel

Submissions: Article submissions are most welcome, and may be delivered to the editor for consideration.

CLUB MINUTES

The February 19, 1988 meeting of the Atlanta Astronomy Club was held at the Bradley Building with president Lee Wilson presiding.

A motion was made to thank Fernbank Science Center for inviting club members to the premieres of new planetarium shows, and approved by the membership.

Program chairman, Gene Powell, showed two videotapes. The first tape was Clyde Tombaugh's personal story of his discovery of the planet Pluto in February 1930. The second videotape was from the PBS Nova series. It was about Supernova 1987A in the Large Magellanic Cloud and how it was discovered February 24th, 1987.

AMATEURS VS. PROFESSIONALS, WHAT IS THE DIFFERENCE?

by Bill Bagnuolo

One of the most interesting exhibits at the Adler Planetarium in Chicago is Herschel's telescope with which he discovered Uranus. What is striking is that this telescope (a 6 5/8" reflector), 200 years ago a powerful professional instrument, is now just a typical amateur telescope. Is the difference between amateur and professional astronomers simply a matter of dates?

I am a research scientist in astronomy at GSU, but I still like amateur astronomy. As a "telescope nut" I made a number of mirrors and still have an 18" that I will make into a telescope -- someday.

Thus, I have seen both "sides." The following are some of the differences between amateur ~~and profes~~sionals that I see.

The most obvious difference is that professionals are paid and amateurs work for free. What is less obvious is that there are times when astronomy is "work"-- e.g., when you are near the end of a 10 day observing run of 13 hour nights in winter. (Fortunately, on most telescopes you no longer have to freeze in the dark, like when I was a grad student in the 70's.) On observing runs the goal is to collect as much good data as rapidly as possible. On some nights you can *feel* the sky moving and that you are slowly falling behind on observations, like on an assembly line. As an amateur I can go out to Villa Rica for a few hours and look through the 20" and my 11x80's, talk to a few people, and then leave when I want.

A related difference is that amateurs are mainly motivated by the aesthetics - the fun of looking at beautiful planetaries or clusters. Professionals have little time for such things. Even when I looked through telescopes with real light (instead of at a screen in a control room) the only time I looked at interesting objects was when the run was already wiped out by cirrus clouds. Professionals are more motivated to know more about the universe from a scientific point of view -- or less nobly to "scoop" the competition ("stop the presses!").

Amateurs also know their way around the sky better than most professionals. Many astronomers don't know or care what the complete names of the constellations are! Stars are just "Al Boo", not "Arcturus". Conversely, one thing that surprised me was how seldom the setting circles are used on the Villa Rica 20". Some of the Astronomy Club members can actually get to dim NGC objects by "Star-Hopping". One reason for a lack of familiarity with the sky by the professionals is that they are buried in the control room, but even in the "old days" a narrow dome slit stopped them from seeing more than a fraction of a constellation. Amateurs take pride in their equipment - usually amateurs will present umpteen slides of it at conferences. Professionals usually remark in a paper something like: "These data were taken at the KPNO 4-meter with a procedure described elsewhere, Smith(1985)."

A more basic difference between amateurs and professionals is (ahem!) their attitude toward science. Amateurs will say things like "the distance to that star is 150.71 light years." Professionals know just how uncertain these numbers are (in this case to +-20%) and how the results are obtained. Amateur data (e.g. submitted to the AAVSO) must be screened for errors; professionals have (or should have) a "feel" for good or bad data and will instinctively reject the latter.

Amateurs generally believe what they read about new discoveries in Sky & Telescope; professionals are more skeptical. When I was a beginning grad student Dr. Joseph Weber gave a talk on gravity waves he thought he had detected. Most of the grad students believed in his experiment, all of the academics did not. A few years later his observations were discredited, although he deserves credit for stimulating interest in the field. The downside of professionalism is the pomposity and occasional petty jealousies and academic politics. Amateurs fortunately don't care about these things and are generous with other amateurs.

Finally, although amateur astronomy is booming (compare ads for telescopes 15 years ago with now), professional astronomy has fallen upon bad times. (You knew this would probably end with a commercial!) Astronomy has been singled out again for federal budget cuts. Next time you write your congressman you might mention this. Anyway, maybe we need a Jerry Lewis-style telethon...

Former Junior Member Reminisces

by Anna Belle Close

Although Bill Close missed the first meeting of the Atlanta Astronomy Club, he attended the second one. Dr. Calder at that meeting invited anyone interested in making a telescope to meet with him afterwards. Bill joined this group and ground a 6" mirror under Dr. Calder's tutelage. The Closes were happy for a number of years with the telescope he built for the mirror. But Bill had been bitten by the TMB (Telescope Makers' Bug) and went on to grind a 16" mirror. It took 18 months from rough grinding,polishing,pitchlap making and figuring to complete the mammoth mirror. Another 18 months passed before the mount was completed and the telescope was searching the heavens from the Close's backyard in the dark-skyed Decatur of the early 50's.

This Christmas we heard from a former Junior Member who now lives in Forest Hills, N.Y. He is Edward (Ed) B. Flowers, more familiarly known to most of us as "Brownie." Brownie was reminiscing in his letter "how much I enjoyed the many observing parties over at your house in Decatur. Those were the days when Bill was grinding mirrors in the bathtub and my favorite telescopes were those of Abbey, Close, and Stusak. Each telescope had its points. The views were wonderful, and those observations still have a romance that contemporary Celestrons cannot match."

Thanks, Brownie. You bring a nostalgic lump to my throat. The tribute to the instruments of the past is certainly appreciated. But in sharing this letter with AD ASTRA readers, I must hasten to explain Brownie's humorous reference to bathtub telescope making. No, Bill was not grinding the mirror in the tub; he had poured the hot, melted pitch onto the 50-pound mirror and needed to press the tool into the pitchlap, so to keep it warm and press it at the same time, he placed it in a tub of hot water and sat himself on it. It is regrettable that I was not into photography at that time for us to have a graphic record of this historic event for the telescopic community to keep in its annals.

Star-Drifters Heroes And Dream-Finders

by Sharone Franklin

There are many heroes of the world. Some people become known as such while others do heroic deeds that are hardly noticed. Some dream of becoming involved with a bold and daring situation which will result in admiration. Others never consider such extreme measures. They prefer to live out their lives quietly - withholding their life's secrets - lips sealed, but eyes and ears open. It has been said that this is a sign of wisdom.

Many people ask me why I spend so much time learning astronomy and gazing at the star-filled sky. Is there really that many interesting objects to look at, they will ask. I am constantly reminded that there are many other hobbies that one can learn and enjoy. Why astronomy?

Obviously we all shouldn't be doing the same things. The world couldn't function if we were mere clones. And it is evident that astronomy is chosen by very few when compared to other hobbies and professions. There are many reasons why this is so. A summation of these reasons would simply be one's individuality which is responsible for likes and dislikes and determination and motivation. No one should be criticized for what they have chosen to do with their lives as long as the results are positive. To seek and find one's individual happiness is to become a hero unto one's self. And once you experience this kind of heroism, you find your dream.

Astronomy is tedious work no matter which area you choose as a speciality. To learn to use a telescope is to learn to utilize patience. It takes time to train your eye to see objects that are small and pale. But given enough practice, you will gradually see remarkable detail. Then you begin to realize that you are gazing into the internal engine that is responsible for the forces of all that exist.

To learn your way around the night sky is to learn to become a star drifter. Using a telescope as the transporter, you drift from star to star. Each star becomes a lighthouse in the sky and guides you through star clusters, nebulae, galaxies, planets and planetoids. You become a nomad. You wander continuously but never without a purpose. Every object becomes an exhibit. You scrutinize every ornament as a composite, just as you would a flower. Then using your eyes as prying tools, you gently lift off the surface and examine the interior. Satisfied, you move on.

Once I spent the night on one of the wings of Cygnus. I examined the open star clusters NGC 6866 and NGC 6819. The latter has about twice the number of stars as the former. Both give the appearance of strewn diamonds sheltered within a black landscape of emptiness. I was far from the blue oceans of home. I stared at these glittering globes like an apprentice in a diamond cutter's workshop. I wanted someone to tell me where they came from. Why did they choose these vacant lots upon which to reside and become a showpiece? How long will it be before they grow too old to maintain their energy? How long before their outer shells will become rawboned and they shine no more? Where are the graveyards for the stars?

Those of us who have chosen astronomy as a hobby or profession certainly do not claim to have found the only path to enjoyment. There are many other routes to fulfillment, but there is only one lifetime. Priorities must be arranged, because the seasons pass quickly and so do our lives. The stars are the eyes that shine. The human spirit is the rainbow upon which dreams are found.

MASS, THE UNIVERSE, AND EVERYTHING

by Richard Jakiel

When I was much younger, I had a certain fondness for numbers and statistics concerning the physical geography of this world. I would study and remember the areas and populations of countries and cities, the length and height of mountain ranges or the length and discharge of the world's great rivers. I never lost that early fascination with numbers and science, as I eventually earned degrees in geology and biology. But of all the sciences, none have the extreme range of numbers as astronomy has in terms of time, mass, temperature, magnetic field strength, and so on. In this essay, we shall briefly examine the distribution and the star magnitude of mass in the universe.

The metric system is used extensively in science (along with most of the world) because of its ease of conversion of the units involved. The gram is defined as the basic unit of mass, with 453.6g = 1 pound, while 1 kilogram(kg) = 1000g or about 2.2 pounds. Using this scale of measure, the average male would have a mass of about 80kg (176#), while a small dog would be only 10kg (22#). When measuring the mass of celestial objects, however, this system becomes quite inadequate. For example, the earth has a mass of 5.976×10^{24} kg (5.976 followed by 24 zeroes), an immense number that is very difficult to comprehend. One point of interest, though, this number when compared to the mass of a small dog (10kg) is nearly equal to Avogadro's number of 6.0226×10^{23} molecules per mole of substance. A more suitable scale would be using the earth's mass as the primary unit. This unit of mass is very useful in describing the mass of the planets such as Jupiter (m=317.95), or Pluto (m=0.002), the largest and smallest planets respectively. The sun, however, is far more massive; with a mass of 332.998 times that of the earth.

Already, the earth as a basic unit of mass is becoming too small a unit to conveniently use. What astronomers use instead is the sun as basic unit (M), but even this unit is eventually stretched to the limit as we shall see later on. Stars have a mass range between 0.08 and 100 solar masses. Objects below 0.08M have insufficient core densities/temperature to "burn" hydrogen, and are labeled as brown dwarfs. Proxima Centauri is the closest and one of the least massive stars known, with a mass of only 0.10M and feebly shines at 10.7 magnitude (0.00008 that of the sun). Supergiant stars such as Eta Carina and S Doradus have masses approaching 100 solar masses. Beyond this limit, the radiation pressures are greater than gravitational contraction leading to extreme instability.

Stars are often clumped together into groups or star clusters. Star clusters generally range from small, loose groupings such as M103 to huge, highly luminous aggregations of hundreds or even thousands of stars such as NGC 869 & 884, the Perseus Double Cluster, or NGC 4755, the Jewel Box in Crux. Thus, the range of masses is between 25 and 1000 solar masses, with a mean of about 250M. Much larger and even more highly compressed are the globular star clusters. They range in mass from the distant and relatively sparse Palomar clusters, to gigantic systems such as M5, M13, 47 Tucanae, and Omega Centauri which have masses in excess of 1.0×10^6M. The average mass of these clusters is estimated to be 6×10^5M, with central densities of 8×10^3M per parsec^3, or about 1.8×10^7 times the mass density of the "solar neighborhood".

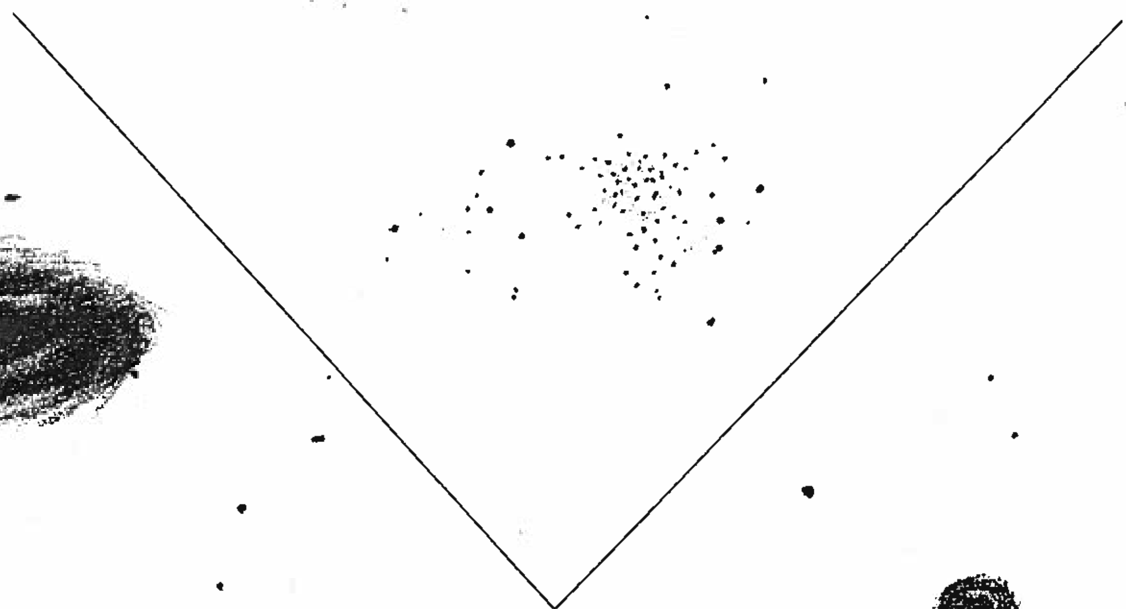
The mass of nebulae covers an even larger dynamic range. Planetary nebula such as M57 and M27 are relatively low mass objects, with typical range of 0.1 to 1.5M. Emission nebula (H II regions) are generally much larger. The striking Orion Nebula (M42/43) has a mass of 1.0×10^4M; while this seems quite impressive, this nebula takes a back seat to such gigantic complexes as Eta Carinae (Keyhole Nebula), or the Tarantula in the Large Magellanic Cloud. These systems along with NGC 604 in M33, have masses up to 1.0×10^6M.

The next largest separate entities in the universe are the galaxies themselves. The range in mass for galaxies is even more extreme than the variations of morphology. Let's start with the system which we are most familiar with - the Milky Way. Our "home" galaxy is often classified as a Sbc, and has an estimated mass of 6×10^{10} to 3×10^{11}M, as based on luminosity of stars plus the sum of the aforementioned objects. There is a major difficulty in determining the mass of a galaxy as the mass estimates reflect. The Andromeda Galaxy is the largest galaxy of the Local Group of Galaxies, with a mass of 4.5×10^{11}M. M33 is much smaller, and with a mass of 4×10^{10}M it is considered a minor system. One of the largest spiral galaxies known is M104, a Sa system of immense size, with a minimum mass of 1.5×10^{12}M. Yet as large as this galaxy is, it is rather insignificant in comparison to some of the giant elliptical galaxies. The largest of these galaxies are the cD (central dominant) ellipticals such as M87 or NGCs 4889 and 4874 in the Coma cluster of galaxies. M87 in Virgo has a mass of 3×10^{13}M, equivalent to that of a small group of galaxies. The extreme size of these systems is thought to be the result of galactic cannibalism, a process in which whole galaxies are consumed to "feed the monster".

And yet, many ellipticals are actually small systems: examples in the Local Group include the Leo II and the Draco systems which are no more massive than a large globular cluster. When these paltry fuzzballs of a galaxy are compared to a cD system, the range of mass is 10^7 - sort of like comparing a mouse with a blue whale.

The largest structures in the universe are groups and clusters of galaxies. The average mass of a group is on the order of 2×10^{13}M, while a cluster of several thousand galaxies might tip the scale at 1×10^{15}M. Even larger structures are the superclusters, gigantic aggregates of dozens of clusters and galaxy groups. Possibly the largest structure in the universe is the supercluster complex noted in the February, 1988 issue of Sky & Telescope. The mass of such as system may be on the order of 1×10^{18}M, or at least 600 times the mass of the local supercluster. When all of these masses are tabulated and compared with current cosmological theory, there is a significant discrepancy between figures. It seems that the universe is undermassive. In fact, it appears that the universe is down right "anorexic", with only 5% of the total mass needed to "close" it off. What is the problem? Is it that the mass calculations are way off or is there some unseen mass unaccounted for?

To be continued in a following article "The Case of the Missing Mass".



Above: NGC 2903, 175x. *Top Right:* NGC 1907, 175x. *Below Right:* NGC 2392 (Eskimo Nebula), 315x. *Far Right:* NGC 2362 (Tau Canis Majoris and Cluster) 95x. All drawings made with the 20" f/4.5 Newtonian by Richard Jakiel.

SMALL, ROUND, AND DIM

by Richard Jakiel

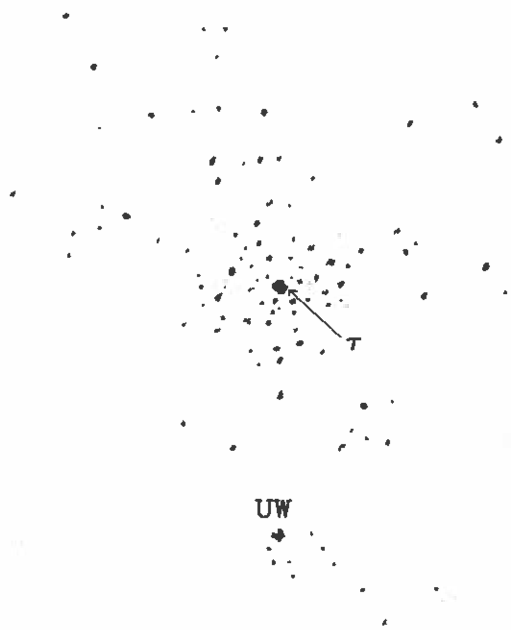
The winter milky way abounds with large, bright star clusters, many of which can be discerned with the slightest optical aid. The comet hunter Charles Messier catalogued nearly one dozen clusters, while a detailed atlas as the Uranometria 2000 lists several hundred more. One of my favorite areas to explore with a telescope is the central region of Auriga. The two dominant objects of the region are M36 and M38, as both are easily visible in a finder scope. M38 (NGC 1912) is larger and more compressed than M36, with over 150 stars of magnitude 8-12 visible in a eight or ten inch telescope. The view in the 20" scope is overwhelming, as the cluster overflows the field with brilliant stars.

Only about half a degree to the south is NGC 1907, a moderately compressed star cluster. This is a relatively small cluster about 5 arcminutes in diameter, so medium magnification is recommended. About 40-50 stars of magnitude 10-14 are visible in an 8 to 10inch scope, with this number increasing to about 75 in the club's 20". Located nearby are two bright emission nebulae. NGC 1931 is the smallest(3'x3') and brightest, and is easily visible in an 8 inch. It reminds me of M78 structurally, with 3 relatively faint stars surrounded by nearly amorphous nebulosity. IC 417 is much larger and fainter, being quite difficult to detect in moderate sized (8-12") scopes. However, it loses its "small, round, and dim" classification in the 20" as delicate, wispy filaments of nebulosity emerge in a 10'x13' region.

Nearby Gemini is noted for having several spectacular objects, such as one of the finest doubles in the sky (Castor), a huge brilliant star cluster (M35), and one of the most famous planetaries - NGC 2392, better known as the Eskimo Nebula. In medium to large apertures (8-20") NGC 2392 reveals a 9.1 magnitude central star surrounded by a small, bright nebulous disk. Beyond this is a thin, partially complete dark annularity, followed by another bright outer shell. This "bull's eye" structure is easy to see at medium to high magnification (20-35x per inch diameter). About eight degrees to the north is a large, dim planetary nebula, NGC 2371/2. The double NGC number is a result of dumbbell structure as each half was originally given its own NGC number.

This planetary is quite large, measuring 54"x35", or about 50% of the area of the ring nebula. It is also quite faint - about 13.0 magnitude, and in Sharone Franklin's new 10" f/6 (120x), two nebulous patches were visible in contact, with the southern fuzz patch being the brighter. In all, NGC 2371/2 has an appearance reminiscent of the mighty bright M76 in Perseus. If you desire a difficult object to test a large scope, try PK 271 +14.7 in Canis Minor. Although listed at magnitude 13.6, its light is spread over a huge 4' partial arc, making this object a good test with a 17.5 or 20 inch telescope. A good test for a medium sized instrument (8-12") may be NGC 1924, a 14.0 magnitude galaxy located less than 2 degrees west of the Orion Nebula.

One of my favorite open clusters is NGC 2362 in Canis Majoris. Centered around Tau Canis Majoris, an O7 supergiant (absolute magnitude -7.5), this cluster consists of over 40 type O and B stars of high luminosity and extreme youth. In a medium sized telescope, ones attention is focussed on the brilliant blue light of Tau and the electric blue glow of the attendant stars. Less than



30' to the north is UW Canis Majoris, an immense eclipsing binary star. The components of this system are of spectral classes O7 and O9, with a combined mass of 57 times that of the sun and an absolute magnitude of -7.4.

The last object reviewed in this column is a bright spiral galaxy, NGC 2903 in Leo. Easy to locate, being only 1.5 degrees south of Lambda Leonis, its 9.7 magnitudes makes it easy to spot even in a small telescope. In a large telescope such as the 20", the spiral structure is readily visible. At 175x, several spiral arms are visible along with large dark dust clouds defining the nuclear region. During the upcoming months, more of these marvelous objects will be examined and described in detail.

CLASSIFIED

For Sale: Home assembled 6" f/5 refractor with Jaegers objective lens and tall Cave equatorial mount with 1" shafts. Scope has 2" Rack and Pinion focuser with star diagonal and 1.25" adapter. Also has 2" 60mm Kellner and Sears 2.4" guidescope with rings, eyepieces, and diagonal. Box for scope and accessories (needs to be refurbished). Also other odds and ends. $900.00. Call Victor Beitzel at 872-1876 after 7 p.m..

THE WORLDS WE SEE

by Pat Frank III

> "Every technology goes through three stages: first a crudely simple and quite unsatisfactory gadget; second, an enormously complicated group of gadgets designed to overcome the shortcomings of the original and achieving thereby somewhat satisfactory performance through extremely complex compromise; third, a final proper design therefrom."
>
> *Robert A. Heinlein*

Why is it that whenever we see a new invention or discovery we are so amazed? It's as if that accomplishment was done by something more than human. And yet throughout history, at almost no time was there such a tremendous leap in evolution that caused the birth of the only individual capable of reaching a certain conclusion, or grasping the correct answer out of thin air. In fact, in many cases the major idea came from a field that was totally unrelated, and went unoticed until somebody thought to wonder what other uses that byproduct might have.

Last month we looked at the invention of the telescope, and you will remember how Galileo, now known as the "inventor of the telescope" to millions of students, actually just made the simple move of pointing it in a new direction - up. Actually, that isn't quite fair. He had the intelligence to write down what he saw as well. For all we know, someone else might have looked first!

The invention of another type of telescope is a prime example of this. In 1936 an amateur astronomer by the name of Grote Reber (1911-) built the world's first radio telescope in his backyard in Wheaton, Illinois. Like Galileo, he did not actually invent the idea. But also like Galileo, he thoroughly recorded everything he observed. In fact, he was the ONLY active radio astronomer for almost ten years.

The actual discovery of radio transmissions from space was made by Karl G. Jansky (1905-1950), a radio engineer at Bell Labs, who was simply trying to find out why there was a certain type of interference of regular shortwave transmissions. Once he had ruled out thunderstorms and other atmospheric interference, he found that there was still something there. He noticed that the last bit of interference was strongest about four minutes earlier each day. Remembering that the earth's rotation was actually four minutes less than twenty-four hours, he realized that the source of the problem was coming from outside the atmosphere altogether (Later it was found that this was background radiation from the Milky Way itself).

Actually, most astronomical discoveries could be said to consist of such occurrences. This may lead one to believe that one has only to put two and two together to solve the mysteries of the universe, and in fact that's pretty much how this planet's research resources are organized. Computer cross-referencing checks all the possible uses of any by-product, and research labs seldom concentrate their efforts to the extent that they ignore possibilities, which is just common sense.

Based on that assumption one could say that most astronomical research is done this way, by professionals working in their laboratories (observatories) well secluded from the public, and ignorant of outside interest. But as we all know, this is not the case, and I'll use that as my topic next time.

Sources:

Exploration of the Universe, George O. Abell, 1982.
The Rolling Stones, Robert A. Heinlein, ACE, 1952.

OBSERVER'S ALMANAC

by Don Barry

Moon Rise, Set, and Phase

(All times are EST)

Date	Rise	Set	Phase	Date	Rise	Set	Phase
03/15	05:24	16:15	11%	04/06	23:49	08:36	85%
03/16	05:59	17:29	5%	04/07	----	09:25	77%
03/17	06:31	18:40	1%	04/08	00:52	10:24	67%
03/18	07:01	19:51	0%	04/09	01:49	11:31	56%
03/19	07:31	21:01	1%	04/10	02:38	12:43	45%
03/20	08:03	22:11	6%	04/11	03:20	13:56	34%
03/21	08:39	23:20	13%	04/12	03:56	15:08	23%
03/22	09:19	----	21%	04/13	04:28	16:18	14%
03/23	10:05	00:26	30%	04/14	04:58	17:28	7%
03/24	10:57	01:27	40%	04/15	05:28	18:37	2%
03/25	11:53	02:21	50%	04/16	05:59	19:47	0%
03/26	12:51	03:07	59%	04/17	06:32	20:57	0%
03/27	13:51	03:46	68%	04/18	07:11	22:06	3%
03/28	14:49	04:19	77%	04/19	07:55	23:12	9%
03/29	15:47	04:47	84%	04/20	08:46	----	16%
03/30	16:43	05:13	90%	04/21	09:41	00:10	24%
03/31	17:39	05:37	95%	04/22	10:40	01:01	33%
04/01	18:36	06:01	98%	04/23	11:40	01:43	43%
04/02	19:34	06:25	99%	04/24	12:39	02:18	52%
04/03	20:35	06:51	99%	04/25	13:37	02:49	61%
04/04	21:38	07:20	96%	04/26	14:34	03:16	70%
04/05	22:43	07:54	91%	04/27	15:30	03:40	79%

(----) indicates phenomenon does not occur on given day.

SATELLITES TONIGHT

Late March gives a rich harvest in bright passes of major satellites. This month, try finding the LDEF (Long Duration Exposure Facility) deployed by the shuttle in 1984, and due to decay in a few years if not retrieved. LDEF is the size of a small bus, but has not yet been seen visually from the Atlanta area. Please report your observations, along with any deviations noted from the prediction, to the AD ASTRA.

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Saturday evening, 05 March 1988   after 07:11 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:44:58PM 197.5 15.4 L 01325 01:26.3 04:37.8 -38d05 +3.0
07:46:17PM 180.2 28.2 L 00902 00:01.0 06:04.4 -28d03 +2.4
07:47:35PM 134.2 40.6 L 00696 21:47.8 08:19.1 -04d32 +2.4
Shadow entry.
 SALYUT 7                   USSR

Monday evening, 07 March 1988     after 07:13 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
08:21:16PM 288.9 23.2 R 01037 05:17.7 01:30.9 +27d51 +2.1
08:22:34PM 325.8 28.8 R 00895 06:01.0 00:48.9 +60d32 +2.1
08:23:53PM 001.4 22.5 R 01063 12:27.1 18:22.7 +78d40 +2.9
Shadow entry.
 SALYUT 7                   USSR

Tuesday evening, 08 March 1988    after 07:14 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:49:42PM 282.4 26.2 R 00955 04:54.0 01:26.9 +24d02 +1.9
07:51:00PM 324.4 34.0 R 00795 05:17.9 01:04.3 +60d38 +1.9
07:52:18PM 004.7 25.4 R 00978 13:49.7 16:32.2 +80d40 +2.7
 SALYUT 7                   USSR

Wednesday evening, 09 March 1988  after 07:15 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:16:49PM 255.7 16.3 R 01289 04:34.4 01:17.4 -02d15 +2.6
07:19:26PM 323.0 40.7 R 00699 04:23.2 01:31.3 +60d02 +1.5
07:22:02PM 027.2 15.8 R 01317 16:02.0 13:54.8 +59d36 +3.9
 SALYUT 7                   USSR

Friday evening, 25 March 1988     after 07:27 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:58:13PM 209.6 23.7 L 01006 02:00.9 05:35.3 -25d59 +2.7
07:59:31PM 172.0 30.5 L 00843 23:29.6 08:08.0 -25d17 +2.7
Shadow entry.
 LDEF                       USA

Saturday evening, 26 March 1988   after 07:28 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
08:11:50PM 300.7 17.7 U 01232 06:04.7 01:49.3 +35d01 +2.6
08:14:27PM 224.1 55.6 L 00565 01:33.5 06:23.1 +06d58 +0.9
08:15:45PM 165.2 33.4 D 00800 23:07.0 08:50.8 -21d28 +2.1
Shadow entry.
 SALYUT 7                   USSR

Sunday evening, 27 March 1988     after 07:28 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:40:10PM 306.8 18.3 U 01208 06:16.5 01:09.7 +40d24 +2.6
07:42:46PM 222.8 70.6 L 00500 00:55.1 06:33.8 +18d47 +0.9
07:45:23PM 143.8 17.8 D 01220 21:21.7 10:09.6 -28d01 +3.6
Shadow entry.
 SALYUT 7                   USSR
08:25:24PM 244.0 15.1 L 01326 04:09.8 04:01.6 -11d53 +3.1
08:26:42PM 225.0 26.4 L 00936 02:45.2 05:27.6 -16d14 +2.4
08:28:01PM 182.9 35.1 L 00763 00:10.3 08:03.8 -21d08 +2.2
Shadow entry.
 LDEF                       USA

Monday evening, 28 March 1988     after 07:29 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:50:03PM 243.6 15.2 L 01324 04:08.7 03:31.2 -12d07 +3.1
07:52:40PM 182.4 35.3 L 00759 00:08.2 07:34.3 -20d53 +2.3
07:53:58PM 140.2 26.4 L 00934 21:30.7 10:13.2 -18d59 +3.5
Shadow entry.
 LDEF                       USA

Thursday evening, 31 March 1988   after 07:32 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:44:24PM 224.7 20.1 L 01121 03:00.8 04:45.2 -21d18 +2.8
07:45:42PM 192.5 24.3 L 00987 00:52.9 06:54.4 -30d41 +2.8
07:47:00PM 160.6 19.8 L 01131 22:32.2 09:16.5 -33d25 +3.6
 LDEF                       USA

Saturday evening, 02 April 1988   after 07:33 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
07:46:49PM 183.7 21.9 L 00801 00:16.7 07:39.6 -34d15 +0.7
07:48:05PM 134.6 35.1 L 00566 21:35.3 10:22.4 -09d10 +0.7
07:49:21PM 082.7 23.2 L 00777 19:04.1 12:54.9 +18d20 +2.8
Shadow entry.
 MIR                        USSR

Sunday evening, 03 April 1988     after 07:34 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
08:02:31PM 248.3 28.0 U 00671 03:40.6 04:35.6 -00d31 -0.1
08:03:47PM 319.8 58.5 R 00399 02:18.8 05:58.9 +53d42 -0.9
08:05:03PM 028.1 27.7 D 00684 17:34.0 14:44.3 +65d07 +1.4
 MIR                        USSR

Monday evening, 04 April 1988     after 07:35 PM EST
 Time(EST)    Az    El  H Range   LHA    RA/2000 D/2000  Mag
08:18:14PM 290.4 15.9 R 01001 05:49.4 02:46.5 +25d35 +0.9
08:19:30PM 326.1 20.3 R 00856 07:01.7 01:35.6 +57d14 +0.9
08:20:46PM 000.8 15.5 R 01027 12:09.2 20:28.5 +71d43 +1.9
 MIR                        USSR
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AD ASTRA

FIRST CLASS

Please direct all address changes or corrections to:
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