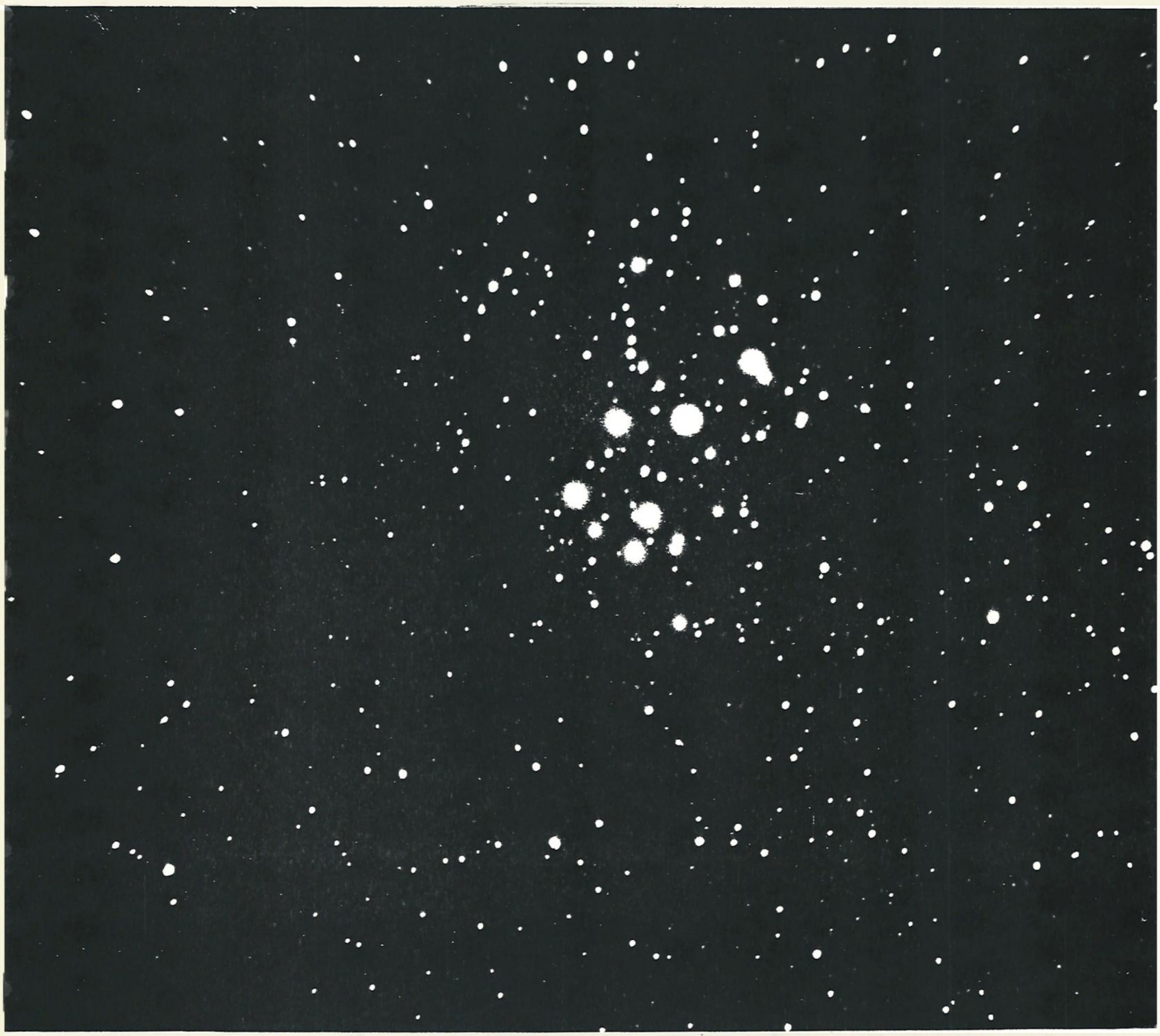
the
WASP
Journal of the Warren Astronomical Society

OCTOBER 1982



One of the many fine clusters to be seen during the autumn and winter months. The pleades in the constellation Tauras was a 20-minute exposure taken with a 300 mm lens.

Photographed by - Frank R. McCullough

Warren Astronomical Society Paper

EDITORS: Frank McCullough
Judy Butcher

Send all articles to-
45200 Keding Apt. 102
Utica, MI 48087
(313) 254-1786

The W.A.S.P. is the official publication of the Warren Astronomical Society and is available free to all club members. Requests by other clubs to receive the W.A.S.P. and all other correspondence should be addressed to the editor at the above address. Articles should be submitted at least one week prior to the general meeting.

W.A.S.

Warren Astronomical Society
P.O. Box 474
East Detroit, MI 48021

President:	Doug Bock	533-0898
1st V.P.:	Frank McCullough	759-5215
2nd V.P.:	Ron Vogt	545-7309
Secretary:	Ken Kelly	839-7250
Treasurer:	John Wetzel	882-6816

The Warren Astronomical Society is a local, non-profit organization of amateur astronomers. The Society holds meetings on the first and third Thursdays of each month. The two meeting locations are listed below:

1st Thursday – Cranbrook Institute of Science
500 Lone Pine Road
Bloomfield Hills, MI

3rd Thursday – Macomb County Community College – South Campus
B Building (b209)
14500 Twelve Mile Rd.
Warren, MI

Membership is open to those interested in astronomy and its related fields. Dues are as follows and include a year's subscription to Sky and Telescope.

Student $18.00
Individual..............$27.00
College $22.00
Family........................$32.00
Senior Citizen $22.00

Stargate

Observatory Chairman: Ron Vogt 545-7309

Stargate Observatory is owned and operated by the Warren Astronomical Society in conjunction with Rotary International. Located on the grounds of Camp Rotary, Stargate features a 12½" club-built Cassegrainian telescope under an aluminum dome. The observatory is open to all club members in accordance with the "Stargate Observatory Code of Conduct".

Lectures are given at Stargate Observatory each weekend. The lecture will be either Friday or Saturday night, depending on the weather and the lecturer's personal schedule. If you cannot lecture on your scheduled weekend, please call the Chairman as early as possible or contact an alternative lecturer. Those wishing to use Stargate must call by 7:00 p.m. on the evening of the observing session. The lecturers for the coming month are:

Oct 1/2	Dave Harrington	879-6765
Oct 8/9	Frank McCullough	254-1786
Oct 15/16	Ron Vogt	545-7309
Oct 22/23	Alan Rothenberg	355-5844
Oct 29/30	Doug Bock	533-0898
Nov 5/6	Ken Strom	977-9489
Nov 12/13	John Root	464-7908
Nov 19/20	Lou Faix	781-3338
Nov 26/27	Dave Harrington	879-6765

MINUTES OF THE AUG. 19, 1982 GENERAL MEETING

The meeting was called to order at about 7:30 p.m.

Doug Bock discussed the Messier contest held at the campout. The winner was: Bob Lennox. We had two clear nights of observing at the campout. We also had our first rocket launches at Camp Rotary. About 50 people attended the convention at Cranbrook.

There is a balance of $1571.83 in the treasury; however, the convention bills have not yet been paid.

The articles of incorporation were received from the State of Michigan so we are now officially incorporated. The new by-laws were passed out to the members we will discuss and vote on them at the September General Meeting.

We will have another star party on Sept. 11, at 8:00 p.m. at Camp Rotary. We will observe deep sky objects and learn the constellations.

From Sept. 17 thru Sept. 19, we are going on a field trip to Cadillac, Mich. to see really dark skies. It is a four hour trip by car. The rules are: total camping, bring your own food, tent and equipment. The moon is new that weekend.

Excerpts from the TV series ‘Cosmos’ by Carl Sagan, were shown on the TV video tape unit.

The meeting ended at about 10:10 p.m.

Respectfully submitted,
Ken Kelly,
Secretary.

(2710) Veverka ~ 1982 FQ

Discovered 1982 Mar. 23 by E. Bowell at the Anderson Mesa Station of the Lowell Observatory.

Named in honor of Joseph Veverka, planetary astronomer at Cornell University. One of the first to study the polarimetric and photometric properties of asteroids, Veverka has made substantial contributions to our knowledge of other small objects in the solar system, notably in his detailed work on Phobos and Deimos. He has also studied the morphology and motions of wind streaks on the Martian surface and has been a strong advocate of space missions to comets.

* * * * *

EPHEMERIDES.

Comet Austin (1982g) Elements MPC 7150

Date ET	R. A. (1950)	Decl.	Delta	r	Elong.	Phase	m1
1982 07 30	05 49.91	-19 28.9	0.489	0.841	55.5	95.9	5.7
1982 08 04	06 31.64	-08 02.4					
1982 08 09	07 35.31	+10 21.7	0.327	0.728	24.3	145.0	4.2
1982 08 14	09 00.19	+29 53.3					
1982 08 19	10 23.26	+40 47.2	0.442	0.659	28.6	132.7	4.4
1982 08 24	11 22.46	+44 21.4					
1982 08 29	11 58.27	+44 46.6	0.717	0.654	40.2	94.8	5.4
1982 09 03	12 19.11	+44 02.4					
1982 09 08	12 31.46	+42 53.0	1.003	0.715	41.6	69.5	6.5
1982 09 13	12 39.16	+41 35.6					
1982 09 18	12 44.32	+40 18.9	1.256	0.823	40.8	53.0	7.6
1982 09 23	12 48.08	+39 03.9					
1982 09 28	12 51.05	+37 55.4	1.465	0.956	40.4	42.8	8.6
1982 10 03	12 53.54	+36 53.2					
1982 10 08	12 55.72	+35 58.0	1.630	1.102	41.5	36.9	9.5
1982 10 13	12 57.68	+35 09.7					
1982 10 18	12 59.45	+34 28.6	1.755	1.252	44.3	33.7	10.2
1982 10 28	13 02.36	+33 28.1					
1982 11 07	13 04.24	+32 56.2	1.901	1.553	54.6	31.3	11.3
1982 11 17	13 04.75	+32 53.4					
1982 11 27	13 03.35	+33 20.4	1.937	1.846	69.9	30.1	12.1
1982 12 07	12 59.44	+34 17.0					
1982 12 17	12 52.26	+35 42.2	1.904	2.130	89.1	27.5	12.7
1982 12 27	12 40.92	+37 31.7					
1983 01 06	12 24.61	+39 36.4	1.862	2.403	111.4	22.4	13.2

Periodic Comet Peters-Hartley Elements MPC 7149

Date ET	R. A. (1950)	Decl.	Delta	r	Elong.	Phase	m2
1982 07 30	16 59.44	-01 56.2	1.049	1.830	124.9	27.1	16.7
1982 08 09	17 08.07	-00 28.4					
1982 08 19	17 18.50	+00 24.4	1.313	1.928	111.4	29.3	17.4
1982 08 29	17 30.45	+00 53.6					
1982 09 08	17 43.61	+01 08.1	1.606	2.038	99.9	29.1	18.1
1982 09 18	17 57.77	+01 14.4					
1982 09 28	18 12.74	+01 17.5	1.917	2.155	89.5	27.7	18.7
1982 10 08	18 28.33	+01 21.1					
1982 10 18	18 44.41	+01 27.8	2.239	2.277	79.4	25.58	19.3
1982 10 28	19 00.86	+01 39.7					
1982 11 07	19 17.53	+01 58.1	2.563	2.403	69.5	22.7	19.9
1982 11 17	19 34.34	+02 23.8					
1982 11 27	19 51.19	+02 57.5	2.881	2.530	59.6	19.7	20.3

Have you been camping lately?

If you didn't make it to the August campout, here are some of the things that went on. Friday evening we drove out to Stargate under clear skies and hot air balloons which were flying low across Van Dyke near 29 Mile Rd. Chris was following me in his van with his newly acquired DS-16. The DS-16 is a 16 inch f/4.5 reflector from Meade. This was to be his first chance to use it in relatively dark skies. After eating supper at Big Boy's (yum), we drove over to the camp and found that Ken Strom was already there. We unpacked our perishables and bedding at the cabin and headed over to the observatory. By now a few others had arrived and were setting up their equipment. We all pitched in unloading the DS-16 out of Christ van. Once that was done, everyone finished setting up as more people arrived. As it got dark, we gave Chris a hand setting his scope on the pole. Then as the Milky Way became evident people began shouting out into the darkness, "I've got M13", or M57 and immediately small crowds formed around their telescope. Whenever the 16 inch was turned on an object most everyone wanted to take a look. As the night went on, clouds came in then left, until finally at about 4:00 am the clouds came in for good. So much for comet hunting and meteor watching. Speaking of meteors, we did see quite a few even though our attention was on the 16 inch. Of course this is by no coincidence since it was the tail end of the Perseid meteor shower. By 4:30 everyone was in bed.

The next morning we woke to clouds. We ate breakfast at about noon and by 3:00 it started to clear. More people showed up by then and we played a little softball, and some went fishing. There was a big Pepsi picnic going on over in the other area of the park. In fact they took up about 2/3 of the park. Some of the new people in the club commented on what a great turn out we had. Of course we couldn't take credit for the 150 people over at the other picnic. Alan brought over some model rockets and we had our own version of the Kennedy Space Center. Around 7:00 we cook up dinner for everyone and had plenty to spare. As darkness came we headed over to the observatory again since the skies looked excellent, even better than Friday. As the glow in the west dimmed everyone picked up where they left off the night before. We announced that we would have a Messier contest, so those who were going to participate got their charts ready, picked up observing partners, and got set to go. After I wrote down 12 objects I looked at them to make sure they would be seen by everyone. At 10:30 I passed out the lists and they were off and running. Bob Lennox pulled out first with M13, quickly followed by Alan and Chris, the team of Roger Tanner and Ken Strom, and then by Ken Kelly and Mark Bieniek. Within 5 minutes all of them had found M57. There was a hush for about the next 25 minutes, when the sound of 'Judge' broke the murmur of the teams mumbling coordinates and chart numbers. It was Alan and Chris pulling out into first place finding M31 at 11:00. Unfortunately that last one they found. Better luck next time. Next Bob Lennox found M56 at 11:08 and tied for first. Next Roger and Ken S. got M31 at 11:09 and there was a 3-way tie. Bob caught M27at 11:12. Meanwhile Ken and Mark picked up M27 also at 11:13. Boy things were hopping now. Ken and Mark then got M3l. Roger and Ken S. caught up again then moved into the lead with two quick strikes. Bob would have to get cooking to catch them. But not until Ken and Mark got two quick ones in M56 and M15. Tied again. However, they were finished for the night, so it was up to the team of Roger Tanner and Ken Strom against Bob Lennox. Roger and Ken took the initiative with their 7th object, M56. But Bob poured on the steam and took his next 6 objects before Roger and Ken found another. In doing so Bob completed the list and won the contest. Roger and Ken captured M81 and M82 for their final objects but couldn't find the last 3 to complete the list. It was a gallant try by all and I think everyone observed objects they had never found before. Bob said there were 5 or 6 new objects on the list for him. I am sure the others would like a chance at another Messier Contest. Stay tuned, we will have one soon. After the contest we searched for other things and turned the 16 inch on some test objects. I had the chance to show Chris how to find various objects and at the name time teach him some constellations. Some packed up after a while and the rest of us hit the sack.

The next morning we got up at 7:00, cleaned up the cabin and headed for home, since we had to be out of the cabin by 9:00. Before we went home, we stopped at Big Boy's for breakfast, chatted a while about the excellent time we had this weekend, then went home. Hope you join us next time.

Douglas H. Bock

RIVERSIDE 1982

We left at 5 am on Friday morning, May 28, without incident. By 11 am, we were in Indio, Calif. within sight of the mountain we were going into. They were snow covered. We began to have fears of a meeting as cold as the one in 1979 when the nighttime temperatures set a record at 15°F. Riding with Dolores and me were Bob Miller, an old friend from East Lansing, Mich., and Dan Churchfield, one of the members of the astronomy club that used to be in Midland, Mich.

As soon as we got to the top of the mountain we were relieved to find that the temperatures were normal, about 70°. As we pulled into the campgrounds we were additionally surprised to find our friend from San Francisco, Ken Wilson, in the car right in front of us! With such a start, things took off immediately. I brought three films for the hosts to show each evening of the three day conference. I had a paper to give as well, but everyone's big reason for coming was the swap meet (a glorified garage sale for easterners), which was scheduled for Saturday.

First we had to check into the bunkhouses. Dolores and I stayed in a family only dorm and the other two, Bob and Dan, stayed in the 'men only' dorm next door. I think we had given Bob a false impression of what to expect. The look on his face said "Oh, my god!" We should have warned him that it definitely wasn't the Hilton; it is more like a Boy Scout camp. Well, he survived. By the time we had unpacked and gotten out onto the telescope field, there were telescopes all over. A large 8" refractor, or lens type, telescope rose in the middle of the field, standing about 15 feet high. But little did we know at that time that this telescope was to be one of the smaller of the large telescopes. We wandered about taking photos and talking to proud owners and builders. When night came we looked through many of the same instruments.

Saturday morning began the talks. At the same time many people were already selling items. I was looking for eyepieces for our telescopes, which can usually be found for ¼ of their normal price, and filters to go with them. Dolores was looking for books. On both counts, by the end of the day, we were successful. Both Bob and Dan found treasures galore and our car, which had come loaded down with many free books and leaflets donated by the Kitt Peak library, went home even more loaded down. After the swap meet, I saw one fellow loading his truck with the items he had not sold. Among the items was a large, stainless steel shaft 4" in diameter and 3' long. I told him that I almost made an offer on it, hoping he would take any offer I would give on the spot rather than lug it all the way home again. To my utter surprise he said that if I wanted it I could have it for the asking, and I asked. I needed the shaft; which by the way is the landing gear axle to a DC-9, for a mount for our 12". Such a bargain! Meanwhile Bob had purchased a number of 8" telescope mirror blanks from Celestron, as had Dan, for $1.00 each. Dan had also bought 76 posters, among, other sundry items. All in all, a very successful spending binge.

The most significant paper of the whole meeting was that afternoon. It was heard by very few due to an unfortunate, and ill advised, reorganization of the papers to be given. The paper was given by Arthur Leonard, an acquaintance of some 15 yrs., and it was entitled, "The Foucau1t-Platzeck Gaviola Test". It involves a new use of the Gaviola test with the less sophisticated equipment of the Foucault test in a manner such that any one capable of doing the Foucault test can do this test which is able to achieve a precision of .01 wave. I have tried this test and I know this to be possible, though I have not yet reached such precision due to my inexperience with the method. If anyone wishes a copy of the paper, let me know, No door prizes were won by anyone in our group but we were none the poorer for it. Nevertheless the prizes were stunning. There were 6 telescopes given away!

The laugh of the meeting was the latest creation of Coulter Optical. It is a 29", count 'em, Dobsonian. It is truly ridiculous. They drove it up in a 2-ton stake truck, which does not come with the instrument. The telescope looks exactly like the smaller versions. I accused them of giving hormone shots to the 10" telescope. But I now think it's a product of genetic engineering. The base, or rocker, weighs 550 lbs, and the tube mirror and box weigh 450 lbs. I told them they should consult a local auto dealer, get a real price on a 2½ ton pick-up truck and offer it as a accessory! The mirror is only, hold onto your hats, 1.65" thick. Truly a piece of rubber. This makes the thickness/diameter ratio nearly 1:18! Though I didn't look through it, everyone, to a person, said the images were poor. Even Ben Mayer, who rarely winces at spending money on astronomy said that this instrument, a generous, appellation, finally cured him of "aperture envy". The 1¼" focuser looked silly on the tube. One of the accessories was a stairway that would take the observer 10 feet into the air to set to the eyepiece near zenith. But, for 3,000 dollars where are you going to get such a light bucket?

Some of the other instrumental highlights included a 20" Ritchey-Chretien portable reflector. Operating at f/8 with a 7" secondary, it gave us a fine view of M-13. Also a 12" f/8 Springfield, complete with 12' high tower that it was mounted on, gave us the finest view of the moon at first quarter. There were many 17" newtonians, the best of which had a tube constructed of wood laminations and a peg and dowel constructed mounting.

Unfortunately, with all this wonderful equipment (about 1100 attendees with more than 200 telescopes), few if any really knew how to use their telescope. I saw M-13 over a dozen times. Mars, Jupiter, and Saturn, at less than 100X in many apertures greater than 10" left me totally under-whelmed. And, the worst yet, were all the big telescopes, >12", that were put on the moon at magnifications of 30x to 80x! Have you ever looked at the moon in a telescope of, say, 18" aperture at a magnification that allows the entire disk in the field, without using a filter? It is as bad as bamboo shoots under the fingernails. First there are tears streaming down the cheek followed by a sizzling sound which is the cornea forming a cataract while the retina fries. These people need to read a basic amateur astronomy book. If the seeing won't allow high magnifications, step down and go to lower magnifications! My pupil broke the sound barrier it had to close so fast.

Next year we will be taking two telescopes and I will probably be giving a paper on the construction of one of them. It's always something to look forward to.

LUNAR ECLIPSE 1982

Delores and I had quite an agenda scheduled. We were going to use the Burrell Schmidt at the Warner and Swasey Observatory during totality. For the rest of the eclipse, and during totality, we had the following planned: a 500mm lens shooting color slides, a 35mm camera with 55mm and 28mm also shooting color slide, a movie camera on a 4½" f/12 refractor for time lapse high resolution movies, and a camera shooting color slides on the finder of the RV-6, an old University Optics 12x40 finder, we had a photometer that I built so we could electronically measure the light variation.

Well, we got up to the mountain amid light scattered clouds and set up all our equipment and readied the Schmidt. I got out the photographic plates and films, set up the RV-6, loaded the movie camera, and by 5pm was waiting for sunset. Then I looked outside again to find the sky, which before was partly cloudy with cumulus clouds, was now becoming covered with heavy thunderhead and a higher deck of stratus. I didn't want to panic. Leaving Kitt Peak would mean giving up the movie I wanted to shoot and the color shots of totality through the 24" Schmidt telescope. So, we waited and watched the skies. The cumulus-thunderhead was bathing the Papago reservation with rain and moving in from the west. The stratus layer was moving in from the Baja to the south. By 6pm the situation was becoming very grim. I made the decision to go north. I called Pete Manly in Phoenix to find out what the people up there were doing. They were all getting together at the parking lot of the Phoenix Zoo. He said it would be quite a media event. Well, it was better than clouds.

We left at 6:30pm. The eclipse was to begin at 9:22pm and we had at least 3.5 hours of driving ahead of us. We had only room for the RV-6 and the cameras. Well at least we would be able to achieve our primary goal which was checking out the simple photometer. Finally we arrived, without incident, at the Zoo at 9:45pm and by 10:00 we were measuring and photographing.

The way the photometer is set up it measures voltage from a 18 volt power source as the voltage changes after passing through light sensitive circuitry. We expected to take a reading every 10 minutes. But, about ¼ of the way into the umbra, Dolores noticed that the values were dropping by about .01 volt every second and she then decided to take a reading every minute. The results were highly successful in that they showed a decline in light that bottomed out at about the correct time. However we still were experiencing heavy cirrus which was very lumpy. Within the space of a minute we could see the changes from the clouds! The photometer was a resounding success. The photometer cost about $2 to make. But, the multimeter cost much more since it had to be a multimeter with a linear scale and most are logarithmic. I hope to develop a voltmeter that is linear specially designed for this instrument which will be of a cost in line with the rest of the instrument.

While Dolores was taking the measures, I was keeping the moon centered up in the telescope and taking the photos. About half way through, the press, TV and newspapers began to bug Pete. We had set up right next to him so I could hear it going on. Then he let them know I work at Kitt Peak. Immediately there were on me. I wound up doing one live camera interview and talked to three or four newspapers. I have since found out that they screwed up the report just like I figured they would. I told them that I do not work for Kitt Peak, and that I am not an astronomer. I even told them in monosyllables. Do you think they could get it right? Hell no! They called me Richard Hill, an astronomer with Kitt Peak. I guess it could have been worse. They could have called me the director or owner of some other observatory. What is the old quote, "at least they spelled the name right?" Did you ever notice that they always spell the name right when they screw up the report? If they manage to report all the other stories with the same accuracy then the papers are only good to wrap fish in. I never saw the Phoenix papers and I am sure that as far as the TV report went, I was a face on the cutting room floor.

We left for Tucson at 2:30 am when the clouds prevented us from seeing any more of the eclipse. Since then I have found out that in Tucson they saw the eclipse, up to the point where the moon disappeared, through broken overcast. After that, nothing. Up on Kitt Peak it was another story. A fog bank rolled over the mountain just as the eclipse began. I guess it was a good decision to leave.

We saw the eclipse, photographed it and measured it. It may not have been the best of conditions but we did it none the less. A good thing too for the next one is 47 years in the future when we will experience such a totality in both terms of length and depth. But, if all goes well, there will be an 80 year old man tottering infirmly on the brink of senility with a patient, steadfast woman seven years his junior by his side both observing the eclipse and telling the thirty year old young upstarts about the great eclipse of '82 in Arizona.

THE SPECTACULARITY OF DEEP SKY OBJECTS

by John Pazmino

It has always been for deep sky objects -- nebulae, galaxies, and clusters -- that there was no single, simple rating by which the observer could assess the object's "impressiveness", "conspicuousness", or "ease of finding" prior to searching out the object in the sky. All the observer had to go by were verbal commentaries, haphazard brightness values, and ill-representative pictures. For the beginning stargazer, interpretation of such notes can be uncertain, hesitant, even downright frustrating. This leads to huge waste of time and effort at the telescope and, frequently, to abandonment of stargazing altogether.

About two years ago, when fellow AAAer Frances McCool and I began to observe together regularly, this lack of a descriptive figure-of-merit for deep sky objects became a severely acute situation. Frances, having the typical stargazer's telescope and other equipage, was first starting out in deep sky observing. And she frittered away her valuable hours looking for a this or that nebula because she had no sure way of ascertaining beforehand how hard it would be to find or what to expect of its appearance when found. True, we two could work together to share the frustrations, but what was really needed was an index -- a "spectacularity" index -- for deep sky objects.

Now, there are two elemental properties of deep sky objects of concern to the observer, the annular size and the total magnitude. The visual impact of the object, based on physiological grounds, depends on both how much total illumination is sent to the observer and how much this illumination is spread out by the object's angular extent on the sky.

So I began by setting down directly the definition of angular illumination from ordinary photometry:

ANGULAR ILLUMINATION = (TOTAL ILUMINATION) / (ANGULAR AREA)

Then, I converted this into the magnitude system by which all good observers are brought up:

ANGULAR MAGNITUDE = -2.5 LOG ((TOT. ILLUM.) / (ANG. AREA) (BASE ILLUM.))

The units here are magnitude per square radian above whatever base illumination one cares to use. I calibrated the magnitudes to the standard stellar photometry so the base illumination is 2.65E-6 lumens per square meter.

Factoring this last equation results in two terms:

ANGULAR MAGNITUDE = (-2.5 LOG ((TOT. ILLUM.) / (BASE ILLUM.)))
+ (-2.5 LOG ((1) /(ANGULAR AREA)))

The second term is a function only of area and can be pretabulated for convenient intervals over the size range of astronomical interest. I call this term the dilution modulus because it acts to spread out the total illumination over the angular extent of the object.

With such a prepared table I can look up an object's dilution modulus, knowing the size, and add it directly to the total magnitude. The algebraic sum is immediately the object's angular magnitude, tantamount to one of the two determinants of the object's spectacularity. The other, the total magnitude, I already had all along.

Having now in hand the determinants of impressiveness and ease-of-finding, I sought a function of the two which would generate a simple, easily evaluated spectacularity index. There heretofore never having been such a function, I could define one myself. Obviously, though, the index must follow the spectacularity in a single-valued, monotonic manner.

I chose a straight addition function:

SPECTACULARITY INDEX = (TOTAL MAGNITUDE) + (ANGULAR MAGNITUDE)
= (2) (TOTAL MAGNITUDE) + (DILUTION MODULUS)

That is to say, the spectacularity index of an object is twice its total magnitude plus its dilution modulus.

All this reasoning took an evening or two of deskwork, but far more was to come. In the course of calculating spectacularity indices for the objects in the usual observing lists, hideous aberrations reared up. Objects known to be impressive received poor indices and vice-versa. The same object taken from different lists got discordant indices.

The cause was in the values cited for total magnitude and angular size. It seemed as if some compilers were truly on the weed! Sizes were copied from previous authors, measured in outsized instruments, enclosed dim outlaying areas, taken from hearsay. Same thing with total magnitudes with the added complication that photographic and visual values were often mixed together without distinction. In many cases the numbers were so misleading that I had to just go outside and examine the object for myself in the sky.

It took the better part of two years to card the entangled literature and assemble (at least for the more prominent objects) a uniform and consistent set of magnitudes and sizes from which valid spectacularity indices could be worked up.

The end results are presented here in two tables. Table I gives the spectacularity index versus total magnitude and angular size. This eliminates even the simple mathematics described above; the index can be read out directly from this table by entering it with the object's magnitude and size.

Table 1 is divided into two zones, the left one for objects of index +1.5 and better and the right one for objects of index worse than +1.5. The left zone embraces those objects suitable for the novice telescope user in an urban setting to work with when just starting out in deep sky observing. The right zone takes in objects for the more practiced observer. More on these zones later.

Table 2 gives all the deep sky objects visible in the latitude of New York whose indices are +1.5 or better; which is to say, all objects which the novice observer should choose from for starting out in looking for deep sky objects under a city sky. Because, despite my concerted efforts, there may yet be further adjustments in an object's adopted magnitude and size, in the table I list those I finally settled on and from which the indices are derived. Should other values prove more appropriate, Table 1 can be used to obtain the new index for the object.

However, contemplated adjustments to either the total magnitude or the angular size ought to be founded where ever possible on actual recourse to the object in the sky, not on quotations from compiled lists. It is essential to enclose in the magnitude and size only the principal seats of light in the object and no more. Taking in the faint peripheral territories will only increase the angular size with no real increase in illumination; this will unfairly depress the object's spectacularity index.

Use of the spectacularity index is quite easy and direct. Just think of it as an ordinary magnitude rating. The algebraically smaller indices denote the more showy, easier-to-find objects.

Take, by way of a simplified example, a sky of uniform transparency. We've just looked at M80 Scorpii, an old favorite. Now we want to look for M 56 Lyrae which we haven't seen before. Turning to Table 2 we see that both M 80 and M 56 have an index of -0.5. While M 56 is half a magnitude fainter than M 80, it is also less than half as large, area-wise. The two factors compensate to yield equal spectacularity indices.

Thus, overall, we would have just as much ease (or trouble) locating M 56 as M 80 and we would be about equally impressed with its aspect. But if instead we wanted to look for M 12 in Ophiuchus we would have quite a bit harder a time finding it than M 80 and it would seem significantly more mediocre. M 12's index is +10, as read out from Table 2.

Suppose, though, the sky is not of uniform transparency. Usually the transparency decreases toward the horizon and there may be regions of poor transparency due to local circumstances. Take the same two clusters, M 80 and M 56 again. M 80 is, say, in a part of the sky whose transparency is one magnitude worse than M 56's part. So instead of M 80's magnitude being +7.5, it is equivalently only +8.5. Look up in Table 1 under +8.5 magnitude, 3 arc minute diameter and take out the equivalent index of +1.5. M 80's equivalent index of +1.5 compared to M 56's index of -0.5 indicates that we should locate M 56 much more easily than M 80 (which we have already appreciated) and it would look much more conspicuous.

The spectacularity index enables us to assess the visibility of objects in different skies. Let us already from our city location have appreciated M 3 in Canes Venatici. Could we try for M 51, also in Canes Venatici, during a visit to our country friend? The sky in the city was overall of transparency +3 and we can reasonably expect an overall transparency of +5 where our friend lives. M 3's index is 0.0 from Table 2. We adopt magnitude +8.5, diameter 8 arc minutes for M 51. Since the difference in transparency is 2 magnitudes in favor of M 51, we look in Table 1 under +6.5 and 8' and read out the equivalent index of -0.5. We under our friend's sky would find M 51 a somewhat easier object to pick up than M 3 is under our own sky.

As a final point, let's go back to Table 1. There are the two zones separating the objects for urban beginners from the more experienced stargazers. The breakpoint of index +1.5 is based on my own experience with many tens of observers of assorted skill working under the skies of New York City. By and large, novice telescope users in the City (transparency averaging +3.5) spend overly and frustratingly long times looking for objects of index worse than +1.5. Some difficulty is experienced at index +1.5, but only enough to present a realistic challenge repaid by a pleasing impact from the object once found.

By going to skies of better transparency the boundary between the two zones shifts to the right by one column in Table 1 for each 0.5 magnitude improvement in transparency, unveiling ever dimmer, more diffuse objects to view. For poorer skies the boundary migrates leftward at the same rate, leaving fewer and fewer objects of merit to look at. Thus, for our country friend, if just starting out in deep sky stargazing, the breakpoint index is +4.5; this includes most of the Messier objects and a good number of objects in the NGC catalog.

Going back to Frances in closing. On one of our earlier get togethers, she sought vainly for M 51. She never did find it. If we employ the spectacularity index the reason is plain. With the adopted magnitude and size for M 51 noted above, its index is +3.5. That particular night -- a rather clear one -- the breakpoint index was +2.5. So Frances was actually going after something a mite beyond her skills at the time.

But now, Frances, that will never happen to you again!

* *

Presented at the 68th annual meeting of the American Association of Variable Star Observers, Cambridge, MA, 26-28 October 1979.

TABLE 1

SPECTACULARITY INDEX VERSUS TOTAL MAGNITUDE AND ANGULAR SIZE

DIAM \ MAGN.	+4.5	+5.0	+5.5	+6.0	+6.5	+7.0	+7.5	+8.0	+8.5	+9.0	+9.5	10.0	10.5
1'	-9.0	-8.0	-7.0	-6.0	-5.0	-4.0	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0
2'	-7.5	-6.5	-5.5	-4.5	-3.5	-2.5	-1.5	-0.5	+0.5	1.5	+2.5	+3.5	+4.5
3'	-6.5	-5.5	-4.5	-3.5	-2.5	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5
4'	-0.0	-5.0	-4.0	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0
5'	-5.5	-4.5	-3.5	-2.5	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5
6'	-5.0	-4.0	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0
7'	-4.5	-3.5	-2.5	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5
8'	-4.5	-3.5	-2.5	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5
9'	-4.0	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+5.0	+5.0	+6.0	+7.0	+8.0
10'	-4.0	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+8.0
12'	-3.5	-2.5	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5	+8.5
14'	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+8.0	+9.0
16'	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+0.0	+9.0
18'	-2.5	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5	+8.5	+9.5
20'	-2.5	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5	+8.5	+9.5
24'	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+8.0	+9.0	10.0
28'	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5	+8.5	+9.5	10.5
32'	-1.5	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5	+8.5	+9.5	10.5
36'	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+8.0	+9.0	10.0	11.0
40'	-1.0	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+8.0	+9.0	10.0	11.0
46'	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5	+8.5	+9.5	10.5	11.5
50'	-0.5	+0.5	+1.5	+2.5	+3.5	+4.5	+5.5	+6.5	+7.5	+8.5	+9.5	10.5	11.5
55'	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+1.0	+8.0	+9.0	10.0	11.0	12.0
60'	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+8.0	+9.0	10.0	11.0	12.0

TABLE 2

DEEP SKY OBJECTS WITH SPECTACULARITY INDEX OF +1.5 AND BETTER

SORTED BY CATALOG NAME

CATALOG NAME	TYPE	CONST	RA HR	(1950) MN	DEC DEG	DIAM MIN	TOT. MAGN	SPEC. INDEX	PROPER NAME
M 2	GC	AQR	21	31	-01.1	8	+6.5	-0.5	AQR CLUS
M 3	GC	CVN	13	40	+28.6	10	+6.5	0.0	CVN CLUS
M 4	GC	SCO	16	21	-26.4	14	+6.0	0.0	
M 5	GC	SER	15	16	+2.3	13	+6.0	0.0	SER CLUS
M 6	OC	SCO	17	37	-32.2	25	+5.0	-1.0	
M 7	OC	SCO	17	51	-34.8	60	+3.0	-3.0	SCO CLUS
M 8	ON	SGR	18	02	-24.3	10	+4.5	-4.0	LAGOON NEB
M 9	GC	OPH	17	16	-18.5	2	+8.0	+0.5	
M 10	GC	OPH	16	55	-4.0	8	+7.0	+0.5	
M 11	OC	SCR	18	48	-6.3	10	+6.0	-1.0	SCT CLUS
M 12	GC	OPH	16	46	-1.9	9	+7.0	+1.0	
M 13	GC	HER	16	40	+36.6	10	+6.0	-1.0	HER CLUS
M 14	GC	OPH	17	35	-3.2	3	+7.5	-0.5	
M 15	GC	PEG	21	23	+12.0	7	+6.5	-0.5	PEG CLUS
M 16	ON	SGR	18	16	-13.8	8	+5.5	+2.5	EAGLE NEB
M 17	ON	SGR	18	18	-16.2	10	+5.0	-3.0	OMEGA NEB
M 18	OC	SGR	18	17	-17.2	7	+7.5	+1.5	
M 19	GC	OPH	17	00	-26.2	4	+7.0	-1.0	
M 20	ON	SGR	17	59	-23.0	8	+5.5	-2.5	TRIFID NEB

M	21	OC	SGR	18	02	-22.5	10	+6.0	-1.0	
M	22	GC	SGR	18	33	-24.0	17	+5.0	-2.0	
M	24	OC	SGR	18	13	-18.5	30	+4.5	-1.5	SGR CLUS
M	27	GN	VUL	19	57	+22.6	6	+7.0	0.0	DUMBBELL
M	28	GC	SGR	18	22	-24.9	5	+7.0	-0.5	
M	29	OC	CYG	20	22	+38.4	12	+7.0	+1.5	
M	30	GC	CAP	21	38	-23.4	6	+7.5	+1.0	CAP CLUS
M	31	GX	AND	0	40	+41.0	40	+3.5	-3.0	AND GALAXY
M	32	GX	AND	0	40	+40.6	2	+8.0	-0.5	
M	34	OC	PER	2	39	+42.6	18	+6.0	+0.5	
M	35	OC	GEM	8	8	+24.3	30	+5.5	+0.5	GEM CLUS
M	36	OC	AUR	5	32	+34.1	16	+6.0	+1.0	
M	37	OC	AUR	5	49	+32.6	24	+6.0	+1.0	
M	39	OC	CYG	21	30	+48.2	30	+5.5	+0.5	CYG CLUS
M	41	OC	CMA	8	45	-20.5	20	+5.0	-1.5	CMA CLUS
M	42	ON	ORI	5	33	-5.4	16	+3.0	-6.0	ORI NEBULA
M	43	ON	ORI	5	33	-5.3	5	+5.0	-4.5	
M	44	OC	CNC	8	38	+19.9	90	+3.5	-1.0	PRAESEPE
M	45	OC	TAU	3	44	+24.0	100	+1.5	-5.0	PLEIADES
M	46	OC	PUP	7	40	-14.7	24	+6.0	+1.0	
M	47	OC	PUP	7	34	-14.4	25	+4.5	-2.0	PUP CLUS
M	48	OC	HYA	8	11	-05.6	30	+5.5	+0.5	
M	50	OC	MON	7	1	-8.3	10	+6.5	0.0	
M	53	GC	COM	13	11	+18.4	3	+8.0	+0.5	
M	54	GC	SGR	18	52	-30.5	2	+7.5	-1.5	
M	55	GC	SGR	19	37	-31.1	10	+6.5	0.0	
M	56	GC	LYR	19	15	+30.1	2	+8.0	-0.5	LYR CLUS
M	57	GN	LYR	18	52	+33.0	1	+8.5	-1.0	RING NEB
M	62	GC	OPH	16	58	-30.1	4	+6.5	-2.0	
M	67	OC	CNC	8	43	+12.0	15	+6.5	+1.0	
M	68	GC	HYA	12	37	-26.5	3	+8.5	-1.5	
M	69	GC	SGR	18	28	-32.4	3	+7.5	-0.5	
M	70	GC	SGR	18	40	-32.4	3	+8.0	+0.5	
M	73	OC	AQR	20	56	-12.8	3	+8.5	+1.5	
M	75	GC	SGR	20	03	-22.1	2	+8.5	+0.5	
M	79	GC	LEP	5	22	-24.6	3	+8.5	+1.5	
M	80	GC	SCO	16	14	-22.9	3	+7.5	-0.5	
M	81	GX	UMA	9	52	+69.3	13	+7.0	+1.5	
M	82	GX	UMA	9	52	+69.9	3	+8.5	+1.5	
M	92	GC	HER	17	16	+43.2	8	+6.5	-0.5	
M	93	OC	PUP	7	42	-23.8	25	+6.0	+1.0	
M	103	OC	CAS	1	30	+60.5	5	+7.0	-0.5	CAS CLUS
M	107	GC	OPH	18	30	-13.0	2	+8.0	-0.5	
M	110	GX	AND	0	40	+41.0	5	+8.0	+1.5	
MEL	25	OC	TAU	4	17	+15.5	240	+1.0	-4.0	HYADES
MEL	111	OC	COM	12	23	+26.4	360	+3.0	+1.0	COM CLUS
NGC	869	OC	PER	2	16	+56.9	30	+4.0	-2.5	DOUBLE CL
NGC	884	OC	PER	2	20	+56.9	30	+4.0	-2.5	DOUBLE CL
NGC	1980	OC	ORI	5	33	-6.0	14	+4.0	-4.0	IOT ORI
NGC	2237	OC	MON	6	30	+4.7	10	+6.5	0.0	
NGC	2244	OC	MON	6	30	+4.9	27	+5.0	-0.5	ROSETTE
NGC	2264	OC	MON	6	38	+10.0	30	+4.5	-1.5	15 MON
NGC	5128	GX	CEN	13	22	-42.8	9	+7.0	+1.0	CEN GALAXY
NGC	5139	GC	CEN	13	24	-47.1	23	+3.5	-4.0	OME CEN
NGC	6356	GC	OPH	17	21	-17.8	2	+8.5	+0.5	
NGC	6638	GC	SGR	18	28	-25.5	1	+9.0	0.0	
NGC	6642	GC	SGR	18	29	-23.5	1	+9.5	+1.0	
NGC	6712	GC	SCU	18	50	-8.8	2	+8.0	-0.5	
PAZ	1	OC	CAM	3	13	+59.7	10	+6.0	-1.0	

A LUNAR EPHEMERIS - PART II

BY KEN KELLY

```
10 ' "LUNAREPH" - PROGRAM TO COMPUTE A LUNAR EPHEMERIS FOR A GIVEN DATE AND UNIV
ERSAL TIME USING CHEBYSHEV POLYNOMIALS STORED ON DISK — BY KEN KELLY.
20 '
30 PRINTCHR$(23):PRINT"PROGRAM TO COMPUTE A LUNAR EPHEMERIS"
40 CLEAR5000:DEFDBLA-H:DEFINTI-N:DEFSTRO:DEFDBLP-Z:PI=3.141592653589793:RAD=180/PI
50 DIMPA(37),PB(39),PD(37),PH(37),PR(37),PS(37) ' POLYNOMIAL ARRAYS
60 FR=0:RL=9999999:GOSUB3010 ' GET U.T. DATE
70 '
80 ' *** ROUTINE TO READ IN AND STORE CHEBYSHEV POLYNOMIALS ***
90 '
100 OL="LUN     :1" ' SET UP FILE SPECIFICATION FOR READ
110 OS=STR$(JY)
120 MID$(OL,5,2)=MID$(OS,2,2)
130 OS=STR$(JM)
140 MID$(OL,7,2)=MID$(OS,1,2)
150 IFMID$(OL,7,1)=" "THENMID$(OL,7,1)="0"
160 MID$(OL,4,1)="R" ' READY TO READ RIGHT ASCENSION POLYNOMIAL
170 A2=100000000 ' SETS UP CONSTANT FOR ROUNDING
180 G0SUB3090 ' READ AND STORE CHEBYCHEV POLYNOMIAL
190 FORI=0TONN:PR(I)=PA(I):NEXT ' STORES POLYNOMIAL FOR LATER USE
200 AR=AA:BR=BB:WR=WW:NR=NN:FR=DF:RL=DL ' STORES CONSTANTS FOR LATER USE
210 MID$(OL,4,1)="D" ' READY TO READ DECLINATION POLYNOMIAL
220 A2=10000000
230 GOSUB3090
240 FORI=0TONN:PH(I)=PA(I):NEXT
250 AD=AA:BD=BB:WD=WW:ND=NN
260 MID$(OL,4,1)="H" ' READY TO READ HORIZONTAL PARALLAX POLYNOMIAL
270 G08UB3090
280 FORI=0TONN:PS(I)=PA(I):NEXT
290 AH=AA:BH=BB:WH=WW:NH=NN
300 MID$(OL,7,2)=STR$(INT((JM+2)/3))
310 IFMID$(OL,7,1)=" "THENMID$(OL,7,1)="0"
320 MID$(OL,1,4)="SIDT" ' READY TO READ SIDEREAL TIME POLYNOMIAL
330 A2=100000000
340 GOSUB3090
350 FORI=0TONN:PS(I)=PA(I):NEXT
360 AS=AA:BS=BB:WS=WW:NS=NN
```

```
1000 '
1010 ' *** ROUTINE TO.GET UNIVERSAL TIME AND EPHEMERIS DATE ***
1020 '
1030 INFUT"ENTER UNIVERSAL TIME IN FORMAT HH.MM.SS.S ";JH,JN,JS!
1040 TU=JH+JN/60+JS!/3600 ' CONVERTS UNIVERSAL TIME TO HOURS
1050 TD=((51.15-48.53)/2.75*(DJ-2443509.5))/365.25+48.53 ' CALCULATES DELTA T
(E.L - U.T.)
1060 TE=TU+TD/3600 ' COMPUTES EPHEMERIS TIME IN HOURS
1070 DE=DJ+TU/24+TD/86400 ' COMPUTES EPHEMERIS DAY
1080 DU=DJ+TU/24 ' COMPUTES UNIVERSAL DAY
1090 DY=INT((275*JM)/9-INT((JM+9)/12)*(1+INT((1900+JY-4*INT((1900+JY)/4)+2)/3))+JO-
30+TU/24 ' COMPUTES DAY OF YEAR
1100 '
1110 ' *** ROUTINE TO COMPUTE LUNAR GEOCENTRIC COORDINATES AND SIDEREAL TINE ***
1120 '
1130 EX=(DY-WR)/AR-1:NN=NR ' COMPUTES TIME PARAMETER FOR POLYNOMIAL CALCULATION
1140 FORI=0TONN:PA(I)=PR(I):NEXT ' MOVES RIGHT ASCENSION ARRAY TO CHEBYSHEV ARRAY
1150 GOSUB3310 ' GOES TO COMPUTE POLYNOMIAL
1160 GR=~X ' SAVES OUTPUT OF SUBROUTINE AS GEOCENTRIC RIGHT ASCENSION
1170 IFGR>24THENGR=GR-24:GOT01170 ' MAKES SURE THAT R.A. IS LESS THAN 24 HOURS
1180 EX=(DY-WD)/AD-1:NN=ND
1190 FORI=0TONN:PA(I)=PD(I):NEXT
1200 G0SUB3310
1210 GD=FX ' SAVES OUTPUT AS GEOCENTRIC DECLINATION
1220 EX=(DY-WH)/AH-1:NN=NH
1230 FORI=0TONN:PA(I)=PH(I):NEXT
1240 GOSUB3310
1250 GH=FX ' SAVES OUTPUT AS GEOCENTRIC HORIZONTAL PARALLAX
1260 EX=(DY-WS)/AS-1:NN=NS
1270 FORI=0TONN:PA(I)=PS(I):NEXT
1280 GOSUB3310
1290 TS=FX ' SAVES OUTPUT AS SIDEREAL T~ME
1300 IFTS>=24THENTS=TS-24:G0T01300
```

```
2000 '
2010 ' *** ROUTINE TO PRINT OUT TIMES AND LUNAR COORDINATES.***
2020 '
2030 OP="%                            % +## +## ##.####"
2040 OO="%                                % +###.#######"
2050 OT="%            % #1#####.########%            % +## +## ##.####"
2060 OV="%                                               % +## +## ##.####"
2070 LPRINT" LUNAR COORDINATES AND TIMES FOR ";JY;JM;JD;CHR$(10)
2080 HH=GR:GOSUB3390
2090 LPRINT USING OP;"GEOCENTRIC RIGHT ASCENSION";IH;IM;IS!
2100 HH=GD:GOSUB3390
2110 LPRINT USING OP;"GEOCENTRIC DECLINATION";IH;IM;IS!
2120 HH=GH/60:60SUB3390
2130 LPRINT USING OP;"GEOCENTRIC HORIZONTAL PARALLAX";IH;IM;IS!
2140 Z=GH!60/RAD;G0SUB6060 ' GET SINE OF HORIZONTAL PARALLAX
2150 SH=Z2:RD=I/SH ' TRUE DISTANCE OF DATE
2160 Z=GR*15/RAD:G0SUB6010 ' GET COSINE OF RIGHT ASCENSION
2170 CR=Z2:Z=GD/RAD:GOSUB6010 ' GET COSINE OF DECLINATION
2180 CD=Z2
2190 GX=RD*CD*CR ' GEOCENTRIC RECTANGULAR X OF DATE
2200 LPRINT USING OQ= "GEOCENTRIC RECTANGULAR X (DATE)";GX
2210 Z=GR*15/RAD=GOSUB6060 ' GET SINE OF RIGHT ASCENSION
2220 SR=Z2
2230 GY=RD*CD*SR ' GEOCENTRIC RECTANGULAR Y OF DATE
2240 LPRINT USING OQ;"GEOCENTRIC RECTANGULAR Y (DATE)";GY
2250 Z=GD/RAD;GOSUB6060 ' GET SINE OF DECLINATION
2260 SD=Z2
2270 GZ=RD*SD ' GEOCENTRIC RECTANGULAR Z OF DATE
2280 LPRINT USING OQ;"GEOCENTRIC RECTANGULAR Z (DATE)";GZ
2290 Z=GX[2+GY[2+GZ[2:GOSUB6370 ' SQUARE ROOT
2300 GD=Z3
2310 LPRINT USING OQ;"GEOCENTRIC DISTANCE     (DATE)";RD
2320 LPRINT USING OQ; "GEOCENTRIC DISTANCE CHK (DATE)";GD
2330 SO=0.2724880*SH
2340 Z=1-S0[2:GOSUB6370
2350 Z=S0/Z3~G0SUB6210 ' ARCSINE OF SEMI-DIAMETER
2360 SD=Z2*RAD:HH=SD:GOSUB3390
2370 LPRINT USING OP; "SEMI-DIAMETER            (DATE)";IH;IM;IS!
2380 HH=TU:GOSUB3390
2390 LPRHIT IJSING OT; "UNIVERSAL DAY" ;DU;" - UNIVERSAL TIME·';; IH;1M; IS~
2400 HH=TE:GOSUB3390
2410 LPRINT USING OT;"EPHEMERIS DAY";DE;" - EPHEMERIS TIME";IH;IM;IS!
2420 HH=TS:G0SUB3390
2430 LFRINT USING OV;"               GREENWICH APPARENT SIDEREAL TIME";IH;IM;IS!
:LPRINTCHR$(1O)
2440 INPUT"DO YOU WANT ANOTHER EPHEMERIS";O
2450 IFO<>"Y"THENEND
2460 G0SUB3010
2470 GOTO1010
```

```
3000 '
3010 ' *** SUBROUTINE TO GET U.T. DATE ***
3020 '
3030 INPUT"ENTER U.T. DATE IN FORMAT YY,MM,DD ";JY,JM,JD
3040 DJ=367*(JY+1900)-INT((7*(JY+1900+INT((JM+9)/12)))/4)+INT(275*JM/9)+JD+17210
13.5 ' COMPUTES THE JULIAN DATE
3050 IFDJ<FRTHENPRINT"ERROR - DATE IS TOO EARLY FOR THIS SERIES":GOTO3030
3060 IFDJ>RLTHENPRINT"ERROR - DATE IS TOO LATE FOR THIS SERIES":GOTO3030
3070 RETURN
3080 '
30°0 ' *** SUBROUTINE TO READ AND TEMPORARILY STORE CHEBYSHEV POLYNOMIALS ***
3100 '
31100PEN"I".1,OL
3120 INPUT#1.DF,bL,AA.BB,WW.NN
3130 IFDJ(DFTHENPRINT"ERROR - USE PREVIOUS SERIES FOR THIS DATE":END
3140 IFDJ)DLTHENPRINT"ERROR - USE NEXT SERIES FOR THIS DATE":END
2150 A0=0
3U:0 FORI=0TONN
3170 INPUT#1,A3
3180 A4=INT(A2*A3+.5) ' POLYNOMIAL IS ROUNDED TO ELIMINATE UNWANTED DIGITS TO THE
RIGHT, WHICH ARE PICKED UP BY THE READ SOFTWARE
3190 PA(I)=A4/A2
3200 A0=A0+PA(I)
3210 NEXT
3220 INPUT#1,A1
3230 CLOSE
3240 A4=INT(A2*A0+.5):A0=A4/A2
3250 A4=INTCA2*A1+.5):A1=A4/A2
3260 IFA0=A1THEN3290
3270 PRINT"SUM OF RECORDS";A0:PRINT"SUMMARY RECORD";A1:INPUT"OK";O
3280 IFO<>"Y"THENEND
3290 RETURN
3300 '
3310 ' *** SUBROUTINE TO COMPUTE CHEBYSHEV POLYNOMIALS ***
3320 '
3330 I=NN:PB(I+1)=0:PB(I+2)=0
3340 PB(I)=2*EX*PB(I+1)-PB(I+2)+PA(I)
3350 I=I-1:IFI>-ITHEN3340
3360 FX=(PB(0)-PB(2))/2
3370 RETURN
3380 '
3390 ' *** SUBROUTINE TO CHANGE HOURS INTO HH,MM,SS ***
3400 '
3410 IG=SGN(HH):HH=ABS(HH)
3420 IH=INT(HH)
3430 HM=(HH-IH)*60
3440 IM=INT(HM)
3450 IS!=(HM-IM)*60 .
3460 IH=IH*IG:IM=IM*IG
3470 RETURN
```

```
6000 '
6010 ' *** COSINE ***
6020 '
6030 GOSUB 6430
6040 Z=Z9-Z
6050 '
6060 ' *** SINE ***
6070 '
6080 GOSUB 6430
6090 I0=0:I2=SGN(Z):Z2=Z9+Z9:Z=ABS(Z):Z=Z-INT(Z/(Z2+Z2))*(Z2+Z2)
6100 IF Z>Z2 THEN Z=Z-Z2:I2=-I2
0110 IF Z>Z9 THEN Z=Z2-Z
6120 IF ABS(Z)<.063 THEN 6140
6120 Z=Z/3:I0=I0+1:GOTO 6120
6140 Z2=-Z*Z:Z2=(((Z2/42+1)*Z2/20+1>*Z2/6+1)*Z
6150 IF I0=0 THEN 6190
6160 FOR I=1T0 I0
6170 Z2=(3-4*Z2*Z2>*Z2
6180 NEXT I
6190 Z2=Z2*I2:RETURN
6200 '
6210 ' *** ARCTANGENT ***
6220 '
6230 GOSUB 6430
6240 I0=0:I1=0:I2=SGN(Z)
6250 Z=ABS(Z):IF Z>1 Z=I/Z:I1=1
6260 IF Z<.077 THEN 6290
6270 Z2=Z:Z=Z*Z+I:GOSUB 6390 :Z=Z2/(Z3+1)
6280 I0=I0+1=GOTO 6260
6290 Z3=Z:I3=-11:GOSUB6480
6300 IF I0=0 GOTO 6320
6310 FOR I=1 TO I0:Z=Z+Z:NEXT
6320 Z2=Z
6330 IF I1=1 Z2=Z9-Z2
6340 Z2=Z2*I2
6350 RETURN
6360 '
6370 ' *** SQUARE ROOT ***
6380 '
6390 Z3=SQR(Z):Z3=(Z3+Z/Z3)/2:Z3=(Z3+Z/Z3)/2:RETURN
6400 '
6410 ' *** 29 = PI/2 ***
6420 '
6430 IF Z9<>0 RETURN
6440 Z4=Z:Z=I:GOSUB 6240 :Z9=Z2+Z2:Z=Z4:RETURN
6450 '
6460 ' *** POWER EXPANSION SUBROUTINE ***
6470 '
6480 Z2=Z*Z:FORI=3TOABS(I3}STEP2:Z3=SGN(I3)*Z3*Z2
6490 Z=Z+Z3/I:NEXT:RETURN
6500 '
```