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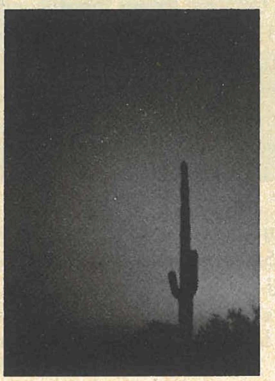

Phoenix photographer Frank Zullo captured the mood of a late spring evening with Orion gliding down the western sky behind a saguaro cactus. His 12-second exposure on Ektachrome 400 was made with a 50-mm f/1.8 lens with the camera mounted on the tracking platform described on page 391. Such highly portable platforms, easily made in one evening, are ideal for both beginning and advanced astrophotographers headed south to view Halley's comet next year.

Astronomical Computing / Conducted by Roger W. Sinnott

Halley's Comet in Stereo

To AID my observing plans, I recently used a computer and plotter to chart the altitude and azimuth of Halley's comet, as seen from the 40° north latitude of my home. Then I hit upon the idea of the pair reproduced below. This three-dimensional diagram is designed to be viewed with a stereoscope, so the left eye sees the left chart and the right eye the right one.

The two plots are identical except for a systematic shift in azimuth values. This was accomplished by inserting the following three lines of code in my Fortran plotting subroutine, where AU is the comet's distance from Earth in astronomical units:

```
SHIFT = 2.0/AU
AZR = AZ - SHIFT
AZL = AZ + SHIFT
```

As a result, when the comet is half an astronomical unit away (for example), the azimuth of a point on the left chart (AZL) is increased 4° and that on the right chart (AZR) decreased by the same amount. After the brain fuses the images, the curves not only indicate the correct altitude and azimuth, but also loom up out of the paper as the comet approaches the Earth!

Symbols are placed on the curves at five-day intervals to distinguish the four stages of the 1985-86 apparition. Small squares denote July 19th to September 2nd, when the comet is in the morning sky and its distance decreases from 4.1 to 3.0 a.u. Circles show it in the evening sky from December 26th to January 25th (1.0 to 1.5 a.u.). The triangles are for the morning sky again, from February 24th to April 10th (1.4 to 0.4 a.u.). Then crosses give the comet's evening-sky location from April 15th to July 4th (0.4 to 2.8 a.u.). In each case, time increases toward the right.

With practice, some people can fuse diagrams of this kind without the aid of a stereoscope. If you find the cross-eyed viewing method easier, you can photocopy the page and swap the diagrams left for right to see the effect. I believe this is a fresh idea for illustrating a comet's motion in the sky.

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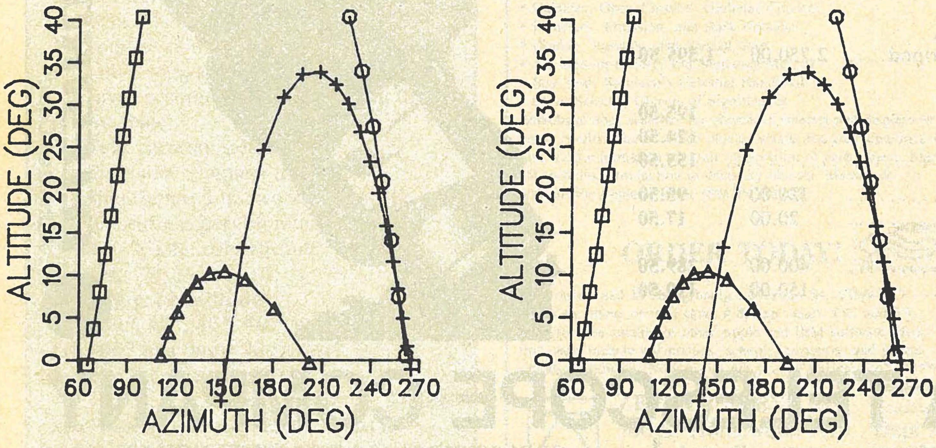

R. B. Minton's stereoscopic diagram shows not only the placement of Halley's comet in the sky, but also its varying distance from Earth during the 1985-86 season. To avoid clutter and enhance the three-dimensional effect he has omitted labels from the curves. The symbols are placed at five-day intervals, and the text describes viewing methods.

WHAT SAROS NUMBER?

After any particular solar eclipse, another quite similar one will take place 6,585.3 days later (called the saros interval), and its track will be displaced about 120° west on the Earth. To aid in distinguishing the many overlapping eclipse series, the Dutch astronomer G. van den Bergh introduced a numbering system in which, for example, the very long total eclipses of June 30, 1973, and July 11, 1991, belong to saros number 136. The numbers are used in the *Canon of Solar Eclipses −2003 to +2526* by H. Mucke and J. Meeus (Vienna, 1983) and elsewhere.

Odd saros-series numbers are for eclipses taking place at the ascending node of the Moon's orbit, even numbers for those at the descending node. Each saros series runs its course in about 1,200 to 1,500 years. A dramatic diagram by Fred Espenak illustrates the progression of a typical series, number 126 (*S&T:* October, 1984, page 299). The accompanying program finds the saros number to which any eclipse belongs when you enter its Julian Day number.

First the program does a rough check to see that the Moon is new on the date you enter. As mentioned in Astronomical Computing for May, 1984, page 455, dividing the Julian Day number by the Moon's synodic period results in a number whose fractional part is about 0.33. Then, when 82,064 is subtracted from the quotient, the integer part is the lunation number on the scheme of Yale astronomer E. W. Brown.

To find the saros number, the program makes use of a period of 358 lunations, which is the interval van den Bergh called the *inex.* One inex after a given eclipse, another will occur with the next higher saros number. In devising the program, I have adopted the July 11, 1991, total eclipse (Brown lunation 848) as a benchmark because it happens to lie at the "peak" of saros 136, the umbral cone being aligned with the center of the Earth. By definition, saros series reach their peaks in numerical sequence, though they do not necessarily begin and end in sequence.

```
10 REM     SAROS SERIES
14 REM
18 PRINT
22 INPUT "JULIAN DAY NUMBER";J
26 Q=J/29.530588-82064
30 B=INT(Q): N=Q-B
34 IF N>0.28 AND N<0.36 THEN 42
38 PRINT "WARNING: NOT NEW MOON!"
42 PRINT "  BROWN LUNATION ";B
46 D=B-848
50 S=136+38*D
54 X=-61*D
58 C=INT(X/358+0.5-D/(12*358*358))
62 S=S+223*C
66 X=X-358*C
70 IF ABS(X-(S-136)/12)<55 THEN 78
74 PRINT "WARNING: NO ECLIPSE!"
78 PRINT "  SAROS NUMBER ";S
82 PRINT "  RELATIVE ECLIPSE ";
86 PRINT INT(X-(S-136)/12+0.5)
90 PRINT
94 END
```

In lines 46-54, the number of lunations from the benchmark is converted to a sum of inex and saros intervals. This is done by making use of the fact that 38 inex intervals minus 61 saros intervals equals one month (that is, eclipses that occur a month apart differ in saros number by 38). An additional refinement, included in line 58, allows for the fact that the inex period is not exact.

Line 70 checks to see if the eclipse is more than 55 occurrences from the peak of its series, and if so issues a warning that the Moon's shadow will completely miss the Earth. The number 55 is an extreme, intended only as a check for reasonableness; no saros series continues quite so long before or after its peak.

The relative eclipse number, as I have called it here, is the number of saros intervals forward (if positive) or back from the peak within the numbered series. The calculations involved in finding whether an eclipse actually takes place on a given date are, of course, far beyond the scope of this brief program.

For example, to what saros series does next month's solar eclipse belong? November 12, 1985, corresponds to Julian Day number 2,446,382, and the dialogue goes as follows:

```
>RUN "SAROS"

JULIAN DAY NUMBER? 2446382
  BROWN LUNATION  778
  SAROS NUMBER  152
  RELATIVE ECLIPSE -27

READY
```

The −27 shows that series 152 is still young; it will not peak until the total eclipse of September 3, 2472.

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SIGNIFICANT DIGITS

In August, 1984, this department noted on page 159 the difficulties of calculating the angular separations of closely spaced stars. A solution was suggested involving the use of haversines. Some years ago I resorted to a similar solution to determine the distance between close points on the Earth's surface, where the same formulas apply.

Surely, the basic trouble is the failure of so many computer manufacturers and software producers to give us sufficient accuracy to evaluate ordinary trigonometrical functions. Twenty years ago, when I was doing calculations for the *Icelandic Almanac* on an old fashioned IBM 1620, I had no such problems. As soon as the machine was exchanged for an IBM 360, the problems began. Suddenly I had to be very careful to specify "double precision" in Fortran programs involving critical cases.

Today, with the increasing use of Basic, the problem is worse than ever. On many microcomputers, specifying "double precision" works for constants and simple arithmetic but, almost unbelievably, not for trig functions! In this respect inexpensive pocket calculators are often vastly superior. What is more, such calculators include many useful functions that the average micro does not have using Basic.

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ELECTRONIC NEWS SERVICE

Computer owners with modems can obtain fast news from SKY & TELESCOPE of comet and nova discoveries, and also program listings from the Astronomical Computing department. After joining CompuServe (through a local Radio Shack or computer dealer), log on and move to Personal Computing and then the Personal File Area. Once there, at any menu, type R ACCESS. Then at the next menu type R NEWS.DAT[70275,125] to receive this service.