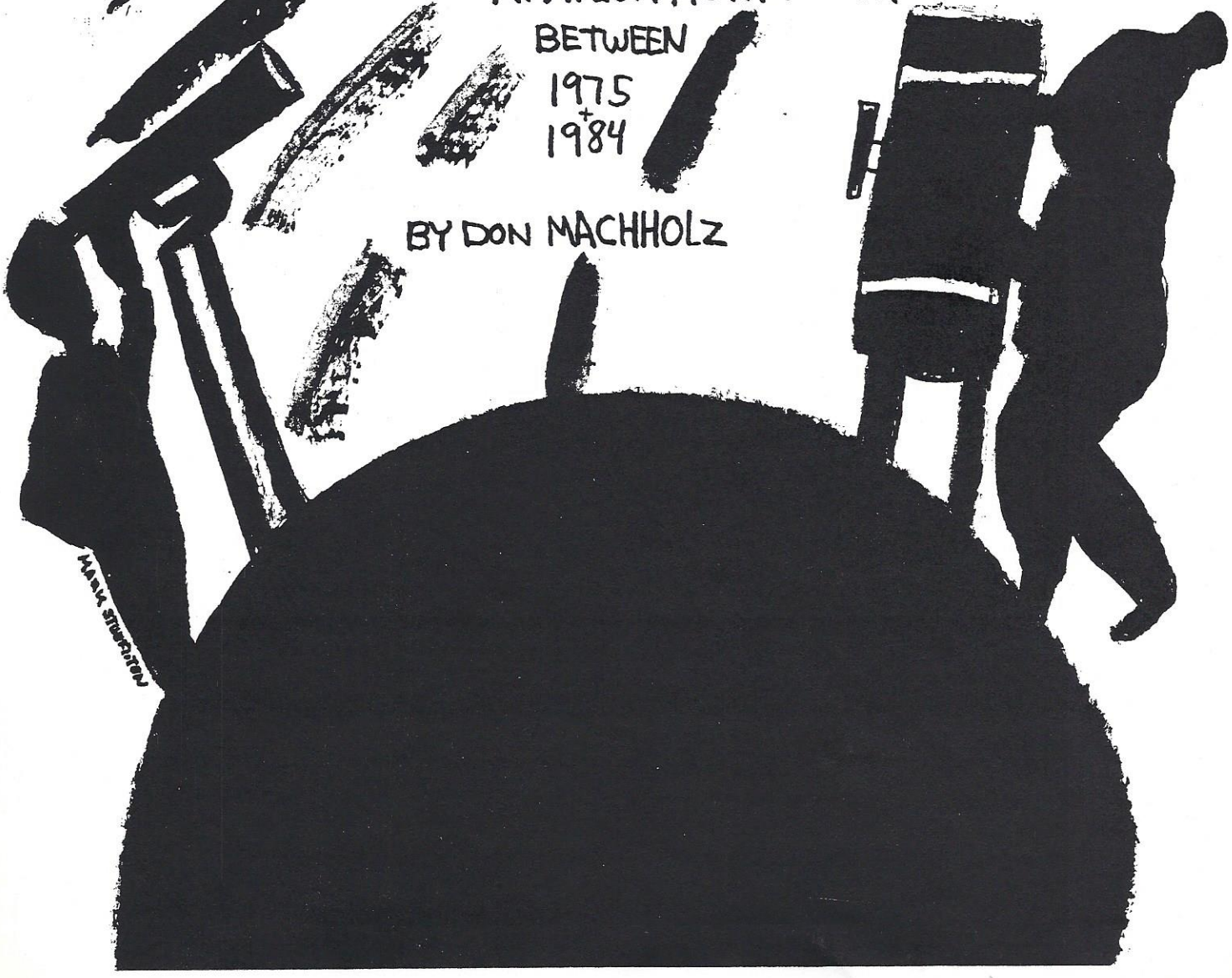
A DECADE OF COMETS

A STUDY OF 33 COMETS DISCOVERED BY AMATEUR ASTRONOMERS BETWEEN 1975 + 1984

BY DON MACHHOLZ



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PART 2: THE INDIVIDUAL COMETS

INTRODUCTION

Following is a synopsis of each of the 33 comets found by amateur astronomers between January 1975 and December 1984. Specific areas for each discovery are explored, along with additional information, where possible. Here is a brief explanation of the data presented.

THE HEADINGS

Identifying Number: Each comet studied is given a number in order of discovery.

The provisional label: The year of discovery is included, then there is a lowercase letter giving the order of discovery or recovery during the year. This is issued by the International Astronomical Union.

The Roman Numeral designation: This gives the year of perihelion passage (when the comet is closest the Sun) followed by a Roman Numeral showing the order of this passage compared to other comets of that same year.

The name of the comet: "Periodic" is used if the comet's orbital period is under 200 years. The names used are those of the discoverers, including those of the Comet 1978n which was originally found in 1881.

THE DISCOVERY DATA

The discovery date, in Universal Time. This is usually taken from the International Astronomical Union's Circulars, and reported to three significant digits, where possible. In the cases of multiple discoveries, all the discovery times are listed.

The distance from the comet to the sun at the time of discovery, in astronomical units. One astronomical unit (AU) is 92.9 million miles.

The distance from the comet to the earth at the time of discovery, in astronomical units.

The discovery position in Right Ascension and Declination, using 1950.0 coordinates. Right Ascension (RA) is similar to longitude on the earth. It is presented in "Hours" and "Minutes". There are 24 hours around the sky and 60 minutes in each hour. Declination (Dec) is similar to latitude. It is measured in degrees (denoted in this study by a "d"), and minutes of arc, (denoted by a "'"). There are 90 degrees from the celestial equator to each pole, declinations south of the equator are "-". There are 60 minutes in each degree. Here the position reported by the discoverer is used. If more than one discoverer is involved, and the finds are within a short period of time, then the position given is the most accurate of the positions reported.

The eclipitic coordinates in longitude and latitude of the comet at the time of discovery. This is presented in degrees, first the longitude, then the latitude.

Sky: This indicates whether the comet was found in the morning or evening sky. "Morning sky" denotes the comet's Right Ascension was within the twelve hours (RA) preceeding (west of) the Sun's Right Ascension. "Evening sky" means the comet was in the area twelve hours following (east of) the sun.

Elongation: The sun-earth-comet angle, or the number of degrees the comet appeared to be from the Sun as seen from Earth at the time of discovery.

Motion: The speed and direction of motion of the comet at the time of discovery. This is found by determining the positions of the comet seven days before and after the discovery date and taking the daily and hourly average. The exceptions are with fast-moving comets. Comet 1983d needed only one days travel for this calculation, while Comet 1984i used three days of positions.

Magnitude: The discovery magnitude. This is the total integrated magnitude of the coma (head) of the comet, a large figure means the comet is faint, a small figure means it's brighter. Magnitude is not easy to determine, the discoverer will usually report it to the nearest whole number, we want it to the nearest tenth. Moreover, the discoverer is not always prepared to make an accurate estimate, in some cases two discoverers' estimates will differ by more than one magnitude. The magnitude used here is derived from early estimates, mathematical formulae, and the discoverer's comments.

Mag./day: This indicates the brightness change of the comet during the 14 days centered on the day of discovery. This assumes that it follows the magnitude formula, but, as we shall see, comets do not always behave. A negative value means the comet was brightening, a positive value means it was dimming.

Azimuth and Altitude: The location of the comet in the discoverer's local sky at the time of discovery is given. This has been calculated from the discoverer's geographical coordinates, the comet's R.A. and Dec., and the date and time. For azimuth: 0d = North, 90d = East, etc. For altitude: 0d is at the horizon and 90d is at the zenith. Atmospheric refraction is not taken into account. If there is more than one discoverer, then all their positions are given.

The difference in minutes between discovery time and Astronomical Twilight, which is defined as the moment when the Sun is 18 degrees below the discoverer's horizon. In the cases of multiple discovery, times are given for each observer.

The Moon phase at the time of discovery.

ORBITAL ELEMENTS

These are usually computed by Dr. Brian Marsden of the Central Bureau for Astronomical Telegrams at the Smithsonian Astrophysical Observatory.

Perihelion date: The Universal Time of the moment when the comet is closest the sun.

Perihelion distance: The distance (in Astronomical Units), of the comet from the sun when the comet is at perihelion.

Eccentricity: The shape of the orbit. A figure of "0" indicates a circular orbit, a "1" is a parabola. Greater than one is a hyperbola.

Orbital period in years, if known.

Argument of the Perihelion: The angle, in degrees, from the point where the comet passes upward through the earth's plane, to its perihelion point. This is measured in the same direction as the comet's motion.

Ascending Node: The point in the comet's orbit where it passes upward through the earth's plane.

Inclination, or "tilt", of the orbit. If the inclination is greater than 90 degrees, the comet is in a retrograde orbit.

"L" value: The longitude of the comet's perihelion in degrees, as seen from the sun.

"B" value: The latitude of the comet's perihelion in degrees, as seen from the sun.

OTHER DATA

Absolute magnitude: The brightness of the comet if it were one Astronomical Unit from both the earth and the sun. This, along with the "n" mentioned below, is usually calculated by such comet computers as Daniel Green, Charles Morris, John Bortle, and Joe Marcus, with minor corrections made to more nearly match the comet's brightness near discovery. This is done because many comets will change in absolute magnitude while under observation, we are concerned with the figures at the time of the comet's discovery.

"n" value: This is used to show the degree of change in the comet's brightness as it moves toward or away from the sun. A large figure indicates the comet's brightness varies greatly with its distance to the sun, a small number means there is little change. The "n" is assumed to be 4.0 unless extended observations show otherwise.

Discovery Probability #1: This percentage is derived from Table II of a study conducted by Dr. Edgar Everhart. It is entitled "Intrinsic Distributions of Cometary Perihelia and Magnitudes", and is printed in the ASTRONOMICAL JOURNAL, (Vol. 72, No. 8) Oct, 1967. This particular number is based only on the comet's absolute magnitude and perihelion distance. Dr. Everhart developed his table from determining discovery probabilities for 21,120 hypothetical comets.

Discovery Probability #2: This is the discovery probability of the comet in its actual orbit, then assuming the ascending node had shifted by 90, 180, and 270 degrees. Each of the four orbits is evaluated for the chance of discovery using

present-day standards in both the Northern and Southern Hemispheres. Moon position is ignored, and the comet is assumed to follow the normal brightness laws, using the known absolute magnitude and "n" values for that comet. The maximum chance for each orbit is 100%, each is divided by four and added together for the total probability.

Holetschek angle: This is the difference between the heliocentric angle of the earth and that of the comet when it is at perihelion. Holetschek, in 1891, determined that when this angle is more than 90 degrees, the chance of discovery is less than when the angle is less than 90 degrees.

THE DISCOVERER, THE DISCOVERY AND THE COMET

What follows is a number of paragraphs describing the circumstances concerning the discovery. This information comes from a wide variety of magazine articles, newspaper clippings, and personal correspondence. Here are some additional notes to keep in mind while reading these sections.

The day of the week is in local time, the date is in universal time.

The position of the comet in the sky as seen from various latitudes is also stated.

The question of: "could this comet have been found earlier?" is also explored. The possible reasons that the comet wasn't discovered sooner than it was are discussed.

One factor of the comet's orbit, the ascending node, is changed by 90d, 180d and 270d, and the possible discovery circumstances are explored.

Sources: Listed are some of the sources for the information presented. The International Astrophysical Observatory Circulars issued by the Central Bureau for Astronomical Telegrams are helpful for discovery details. Often this is augmented by my personal correspondence with the comet discoverer himself. Orbital data are usually found in the "Catalogue of Cometary Orbits" by Dr. Brian Marsden. Magnitude estimates often come from the IAU Circulars, THE INTERNATIONAL COMET QUARTERLY, and THE COMET NEWS SERVICE, all of which made this study possible. The magnitude parameters are often found in the sources listed above, or in the book "Comets", edited by Laurel Wilkening, in the section "Comet Head Photometry: Past, Present and Future" by David D. Meisel and Charles S. Morris. Often the magnitude formula, variable and debatable in itself, is for the complete observation period. I will often make a minor adjustment to fit the more narrow discovery period. Where formula is not available and the comet acted "normal", I will assume that "n" = 4 and match the absolute magnitude to the comet's discovery brightness.

#13) 1978j = 1978 XX

Periodic Comet Haneda-Campos

Disc.: 1) Sept. 01.517 2) Sept. 01.882, 1978.
Dis. to Sun: 1.21 AU. Dis. to Earth: 0.23 AU.
RA: 20h 51.0m Dec.: -29d27'. Ecl. pos.: 307.1d; -11.6d.
Evening sky. 147d from Sun. Motion: 0.6 deg/day = 1.4'/hr SSE.
Mag.: 10.0. Mag/day = -0.06.
Azu: 174d/267d. Alt: 23d/76d.
105/249 min. after Ast. Twi.
Moon phase: One day before New Moon.
Peri: Oct. 09.50, 1978 at 1.10 AU. E. = 0.665. A/P = 240.44d.
Orbital Period = 5.96 yrs.
A/N = 131.59d. Incl = 5.95d. L = 011.9d. B = -05.2d.
A/M = 12.3. N = 4.0. Disc. Prob. #1 = 0.0%. #2 = 15%.
Holetschek angle = 4d.

This periodic comet was discovered by amateurs from both the Northern and Southern Hemispheres. Toshio Haneda of Japan, in his late 60's, had searched for 463 hours over sixteen years before finding this comet with a 3.3" (85mm) refractor. On that evening, Haneda, a retired electrical engineer, had began sweeping the western sky, but clouds forced him to the north, then to the southern sky, where the object was found. Nearly nine hours later Jose de Silva Campos of Durban, South Africa, swept it up high in his sky, he was using a 5" (13cm) refractor. Campos had spent 116 hours searching before finding Comet 1978j.

The comet was in the constellation Microscopium upon discovery, it was in the evening sky, 141 degrees from the sun. It appeared diffuse, with condensation, and about 2' in diameter. The comet had been above the horizon nearly all night as seen from most latitudes. The moon was one day before new and had been out of the evening sky for about ten days.

As for its magnitude, it appears this comet fluctuated somewhat. Prediscovery photos at Palomar with the 48" Schmidt showed nothing to mag. 19.5 during July 10-14. It was later found on prediscovery photos taken Aug. 10 with an 18" Schmidt at mag. 13-14. On Aug. 11 a Perth Observatory photo using a 25cm focus camera showed it at mag. 11. My records show that I swept over it on Aug. 9, 10 and 30 without seeing the comet, if it was brighter than roughly mag. 10.8, I should have found it. Haneda reported it at mag. 10 and Campos said it was ninth magnitude. Estimates the next two days varied from 9 to 10.5, I observed it on Sept. 7.3 and 9.3 at mag. 10.4, but I could not find it on Sept. 8.3 using a 10", f/3.8 reflector. The comet did not brighten as predicted but instead grew fainter over the next few weeks. Additionally, it has not yet been recovered as of early 1985.

If the comet had behaved normally, it would have been mag. 12.0 on Aug. 1, at RA: 20h 42m, Dec: -17d, not far from M 72. By Aug. 11 it would have brightened to mag. 11.2 and moved 3 degrees further south. By the time the moon had again cleared the evening sky, Aug. 19, the comet would have been mag. 10.7 and another 3 degrees further south. However, as it actually turned

out, the comet probably brightened rapidly shortly before discovery.

If the ascending node had changed by 90d, 180d or 270d, the comet would not have become brighter than mag. 13.5, even if it did outburst as much as it did at its actual ascending node. Under the actual conditions, if it were not discovered during that particular lunation, it probably would have remained undiscovered.

Sources: Discovery: IAU Cir. 3259 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" = 4.0 assumed. A/M designed to fit early magnitude estimates.

#14) 1978l = 1978 XIII

Comet Machholz

Disc.: Sept. 12.511, 1978.
Dis. to Sun: 1.81 AU. Dis. to Earth: 1.85 AU.
RA: 06h 39.3m Dec.: -18d24'. Ecl. pos.: 102.4d; -41.1d.
Morning sky. 72d from Sun. Motion: 0.8 deg/day = 2.0'/hr SSW.
Mag.: 10.7. Mag/day = -0.01.
Azu: 133d. Alt: 19d. 3 min. before Ast. Twi.
Moon phase: Three days after First Quarter.
Peri: Aug. 13.67, 1978 at 1.77 AU. E. = 1.000. A/P = 224.76d.
A/N = 289.98d. Incl = 130.64d. L = 077.1d. B = -32.3d.
A/M = 06.8. N = 4.0. Disc. Prob. #1 = 17%. #2 = 60%.
Holetschek angle = 117d.

This comet was discovered by the author on Tuesday morning, Sept. 12, 1978, after 1700 hours (and five minutes) of sweeping. This took 3.7 years and 691 comet hunting sessions. The instrument used was a 10", f/3.8 reflector at 36x, mounted equatorially. It gave a 2.8 degree field of view with a homemade eyepiece.

The comet was in the constellation Canis Major, only 2 degrees south of the star Sirius. It appeared diffuse, mag. 10.7 and 3' across. The comet was then 19 degrees above the horizon, but from -40d latitude it was 49d high, and from the equator it was 48d high in the sky at morning astronomical twilight. The moon was three days past first quarter so it had been out of the morning sky for fifteen days. Following discovery the comet continued moving south, brightening to mag. 10.5 and finally fading by year's end as it pulled away from both the earth and sun.

Before discovery the comet was closer to the sun and fainter. On Aug. 1 it was 32 degrees from the sun, mag. 11.3 and at RA: 06h 41m, Dec: +4.3d. By Aug. 15 it had moved 5.6 degrees due south and was 45 degrees from the sun at mag. 11.1. This is the last morning before moon interference, and even here it would have been a difficult find. As the moon cleared the sky (Aug. 29), we find the comet 7 degrees further south and mag. 10.9, 58 degrees from the sun. Here it could have been found, but it would not have been easy, especially with a Milky Way backdrop. It appears the comet was not discovered earlier due to faintness and closeness to the sun. It was even missed by the

eventual discoverer on Aug. 29 and Sept. 8., and on the latter date the equally faint open cluster NGC 2309 was picked up! Indeed, on the morning of the discovery, the area being swept was from declination -20d and southward. Yet the discoverer swept north of this northern limit in order to pick up Sirius and help him recognize his sweeping location. It was this that aided the discovery.

If the ascending node had changed by 90d, the comet would have been easiest discoverable in the evening sky in Virgo in May, 1978 at mag. 10.7. If missed as it neared the sun and grew fainter, it would likely not be discovered. With another 90d shift of A/N the comet would have been easily found in the deep southern sky near opposition in July, 1978 at mag. 9.3.

With a final A/N shift of 90d the comet would have been found at mag. 9.6, deep in the southern morning sky in late August, 1978. So in each of the four cases there was some chance for discovery, in two cases it would have been easy.

Sources: Discovery: IAU Cir. 3267 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" = 4.0 assumed. A/M designed to fit magnitude estimates near discovery.

#15) 1978m = 1978 XV

Comet Seargent

Disc.: Oct. 1.771, 1978.
Dis. to Sun: 0.58 AU. Dis. to Earth: 0.95 AU.
RA: 11h 54.0m Dec.: -37d00'. Ecl. pos.: 196.6d; -34.0d.
Morning sky. 35d from Sun. Motion: 1.6 deg/day = 4.0'/hr SSW.
Mag.: 5.0. Mag/day = +0.11.
Azu: 126d. Alt: 13d. 23 min. after Ast. Twi.
Moon phase: Day of New Moon.
Peri: Sept. 14.85, 1978 at 0.37 AU. E. = 0.998. A/P = 207.75d.
Orbital Period = 3,127.76 yrs.
A/N = 41.08d. Incl = 67.82d. L = 232.3d. B = -25.5d.
A/M = 7.5. N = 4.0. Disc. Prob. #1 = 24%. #2 = 80%.
Holetschek angle = 119d.

This comet was pulling away from the sun when discovered by David A. Seargent of The Entrance, New South Wales, Australia. David used a pair of 15x80 binoculars to find this objct on Monday morning, Oct. 1. While Mr. Seargent did not keep an exact count, this find took 600-700 hours of sweeping. He always uses binoculars, at first using 20x65's, then 15x80's beginning in Dec. 1977. Throughout the years he has independently "discovered" some comets, including Comet Bennett on Jan. 2, 1970, four days after Jack Bennett found it. Then, he swept to within three degrees of Comet Bradfield (1978c) the day after it was discovered by William Bradfield.

When found, the comet was showing a tail of under one degree in length, was magnitude 5.0 and had a small coma diameter of about 1'. (The size increased to 8' within two weeks.) It was diffuse and with condensation, and

was found in the constellation Centaurus. From Seargent's location it was at a low elevation (13 degrees) and found midway between astronomical and nautical twilights. From anywhere north of about -20d latitude the comet was below the observer's horizon at morning astronomical twilight on the day it was found. Following discovery the comet continued moving south while getting fainter. In the darker skies the tail appeared as long as two degrees.

Three months prior to discovery the comet was at mag. 11.5, north of the sun at an elongation of 43 degrees in the evening sky. It moved south (in relation to the stars) at 0.4 degrees per day, by Aug. 1 (four days before new moon) it was 37 degrees north of the sun at mag. 9.5, still in the evening sky. It continued to slowly brighten as it neared the sun, becoming a difficult object by Aug. 13 when moonlight interfered. By that time it was still in the evening sky, mag. 8.1 and 32 degrees from the sun. If the comet had brightened normally, it should have been easily discoverable in the evening northern sky two to three months before it was actually found. As it was, I swept over its positions on the evenings of July 2 and July 29 with a 10" reflector and I did not see it. So the possibility remains that the comet brightened quickly as it neared the sun.

If the ascending node had changed by 90d, the comet would have been discoverable in the evening northern sky in mid-Aug. 1978 at mag. 7 and 50 degrees from the sun. With another shift of 90d the comet would have been discoverable about 45 degrees due north of the sun, mag. 7 during August. With a final shift of ascending node the comet would have been a difficult find, brighter than mag. 9 for a short time at elongations greater than 40 degrees in the morning northern sky, then staying close to the sun for the next few weeks. So in most instances the comet would probably have been discovered.

Sources: Discovery: IAU Cir. 3277 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" = 4.0 assumed. A/M to match magnitude estimates near discovery.

#16) 1978n = 1978 XIX

Periodic Comet Denning-Fujikawa

Disc.: Oct. 9.813, 1978.
Dis. to Sun: 0.79 AU. Dis. to Earth: 0.30 AU.
RA: 10h 23.8m Dec.: +05d24'. Ecl. pos.: 156.0d; -04.4d.
Morning sky. 39d from Sun. Motion: 1.2 deg/day = 2.9'/hr NNW.
Mag.: 10.0. Mag/day = +0.07.
Azu: 099d. Alt: 21d. 7 min. after Ast. Twi. (approx).
Moon phase: One day after First Quarter.
Peri: Sept. 2.04, 1978 at 0.78 AU. E. = 0.820. A/P = 334.05d.
Orbital Period = 9.02 yrs.
A/N = 040.96d. Incl = 8.67d. L = 015.3d. B = -03.8d.
A/M = 13.7. N = 4.0. Disc. Prob. #1 = 00%. #2 = 20%.
Holetschek angle = 7d.

Shigehisa Fujikawa of Onohara, Kagawa, Japan, found this, his fourth

comet, on Tuesday morning, Oct. 9, when it was pulling away from both the earth and sun. It had been three years since Fujikawa's last discovery, that being Comet 1975 XII. Perhaps Fujikawa was using 20x120 binoculars, or he might have still been using his 6" reflector. Within a week of discovery Dr. Brian Marsden calculated the orbit and it soon became apparent that this comet is identical to Comet Denning (1881 V) which had not been observed for eleven revolutions. The comet was then given its present name.

The comet was 39 degrees from the sun and in the constellation Sextans when found. Its reported magnitudes ranged from 9 to 11, it appeared very diffuse and about 2' across. It was found 17 degrees north of the projected path for any comets from the Sungrazing group. From Fujikawa's location the comet was nearly due east and about 20 degrees high in his sky when found. North of the earth's equator the comet was similarly located, but near -40d declination it was only 3 degrees above the horizon at morning astronomical twilight. It was later learned that Kazimeras Cernis of the USSR independently discovered this comet on Oct. 11, using 20x110 binoculars. He was unable to communicate the information, however. Following discovery the comet faded as it moved nearly due north at 0.5 degrees/day. Within a month it was fainter than mag. 12.2.

Could it have been found earlier? For about 10 days prior to discovery the moon was out of the sky, but the comet was closer than 30 degrees from the sun until Oct. 5. However, between mid-Aug. and mid-Sept. the comet brightened from magnitude 11.7 to 9.7 as its elongation decreased from 87 to 32 degrees in the evening southern sky. Why wasn't it found then? Perhaps its diffuse appearance aided to this, it is possible that its magnitude wasn't consistant. Dr. Marsden points out it was missed in Oct. 1916, Sept. 1960 and Sept. 1969, when it should have been discoverable.

With ascending node changes of 90d, 180d and 270d, the comet would have stayed fainter than magnitude 12.5. Its faint absolute magnitude contributes to this.

Sources: Discovery: IAU Cir. 3284 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" = 4 assumed. A/M to match to magnitude estimates near discovery.

17) 1978o = 1978 XVIII

Comet Bradfield

Disc.: Oct. 10.785, 1978.
Dis. to Sun: 0.53 AU. Dis. to Earth: 0.84 AU.
RA: 11h 01.5m Dec.: -19d09'. Ecl. pos.: 174.8d; -23.7d.
Morning sky. 32d from Sun. Motion: 1.5 deg/day = 3.7'/hr SSW.
Mag.: 8.4. Mag/day = +0.01.
Azu: 104d. Alt: 14d. 8 min. after Ast. Twi.
Moon phase: Two days after First Quarter.
Peri: Sept. 29.09, 1978 at 0.43 AU. E. = 1.000. A/P = 240.45d.
A/N = 357.72d. Incl = 138.26d. L = 124.9d. B = -35.4d.
A/M = 11.6. N = 4.0. Disc. Prob. #1 = 00%. #2 = 60%.
Holetschek angle = 120d.

The third comet found during this lunation, this comet was also the third found in ten days and the fifth in five weeks. For William Bradfield of Australia this was his eighth find, he once again used his 6" (15 cm), f/5.5 refractor. This was his second discovery of the year, coming 75 search hours after his 1978c find.

The comet was found on a Wednesday morning, 32 degrees from the sun, in the constellation Crater. Its position was 9 degrees south of the projected path for Sungrazing comets. It appeared about 3' and was diffuse with condensation. For Bradfield, the comet, found after astronomical twilight, was 14 degrees high. From the equator it was 11 degrees high at astronomical twilight but from a latitude of 40d north it was 4 degrees below the horizon. Following discovery the comet continued south and became fainter, fading to magnitude 11 within a month.

Could the comet have been found sooner? As seen from earth, the comet was on the other side of the sun in September with small elongations. Before that time it was fainter than mag. 12. As it moved from behind the sun, it brightened. By October 3 it was its brightest (mag. 8.3) but only 24 degrees from the sun. As it moved further from the sun it became discoverable. For an object of magnitude 8.4 an elongation of at least 25 degrees is usually needed for discovery. This occured Oct. 4, giving about a week of any possibility of discovery. Therefore, it was found near its earliest opportunity for discovery. If it had not been found when it was, it would still have been visible following full moon (Oct. 16) in the morning southern sky.

If the ascending node had changed by 90d, the comet would have been visible during late Aug and early Sept. in the evening sky as it brightened from mag. 11.0 to 9.2 and its elongation decreased from 80 to 30 degrees. Following conjunction with the sun it would have been a difficult object in the morning sky. With another 90d shift of ascending node the comet would have probably been found in the morning sky at mag. 9-10 as it moved rapidly south and toward the sun. Following a double conjunction it would have emerged too faint to observe. With a shift of an additional 90d in the A/N the comet would undergo a triple conjunction with the sun, being briefly visible 35 degrees from the sun in the evening southern sky at mag. 9-10. So in all four cases brief discovery windows were open, the faint absolute magnitude and the small perihelion distance kept these windows small.

Sources: Discovery: IAU Cir. 3286 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" assumed. A/M to match magnitude estimates near discovery.

#18) 1979c = 1979 VII

Comet Bradfield

Disc.: Jun. 24.417, 1979.
Dis. to Sun: 0.82 AU. Dis. to Earth: 1.14 AU.
RA: 08h 37.5m Dec.: -01d20'. Ecl. pos.: 132.1d; -18.9d.
Evening sky. 44d from Sun. Motion: 1.2 deg/day = 3.1'/hr NNE.
Mag.: 10.2. Mag/day = -0.09.
Azu: 280d. Alt: 16d. 50 min. after Ast. Twi.
Moon phase: Day of New Moon.
Peri: July 23.26, 1979 at 0.41 AU. E. = 1.000. A/P = 47.65d.
A/N = 163.52d. Incl = 136.24d. L = 125.1d. B = +30.7d.
A/M = 10.8. N = 4.5. Disc. Prob. #1 = 02%. #2 = 60%.
Holetschek angle = 175d.

It had been eight and one-half months and 98 search hours since William Bradfield had found his last comet. This, his ninth discovery, was again made with his 6" (15 cm) refractor at 26 power. Daniel Green points out that this exceeds William Reid's record of eight finds from South Africa between 1918 and 1927. Bradfield had now found more comets than any other Southern Hemisphere observer.

The comet was diffuse and about 3' in diameter on Sunday evening, June 24 when first spotted. It was in the constellation Hydra and just south of the equator. All of Bradfield's discoveries have been made when the comet was south of the equator, this being the most northernly of them. If he had found this one two days later it would have been north of the equator. It was 25 degrees above his horizon at astronomical twilight, he found it almost an hour later. From the earth's equator it was 17 degrees high. From 40d N. latitude the comet was 14 degrees below the horizon at astronomical twilight. Following discovery the comet went behind the sun and emerged in the morning, northern sky in early August. From there it grew steadly fainter, becoming mag. 11 by Sept. 12 and mag. 18-19 by late Sept.

Could the comet have been found earlier? The moon had been out of the sky for nearly two weeks, the comet was 20 degrees further south and mag. 11.1 on June 12, this would have been a difficult discovery due to the comet being faint and diffuse. As the comet moved north it brightened until it was within the reach of the 6" refractor. Prior to June 12 the moon was in the sky and the comet was fainter. So the comet was found near the time it was first discoverable.

If the ascending node had changed by 90d, the comet would have been discoverable 35 degrees due south of the sun in early July at magnitude 7. It would have neared the sun, growing brighter, then fainter. If the A/N had changed by another 90d the comet would probably not be seen, for although it would have reached mag. 5.5, it would have remained within 35 degrees of the sun whenever it was brighter than mag. 11.0. With a final shift of 90d in A/N, the comet would have been discoverable for only a short time in early August, as the comet emerged into the evening northern sky at mag. 7.1 some 31 degrees from the sun. Then, for the next four weeks it would move southward

and dim to mag. 11.3.

Sources: Discovery: IAU Cir. 3372 (Daniel Green). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" from Charles Morris, A/M increased by 0.2 to match estimates near discovery.

19) 1979i = 1979 IX

Comet Meier

Disc.: Sept. 20.063, 1979.
Dis. to Sun: 1.48 AU. Dis. to Earth: 1.50 AU.
RA: 13h 34.5m Dec.: +68d38'. Ecl. pos.: 144.8d; +65.3d.
Evening sky. 69d from Sun. Motion: 0.5 deg/day = 1.2'/hr SSW.
Mag.: 11.8. Mag/day = -0.01.
Azu: 333d. Alt: 38d. 46 min. after Ast. Twi.
Moon phase: One day before New Moon.
Peri: Oct. 17.35, 1979 at 1.43 AU. E. = 0.973. A/P = 112.58d.
Orbital Period: 390.58 yrs.
A/N = 296.93d. Incl = 67.08d. L = 073.8d. B = +58.3d.
A/M = 9.2. N = 4.0. Disc. Prob. #1 = 01%. #2 = 10%.
Holetschek angle = 50d.

Rolf Meier of Canada searched for 29 hours and 17 months to find this, his second comet. Once again he used the 16", f/5 reflector at 56x, with a 1.2 degree field of view. It is owned by the Royal Astronomical Society of Canada and located near Ottawa.

When discovered on Wednesday evening, Sept. 20, the comet was in the constellation Draco. It was faint, (magnitude 11.8), diffuse with some condensation and roughly 1.5' in diameter. The comet also displayed a short tail in some instruments. Seen from Meier's location the object was 38 degrees high in his northern sky when found nearly an hour after astronomical twilight, from the equator it was only 3 degrees above the horizon at a similar time. From any latitude north of 22d N. the comet was above the horizon for the whole night. Following discovery, the comet brightened by only another 0.3 magnitude as it traveled the northern polar region, including a traverse of the Big Dipper Bowl. Since it did not brighten much, it probably would not have been found if Meier had not discovered it.

Could the comet have been found earlier? The comet had been in moonless sky for about ten days, prior to that it was fainter and more difficult. We would not expect most amateurs to find a 12 magnitude object, so it seems that faintness was the main reason the comet was not found earlier.

If the ascending node had changed by 90d, the comet would have never been brighter than mag. 12.3, and then only when its within 50 degrees of the sun. Similar conditions would exist with another shift of 90d. With a final shift of 90d the comet would have the best chance of discovery, brightening to mag. 11.4 in the northern evening sky. So of the four possibilities we examined, the comet would have been undiscoverable in two cases, and near the limit of discoverability in the other two.

PART 2: THE INDIVIDUAL COMETS (1979i)

Sources: Discovery: IAU Cir. 3408 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden, calculations by Nakano. Magnitude Formula: Charles Morris, A/M dimmed by 0.1 to match estimates near discovery.

20) 19791 = 1979 X

Comet Bradfield

Disc.: Dec. 24.753, 1979.
Dis. to Sun: 0.55 AU. Dis. to Earth: 1.22 AU.
RA: 16h 19.0m Dec.: -35d20'. Ecl. pos.: 249.1d; -13.7d.
Morning sky. 26d from Sun. Motion: 0.5 deg/day = 1.2'/hr SSW.
Mag.: 5.0. Mag/day = -0.01.
Azu: 126d. Alt: 11d. 24 min. after Ast. Twi.
Moon phase: One day before First Quarter.
Peri: Dec. 21.60, 1979 at 0.55 AU. E. = 0.988. A/P = 257.58d.
Orbital Period = 293.15 yrs.
A/N = 102.51d. Incl = 148.60d. L = 207.0d. B = -30.6d.
A/M = 8.0. N = 5.3. Disc. Prob. #1 = 23%. #2 = 85%.
Holetschek angle = 118d.

Discovered on Tuesday morning, Christmas Eve, this comet was William Bradfield's tenth discovery, he again used his 6", f/5.5 refractor. He has found three of the last four amateur discoveries, his third within fifteen months. His previous discovery was exactly six months earlier, he had since searched 67 hours. Following discovery it appeared at first that this comet might be identical to Comet 1770 II, called The Great Comet. As the orbital elements were refined, however, it became clear that this comet is different than The Great Comet.

At discovery the comet displayed a short tail, appeared diffuse with condensation, and was roughly 1' in diameter. In the following week the diameter increased to 2' and the tail grew in length to 2 degrees. The comet was in the constellation Scorpius. Bradfield first observed it long after astronomical twilight when it was 11 degrees high in his sky. As seen from the equator the comet was 6 degrees above the horizon at astronomical twilight, from a latitude of 40d N. the comet was 8 degrees below the horizon at a similar time.

Following discovery the comet was exclusively a Southern Hemisphere object until late Jan., 1980; when it became visible in the Northern Hemisphere as the moon cleared out of the sky. By then it was still bright (mag. 5.3) and about 30' in diameter as it crept to within 0.2 AU of the earth. The comet also flared around Feb. 3.

Could the comet have been found earlier? It would seem so, if we look at its prediscovery positions. Three months before discovery the comet was mag. 12.0 and at RA: 18h 30m, Dec: 00d. At the next new moon (Oct. 22) the comet was at RA: 17h 37m, Dec: -13d, in the evening sky, and it should have been mag. 10.7. At this point it would have been discoverable under good conditions. From this time, when it was 55 degrees from the sun, until three

weeks later, when it would have been at RA: 17h 14m, Dec: -21d, mag. 9.2 and 28 degrees from the sun, it was not seen, or at least reported, by anyone. My records show I swept this area Nov. 9, the comet would have been less than 2 degrees south of M 9 and magnitude 9.5. Using a 10" reflector at 36x, I observed M 9 and NGC 6356 but not the comet.

Two reasons could account for the non-discovery of this comet during November. First, when I swept the area I was just a few degrees off the horizon and the comet may have been just beyond the magnitude grasp under such conditions. Secondly, the comet may not have been as bright as mag. 9.5; the fact that it was not found by the whole Northern Hemisphere for more than a month would indicate that it was not as bright as we think it was. There is the probability that the comet brightened rapidly before discovery, the fact that it later flared slightly reminds us that its light was not always stable.

If the ascending node had changed by 90d, the comet would have quickly moved through the northern sky, at a large elongation, from the morning to the evening sky, brightening from mag. 10 to 6. It would have been found. With an additional shift of 90d in A/N the comet would have been easily seen in the morning sky, decreasing in elongation as it brightened to mag. 3.5. With a final shift of 90d the comet would have swung into the southern evening after conjunction with the sun in late Dec. 1979, it probably would have been found at that time, at mag. 4.4 some 39d from the sun. The moderate perihelion distance and absolute magnitude give this comet a very good chance of telescopic discovery no matter what time of our year it comes in. This also means there's a fair chance it was visually observed at 293-year intervals when it visited us in the past.

Sources: Discovery: IAU Cir. 3437 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden, calculations by Landgraf. Magnitude Formula: "N" from Charles Morris, A/M increased by 0.4 to match estimates near discovery.

#21) 1980k = 1980 IV

Comet Cernis-Petrauskas

Disc. Jul. 31.708, 1980.
Dis. to Sun: 1.01 AU. Dis. to Earth: 1.46 AU.
RA: 11h 50.0m Dec: +32d40'. Ecl. Pos.: 163.0d; +28.5d.
Evening sky. 43d from Sun. Motion: 1.2 deg/day = 3.0'/hr E.
Mag.: 8.5. Mag/day = +0.09.
Azu: 298d. Alt: 17d. 24 min. after Ast. Twi.
Moon phase: Four days after Full Moon.
Peri: Jun. 22.44, 1980 at 0.52 AU. E. = 1.000. A/P = 337.81d.
A/N = 159.92d. Incl = 49.07d. L = 145.0d. B = -16.6d.
A/M = 7.7. N = 4.0. Disc. Prob. #1 = 25%. #2 = 75%.
Holetschek angle = 126d.

Kazimeras Cernis and Jovaras Petrauskas, sweeping together, found this comet on Thursday evening, July 31. Cernis, using 20x110 binoculars, found it after 880 hours of sweeping. In the past he independently discovered Comets

Bradfield (1974 III), Kobayashi-Berger-Milon (1975 IX) and Denning-Fujikawa (1978 XIX). However, he found them after the original discoverers and was unable to announce them quickly. Jovaras Petrauskas used 12x80 binoculars and had searched for about 100 hours to find this comet. They were searching together from the Maidenak Mountains in Uzebekistan.

As it was, this discovery was not confirmed for three weeks. First, communications were slow getting to the Smithsonian Astrophysical Observatory. Secondly, the comet was moving more than three times faster than originally estimated, so most of us didn't know exactly where to look. Third, the comet was roughly mag. 8.5 upon discovery but rapidly grew fainter over the following weeks. And finally, word of some confirmation photos by Paul Wild was not relayed from Switzerland for more than two weeks.

The comet was found in the constellation Usra Major, it was about 1.5' in diameter and diffuse with some condensation when found. From 40d N. latitude and at the earth's equator the comet would have been 21 to 23 degrees above the NW horizon at astronomical twilight. At 40d S. latitude the comet would have been only 3 degrees above the horizon at a similar time. Following discovery the comet continued to pull away from the sun and grow fainter.

Could this comet have been found earlier? Calculations show the comet was within 23 degrees of the sun for a surprisingly long time-from before April 1980 until July 2. On April 3 it would have been mag. 12.0, it brightened to mag. 5.6 in late June, then began to dim as it pulled away from the sun in July, 1980. Full moon was July 27, in the ten days prior to that the moon was in the evening sky making discovery difficult as the comet crept from an elongations of 34 to 41 degrees. The comet was found four days after full moon, probably the second moon-free evening for comet hunting since full moon. So it seems that the comet's closeness to the sun and the presence of the moon in the evening sky prevented earlier discovery.

If the ascending node had changed by 90d, the comet would have been easily discoverable in the evening sky, getting as bright as mag. 4.0 and staying at least 26 degrees from the sun. With another A/N shift of 90d, Comet 1980k would be discoverable as it approached the sun from the south in the evening sky, and as it receded in the northern morning sky. With a final shift of 90d the comet would have been discoverable for only a brief time, as it approached the sun from the southern morning sky.

Sources: Discovery: IAU Cir. 3498, 3499, 3504 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" assumed. A/M to match estimates near discovery.

PART 2: THE INDIVIDUAL COMETS (1980q)

#22) 1980q = 1980 XII

Comet Meier

Disc.: Nov. 6.111, 1980.
Dis. to Sun: 1.59 AU. Dis. to Earth: 1.54 AU.
RA: 18h 06.2m Dec.: +42d09'. Ecl. pos.: 272.7d; +65.3d.
Evening sky. 75d from Sun. Motion: 0.7 deg/day = 1.6'/hr SSW.
Mag.: 10.3. Mag/day = +0.01.
Azu: 307d. Alt: 24d. 195 min. after Ast. Twi.
Moon phase: One day before New Moon.
Peri: Dec. 9.65, 1980 at 1.52 AU. E. = 0.995. A/P = 87.96d.
Orbital Period = 4,802.35 yrs.
A/N = 24.74d. Incl = 100.98d. L = 305.3d. B = +78.8d.
A/M = 7.4. N = 4.0. Disc. Prob. #1 = 12%. #2 = 50%.
Holetschek angle = 133d.

Rolf Meier found this comet some 25 search hours and thirteen and one-half months after his second find. He again used a 16" reflector at 56x.

The comet was about five degrees from the star Vega when found on Wednesday evening, Nov. 6. It was in the constellation Hercules, appeared very diffuse and was about 3' in diameter. From any location north of about 20d South Latitude the comet was above the horizon at evening astronomical twilight. Following discovery the comet grew slightly fainter as its evening elongation decreased. Then in early 1981 it appeared in the morning sky and held a steady 9-10 magnitude, for a few weeks. On Apr. 26, 1981 it passed directly over the star Arcturus. It then dimmed to mag. 12 by May, 1981.

Could the comet have been found earlier? If the comet had behaved properly, it should have been found before it was. Near new moon on Sept. 11, the comet was mag. 11.0 and at RA: 01h 33m, Dec: +61d. It then traveled through the polar region. A month later it was at RA: 19h 45m, Dec: +65d, mag 10.3 and still 100 degrees from the sun. From this point the comet traveled SSW and maintained its magnitude until discovery one month later.

Several reasons could account for its non-discovery. First, it was traveling through the Milky Way, this provides a low-contrast background and would tend to hide the comet. Secondly, the comet wandered through parts of the sky far from the sun, comet hunters do not normally sweep these areas. Finally, we do not know for sure if the comet behaved normally before discovery. It may have brightened rapidly before discovery, but there is no evidence to indicate it acted this way.

If the ascending node had changed by 90d, the comet would have had only a fair chance of discovery, this being in late November, in the northern evening sky, with the comet at mag. 10.2 and 70 degrees due north of the sun. With another 90d shift in A/N the comet would be in a similar position and brightness in Dec., 1980. In the final shift on the A/N the comet would have again reached mag. 10.3, in Jan., 1981, this time in the northern morning sky.

PART 2: THE INDIVIDUAL COMETS (1980q)

Sources: Discovery: IAU Cir. 3535 (Dr. Brian Marsden). Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brian Marsden. Magnitude Formula: "N" assumed. A/M to match estimates near discovery.

#23) 1980t = 1980 XV

Comet Bradfield

Disc.: Dec. 17.751, 1980.
Dis. from Sun: 0.46 AU. Dis. from Earth: 1.20 AU.
RA: 16h 20.0m Dec: -36d16'. Ecl. Pos.: 249.3d; -14.3d.
Morning sky. 22d from Sun. Motion: 0.7 deg/day = 1.8'/hr. ENE.
Mag.: 6.0. Mag/day = -0.24.
Azu: 130d Alt.: 7d. 18 min. after Ast. Twi.
Moon Phase: Three days after First Quarter.
Peri.: Dec. 29.54, 1980 at 1.61 AU. E. = 0.999. A/P = 358.29d.
Orbital Period = 29,882.29 yrs.
A/N = 114.65d. Incl. = 138.59d. L = 115.9d. B = -01.1d.
A/M = 8.0. N = 3.0. Disc. Prob. #1 = 04%. #2 = 100%.
Holetschek angle = 18d.

William Bradfield found this, his eleventh comet on Thursday morning, Dec. 17. But rather than using his 6" (15 cm) refractor, he used a pair of 7x35 binoculars. This came 51 weeks and 113 search hours after his previous find. This position of the comet at discovery was about one degree away from the location of the earlier find too.

Mr. Bradfield says that this discovery was "a combination of method and luck." The first available (moon-free) date for sweeping was on Dec. 6, but clouds prevented observation until Dec. 17. On that morning, after 1.5 hours of sweeping, he turned from his six-inch scope to the 7x35 binoculars. Suddenly he spotted the object, near the threshold of visibility. He swung his telescope to the area and saw a sixth magnitude comet with a tail.

When found, the comet was sharply condensed and about 2' in diameter with a short tail. It was in the constellation Scorpius, and 22 degrees from the sun. Bradfield found it 18 minutes after astronomical twilight, when it was 7 degrees above the horizon. At astronomical twilight, from his location, the comet was 3 degrees high, from the equator it was less than one-half degree high. From 40d North Latitude the comet was still 12 degrees below the horizon. Following discovery the comet swept back toward the sun, it then appeared in the northern evening sky. At that point it was mag. 5 and displayed a tail of up to five degrees long. It seemed to flare by about one magnitude in mid-Jan. It was later reported that Marco Cavagna independently discovered it from Italy on Jan. 5.71, when it was low in the western sky. Probably quite a few other observers "discovered" it then too.

Could this comet have been found sooner? On Oct. 15, it was 40 degrees from the sun in the southern evening sky, but magnitude 11.7. It brightened as it neared the sun, undergoing conjunction a month later. By Dec. 10 it was mag. 7.4, but only 20 degrees from the sun in the southern morning sky. Over the next week it brightened by 0.2 mag/day until discovery on Dec. 17. So, if

it had not been cloudy on Dec. 6, and Bradfield had swept this area only at that time, he wouldn't have found this comet. It was later learned (IAU Cir. 3564) that a prediscovery image of the comet was found on a photographic plate taken July 18-five months before Bradfield. It shows the comet at mag. 16, about what would be expected if it were acting correctly.

If the ascending node had changed by 90 degrees, the comet would have been discoverable opposite the sun in the southern sky in Oct. 1980 at mag. 10. From here it would have brightened to mag. 6 in the evening sky, both before and after solar conjunction. If the ascending node had changed by another 90d, the comet would have been found in the morning equatorial regions at mag. 10.5 and 90 degrees from the sun in Oct. 1980. It would have then brightened to mag. 6 after it crossed opposition and into the evening sky. With a final shift of 90d the comet would have been discoverable at mag. 9.5 in the morning equatorial region in mid-Nov., 1980. It would have then reached mag. 6 within a month. So in all four cases easy discovery would have taken place.

Sources: Discovery: IAU Cir. 3554 (Dr. Brian Marsden). Disc. Data: Personal Communications. Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brain Marsden. Magnitude Formula: Charles Morris, A/M increased by 0.3 to fit early observations.

#24) 1980u = 1981 II

Comet Panther

Disc.: Dec. 25.788, 1980.
Dis. from Sun: 1.71 AU. Dis. from Earth: 1.92 AU.
RA: 18h 46.7m Dec: +38d54'. Ecl. Pos.: 289.4d; +61.5d.
Evening sky. 63d from Sun. Motion: 0.3 deg/day = 0.6'/hr. NE.
Mag.: 9.7. Mag/day = -0.01.
Azu: 300d Alt.: 27d. 53 min. after Ast. Twi.
Moon Phase: Four days after Full Moon.
Peri.: Jan. 27.32, 1981 at 1.66 AU. E. = 0.999. A/P = 105.60d.
Orbital Period = 64,524.99 yrs.
A/N = 331.30d. Incl. = 82.64d. L = 126.7d. B = +72.8d.
A/M = 5.9. N = 4.0. Disc. Prob. #1 = 33%. #2 = 60%.
Holetschek angle = 1d.

Roy W. Panther of Walgrave, near Northhampton, England, discovered this, his first comet, on Christmas night, 1980. He had been sweeping for 601.5 hours spread over 699 nights and 33 years. Roy used an 8" (20 cm) f/4 reflector with a Kellner eyepiece giving 35x. The telescope is mounted altazimuth and counterweighted to reduce eyepiece movement.

Mr. Panther began comet hunting in July, 1947, with a 3" refractor. Through the years he had missed three comets by a few degrees. On Dec. 25, 1980, he thought he would sweep for comets, even though it was Christmas night, because the sky was exceptionally clear. He located M 56 and it appeared brilliant. A few minutes later he picked up a "fainter M 56" about three minutes of arc across (he originally reported it as 5' across). It was diffuse with some condensation, and in the constellation Lyra, about three degrees east

of the star Vega.

The comet was so far north it was circumpolar for Panther. From 40d north latitude it was 26 degrees high at evening astronomical twilight, then it set in the NNW, rising later, becoming 16 degrees high by morning astronomical twilight. From the equator it was never above the horizon after dark. Following discovery the comet remained visible for about four months, passing within 0.5 degrees of the North Celestial Pole on Mar. 11, 1981, at mag. 9.1.

Could this comet have been found earlier? If it had behaved normally, it would have been easily found during Sept., 1980, as it was slowly brightening in the evening sky. It should have been magnitude 11.0 on Sept. 11 when near M 29. From here it drifted to near its discovery position within six weeks, brightening to magnitude 10.5. During the final two months it made a small loop, continuing to brighten by 0.7 magnitude, until discovery. One would wonder why it wasn't found sooner.

Several reasons natually come to mind. First, it was about 70 degrees from the sun, further than the areas commonly swept by comet hunters. Secondly, it was seen against a Milky Way background, giving little contrast. Third, Northern Hemisphere weather was not good and prevented much sweeping of the sky.

Later, pre-discovery photographs were released which gave a different story. One, taken Oct. 28, showed the comet to be mag. 12.5, this is about 2 magnitudes fainter than we would expect. Another, taken Nov. 26, shows that the comet was mag. 10.3, while our calculations say it should have been mag. 10.1. It therefore seems as though this comet brightened rapidly during November, and this is probably why it was missed earlier.

If the ascending node had changed by 90d, the comet would have been discoverable in the far-northern regions of the morning sky at mag. 11. It would have brightened to mag. 9.8 over the next few months. If the ascending node had changed by another 90d, the comet would be a difficult find at mag. 10.9 at the morning sky, less than 60 degrees from the sun. From here it would have dimmed. With a final shift of 90d, the comet might have been found in the evening sky, less than 60 degrees from the sun. It would not have become brighter than mag. 10.5. So in two cases it would have been an easy discovery, in two other instances it would have been difficult.

Sources: Discovery: IAU Cir. 3556 (Dr. Brian Marsden). Disc. Data: "Tonight's Asteroids" # 60. "Amateur Astronomer Handbook" by James Muirden. "Journal of British Astronomical Assoc."1981,91,3; p 211-2. Orbital Elements: "Catalogue of Cometary Orbits", by Dr. Brain Marsden. Magnitude Formula: "N" = 4 assumed. A/M designed to fit early observations.