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Comets in 1975

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With no fewer than 13 confirmed discoveries, 1975 holds by a handsome margin the record for new comets, its closest rivals being 1948 (with 11, this number including comet 1948 a, which was actually discovered in 1947 December but not confirmed until the following month), 1973 (with 9) and 1947 (with 8, not counting comet 1948 a; in addition, both the 1947 and 1948 letter designations included one more comet that was never confirmed). Of the 13* comets of 1975, no fewer than six – another record – turned out to be new short-period comets; not surprisingly, five of these would have been unobservable before recent approaches to Jupiter caused their perihelion distances to be significantly reduced, but it seems somewhat curious that the remaining short-period comet – the first visual discovery of a short-period comet since the rediscovery of P/Perrine–Mrkos in 1955 – has never been discovered before. Reversing a trend of recent years, all but one of the seven long- or non-periodic comets of 1975 were visual discoveries by amateur astronomers, and although four of these discoveries were made in Japan, the last few weeks of the year saw these four move far to the south, southern-hemisphere observers having in fact a total of six moderately bright comets in view during that time. Only four short-period comets were recovered during the year, so the letter designations reached to the letter q (r had been reached in 1970, but one of the letter-designated comets of that year was not confirmed); and with nine definite and two possible 'holdovers' from previous years and the three 'annual' comets, the total number of objects under observation during 1975 could have been as many as 31 – two more than in the previous record year of 1973.

P/Schwassmann–Wachmann 1, which had been particularly active in 1974, was still at mag 15·6 on January 15, according to observations made by H.L.Giclas with the Lowell Observatory 33-cm photographic telescope. After conjunction with the Sun, the comet was re-observed by C.Y.Shao and G.Schwartz with the 155-cm *f*/5 reflector at the Harvard Observatory

*Since it was first recognized, before its 1975 discovery on a single plate taken the previous year, comet 1975 b could reasonably be counted with the comets of 1974; on the other hand, the number for 1975 could also be augmented with at least one unconfirmed – but undoubtedly real – comet.

Agassiz Station on August 19 and September 4; the comet's appearance was essentially normal, the magnitude being about 17. On October 7 a sharply condensed nucleus of magnitude about 18·0 was photographed by E.Roemer with the Steward Observatory's 229-cm *f*/9 reflector, located on Kitt Peak; the comet was evidently then somewhat active, for the nucleus was embedded in a small, bright, and somewhat asymmetric coma, mostly to the south–southwest. A.Mrkos, observing at the Kleť Observatory, found that the comet had brightened to total mag 13·3 on October 25, and on the following night the comet was perhaps 0·3 mag brighter; some fading then set in, and by the 31st the magnitude was down to 14·5. Schwartz and Roemer both noted that the comet was brighter than normal on November 3; the single exposure by the latter observer with the 154-cm *f*/13·5 reflector at the Lunar and Planetary Laboratory's Catalina Station revealed a strong, sharp nucleus of magnitude about 17·0 in a faint coma. From his failure to detect the comet in early December Mrkos concluded that the magnitude was fainter than 18, but his observations during December 28–31 showed that the comet had again brightened to mag 15. An exposure by Roemer with the Catalina telescope on December 26 confirmed that the comet was completely stellar in appearance and of magnitude about 15·0.

P/Encke, at aphelion in December, appeared faintly on a 46-min exposure with the Agassiz reflector on September 1, but a similar exposure on October 5 does not seem to have revealed the comet. Rather weakly exposed, but apparently stellar images were also obtained on 60-min exposures in good seeing by Roemer with the Steward reflector on September 12, the magnitude being about 20·2.

P/Gunn, brightening as it approached perihelion passage in 1976 February, was under observation during 1975 with the Catalina, Steward, Agassiz and Kleť reflectors and also by C.Torres with the Maksutov astrograph at the University of Chile's Cerro El Roble Station and by the Japanese observers N.Kojima (Ishiki, Aichi) and T.Seki (Kochi Observatory, Geisei Station), this last observer reporting the total magnitude as 14 on March 21. Practically stellar images of magnitude about 17·4 appeared on 30-min exposures with the Catalina telescope on February 9, while 10-min exposures on April 11 yielded rather weak, but sharply condensed images of magnitude near 16·2. At Kleť Observatory, Mrkos and Růžena Petrovičová-Kopfsteinová judged the total magnitude as 15·5–16·0 during May 10–14. Roemer recorded the comet as a fairly weak spot of magnitude about 18·4 on June 9 (Catalina), and the last observations before conjunction were obtained with the Steward telescope on August 8, when the comet was still rather well condensed, in spite of patchy clouds and mediocre seeing, its magnitude very roughly 17·6.

1972 XII (= 1972 l), Araya, was possibly observed by Z.M.Pereyra with the 154-cm *f*/5 reflector at Bosque Alegre on June 17, the total magnitude being given as 16·0; the position from one of these exposures is in very good agreement with the orbit, and at the time the heliocentric distance was 8·3 AU. On the other hand, Torres failed to find comet Araya on five exposures at Cerro El Roble during June, July and August.

OBSERVATIONS 1972 NOVEMBER 15 TO 1975 JUNE 17 (?)

1973 g, P/Reinmuth 2, was photographed by Roemer with the 229-cm reflector early in the year. The comet was well condensed, of about mag 19·0 on January 7 and 19·8 on February 5.

OBSERVATIONS 1973 APRIL 26 TO 1975 FEBRUARY 5

1973 X (= 1973 k), Sandage, was under observation by Seki (using a 40-cm *f*/5 reflector) in January and February, the magnitude being about 19. The comet was also recorded by Roemer (Steward) on January 6 as a sharp condensation of magnitude near 20·6 in a trace of coma. The comet was perhaps 0·4 mag brighter on March 5, but there was no trace of it on a 60-min exposure obtained in poor seeing and at low altitude on June 3.

OBSERVATIONS 1973 JULY 4 TO 1975 MARCH 5

1973 l, P/Schwassmann–Wachmann 2, was quite widely observed during the first half of 1975, observations being reported by Roemer, Seki, Torres, R.E.McCrosky and Schwartz with the Agassiz reflector, and by A.C.Gilmore and Pamela M.Kilmartin with the 41-cm reflector at the Carter Observatory, Wellington, and L.Krumenaker with the 61-cm Schmidt telescope at the Warner and Swasey Observatory. Gilmore estimated the nuclear magnitude as 16·1 on January 12 and March 18 and 15·7 on April 18, while Seki noted brightening from total mag 14 (with a tail 10 arcmin long in pa 300°) on January 17 to 13 on March 21. On February 9 Roemer (Catalina) recorded the comet as well condensed, of magnitude about 17·0, with a trace of fan-shaped tail to the northwest. Very sharply condensed images appeared on exposures with the same telescope on March 13, the magnitude being about 16·2, and a circular coma with a strong condensation appeared on an exposure by McCrosky on April 18. Catalina observations showed the comet near mag 17·3 on May 9, and it had faded by perhaps 0·8 mag when photographed with the Steward reflector on June 4. The comet was still under observation at the Agassiz Station one week later, but clouds thwarted further attempts to observe it on July 4 and 6.

OBSERVATIONS 1973 AUGUST 5 TO 1975 JUNE 11

1973 m, P/Borrelly, maintained its brightness well during the first few months of the year, Seki reporting it at total mag 18 on January 23. Sixty-minute exposures with the Steward reflector (Roemer) on February 5 showed a sharp condensation of magnitude about 20·6 with a tail extending as much as 2·0 arcmin to the northwest, and although the comet was not found on a pair of Catalina exposures on March 14, weak images of it did appear, at magnitude about 20, on plates obtained with the Agassiz reflector on March 5 and 19 (in spite of some interference from moonlight on the former occasion). Weak, but definite, small and sharply condensed images of mag 21·2 could still be recorded with the Steward reflector on May 4, and a very faint tail extended 0·5 arcmin to the northwest. At this time the heliocentric distance had increased to a record 3·5 AU. A 54-min exposure with the Agassiz telescope on May 17 failed to show the comet.

OBSERVATIONS 1973 AUGUST 23 TO 1975 MAY 4

1973 n, P/Gehrels 2, seems to have been recorded on the better of a pair of 90-min exposures with the 229-cm reflector on March 7. The image, which is right at the expected position, appears as a small weak spot of mag 21·0–21·5.

OBSERVATIONS 1973 SEPTEMBER 28 TO 1975 MARCH 7

1974 c, Lovas, was picked up after conjunction by Gilmore on January 8 at nuclear mag 16·3. The comet declination was at −36° and moving southwards, and the only known observations of the comet in the northern hemisphere during 1975 were by Seki, who gave the total magnitude as 15·0 on January 9 and 13. Hovering around declination −65° to −70° from April to November, the comet was well placed for observation in the southern hemisphere throughout the year, Gilmore and Kilmartin noting the comet generally to be strongly condensed, the condensation brightening to mag 15·4 on April 16 and 14·6 on June 17. J.A.Bruwer, using the Franklin–Adams camera at the South African Astronomical Observatory's outstation in Hartbeespoort, reported the total magnitude as 13·0 in June and July, perhaps three magnitudes fainter than had been anticipated. Although not due at perihelion until August 22, comet Lovas was by then receding from the Earth, and it faded slightly; nevertheless, Kilmartin and Gilmore estimated the nuclear magnitude to be as bright as 14·4 and 15·0 on October 31 and November 30 respectively. An exposure by Torres in early December still showed a very faint broad tail extending 5 arcmin to the southwest. Astrometric observations of the comet were also made by W.Rea at Mount John University Observatory; by M.Zemelman and Betty Mintz Blanco at Cerro Tololo Interamerican Observatory; by G.Sanchez, M.R.Cesco and H.Mira at the Felix Aguilar Observatory's station at El Leoncito; and by M.P.Candy and his colleagues at the Perth Observatory.

OBSERVATIONS 1974 MARCH 21 TO 1975 DECEMBER 6, CONTINUING

1974 d, P/Finlay, was last observed at this return by Roemer on a single 44-min exposure with the 229-cm reflector on January 7, when it was at a record heliocentric distance of 2·4 AU. The condensed image of the comet, of apparent mag 19·5–20·0, was undoubtedly dimmed by clouds.

OBSERVATIONS 1974 JUNE 24 TO 1975 JANUARY 7

1974 f, P/Honda–Mrkos–Pajdušáková, just past perihelion at the beginning of the year, began to move rapidly southwards. Astrometric observations were reported by Seki and by T.Urata (Nihondaira Observatory) on January 2 and 3, and on the first few nights of the year the comet was observed visually by three amateur astronomers in the United States: D.Green (Boone, North Carolina), J.Bortle (Stormville, New York) and C.Sherrod (North Little Rock, Arkansas); on January 2 Bortle, using 15×80 binoculars, estimated the total magnitude as 7·7 and noted a very sharply condensed coma of diameter 2·0 arcmin and possibly a very short tail roughly in pa 70–80°. At Woden, near Canberra, D.Herald photographed the comet several times during January, the comet fading from

mag 8·1 on January 7 to 10 on January 20 and fainter by the end of the month. An observation on January 12 by Gilmore with the Carter Observatory's 10-cm *f*/10 astrograph showed the comet at total magnitude 9·6. The comet was also observed by Torres in mid-January and by Rea with the Mount John 25-cm astrograph on February 2 and 3. A visual observation on February 2 by D.Goodman (Nelson, New Zealand, 13-cm refractor) gave the magnitude as 10·2. On February 5 P/Honda–Mrkos–Pajdušáková passed 0·23 AU from the Earth and within 1° of the south celestial pole. A 15-min exposure with the Carter reflector on February 18 was apparently insufficient to record the comet, and the only subsequent observation was a single 60-min exposure obtained on March 13 at the Catalina Station. Somewhat diffuse and estimated at nuclear magnitude about 19·3, the comet was then at declination −24°, 0·5 AU from the Earth and a record 1·4 AU from the Sun.

OBSERVATIONS 1974 NOVEMBER 10 TO 1975 MARCH 13

1974 g, van den Bergh, was under observation at the beginning of the year by Roemer, by Seki, and by Schwartz and J.H.Bulger at Harvard's Agassiz Station. Exposures with the Steward telescope on January 6 showed the comet to be well condensed, of magnitude about 18·5, and in spite of cirrus, a nearly stellar condensation of magnitude about 18·8 was recorded on February 5. On January 14 Seki gave the total magnitude as 18. The last pre-conjunction observations were obtained by Bulger on March 4 and by Roemer on the 7th, the latter observer noting a well-condensed image of magnitude near 18·2. These same observers picked up the comet again on September 4 and 12, respectively. The single exposure on September 12 yielded a well-condensed nucleus of magnitude about 19·8 and a trace of tail extending 0·1 arcmin northwestwards. The comet was perhaps as bright as mag 19·2 on October 7, with a more definite fan-shaped tail near pa 300°. The following night the Agassiz observers also noted a possible short tail in pa 318°. A distinct tail 4 arcmin long appears on a 50-min exposure (Kodak IIIa-J emulsion) taken by S.van den Bergh with the 122-cm Schmidt telescope at Palomar on November 5, the comet's magnitude being essentially the same as at discovery just one year before. An exposure by Roemer on December 4 showed a strong condensation of magnitude about 19·0, again with a trace of fan-shaped tail to the northwest, and by the end of the month the comet was perhaps a little fainter.

OBSERVATIONS 1974 NOVEMBER 12 TO END OF 1975, CONTINUING

1974 i, P/Wirtanen, was last recorded by Roemer on 90-min exposures with the Steward reflector on February 6 as a weak, poorly defined spot of magnitude about 21·5.

OBSERVATIONS 1974 DECEMBER 20 TO 1975 FEBRUARY 6

1975 a, the first visual discovery of a comet from the northern hemisphere in almost four years, was detected on January 4·5 by the Reverend Leo Boethin, a missionary who lives near Bangued, The Philippines, and who

regularly hunts for comets with a 20-cm reflector. Moving east–northeast in Aquarius, the comet was estimated at mag 12·3 – extremely faint for a visual discovery – 3 arcmin in diameter and only slightly condensed. The comet was perhaps 0·3 mag brighter the following evening, and after apparently observing the comet again on January 6 and 7, the discoverer listed all four observations in a letter to the IAU Central Telegram Bureau, where it was received on January 17. Two days *earlier*, when the Moon was already three days past new, the Central Bureau had received a letter written by the discoverer on January 9, in which the Bureau was advised to ignore the as yet not received January 6 and 7 observations and substitute different positions from January 7 and 8. Moonlight and the questionable nature of the observations prevented any serious attempts elsewhere to make a confirmation, but the discoverer was himself able to follow the comet until January 16, and he succeeded in picking it up again on January 29, after the Moon had left the evening sky. Fortunately, Boethin quickly cabled his February 1 position of the comet to the Central Bureau; and when a tentative confirmation had been made, on February 4 by C.Scovil with the 56-cm Maksutov telescope in Stamford, Connecticut, the Central Bureau made a limited announcement of the comet's discovery. As a result of this the comet was photographed by Urata on February 5, but the cablegram reporting this observation did not reached the Central Bureau. General announcement of the comet was therefore not made until February 9, following definite observations of the comet by Bortle and McCrosky; in the meantime the comet had also been photographed, on February 8, by Kojima and Seki. Using a 32-cm reflector, Bortle described the comet's total visual magnitude as 11·2–11·3 during February 9–15, in good agreement with the discoverer's estimate of mag 11·0 on February 14.

The delay in announcement of the comet was unfortunate, for – as was already suspected from accurate positions during February 5–10 and the approximate positions of early January by the discoverer – comet Boethin turned out to be of short period, and the loss of potential accurate observations during the January dark of the Moon will make recovery of the comet more difficult at the next return in 1986. It should also be recorded here that Boethin had belatedly reported the discovery of three other comets between 1965 and 1973, none of which could ever be confirmed.

Photographic observations on February 28 by Seki and by Mrkos showed that comet Boethin had then faded to mag 13, while Bortle visually estimated the magnitude as 12·4–12·6 and the coma diameter as 1–2 arcmin during March 5–10. Images recorded with the Steward reflector on March 7 (Roemer) were small and condensed, of magnitude about 17·3, and Catalina observations one week later showed the condensation to be of mag 17·6, possibly embedded in a very faint coma as large as 1 arcmin across. The comet was about 1 mag fainter on further exposures with the Catalina telescope on April 9, while during the preceding ten days Seki and R.L.Waterfield, the latter observing with a 15-cm *f*/4·5 Cooke triplet at Woolston, Somerset, had given the total magnitude as 15·0–15·5. Faint, diffuse images of the comet appeared on exposures by Schwartz at the Agassiz Station on April 29 and 30, and Roemer was subsequently able to obtain additional single

exposures with the 229-cm reflector: on May 4 the comet was recorded as a fairly weak, but quite definite, very small spot of magnitude about 19·3 adjacent to a star trail, while on June 3 the poor seeing and low altitude caused the image to be very large and weak, of magnitude roughly 19·8, but it was successfully measured for an accurate position.

OBSERVATIONS 1975 JANUARY 4 TO JUNE 3

1975 b, which eventually received the name P/West–Kohoutek–Ikemura, was also attended by unusual circumstances at its discovery. On February 27·8, while he was attempting to recover a cometary suspect found on a plate taken with the 32-cm Schmidt telescope at the Hamburg–Bergedorf Observatory 18 days previously, Luboš Kohoutek apparently made the recovery and immediately telexed both observations to the Central Telegram Bureau. A diffuse object with condensation, of mag 13 on the February 27 exposure, the comet was then in Aries and seemed to have moved at an average daily rate of 0°·8 westward and 0°·2 southward since the earlier exposure. Since there was no reason to doubt the observations, the Central Bureau promptly relayed them to observatories round the world, and by the time evening next fell in Japan several observers there were attempting to photograph the comet. They were not immediately successful, and on March 1·5 one of those observers, Toshihiko Ikemura, of Shinshiro, Aichi, noted a twelfth magnitude cometary image *east* and *north* of the February 27 position given by Kohoutek. By the following evening this object had moved rather more than 0°·5 further east and north, and it could also be identified on the February 28 exposures by Kojima, Seki and K.Suzuki (observing near Asuke, Aichi), as well as on a plate that had been taken with the 41-cm astrograph at the Agassiz Station on March 1. The object was clearly identical with Kohoutek's February 27 comet (of which there were in fact two exposures, though of identical durations and on the same plate, and the direction of motion was therefore ambiguous) but was obviously not identical with his February 9 object. Several preliminary orbit computations (only one of which was published) by K.Hurukawa and T.Hirayama (Tokyo Astronomical Observatory) and by B.G.Marsden (Center for Astrophysics) showed that the inclination could be no more than some 30° – always an indication that a comet might be a short-period one – and Marsden quickly realized that the comet was certainly identical with the object discovered by Richard M.West in January on a single exposure obtained at the European Southern Observatory in 1974 October (see the 1974 report); the orbital revolution period was 6·1 yr, and the comet had been forced into its current orbit (from one having a period of perhaps 30 yr and a perihelion distance of about 5 AU) as the result of its having passed only 0·01 AU from Jupiter in 1972 March.

According to Bortle, P/West–Kohoutek–Ikemura appeared visually on March 5 as a small, uncondensed coma of mag 12·3, and had faded to mag 12·6 by March 16. Short exposures with the Steward reflector (Roemer) on March 7 revealed a condensation of magnitude about 17·5 at the apex of an asymmetric coma to the east. Seki, who had judged the total magnitude to be 11 on February 28, noted fading to mag 13·5 on March 16 and to 15

on April 3, while an exposure by R.H.S.South at R.L.Waterfield's Observatory showed the magnitude to be 15·3 on May 4. Further observations were obtained later that month by Roemer and by Schwartz, Steward exposures on May 17 showing the comet to be fairly well condensed and of magnitude about 19·0.

OBSERVATIONS 1974 OCTOBER 15 TO 1975 MAY 30

1975 c was the cometary object discovered by Kohoutek on his plate of February 9·8. This was a single 14-min exposure taken for the planetary nebula Baade 1, and Kohoutek noted the faint, trailed fourteenth magnitude cometary image while examining the plate on February 17. Moonlight precluded an adequate search for the comet until February 27, at which time Kohoutek took three plates, two to the west (and somewhat south) and one to the east (and somewhat north) of the February 9 position. It was the second of these plates that immediately yielded the very obvious image that turned out to belong to comet 1975 b. The next day, while examining the third plate under a microscope, Kohoutek noticed the double image of another diffuse moving object; it was of mag 15 and not much brighter than the plate limit. On learning that the comet on the second plate could not be the February 9 object, Kohoutek reported this other observation, and observations with the Agassiz reflector on March 5 and 6 confirmed that the faint object on the third February 27 plate was indeed the February 9 comet. As with comet 1975 b, comet 1975 c was moving to the east and north, and it, too, was a new short-period comet that had passed close to Jupiter in 1972. Dr. Kohoutek's comet discoveries now number five, his first having been found in 1969 and the second and third in short succession in 1973.

Exposures by Roemer on March 7 showed 1975 c, P/Kohoutek, to be strongly centrally condensed (more so than was comet 1975 a on the same night); the condensation, of magnitude about 17·2, was contained in a coma estimated visually to be about 1 arcmin across. On March 13 plates taken with the Catalina reflector yielded a sharp condensation of magnitude about 17·3 in a small asymmetric coma, mostly to the northeast. Seki gave the total magnitude as 15 on March 7 and as 16 9n the 18th but surprisingly – in view of the increasing heliocentric and geocentric distances – the comet was as bright as mag 14 on April 3. A plate exposed a few hours later at Woolston showed a highly condensed inner coma 10 arcsec in diameter, surrounded by a very faint outer coma 60 arcsec in diameter; the magnitude was 15·5. The strong condensation was possibly as bright as mag 14·5–15·0 on a 16-min panchromatic exposure by Shao on April 29, and six nights later Roemer also found the comet much brighter than expected and yielding strong, somewhat tadpole-shaped images of nuclear magnitude about 16·5 (blue) with a faint tail. On May 9 a good Agassiz plate showed the comet to be some 0·5–1·0 mag fainter than on April 29, and a final exposure of the comet was obtained there on May 30. The comet was not found on a single exposure, cut short by clouds and made at low altitude anyway, with the Catalina telescope on June 8, but a further pair of observations was made at the 1976 opposition.

OBSERVATIONS 1975 FEBRUARY 9 TO MAY 30, CONTINUING

1975 d was a ninth-magnitude comet, not obviously condensed, discovered in Cetus on March 12·4 by William A.Bradfield, of Dernancourt, near Adelaide. His third cometary discovery, it was found by Bradfield three years to the day after his first comet and 13 months (during which he had spent 145 hours comet-hunting) after his second. From early accurate positions reported by Herald and by Gilmore and Kilmartin it was established that, although comet 1975 d was near its perihelion distance of 1·2 AU, it was located on the far side of the Sun, 2·0 AU from the Earth at discovery; its relatively slow motion would maintain the comet for some three months as an evening object observable only from the southern hemisphere, although it also appeared that observations should be possible with large telescopes the world over as the comet approached opposition early in 1976.

Visual inspection by F.Dossin with the 152-cm reflector at the European Southern Observatory on March 16 showed a condensation of mag 12·5 in a fan-shaped coma extending 15 arcsec to the north and east. Image-tube spectrograms obtained by J.P.Swings with the 100-cm reflector at the same observatory on March 16 and 17 (before the orbit had been determined) showed detailed structure in the blue emission bands of CN, C_2 and C_3, and a medium-strength continuum from the vicinity of the central condensation; except for the absence of CH at λ 4315, the spectrum appeared to be closely similar to that of comet 1941 I at a heliocentric distance of 1·14 AU. An observation by Kilmartin with the Carter Observatory astrograph on April 4 showed that the total magnitude was still 9·0, while 15-min exposures with the 41-cm reflector showed a diffuse, eleventh-magnitude condensation 20 by 40 arcsec, elongated towards pa 170°. Rather similar magnitudes were quoted in early April by Herald, who then also remarked on a fan-shaped tail; on the 28th the total magnitude was 9·5–10·0. Gilmore reported the nuclear magnitude as 12·2 on April 18, dropping to 13·3 on May 12, but only weak and diffuse images could be recorded with 10-min exposures on June 17 and 18, when the comet was low in the sky (clouds and moonlight also interfering on the 18th). Astrometric observations were also reported by Torres and his colleagues at Cerro El Roble (March–June) and by J.Hers, using a 20-cm reflector at Randburg, near Johannesburg (April–May).

OBSERVATIONS 1975 MARCH 12 TO JUNE 18, CONTINUING

1975 e was discovered by Tamara Mikhajlovna Smirnova, a staff member at the Institute for Theoretical Astronomy, in late March on 60-min exposures obtained on March 4·8 and 16·8 in the course of the regular programme of observations of minor planets with the 40-cm *f*/4 astrograph at the Crimean Astrophysical Observatory. Of mag 15·0–15·5 and retrograding very slowly in Leo, the object was not definitely identified as a comet until a further exposure had been obtained by Nikolaj Stepanovich Chernykh on March 30. This and further exposures by Chernykh in early April showed a sharply condensed coma of diameter 15–20 arcsec, in some cases with an extension of about 1 arcmin to the west. Smirnova subsequently identified the comet on a plate taken on March 14, and G.R.Kastel' calculated that the comet has perihelion distance of 3·6 AU and orbital eccentricity of only

0·14, this orbit having evolved, following the comet's encounter with Jupiter in 1963, from a more nearly circular one with a perihelion distance in excess of 5 AU.

P/Smirnova–Chernykh was also under observation during the first half of April by Seki, Kojima, Waterfield (and G.H.Rutter), Krumenaker, Roemer and McCrosky. Two 20-min exposures (through cirrus) with the 229-cm reflector on April 17 showed a well-condensed nucleus of magnitude about 18·0 at the apex of a small fan-shaped coma extending 0·1 arcmin to the southeast. South and Waterfield discerned a slightly diffuse central coma of mag 16·0 on April 29, and during the first half of May the magnitude was given by Chernykh as 16·0–16·5; a final attempt by Chernykh to photograph the comet on June 2 failed on account of poor seeing. On May 4 the comet was recorded with the Steward reflector as sharply condensed, of magnitude about 17·0, with a trace of fan-shaped coma or tail to the southeast. The appearance was somewhat similar on June 4, but perhaps 0·8 mag fainter. The object was picked up again in the morning sky on December 4 with the same telescope, the magnitude being then about 18·1, and observations may presumably be possible all the way around the orbit.

OBSERVATIONS 1975 MARCH 4 TO END OF YEAR, CONTINUING

1975 f was P/Wolf, recovered on May 17·4 by Roemer (assisted by L.M.Vaughn) on 60-min exposures with the 229-cm reflector . The images were quite definite though fainter than mag 21·5. Very faint, borderline, suspect images had been noted on several exposures at the Agassiz Station since mid-April, and after the recovery had been reported, one of two candidate images marked on a single 53-min exposure obtained by Shao on the night of the recovery could definitely be identified with the comet, the (panchromatic) magnitude being about 21. A rather stronger image, stellar in appearance, was recorded on a 33-min Agassiz exposure on June 11, and a pair of Steward plates on August 8 showed small, stellar-appearing images of magnitude near 20·0 (blue). Interference from clouds affected both the Agassiz and Steward observations in September, but single exposures were obtained with both telescopes on October 7; the Steward exposure, made in very windy conditions, yielded a fairly weak but apparently stellar image of magnitude about 19·8. A further observation was made at the Agassiz Station on November 5, and weak, essentially stellar images of magnitude near 20·2 appeared on two 60-min exposures obtained on December 6 with the Catalina reflector in very good seeing conditions.

OBSERVATIONS 1975 MAY 17 TO DECEMBER 6 (CONTINUING?)

1975 g was discovered by Andrew Jonathan Longmore on a plate taken on June 10·6 by P.R.Standen in the course of the Southern Sky Survey with the UK 122-cm Schmidt telescope at Siding Spring Observatory. On the Kodak IIIa-J exposure the comet was of seventeenth magnitude, diffuse, with some condensation and a faint tail about 15 arcsec long, and further observations the following night with the Schmidt and with the 3·9-m Anglo–Australian Telescope confirmed slow southwesterly motion in Pavo.

Some confusion over the magnitude meant that exposures, though well centred on the comet's position, by Gilmore in Wellington on June 17 failed to record the comet, while a 60-min exposure on the 19th evidently missed the field. A search by Torres at Cerro El Roble on July 15 seems also to have been unsuccessful.

A further approximate position was reported on July 25 from a UK Schmidt plate taken by M.E.Sim on July 9, but it was still impossible to predict the comet's position within the 45 arcmin field of the Carter Observatory reflector, and Gilmore took four 60-min exposures in vain on July 30 and August 1. Accurate measurements finally became available from the three Schmidt plates early in August, and although the distribution of observations was very poor for a reliable orbit determination, it was reasonably clear that comet Longmore was yet another of short-period. A further observation by T.Hawarden with the UK Schmidt on August 6 indicated that the comet had then faded to mag 19, while observations at the European Southern Observatory five days later gave the magnitude as slightly brighter than 20. The comet was probably too faint for Torres on August 13 and 16 and for Gilmore on August 25, but a final pair of successful plates was obtained on October 4 by V.M. and B.M.Blanco with the new 4-m reflector at Cerro Tololo Interamerican Observatory, the magnitude being given as 19. Since P/Longmore was at perihelion in 1974 November, there seemed a possibility that it may have been recorded at its previous opposition in 1974 February (at which time its declination was near $+40°$), but C.T.Kowal reports that the comet was probably just off the edge of the most suitable exposure made with the 122-cm Palomar Schmidt. The present orbit of this comet arose as a result of an encounter with Jupiter in 1963.

OBSERVATIONS 1975 JUNE 10 TO OCTOBER 4

1975 h, by far the best observed comet of the year, was found on July 2·7 by Toru Kobayashi while observing from a mountain site near Takefu, Fukui, with a 15-cm reflector (magnification 30×). At the age of 15 Kobayashi had been an independent discoverer of comet 1970 X and since that discovery had spent 117 hours comet-hunting. In Aquarius, and of mag 8·5, the new object was 12 arcmin across and only slightly condensed, and its existence was confirmed by T.Matsumoto, N.Fujii and T.Harada, who were with Kobayashi at the time. Bad weather prevented these observers from establishing the object's motion, and no further observations could in fact be made from Japan until July 6, when T.Ando, T.Yoshida and Y.Matsui relocated the comet some 3° west and 5° north of the earlier position. In the meantime, word of the probable discovery had been transmitted to the Central Telegram Bureau, but attempts to confirm the comet on July 4 and 5 by three or four amateurs in the United States were unsuccessful. Nevertheless, the comet's brightness, generally considered to be close to mag 7, and its location near M 2 led to a large number of independent discoveries. The first seven of these were made by Richard de Rose (Westfield, Massachusetts) and D.Douglas Berger (Union City, California) on July 5·3; F.R.VanLoo (Itegem, Belgium) and Octaaf Steen (Ardooie, Belgium) on July 7·0; and Don Stotz (Topeka, Kansas), Dennis

Milon (Cambridge, Massachusetts) and Walter E.Davies (Livermore, California) on July 7·3–7·4. Of these discoverers, the first two to report the comet to the Central Bureau were Berger, observing with a 20-cm reflector at a star party in Henry Coe State Park in northern California; and Milon, observing with a 10-cm reflector on Mount Washburn, in Yellowstone National Park, Wyoming – thus the comet received the name Kobayashi–Berger–Milon. Berger also quickly reported his find to the nearby Lick Observatory, where E.A.Harlan was immediately able to photograph the comet with a 10-cm camera, while A.R.Klemola obtained the first accurate positions with the 51-cm double astrograph on the following night. An independent photographic discovery of the comet on July 10·0 by Edgar Penzel at the School Observatory and Satellite-Observing Station in Rodewisch, East Germany, led H.Huth to identify images of the comet on patrol plates taken at the Sonneberg Observatory as early as July 5; and an image of the comet was also identified on a Harvard patrol plate taken earlier that same day.

Observing near Satellite Beach, Florida, the comet was seen by D.Sharpe with the naked eye on July 9. On the 13th J.Young visually detected a tail $\frac{1}{4}°$ long, while a photograph with a 15-cm refractor showed a tail 1° long in pa 205°. Using 10 × 50 binoculars, Bortle the next night estimated the total magnitude as 5·6 and noted a bright inner coma 18 arcmin in diameter surrounded by a faint halo 25–30 arcmin across. Short exposures by Roemer (Steward) a few hours later showed a central condensation of mag 14·0–14·5 embedded in an inner coma some 0·5 arcmin in diameter; a 10-min exposure yielded a somewhat asymmetric coma about 4 arcmin in diameter, with its greatest extension, and also the barest suggestion of a tail to the west of south. On July 22, with the comet in Draco and near its minimum distance of 0·26 AU from the Earth, Bortle, observing from Japan, noted the magnitude as 4·9 and the coma diameter as 18 arcmin, in spite of a full Moon. Although comet 1975 h was still more than six weeks from perihelion, its increasing distance from Earth caused the coma diameter to diminish and the total brightness to remain more or less constant. Several observers reported the comet as mag 4·0–4·5 during much of August.

Spectrograms obtained around the end of July by C.Fehrenbach and his associates at the Haute Provence Observatory showed intense emissions of CN λ 3883 and C_3, but the Swan bands were rather weak; CN λ 4216 and CH were also evident, as were infrared bands of CN around λ 9150. Spectrograms taken by E.Devinney and C.McCracken at the Goddard Space Flight Center also covered the red and near-ultraviolet regions, and these observers also noted some NH_2 bands, possible [O I] λ 6300, NH λ 3360 and a hint of OH λ 3090. At the University of Colorado, G.Emerson and C.Lillie remarked that rectification of their results showed the OH λ 3090 emission to be four times as intense on July 27 as that of CN λ 3883 and twice as intense on August 5 as the CN emission. A.C.Danks and his colleagues at the McDonald Observatory mentioned some unidentified emission bands at λ 4847 and λ 4964. As for the tail spectrum, P.A.Wehinger and S.Wyckoff reported that the only tail features observed on spectrograms (covering the range λλ 3000–9000) obtained on August 8 and 9 with the 100-cm reflector

at the Wise Observatory were weak traces of H_2O^+ emission over λλ 6160–6210 and λλ 6990–7050. Ultraviolet observations from the Princeton University experiment on the Satellite *Copernicus* on July 27 indicated that the intensity of Lα was comparable to that observed in comet 1973 XII about a month after its perihelion passage. Observing comet 1975 h with the 46-m radio telescope at the Algonquin Observatory in early September, L.W.Avery and B.H.Andrew reported the detection of radio emission from CH at a frequency of 3335·48 MHz.

A 10-min exposure (7·5 cm *f*/4 camera) by Emerson on July 27 revealed a type I tail 8¼° long in pa 121°, while a 40-min exposure by M.J.Hendrie (Colchester, Essex) with his 10-cm camera on August 2 in excellent conditions showed a 6° tail in pa 84°. F.Börngen reported that long exposures in early August with the 134-cm *f*/3 Schmidt at the Tautenburg Observatory showed the main tail to be flanked by several fainter, straight thread-like streamers. A screw-like structure in the tail was also evident, as was subsequently remarked upon by Waterfield, who noted that the distance between two successive twists (which also corresponded to alternations in the intensity of the tail) was a little under 2°, three such twists being evident in the 11° and 13° tail-lengths (in pa 60–70°) photographed on August 9 and 12, respectively. Short exposures by Roemer with the Steward telescope on August 7 showed a quite sharply defined condensation, no more than 3 arcsec in diameter, embedded in a coma about 1 arcmin in diameter. A 10-min exposure showed the head to be at least 6 arcmin across, somewhat oval-shaped, with its long axis in pa 160–340°; a rayed tail extended more than 15 arcmin to the edge of the field, in the sector between pa 55 and 90°.

On August 12, M.J.Mayo, observing from Lockwood Valley, California, with 7×35 binoculars, traced the tail out visually to more than 7°. Moonlight then began to interfere with observations to some extent, but during August 25–September 2, and in spite of strong twilight, Mayo consistently reported visual tail lengths of 8–10°. Bortle observed a maximum tail length of 7½° (in pa 28°; and using 7×50 binoculars) on August 28, a 32-cm reflector revealing a broad tail spine. On September 4 Bortle saw the comet after sunset and again just before sunrise as it moved into the morning sky. On September 14 and 15 he observed (10×50 binoculars) a 1° tail in pa 320°, with the comet still only very slightly fainter than on July 22. When he was next able to observe the comet, on September 29, it had faded to mag 6·4, and no tail could be detected. Giclas could still photograph a 30 arcmin tail (in pa 270°; also a spike in pa 341°) on October 12 and made an astrometric observation on the 16th, but the comet was then well south of the Sun in the dawn sky, and subsequent observations had to be made from the southern hemisphere. Also on the 16th, A.F.Jones (Nelson, New Zealand), using a 4·5-cm refractor, estimated the comet's magnitude as 8·0. On November 5, I.Cooper (Palmerston North, New Zealand, 10-cm refractor) found that the comet had faded to mag 10·0, and on the 13th the comet was judged at mag 10·3 by B.Sumner at Windsor, Queensland (15-cm reflector). The comet was still visible with the Carter Observatory 41-cm reflector at the beginning of December, and photographic observations showed the nuclear magnitude to be 15·2–15·3. The comet was still under

observation at Cerro El Roble at the year's end, an exposure on December 30 showing a faint tail 25 arcmin long to the north–northwest.

OBSERVATIONS 1975 JULY 2 TO END OF YEAR, CONTINUING

1975 i was periodic comet Churyumov–Gerasimenko, recovered by Roemer and R.A.McCallister on a single 60-min exposure with the 229-cm reflector on August 8·3. Making its first return to perihelion since its discovery in 1969, the comet was well condensed, of magnitude about 19·5, and located roughly midway between the predictions by Marsden and N.A.Belyaev (Institute for Theoretical Astronomy). On September 9, in rather good seeing for the low altitude, the comet was apparently nearly stellar, of magnitude about 19·6. A pair of 30-min exposures on October 6 yielded images that were not too strong, of magnitude about 19·1, and the comet was about equally bright when observed in poor seeing on November 1. A final single 60-min exposure in December with the Catalina 154-cm reflector showed a well-condensed image of magnitude about 18·8 and a trace of fan-shaped tail extending 0·1 arcmin to the northeast, although the four-day old Moon was nearby.

OBSERVATIONS 1975 AUGUST 8 TO DECEMBER 7

1975 j was discovered on October 5·7 by Hiro-aki Mori, a 33-year old teacher in Mukegawa, Gifu, while hunting for comets with 20 × 120 binoculars; it was independently discovered respectively 20 and 70 min later by Yasuo Sato, of Nishinasuno, Tochigi (15-cm reflector, 25 ×), an independent discoverer of comets 1968 IV, 1969 IX and 1970 X, and by Shigehisa Fujikawa, of Onohara, Kagawa (16-cm reflector, 23 ×), who was also involved in the discoveries of comets 1968 IV, 1968 VI, 1969 VII and 1970 I. In northwestern Hydra, the new comet was described by its discoverers as of mag 10–11, a diffuse object with neither condensation nor tail. Some 1·9 AU from the Sun at discovery, it brightened steadily as its heliocentric and geocentric distances decreased, Bortle (32-cm reflector) noting the magnitude as 10·0 on October 8, 9·5 on October 21 and 8·9 on November 1; by this last date the comet had become moderately condensed, was some 2·5 arcmin across and had a suggestion of a very faint, straight tail 12 arcmin long towards pa 330°. A spectrogram obtained by Devinney and McCracken on October 31 showed the gas-continuum ratio to be less than in comet 1975 h in July. Short exposures of comet 1975 j with the Catalina reflector (Roemer) on November 3 gave good, strong, well-condensed images of magnitude very roughly 14·3, embedded in a trace of coma, but no tail was evident on these plates or to Bortle in his subsequent observations, which continued to November 16, when the comet had brightened to mag 8·4 (7·8 in 10 × 50 binoculars). The comet was then moving rapidly southwards, and Jones (4·5-cm refractor) gave further magnitude estimates of 8·5 on November 30, 8·1 on December 13 and 8·5 on December 27; on this last date observations with a 32-cm reflector showed a suspicion of a faint tail, 10 arcmin long, in pa 20°. An exposure with the European Southern Observatory's Schmidt telescope on December 8 accidentally recorded the comet

with a tail more than 1° long, and at Cerro El Roble S.Barros described a 2° tail on December 30.

OBSERVATIONS 1975 OCTOBER 5 TO END OF YEAR, CONTINUING

1975 k was first detected on October 5·8 by Shigenori Suzuki, the first discoverer of comet 1970 X, who lives in Kira, Aichi; his discovery, which was made with a 14-cm reflector (22×), came 50 min after Mori's discovery of comet 1975 j. Within the next 30 min there were no fewer than four more independent discoveries of comet 1975 k, among them one by Mori who found the two comets 1975 j and 1975 k within an interval of only 70 min! Never before has an individual discovered two comets on the same night, although K.C.Bruhns found comets on consecutive nights in 1862, and pairs of comets were found within less than 48 hours by J.L.Pons in 1818 and by J.H.Metcalf in 1919. Three of the discoveries of comet 1975 k seem to have been made within an interval of 2 min, but under the three-name limit rule, the comet received the name Suzuki–Saigusa–Mori, the second discoverer having been Yoshikazu Saigusa, of Kofu, Yamanashi, who used a 15-cm reflector, 27×. The fourth and fifth discoverers, who found the comet within 10 min of Saigusa and Mori, were Kiyomi Okazaki (Kahoku, Yamagata, 15-cm reflector, 25×) and Shigeru Huruyama (Tone, Ibaraki, 15-cm reflector, 28×). A sixth discoverer of this comet was Giovanni Casari, of Novi di Modena, Italy, who found the comet visually (25-cm reflector, 31×) on October 6·2 and confirmed it photographically.

At discovery comet 1975 k was diffuse, uncondensed and tailless, of mag 8–9 and moving east–southeastwards in Ursa Major at a rate of only 8 arcmin per day. This very slow apparent motion was because the comet was moving almost directly towards the Earth, its geocentric distance decreasing from 0·94 AU at discovery to only 0·104 AU on October 31; this and the practically identical close approach of comet 1961 VIII (0·102 AU on 1961 November 15) represent the closest approaches a comet is known to have made to the Earth since P/Schwassmann–Wachmann 3 passed by at a distance of only 0·062 AU on 1930 May 31. Using 10×50 binoculars, Bortle watched comet 1975 k brighten and grow larger in size, from mag 8·2 and coma diameter 3·0 arcmin on October 8, to 7·0 and about 9 arcmin on the 21st and to 5·5 and 12 arcmin on the 28th. On this last date the boundaries of the coma were very diffuse, and the area of greatest condensation was quite broad and centrally located; 20×120 binoculars revealed the coma to be surrounded by the suggestion of a very faint, diffuse, circular cloud up to 1° in diameter; there was an indication of a broad, straight tail up to 1° long in pa 0°, and occasionally also of a large, diffuse cloud elongated in pa 10–190°. The comet was then at a phase angle of 137° and moving rapidly eastwards and southwards and into inferior conjunction with the Sun. The final observations from the northern hemisphere seem to have been those made on October 29 photographically by Mrkos and by W.Ferreri (Pino Torinese Observatory) and visually by A.Bernasconi (Saronno, Italy, 5×60 binoculars) and by D.Wallentine (Albuquerque, New Mexico, 7×35 binoculars), this last observer giving the comet's magnitude as 5·5.

On November 2, when the comet had moved from the morning to the evening sky and to a declination of $-42°$ in southern Scorpius, it was briefly glimpsed by Cooper in New Zealand, this observer estimating the total magnitude as 4·5 (10-cm reflector). Photographic astrometric observations were made the following day by Herald and Hers, while on the 4th B.Nikolau (Palmerston North, New Zealand) reported the comet as a naked-eye object of mag 4·1. Using $2·5 \times 23$ binoculars Jones estimated the magnitude as 5·6 on November 7 (while with a 32-cm reflector there was a suspicion of a wisp of tail), and as the comet receded and slowed its apparent motion in the constellations of Indus and Grus it faded to mag 7·5 on November 11 (4·5-cm refractor), 9·2 on November 23 and 9·5 on December 2 (7·8-cm refractor); the comet seemed perhaps a little brighter on December 6 and 7 (mag 8·9, 7·8-cm refractor), and 10-min exposures by Gilmore produced a diffuse spot of mag 13·6. On the 10th Boethin noted the coma as 6 arcmin across and condensed in spite of bright moonlight. At the next dark of the Moon the comet was much fainter visually, Jones, this time using a 32-cm reflector, giving the magnitude as 12·5 on December 22 and 12·8 on the 28th, averted vision being needed to see the comet on the latter occasion.

OBSERVATIONS 1975 OCTOBER 5 TO END OF YEAR, CONTINUING

1975 l was periodic comet Harrington–Abell, recovered by Roemer, assisted by M.A.Daniel, on October 6·4 with the Steward reflector. On the 60-min exposures the comet was fairly weak, but nearly stellar in appearance, of magnitude about 20·4. It had evidently been too faint to show on similar exposures on September 9. A faint image of the comet also appears on a plate taken by Schwartz on October 7 with the Agassiz reflector. The recovery of this comet within 0·5 arcmin of a prediction by Marsden from observations in 1955, 1962 and 1968–69 is of some interest in view of the comet's passage only 0·037 AU from Jupiter in 1974. Sharply condensed images, of magnitude near 20·0, appeared on Steward exposures of November 1; and on December 5, in very good seeing, the essentially stellar images were perhaps 0·5 mag brighter.

OBSERVATIONS 1975 OCTOBER 6 TO END OF YEAR, CONTINUING

1975 m, periodic comet Arend, was recovered by Roemer and Daniel on a single 50-min exposure on October 6·5 as a sharply condensed object of magnitude about 19·5 in a faint trace of coma. A somewhat longer exposure the following night showed the condensation to be at the apex of an asymmetric coma mostly to the northwest. A 40-min exposure at the Agassiz Station on September 5 had failed to record the comet, but a satisfactory image was obtained there by McCrosky on November 7. Well-condensed images of P/Arend were obtained again by Roemer on November 1 and December 4, the magnitude being about 19·5 on each occasion.

OBSERVATIONS 1975 OCTOBER 6 TO END OF YEAR, CONTINUING

1975 n was discovered on November 5 by West at the European Southern Observatory's headquarters in Geneva near a corner of a plate taken by

Guido Pizarro on September 24 with the 100-cm Schmidt telescope at La Silla. In Microscopium, this comet was of total mag 14–15, had a coma some 2–3 arcsec in diameter and a faint, diffuse tail extending about 10 arcsec to the north. West was then able to find similar, but fainter images (mag 16–17) on plates taken by Pizarro and his brother Oscar about an hour of right ascension further east on August 10 and 13. It was not completely clear that the August and September observations referred to the same object, although they were well satisfied by a parabolic orbit; further observations at La Silla during November 8–11, when the comet had brightened to mag 12·5–13·0 and its 4 arcsec condensation was surrounded by a diffuse halo some 20 arcsec in diameter, confirmed the identity and showed that comet West would move in from a heliocentric distance of 3·6 AU on August 10 to one of only 0·2 at perihelion in 1976 February, near which time it was expected to be a bright, naked-eye object.

Exposures with the Carter Observatory's 41-cm reflector on November 9 and 11 yielded measurable images, although those on the first date were involved with a star. On the latter date the comet's magnitude was judged to be 14·4–14·5, and further plates taken during the following month showed generally steady brightening, by about one magnitude by December 6. Comet West was also under observation during November at the Perth Observatory, by R.R.D.Austin with Mount John Observatory's astrograph and by Herald, who recorded a very faint trailed image of mag 12–13 on November 29. Although at declination about $-38°$ and very low in the south-southwest after sunset, comet West was photographed during the first week of December by northern-hemisphere observers Seki and Giclas, and on December 6 Torres noted a faint, broad tail 1 arcmin long. On December 4 Boethin remarked that the comet was just detectable visually with his 20-cm reflector, the comet being very diffuse and some 8 arcmin in diameter. Also using a 20-cm reflector, Nikolau suggested brightening from mag 10·1 on December 23 to 9·0 on the 26th, while Jones (7·8-cm refractor) gave the magnitude as 9·5 on the 23rd and 8·7 on the 30th, the comet being strongly condensed on the latter occasion.

OBSERVATIONS 1975 AUGUST 10 TO END OF YEAR, CONTINUING

1975 o, a seventeenth-magnitude object retrograding in southwest Aries, was discovered by Tom Gehrels on exposures obtained (with the assistance of R.Adams) with the 122-cm Palomar Schmidt on October 27·1, 28·2 and 30·1 in the course of his survey for unusual solar system objects. The object was so nearly stellar in appearance that there was initially some doubt as to whether it was a comet or a minor planet, but it seemed to be surrounded by some diffuseness, and observations by Bulger and McCrosky at the Agassiz Station during November 7–10 confirmed its probable cometary nature. It turned out to be yet another short-period comet, named P/Gehrels 3, its orbit being very similar in size, shape and evolution to that of comet 1975 e (except that the encounter with Jupiter took place in 1973). Further observations were made with the Agassiz and Catalina reflectors during December. The Catalina observations on December 7 yielded a well-condensed nucleus of magnitude about 18·4 in a trace of coma. On the

25th the sharply condensed images were of magnitude about 18·8, and the coma had its greatest extension to the south.

OBSERVATIONS 1975 OCTOBER 27 TO END OF YEAR, CONTINUING

1975 p, Bradfield's fourth comet, was discovered on November 11·7 as a diffuse and uncondensed, tenth-magnitude, tailless object in Antlia. Although the discoverer, who had spent 106 hours comet-hunting since finding 1975 d, was not conducting his search with the aid of the search ephemeris for Kreutz sungrazers, the discovery position and rough motion suggested that comet 1975 p might be a member of this group. This turned out not in fact to be the case, but the initial orbit, determined from observations by Herald and by E.Moore (Joint Observatory for Cometary Research) during November 13–17, indicated that the comet should become visible with the naked eye at the beginning of the new year. The comet did not brighten as rapidly as was anticipated, however, T.B.Tregaskis (Mount Eliza, Victoria, 15-cm reflector) noting the magnitude as 9 on November 13, 8 on November 28 and 7·5 on December 1; on this last date there was a 5 arcmin tail. Short exposures with the Carter reflector (Gilmore) on November 28 showed a strong condensation in a diffuse coma 1 arcmin across with a narrow tail 2 arcmin long in pa 245°, while longer exposures with the Maksutov astrograph at Cerro El Roble (Torres), gave tail lengths 50 arcmin on December 6 and 80 arcmin on the 7th. On the 5th Goodman, using a 32-cm reflector, noted a prominent tail visually, some 45 arcmin long in pa 240°, with a fainter secondary tail on one side. The last pre-perihelion observations seem to have been those by Hers and Herald on December 8. Four Japanese observers – M.Satake, Y.Matsui, K.Uami and K.Mameta – reported observations of the comet at mag 1–3 immediately after sunset on December 24, 25 and 26; but by the 31st, when the comet was picked up by S.Furia (Varese, Italy, 7×50 binoculars), it had faded to mag 6·7.

OBSERVATIONS 1975 NOVEMBER 11 TO END OF YEAR, CONTINUING

1975 q, discovered on December 5·7 by Yasuo Sato, was the fifth comet in the discovery of which Sato had shared. Moving rapidly southeastwards in Coma Berenices, this comet was of mag 9, with neither condensation nor tail. A confirmatory observation was obtained on December 7 by Harlan with the 10-cm camera at Lick Observatory, this observer noting some central condensation. It also appeared that the comet had been observed by S.Utsunomiya at Ogumi, Kumamoto, as early as November 30·8, but confirmation was not possible at the time; the magnitude was 9·5–10·0. On December 10 Seki reported a tail 15 arcmin long in pa 270°, while a 9-min exposure a few hours later by McCrosky showed a 4 arcmin tail around pa 295°. On the 12th an exposure at the Agassiz Station gave a nuclear magnitude of about 13·8 (Kodak IIa-O emulsion), and the following night Waterfield noted a strongly condensed inner coma 30 arcsec in diameter, a diffuse outer coma 3 arcmin in diameter, and a total magnitude of 8·0. Using 11×60 binoculars, Austin gave the visual magnitude as 9·1 on the 13th and 8·3 on the 14th. The comet was then starting to move rapidly southwards, at a daily rate of 7° on the 19th, when the comet was at its

minimum distance of 0·28 AU from the Earth. At Utsunomiya, Japan, T.Kurosaki followed the comet photographically until December 18; and on the 21st, when the comet's declination was −52°, P.Maley (Houston, Texas, 13-cm refractor) made a visual magnitude estimate of 8·5. Astrometric observations were being made during the last week of the year and/or early in the new year by P.Jekabsons and others at the Perth Observatory, by Hers, Herald and Gilmore.

OBSERVATIONS 1975 NOVEMBER 30 TO END OF YEAR, CONTINUING

Of the two dozen or so reports of unconfirmed cometary discoveries received by the IAU Central Telegram Bureau during 1975 the following were mentioned on the IAU *Circulars* or *Yamamoto Circulars*, or both:

(1) Eleanor Helin found a possible cometary object, of mag 14, on a single exposure taken for the minor planet 1973 QA on February 20·0 with the 46-cm Palomar Schmidt. The diffuse, condensed image was located some 7° southwest of Regulus and seemed to be moving northwest (or southeast) at 12 arcmin per day. An attempt to confirm the object with the 122-cm Schmidt on February 23 was unsuccessful.

(2) Milan Antal reported the discovery of a fourteenth-magnitude uncondensed cometary image on an exposure at the Skalnaté Pleso Observatory on July 8·9. Just west of μ Sagittarii, the corresponding daily motion was about 1° west–southwest or east–northeast. The image was evidently not noticed until a fortnight after the plate had been taken, and no confirmation was possible.

(3) Wayne Johnson, a student at the University of Arizona, reported the visual discovery of a comet in Gemini while looking for M 35 on October 4·4. Of mag 9–10, the object was 10 arcmin in diameter and had both a central condensation and a short tail. Another observation the following night suggested a daily motion of some 2° to the northwest. Subsequent attempts to locate any comet were unsuccessful, and it seems probable that the October 4 object was NGC 2261 and possible that the following night's observation referred to IC 2169.

(4) An eighteenth-magnitude, diffuse, haloed trail found by West on November 20 on a plate taken with the European Southern Observatory's Schmidt telescope at La Silla on October 2·1 undoubtedly referred to a real comet. Located some 6° southwest of Fomalhaut, this object was moving northeast at 7 arcmin per day, the sense of motion being unambiguous because images did not appear on partly overlapping plates taken east of the position one and three days earlier. Attempts by H.E.Schuster to recover the object at La Silla on November 20 and 21 were unsuccessful. Another very faint trail, more diffuse than trails of minor planets of comparable brightness, was later identified by West on the August 10 plate that contained the first image of comet 1975 n, but it proved impossible to link this with the October 2 comet.

Ephemerides were also available for the following comets:

1972 IX, Sandage; 1973 XII, Kohoutek; and 1974 h, Bennett. The ephemerides extended into the early part of the year, but the comets were evidently very faint, and no serious attempts were made to observe them.

1895 II, P/Swift; and 1918 III, P/Schorr. See the 1974 report.

1906 VI, P/Metcalf; and 1896 V, P/Giacobini. Predictions for these one-apparition periodic comets were provided by Belyaev, N.Yu.Goryajnova and V.V.Emel'yanenko. Neither return was particularly favourable, and no observations seem to have been attempted.

P/Perrine–Mrkos. Due at perihelion on 1975 August 2, this comet was moderately placed for recovery. It was easily expected to attain a nuclear magnitude of 18–19, and its total magnitude could have reached 15. A 30-min exposure by Roemer with the Steward reflector on August 8 covered the range $\Delta T = -0{\cdot}42$ to $+0{\cdot}55$ day from Marsden's prediction, while 40-min exposures on September 12 extended the range to $\Delta T = -1{\cdot}3$ to $+1{\cdot}5$ day. No reasonably condensed image appeared near the line of variation to a (nuclear) magnitude limit of about 19·0–19·5. In view of the unexpectedly large positional error of the 1968 prediction (see the 1968 report), an extended search was desirable, and Kowal took a plate with the 122-cm Palomar Schmidt on October 2. This covered the range $\Delta T = -5$ to $+8$ day, and there was no trace of the comet to mag 19 or fainter. A single accurate position reported by Seki on August 13 of an uncondensed image of mag 17 on the line of variation at $\Delta T = -0{\cdot}04$ day could not be confirmed, and the possibility that the comet experienced a brief outburst (as in 1955 when Mrkos discovered it) cannot be completely dismissed. On the other hand, the erratic dynamical behaviour of this comet is similar to that of P/Brorsen a century ago and, together with peculiar photometric anomalies, this is perhaps a symptom that a comet is about to disappear completely.

P/Westphal. This famous comet, with period about 62 yr, faded out as it approached perihelion in 1913. This fading, together with the severe difficulties experienced in linking the observations in 1852–53 and 1913, did not provide much encouragement for the possibility that the comet would be re-observed in 1975. Several predictions were available, among them one by L.M.Belous (Leningrad) giving $T =$ 1975 December 26 and one by H.J.Carr (Cincinnati) giving $T =$ 1976 January 3. Non-gravitational forces acting on the comet presumably made the uncertainty rather larger than the difference between the predictions. If the comet followed its behaviour in 1852, it could have attained tenth magnitude towards the end of the year, and many searches, both visual and photographic, were made. Earlier in the year the comet would have been more suitable for recovery in the southern hemisphere, but it did not show on exposures at Cerro El Roble on August 15 and 16 that had a magnitude limit close to 20 and ranged over $\Delta T = \pm 10$ day from Belous' prediction. A somewhat similar search (but down to a magnitude limit no fainter than 18) was made around the same time by C.U.Cesco at El Leoncito.

P/van Houten, 1961 X. Although not due at perihelion until early 1977, this comet has a large perihelion distance and rather low orbital eccentricity and could have been as bright as mag 18–19 during late 1975. There is an uncertainty of several months in T, and the variation was somewhat smaller than it will be at the opposition in late 1976. Predictions were provided by S.Nakano (Tokorozawa, Japan) and by Marsden, but three pairs of plates

taken by Kowal on September 30 and October 1 covering the range $\Delta T = \pm 70$ day from the nominal date $T = 1977$ January 1 did not show any obvious comet brighter than mag 19.

The following photometric parameters (reduced to an effective aperture of 6·8 cm) have been provided by J.E.Bortle, Stormville, New York:

Comet	No. of observations	Arc	H_0	n	H_{10}
1975 a	7	1975 February 9–March 10			9·76±0·08
1975 b	4	1975 March 5–16			9·60±0·04
1975 h	27	1975 July 8–October 8	7·11±0·04	3·33±0·09	(7·29)
1975 j	5	1975 October 8–November 16			5·08±0·05
1975 k	6	1975 October 8–28			9·80±0·14

E.Everhart, University of Denver, has provided values of u_b = osculating $1/a$ minus original (barycentric) $1/a$ and u_a = future (barycentric) $1/a$ minus osculating $1/a$ for the new long-period comets of 1975. The first set of figures below (in units of 10^{-6}/AU) has been calculated on the assumption that the osculation epoch is at perihelion, and the second set corresponds to the nearest standard 40-day date.

Comet	Perihelion		40-day date			Total
	u_b	u_a	u_b	u_a		u_b+u_a
1975 d	−1185	+322	−1181	+318	(1975 April 18·0)	−863
1975 h	−1043	+353	−1044	+354	(1975 September 25·0)	−690
1975 k	−423	+265	−459	+301	(1975 November 4·0)	−158
1975 p	+ 47	+1226	+ 49	+1224	(1975 December 14·0)	+1273
1975 j	−375	− 43	−374	− 45	(1975 December 14·0)	−419
1975 q	−676	− 52	−672	− 56	(1976 January 23·0)	−728
1975 n	−1423	−117	−1423	−117	(1976 March 3·0)	−1540

The following continuation of the numerical designations of comets (in order of perihelion passage) is taken from *IAU Circ.* 2898 (1976). The perihelion times (T) are from orbits noted in these annual reports.

Comet	T	Name	Year and letter
1974 I	January 4·0	P/Brooks 2	1973 j
II	February 15·3	P/Schwassmann–Wachmann 1	–
III	March 18·4	Bradfield	1974 b
IV	April 1·5	P/du Toit 1	–
V	April 29·0	P/Encke	–
VI	May 8·2	P/Reinmuth 2	1973 g
VII	May 12·7	P/Borrelly	1973 m
VIII	May 13·1	Cesco	1974 e
IX	May 19·9	P/Forbes	1974 a
X	July 3·9	P/Finlay	1974 d
XI	July 5·6	P/Wirtanen	1974 i
XII	August 8·2	van den Bergh	1974 g
XIII	September 12·3	P/Schwassmann–Wachmann 2	1973 l
XIV	November 4·3	P/Longmore	1975 g
XV	December 1·5	Bennett	1974 h
XVI	December 28·1	P/Honda–Mrkos–Pajdušáková	1974 f

On the following pages the elements of recently computed orbits are tabulated. The times are in Ephemeris Time, and the angles are referred to

Ref.		Comet	*T*	*q*	*e*	*Elements of* *P* y
(1)	1340	Bright Comet	40 May 13·62	1·1362	1·0	–
(2)	1682	P/Halley	82 Sept. 15·2789	0·582593	0·967928	77·4
(2)	1759 I	P/Halley	59 Mar. 13·0599	0·584447	0·967684	76·9
(2)	1815	P/Olbers	15 Apr. 26·4919	1·212912	0·931717	74·9
(3)	1819 III	P/Pons–Winnecke	19 July 19·6762	0·771919	0·754153	5·56
(2)	1835 III	P/Halley	35 Nov. 16·4385	0·586542	0·967391	76·3
–	1847 V	P/Brorsen–Metcalf	47 Sept. 10·050	0·48732	0·97213	73·1
–	1851 IV	Brorsen	51 Oct. 1·2962	0·142053	1·0	–
(4)	1858 I	P/Tuttle	58 Feb. 24·0174	1·025536	0·821218	13·7
(3)	1858 II	P/Pons–Winnecke	58 May 2·5380	0·768940	0·754854	5·56
(3)	1869 I	P/Pons–Winnecke	69 June 30·4412	0·781519	0·751944	5·59
(4)	1871 III	P/Tuttle	71 Dec. 2·2967	1·030106	0·821115	13·8
(3)	1875 I	P/Pons–Winnecke	75 Mar. 12·5996	0·829005	0·741022	5·73
(5)	1880 V	Pechüle	80 Nov. 9·9200	0·659736	1·0	–
(6)	1884 II	P/Barnard 1	84 Aug. 16·9682	1·279730	0·584037	5·40
(7)	1884 III	P/Wolf	84 Nov. 18·2872	1·571968	0·560895	6·77
(4)	1885 IV	P/Tuttle	85 Sept. 11·8047	1·024671	0·821560	13·8
(6)	1886 IV	P/Brooks 1	86 June 7·2124	1·325444	0·571760	5·45
(3)	1886 VI	P/Pons–Winnecke	86 Sept. 4·8861	0·885499	0·726189	5·82
(2)	1887 V	P/Olbers	87 Oct. 8·9734	1·199088	0·930974	72·4
(8)	1889 III	P/Barnard 2	89 June 21·243	1·103639	0·956965	130·0
(9)	1889 V	P/Brooks 2	89 Sept. 30·8376	1·949839	0·470808	7·07
(7)	1891 II	P/Wolf	91 Sept. 3·9298	1·592795	0·557122	6·82
(3)	1892 IV	P/Pons–Winnecke	92 July 1·4036	0·886551	0·725928	5·82
(10)	1892 VI	Brooks	92 Dec. 28·5864	0·975989	1·000441	–
(11)	1894 I	P/Denning 2	94 Feb. 9·954	1·147197	0·698400	7·42
(9)	1896 VI	P/Brooks 2	96 Nov. 4·6296	1·959224	0·469453	7·10
–	1896 VII	P/Perrine–Mrkos	96 Nov. 25·120	1·11022	0·67866	6·42
(3)	1898 II	P/Pons–Winnecke	98 Mar. 20·8657	0·923824	0·714857	5·83
(7)	1898 IV	P/Wolf	98 July 5·0654	1·603058	0·555337	6·85
(4)	1899 III	P/Tuttle	99 May 4·5562	1·013785	0·822269	13·6
–	1903 IV	Borrelly	03 Aug. 28·1087	0·330182	1·000406	–
(9)	1903 V	P/Brooks 2	03 Dec. 6·7426	1·958917	0·469752	7·10
(2)	1905 II	P/Borrelly	05 Jan. 17·2944	1·395366	0·615229	6·91
(12)	1906 IV	P/Kopff	06 May 3·1616	1·699005	0·516158	6·58
(3)	1909 II	P/Pons–Winnecke	09 Oct. 9·7940	0·973080	0·701756	5·89
–	1909 III	P/Perrine–Mrkos	09 Nov. 1·323	1·17301	0·66425	6·53
(2)	1910 II	P/Halley	10 Apr. 20·1776	0·587188	0·967300	76·1
(9)	1911 I	P/Brooks 2	11 Jan. 8·6570	1·963035	0·468818	7·10
(10)	1911 V	Brooks	11 Oct. 28·2368	0·489429	0·997005	–
(2)	1911 VIII	P/Borrelly	11 Dec. 18·4897	1·402655	0·614072	6·93
(7)	1912 I	P/Wolf	12 Feb. 24·2576	1·587178	0·557987	6·80
(4)	1912 IV	P/Tuttle	12 Oct. 28·9734	1·029970	0·818387	13·5
–	1914 IV	Campbell	14 Aug. 5·4708	0·712756	0·998666	–
(3)	1915 III	P/Pons–Winnecke	15 Sept. 2·7818	0·970643	0·702376	5·89

cometary orbits

ω °	☊ °	i °	Epoch	Obs.	Arc	Ref.
32·46	186·95	176·49	–	3	1340 Mar. 26–Apr. 6	(1)
109·1975	54·8437	162·2582	82 Aug. 31·0	876*	1682–. . .–1911	(2)
110·6856	56·5248	162·3658	59 Mar. 21·0	876*	1682–. . .–1911	(2)
65·5796	85·3406	44·4992	15 Apr. 17·0	144*	1815, 1887–88, 1955–56	(2)
161·9591	114·8148	10·7498	19 July 25·0	18	1819, (1858)	(3)
110·6816	56·7987	162·2520	35 Nov. 18·0	876*	1682–. . .–1911	(2)
129·452	311·235	19·138	47 Sept. 16·0	138	1847, 1919	–
294·4418	45·7318	73·9821	–	15	1851 Oct. 23–Nov. 20	–
206·7839	270·3455	54·4073	58 Feb. 10·0	222	1858, 1871–72	(4)
162·1740	114·7615	10·7971	58 May 1·0	190	1858, 1869	(3)
162·4272	114·6241	10·8005	69 July 2·0	190	1858, 1869	(3)
206·7836	270·4107	54·2818	71 Nov. 29·0	78	1871–72, 1885	(4)
165·1844	112·4920	11·2797	75 Jan. 2·0	144	1869, 1875	(3)
11·6949	250·3474	60·7023	81 Jan. 20·0	299	80 Dec. 16–81 Mar. 31	(5)
301·0349	6·0613	5·4684	84 June 23·0	179	1884 July 24–Nov. 8	(6)
172·6974	207·2961	25·2539	84 Nov. 20·0	336*	1884–. . .–1919	(7)
206·7828	270·5428	54·3298	85 Sept. 16·0	33	1885, 1899	(4)
176·8525	54·4513	12·6733	86 Apr. 4·0	39	1886 May 25–July 3	(6)
172·0667	104·9329	14·5243	86 Aug. 2·0	88	1875, 1886	(3)
65·3462	85·3654	44·5729	87 Oct. 16·0	144*	1815, 1887–88, 1955–56	(2)
60·1785	271·8792	31·2299	89 June 17·0	27	1889 June–Aug.	(8)
343·6317	18·7898	6·0751	89 Sept. 30·0	126	1889–91, 1896–97	(9)
172·7973	207·2025	25·2373	91 Sept. 5·0	336*	1884–. . .–1919	(7)
172·1356	104·8892	14·5219	92 Feb. 29·5	122	1892, 1898	(3)
252·6686	265·3219	24·8011	93 Jan. 17·0	123	92 Sept. 1–93 July 10	(10)
46·3229	85·0784	5·5297	94 Feb. 6·0	103	1894 Mar. 27–June 5	(11)
343·8215	18·7395	6·0653	96 Oct. 8·0	105	1896–97, 1903–04	(9)
163·874	247·344	13·667	96 Nov. 17·0	125*	1896–97, 1909, 1955	–
173·3801	101·5609	16·9930	97 Dec. 2·0	122	1892, 1898	(3)
172·8692	207·1895	25·1989	98 July 10·0	336*	1884–. . .–1919	(7)
206·6393	270·5416	54·4883	99 Apr. 16·0	97	1899, 1912–13	(4)
127·2578	294·2109	85·0123	03 Sept. 3·0	239	1903 June 22–Oct. 23	–
343·6444	18·7361	6·0672	03 Nov. 22·0	26	1903–04, 1910	(9)
352·3519	77·3812	30·4847	05 Jan. 15·0	162*	1904–. . .–1961	(2)
19·7943	264·3080	8·7125	06 Apr. 20·0	146	1906, 1919	(12)
172·2938	99·8963	18·2853	09 Sept. 11·0	90	1909–10, 1915	(3)
166·832	242·919	15·693	09 Oct. 21·0	125*	1896–97, 1909, 1955	–
111·7135	57·8427	162·2120	10 May 9·0	876*	1682–. . .–1911	(2)
343·5208	18·7601	6·0636	10 Nov. 25·0	26	1903–04, 1910	(9)
153·0148	293·5000	33·8063	11 Oct. 11·0	619	11 July 22–12 Feb. 28	(10)
352·3745	77·3755	30·4417	11 Dec. 10·0	162*	1904–. . .–1961	(2)
172·8310	207·1953	25·2621	12 Feb. 28·0	336*	1884–. . .–1919	(7)
206·9508	270·2775	55·0483	12 Nov. 14·0	97	1899, 1912–13	(4)
270·3460	0·8845	77·8295	14 Aug. 16·0	59	1914 Sept. 20–Nov. 17	–
172·3827	99·8455	18·3054	15 Jan. 30·5	90	1909–10, 1915	(3)

Ref.	Comet		*T*	*q*	*e*	*Elements of* *P* y
–	1918 III	P/Schorr	18 Sept. 30·0234	1·882365	0·468443	6·66
(2)	1918 IV	P/Borrelly	18 Nov. 17·0978	1·395786	0·615088	6·91
(7)	1918 V	P/Wolf	18 Dec. 13·9885	1·582148	0·558686	6·79
(12)	1919 I	P/Kopff	19 June 28·7273	1·707105	0·514769	6·60
–	1919 III	P/Brorsen–Metcalf	19 Oct. 17·361	0·48428	0·97201	72·0
(8)	1921 I	P/Dubiago	21 May 5·327	1·114838	0·928065	61·0
(3)	1921 III	P/Pons–Winnecke	21 June 13·4017	1·040924	0·685529	6·02
(2)	1925 VIII	P/Borrelly	25 Oct. 7·5262	1·388178	0·616450	6·89
(9)	1925 IX	P/Brooks 2	25 Nov. 1·8075	1·861657	0·487297	6·92
(5)	1926 I	Blathwayt	26 Jan. 2·8048	1·345480	0·992396	–
(12)	1926 II	P/Kopff	26 Jan. 28·4409	1·698387	0·516422	6·58
(4)	1926 IV	P/Tuttle	26 Apr. 28·7644	1·030921	0·818521	13·5
(3)	1927 VII	P/Pons–Winnecke	27 June 21·0579	1·039240	0·685686	6·01
(12)	1932 III	P/Kopff	32 Aug. 21·4152	1·688189	0·518119	6·56
(2)	1932 IV	P/Borrelly	32 Aug. 27·2928	1·385539	0·616726	6·87
(9)	1932 VIII	P/Brooks 2	32 Oct. 9·5246	1·869987	0·486105	6·94
(3)	1933 II	P/Pons–Winnecke	33 May 18·7803	1·101818	0·669664	6·09
(12)	1939 II	P/Kopff	39 Mar. 13·0464	1·682069	0·519099	6·54
(3)	1939 V	P/Pons–Winnecke	39 June 22·7081	1·101498	0·669625	6·09
–			39 June 22·7150	1·101471	0·669678	6·09
(9)	1939 VII	P/Brooks 2	39 Sept. 15·4149	1·871481	0·486040	6·95
(4)	1939 X	P/Tuttle	39 Nov. 10·6120	1·022588	0·820596	13·6
–	1941 I	Cunningham	41 Jan. 16·2340	0·367751	1·000485	–
(3)	1945 IV	P/Pons–Winnecke	45 July 10·5857	1·159224	0·654873	6·16
–			45 July 10·5895	1·159202	0·654860	6·16
(12)	1945 V	P/Kopff	45 Aug. 11·2737	1·495672	0·556085	6·18
(9)	1946 IV	P/Brooks 2	46 Aug. 25·7927	1·878829	0·484618	6·96
–	1947 VIII	Wirtanen	47 Sept. 4·4310	3·261102	1·002278	–
–	1948 X	Bester	48 Oct. 22·8660	1·273428	0·997499	–
–	1948 XII	P/Honda–M.–P.	48 Nov. 17·7165	0·559269	0·814203	5·22
(13)	1949 III	Wilson–Harrington	49 Oct. 11·815	1·03293	1·0	–
–	1950 I	Johnson	50 Jan. 19·3128	2·553231	1·000698	–
(3)	1951 VI	P/Pons–Winnecke	51 Sept. 8·6026	1·160387	0·654651	6·16
–			51 Sept. 8·6129	1·160469	0·654566	6·16
(12)	1951 VII	P/Kopff	51 Oct. 20·3766	1·494844	0·556101	6·18
–	1951 IX	P/Harrington–W.	51 Oct. 30·4249	1·664112	0·515373	6·36
(2)	1953 IV	P/Borrelly	53 June 9·4930	1·450058	0·604070	7·01
(9)	1953 V	P/Brooks 2	53 Aug. 7·3600	1·866090	0·486675	6·93
–	1954 II	Pajdušáková	54 Jan. 24·6714	0·072347	1·0	–
–	1954 III	P/Honda–M.–P.	54 Feb. 5·1055	0·555636	0·815093	5·21
–	1954 VIII	Vozárová	54 June 1·9350	0·677461	1·000286	–
–	1954 XIII	P/Harrington–Abell	54 Dec. 12·8438	1·774222	0·524191	7·20
(2)	1956 IV	P/Olbers	56 June 19·1392	1·178450	0·930334	69·6
–	1957 V	Mrkos	57 Aug. 1·4373	0·354933	0·999365	–
(12)	1958 I	P/Kopff	58 Jan. 20·4336	1·517683	0·555402	6·31

cometary orbits

ω °	☊ °	i °	Epoch	Obs.	Arc	Ref.
279·0906	118·3354	5·5745	18 Oct. 14·0	19	1918 Nov. 23–Dec. 31	–
352·3981	77·3706	30·4914	18 Nov. 23·0	162*	1904–. . .–1961	(2)
172·9341	207·1348	25·2889	18 Dec. 18·0	336*	1884–. . .–1919	(7)
19·7175	264·2725	8·6957	19 June 11·0	146	1906, 1919	(12)
129·569	311·169	19·210	19 Oct. 9·0	138	1847, 1919	–
97·4177	66·5248	22·3239	21 May 1·0	43	1921 Apr.–June	(8)
170·2605	98·5283	18·9253	21 Jan. 3·5	155	1915, 1921	(3)
352·4223	77·3787	30·5105	25 Oct. 17·0	162*	1904–. . .–1961	(2)
195·7022	177·7693	5·5496	25 Nov. 6·0	63	1925–26, 1932–33	(9)
328·2539	136·4246	128·3038	26 Feb. 14·0	47	1926 Jan. 16–Mar. 17	(5)
19·6771	264·2673	8·7076	26 Feb. 14·0	78	1926, 1932–33	(12)
206·9737	270·1341	54·9553	26 May 5·0	27	1926, 1939	(4)
170·3670	98·4691	18·9408	26 Nov. 29·0	268	1927–28, 1933	(3)
19·7195	264·2057	8·7065	32 Sept. 10·0	78	1926, 1932–33	(12)
352·5506	77·3082	30·5295	32 Aug. 21·0	162*	1904–. . .–1961	(2)
195·8300	177·6985	5·5450	32 Sept. 30·0	63	1925–26, 1932–33	(9)
169·2408	96·8569	20·1160	33 Jan. 8·0	144	1933, 1939	(3)
19·8396	264·1583	8·7125	39 Feb. 26·0	81	1939, 1945–46	(12)
169·3367	96·8051	20·1218	39 Feb. 1·0	145	1939, 1945	(3)
169·3482	96·8007	20·1231	39 June 26·0	124*	1939–. . .–1970	–
195·6843	177·7024	5·5456	39 Sept. 24·0	56	1939–40, 1946–47	(9)
206·9561	269·8403	54·6489	39 Oct. 24·0	27	1926, 1939	(4)
199·5763	295·8873	49·8909	41 Jan. 6·0	189	40 Sept. 19–41 June 17	–
170·1083	94·4553	21·6936	45 Apr. 2·5	145	1939, 1945	(3)
170·1141	94·4531	21·6939	45 July 4·0	124*	1939–. . .–1970	–
31·5425	253·1188	7·2231	45 Aug. 13·0	81	1939, 1945–46	(12)
195·6059	177·6963	5·5394	46 Aug. 28·0	56	1939–40, 1946–47	(9)
73·4524	121·4108	155·0818	47 Sept. 12·0	26	48 Oct. 7–50 Aug. 17	–
274·2030	66·9702	87·6034	48 Oct. 16·0	24	48 Nov. 24–49 Feb. 26	–
184·1239	233·0949	13·1599	48 Nov. 25·0	28*	1948–49, 1954, 1964	–
87·596	272·498	3·901	–	11	1949 Nov. 19–25	(13)
40·0965	221·6323	131·3551	49 Dec. 30·0	64	49 May 20–51 Mar. 8	–
170·1975	94·4092	21·6907	51 Jan. 11·5	40	1945, 1951	(3)
170·2031	94·4026	21·6901	51 Aug. 22·0	124*	1939–. . .–1970	–
31·7166	253·0251	7·2202	51 Oct. 1·0	40	1945–46, 1951	(12)
343·0012	127·7896	16·3540	–	7	1952 Jan. 30–Feb. 25	–
350·9573	76·1763	31·0899	53 June 12·0	40*	1932–. . .–1975	(2)
195·6898	177·6813	5·5510	53 Aug. 11·0	55	1946–47, 1953–54	(9)
94·0537	114·5577	13·5761	–	22	1953 Nov. 7–Dec. 29	–
184·1349	233·0867	13·1955	54 Jan. 18·0	28*	1948–49, 1954, 1964	–
357·2544	122·1237	116·1581	54 May 18·0	39	1954 July 28–Dec. 18	–
338·0778	145·9532	16·8279	54 Dec. 4·0	25	1955, 1962, 1968–69	–
64·6356	85·4121	44·6118	56 June 16·0	144*	1815, 1887–88, 1955–56	(2)
40·3135	67·6252	93·9392	57 July 21·0	108	57 Aug. 5–58 July 9	–
161·7932	120·9199	4·7069	58 Feb. 6·0	35	1958, 1963–65	(12)

Ref.		Comet	*T*	*q*	*e*	*Elements of* *P* y
(14)	1960 III	P/Schaumasse	60 Apr. 18·0568	1·195828	0·705497	8·18
(2)	1960 V	P/Borrelly	60 June 13·2390	1·454134	0·603393	7·02
(9)	1960 VI	P/Brooks 2	60 June 17·1118	1·763141	0·504834	6·72
(15)	1961 II	Candy	61 Feb. 8·9144	1·061635	0·990040	–
–	1961 VIII	Seki	61 Oct. 10·6408	0·681129	0·991812	759·0
–	1961 IX	P/Grigg–Skjellerup	61 Dec. 31·3574	0·857750	0·702980	4·91
–	1962 II	P/Harrington–Abell	62 Feb. 23·7769	1·781274	0·523095	7·22
–	1963 VIII	P/Kearns–Kwee	63 Dec. 7·0037	2·213170	0·486531	8·95
(16)			63 Dec. 7·0047	2·213169	0·486531	8·95
(17)			63 Dec. 7·0049	2·213160	0·486533	8·95
(3)	1964 I	P/Pons–Winnecke	64 Mar. 24·5500	1·230097	0·639419	6·30
–			64 Mar. 24·5507	1·230137	0·639378	6·30
(12)	1964 III	P/Kopff	64 May 16·1659	1·519732	0·554995	6·31
–	1964 VII	P/Honda–M.–P.	64 July 6·5609	0·555742	0·815018	5·21
–	1964 VIII	Ikeya	64 Aug. 1·2111	0·821752	0·984643	391·0
–	1964 X	P/Holmes	64 Nov. 15·9288	2·346950	0·378897	7·35
(16)	1965 I	P/Tsuchinshan 1	65 Jan. 28·6291	1·486320	0·578255	6·62
(16)	1965 II	P/Tsuchinshan 2	65 Feb. 9·2942	1·768969	0·506530	6·79
–	1967 I	P/Grigg–Skjellerup	67 Jan. 16·4749	1·002943	0·662438	5·12
(4)	1967 V	P/Tuttle	67 Mar. 31·2894	1·022914	0·821904	13·8
(2)	1967 VIII	P/Borrelly	67 June 17·7220	1·446614	0·604460	6·99
–	1968 VII	Bally–Clayton	68 Aug. 20·8448	1·771085	1·0	–
–	1969 III	P/Harrington–Abell	69 May 10·8203	1·773435	0·524047	7·19
(11)	1969 IV	P/Churyumov–G.	69 Sept. 11·0438	1·284928	0·633030	6·55
–	1969 V	P/Honda–M.–P.	69 Sept. 22·9778	0·558688	0·814285	5·22
–	1970 III	Kohoutek	70 Mar. 21·6374	1·719085	0·999125	–
–	1970 VIII	P/Pons–Winnecke	70 July 21·0316	1·247372	0·636002	6·34
(3)			70 July 21·0438	1·247146	0·635997	6·34
(12)	1970 XI	P/Kopff	70 Oct. 2·3275	1·566996	0·546125	6·42
–	1970 XII	P/Kojima	70 Oct. 7·0510	1·630895	0·514843	6·16
–	1971 I	Gehrels	71 Jan. 6·5341	3·276561	0·996943	–
(16)	1971 VIII	P/Tsuchinshan 1	71 Sept. 16·2148	1·492413	0·577228	6·63
(16)	1971 X	P/Tsuchinshan 2	71 Nov. 29·9223	1·775053	0·505534	6·80
(18)			71 Nov. 29·9248	1·775075	0·505560	6·80
–	1972 I	P/Holmes	72 Jan. 30·8221	2·155170	0·413637	7·05
–	1972 II	P/Grigg–Skjellerup	72 Mar. 2·6535	1·001297	0·662863	5·12
(16)	1972 XI	P/Kearns–Kwee	72 Nov. 28·4386	2·228579	0·485243	9·01
–			72 Nov. 28·4398	2·228581	0·485243	9·01
(19)			72 Nov. 28·5031	2·228667	0·485228	9·01
–	1972 XII	Araya	72 Dec. 18·9494	4·860755	0·999901	–
–	1973 I	P/Gehrels 1	73 Jan. 24·7423	2·935319	0·506783	14·5
(20)	1973 V	P/Clark	73 May 24·8783	1·560356	0·500345	5·52
–	1973 IX	Gibson	73 Aug. 10·0068	3·842738	1·0	–
(21)	1973 XI	P/Gehrels 2	73 Dec. 1·6214	2·348450	0·409834	7·94
(9)	1974 I	P/Brooks 2	74 Jan. 4·0153	1·840086	0·491195	6·88

cometary orbits

ω °	☊ °	i °	Epoch	Obs.	Arc	Ref.
51·9503	86·2410	12·0185	59 Oct. 9·0	190	1951–52, 1959–60	(14)
350·9755	76·1926	31·0666	60 June 15·0	40*	1932–. . .–1975	(2)
197·0933	176·8885	5·5713	60 July 5·0	16	1960–61, 1973	(9)
136·6106	176·5792	150·9612	61 Jan. 21·0	73	60 Dec. 30–61 May 14	(15)
126·5900	246·6704	155·7128	61 Oct. 28·0	56	1961 Oct. 11–Dec. 29	–
356·3840	215·3617	17·6201	62 Jan. 16·0	23*	1952–. . .–1972	–
338·0108	145·9526	16·8159	62 Feb. 25·0	25	1955, 1962, 1968–69	–
131·1914	315·4390	8·9915	63 Nov. 27·0	110	1963–65, 1971–73	–
131·1916	315·4390	8·9914	63 Nov. 27·0	136	1963–65, 1971–73	(16)
131·1902	315·4398	8·9913	63 Nov. 27·0	102	1963–65, 1971–73	(17)
172·0281	92·8799	22·3258	64 Jan. 3·5	28	1964, 1970	(3)
172·0307	92·8770	22·3261	64 May 5·0	124*	1939–. . .–1970	–
161·9261	120·8707	4·7079	64 May 5·0	35	1958, 1963–65	(12)
184·1316	233·1268	13·1963	64 July 24·0	28*	1948–49, 1954, 1964	–
290·8080	269·2965	171·9195	64 July 24·0	38	1964 July 10–Sept. 4	–
21·8012	329·5545	19·5179	64 Nov. 21·0	26	1964–65, 1971–73	–
22·6216	96·2442	10·5295	65 Feb. 9·0	20	1965, 1971	(16)
203·0098	287·7143	6·7342	65 Feb. 9·0	29	1965, 1971–72	(16)
359·1712	212·6845	21·0493	67 Jan. 30·0	23*	1952–. . .–1972	–
206·9129	269·7864	54·3738	67 Apr. 20·0	50	1939, 1966–67	(4)
351·0306	76·1402	31·1157	67 June 19·0	40*	1932–. . .–1975	(2)
26·8683	318·6971	93·1642	–	52	1968 Aug. 25–Nov. 22	–
338·0815	145·8926	16·8382	69 May 19·0	25	1955, 1962, 1968–69	–
11·2014	50·3575	7·1455	69 Sept. 16·0	51	1969–70, 1975	(11)
184·1651	233·1046	13·1696	69 Sept. 16·0	32*	1964, 1969, 1974–75	–
123·4739	301·0594	86·3089	70 Apr. 4·0	210	69 July 23–71 Feb. 21	–
172·2468	92·7842	22·3227	70 Aug. 2·0	124*	1939–. . .–1970	–
172·2511	92·7957	22·3226	69 Dec. 12·5	28	1964, 1970	(3)
162·7627	120·3852	4·7243	70 Oct. 21·0	50	1963–65, 1970	(12)
198·1141	291·1400	4·0914	70 Oct. 21·0	49	70 Dec. 27–71 June 27	–
128·6899	24·0084	175·6103	71 Jan. 9·0	14	72 Mar. 16–73 Feb. 9	–
22·7198	96·1894	10·5170	71 Sept. 6·0	20	1965, 1971	(16)
203·1661	287·6313	6·7255	71 Nov. 25·0	29	1965, 1971–72	(16)
203·1663	287·6330	6·7259	71 Oct. 16·0	27	(1965), 1971–72	(18)
23·4362	327·4615	19·2181	72 Feb. 13·0	26	1964–65, 1971–73	–
359·2825	212·6508	21·0671	72 Mar. 24·0	23*	1952–. . .–1972	–
131·2494	315·4066	8·9784	72 Nov. 19·0	136	1963–65, 1971–73	(16)
131·2492	315·4067	8·9785	72 Nov. 19·0	110	1963–65, 1971–73	–
131·2737	315·4057	8·9787	72 Nov. 19·0	65	(1963–65), 1971–73	(19)
267·2095	314·1873	113·0852	72 Dec. 29·0	71	72 Nov. 15–75 June 17	–
28·9452	14·6286	9·6444	73 Feb. 7·0	16	72 Oct. 11–73 Sept. 23	–
209·1272	59·1306	9·5008	73 June 7·0	21	1973 June 1–Nov. 21	(20)
221·2928	243·9008	108·0671	–	10	73 Nov. 30–74 Jan. 26	–
183·3383	215·6128	6·6703	73 Nov. 14·0	35	73 Sept. 29–74 Feb. 25	(21)
198·1572	176·2857	5·5520	74 Jan. 3·0	16	1960–61, 1973	(9)

Ref.		Comet	*T*	*q*	*e*	*Elements of* *P* y
(2)	1974 VII	P/Borrelly	74 May 12·6611	1·316482	0·631947	6·76
–	1974 VIII	Cesco	74 May 12·9631	1·372826	0·978898	525·0
–	1974 XII	van den Bergh	74 Aug. 7·8307	6·019048	1·003889	–
–	1974 XIV	P/Longmore	74 Nov. 4·4230	2·402170	0·342421	6·98
–	1974 XVI	P/Honda–M.–P.	74 Dec. 28·1444	0·578869	0·809080	5·28
(22)	1975 a	P/Boethin	75 Jan. 5·6234	1·093620	0·779360	11·0
–			75 Jan. 5·6313	1·093694	0·779544	11·0
(6)	1975 c	P/Kohoutek	75 Jan. 18·1898	1·568032	0·537076	6·23
(23)			75 Jan. 18·1920	1·568028	0·537082	6·23
–			75 Jan. 18·1927	1·568031	0·537089	6·23
(24)	1975 b	P/West–K.–I.	75 Feb. 25·7828	1·398348	0·581839	6·12
–	1975 d	Bradfield	75 Apr. 4·5802	1·216946	1·001439	–
(25)	1975 m	P/Arend	75 May 24·6836	1·846905	0·537640	7·98
(26)	1975 e	P/Smirnova–C.	75 Aug. 6·3676	3·567228	0·145379	8·53
(27)			75 Aug. 6·4742	3·567253	0·145446	8·53
(28)	1974 c	Lovas	75 Aug. 22·1824	3·011442	0·999595	–
–	1975 h	Kobayashi–B.–M.	75 Sept. 5·3348	0·425561	1·000095	–
–	1975 k	Suzuki–S.–M.	75 Oct. 15·3602	0·838047	0·985653	446·0
–	1975 p	Bradfield	75 Dec. 21·1813	0·218719	1·000004	–
–	1975 j	Mori–S.–F.	75 Dec. 25·8843	1·603876	0·997160	–
–	1975 q	Sato	76 Jan. 3·9353	0·863949	1·0	–
(29)			76 Jan. 3·9356	0·863943	1·0	–
(30)	1975 f	P/Wolf	76 Jan. 25·3563	2·500771	0·395685	8·42
(31)			76 Jan. 25·3573	2·500775	0·395684	8·42
(32)			76 Jan. 25·5217	2·500744	0·395723	8·42
(33)	1975 n	West	76 Feb. 25·2212	0·196630	0·999955	–
(11)	1975 i	P/Churyumov–G.	76 Apr. 7·2277	1·298487	0·630566	6·59
(34)	1975 l	P/Harrington–Abell	76 Apr. 21·8382	1·776310	0·540040	7·59
–	1975 o	P/Gehrels 3	77 Apr. 14·9206	3·426194	0·157576	8·20

cometary orbits

ω °	☊ °	i °	Epoch	Obs.	Arc	Ref.
352·6739	75·1176	30·2155	74 May 13·0	40*	1932–. . .–1975	(2)
176·7406	165·0304	173·1648	–	17	1974 July 27–Oct. 8	–
151·7711	225·4027	60·8577	74 Aug. 21·0	40	74 Nov. 12–75 Dec. 2	–
196·2884	15·0056	24·4017	74 Nov. 9·0	8	1975 June 10–Oct. 4	–
184·5683	232·9804	13·1337	74 Dec. 19·0	32*	1964, 1969, 1974–75	–
11·1176	26·9719	5·9117	74 Dec. 19·0	45	1975 Feb. 5–June 3	(22)
11·1276	26·9698	5·9117	74 Dec. 19·0	44	1975 Feb. 5–June 3	–
169·7550	273·1917	5·4182	74 Dec. 19·0	23	1975 Feb. 9–May 30	(6)
169·7564	273·1917	5·4182	75 Jan. 28·0	23	1975 Feb. 9–May 30	(23)
169·7571	273·1914	5·4182	75 Jan. 28·0	23	1975 Feb. 9–May 30	–
358·0065	84·6569	30·0802	75 Mar. 9·0	36	74 Oct. 15–75 May 30	(24)
264·1281	157·2121	55·2499	75 Apr. 18·0	56	75 Mar. 15–76 Jan. 27	–
46·9222	355·6584	19·9556	75 May 28·0	*p* *	1951–52, 1959–60, 1967	(25)
90·2058	77·0996	6·6412	75 Aug. 16·0	39	75 Mar. 4–76 Jan. 8	(26)
90·2195	77·1024	6·6413	75 Aug. 16·0	40	75 Mar. 4–76 Feb. 5	(27)
261·3644	11·6714	50·6421	75 Aug. 16·0	91	74 Mar. 21–75 Dec. 6	(28)
116·9756	295·6526	80·7779	75 Sept. 25·0	296	1975 July 6–Dec. 6	–
152·0241	216·1091	118·2381	75 Nov. 4·0	82	75 Oct. 6–76 Jan. 4	–
358·0972	270·6123	70·6259	75 Dec. 14·0	56	75 Nov. 13–76 Jan. 26	–
246·2510	277·9783	91·6054	75 Dec. 14·0	129	75 Oct. 6–76 Feb. 21	–
215·4852	280·7896	93·9434	–	49	75 Dec. 9–76 Jan. 7	–
215·4858	280·7896	93·9424	–	49	75 Dec. 9–76 Jan. 4	(29)
161·1452	203·8086	27·3320	76 Jan. 23·0	*p*	1925–. . .–1967	(30)
161·1453	203·8087	27·3319	76 Jan. 23·0	*p*	1925–. . .–1967	(31)
161·1403	203·8089	27·3315	76 Jan. 23·0	*p*	1925–. . .–1951	(32)
358·4186	118·2332	43·0710	76 Mar. 3·0	40	75 Aug. 10–76 Mar. 22	(33)
11·3139	50·3750	7·1250	76 Apr. 12·0	51	1969–70, 1975	(11)
138·4528	336·7758	10·1689	76 Apr. 12·0	*p*	1955, 1962, 1968–69	(34)
229·9554	242·8547	1·0836	–	11	1975 Oct. 27–Dec. 29	–

the ecliptic and mean equinox 1950·0. The column headed 'Obs.' gives the number of observations on which the calculation is based, the symbol *p* indicating predicted elements only; an asterisk means that non-gravitational acceleration terms were included. The column headed 'Arc' gives the interval of time covered by the observations used in the calculation; a date in parentheses indicates that the mean motion was assumed in order to link roughly with the observations at that time, rather than that actual observations were used in the orbit determination. If no reference is given, the elements are from unpublished calculations by B.G.Marsden and/or Z.Sekanina at the Center for Astrophysics; and in such cases, if an Epoch is specified, perturbations by all nine planets have been taken into account. Non-gravitational parameters, calculated according to the Style II specified in *Catalogue of Cometary Orbits* 1975 or by Marsden, Sekanina & Yeomans (1973, *Astr. J.*, **78**, 211) are:

		A_1	A_2
P/Halley	1682–1911	+0·18	+0·0159*
P/Olbers	1815–1956	+0·22	+0·0654
P/Perrine–Mrkos	1896–1955	−0·08	−0·0597
P/Borrelly	1904–1961	+0·13	−0·0421
	1932–1975	+0·10	−0·0378
P/Pons–Winnecke	1939–1970	−0·01	+0·0018
P/Honda–Mrkos–Pajdušáková	1948–1964	+0·14	−0·0420
	1964–1975	+0·06	−0·0488
P/Grigg–Skjellerup	1952–1972	+0·03	−0·0008

*This quantity is multiplied by exp 0·01 τ, where τ is the time since 1911 October 15·0, measured in units of 10^4 day.

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