

Comets in 1973

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During 1973 a record 28 comets were under observation, one more than during 1970. Nine new comets were discovered, a number that has been exceeded only twice before, in 1947 and 1948: perhaps of some significance is the fact that every one of the nine was a photographic discovery by a professional astronomer. Comet 1973 f, one of two comets discovered by Luboš Kohoutek with the 80-cm Hamburg Schmidt telescope while attempting to recover some of the minor planets he had found during 1971 October (in the course of a search for P/Biela: see the 1971 report, page 423), was widely touted to become the ‘comet of the century’ as its heliocentric distance decreased from 4.7 a.u. at discovery in March to 0.14 a.u. at perihelion passage on December 28; although comet 1973 f failed to live up to expectations for its extreme brilliance, the unprecedentedly long lead time caused it to become the most widely studied comet on record, and observations were made, for the first time, by men in space. Three of the nine new discoveries of 1973 were short-period comets, and although one of them could be identified with a comet observed during the nineteenth century, it had been hopelessly lost since then. Six short-period comets were recovered in 1973 on the basis of prediction, and one of these exhibited two sudden surges in brightness far exceeding any previously observed cometary outbursts. Observations were also made of the three ‘annual’ comets and of ten of the discoveries or recoveries of 1971 and 1972.

P/Schwassmann–Wachmann 1 had evidently experienced an outburst shortly before it was photographed by A.Mrkos with the 40-cm Maksutov telescope at the Kleť Observatory on July 5 and 6; the total magnitude was then 13.6. Observations by Růžena Petrovičová with the same telescope on August 23 indicated a nuclear magnitude of 17.0. Elizabeth Roemer could see the comet with the 154-cm *f*/13.5 reflector at the Catalina Station of the Lunar and Planetary Laboratory, University of Arizona, on September 3, and a 30-min exposure showed a strongly condensed image, with an apparently stellar nuclear condensation of magnitude about 16.4 and a very faint trace of coma to the east and south; the comet was again easily visible later in the month, both with this telescope and the Steward Observatory’s 229-cm *f*/9

reflector on Kitt Peak. A 45-min exposure by C.Y. Shao with the 155-cm $f/5$ reflector at the Agassiz Station of the Harvard College Observatory on September 27 indicated that the comet was of magnitude 16.5. Positional observations were also made in late September by Mrkos, by S.I. Gerasimenko at the Dushanbe Observatory, and by C.B. Stephenson and his colleagues at the Nassau Station of the Warner and Swasey Observatory. Observations by Roemer with the 229-cm reflector on October 21 suggested that there had been another outburst, but the comet could no longer be recognized visually with the 154-cm reflector a week later.

P/Encke was recorded by Roemer with the Steward reflector on September 21 as essentially stellar in appearance and of magnitude 20.5. The brightness had been practically the same at the aphelic opposition a year earlier, although the comet had then been more than 1 a.u. farther from both the Sun and the Earth. Roemer also observed P/Encke on October 22, and the only other observation during the year seems to have been that by Shao on October 24, the magnitude still being then 20.0 or fainter. Considerable brightening was expected to take place as the comet approached its fiftieth observed perihelion passage in 1974 April.

P/Gunn was also of stellar appearance when Shao photographed it on January 3, the magnitude being 19.7. Roemer made a very similar estimate five nights later with the Steward telescope, although she also noted a trace of tail extending some 6" to 8" in p.a. 260° . A 58-min exposure on October 6 with the Harvard reflector failed to record the comet, but a 48-min exposure (on panchromatic 127-02 emulsion) with the same telescope on December 19 showed the comet clearly: its (visual) magnitude was about 18, and there was a tail 2' to 3' long in p.a. 270° . P/Gunn was also photographed by Roemer with the 229-cm reflector on December 30.

1971 b, P/Holmes, was observed for the last time at this return on January 30, when two 60-min exposures with the 229-cm reflector (Roemer) revealed it as a small, rather weak spot of magnitude about 20.7.

Observations 1971 June 20 to 1973 January 30

1971 c, P/Kearns-Kwee, at perihelion in 1972 November, was quite widely observed during January, but it then faded rapidly. Roemer described the comet as well condensed, of magnitude 16.5, on 10-min exposures with the Catalina telescope on January 1, and a few hours later Mrkos noted the magnitude as 15.6. Visual observations by J.E. Bortle (Stormville, New York) with a 32-cm reflector on January 2 and 3 indicated a total magnitude of 12.8. Using R.L. Waterfield's 15-cm

f/4.5 Cooke triplet at Woolston, Somerset, G.H.Rutter and Waterfield recorded a short tail in p.a. 270° on January 6, and they remarked that, as in 1963–64, the coma was very strongly condensed; the magnitude was 13.9. At Kochi, Japan, T.Seki photographed a tail 60" long on January 12. Bortle estimated the magnitude visually to be still 13.0 on January 26; but B.Milet (Nice Observatory), who had found the photographic magnitude to be 13 in early January, remarked that the comet was down to magnitude 17 on February 5. Mrkos also last photographed the comet on February 5, while at the Pino Torinese Observatory V.Zappalà was able to follow the comet until the 7th. Well-condensed images of the comet were obtained by Roemer on 30-min exposures with the Catalina instrument as late as April 4, the magnitude then being 18.1; and the comet could also be identified on a plate exposed between clouds at the Agassiz Station by R.E.McCrosky two nights later. It was doubtful whether further observations would be possible at the 1974 opposition.

Observations 1971 July 26 to 1973 April 6

1972 c, P/Tempel 2, was reobserved by Roemer with the 229-cm reflector on September 22, and a further pair of plates was obtained—with some interference from cirrus clouds—at the end of December. A starlike image of the comet also appears on a 46-min exposure by McCrosky and M.Mattei on December 19, the effective visual (127-02 emulsion) magnitude being about 19.

Observations 1972 January 22 (?) to 1973 December 30

1972 d, P/Giacobini–Zinner, was recorded on a single cloud-affected exposure by Roemer with the 154-cm reflector on February 6. The image of the comet was well exposed—a small, round, condensed spot of magnitude about 18.8. Inadvertently omitted from the 1972 report was mention of observations by Seki, N.Kojima (Ishiki, Japan) and M.Antal (Skalná Pleso Observatory) in 1972 November and December; Seki had judged the total magnitude to be 15.5 on December 4.

Observations 1972 March 11 to 1973 February 6

1971 I (= 1972 e), Gehrels, was photographed by McCrosky and Shao on January 3, the magnitude on the 102-min exposure (on baked IIIa-J emulsion) being 20.0. On 70- and 67-min 103a-O exposures by Roemer at Kitt Peak on January 8 the images of the comet were slightly elongated, possibly because of the presence of a tail some 5" long in p.a. 105° ; the magnitude was 21.0. A very faint image of the comet was also obtained by the discoverer with the 122-cm Schmidt telescope at Palomar on February 9, and the final observations seem to have been

made by Z.M.Pereyra with the 154-cm $f/5$ reflector at Bosque Alegre during February 25–27, when the comet's heliocentric distance was 7.4 a.u.

Observations 1972 March 16 to 1973 February 27

1972 h, Sandage, was picked up in the morning sky in January by Seki, and also by T.Urata (Nihondaira Observatory), the magnitude being about 14. The characteristic broad tail of a comet of large perihelion distance was evident on a 30-min exposure by Roemer with the Catalina reflector on February 4, while a shorter exposure showed a sharply condensed nucleus of magnitude about 16.5. Three weeks later at Woolston, Waterfield and N.Wood also remarked on a possible faint tail (in p.a. 270°). On April 4 Roemer obtained two well-condensed, magnitude 16.7 images of the comet, and photographic observations were also made in March and early April by Waterfield and M.J.Hendrie at Woolston, by Antal, and by Mrkos and Petrovičová. An extensive series of visual observations by Bortle indicated that the visual magnitude hovered around 13 from March to September. Plates taken by R.H.S.South and Wood at Woolston on June 30 showed a moderately condensed inner coma of diameter 30", and on July 2 Roemer remarked on an asymmetric coma or short tail extending about 0'.1 northwards, the well-condensed nucleus being of magnitude 17.9. South and Waterfield estimated the magnitude as 14.0 on September 26, and Roemer could easily see the comet with the 229-cm reflector on October 22. On plates taken by McCrosky and G.Schwartz at the Agassiz Station on December 2 Shao noted a sharp, strong nucleus, of magnitude 16.8, and a fan-shaped coma between p.a. 0° and p.a. 100° ; the coma was 30" across and uniformly bright.

Observations 1972 June 9 to end of 1973, continuing

1972 i, P/Reinmuth 1, yielded strong, well-condensed images of magnitude 17.8–18.0 on plates taken with the Catalina reflector on January 1 (Roemer). A rather similar figure was quoted by Mrkos on January 1, 6 and 8, and Kojima gave the magnitude as 17 on the 9th. The only later observations seem to be a 40-min exposure by Roemer at the Catalina Station on April 3 and a 22-min exposure at the Agassiz Station three nights later; on each occasion the magnitude was given as 18.3.

Observations 1972 September 12 to 1973 April 6

1972 j, Kojima, appeared on two 3-min Ila-O exposures by Roemer on January 1 as a sharply condensed nucleus of magnitude 15.0 in an asymmetric coma extending a few seconds of arc to the north and east. Bortle and A.F.Jones (Nelson, New Zealand), who were both using

32-cm reflectors, agreed that the total magnitude was near 10.5 on January 1–3, and that there was a tail some 3' to 5' long in p.a. 90° or slightly farther south. Plates taken by Wood and Waterfield on January 21 showed a narrow tail 2' long in p.a. 120° and a broad, diffuse tail 1.5' long in p.a. 80°, while, on February 24, there was a single faint tail in p.a. 110°. Around February 10, Bortle and Jones judged the magnitude to be 11.0–11.2, and Bortle estimated 11.6 on the 27th. In poor seeing, K. Simmons (Jacksonville, Florida, 20-cm reflector) estimated the magnitude on March 1 to be very approximately 9.8, and the last pre-conjunction observations seem to be those by Mrkos on March 5, when the photographic total magnitude was 12.8.

After conjunction, comet Kojima was picked up by Gerasimenko on August 1 and by the discoverer on the 7th, at which time the total magnitude was given as 14. Roemer found the comet to be essentially stellar, of magnitude 16.2, on September 3. Other observations were made during September by Stephenson and his colleagues, by Gerasimenko, Kojima and Seki, this last observer (by now observing from his new station at Geisei) still finding the magnitude to be 14 on September 30. Roemer could still observe the comet visually in November, and there was hope that further photographic observations could be made after the next conjunction in 1974, at which time the comet's heliocentric distance would be 5 a.u. and more.

Observations 1972 October 31 to 1973 November 19, continuing

1972 k, P/Gehrels 1*, produced fairly well-condensed images of magnitude 19.0 on January 1 (Roemer), while on the 3rd McCrosky and Shao felt that the comet was more diffuse than it had been a month previously. Two 30-min exposures by Roemer with the Kitt Peak telescope on January 29 revealed a sharp condensation of magnitude 18.4 in a trace of coma. Satisfactory, but very weak, images of the comet appeared on 60-min exposures with the same telescope on September 23, but further attempts to record the comet on October 21 (in poor seeing) and December 31 seem to have been unsuccessful.

Observations 1972 October 11 to 1973 September 23

1972 l, Araya, which had passed through perihelion at the record distance (for a long-period comet) of 4.86 a.u. in 1972 December, remained south of declination -41° during 1973. Observations were made during the first few months of the year by the discoverer with the Curtis Schmidt telescope at Cerro Tololo Interamerican Observatory,

*The numeral has been added to distinguish this comet from 1973 n, P/Gehrels 2 (q.v.).

by C. Torres at the Cerro El Roble Station of the University of Chile, and by J. Gibson at the Yale-Columbia Southern Station, El Leoncito, Argentina. A yellow plate taken by Gibson with the 51-cm double astrograph on April 11 showed a sharp condensation located somewhat eccentrically in an elliptical coma measuring 10" by 11", although the simultaneous blue exposure (rather heavily fogged by moonlight) revealed only an extremely weak and rather uncondensed image of the comet. After conjunction, comet Araya was picked up on July 5 by J. A. Bruwer with the Franklin-Adams camera at the Johannesburg-Hartbeespoort outstation of the South African Astronomical Observatory; the magnitude was 13.3. Further observations were made at Cerro Tololo, Cerro El Roble and El Leoncito later in the year.

Observations 1972 November 15 to end of 1973, continuing

1973 a was discovered by André Heck and Gérard Sause on a plate taken on January 11.1 with the 60-cm $f/3.5$ Schmidt telescope operated by the CNRS and Liège Observatories at the Haute Provence Observatory. A twelfth-magnitude object located among the galaxies of northern Virgo, the new comet had a tail some $\frac{1}{2}^\circ$ long. The discovery was confirmed 12 hr later by W. L. W. Sargent with the 122-cm Schmidt telescope at Palomar and by Heck the next night at Haute Provence. A spectrogram obtained by Y. Andrillat with the Haute Provence 193-cm reflector on January 13 showed a weak continuum with no cometary emission features—which is not particularly surprising, since the comet was then some 2.7 a.u. from the Sun. After announcement of the discovery, images of the comet were found on photographs taken by M. Koishikawa at the Sendai Municipal Observatory on January 4.8, by L. Briquieu at the Laboratoire d'Astronomie, Montpellier, on January 10.2, and by Urata on January 11.8. On January 26 Bortle estimated the comet's magnitude as 10.7 and noted a striking fan-shaped coma-tail combination extending $1\frac{1}{2}'$ in p.a. 200° . By February 10, he found that the tail had increased to a length of 10', and four nights earlier Milet had photographed a 25' tail; at that same time 3-min exposures by Roemer had yielded fairly well-condensed images of magnitude 15.5–16.0. A plate taken by Waterfield and I. M. Purcell at Woolston on February 21 showed a diffuse fan tail 5' long in p.a. 150° to 210° , while Bortle traced a faint, straight tail out visually for 14' on February 25 and 28.

During the first half of March, Bortle estimated the magnitude as 11.4, and the tail length had decreased to little more than 5'; but on March 24, when the comet had faded to magnitude 11.9, he found that the narrow, straight tail extended for the extraordinary length of 24' (in p.a. 120°). Fairly well-condensed images, of magnitude 16.7, appeared on exposures by Roemer with the 154-cm reflector on April 4,

and the comet was also photographed by McCrosky and by Mrkos at the beginning of May, the last observer giving the total magnitude as 14.2 on May 3. Plates taken by Roemer with the 229-cm reflector in very poor seeing on May 25 showed the comet to be just a very weak spot. After conjunction, comet Heck-Sause was reobserved by Roemer on November 21 and by Schwartz on December 2. Although the comet was more than 5 a.u. from the Sun it was still surprisingly bright: on the December 2 plate Shao estimated a nuclear magnitude of about 18, and there appeared to be a faint coma near p.a. 220° .

Observations 1973 January 4 to end of year, continuing

1973 b was periodic comet Tuttle-Giacobini-Kresák, recovered by Roemer, assisted by J.Q.Latta, on 60-min exposures with the 229-cm reflector on January 8.4. The images of the comet were very small and rather weak, of magnitude about 21.0, and announcement of the recovery was delayed until further plates could be secured on January 29. The comet had brightened to magnitude 18.1 by April 27, and observations then and on the previous night revealed a fan-shaped coma or trace of tail extending westwards for up to $15''$. On May 20.9 the comet was photographed by F.Seiler (Munich) with a 15-cm $f/2.3$ Maksutov telescope; the magnitude estimated from the panchromatic film was 12–14, and the comet had a slight protrusion to the west. Exactly one week later, however, this same observer found that the comet had brightened by eight to ten magnitudes—to total magnitude 4; and there was a conspicuous tail extending some $6'$ in p.a. 105° to 110° . By May 31.9 the comet had faded to magnitude 6–7, although the tail was perhaps slightly longer. The outburst was also noticed in Japan, with the comet being observed photographically by S.Ako (Siraishi) at magnitude 8 on May 26.5 and visually by K.Mameda (Kobe) at magnitude 5 on May 27.5. Photographs taken by Antal at the $f/14.6$ Cassegrain focus of the 200-cm reflector at the Ondřejov Observatory on May 29.9 (some 3 or 4 hr before the comet passed perihelion, 1.15 a.u. from the Sun) showed a central condensation of magnitude 13.0 within a diameter of $3''.5$ and of magnitude 12.0 within a diameter of $7''.0$; the comet's total visual magnitude was 6.5, fading to 10.0 by June 1.9. Bortle, who had been unable to detect the comet with his 32-cm reflector on May 23.1 and 24.1, found it to be of magnitude 10.2 (in a 15-cm reflector) on June 3.1. Short exposures, in moonlight, by Roemer with the Steward reflector on June 7 showed a fairly well-condensed nucleus of magnitude 18.9 embedded in a coma some $0'.3$ across, although visually the comet was a diffuse spot perhaps ten times larger than this. Photographs by Antal (with the 30-cm $f/5$ astrograph at the Skalnaté Pleso Observatory) on June 13 yielded a total magnitude of 12.6, and on June 23 the magnitude was 13.2. On July 2 Roemer observed a sharply

condensed, nearly stellar, nucleus of magnitude 18.8 embedded in a rather faint coma about 1' in diameter, and on July 4.1 McCrosky and Shao judged the comet's total magnitude to be 14–15.

By the time of the next known observation, by Antal on July 6.9, P/Tuttle–Giacobini–Kresák had experienced another tremendous surge in brightness; the visual magnitude was then 5.6, while an 8-min exposure with the Skalná Pleso astrograph showed the photographic magnitude to be 4.8; the coma was circular, of diameter 4', and there was a tail 9' long to the east. Antal found that the comet had faded by slightly over 1 mag the next evening, and an hour or so after that the outburst was independently detected by Waterfield, who judged the comet's magnitude on his heavily over-exposed plate to be about 4.5; there was a diffuse, straight tail 45' long in p.a. 105°. That same evening Bortle (using 10 × 50 binoculars) estimated the magnitude to be 6.5, and a 10-min exposure by McCrosky and Shao showed a strong condensation, of magnitude 8–9, from which a very prominent, sharp, narrow tail extended for 2' to 3' in p.a. 120°. Both tail and condensation were embedded in a faint, U-shaped coma (with the sides of the U more or less parallel to the tail) of diameter 2'. On the following night the comet's whole appearance was more diffuse, the coma had doubled in size, and the tail had lengthened. On July 10.0 Waterfield remarked that the coma extended for 8' in p.a. 100° and perhaps half as much perpendicular to this; two faint jets, one 1.5' long in p.a. 110° and the other 1.0' long in p.a. 240°, extended from the central condensation. Both Waterfield and the Harvard observers remarked that the outer edge of the coma was more clearly defined on its northern side. Spectroscopic observations by J.-P. Swings and J.-M. Vreux at Haute Provence on July 7.9 revealed strong bands of C₂, C₃ and CN on a medium-strength continuum, with a weak dust tail; on the next night, emissions of CH and CH⁺ were also detected on the weak continuum.

According to Jones, the total magnitude had faded to 8.9 on July 10 and 11 and to 10.6 on the 19th. Bortle indicated fading from magnitude 9.8 on July 12 and 13 to 11.0 on July 24, 11.3 on the 25th and 11.5 on the 30th. D. Seargent (The Entrance, New South Wales), using 20 × 65 binoculars, judged the magnitude to be 10.5 during July 18–21. A photograph by D. Latham with the large Agassiz reflector on July 31 showed the comet at magnitude about 15. Bortle failed to find the comet with his 32-cm reflector on five occasions between August 6 and September 7, but H. L. Giclas photographed it with the Lowell Observatory astrograph on September 18 and 19, and Roemer recorded it with the 229-cm reflector four nights later. Giclas gave the magnitude as 17, which is still considerably brighter than normal, for the comet was then located slightly beyond its previous record observed heliocentric distance of 1.68 a.u. and at a comparable geocentric distance.

Observations 1973 January 8 to September 23

1973 c, periodic comet Wild, was suspected by Roemer on one of two 60-min search exposures taken by Latta and herself on January 8.3. The image was somewhat trailed and of magnitude 19.5–20.0. The same object, at a position corresponding to a correction of $\Delta T = +0.75$ day to the prediction (an unusually small correction, since P/Wild had been seen only once before, in 1960), was apparently recorded again in poor seeing on January 29; but the recovery was not announced until two good exposures could be obtained with the Catalina telescope on February 4—at which time the magnitude was estimated as about 19.0, and there was possibly a trace of a tail extending for a few seconds of arc near p.a. 260° . Roemer obtained further pairs of 30-min exposures with the Kitt Peak instrument on three more nights in March to June, and on each occasion the comet was generally sharply condensed, of magnitude 19.1–19.4 and again showing a trace of tail.

Observations 1973 January 8 to June 5

1973 d was the third comet discovered by Tom Gehrels during searches for new Apollo-type asteroids with the 122-cm Palomar Schmidt. Picked up on February 8.3 as a sharply condensed nineteenth-magnitude object in Cancer, this comet was confirmed by the discoverer 24 hr later. A period of bad weather then set in at Palomar, and the Moon was approaching first quarter, so it was particularly fortunate that McCrosky and Shao were able to obtain two good exposures of this very faint comet with the Harvard telescope on February 10. Attempts to calculate the orbit from observations on the three consecutive nights suggested that the comet might be of short period, although there was no definite indication of this until McCrosky and Shao were next able to observe the comet on February 25, by which time it had faded to magnitude 20. It also seemed probable that the comet was identical with P/Swift 1, although it was not clear whether there had been nine revolutions or ten since the previous observations in 1889–90. McCrosky obtained further plates on February 28 and March 1, while the final pair of exposures on March 26 by Roemer with the 229-cm reflector were crucial in establishing that there had, in fact, been nine revolutions, the period therefore being about 9.2 years. On these March 26 plates the comet's image was close to magnitude 21.0, and a further exposure on April 8 failed to record the comet. P/Swift–Gehrels should have been as bright as fifteenth magnitude and have passed within 1° of P/Kearns–Kwee in 1972 August, but it does not seem to have been photographed at that time; attempts to identify P/Swift–Gehrels at its moderately favourable 1935 and 1944 perihelion passages have also been unsuccessful.

Observations 1973 February 8 to March 26

1973 e, the first of the two comets Kohoutek, was found on February 28.0 during a search for the minor planet 1971 UP₁. The new comet was in Leo, of magnitude 14, centrally condensed but without a tail. Other early observers, notably Kojima, Seki and Giclas, found the comet to be more diffuse, although Wood and Waterfield noted on March 5 that the very diffuse coma, 3' across, contained a highly condensed inner region some 20" in diameter. Visually, Bortle estimated the total magnitude as 12.1 on March 24, and the comet was possibly very slightly brighter in April as its decreasing distance from the Sun more or less compensated for its increasing distance from the Earth. Poor seeing at the Catalina Station on April 3 resulted in rather diffuse images of magnitude about 17.1 (Roemer), while Steward-reflector plates on the 26th in better conditions showed an essentially stellar nucleus, of magnitude 16.9, embedded in a faint coma some 0.3' across. A somewhat out-of-focus image obtained by McCrosky on May 1 was of magnitude about 14. The object became difficult for Bortle's 32-cm reflector during May, and on June 3, four days before the comet's perihelion passage, this observer judged the magnitude to be 12.4. The comet was in conjunction with, but well to the north of, the Sun in early June, and no further observations seem to have been made until August 1, when the discoverer gave the magnitude as 15. The comet was fully two magnitudes fainter when Kohoutek next observed the comet on September 22; at about this time Roemer remarked that visually comet 1973 e was fainter than comet 1972 h. Two final observations of comet 1973 e were made by Roemer with the 229-cm reflector a month later.

Observations 1973 February 28 to October 22

1973 f, the comet which has undoubtedly received more publicity than any other except for P/Halley, was identified by Kohoutek on March 18 on plates he had taken on March 7.9 and 9.9 for 1971 UG. At discovery comet 1973 f was of magnitude 16, a centrally condensed object in Hydra, moving very slowly (at about 0.2° per day) to the west-north-west. This slow motion enabled the discoverer to locate the comet with little difficulty on March 21, by which time the magnitude had brightened to 15. Kohoutek was subsequently able to identify a prediscovery image of the comet near the edge of a plate taken (also for 1971 UG, which, incidentally, was not recovered) on January 28.9, at which time the magnitude was 16 and the heliocentric distance 5.2 a.u. On March 30 and April 2 Waterfield remarked that the coma was slightly elongated towards p.a. 60° and 90° (respectively), while 10-min exposures at the Catalina Station (Roemer) on April 4 showed an essentially stellar condensation of magnitude 17.0 in a trace of coma; the appearance was similar on 229-cm reflector plates taken on April 28,

while visually the comet was a sharp condensation in a coma some 1' in diameter. An image-tube spectrogram obtained by W.G. Tift with the same telescope the following night showed a strong continuum with no obvious emission features. According to Seki on April 22 and to Mrkos on the 30th, the comet had brightened to magnitude 14.5, and the last observations before conjunction seem to have been made by the discoverer on May 5.

The comet's heliocentric distance had decreased to 2.2 a.u. when the comet was reobserved in the morning sky, first by Seki on September 23.8, and then by C.A. Wirtanen with the 51-cm double astrograph at the Lick Observatory on September 25.5; according to Seki the total magnitude was 10.5. The first visual post-conjunction observations were made on September 29.5 by Roemer at the Catalina Station and by J. Young and M.J. Mayo at the Table Mountain Observatory, Wrightwood, California, these last observers estimating the magnitude as 10.7 (15.2-cm refractor, 60 $\times$). Roemer noted a conspicuous tail, and a 10-min exposure showed it to be a broad fan extending at least 2' to the north and west of a nearly stellar condensation of magnitude 14.5. According to Bortle, the total magnitude (in 15 $\times$ 80 binoculars) brightened from 10.0 on October 1 to 8.3 on the 27th. Infrared observations by G. Rieke at the Lunar and Planetary Laboratory on October 7 and 8 showed that at λ 100 000 the magnitude was already 3.8 (suggesting that the visual magnitude would be about 11). A 20-min exposure by Roemer on 098-02 (red) emulsion on October 15 showed an 8' tail, and a spectrogram obtained by R. White with the same 229-cm reflector the following night showed the expected emissions of CN and C₃, with C₂ just beginning to appear. Observations on October 30 by H. Spinrad, Harding E. Smith and J. Leibert with the Lick 305-cm reflector suggested that the [O I] lines at λ 6300 and λ 6363 had appeared, and the presence of these lines was confirmed by G.H. Herbig with the same telescope on November 8. Herbig also remarked on rather strong tail emissions at $\lambda\lambda$ 6148, 6159 and 6200. Two of these were also noted by P. Benvenuti and K. Wurm at the Asiago Astrophysical Observatory on October 29, and the features seem also to have been observed by F.D. Miller in the spectrum of comet 1963 I. G. Herzberg and H. Lew identified these lines as due to the (0,8,0)–(0,0,0) transition of H₂O⁺, and further lines observed by Benvenuti and Wurm at $\lambda\lambda$ 6977 and 7038 could possibly have arisen from the (0,6,0)–(0,0,0) transition.

By November 20 the comet had brightened to magnitude 6.7 (Bortle, 10 $\times$ 50 binoculars), and the following night Roemer noted evidence of type I tail structure, in addition to the type II tail observable hitherto. At Las Cruces, New Mexico, W. Haas saw the comet with the naked eye on the 22nd (magnitude 5.0), and during the remainder of the month

the comet showed quite spectacular development. On the 29th, a plate taken by M. Belton with the $f/2$ Schmidt telescope at Kitt Peak showed a tail $3^{\circ}8'$ long, with a conspicuous knot around its midpoint. A University of Wisconsin group, observing 1973 f with the Fabry–Perot spectrometer on the McMath solar telescope at Kitt Peak during December 3–6, detected cometary H α emission for the first time; a spectrogram obtained by Andrillat with the Haute Provence reflector on December 6 showed several lines in the (2,0), (3,1) and (4,2) bands of the red CN system; and according to M.K.V. Bappu and his colleagues at the Indian Institute of Astrophysics, Na I emission appeared between December 7.0 and 9.0, when the comet's heliocentric distance had decreased to 0.7 a.u. On December 13 Bortle estimated the comet's total magnitude to be 4.4.

As the comet moved back into the dawn in early December, optical observations were becoming more difficult. At this time, however, it seems that reasonably definite cometary radio emissions were observed. Using the National Radio Astronomy Observatory's 11-m telescope on Kitt Peak, B.L. Ulich and E.K. Conklin attributed features observed near a frequency of 110.7 GHz to the molecule CH₃CN; and shortly afterwards L. Snyder and his associates reported radio emission from HCN. Radio astronomers in France and the USA also claimed to have observed radio *absorption* from the OH lines near 1.7 GHz.

Infrared observations on December 20 by E.P. Ney and H. Hefele (University of Minnesota) and also by M. Zeilik (at Kitt Peak) were consistent in giving magnitudes of -5 near λ 100 000 and -6 near λ 200 000 (for a diaphragm size of about $20''$). There was an unconfirmed report by Haas of a 15° tail (in p.a. 271°) on December 18, and the last ground-based observation before perihelion was made by J.C. Bennett at Pretoria on the 22nd, at which time the magnitude (in a 12-cm refractor, $21\times$) was very roughly 2.9. The *Skylab* astronauts were able to follow the comet right through perihelion, however, and a coronagraph observation made by them some 12 hr before perihelion passage showed the comet $\frac{3}{4}^{\circ}$ from the centre of the Sun and possibly brighter than magnitude -3 . A day or so after perihelion passage the astronauts noted that the comet had developed a spectacular sunward spike (deviating some 5° to 7° from the sunward direction), and Z. Sekanina (who had predicted that a sunward tail would appear) deduced that it was due to submillimetre- and even millimetre-sized meteoroids ejected from the nucleus at least two months earlier.

At the Joint Observatory for Cometary Research (near Socorro, New Mexico) W. Gates and R.G. Roosen glimpsed the comet with a 5-cm elbow telescope soon after sunset on December 31.0, and a few minutes later G.H. Newsom observed the comet at the Perkins Observatory, Flagstaff, Arizona; using a 10-cm refractor, the latter observer estimated

the magnitude as -0.5 and noted a tail $20'$ long in the bright twilight.

Observations 1973 January 28 to end of year, continuing

1973 g, periodic comet Reinmuth 2, was recovered by Roemer and G. Reskin with the 229-cm reflector on April 26.3. The comet was essentially stellar in appearance, of magnitude about 20.0. Poor seeing on May 25 caused the comet to record itself only as a small, quite weak spot of magnitude perhaps 20.5. No other observations were reported during the year, but the comet will be more easily observable at its post-perihelion opposition in the latter part of 1974.

Observations 1973 April 26 and May 25, continuing

1973 h, the fifth new comet of the year, was a thirteenth-magnitude object in Boötes, discovered by John P. Huchra with the 122-cm Palomar Schmidt on April 25.3. The comet was diffuse and condensed, but no tail was observed. A confirmatory observation was made by R. Green with the 46-cm Schmidt on May 3, and the discoverer observed the comet again on May 5 and 6. Further astrometric observations were made during May 5–14 by K. Suzuki (Toyota, Japan), Seki, Kojima, McCrosky and Shao, and Antal, and by the end of the month it was possible to establish that the orbital eccentricity was less than 0.98. A 30-min exposure by Roemer with the 154-cm reflector on May 31 showed the coma to be well condensed, of magnitude 18.4, while observations with the other telescope on June 5 revealed a trace of coma, the practically stellar nucleus being of magnitude 18.7. On June 2 Wood and Waterfield observed an inner coma of diameter $15''$ in a very faint outer coma of diameter $1'.5$; the total magnitude was 14.5–15.0. Later that same night Shao, using the 155-cm reflector, judged the magnitude as closer to 16. Giclas was still observing the comet with the Lowell photographic telescope on June 24, and two 30-min exposures with the 229-cm reflector (Roemer) one week later yielded nearly stellar images of magnitude about 19.1.

Observations 1973 April 25 to July 1

1973 i was discovered by Michael Clark on June 9.7 near the edge of a 60-min exposure taken with a 10-cm $f/6$ camera in the course of the southern variable-star patrol conducted by the Bamberg Observatory at Mount John University Observatory, Lake Tekapo, New Zealand. On the following morning, it could be confirmed that the thirteenth-magnitude diffuse object in Microscopium had moved some $20'$ to the east and south, and that there was a tail some $1'$ long in p.a. 260° ; an image of the comet was also located on another patrol plate taken on June 1.7. A 15-min exposure by A. C. Gilmore and Pamela M. Kilmartin with the 41-cm Cassegrain reflector at the Carter Observatory in

Wellington on June 11 showed a whisp of a tail, possibly fan-shaped, 30" long in p.a. 250° . Further observations at the Carter Observatory on June 12 and 17 suggested that the new comet was a short-period one, and after the Wellington observers had measured the discovery plates it became quite clear that the comet's period was only 5.5 years. On June 23 Kojima and Seki both gave the magnitude as 13.5, and 10-min exposures at the Carter Observatory on July 3 showed the coma as a minute oval 8" by 4", of magnitude 14, and extending mainly towards p.a. 270° from the essentially stellar condensation.

A plate exposed by Roemer at Kitt Peak on July 2 was heavily affected by cloud, and the rather weak, but sharply condensed nucleus could hardly have been fainter than magnitude 18.8. P/Clark was also observed in early July by Gibson and by Giclas, and Bruwer obtained an extensive series of observations with the Franklin-Adams camera in July and August, during which time he estimated the total magnitude to fade from 12.0 to 13.0. Gibson followed the comet at El Leoncito until September 26. Roemer described the nuclear magnitude on September 22 as 18.8, and she again recorded the comet with the Steward instrument on October 21 and November 21. A further plate, taken in moonlight on December 31, did not show the comet, and the same seems to be true of a plate taken at the Agassiz Station on December 22.

Observations 1973 June 1 to November 21

1973 j was periodic comet Brooks 2, recovered by Roemer and Latta with the 229-cm reflector on July 1.4 as a sharp condensation of magnitude 20.0 with the barest trace of tail extending 3" to the south-west. No convincing image of the comet had appeared on plates exposed on April 28. The comet was also photographed on July 7 by McCrosky and Shao, who estimated the magnitude as 19. Fairly well-condensed images of magnitude 18.7 appeared on two exposures by Roemer with the 154-cm reflector on September 3, and the comet was comparably bright on 229-cm reflector plates taken on September 22. Further observations were made by Roemer in October and November.

Observations 1973 July 1 to November 25

1973 k was discovered by Allan R. Sandage on July 4.2 while photographing with the 122-cm Schmidt the same quasar field in Serpens Caput in which he had found comet 1972 h. Also like 1972 h, comet 1973 k had a large perihelion distance: at 4.81 a.u., it was only slightly less than that of comet 1972 l. At discovery the new comet was of fifteenth magnitude, diffuse with condensation and a tail extending 1.5 to the south-east. Further observations were made by Sandage on July 5, and by McCrosky and Shao on July 7, 8 and 9. Sandage again

picked up the comet on August 4 and 5. Roemer could see the comet on September 3 (154-cm reflector); photographically, the well-condensed nucleus, of magnitude about 18.0, had a trace of coma to the north. Diffuse at the low altitude, the comet was again observed by Roemer on September 22 and by McCrosky and Shao on the 26th, the latter observers giving the total magnitude as 15.7. After conjunction the comet was first reobserved by Seki, who described the magnitude on December 26 as 17.

Observations 1973 July 4 to end of year, continuing

1973 l was periodic comet Schwassmann–Wachmann 2, recovered by Antal (using the Meinel–Schmidt camera at the Cassegrain focus of the 200-cm Ondřejov reflector) on August 28.1 and by Shao and Schwartz at the Agassiz Station on August 29.3. Both Antal and Shao judged the magnitude to be about 19.0, and the latter observer was subsequently able to identify a very faint, fuzzy image of the comet on a poorly guided plate taken on August 5.3. On September 4 Roemer observed a well-condensed nucleus of magnitude about 19.2, from which a narrow tail extended about 0.2 westwards. Shao noted brightening to perhaps magnitude 17.5 on plates taken at the Agassiz Station on September 26 and October 6, and rather similar estimates were made around the same time by Kojima and Mrkos. Roemer could see the comet on October 21 as a central condensation embedded in an asymmetric coma, and during the following few days Kojima and Seki gave the total magnitude as 16. On exposures with his 31-cm $f/5.8$ reflector at Tokai, Japan, on November 24, T. Furuta indicated the nuclear magnitude as still 17.5.

Observations 1973 August 5 to November 24, continuing

1973 m, periodic comet Borrelly, was recovered by Pereyra, assisted by B. Candellero, Beatriz Oviedo de Zarate and H. C. Zarate, with the Bosque Alegre reflector on August 23.1. The nuclear magnitude was 19.5. The comet was at declination -55° , and no further observations have been reported; it should be accessible to observers in the northern hemisphere in late 1974.

Observations 1973 August 23 (continuing?)

1973 n was another new short-period comet (period 7.9 years) discovered by Gehrels with the 122-cm Schmidt, and to distinguish it from comet 1972 k, it is designated P/Gehrels 2. Discovered on September 29.4, and observed on other occasions during the following six nights, the new comet was slowly retrograding in Pisces, a coma of magnitude 15–16 with a fan tail some 2' long in p.a. 230° to 260° . Announcement of the discovery was not made until late October, and accidental images of the comet were subsequently identified by Eleanor Helin on films

taken with the 46-cm Palomar Schmidt on September 28.3 and by P. Wild (Astronomical Institute, Berne) on a supernova-search film taken at Zimmerwald on September 30.9. Only an approximate position could be derived from the very faint image on a plate taken on October 28 by Shao with the 20-cm astrograph at the Agassiz Station, although accurate positions were obtained by Giclas and by A. R. Klemola with the 51-cm Lick double astrograph on October 31 and by Giclas, Kojima, Seki and Antal the following day. A sharp condensation was evident on an exposure with the 155-cm reflector on November 3 (McCrosky). On the 16th Waterfield photographed a moderately condensed coma 15" in diameter surrounded by a fainter outer coma 30" in diameter, and between then and December 17 the magnitude faded from 15.5 to 16.2. Clouds prevented Roemer from seeing the comet on December 31, but it was easily photographed.

Observations 1973 September 28 to end of year, continuing

1973 o, the ninth new discovery and last comet of the year, was picked up by Gibson with the 51-cm double astrograph at the Yale-Columbia Southern Station on November 24.2. A fifteenth-magnitude object at declination -53° in Horologium, it had moved some $1^\circ.6$ to the south and west by November 29. It was not immediately clear whether the object was a comet or an unusual minor planet, but further observations (one of them by C. U. Cesco) with the same telescope demonstrated that it was yet another comet of large perihelion distance (3.8 a.u.). Yellow and blue 40-min exposures by the discoverer on December 20 showed faint streamers of a tail some 15" long in p.a. 355° and 15° , and on the 31st there was a 1' tail in p.a. 25° . As of the year's end, no observations seem to have been made elsewhere.

Observations 1973 November 24 to end of year, continuing

Predictions were also available for the following periodic comets:

1890 VII, P/Spitaler. As indicated in last year's report, searches were continued by C. T. Kowal with the 122-cm Palomar Schmidt during January.

P/de Vico-Swift. This comet was expected at perihelion on February 15.9, but as a result of a close approach to Jupiter in 1968 the perihelion distance was increased to 2.2 a.u. There was no chance of recovering the comet.

P/Brorsen. As also indicated in last year's report, Kojima made searches for this comet in January.

P/Harrington. An ephemeris was supplied by G. Sitarski (Warsaw), but the comet was very badly placed for observation ($T = 1974$ Feb. 17.1) and unlikely to become brighter than magnitude 20.

1930 VI, *P/Schwassmann-Wachmann 3*. Rather similar predictions for the current return were prepared by N.A.Belyaev and S.D.Shaporev (Leningrad) and by the writer, but conditions were not particularly favourable and recovery before 1979 seemed unlikely.

P/Forbes. An ephemeris for this comet began in December, and the comet was recovered in 1974 January.

The following photometric parameters (reduced to an effective aperture of 6.8 cm) have been provided by J.E.Bortle, Stormville, New York:

Comet	H_0	n	H_{10}	A	B
1971 c			8.50 ± 0.05		
1972 h			2.60 ± 0.14		
1972 j			5.76 ± 0.08		
1973 a	-3.98 ± 1.14	11.11 ± 0.96	(4.44)	-15.29	+14.18
1973 b			5.7 to >12		
1973 e	8.40 ± 0.21	4.86 ± 0.42	(8.77)	+0.17	+8.46
1973 f	5.50 ± 0.07	2.42 ± 0.07	(5.13)	+0.53	+4.89

A and B are the Levin parameters. The arcs and number of observations for the various comets were: 1971 c, 1972 Dec. 12–1973 Jan. 26 (6); 1972 h, 1972 Nov. 4–1973 Sept. 20 (11); 1972 j, 1972 Nov. 16–1973 Feb. 27 (14); 1973 a, 1973 Jan. 26–Apr. 7 (11); 1973 b, 1973 June 3–July 30 (7); 1973 e, 1973 Mar. 24–June 3 (8); 1973 f, 1973 Oct. 1–Dec. 13 (13).

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 1973. The first set of figures below (in units of 10^{-6} a.u.⁻¹) 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		$u_b + u_a$
1973 a	-248	+562	-249	+562	(1972 Oct. 10.0)	+313
1973 h	+410	+420	+413	+418	(1973 Mar. 19.0)	+831
1973 e	-620	+1195	-620	+1195	(1973 June 7.0)	+575
1973 o	-245	+65	-239	+59	(1973 Aug. 26.0)	-180
1973 k	-546	+519	-548	+521	(1973 Nov. 14.0)	-27
1973 f	-76	+602	-75	+602	(1973 Dec. 24.0)	+526

The following continuation of the numerical designations of comets (in order of perihelion passage) is taken from *I.A.U. Circ.*, No. 2612 (1973). The perihelion times (T) are from orbits noted in these annual reports.

		<i>Elements of</i>					
Ref.	Comet	<i>T</i>	<i>q</i>	<i>e</i>	<i>P</i> <i>y</i>		
(1) 1737 II	Kegler	37 June 3·53	0·8381	1·0	—		
(1) 1750	Wargentini	50 Feb. 23	0·20	1·0	—		
(2) 1786 I	P/Encke	86 Jan. 31·360	0·33603	0·84842	3·30		
(3) 1788 II	P/Herschel-R.	88 Nov. 20·637	0·74902	0·97483	162·0		
(2) 1795	P/Encke	95 Dec. 21·963	0·33549	0·84859	3·30		
(2) 1805	P/Encke	05 Nov. 21·9864	0·340645	0·846528	3·31		
(4) 1847 V	P/Brorsen-Metcalf	47 Sept. 10·0683	0·487678	0·970741	68·0		
(5) } 1852 IV	P/Westphal	52 Oct. 13·218	1·24990	0·91948	61·2		
(6) }		52 Oct. 13·222	1·24985	0·91952	61·2		
(7) }		52 Oct. 13·2389	1·250159	0·920158	62·0		
— 1858 III	P/Tuttle-G.-K.	58 May 3·584	1·14037	0·62718	5·35		
(8) 1867 I	P/Stephan-Oterma	67 Jan. 20·6313	1·575266	0·858377	37·1		
(9) 1867 II	P/Tempel I	67 May 24·2174	1·562104	0·507708	5·65		
(9) 1873 I	P/Tempel I	73 May 10·2804	1·771159	0·462625	5·98		
(9) 1879 III	P/Tempel I	79 May 7·6034	1·771126	0·462546	5·98		
— 1889 I	Barnard	89 Jan. 31·6682	1·814916	1·001230	—		
(10) 1889 II	Barnard	89 June 11·3139	2·255596	0·999818	—		
(11) 1889 VI	P/Swift-Gehrels	89 Nov. 30·097	1·35775	0·68974	9·15		
— 1892 II	Denning	92 May 11·7275	1·970726	1·000371	—		
(12) 1896 V	P/Giacobini	96 Oct. 28·5342	1·454747	0·588483	6·65		
— 1897 I	Perrine	97 Feb. 8·6040	1·062791	1·000983	—		
— 1898 VII	Coddington-Pauly	98 Sept. 14·5453	1·701595	1·000934	—		
(10) 1898 VIII	Chase	98 Sept. 20·6177	2·284591	0·999507	—		
— 1900 I	Giacobini	00 Apr. 29·4108	1·331529	1·001058	—		
(13) 1901 II	P/Encke	01 Sept. 15·9613	0·341594	0·846043	3·30		
(10) 1903 II	Giacobini	03 Mar. 23·9758	2·773525	1·000603	—		
(10) 1904 I	Brooks	04 Mar. 7·6394	2·707793	1·001343	—		
— 1904 II	Giacobini	04 Nov. 3·8048	1·882049	1·000678	—		
(13) 1905 I	P/Encke	05 Jan. 12·3801	0·338882	0·847123	3·30		
(14) 1906 VI	P/Metcalf	06 Oct. 10·0794	1·631163	0·584480	7·78		
— 1907 I	Giacobini	07 Mar. 19·6080	2·051703	1·001114	—		
— 1907 III	P/Tuttle-G.-K.	07 May 29·0865	1·164914	0·629489	5·57		
(13) 1908 I	P/Encke	08 May 1·4104	0·337816	0·847535	3·30		
— 1910 IV	Metcalf	10 Sept. 16·7800	1·948013	0·999797	—		
(13) 1911 III	P/Encke	11 Aug. 19·5351	0·338447	0·847255	3·30		
(15) 1911 V	Brooks	11 Oct. 28·2346	0·489422	0·997063	—		
(15) 1911 VI	Quénisset	11 Nov. 12·8542	0·787727	0·998135	—		
(7) } 1913 VI	P/Westphal	13 Nov. 26·7685	1·254180	0·919647	61·7		
(6) }		13 Nov. 26·826	1·25402	0·91983	61·9		
(5) }		13 Nov. 26·827	1·25407	0·91980	61·8		
— 1914 II	Kritzingen	14 June 4·6938	1·198527	1·000106	—		
(10) 1914 III	Neujmin	14 July 30·4866	3·746800	1·003290	—		
(13) 1914 VI	P/Encke	14 Dec. 5·4289	0·337841	0·847488	3·30		
(16) 1916 I	P/Taylor	16 Jan. 31·3997	1·557995	0·546248	6·36		
		16 Jan. 31·4188	1·557980	0·546402	6·37		

cometary orbits

ω °	Ω °	i °	Epoch	Obs.	Arc	Ref.
129°96	135°99	63°84	—	8	1737 July 2–9	(1)
285	303	132	—	3	1750 Feb. 1–5	(1)
182°202	336°469	13°687	86 Jan. 18°0	20*	1786, 1795, 1805	(2)
29°572	355°274	63°840	88 Nov. 23°0	19	1788–89, (1939–40)	(3)
182°258	336°448	13°690	96 Jan. 6°0	20*	1786, 1795, 1805	(2)
182°3163	336°4447	13°5874	05 Nov. 15°0	28*	1795, 1805, 1818–19	(2)
129°4068	311°2224	19°1284	47 July 18°0	62	1847, 1919	(4)
57°033	347°538	40°931	52 Sept. 29°0	319	1852–53, 1913	(5)
57°034	347°541	40°932	52 Sept. 29°0	141	1852–53, 1913	(6)
57°0539	347°5487	40°9452	52 June 21°0	101	1852–53, 1913	(7)
25°776	177°111	18°906	58 May 1°0	55*	1858, 1907, 1951	—
357°5022	79°6437	18°2044	66 Oct. 6°0	90	1867, 1942–43	(8)
134°9296	102°2739	6°3917	67 May 14°0	394	1867, 1873, 1879, 1972	(9)
159°3700	79°7472	9°7659	73 May 22°0	394	1867, 1873, 1879, 1972	(9)
159°5399	79°7034	9°7670	79 May 31°0	394	1867, 1873, 1879, 1972	(9)
340°4625	358°2749	166°3777	89 Feb. 7°0	173	88 Sept. 3–90 July 19	—
236°0778	311°5380	163°8470	89 June 7°0	41	89 Apr. 1–90 Sept. 8	(10)
69°814	331°163	10°299	89 Dec. 24°0	22	1889–90, (1973)	(11)
129°3253	254°2404	89°6971	92 May 22°0	48	92 Mar. 19–93 Jan. 12	—
140°5202	194°1883	11°3569	96 Nov. 17°0	60	96 Sept. 4–97 Jan. 5	(12)
172°3277	87°2233	146°1368	97 Feb. 5°0	44	96 Nov. 4–97 Apr. 27	—
233°2624	74°7125	69°9347	98 Sept. 28°0	69	98 June 12–99 Dec. 7	—
4°6251	96°5611	22°5059	98 Sept. 28°0	70	98 Nov. 15–99 June 4	(10)
24°4010	41°0886	146°4441	00 Apr. 11°0	32	1900 Feb. 3–Aug. 18	—
183°9910	335°4927	12°8991	01 Sept. 13°0	92*	1901, 1904, 1908	(13)
5°8237	118°1179	43°8991	03 Mar. 27°0	191	02 Dec. 4–03 June 24	(10)
53°5346	276°4276	125°1292	04 Mar. 21°0	208	04 Apr. 17–05 May 8	(10)
40°7453	219°0913	99°6036	04 Nov. 16°0	48	04 Dec. 18–05 May 2	—
184°6257	335°0581	12°5797	04 Dec. 26°0	92*	1901, 1904, 1908	(13)
199°7842	195°1690	14°6271	06 Oct. 7°0	73	06 Nov. 15–07 Jan. 12	(14)
317°1088	97°7777	141°6609	07 Apr. 15°0	67	07 Mar. 9–08 Feb. 26	—
36°2729	167°0352	13°9194	07 May 25°0	91*	1907, 1951, 1962	—
184°6261	335°0585	12°5945	08 May 19°0	18*	1908, 1911, 1914	(13)
50°9643	290°0849	121°0528	10 Sept. 6°0	200	10 Aug. 11–11 June 16	—
184°6577	335°0378	12°5802	11 Sept. 1°0	18*	1908, 1911, 1914	(13)
153°0169	293°5026	33°8088	11 Oct. 30°0	954	11 July 22–12 Feb. 28	(15)
122°0357	35°7363	108°1116	11 Nov. 4°0	508	11 Sept. 24–12 Feb. 17	(15)
57°0565	347°3082	40°8727	13 Aug. 21°0	101	1852–53, 1913	(7)
57°112	347°302	40°884	13 Nov. 9°0	141	1852–53, 1913	(6)
57°110	347°299	40°883	13 Nov. 9°0	319	1852–53, 1913	(5)
72°2321	199°4116	23°9197	14 May 28°0	62	1914 Mar. 31–Sept. 23	—
14°0060	270°8130	71°0404	14 Aug. 16°0	39	14 June 28–15 July 15	(10)
184°6465	335°0388	12°5864	14 Dec. 14°0	26*	1914, 1917–18, 1921	(13)
354°7991	114°3670	15°5230	16 Jan. 28°0	—	15 Dec. 2–16 Mar. 9	(16)
354°8153	114°3638	15°5243	16 Jan. 28°0	—	1916 Jan. 22–May 28	

		<i>Elements of</i>					
Ref.	Comet	<i>T</i>	<i>q</i>	<i>e</i>	<i>P</i> <i>y</i>		
—	1917 III	Wolf	17 June 17·0735	1·686446	0·999405	—	
(13)	1918 I	P/Encke	18 Mar. 24·8451	0·340770	0·846378	3·30	
(17)	1918 III	P/Schorr	18 Sept. 30·2879	1·883338	0·468197	6·66	
(4)	1919 III	P/Brorsen–Metcalf	19 Oct. 17·3632	0·484886	0·971964	71·9	
—	1919 V	Metcalf	19 Dec. 7·8092	1·115291	1·000222	—	
—	1921 II	Reid	21 May 10·4496	1·008457	1·000357	—	
(13)	1921 IV	P/Encke	21 July 13·5899	0·340010	0·846652	3·30	
(10)	1922 II	Baade	22 Oct. 26·5291	2·258774	1·000755	—	
—	1924 I	Reid	24 Mar. 13·9493	1·755695	0·998598	—	
(13)	1924 III	P/Encke	24 Oct. 31·9356	0·341073	0·846249	3·30	
—	1925 I	Orkisz	25 Apr. 1·5065	1·109477	1·000605	—	
(10)	1925 VI	Shajn–Comas Solá	25 Sept. 6·9464	4·180785	1·002432	—	
—	1925 VII	Van Biesbroeck	25 Oct. 2·9730	1·566243	1·000382	—	
(10)	1927 IV	Stearns	27 Mar. 22·7491	3·683902	0·998179	—	
(18)	1927 VII	P/Pons–Winnecke	27 June 21·0579	1·039240	0·685686	6·01	
—	1927 IX	Skjellerup–M.	27 Dec. 18·1809	0·176157	0·999840	—	
(13)	1928 II	P/Encke	28 Feb. 19·8428	0·332628	0·849503	3·29	
(13)	1931 II	P/Encke	31 June 3·1153	0·331847	0·849795	3·28	
(10)	1932 VI	Geddes	32 Sept. 21·0747	2·313581	1·001431	—	
—	1932 VII	Newman	32 Sept. 24·5505	1·647412	1·000602	—	
(18)	1933 II	P/Pons–Winnecke	33 May 18·7803	1·101818	0·669664	6·09	
(13)	1934 III	P/Encke	34 Sept. 15·2802	0·331852	0·849809	3·28	
(10)	1936 I	Van Biesbroeck	36 May 11·6361	4·043409	1·002045	—	
—	1937 V	Finsler	37 Aug. 15·6658	0·862744	0·999985	—	
(19)			37 Aug. 15·6680	0·862728	0·999232	—	
(13)	1937 VI	P/Encke	37 Dec. 27·7516	0·332342	0·849633	3·29	
(18)	1939 V	P/Pons–Winnecke	39 June 22·7081	1·101498	0·669625	6·09	
(3)	1939 VI	P/Herschel–R.	39 Aug. 9·464	0·74849	0·97405	155·0	
(13)	1941 V	P/Encke	41 Apr. 17·1447	0·341314	0·846192	3·31	
(8)	1942 IX	P/Stephan–Oterma	42 Dec. 19·0914	1·595289	0·860910	38·8	
(20)	1944 III	P/du Toit I	44 June 17·4958	1·276957	0·788031	14·8	
(10)	1944 IV	van Gent	44 July 17·6133	2·225933	1·002085	—	
(18)	1945 IV	P/Pons–Winnecke	45 July 10·5858	1·159222	0·654874	6·16	
—	1946 I	Timmers	46 Apr. 13·2632	1·724129	1·001169	—	
—	1946 II	Pajdušáková–R.–W.	46 May 11·4366	1·018252	1·0	—	
—	1946 VI	Jones	46 Oct. 26·7791	1·136113	1·000776	—	
(10)	1947 I	Bester	47 Feb. 7·3634	2·407663	1·000947	—	
—	1947 IV	Rondanina–Bester	47 May 20·9628	0·559799	0·997427	—	
—	1947 V	Bester	47 May 31·1131	1·402863	1·0	—	
(10)	1947 VI	Wirtanen	47 July 18·3452	2·827968	1·001052	—	
(10)	1947 VIII	Wirtanen	47 Sept. 4·4124	3·261194	1·002213	—	
(13)	1947 XI	P/Encke	47 Nov. 26·3266	0·341018	0·846292	3·30	
—	1948 II	Mrkos	48 Feb. 16·6923	1·499557	1·001085	—	
—	1948 III	Johnson	48 Apr. 8·9538	4·708380	1·0	—	
—	1948 V	Pajdušáková–Mrkos	48 May 16·6123	2·107056	1·000787	—	

cometary orbits

ω °	Ω °	i °	Epoch	Obs.	Arc	Ref.
120°6239	183°7566	25°6656	17 June 21°0	186	16 Apr. 4–18 Jan. 29	—
184°6747	335°0299	12°5349	18 Mar. 28°0	26*	1914, 1917–18, 1921	(13)
279°2509	118°3139	5°5766	18 Oct. 14°0	18	1918 Nov. 23–Dec. 31	(17)
129°4688	311°2017	19°2185	19 Aug. 20°0	62	1847, 1919	(4)
185°7461	121°4039	46°3862	19 Nov. 18°0	87	19 Aug. 25–20 Feb. 3	—
64°4989	268°7468	132°1871	21 Apr. 21°0	146	1921 Mar. 15–Nov. 26	—
184°7000	335°0163	12°5453	21 July 10°0	94*	1921, 1924, 1927–28	(13)
118°3040	220°8761	51°4610	22 Nov. 2°0	185	22 Oct. 22–24 Jan. 28	(10)
271°4341	114°3771	72°3306	24 Feb. 25°0	63	1924 Mar. 30–Oct. 7	—
184°7150	335°0011	12°5258	24 Oct. 22°0	94*	1921, 1924, 1927–28	(13)
36°1854	318°4118	100°0172	25 Mar. 31°0	201	25 Apr. 6–26 May 2	—
205°7596	357°8403	146°7065	25 Sept. 7°0	59	25 Mar. 23–27 Mar. 4	(10)
106°4021	334°9126	49°3246	25 Oct. 17°0	129	25 Nov. 17–26 May 31	—
11°1407	214°9517	87°6574	27 Mar. 21°0	135	27 Mar. 13–31 Mar. 12	(10)
170°3670	98°4691	18°9408	26 Nov. 29°0	268	1927–28, 1933–34	(18)
47°1523	77°5456	85°1117	27 Dec. 26°0	34	27 Dec. 5–28 Mar. 29	—
184°9178	334°9012	12°5526	28 Feb. 4°0	94*	1921, 1924, 1927–28	(13)
184°9033	334°9064	12°5654	31 May 19°0	83*	1927–28, 1931, 1934	(13)
329°6995	215°3981	124°9936	32 Sept. 10°0	161	31 Aug. 14–34 July 19	(10)
69°7933	245°3898	78°3916	32 Sept. 10°0	48	1932 June 21–Dec. 30	—
169°2408	96°8569	20°1160	33 Jan. 8°0	144	1933–34, 1939	(18)
184°9358	334°8899	12°5619	34 Aug. 31°0	83*	1927–28, 1931, 1934	(13)
44°9016	299°8605	66°1084	36 Apr. 22°0	107	35 July 3–37 Nov. 10	(10)
114°8260	58°7134	146°4127	37 Aug. 15°0	212	1937 July 4–Dec. 30	—
114°8335	58°7158	146°4131	37 June 16°0	252	1937 July 4–Sept. 6	(19)
184°9337	334°8901	12°5510	37 Dec. 13°0	54*	1934, 1937, 1941	(13)
169°3367	96°8051	20°1218	39 Feb. 1°0	145	1939, 1945	(18)
29°298	355°282	64°200	39 Aug. 5°0	75	(1788–89), 1939–40	(3)
185°1571	334°7714	12°3521	41 May 6°0	54*	1934, 1937, 1941	(13)
358°2721	78°6084	17°9011	42 Oct. 18°0	90	1867, 1942–43	(8)
257°0183	22°4563	18°7450	44 July 9°0	32	1944 May 29–Oct. 22	(20)
336°9772	202°8020	95°0113	44 July 9°0	25	44 June 1–45 Aug. 11	(10)
170°1083	94°4554	21°6935	45 Apr. 2°5	40	1945, 1951	(18)
54°3231	128°9679	72°8472	46 Apr. 10°0	183	46 Feb. 2–47 Aug. 9	—
22°2617	301°3064	169°5580	—	49	1946 June 1–July 28	—
320°4200	237°6333	56°9677	46 Oct. 27°0	101	46 Aug. 16–48 Nov. 23	—
348°6206	34°8588	108°1692	47 Feb. 24°0	97	46 Nov. 2–48 Oct. 2	(10)
303°7548	353°2111	39°2949	47 May 15°0	27	1947 Mar. 26–Sept. 21	—
357°3948	232°3665	111°4129	—	16	1947 May 19–Aug. 7	—
9°3797	311°0981	97°3266	47 Aug. 3°0	31	47 July 23–48 Oct. 2	(10)
73°4524	121°4107	155°0818	47 Sept. 12°0	22	48 Oct. 7–49 Sept. 24	(10)
185°1884	334°7446	12°3520	47 Dec. 1°0	88*	1941, 1947, 1950–51	(13)
61°9268	198°6019	77°5391	48 Feb. 19°0	78	1948 Jan. 18–Nov. 30	—
191°8346	139°7156	53°2378	—	36	1948 Sept. 4–Dec. 3	—
66°9043	246°9543	92°9214	48 May 9°0	95	48 Mar. 13–50 Feb. 9	—

		<i>Elements of</i>					
Ref.	Comet	<i>T</i>		<i>q</i>	<i>e</i>	<i>P</i> <i>y</i>	
(10)	1949 I	Wirtanen	49 May	1·1091	2·517207	0·999352	—
(10)	1950 I	Johnson	50 Jan.	19·3134	2·553233	1·000686	—
(13)	1951 III	P/Encke	51 Mar.	16·2073	0·337996	0·847448	3·30
—	1951 IV	P/Tuttle-G.-K.	51 May	9·3695	1·116470	0·640579	5·47
(18)	1951 VI	P/Pons-Winnecke	51 Sept.	8·6026	1·160387	0·654651	6·16
—	1952 I	Wilson-Harrington	52 Jan.	12·9486	0·740427	0·999739	—
—	1953 I	Harrington	53 Jan.	5·4177	1·664977	0·995910	—
—	1953 II	Mrkos	53 Jan.	24·8599	0·777729	1·000343	—
—	1953 III	Mrkos-Honda	53 May	26·4358	1·022132	0·997391	—
(10)	1954 V	Abell	54 Mar.	24·1152	4·495680	1·002791	—
(13)	1954 IX	P/Encke	54 July	2·5203	0·338397	0·847304	3·30
—	1954 X	Abell	54 July	7·3492	0·970116	1·000564	—
—	1955 III	Mrkos	55 June	4·1669	0·534419	0·989361	356·0
(10)	1955 VI	Baade	55 Aug	13·3050	3·869934	1·000509	—
(10)	1956 I	Haro-Chavira	56 Jan.	26·6645	4·076871	1·004667	—
(13)	1957 VIII	P/Encke	57 Oct.	19·8528	0·338110	0·847403	3·30
—	1958 III	Burnham	58 Apr.	16·3036	1·322689	0·999943	—
—	1959 I	Burnham-Slaughter	59 Mar.	11·5194	1·628199	0·999867	—
—	1959 IX	Mrkos	59 Nov.	13·2162	1·253464	0·999748	—
(10)	1959 X	Humason	59 Dec.	11·2050	4·266927	1·000884	—
(21)	1960 VI	P/Brooks 2	60 June	17·1150	1·763199	0·504848	6·72
(13)	1961 I	P/Encke	61 Feb.	5·5992	0·338998	0·847067	3·30
—	1961 II	Candy	61 Feb.	8·9175	1·061612	0·989900	—
—	1962 V	P/Tuttle-G.-K.	62 Apr.	23·8779	1·122558	0·639208	5·49
(13)	1964 IV	P/Encke	64 June	3·4878	0·339268	0·846991	3·30
—	1964 X	P/Holmes	64 Nov.	15·9192	2·346950	0·378897	7·35
(22)	1966 I	P/Giacobini-Zinner	66 Mar.	28·2730	0·933487	0·729421	6·41
(10)	1966 V	Kilston	66 Oct.	28·0724	2·384748	0·999376	—
—	(9)	P/Tempel 1	67 Jan.	12·6976	1·502862	0·518070	5·51
—			67 Jan.	12·7193	1·502820	0·518123	5·51
(23)	1967 XI	P/Reinmuth 2	67 Aug.	18·1581	1·941871	0·455490	6·73
(13)	1967 XIII	P/Encke	67 Sept.	22·0598	0·338218	0·847400	3·30
(24)	1968 IV	Tago-Honda-Y.	68 May	16·2757	0·680374	0·995584	—
—	1968 VI	Honda	68 Aug.	7·9231	1·160434	1·000665	—
(10)	1969 I	Thomas	69 Jan.	12·2473	3·316033	0·995301	—
—	1969 II	P/Gunn	69 Apr.	18·8105	2·442106	0·319446	6·80
—	1969 IX	Tago-Sato-Kosaka	69 Dec.	21·2677	0·472638	0·999920	—
—	1970 III	Kohoutek	70 Mar.	21·6371	1·719088	0·999137	—
—	1970 XV	Abe	70 Oct.	20·6990	1·112539	1·000048	—
—	1971 I	Gehrels	71 Jan.	6·9408	3·274762	1·0	—
(13)	1971 II	P/Encke	71 Jan.	9·9840	0·338910	0·847154	3·30
—	1971 V	Toba	71 Apr.	17·2511	1·233308	1·000844	—
—	1972 I	P/Holmes	72 Jan.	30·8055	2·155132	0·413645	7·05
—	(9)	P/Tempel 1	72 July	15·3953	1·496674	0·519612	5·50
—			72 July	15·3963	1·496671	0·519504	5·50

cometary orbits

ω °	Ω °	i °	Epoch	Obs.	Arc	Ref.
229·9433	119·9002	130·2713	49 May 4·0	57	48 July 15–50 May 15	(10)
40·0965	221·6324	131·3550	49 Dec. 30·0	65	49 May 20–51 Feb. 9	(10)
185·2083	334·7433	12·3816	51 Mar. 15·0	88*	1941, 1947, 1950–51	(13)
37·9371	165·6441	13·7908	51 Apr. 24·0	73*	1951, 1962, 1973	—
170·1975	94·4092	21·6907	51 Jan. 11·5	40	1945, 1951	(18)
269·6066	76·1833	152·5327	52 Jan. 29·0	116	51 Aug. 7–52 Feb. 26	—
191·6314	220·6904	59·1199	53 Jan. 23·0	66	52 Aug. 20–53 June 29	—
253·8232	342·8832	97·1773	53 Jan. 23·0	64	52 Dec. 10–53 July 18	—
85·7464	275·1874	93·8561	53 May 23·0	51	53 Apr. 14–54 Jan. 1	—
73·7544	320·6386	123·9273	54 Apr. 8·0	28	55 Apr. 13–56 Apr. 30	(10)
185·1977	334·7475	12·3745	54 June 27·0	79*	1950–51, 1953–54, 1957	(13)
194·3817	2·3350	53·2224	54 June 27·0	82*	53 Oct. 16–54 Sept. 15	—
32·5090	48·2434	86·4978	55 June 22·0	74	1955 June 14–Sept. 8	—
144·6773	264·6425	100·3892	55 Aug. 1·0	67	54 Aug. 10–57 Nov. 26	(10)
57·2911	72·1749	79·5985	56 Jan. 8·0	74	55 Jan. 13–58 May 15	(10)
185·2252	334·7328	12·3755	57 Oct. 9·0	79*	1950–51, 1953–54, 1957	(13)
16·4559	150·5054	15·7938	58 Apr. 27·0	75	1958 Feb. 16–Sept. 15	—
100·7396	323·0787	61·2520	59 Feb. 1·0	85	58 Sept. 7–60 Apr. 21	—
84·6737	99·9396	19·6356	59 Nov. 8·0	29	59 Dec. 4–60 Sept. 26	—
46·4667	306·5669	125·4652	59 Dec. 18·0	30	60 June 18–61 June 7	(10)
197·0935	176·8918	5·5714	60 July 5·0	32	1953–54, 1960–61	(21)
185·2281	334·7216	12·3603	61 Jan. 21·0	53*	1957, 1960–61, 1963–64	(13)
136·6144	176·5797	150·9618	61 Jan. 21·0	63	60 Dec. 30–61 May 14	—
38·0063	165·5717	13·7640	62 Apr. 6·0	73*	1951, 1962, 1973	—
185·9101	334·2375	11·9754	64 June 14·0	40*	1963–64, 1967, 1970	(13)
21·7985	329·5543	19·5179	64 Nov. 21·0	18	1964–65, 1971–72	—
172·9188	195·9649	30·9444	66 Apr. 25·0	94	1965, 1972	(22)
154·4802	155·3556	40·2709	66 Nov. 11·0	227	1966 Aug. 9–Nov. 13	(10)
179·1255	68·3721	10·5388	67 Jan. 30·0	62	1967, 1972	—
179·1243	68·3719	10·5383	67 May 10·0	394	1867, 1873, 1879, 1972	(9)
45·5858	296·1089	6·9808	67 Aug. 18·0	11	(1960–61), 1967	(23)
185·9146	334·2358	11·9888	67 Sept. 27·0	40*	1963–64, 1967, 1970	(13)
50·4557	232·4077	102·1693	68 May 24·0	48	1968 Apr. 30–June 5	(24)
88·7049	106·0404	143·2408	68 Aug. 12·0	131	1968 July 13–Nov. 10	—
82·5765	15·4138	45·2230	69 Jan. 19·0	42	68 Dec. 19–69 May 18	(10)
197·1352	68·0348	10·3934	69 Apr. 9·0	9	70 Oct. 27–71 Nov. 18	—
267·8274	100·9629	75·8196	69 Dec. 5·0	281	69 Oct. 13–70 Apr. 5	—
123·4737	301·0593	86·3089	70 Apr. 4·0	197	69 July 23–70 May 24	—
96·5799	21·0007	126·7141	70 Oct. 21·0	241	70 July 5–71 Apr. 29	—
128·6820	24·0300	175·6080	—	13	72 Mar. 16–73 Jan. 8	—
185·9450	334·2154	11·9737	71 Jan. 9·0	40*	1963–64, 1967, 1970	(13)
152·3575	103·3757	109·6851	71 Mar. 30·0	113*	1971 Mar. 9–Aug. 20	—
23·4339	327·4609	19·2180	72 Feb. 13·0	18	1964–65, 1971–72	—
179·1907	68·3477	10·5494	72 July 22·0	62	1967, 1972	—
179·1905	68·3484	10·5493	72 Mar. 24·0	394	1867, 1873, 1879, 1972	(9)

Elements of

Ref.	Comet	<i>T</i>	<i>q</i>	<i>e</i>	<i>P</i> <i>y</i>
(25) } (22) }	1972 VI P/Giacobini-Zinner	{ 72 Aug. 4·8869 72 Aug. 4·8888	0·994015 0·994018	0·715074 0·715081	6·52 6·52
(11)	1972 VII P/Swift-Gehrels	72 Aug. 31·089	1·35385	0·69222	9·23
(26)	1972 VIII Heck-Sause	72 Oct. 5·4152	2·510799	1·0	—
(10)	1972 IX Sandage	72 Nov. 14·8589	4·275783	1·006387	—
(27)	1972 XII Araya	72 Dec. 18·9422	4·860754	0·999913	—
(28)	1972 k P/Gehrels 1	73 Jan. 25·207	2·93486	0·50731	14·5
(29)	1972 j Kojima	73 Feb. 12·2771	2·147033	1·001020	—
—	1973 h Huchra	73 Mar. 11·5857	2·384384	0·972800	821·0
—	1973 i P/Clark	73 May 24·8786	1·560299	0·500338	5·52
—	1973 b P/Tuttle-G.-K.	73 May 30·0873	1·151919	0·632996	5·56
(30)	1973 k Kohoutek	73 June 7·1817	1·382022	0·998739	—
(31)	1973 c P/Wild	73 July 2·0454	1·980423	0·647063	13·3
—	1973 o Gibson	73 Aug. 10·1241	3·843731	1·0	—
—	1973 k Sandage	73 Nov. 9·1787	4·811702	1·0	—
—	1973 n P/Gehrels 2	73 Dec. 1·5047	2·348604	0·409809	7·94
—	1973 f Kohoutek	73 Dec. 28·4306	0·142427	1·000010	—
(32) } (21) }	1973 j P/Brooks 2	{ 74 Jan. 4·0284 74 Jan. 4·1577	1·840070 1·840041	0·491193 0·491209	6·88 6·88
—	P/Schwassmann-W.1	74 Feb. 15·3192	5·447847	0·105430	15·0
(33) } (13) }	P/Encke	{ 74 Apr. 28·9943 74 Apr. 28·9999	0·338125 0·338133	0·847450 0·847449	3·30 3·30
(23) } (34) }	1973 g P/Reinmuth 2	{ 74 May 7·9491 74 May 8·1482	1·940835 1·941046	0·455816 0·455776	6·74 6·74
(35)		74 May 8·1499	1·941050	0·455776	6·74
(36) } (37) }	1973 m P/Borrelly	{ 74 May 12·6479 74 May 12·6525	1·316456 1·316530	0·631951 0·632046	6·76 6·77
(38)	1973 l P/Schwassmann-W.2	74 Sept. 12·3591	2·142191	0·385527	6·51

cometary orbits

ω °	Ω °	i °	Epoch	Obs.	Arc	Ref.
171·9062	195·1311	31·7093	72 Aug. 31·0	80*	1959–60, 1965, 1972	(25)
171·9066	125·1310	31·7095	72 Aug. 31·0	94	1965, 1972	(22)
84·400	314·233	9·251	73 Feb. 7·0	10	(1889–90), 1973	(11)
346·2172	175·1760	138·6334	—	133	1973 Jan. 4–Apr. 5	(26)
56·6703	224·7861	79·3721	72 Nov. 19·0	113	72 June 9–73 Apr. 5	(10)
267·2085	314·1870	113·0852	72 Dec. 29·0	33	72 Nov. 15–73 Nov. 2	(27)
29·059	14·630	9·646	—	11	72 Oct. 11–73 Jan. 3	(28)
334·2978	42·4837	141·8511	73 Feb. 7·0	242	72 Oct. 31–73 Sept. 30	(29)
123·4850	57·1492	48·3239	—	34	1973 Apr. 25–June 24	—
209·1286	59·1276	9·4998	—	26	1973 June 1–Sept. 26	—
38·7791	165·1521	13·5964	73 June 7·0	73*	1951, 1962, 1973	—
74·8585	164·1184	121·6045	73 June 7·0	27	1973 Feb. 28–Sept. 22	(30)
167·9370	358·2019	19·8909	73 July 17·0	p	1960 Mar. 26–June 27	(31)
221·3256	243·9083	108·0712	—	8	73 Nov. 30–74 Jan. 25	—
72·6893	278·5473	137·4032	—	14	73 July 4–74 Jan. 27	—
183·2999	215·6124	6·6709	—	35	73 Sept. 29–74 Jan. 13	—
37·8238	257·7651	14·3050	73 Dec. 24·0	346	73 Jan. 28–74 Jan. 31	—
198·1485	176·2893	5·5521	73 Dec. 24·0	p *	1946–47, 53–54, 60–61	(32)
198·1566	176·2894	5·5521	74 Jan. 3·0	p *	1953–54, 1960–61	(21)
14·4675	319·6363	9·7471	74 Feb. 2·0	135	1957–. . .–1973	—
185·9288	334·2224	11·9820	74 Apr. 23·0	p *	1957–. . .–1970	(33)
185·9302	334·2217	11·9822	74 Apr. 28·0	p *	1963–64, 1967, 1970	(13)
45·3738	296·1135	6·9800	74 Apr. 23·0	p	(1960–61), 1967	(23)
45·4273	296·0986	6·9788	74 Apr. 23·0	p	1947–48, 53–54, 60–61	(34)
45·4265	296·0985	6·9789	74 Apr. 23·0	p	1947–. . .–1967	(35)
352·6722	75·1192	30·2153	74 May 13·0	p *	1904–. . .–1968	(36)
352·6617	75·1224	30·2126	73 Dec. 19·0	p *	1904–. . .–1968	(37)
357·3139	125·9685	3·7273	74 Sept. 30·0	p *	1941–. . .–1969	(38)

Comet	T		Name	Year and letter
1972 I	January	31·2	P/Holmes	1971 b
II	March	2·6	P/Grigg-Skjellerup	1972 b
III	March	27·7	Bradfield	1972 f
IV	May	16·5	P/Neujmin 3	1972 g
V	July	15·4	P/Tempel 1	1972 a
VI	August	4·9	P/Giacobini-Zinner	1972 d
VII	August	31·1	P/Swift-Gehrels	1973 d
VIII	October	5·4	Heck-Sause	1973 a
IX	November	14·9	Sandage	1972 h
X	November	15·0	P/Tempel 2	1972 c
XI	November	28·5	P/Kearns-Kwee	1971 c
XII	December	19·0	Araya	1972 l

On the following pages the elements of recently computed orbits are tabulated. The times are in Ephemeris Time, and the angles are referred to 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 Z.Sekanina and/or the writer; 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* 1972 or by Marsden, Sekanina & Yeomans (1973, *Astr. J.*, **78**, 211), are:

		A_1	A_2
P/Encke	1786–1805	−2·17	−0·0361
	1795–1819	−0·29	−0·0385
P/Tuttle–Giacobini–Kresák	1858–1951	+3·17	+0·0056
	1907–1962	−0·03	+0·0474
	1951–1973	+0·66	+0·0216
P/Giacobini–Zinner	1959–1972	+0·34	+0·0235
1954 X	Abell	+5·9	−0·3
1971 V	Toba	+5·0	−1·4

REFERENCES AND NOTES TO TABLE OF ELEMENTS

- (1) Marsden, B.G., 1973. *Astr. J.*, **78**, 654. These orbits are uncertain, particularly that for comet 1750.
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- (4) Belous, L.M., 1974. *Kiev Komet. Tsirk.*, No. 161. Perturbations by Mercury to Pluto. Mean residual 2".58.
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- (13) Bokhan, N.A. & Chernetenko, Yu.A., 1973. *Kiev Komet. Tsirk.*, No. 145 and private communication. Perturbations by Mercury to Pluto. In 1974 $\Delta T = +0^d.01$.
- (14) Belyaev, N.A., Emel'yanenko, V.V. & Goryajnova, N.Yu., 1973. Private communication. Perturbations by Venus to Saturn. Mean residual 2".33. The next perihelion time is predicted for 1975 June 20.9.
- (15)*Van Biesbroeck, G., 1974. Private communication. Perturbations by Venus to Neptune. T is in Universal Time.
- (16) Belyaev, N.A., Emel'yanenko, V.V. & Goryajnova, N.Yu., 1973. Private communication. Perturbations by Venus to Uranus. The first orbit refers to component A (mean residual 2".69), the second to component B (mean residual 2".14).
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- (36) Yeomans, D.K., 1973. *I.A.U. Circ.*, No. 2531. Perturbations by Mercury to Pluto. $\Delta T = +0^d.01$.
- (37) Belous, L.M., 1973. *I.A.U. Circ.*, No. 2531. Perturbations by Venus to Neptune. $\Delta T = -0^d.01$.
- (38) Marsden, B.G., 1973. *I.A.U. Circ.*, No. 2527. Perturbations by Mercury to Pluto. $\Delta T = -0^d.02$.

CORRIGENDA

1971 report, *Q. Jl R. astr. Soc.*, **13**, No. 3 (1972):
Page 426, line 9. For 189 read -189.

1972 report, *Q. Jl R. astr. Soc.*, **14**, No. 4 (1973):
Page 404, line 27 of table. For Schwassman read Schwassmann.
Page 404, line 30 of table. For 70.50 read 7050.
Page 404, line 39 of table. For 999.9 read 9900.
Page 405. Delete the footnote.

Catalogue of Cometary Orbits 1972 (Smithsonian Astrophysical Observatory, Cambridge, Mass.):

Page 36, comet 1947 V. For 47 NO 25* read 47 AU 07.
Page 36, comet 1948 II. For 49 JA 28 read 48 NO 30.
Page 37, comet 1954 X. For 55 FE 24 read 54 SE 15.
Page 47, comet 1930 I. For 1 (2) 7 read 2 (2) 7.

*It is with the deepest regret that we record the death of Dr Van Biesbroeck on 1974 February 23 at the age of 94. Although he calculated many definitive cometary orbits, he was far better known for his observational work, which spanned more than two-thirds of a century.