

THE COMET OF 1533

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1. Introduction

One of the most impressive successions of cometary apparitions in pre-telescopic times occurred during the fourth decade of the sixteenth century. Following several decades poor in major comets, the apparitions of 1531, 1532 and 1533 (which were followed by the less spectacular events of 1538 and 1539) provided the first opportunities for observing reasonably bright comets over extended periods of time since the times of Toscanelli and Regiomontanus.

In view of the unresolved philosophical questions of that era, relating to the position of comets in the universe, their distances from Earth, and—last but not least—their physical nature and genesis, it is no surprise that the very first of the series, the comet of 1531, caused not only a flurry of observational activity but also the publication of a number of tracts on comets. The most important publication of this year was Regiomontanus's *De cometæ magnitudine longitudineque ac de loco ejus vero problemata XVI*, edited by Johann Schöner. In 1532, Peter Apian published his first account on the comet of 1531 and for the first time in a concise way announced the (periodically discovered and forgotten) antisolar direction of cometary tails. Apian's observations, as published a second time (together with his accounts of the following four comets of the decade) in an appendix to his *Astronomicum Caesareum*, later became crucial for Edmond Halley's identification of this comet with the apparitions of 1607 and 1682.

Like other observers of his time, Apian was primarily concerned with establishing an eyewitness account of the nature and motion of comets in general, and this attitude seems to be at least partly responsible for the fact that his observations became increasingly less well-documented and also markedly fewer in number for the subsequent apparitions. The comet of 1532 was still observed and documented in detail sufficient to enable Halley to compute this orbit also; the following comets are treated more summarily, with only one single observation being given for each of the 1538 and 1539 events. However, despite its inhomogeneity, Apian's compilation of observational evidence did serve as the principal source of data on the comets of his time. Not only are the *Astronomicum Caesareum* observations found in many comet-related works of the sixteenth and early seventeenth centuries, but they were also included by Hevelius in full in his *Cometographia* (1668), while other contemporary accounts were quoted more summarily. Hevelius's work in turn served as an important source of material for later cometographers.

After the widespread interest aroused by the bright comets of 1531 and 1532, the comet of 1533 attracted attention for its spectacular motion. Its apparent path on the sphere closely followed the Milky Way, thus displaying simultaneously retrograde and latitudinal motions. This striking evidence of the non-planetary nature of comets, while well known since the time of Aristotle, was commented upon by nearly all contemporary writers on the subject.

Rainer Gemma Frisius (in his *Structura radii astronomici et geometrici*) explicitly refers to the comet of 1533 to illustrate his statement that comets, besides sharing the ‘universal’ (*i.e.* daily east-to-west) motion, display their own ‘external’ proper motions, “the ones with the sequence of [zodiacal] signs, the others in the opposite direction [*in precedentia*], some in latitude”. Fracastoro (*Homocentrica*, 1538) employs his own observations of the comet of 1533 and its two predecessors as a basis for introducing a special cometary sphere which moves about an axis situated in the ecliptical plane (thus providing latitudinal motion orthogonal to the classical Eudoxian spheres). Apian in turn comments on the retrograde motion of the comet “which did cause no little dissent amongst astrologers and philosophers”.

It seems indeed that the rather widespread and controversial efforts to interpret the fresh observational evidence in terms of a philosophical understanding of the comets’ nature and origin were the reason for the scarcity of quantitative observations of the comet of 1533 as well as for their largely eclectic presentation by contemporary authors and later compilers. In sharp contrast to the case of the comets of 1531 and 1532, whose orbits were determined by Halley from Apian’s account, very little material was available to Cornelis Douwes and W. H. M. Olbers who were the first researchers actually to calculate orbits for this comet. They had only the short arc observed by Apian available as a basis for their calculations. While Olbers did notice the ambiguity of the comet’s motion (both a retrograde and a direct orbit representing the observations), he had to opt for the *direct motion* which did provide the better fit for the observations available to him and seemed to be consistent with some of the circumstantial evidence known at the time.

Meanwhile, the oriental observations as collected by E. Biot, J. Williams, and Ho Peng Yoke did provide additional evidence. While this material is quite sufficient for a critical assessment of Douwes’s and Olbers’s orbits, it still does not allow a fully valid and unambiguous solution to be determined. However, additional European observations became available recently in a tract by Achilles Pirmin Gasser of Lindau, who apparently did not partake in the philosophical controversy of his time and consequently escaped the attention of the later cometographers. By means of a critical discussion of all the observational evidence now available (including also the seemingly contradictory data provided by Fracastoro and omitted by Hevelius) it is possible to determine an orbit which is consistent with the historical observations. This orbit not only turns out to be *retrograde* but also shows some similarity to the solution arrived at by Douwes. It avoids, however, the arbitrary corrections of observing times introduced by the latter, which caused Olbers to doubt the validity of the retrograde solution. At the same time, the combination of Apian’s and Gasser’s observations allows us to exclude the direct case definitely.

The peculiarities of the various historical accounts make it convenient for us to present them in the chronological order of availability of the sources. In what follows, references to the contemporary philosophical controversy are restricted to the minimum necessary for the proper interpretation of certain observations.

2. *Peter Apian’s Observations and the Orbits Determined by Douwes and Olbers*

Apian begins his account of the comet¹ with the statement:

The third of the comets appeared in 1533, in the month of June; while it indeed did shine for many days, it was not more than four [times] seen by myself; it is known to me that to it there was a tail generated very quickly by the Sun, so as to make me look, for undertaking the work [of observing] in vain, the more sedulous an observer.

His discussion of these four observations may be summarized as follows:

1533 June	Longitude	Latitude	Complement of declination	Distance to Sun	Elongation from Sun	Longitude of Sun
18	♐ 3°40′	+32°	38°	66°	61°26′	♌ 5° 6′
21	♏ 29°20′	+36°20′	35°	73°	68°30′	♌ 8°
23	♏ 21°30′	+40°30′	33°50′	81°	78°23′	♌ 9°53′
25	♏ 15°	+43°	33°20′	88°	86°48′	♌ 11°48′

In addition, he states that, on the 18th, the tail of the comet did point toward Algenib, and the tail measured 15° in length on the 21st.

The month of these observations is not June but July; this is shown by the solar longitudes given and confirmed by the overall description of the comet’s motion provided by other sources.

The place of observation was with near-certainty Ingolstadt (11°·4E, 48°·8N). While no exact hour of observation is given, the map accompanying the *Astronomicum Caesareum* account shows the longitude of the ascendant as ♐ 24° which is consistent, within a few minutes, with local midnight for 25 July in the relevant latitude. This does of course not imply that Apian did his observing at midnight, but rather that he did attempt to reduce his observations accordingly; this is borne out not only by the fact that the map does show a sizeable part of the sky below the horizon for the sole purpose of including the four solar positions, but also by his statement:

Around midnight it was visible to the sedulous up to sunrise, and it always inhabited the same region of the sky, between the north and the azimuth of the Sun (*subsolanum situs*). Near sunrise, it held an elevated position nearly on the meridian.

The accuracy of this general statement is demonstrated by the fact that the time of culmination on the morning of 19 July (following the first observation) is 7^h, and for the fourth observation 4^h30^m. Sunrise was, respectively, at 4^h27^m and 4^h36^m. If Apian did this “sedulous” observing between midnight and sunrise, the fast motion of the comet may have introduced errors of up to one degree into his self-reduced positions, in addition to the observational errors. Observations may also have been performed before midnight because the first (18 July) position is shown with the tail pointing slightly to the north past Algenib at midnight, while the *verbatim* record gives the direction as towards this star (“ad stellam eandem fixam dirigentem”), which would have been true a few hours before.

Further, the tail might have been not as straight as drawn on the map (which was intended to illustrate its antisolar orientation). The internal consistency of the midnight positions as tabulated above turns out to be moderately satisfactory: the longitudes are consistent with the elongations with the sole exception of 21 July (10′ difference); the great circle distances to the Sun correspond to the positions with errors increasing from 5′ (first observation)

to 20' (last value). The declinations (or rather polar distances) also correspond well to the ecliptical coördinates; the differences for the first three observations are below 10', while the fourth value (for 45° + 43° as given above) ought to be 33°44'. The trend of these small inconsistencies among Apian's figures seems to reflect his method of reduction which, being trigonometric in nature, apparently led to numerical errors with the solar elongation (or distance) approaching quadrature. Since neither the method of reduction employed by Apian nor his original observations are known to us (it may be assumed² that he used the torquetum and meteoroscopium), a correction of the positions as tabulated above on the basis of, for example, the polar distance does not seem to be warranted.

Apian summarizes his findings on the apparent path of the comet by stating that it reached its maximum latitude of 60° “circa Arietis principium”, and its motion was contrariwise to the order of signs “ex Geminis . . . in Taurum”. These statements, but mostly the misprinted month of observation, make it quite easy to trace his observations through the subsequent literature on comets.³

The first determination of the orbit was performed by Cornelis Douwes at the request of N. Struyck, who published the result first in his 1749 catalogue of cometary orbits (which was largely a new edition of Halley's list) and later in his own cometography.⁴ The elements were as follows:

$T_0 = 1533 \text{ June } 16^{\text{d}}19^{\text{h}}30^{\text{m}}0^{\text{s}} \text{ London M.T.}$
 $\Omega = \Omega \ 5^{\circ}44'0''$
 $i = 35^{\circ}49'0'' \text{ retro.}$
 $\varpi = \Omega \ 27^{\circ}16'0''$
 $q = 0.20280$

Struyck, in his extensive discussion of the comet in *Staartsterren*, points out that the observations were “raw” and did need “some adjustment of hours” (which turned out to be rather extensive); he even suggests reducing the dates by one day each. Without implementing the latter measure, he provides the following calculated positions, together with the residuals in the sense “computed minus observed”:

M.T. London			C—O	
July 18 ^d 15 ^h	2z 3°41'	+31°59'	+ 1'	— 1'
21 ^d 8 ^h	1z28°11'	+36° 6'	— 69'	—14'
23 ^d 15 ^h	1z22° 4'	+40° 2'	+34'	—28'
25 ^d 16 ^h	1z15° 1'	+43°40'	+ 1'	+40'

While these values fit Apian's longitudes and latitudes, the “adjustment of hours” amounts to altogether neglecting the solar longitudes of the *Astronomicum Caesareum*, after using them to correct the month of observation misprinted by Apian and retained by his successors. This correction indeed is the only one proposed by Douwes or Struyck that is valid.⁵

Although the orbital elements as published by Struyck were included without comment by Pingré in his 1783/84 *Comètographie*, any attempt at calculating an ephemeris from these elements led to unacceptable results. This was already noted by Barker in 1757,⁶ who finds that the elements do not by any means represent the observations as documented in Hevelius's *Cometographia*, and suspects some error or misprint. The problem was finally solved by Olbers

whose 1797 paper *Über den von Apian im Jahre 1533 beobachteten Kometen*⁷ was to become the standard reference on the subject, despite the fact that Olbers himself did not claim his results to be conclusive due to lack of corroborating observational evidence.

Olbers demonstrates that the misrepresentation of the observations as noted by Barker was in fact due to a trivial error by either Douwes or Struyck in calculating the longitude of perihelion prior to publication of Douwes’s other-wise correct results. The argument of perihelion consistent with the observations and with Douwes’s other elements is 21°32′, and this value is to be applied with the negative sign (due to the retrograde motion), thus yielding a longitude of perihelion of 104°12′ rather than 147°16′ as published by Struyck. While thus reconstructing the motion of the comet according to Douwes’s elements and the rather lengthy discussion by Struyck in *Staartsterren*, Olbers was dissatisfied with the “adjustment of hours” procedure discussed above which not only neglected Apian’s solar longitudes in favour of minimizing the residuals of positions but also employed twilight and daytime hours without any indication of the necessity for such measures. Furthermore, noting that the short arc subtended by Apian’s observations represented the rather rare case of two different real roots of the cometary equation,⁸ Olbers proceeded to calculate a direct orbit which represents the observations at hand without the necessity of shifting the hours of observation and thus neglecting Apian’s solar longitudes.

Olbers gives the following set of elements:

$$\begin{aligned} T_0 &= 1533 \text{ June } 14^{\text{d}}22^{\text{h}}5^{\text{m}} \text{ M.T. Berlin} \\ \Omega &= 9^{\text{z}}29^{\circ}19' \\ i &= 28^{\circ}14' \\ \varpi &= 7^{\text{z}} \ 7^{\circ}40' \\ q &= 0.32686 \end{aligned}$$

These elements are based upon three longitudes and four latitudes, the second longitude being dismissed as erroneous.⁹ Olbers’s computed values and their residuals are:

July	C—O			
18	2 ^z 3°50′	+31°50′	+10′	−10′
21	—	+36°30′	—	+10′
23	1 ^z 20°52′	+40°23′	−38′	− 7′
25	1 ^z 15°10′	+43°10′	+10′	+10′

Olbers himself rates the arithmetical problems incurred in calculating his solution as unusually involved but demonstrates that the residuals do not exceed the inherent errors of Apian’s positions which contain both observational and computational inaccuracies. By discussing the less well quantified data available from other sources, he satisfies himself that the direct orbit does represent the overall apparition of the comet somewhat better than Douwes’s retrograde solution and is therefore (rather than on the evidence of the residuals alone) to be preferred.

The most important observation outside Apian’s arc had been reported by Rainer Gemma Frisius, who observed the comet “in July, moving from Capella along the Milky Way, through the constellation Cassiopeia, that is, simultaneously [in the direction of] preceding signs and far into the North”.¹⁰ This account by itself is consistent with Apian’s observations (indeed, the *Astronomicum Caesareum* map shows Capella (Hircus) explicitly in a position the

comet would be expected to have occupied some time before Apian's first observation) but is otherwise not very conclusive. More specific, however, is the description provided posthumously by Gemma Frisius's son Cornelius Gemma, who—explicitly referring to his father—writes that the comet appeared “about the beginning of July, in the 5th degree of Gemini, in the vicinity of Capella, lat. 24° , decl. 48° ; it never set . . . [and] moved about the Milky Way through the constellation Cassiopeia to Cygnus to where it started to disappear”.¹¹ Both quotations are reported by Hevelius and appear in the subsequent literature. The longitude which rather obviously is the 15th degree of Gemini was first corrected by Struyck who (in *Staartsterren*) points out that if the observation were to be dated 11 July, it would be consistent with the orbit determined by Douwes. Olbers's orbit would lead to the even later date of 15 July. Both dates are not easily interpreted as the “beginning” of July, but this inconsistency is a minor one.

Since Gemma Frisius observed at Leiden ($52^\circ 2'N$), the asserted constant circumpolarity of the comet is fully consistent with the first observation in the vicinity of Capella. The comet becomes circumpolar for Leiden on 1 July for Douwes's orbit, on 11 July for Olbers's solution.

Being unable to resolve the ambiguity of observations, Olbers tries unsuccessfully to interpret an observation by Fracastoro:

An observation by Fracastoro could give us light in this matter, if only this observation were understandable. He asserts having seen the comet on July 7 in Medusa's Head. The comet, he says, formed with the two stars above the bright one in Medusa nearly a triangle. In the following night it was distant from these stars 3 degrees north.

The comet can never have been in Medusa's Head in 1533; moreover, I do not know any two stars located above the bright one in Medusa. . . . On July 7 at 3 o'clock in the morning the comet was according to Downes in $18\frac{1}{2}^\circ \Pi$ with $18\frac{2}{3}^\circ$ northern latitude; according to my elements, in $28^\circ \Pi$ with $8\frac{1}{3}^\circ$ northern latitude. Both positions give no reason for any probable conjecture as to the star to which Fracastoro was referring. If, however, what Pingré quotes from Fracastoro is true, that the comet on this day was rising at 2 o'clock in the morning, then one will have to prefer . . . the direct orbit.¹²

Fracastoro's full account, however, provides considerably more detail:

By some [the comet] was seen on the first day of July between the Pleiades and the stars which are in the horn of Aries, by us not before the 7th. It rose nearly at the second hour of the night; the star was a little greater than Jupiter, while its tail or beard was as long as to be equal to a military lance in the sky. When first seen by us it was in the head of Gorgo, and it made nearly a triangle with those two stars which are above the bright one. In the following night it was distant from these [stars] to the north nearly 3 degrees. On the 21st day, at about the 8th hour of the night, it was seen near the star which is in the right hand of Perseus, where the sabre is; therefore it was nearly 15 degrees in latitude away from the place where it was first seen by us. On the 27th day it appeared near the star which is in the seat of Antiope, nearly 30 degrees changed in latitude since

the first day when we saw it first, but nearly 65 degrees since the day when the others did see it.¹³

This text shows that Fracastoro was primarily concerned with the comet's latitudinal motion, fully in accord with his attempt to introduce a cometary sphere moving in a direction normal to Eudoxus's planetary spheres.

The positions are compatible to a surprising extent with the end of the comet's tail according to Apian: the star in the seat of Antiope (Cassiopeia) is probably β Cas, the star in the right hand of Perseus most certainly χ Per. Somewhat more enigmatic are the stars above Algol ("the bright one"). Since the Moon was full, α and γ Per would appear to be a good choice especially for an observation moderately near the horizon. However, the *Astronomicum Caesareum* shows quite clearly that α Per (Algenib) must have been near or in the tail of the comet by the 16th or 17th. This leaves us with a choice of several more southerly (and weaker) stars which were more difficult to see at the time; crediting Fracastoro with a fair knowledge of the constellations, l and κ Per seem to be the most likely candidates. Olbers's interpretation of the time (on the 7th) as two o'clock in the morning (as quoted by Pingré) is consistent with his position of the comet's head; from the time (8th hour) of the 21 July observation (which was omitted by Pingré) we may infer, however, that Fracastoro did use the variable hours, counting from sunset to sunrise. Since he observed at or near Verona (latitude $45^{\circ}5N$), this gives us, for the second hour, approximately 21^h local time as the rising time on the 7th—which conforms reasonably well with the rise of Algol and indicates that Fracastoro refers to the time of the first appearance of the comet (or rather, the tail) above the northern horizon.

The rise of the comet in the north and its northward motion are consistent both with Fracastoro's theoretical interpretation and with the accounts given by other Italian sources.¹⁴ The explicit reference made by Fracastoro to the magnitude of the head of the comet, however, seems to be difficult to reconcile with the fact that (according to Olbers) the head would not have appeared until about five hours later. Jupiter, used as a magnitude reference, did culminate at about 21^h30^m and was setting in the south-west shortly before two o'clock. We may conclude from this evidence that the comet rose tail first for Verona, but with the head in a position slightly more northerly than inferred from Olbers's elements.

This is actually a point in favour of Douwes's orbit, which leads to a rising time for the head of 22^h30^m. However, Gemma's observations of the comet moving into Cygnus and starting there to disappear seem to be represented better by Olbers's than by Douwes's elements. The observation "by others" on 1 July as reported by Fracastoro (between the Pleiades and the horns of Aries) is by no means consistent with either set of elements.

Another piece of evidence employed by Olbers in his attempt to resolve the ambiguity is the fact that, according to Apian as well as the other records, the magnitude of the comet steadily declined. As pointed out already by Struyck in *Staartsterren*, Douwes's orbit implies a rather close approach of the comet to the Earth in early August, which would (if we assume a square-distance law for the brightness of the comet) be inconsistent with the observations, thus favouring Olbers's solution. Using modern values for the brightness exponent

(e.g. $n = 4$), we get a steady decline of brightness for both orbits. Using, furthermore, the magnitude of Jupiter on 7 July (which was $-2^m.2$) as a reference, the decline in brightness during August and September is slightly faster for Olbers's elements than for Douwes's orbit, but both solutions are compatible with the comet's gradual disappearance in August or September which is reported in the cometographies from Hevelius to Pingré.

Thus, Olbers's attempt to resolve the ambiguity of the double solution by interpreting the less quantified or (in the case of Fracastoro) incomplete accounts of additional sources turns out to yield even less conclusive results than those claimed by Olbers himself. However, the residuals of Apian's positions as well as the seemingly superior representation of the late motion of the comet in Cygnus still favour Olbers's solution, while the evidence in favour of Douwes's retrograde orbit is based solely upon its somewhat better representation of Fracastoro's 7 July observation and the earlier date resulting for Gemma's "Hircus" observation.

For the relevant period of time, the ephemerides resulting from both sets of elements are tabulated in Table 1.

TABLE 1.

0 ^h U.T. 1533	Olbers			Douwes		
	λ	β	Δ	λ	β	Δ
June 22	106.8	− 9.3	0.677	90.8	+ 7.5	1.175
30	98.6	− 2.6	0.498	83.2	+13.9	1.009
July 8	86.4	+10.0	0.397	76.8	+19.9	0.824
16	70.7	+26.0	0.359	68.4	+27.9	0.644
24	50.7	+40.5	0.372	52.4	+39.8	0.489
Aug. 1	27.5	+48.8	0.426	13.7	+51.6	0.408
9	6.0	+50.9	0.512	325.4	+44.9	0.457
17	350.4	+49.2	0.620	304.2	+31.8	0.614
25	340.2	+46.2	0.745	295.8	+23.0	0.825
Sept. 2	334.0	+43.0	0.890	292.0	+17.5	1.062
10	330.2	+40.0	1.046	290.4	+14.0	1.311
18	328.1	+37.3	1.215	289.9	+11.5	1.568

3. The East Asian Sources

The first reference to observations of the comet from the Far East is made in 1783 by Pingré who quotes Gaubil's account of Chinese observations during the sixth month in the "constellations" *Mao* (Pleiades) and *Pi* (Hyades).¹⁵ During the nineteenth century, more detailed records from the Chinese annals became available. In his *Catalogue des comètes observées en Chine*, E. Biot¹⁶ provides the following compilation which also appears, essentially *verbatim*, in the more detailed catalogue of J. Williams¹⁷ as well as in the modern compilation by Ho Peng Yoke:¹⁸

In the 12th year of the same epoch [Kea Tsing, during the reign of She Tsung], 6th month, day Sin Sze [July 1], a comet was seen in Wu-Chhê [Auriga]. Its length was 5 cubits. It swept Thai-Ling [right part of Perseus, with Gorgo] and Thien-Ta-Chiang-Chün [Triangulum with γ And]. It gradually increased to about 10 cubits. It swept Ko-Tao [left part of Cassiopeia] and passed over Thêng-Shê [Lacerta with stars in Cassiopeia, Andromeda, Cepheus, Cygnus]. In the 8th moon, day Woo-Seuh [September 16], it disappeared.

The motion of the comet as described here is not only consistent with our European sources but also seems to confirm our interpretation of Fracastoro's account, the comet's tail "sweeping" the asterisms in Perseus and Cassiopeia. In addition, definite dates of the first and last observations are provided.

Evaluating the evidence, an anonymous author summarizes the related problems in the *Astronomical Column of Nature* in 1875:¹⁹

In addition to Apian's account of this comet we have a brief one by Gemma Frisius, who states that after having been seen about the beginning of July in 5° (or rather, as Pingré corrects him, in 15°) of the sign Gemini, near the star Capella, with 24° of latitude and 48° north declination, it passed by a westerly motion, or contrary to the order of signs, to the constellation Cassiopeia, which it traversed, finally disappearing in Cygnus. Fracastor has also left us an account of the comet's track, though there is some ambiguity about it. Since Olbers calculated the orbit the Chinese observations have been published, in the 1st instance by M. Edouard Biot, in the additions to the *Connaissance des Temps* 1846, and more recently in Mr. Williams' work upon Cometary Observations in China, and it would appear that the comet moved to the vicinity of π Cyg, and was last seen on Sept. 16. If we compare the elements of Douwes and Olbers with the track thus roughly defined, we see that the retrograde orbit of Douwes is hardly probable, and that possibly a modification of the direct orbit of Olbers would be found to sufficiently represent the path of the comet, according to Apian, Gemma, and the Chinese Annals.

The reference made to π Cyg is based upon the contemporary identifications of Thien-Chin: Biot gives " π Cygne et étoiles d'Andromède", Williams " ω Cygni [*sic*!]" and stars near in Lacerta, &c.". Douwes's orbit indeed calls for a more southerly track in August and September, but Olbers's solution also calls for modification because of the clearly defined first observation on 1 July. On this day, according to Olbers, the comet would just have been passing its ascending node at 11° – 12° elongation from the Sun. The corresponding position would have been in Gemini (asterism Tung-Ching) and too close to the Sun for a heliacal rising of even part of the tail; besides, the whole comet was observed, its tail being five cubits in length.²⁰

The *Nature* note was explicitly referenced in Galle's 1894 catalogue,²¹ and the comet's orbit duly rated as very uncertain (*höchst unsicher*) in Valentiner's handbook (1898);²² however, no attempt to modify the Olbers elements accordingly is known. If any such attempt was made, it may never have been published because of its unsuccessful results.

The rather straightforward method of decreasing the longitude of the ascending node (and, correspondingly, the inclination) leads to numerous orbits which are not only consistent with the comet's heliacal rise in or near Auriga on 1 July but also with its assumed disappearance in Thêng-Shê in September. However, all solutions of this type lead either to unacceptable values of the comet's latitude, especially during the second half of July, or to daily motions which cannot be reconciled with Apian's observations even if one assumes that his longitudes (or dates) contain larger errors than we had thus far reason to assume, given the remarkably good representation of the observations by both sets of elements and especially those of Olbers.

Ho Peng Yoke's new catalogue, published in 1962, contains additional observations. Of special importance proves to be a Korean account: there, the comet was first seen on 27 June at the north of Wu-Chhê with a tail measuring 7 or 8 feet; it entered Thien Chhuan (left part of Perseus), passed Wang Liang (right part of Cassiopeia), and reached Thien-Chin (wings and tail of Cygnus, with Deneb). After 26 August its size gradually diminished.²³

While again the motion of the comet proves to be consistent with the records discussed previously, two new and important facts appear: the first observation, to the north of Auriga, is now as early as 27 June, and the comet gradually diminished on (or, rather, from) 26 August after reaching Thien-Chin. This by no means contradicts the Chinese Annals which, indeed, never explicitly stated that the comet disappeared in Thên-Shê as implied in *Nature*. The comet "passed over Thên-Shê" (Chinese), moved on to Thien-Chin (Korean); by 26 August it started to diminish, on 16 September it disappeared. It turns out that this combination of both accounts, together with the heliacal rising on 27 June in the comparatively large asterism-free region to the north of Wu-Chhê, allows for a better interpretation of the East Asian and European material in terms of modifications of Olbers's orbit; there are numerous solutions which not only fit the apparent path of the comet, including the heliacal rising as described, but also show it near-stationary from the third decade of August, thus lending emphasis to its "diminishing" prior to its disappearance. However, these solutions are still by no means compatible with the daily motion necessary from Apian's observations during the second half of July.

On the other hand, it is possible to regard Apian's (and also Gemma's) observations as middle places to be represented by a parabolic orbit through the extreme positions calculated for 27 June and 26 August from suitable 'modified Olbers-type' orbits. In this instance, however, we find that not only does the range of possible solutions vary excessively with the assumptions made for the exact June and August positions but also that, again, not only direct but also retrograde orbits fit the accumulated observations equally well. While this approach does not yield any firmly established solution in terms of a sufficiently accurate determination of orbital elements, it serves to verify the consistency of the observational material discussed above. Despite the remaining uncertainty of the explicit positions of the comet for 27 June and 26 August, the respective regions of the sky which it must have occupied on these dates may thus be regarded as quite firmly established.

Ho Peng Yoke also quotes from the Ming annals:²⁴ the position of the comet in the 18th and 19th *hsiu* (*Mao* and *Pi*), as already reported by Gaubil and included by Pingré in his *Cométographie*, is of course still consistent with our findings concerning its actual motion during the sixth month (26 June to 25 July).²⁵ However, the comet is also said to have been in *Tung-Ching* during the eighth month (24 August to 22 September). (This asterism corresponds to the feet of Gemini and marks the 22nd *hsiu*.) Both position and longitude are inconsistent with the motion of the comet as we now know it. Williams's definition of the 22nd *hsiu*, named *Tsing* in his atlas but related to the same stars in Gemini, covers asterisms from Perseus through Orion, Canis Minor, Canis Major, Monoceros, Columba to Carina, which is even less helpful.

Besides the possibility of some error during compilation of the quite condensed and abridged Ming annals,²⁶ there may be some sort of transcription error in Ho Peng Yoke's catalogue: besides *Thêng-Shê* and *Thien-Chin*, the comet may conceivably also have reached *Thien-Shih* (stars in Hercules, Aquila, Serpens Cauda) before disappearing finally on 16 September. In fact, this conjecture would be consistent with the results to be presented subsequently.

4. The Observations by Achilles Pirmin Gasser of Lindau

Unnoticed by contemporary scholars and subsequent cometographers alike, the observations of Achilles Pirmin Gasser were documented only in a short astrological treatise (or *Practica*) directed to the Council of the author's home town of Lindau and intended to explain the astrological significance of the comet which "has been seen in the summer of the 1533rd year for some time in the morning and subsequently also for a long time in the evening".²⁷ The comet seems to have been of considerable interest to the local population because Gasser remarks that he started to observe it "after good reports from many people"; furthermore, on 11 July it culminated at a quarter to nine hours in the morning in the zenith of Lindau (9°·7E, 47°·5N).

Gasser gives the following positions:²⁸

June 29	morning well past 2 ^h	longitude 21°	♐	latitude 12°N
July 2	morning	29	♐	15
9	morning	14	♐	22
12	evening past 10h30 ^m	10	♐	26
18	late at night	4	♐	32
22		26	♏	38
37	[sic]	2	♏	46
31	9 ^h p.m.	in	♐	51 or more

The following supplemental data are also contained in the record:

June 29:	altitude 5°; azimuth 43° (N to E); tail to SE
July 2:	tail 6°
July 12:	altitude 7°
July 18:	tail 7°, along great circle eastward into Algenib
July 37 [27]:	tail 5°
July 31:	no tail

The comet's motion was consistently retrograde, from the end of the sign of Gemini through Taurus to the middle of Aries in longitude, but at the same time along the Milky Way, and it moved from Erichthonius (Auriga) to below the right side of Perseus and through Cassiopeia. The daily motion was in the beginning less than 45' of arc in longitude, and about 1° in latitude. After becoming circumpolar around 11 July, its speed increased to more than 1° in longitude and latitude each and, by 20 July, to 2° in longitude and 1°·5 in latitude. At last its longitudinal motion was 5°·5 or more per day. From its first rising before sunrise, it moved northward in declination, thus soon setting in the evening after sunset and becoming circumpolar by 11 July (explicitly repeated in this context!), continuing to move northward until 27 July when it started to move a little southward in declination.

These plentiful cross-references, supplemented by accounts of the astrologically significant planetary aspects and the backward-extrapolated position of the

comet at the time of its generation (26 June, 1½ hours past noon, in 24° Π, latitude 10°N, due to a retrograde conjunction of Mercury with the Sun and the proper positions of the other planets), not only confirm our previous findings but are also useful in establishing a measure of accuracy for Gasser's numerical values. In general, for longitudes he employs the phrase "in the *n*th degree of sign Z", indicating an interval, while his latitudinal data are distances from the ecliptic. Both longitudes and latitudes are given to full degrees. The longitude of 2 July is obviously incompatible with the consistently retrograde motion mentioned explicitly by Gasser, so (in accordance with the author's diligent account of daily motions) we may assume a simple typographical error and correct it to 19° Π. The altitudes for 29 June and 12 July turn out to be systematically too small; since the azimuth of 29 June is consistent with the ecliptical coördinates, we assume that altitude and azimuth were measured independently against the local horizon which, to the north, from Lindau, is reasonably flat but not mathematically exact. Gasser apparently neglected to cross-correlate his altitudes with his ecliptical coördinates. The typographical error in the date of 27 July ("37") is readily enough corrected from both the latitudinal motion of the comet and the reference to its reaching maximum declination on this very date; the longitude seems to be in error.

The observation of 9 July corresponds well with Gemma's observation ("near Hircus"); the 18 July observation is for all practical purposes identical with Apian's, even including the orientation of the tail along a great circle toward Algenib. The difference in tail length seems to be a systematic effect, Gasser's values for tail lengths being consistently smaller than Apian's; the 20' difference in longitude may reflect a small difference in observing time but is most likely due to Gasser's habit of using integer intervals of longitude.

TABLE 2.

U.T. 1533	Longitude	Latitude	Observer
June 29·125	81°	+12°	Gasser
July 2·1	79	15	Gasser
9·1	74	22	Gasser, (Gemma)
12·964	70	26	Gasser
19·032	63·67	32	Apian, (Gasser)
22·032	(59·33)	36·33	Apian
23	56	38	Gasser
24·032	51·5	40·5	Apian
26·032	45	43	Apian
28	(32)	46	Gasser

Combining Gasser's, Apian's and Gemma's positions, we obtain the observations listed in Table 2. This set of observations, rather surprisingly, is better represented by Douwes's orbit than by Olbers's result. However, it allows an independent and rather satisfactory parabolic orbit to be determined due to the longer period of time, and the longer arc subtended on the sphere. While at first attempt several solutions, both direct and retrograde, seem to be possible, depending on the choice of pivotal points for the determination of the parabola, ambiguities are excluded when we attempt to represent the whole body of observations by the orbits in question. The only solution which adequately represents the places listed above (with the exception of two longitudes which

were already found to be in doubt during the previous discussion) is the one based upon the observations of 2 July and (alternatively) 24 or 26 July as pivotal places, with 19 July as the middle place connected with the Sun's position by great circle in the usual way. It was found convenient to average the resulting sets of elements; similar solutions are obtained by combining the observations of 24 and 26 July to one fictitious place for 25 July and also by forming normal places for 29 June to 9 July, 12 to 22 July, and 23 to 28 July.

The resulting elements are as follows:

$T_0 = 1533 \text{ June } 15.417 \pm 0.061$
 $\Omega = 118^{\circ}.835 \pm 0^{\circ}.135$
 $\omega = 21^{\circ}.304 \pm 4^{\circ}.663$
 $i = 149^{\circ}.631 \pm 0^{\circ}.044$
 $q = 0.2548 \pm 0.0194$
(equator and equinox of date)

The errors given are formal mean errors indicating the range of values which represent the observed places with a comparable degree of accuracy.

The computed places and the residuals are given in Table 3. The longitudes for 22 and 28 July were corrected to $57^{\circ}.33$ and to 37° , respectively. Both values are primarily suggested by the newly determined orbit but supported by circumstantial evidence: $57^{\circ}.33$ for the second observation by Apian was already suggested by Pingré from the trend of the *Astronomicum Caesareum* observations, while the figure 37 appears in Gasser's account as the date of the observation under discussion, instead of 27.

TABLE 3.

	λ	β	$\Delta\lambda \cos \beta$	$\Delta\beta$
June 29.125	81.27	+12.85	+0.26	+0.85
July 2.1	79.09	+14.88	+0.09	-0.11
9.1	73.69	+20.22	-0.29	-1.78
12.964	70.28	+23.92	+0.26	-2.08
19.032	62.45	+31.32	-1.03	-0.68
22.032	56.70	+35.98	(-0.51)	-0.35
23	54.43	+37.66	-1.24	-0.34
24.032	51.67	+39.45	+0.13	-1.05
26.032	45.28	+43.11	+0.21	+0.11
28	37.27	+46.74	(+0.19)	+0.74

The residuals could be slightly reduced by formally introducing the middle places of Gasser's longitudinal intervals or by allowing some $\pm 30'$ interval of observational accuracy as a basis for correcting the observations. These alternatives, however, do not yield any significant improvement. The method of least squares diverges; and neither do non-parabolic hypotheses improve the representation of the observations. The orbital elements listed above may therefore be regarded as the best solution possible for the observational material in hand. Concerning the comet's brightness, from Fracastoro's 7 July observation of the head as being slightly brighter than Jupiter (mag = -2.2) and the time of its disappearance from the East Asian sources, we find a reduced magnitude $H_{10} = 0^m.5$ and a brightness exponent of $n = 6$ adequately to represent the apparition. The ephemeris given in Table 4 illustrates motion and brightness of the comet.

TABLE 4.

1533 (0 ^h U.T.)	λ	β	r	Δ	mag.
June 14	96.1	+ 0.7	0.260	1.261	−7.8
22	87.3	8.0	336	205	−6.2
30	80.7	13.5	521	1.040	−3.7
July 8	74.7	19.4	711	0.854	−2.1
12	71.3	23.1	802	761	−1.5
16	66.9	27.5	890	670	−1.1
18	64.2	30.1	933	626	−1.0
20	60.9	33.0	0.976	585	−0.8
22	56.9	36.2	1.018	546	−0.7
24	51.9	39.7	060	510	−0.6
26	45.5	43.3	101	479	−0.5
28	37.4	47.0	141	454	−0.4
Aug. 1	14.6	52.6	220	424	−0.1
9	324.4	47.2	373	469	0.9
17	302.1	33.9	520	627	2.2
26	293.5	24.8	662	0.840	3.4
Sept. 3	289.7	19.2	798	1.080	4.5
11	288.0	15.5	1.931	332	5.4
19	287.5	+12.9	2.059	1.591	6.2

5. Discussion of Ephemeris

Besides the quantified observations used in establishing the orbit, the whole body of observational accounts discussed above is adequately represented by the new set of elements. The apparition of the comet of 1533 may be described as follows:

Prior to its perihelion passage, the comet was invisible from the northern hemisphere. After passing its ascending node on 13 June and its perihelion on 16 June, its increasing northerly declination and its retrograde motion soon led to favourable observing conditions in the morning sky. Accordingly, it was observed on 27 June in Korea (for 35° latitude, it rose at 2^h30^m, 2^h.3 before sunrise), and subsequently also in Europe. The first accurate observation was made by Gasser on 29 June; the comet showed a sizeable tail on this day even though its distance (1.06 AU) and angular proximity to the Sun (27°) imply a rather unfavourable geometry in this respect. On or about 1 July it was observed in China to reach the longitude represented by the 19th *hsiu* (Hyades, *Pi*), which in combination with its subsequent retrograde motion toward the 18th *hsiu* (Pleiades, *Mao*) is not only reflected in the Ming annals and Gaubil's report, but is probably also the reason for the spurious reference by Fracastoro to the observation "by others" on this date. Fracastoro was probably subsequently in touch with Portuguese sailors who brought the rumour from China. Subsequently, while the comet's magnitude had in fact already decreased, it nevertheless became more conspicuous due to the lengthening of its tail (because of its moving closer to Earth and towards quadrature with respect to Sun), and on account of its northerly motion which led to increasing elevation and soon to continuous visibility when the comet became circumpolar. On 7 July, Fracastoro observed its rise tail-forward at 21^h in the north. Assuming a tail length of 10°, we find the tip of the tail in inferior culmination at the horizon of Verona at 20^h; the head of the comet rose at 23^h. The tip of the tail formed then nearly an equilateral triangle with α and κ Per; presumably this was a very conspicuous configuration since α Per was located roughly in the axis direction of the antisolar tail. The head, slowly decreasing in magnitude, was

slightly brighter than Jupiter. By 9 July, Gemma observed the comet at Leiden, where it had been circumpolar for some days; in fact, it had become circumpolar already as far south as Lindau, where, because of the peculiarities of the local horizon, Gasser failed to note this event until two days later. (Gasser correctly denotes this date as approximate.) Having passed Capella, or Hircus, the comet continued to move toward Algenib, its tail continuing to point towards this star and increasing in length, until, having swept across Algenib by the 18th, it reached the maximum extension of 15° by 22 July. The accounts of the comet's motion during this time are fully consistent if we take into account the local geometries of the northern sky for the various observers as well as Fracastoro's habit of noting only the latitudinal motion of the comet and therefore documenting it by means of the tail positions. The East Asian sources correspondingly discriminate between the comet (or its head) moving among the asterisms, in contrast to the tail "sweeping" them. On 22 July the comet crossed the Earth's orbit, and subsequently the length of the tail decreased for reasons of perspective. In full accord with Gasser's account, it reached maximum declination (56°·9) on 27 July while still accelerating its apparent motion; on 31 July, the date of Gasser's last observation, the comet was at 15° longitude and 52°·6 latitude, fully consistent with Gasser's rough data for this date. It no longer showed a visible tail but was still of considerable brightness. In fact, its closest approach to Earth occurred on 2 August (0·422 AU, accounting for the comet appearing as a diffuse star of $-0^m\cdot3$). Subsequently, the tailless object continued along the Milky Way, neglected by European observers but diligently observed by the Chinese whose "guest stars" did not need a tail as a vital characteristic. It moved through *Thêng-Shê*, reached *Thien-Chin* by 5 August, left this asterism by mid-August while all the time slowing down and decreasing in magnitude. By 26 August, the date of its gradual diminishing according to the Korean observers, it was an inconspicuous object of magnitude 3·4 and just about to enter *Thien-Shih*. Subsequently, while it was decreasing in brightness, its slow motion made it easy to trace in the evening sky, moving slowly southward in declination while showing no appreciable motion in right ascension, until by 16 September it disappeared in the south-west.

It thus appears that the orbit presented above accounts for all observations known to us. The few interpretations of otherwise contradictory data which have been necessary were forced by their incompatibility, not with the orbital calculations, but rather with the majority of observations.

Acknowledgements

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REFERENCES

1. P. Apianus, *Astronomicum Caesareum* (Ingolstadt, 1540; reprint: Leipzig, 1967), Pars secunda, "Observatio Cometae Tertii": "Tertius Cometarum anno 1533 apparuit mense Iunio, qui licet multis diebus luxerit, non tamen amplius quam 4 à me visus est, citissimè enim caudam à Sole quo^a gigni huic mihi cognitum^m est, adeo ut viderer frustra operem insumpturus sedulior contemplator."

Following his account of the observations, he amplifies: “Circa noctis medium conspicuus sedulo usque ad Solem orientem, regionem coeli eandem perpetuo inhabitans intra Boream & subsolanum situs. Sole iam orituro, fere meridianum iam elevatus tenebat.”

2. D. Wattenberg, *Peter Apianus und sein Astronomicum Caesareum* (Leipzig, 1967; attachment to the reprint of *Astronomicum Caesareum*), 27, as well as Apian’s own remarks in the introduction of *Pars secunda*, where he describes at length the solution of problems of spherical trigonometry by means of the meteoroscopia.
3. The most important *verbatim* quotation of the relevant parts of Apian’s account, with but few omissions, is found in Hevelius’s *Cometographiae Liber XII* (Danzig, 1668), 847. Here and in St. Lubienitzky, *Theatrum cometicum* (Leiden, 1681), a number of secondary accounts are quoted. A.-G. Pingré, besides noting the correct month (July), in his *Cométographie* (Paris, 1783), i, 496, still retains one reference to mid-June (*Annales Augstburgenses*).
4. N. Struijck, “Viae cometarum”, *Philosophical transactions*, xlv (1749), 89–92; and *Vervolg van de beschryving der Staartsterren* (Amsterdam, 1753), 24–26. The latter, which contains Halley’s catalogue augmented by only two new orbits whose authors, Douwes and Struyck himself, are mentioned in the accompanying text, may have been the source of Lalande’s erroneous assertion in his *Astronomie* that Halley also computed an orbit for this comet; cf. Olbers in Bode’s *Astronomisches Jahrbuch für das Jahr 1800* (Berlin, 1797), reprinted in C. Schilling (ed.), *Wilhelm Olbers, sein Leben und seine Werke*, i: *Gesammelte Werke* (Berlin, 1894), 641. Lalande’s simultaneous reference to Pingré as yet another computer of the comet’s orbit is still less explicable.
5. D. Wattenberg, *op. cit.*, 27, erroneously attributes this correction to Olbers.
6. Thomas Barker, *Account of the discoveries concerning comets* (London, 1757), 13.
7. Published in Bode’s *Astronomisches Jahrbuch für das Jahr 1800*, 126–31; reprinted in Schilling, *op. cit.* (ref. 4), 217–21.
8. It is probably the first actual case of a double solution documented in the literature.
9. The validity of this particular longitude had already been doubted by Pingré, *Cométographie*, who proposed $57^{\circ}20'$ as better fitting the apparent motion of the comet. This is the only computational activity on the comet of 1533 known from Pingré and hardly enough to explain Lalande’s remark discussed in ref. 4 above!
10. “Vidimus unum anno 1533 in Iulio, ab Hirci sydere secundum viae lactae ductum, motum per Cassiopeiae sydus, hoc est, simul in praecedentia signorum & longe in Boream” (Rainer Gemma Frisius, *Structura radii astronomici et geometrici*, cap. xix; reprinted by Ioan. Bellerus in his *Cosmographia* (Antwerp, 1584), 314).
11. “Item anno 1533 circa initia Iulii, alter in 5. II circa sydus Hirci, lat. 24° , decl. 48, is nunquam occidebat, movebatur tamen in orbem primi mobilis, deinde & proprio contra successum signorum, nova ratione circa lacteam viam (ut pater annotat) per cas. sydus ad Cygnum usq ubi tum primum evanuit” (Cornelius Gemma, *De naturae divinis characterismis* (Antwerp, 1575), lib. I, cap. viii, 211).
12. “Eine Beobachtung Fracastors könnte uns hierin Licht geben, wenn diese Beobachtung nur zu verstehen wäre. Er behauptet, den 7ten Julius den Kometen im Medusenkopf gesehen zu haben. Der Komet machte, sagt er, mit den beiden Sternen, die über dem hellen in der Medusa sind, fast einen Triangel. In der folgenden Nacht war er 3° nördlich von diesen Sternen entfernt.
Im Medusenkopf kann der Komet 1533 nie gewesen sein; auch kenne ich keine zwei Sterne, die über dem hellen in der Medusa stehen. . . . Am 7ten Julius um 3 Uhr morgens war der Komet nach Downes [*sic*] in $18\frac{1}{2}^{\circ}$ der Π [= $78^{\circ}.5$] mit $18\frac{3}{4}^{\circ}$ nördlicher Breite, nach meinen Elementen in $28^{\circ} \Pi$ [88°] mit $8\frac{1}{4}^{\circ}$ nördlicher Breite. Beide Örter geben zu keiner wahrscheinlichen Vermutung über den Stern, den Fracastor gemeint hat, Anlaß. Ist es aber wahr, was Pingré aus Fracastor unführt, daß der Komet an diesem Tag um 2 Uhr morgens aufging, so wird man die rechtläufige Bahn . . . vorziehen müssen” (Olbers, *op. cit.* (ref. 7)). Douwes is consistently spelt “Downes” throughout the paper, in accordance with Struyck’s Royal Society (*Philosophical transactions*, cf. ref. 4) presentation.
As will be shown, the triangle as seen by Fracastoro was formed by the part of the comet’s tail appearing above the local horizon and pointing towards one of the two stars in question, thus providing a sight worth mentioning.
13. G. Fracastoro, *Homocentrica* (Venice, 1538), sect. III, cap. 23. Pingré quotes the account nearly in full; the only important omission is the time (8th hour) for 21 July. The hour for 7 July reads in Pingré’s translation “se levoit à deux heures de nuit” which is clearly closer to the original text than Olbers’s “um 2 Uhr morgens”!

14. *E.g.*: “A Septentrione ortum fuisse Riccioli testatur” (Lubienetzki, *op. cit.* (ref. 3)). Since this compiler quotes separately Riccioli’s summary of Fracastoro’s account, we assume “a septentrione ortum fuisse” to originate from another source or to have been common knowledge among Italian observers of the comet.
15. The concept of Chinese lunar mansions (*hsiu*) which is based upon the zodiacal asterisms and consequently leads to ambiguities quite analogous to those found in Europe when using zodiacal signs and constellations was not known to Pingré. It seems to have been introduced into astronomical literature by J. Williams (*cf.* ref. 17).
16. Published in *Connaissance des temps 1846*, additions, 60–68.
17. John Williams, *Observations of comets from B.C. 611 to A.D. 1640, extracted from the Chinese annals* (London, 1871).
18. “Ancient and mediaeval observations of comets and novae in Chinese sources”, *Vistas in astronomy*, v (1962), 127–225. Unless stated otherwise, we follow Ho Peng Yoke’s transliteration of the names of stars and asterisms as well as the identifications provided on his maps. For the dates, we retain Williams’s spelling. Ho provides the transliterations *hsin-ssu* and *wu-hsü* for the dates of first and last observations and provides the corresponding European dates but not the full chronological tables published by Williams. For *Thai-Ling* on his maps, he uses *Ta-Ling* in the text. The tail lengths are given as over 5 and over 10 feet, respectively.
Ho quotes the following Chinese sources: Hsü Wên Hsien Thung Khao, 212/66b, author Wang Chhi, year 1586, revised during the eighteenth century; Ming-Shih, 27/11b, authors Chang Thing Yü *et al.*, year 1739; Ming Hui Yao, ch. 68, author Lung Wen Pin, year 1865.
19. *Nature*, xii (1875), 88 (= no. 292, 3 June 1875).
20. The *cubit*, originally a unit of length (‘foot’), is quite commonly used to measure angles, or distances, on the sphere. On the interpretation of the *cubit* in astronomical records *cf.* Williams, *op. cit.* (ref. 17) and D. H. Clark and F. R. Stephenson, *The historical supernovae* (New York, 1977).
21. J. G. Galle, *Verzeichnis der Elemente der bisher berechneten Kometenbahnen* (Leipzig, 1894).
22. N. Herz, *Kometen und Meteore*, in W. Valentiner (ed.), *Handwörterbuch der Astronomie* (Breslau, 1898), ii, 52.
23. *Op. cit.* (ref. 18); the source given is Chungbo Munhon Pigo, 6/27b. A Japanese account of the comet having been observed from 15 July for about two weeks in the north adds nothing of substance to the material under discussion.
24. This account is quoted separately but attributed to the Ming Hui Yao, the last of the Chinese compilations listed as sources of the combined account (*cf.* ref. 18).
25. The Ming Hui Yao consistently refers to lunar mansions, or *hsiu*, which were introduced into European literature, apparently from other sources, by Williams a few years after its compilation. While the *Mao* and *Pi* references were known in Europe considerably earlier, *i.e.* at least since the times of Gaubil and Pingré, they could not be properly interpreted, as longitudes rather than full positions, before introduction of the *hsiu*. This leads to the possibility of interpreting the observation “by others” between the horns of Aries and the Pleiades, which is reported by Fracastoro, as an early version of the same *hsiu*-related account which may have been brought to Europe by Portuguese sailors.
26. The *Tung-Ching* reference is only the Ming Hui Yao (1865), while Ho provides for the comet of 1532 the following account from all three Chinese compilations (*cf.* ref. 18): “On a *chi-mao* day in the 8th month of the 11th year [2 September 1532], a comet appeared at the *Tung-Ching*.” Not only is the longitude fully consistent with the position of this comet on this date (98° longitude, –47° latitude), but the wording in the 1533 account (“during the 8th month it *again* was seen at the *Tung-Ching*”) does suggest a reappearance or new appearance better compatible with the first observation of the 1532 comet (which was preceded in March by yet another guest star of 19 days’ visibility) than with the continuously weakening comet of 1533.
27. A. P. Gassar, *Ein kurtze underricht von dem Cometen / vnd harigen Sternen / so den Summer des M.D.XXXIII. Jars etlich zeit zu morgens / darnach auch lang zu abendts ersehen ist worden*. Referenced in E. Zinner, *Geschichte und Bibliographie der astronomischen Literatur* (Leipzig, 1941), nos. 1527–8. Gasser later became the official historiographer of the city of Augsburg and compiler of the *Annales Augstburgenses* which contain a reference to the comet obviously influenced by Apian (observation in mid-June), *cf.* Pingré, *Cométographie*.
28. Man hat nun in Gottes namen im nechst vergangenem Brachmonat des 1533. Jars wider ein neuen Cometen ersehen / den selbigen hab ich nach gutem bericht viler menschen

auff Petri vnd Pauli (das ist am xxix. tag obgemeltes Monats) mit ernstlichem fleyß inn der nacht ein gut weil nach zwey vren an der refier des hymels obseruiert / da der Nordostner (latine Aquilo) her wehet / vnd meines abmerckens dazumalen in dem xxj. grad der Zwillig / etwa xij. gradus in Mitnechtlicher Breyte von der Ecclyptica gefunden / bey 5. gradus über den Horizontem hoch / im 43. Azimut Orientali / Septentrionali / seinen schwantz beseytz zwischen Auffgang vnnnd Mittag von der Sonnen übersich gehörendt. . . .

Erstlich den andern tag im Hewmonat hab ich disen Cometen frü gegen dem morge im 29. graden der Zwillig gefunden / 15. gradus Mitnächtlicher breyte / vn seines fewers glast schyer 6. gradus lang. Den neüntem tag Julij hab ich jn abermals am morgens gefunden in dem 14. graden Geminorum / 22. gradus gegen Mitternacht vom Sonnenweg. Den zwölfften tag Hewmonats hab ich zu abents jn / mehr dan ein halbe stund nach zehenen / bey 7. gradus ob dem Horizonten funden / im 10. graden der Zwillig / 26. gradus von der Ecclyptica inn Septemtriones. Der gleichen den 18. Julij / hab ich jn aber zu abents spat funden im 4. graden Geminorum / 32. gradus Mitnächtlicher breyte / vnnnd seines scheins stromen wol 7. gradis circuli magni langk inn den hellen sternem Algenib genant / gen Orient außgestreckt. Den 22. Hewmonats hab ich jn inn dem 26. graden des Stiers gefunde / mit 38. graden gegen den Septemtrion werts. Den 37. Julij hab ich jn wider gefunden etwa 5. gradus Equinoctiales nur lang / im 2. graden Tauri / vom Sonnenweg 46. gradus mitnächtlicher weyte. Auffs jüngst hab ich jn am letsten tag des Hewmonats gerad zu neün vren nach mittag vnder dem Thierzeychen / das man den Wider (latine Arietem) heßß / bey 51. gradus oder mehr gegen Mitternacht von der Ecclyptica in aller höhe on ein schwantz gefunden. Darauß ich dann gentzlich beschleuß / das dises Cometen eygner lauff acht vnd dreyssig tag [counting from the comet's alleged generation on 26 June—W.K.] vnder dem milchweg oder Jacobs straß (Galaxia genandt) stets hindersich wider die rechten ordnung der zwölff hauptzeychen vom end der Zwillig durch den Stier biß zum mittel des Widers / gestrackts in der bildnuß Erichthonij / darnach vnderhalb der rechten seyten Persei her vnd durch das gestirn Cassiopeie überal gewesen sey / Der massen das er nach d lenge des Thierkreyß anfänglich inn einer gantzen reuolution des ersten hymmels kaum 45. minuten durchgangen / inn seiner breyte aber von dem mitlesten teyl des Zodiaci gegen desselben Mitnächtlichen Polo / eben ein gradum übersich geruckt hab / biß er etwa vmb den eylfften tag Julij hat angefahren seinen gang so vil zu fürdern / das er motum diurnum in longitudine vn latitudine gleich / mehr dann ein gantzen gradum gehabt hat / wie dann auch vmb den zweintzigsten Julij sein täglicher eygner lauff innerthalb 24. stunden ist ob 2. gradus in longitudine hindersich / vnd anderthalben gradus inn latitudine von der Sunen weg über sich gwesen. Also das er da gantz schneller hat angehabe sich zubewegen / vnd vffs letst etlich tag / ye einen wol fünffthalb gradus / oder mehr repedando inn der lenge Zodiaci durchlauffen.

Bey welchen nun leicht zu mercken ist / daß diser nur ein Comet / vnd nicht zwen / von erst zu morgens vor der Sonnen auffgang / darnach auch zu abends bald nach der Sonnen nidergang scheinendt gewesen sey / der von seiner ersten declination (ab dem Ebennechtigen circkel zu rechnen) ymmerdar gegen dem Meersternen Poli arctici / doch schlims ye höher vnnnd höher sich geschupfft hat / bis das er vmb den eylfften tag Julij so hoch kummen ist / das er nicht mehr weder auff noch nider geen / sonder allweg ob dem erdtrich hie / wo der tag vnd Sonnen liecht / vnnnd sunst nit verblichen / gesehen hat mügen werden. Inn solcher bewegnuß er fortan noch weiter zu dem Septemtrion vil tag gezogen ist / biß an den xxvii. Julij / da hat er sich erst anzufahe wider herab gegen den Equatore zuhalten / aber darumb das er zu bald erlasch / hat er jm wenig gradus mehr nähmen mügen.