Periodic Comets Found in Historical Records

Ichiro HASEGAWA

Otemae Junior College, Inano 2-chome, Itami-shi, Hyogo 664

and

Syuichi NAKANO

Computing Section, Oriental Astronomical Association, 3-19, Takenokuchi 1-chome, Sumoto-shi, Hyogo 656

Abstract

The following comets are identified with those of records found in Chinese, Korean, and Japanese histories: Periodic Comet Pons-Gambart (D/1827 M1 = 1827 II)= Comet 1110 K1, Comet 1861 J1(1861 II) = Comet 1500 H1, and Comet 1337 M1 = Comet 1468 S1. All of the historical records of those comets are presented here.Their orbital elements were improved and linked with each other, including the planetary perturbations in order to confirm their identifications.

Key words: Celestial mechanics — Comets: individual (C/1337 M1, C/1861 J1, and P/Pons-Gambart) — Solar system: general

1. Introduction

The orbits of bright and well-recorded comets found in historical records have been computed, and some possible identifications of those comets with periodic comets observed in recent years are suggested (Hasegawa 1979). Of those candidates for such identifications, 109 Periodic Comet Swift-Tuttle was confirmed to be identified with comets observed in −68, 188, and 1737 (Marsden et al. 1993; Yau et al. 1994).

One of the methods used to find candidate comets to be identified was to search for orbits which strongly resembled each other. The other method was to compare the recorded positions of a comet, or its path, in the sky with the ephemerides calculated with different assumed perihelion times of the comet. When a possible candidate was found, we calculated its motion during those apparitions.

Numerical integrations of a comet's motion were performed while taking into account the perturbations of all nine planets at a constant half-day step size using the method of the n-body problem; improvements of comet's orbit were also carried out using a least-squares method of the variation in the orbital elements in order to confirm the identification of comets. Because nongravitational parameters can not be determined from inaccurate records of historical comets, these effects were not included in our calculations. Each comet is discussed separately in the sections below.

The new cometary designations adopted by the IAU in 1994 August, and given in the Catalogue of Cometary Orbits (Marsden et al. 1995), are used here with the old one for a reference; to all sexagenary dates from historical records given in the tables of this paper are appended their serial numbers.

2. Periodic Comet Pons-Gambart (D/1827 M1 = 1827 II) and Comet 1110 K1

On the morning of 1110 May 29, a comet appeared in the eastern sky and was recorded in the historical records of China, Korea, and Japan. The original records are given as follows:

大観四年五月丁未（九日）彗出奎婁光芒長六尺北行入紫微垣西北入濁不見 [On the day of ting-wei-44 in the fifth month of the fourth year of the Ta-Kuan reign period (1110 May 29), a comet appeared between Khuei (the 15th lunar mansion) and Lou (the 16th lunar mansion). Its ray was 6 chih (about 6°) in length. It passed to the north and then entered the Tze-Wei Enclosure. In the northwest, it entered the horizon and went out of sight.] [宋史 天文九 (Sung Shih, Celestial Phenomena); Williams 1871, p60; Ho 1962, p187; Beijing Observatory 1988, p419.]

叡宗五年五月己酉彗星入紫微, 乙卯二更彗煋発天将軍閣道星間至暁乃滅. 丁巳夜彗星発策星, 戊午発王良星西北, 己未発華蓋伝舎間, 庚申発華蓋中, 辛酉発華蓋下六甲星北, 癸亥夜行御女星内 [On the day of chi-yu-46 in the fifth month of the fifth year of the Yejong (May 31), a comet entered the Tze-Wei. On the day of i-mao-52 (June 6), at the second watch of the night (between 8 and 11 o'clock in the evening), it appeared between Thien-Chiang-Chun and Ko-
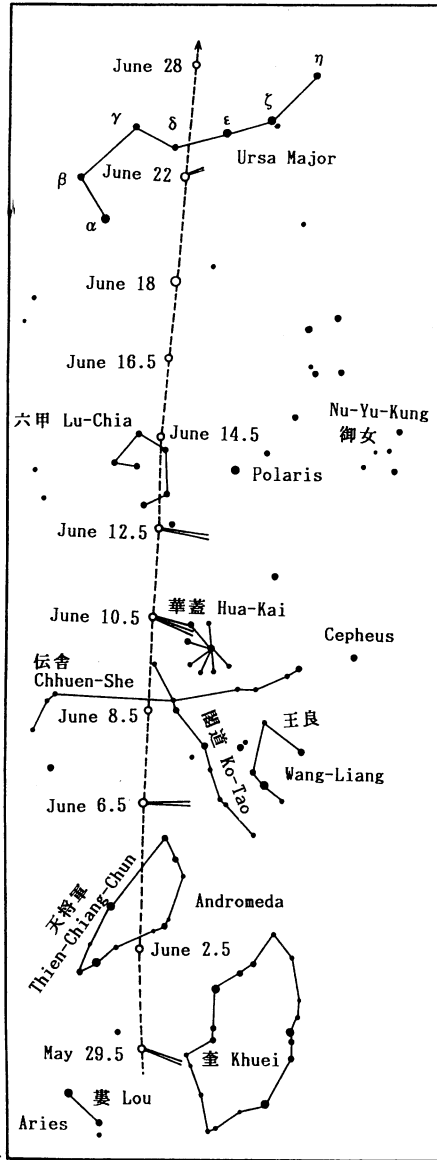
Fig. 1. The computed path of Comet 1110 K1 = Comet Pons-Gambart (D/1827 M1 = 1827 II) from May 29.5 to June 28 in 1110.
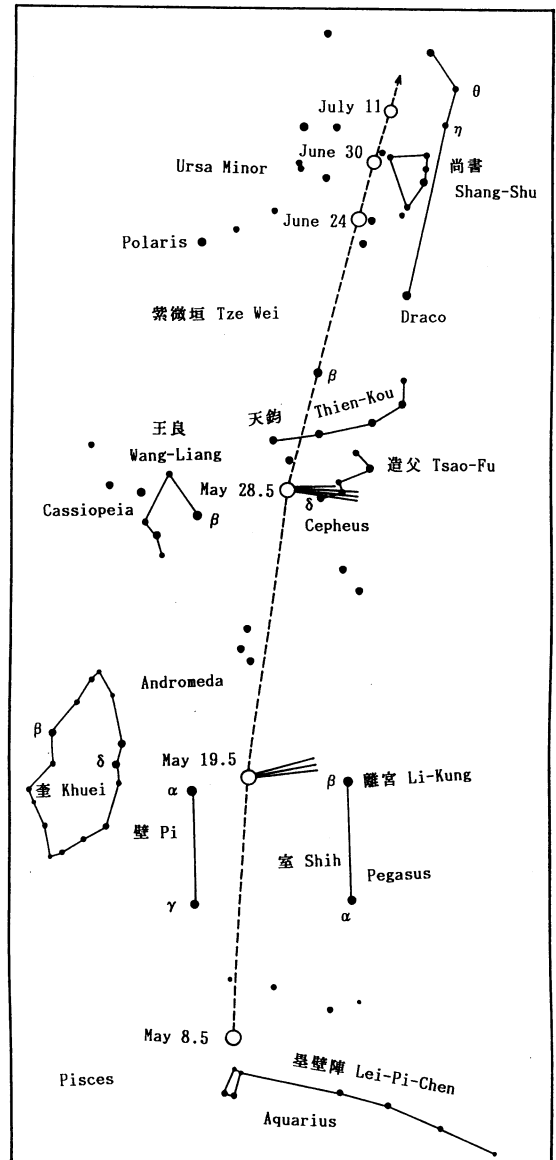

Fig. 2. The computed path of Comet 1500 H1 = Comet 1861 J1(1861 II) from May 8.5 to July 11 in 1500.

Tao, and disappeared in the morning. On the day of ting-ssu-54 (June 8), at night it appeared at Tse-Hsing. On the day of wu-wu-55 (June 9) it appeared at the northwest of Wang-Liang. On the day of chi-wei-56 (June 10) it appeared between Hua-Kai and Chhuan-She. On the day of keng-shen-57 (June 11) it appeared in Hua-Kai. On the day of hsin-yu-58 (June 12) it was below Hua-Kai and the north of Lu-Chia. On the day of kuei-hai-60 (June 14), at night it went into the stars of Nu-Yu-Kung.] [高麗史 (Koryo-sa);

Sekiguchi 1917a, p188; Ho 1962, p187]

天永元 (天仁三) 年五月十二日庚戌、彗星東ニ見ハル、長サ六尺、六月十日ニ至リ滅ス [On the 12th day kanoe-inu-47 in the fifth month of the first year of the Ten-ei (the third year of the Tennin) reign period (June 1), a comet appeared in the east. It was 6 syaku (6°) in length. On the 10th day in the sixth month (June 28), it disappeared.] (Kanda 1935, p505)

In table 1, the orbital elements determined from three positions of the comet recorded in 1110 (Comet 1110

Table 1.   Orbital elements of Comet 1110 K1
derived from historical records.

Observations: 1110 May 29, June 6, and June 11

$$T = 1110 \text{ May } 18.0 \text{ TT} \quad \omega = 358°$$
$$q = 0.83 \text{ AU} \qquad\qquad \Omega = 321° \left.\right\} 2000.0$$
$$\qquad\qquad\qquad\qquad\qquad i = 137°$$
(Hasegawa 1979)

Table 2.   Linkage of Comet Pons-Gambart
(D/1827 M1) with Comet 1110 K1.

Observations in 1110:

1110 TT	$\alpha(2000)\delta$		$\Delta\alpha\cos\delta$	$\Delta\delta$
May 29.8	$1^h 42^m$	$+27$	$+0°5$	-0.1
June 6.5	2 00	$+55$	-0.3	$+1.3$
June 12.5	4 00	$+80$	-0.9	$+0.7$

Orbital elements:

	Comet 1110 K1	Comet Pos-Gambart (D/1827 M1)
Epoch =	1110 June 5.0	1827 June 13.0 TT
$T =$	1110 May 30.07	1827 June 7.70297 TT
$q =$	0.8289724	0.8067023 AU
$e =$	0.9490136	0.9503946
$a =$	16.258699	16.262402 AU
$P =$	65.56	65.58 yr
$\omega =$	19°2056	19°3111
$\Omega =$	318°9585	320°0607 } 2000.0
$i =$	135°8745	136°4518
Number of Observations	3	50
r.m.s.	$\pm0°7$	$\pm14''3$

K1) are given. This orbit resembles that of the Periodic Comet Pons-Gambart (D/1827 M1), and a possible identification was suggested (Hasegawa 1979). The periodic orbit of Comet Pons-Gambart (D/1827 M1) was determined by Ogura (1917). Nakano (1985; presented in Marsden, Green 1985) improved the orbit using the newly determined positions of comparison stars used for observation of the comet in 1827.

New sets of orbital elements were determined including the planetary perturbations. The results are given in table 2, and the period of the comet in 1827 was derived to be 65.6, which is nearly equal to the value of 64 given by Ogura (1917). The residuals for the positions of the comet in 1110 were calculated from the linked orbit, and are given under the headings of $\Delta\alpha\cos\delta$ and $\Delta\delta$ in table 2. The path of Comet 1110 K1 is shown in figure 1 along with the Chinese constellations indicated in the historical records given above. We can see a good fit of the path and the positions of the comet compared to the records.

Table 3. Estimations of the absolute magnitude
of Comet Pons-Gambart (D/1827 M1).

Date	Elongation	Δm	m_1	H_{10}^*	Sources
1110 May 29.8	54°	-1.7	5	6.7	This paper
June 28.5	63	-0.4	6	6.4	This paper
1827 June 24	58	-2.0	5	7	Vsekhsvyatskii (1964)
Adopted value				6.5	

* $H_{10} = m_1 - \Delta m$, where $\Delta m = 5\log\Delta + 10\log r$, Δ is the geocentric, and r is the heliocentric distance of comet.

To settle the observing conditions for naked-eye comets, the total visual magnitude, the elongation from the Sun, and the altitude of the comet are needed. The elongation and altitude are calculated from the orbital elements; however, we must know the absolute magnitude H_{10} in order to calculate the visual magnitude of a comet m_1. In order to estimate H_{10}, we assumed the discovery magnitude of a naked-eye comet to be 5, and the magnitude of a comet when it disappears at the high altitude to be 6. For Comet Pons-Gambart (D/1827M1), the adopted value of H_{10} is given in table 3. In table 4, the orbital elements and the observing conditions are given for every perihelion passage between -194 and 2022. In the column of Observing conditions, ◯ is given for a good condition, and × for poor. In Notes, the historical records of comets appeared in the year of the perihelion passage of Comet Pons-Gambart (D/1827 M1), and some remarks concerning identifications are appended. In the year 1239 (Note 12), the most probable record for Comet Pons-Gambart (D/1827 M1) is given; however, because the maximum brightness is estimated to be fainter than 5 mag on 1239 May 21, it seems to be likely that sufficient descriptions of the comet for orbit determination have not been recorded. Between -194 and 1956, unfortunately, there have been few returns of Comet Pons-Gambart (D/1827 M1) with good observing conditions, except in 1110 and 1827. The next return is expected to be in 2022.

3. Great Comet in 1861(Comet 1861 J1 = 1861 II) and Comet 1500 H1

Comet Pons-Gambart (D/1827 M1) was predicted to return to its perihelion in 1500 (see table 4); in that year a bright comet was recorded in both Chinese and Japanese historical records; however, it was not identified with Comet Pons-Gambart (D/1827 M1). The orbit of Comet 1500 H1 was already published by Hind (1861) and Hasegawa (1979); however, there are follow-

Table 4. Orbital elements and observing conditions of Comet Pons-Gambert (D/1827 M1=1827 II) linked with Comet 110 K1.

T (TT)	q (AU)	e	ω	Ω (2000.0)	i	Epoch (0h TT)	Observing conditions*	Note
−194 Mar. 26	0.838	0.9490	18.°5	317.°0	136.°0	−194 Mar. 23	×	1
−129 Feb. 16	0.839	0.9485	18.4	317.0	136.1	−129 Mar. 2	×	
− 63 Jan. 2	0.837	0.9488	18.5	317.2	136.1	− 64 Dec. 25	×	
1 Apr. 7	0.838	0.9483	18.4	317.1	136.2	1 Apr. 8	×	2
66 Apr. 17	0.844	0.9479	18.6	317.3	136.0	66 Apr. 27	×	3
130 Apr. 13	0.839	0.9482	18.5	317.3	136.1	130 Apr. 11	×	4
195 June 10	0.840	0.9482	18.6	317.4	136.0	195 June 9	○	5
259 Nov. 20	0.835	0.9485	18.6	317.5	136.1	259 Dec. 10	×	6
325 Feb. 9	0.837	0.9485	18.7	317.7	136.1	325 Feb. 6	×	
389 Oct. 17	0.838	0.9485	18.9	317.9	136.0	389 Oct. 28	×	7
455 June 25	0.840	0.9486	19.1	318.1	135.7	455 July 14	○	8
521 Feb. 12	0.835	0.9493	19.1	318.2	135.7	521 Feb. 17	×	
587 Aug. 21	0.835	0.9492	19.2	318.4	135.8	587 Aug. 10	○	9
652 Oct. 19	0.831	0.9493	19.1	318.4	136.0	652 Oct. 7	×	
719 Mar. 14	0.829	0.9496	19.1	318.5	135.9	719 Mar. 30	×	10
784 May 17	0.828	0.9494	19.0	318.5	136.0	784 May 27	×	
850 July 21	0.826	0.9496	19.1	318.7	136.0	850 July 20	○	
914 Dec. 31	0.830	0.9489	19.0	318.7	136.2	914 Dec. 11	×	
980 July 28	0831	0.9491	19.3	318.9	135.8	980 July 17	×	
1044 Dec. 26	0830	0.9489	19.1	318.8	135.9	1044 Dec. 8	×	
1110 May 30.1	0.8290	0.9490	19.2	319.0	135.9	1110 June 5	○	
1174 June 20.5	0.8260	0.9490	19.1	319.0	136.2	1174 June 29	○	11
1239 Apr. 15.4	0.8270	0.9488	19.2	319.1	136.2	1239 Apr. 29	○	12
1303 Oct. 25.7	0.8199	0.9497	19.3	319.3	136.1	1303 Oct. 30	×	13
1369 July 19.5	0.8209	0.9497	19.4	319.5	135.9	1369 July 15	○	
1434 Oct. 29.3	0.8153	0.9503	19.3	319.5	136.0	1434 Oct. 22	×	14
1500 Dec. 31.7	0.8167	0.9501	19.4	319.7	136.0	1500 Dec. 14	×	15
1565 Oct. 31.1	0.8131	0.9503	19.4	319.8	136.1	1565 Oct. 14	×	
1631 Nov. 29.4	0.8093	0.9506	19.4	319.9	136.2	1631 Dec. 17	×	
1696 Dec. 12.7	0.8074	0.9506	19.3	319.9	136.2	1696 Nov. 25	×	
1762 Dec. 25.3	0.8067	0.9507	19.4	320.1	136.3	1762 Dec. 10	×	
1827 June 7.7	0.8067	0.9504	19.3	320.1	136.5	1827 June 13	○	
1892 June 12.1	0.8111	0.9500	19.4	320.2	136.4	1892 July 1	○	16
1956 Sept. 2.3	0.8044	0.9505	19.4	320.2	136.5	1956 Sept. 4	×	
2022 Jan. 31.4	0.8052	0.9505	19.4	320.4	136.4	2022 Jan. 21		

* Observing conditions: ○ for good, and × for poor conditions. See the text.
Notes:

1. −194. En−194, Mithridate naquit; on vit une comète. (Pingré 1783, p266)

2. 1. L'an 1, comète ou flambeau ardent dans le Lion, pendant trois nuits. (Pingré 1783, p283) This is not Comet Pons-Gambart (D/1827 M1) which was seen in Andromeda.

3. 66. In February, 1P/Halley was seen in Capricornus.

4. 130. Comète tres-favorable a Usard, roi d'Angleterre. (Pingré 1783, p291)

5. 195? En 195, du temps de l'empereur Severe, on vit une comète. (Pingré 1783, p295)

Table 4. (continued)

6. 259. 甘露四年十月丁丑客星見太微中転東南行歴軫宿積七日滅 [On the day of ting-chhou-14 in the tenth month of the fourth year of the Kan-Lu reign period (259 November 23) a guest star was seen in the region of Leo–Virgo. It moved to the southeast and passed Corvus. It disappeared after seven days.] [晋書天文志 (Chin Shu, Celestial Phenomena), vol 13, p390; Ho 1962, p156; Beijing Observatory 1988, p393]

This is not Comet Pons-Gambart (D/1827 M1) which was seen in Scorpius.

7. 389. A strange and unusual star was seen in the sky... it shone at first in the middle of the night near Venus in the east in what they call the zone of the zodiac (Philostorgius). A star rising in the northeast and blazing in the manner of Venus, rather than gleaming, made its appearance, and on the twenty-sixth day ceased to be. (Marcellinus). (Pingré 1783, pp303–305; Barrett 1978, p104)

This is not Comet Pons-Gambart (D/1827 M1) which was seen in the southwest after sunset.

8. 455. La mort de Valentinien fut precedee de l'apparition d'une comète. Valentinien fut tué le 16 Mars 455. (Pingré 1783, p313)

This may be Comet Pons-Gambart (D/1827 M1) which was seen in the north at the end of June.

9. 586 ou 587. En la quatrieme année de l'empereur Maurice, on vit une comète environnee d'un nuage sombre. (Pingré 1783, p324)

Comet Pons-Gambart (D/1827 M1) was bright in the west in 587 August.

10. 719. Comète dans le Sagittaire. (Pingré 1783, p334)

This is not Comet Pons-Gambart (D/1827 M1) which was seen in the north.

11. 1174. Pingré (1783, p629) gives a wrong year of 1174 for a Chinese record of a comet instead of 1175.

12. 1239. 延応元年四月廿三日壬戌天霽戌刻乾方有妖気光芒指巽長八尺広一尺色白赤 [On the 23rd day in the fourth month of the first year of the En-O reign period (1239 May 27), the sky was clear and at 8 o'clock in the evening, an evil star was seen in the northwest. Its tail pointed to the southeast, and 8 syaku (about 8°) in length, 1 syaku (about 1°) in width, and white-red in color]. [吾妻鏡 (Azuma-kagami), Kanda 1935, p532]

Le 3 Juin, on vit une Etoile chevelue, accompagnee d'un Astre. (Pingré 1783, p403)

Probably this is Comet Pons-Gambart (D/1827 M1) which was located at $\alpha = 11^{\rm h} 51^{\rm m}$, $\delta = +76°$ (1239 equinox) on 1239 May 27.

13. 1303. 嘉元元年六月十三日彗星艮方芒気一尺余其色白有軸星 [On the 13th day in the sixth month of the first year of the Ka-Gen reign period (1303 July 27) a comet was seen in the northeast. Its tail was about 1 syaku (1°) in length, white in color and had an axis-star.] [師守記 (Moromoriki), Kanda 1935, p552]

On vit une comète en automne durant un mois. (Pingré 1783, p424)

This is not Comet Pons-Gambart (D/1827 M1) which was located at $\alpha = 4^{\rm h} 42^{\rm m}$, $\delta = -20°$ (1303 equinox) on 1303 July 27.

14. 1434. 永享六年八月九日彗星東ニ見ハル [On the ninth day in the eighth month of the sixth year of Ei-Kyo reign period (1434 September 11) a comet appeared in the east.] (Kanda 1935, p574; Ho 1962, p202)

This is not Comet Pons-Gambart (D/1827 M1) which was located near the south pole on 1434 September 11.

15. 1500. The orbit of a comet which appeared in 1500 was calculated; This comet is not Comet Pons-Gambart (D/1827 M1). See section 3.

16. 1892. 1) 光緒十八年三月彗星見 [In the third month of the 18th year of the Kuang-Hsu reign period (1892 March 28–April 26) a comet was seen.] (Ho, Ang 1970, p88; Beijing Observatory 1988, p552)

This is Comet Swift (1892 E1 = 1892 I).

2) 光緒十八年九月夜半彗星見東方 [In the ninth month of the 18th year of the Kuang-Hsu reign period (1892 October 21–November 18) at midnight, a comet was seen in the east.] (Beijing Observatory 1988, p552)

Probably, this is not Comet Pons-Gambart (D/1827 M1).

ing records in China and Japan.

弘治十三年四月甲午彗星見室宿塁壁陣上. 丙申夜彗星見室宿西北. 己亥夜彗星見室壁乃間芒長尺余. 乙巳彗星芒長三尺余尾指離宮. 五月甲寅夜彗星掃造父星. 丁卯夜彗星行過紫微垣漸微. 辛

巳夜彗星入紫微垣近女史. 六月丁亥彗星達犯尚書星. 戊戌夜彗星不見 [On the day of chia-wu-31 in the fourth month of the 13th year of the Hung-Chih reign period (1500 May 8), a comet appeared above Lei-Pi-Chen in Ying-Shih (13th
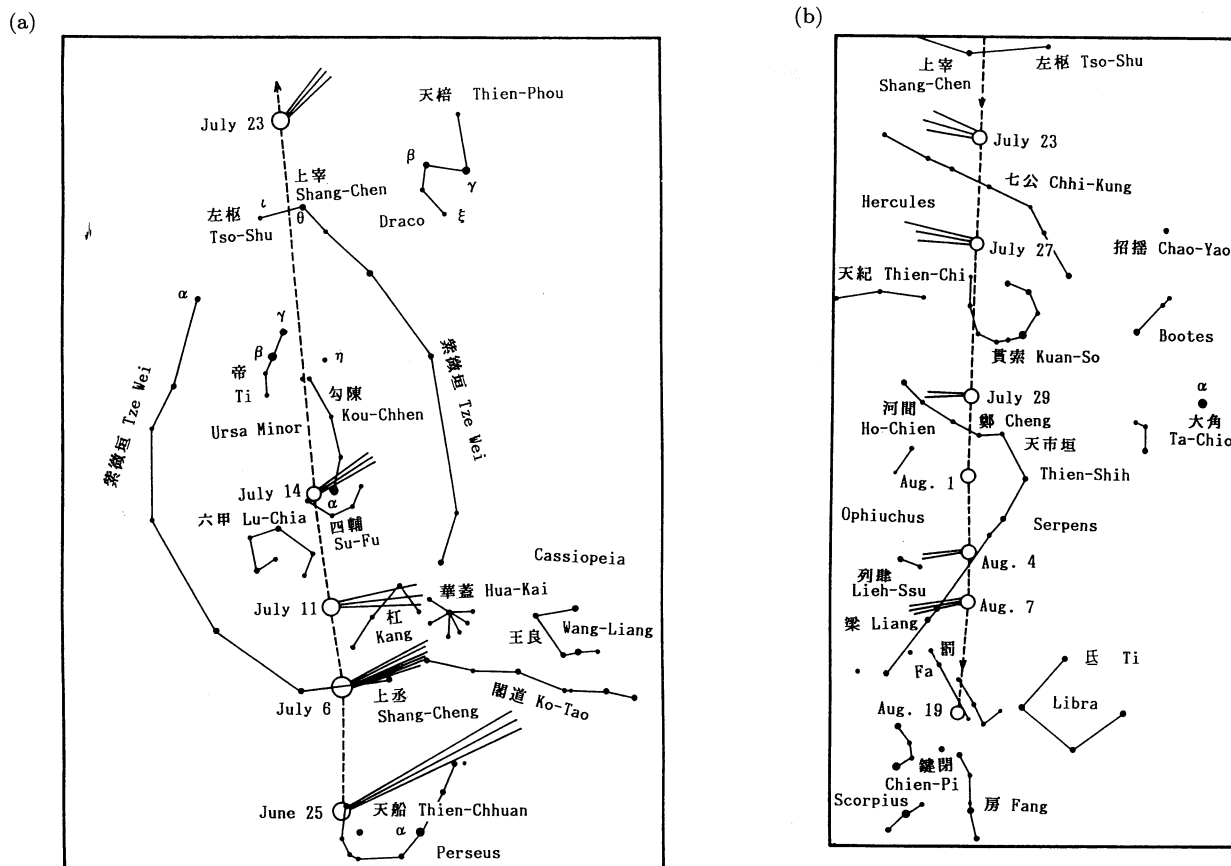
Fig. 3. The computed path of Comet 1337 M1 in 1337: a) during June 25 and July 23, b) during July 23 and August 19.

lunar mansion). On the night of the day of ping-shen-33 (May 10), it appeared in the northwest of Ying-Shih. On the night of a day of chi-hai-36 (May 13), it apperared between Ying-Shih and Tung-Pi (14th lunar mansion), and its ray was over one chih (1°). On the day of i-ssu-42 (May 19), its ray was more than three chih (3°) pointing to Li-Kung. On the night of a day of chia-yin-51 of the fifth month (May 28) it swept past Tsao-Fu. On the night of the day of ting-mao-4 (June 10), it passed the Tzu-Wei Enclosure, and became smaller. On the night of the day of hsin-ssu-18 (June 24), it entered the Tzu-Wei Enclosure approaching Nu-Shih. On the day of ting-hai-24 in the sixth month (June 30), it trespassed Shang-Shu. On the night of the day of wu-hsu-35 (July 11) it disappeared.] [明孝宗実録 (Ming Xiao-tsung Shih-lu), vol161, p2; Beijing Observatory 1988, p432]

弘治十三年四月甲午彗星見壘壁陣上, 入室壁間, 漸長三尺余指離宮, 掃造父, 過太微垣漸微, 入紫微垣近女史犯尚書. 六月丁酉没 [On the day of

chia-wu-31 (May 8), a comet appeared above Lei-Pi-Chen. It entered between Ying-Shih and Tung-Pi and increased its length to over three chih (3°), pointing towards Li-Kung, and swept Tsao-Fu. After passing the Thai-Wei Enclosure it became smaller. It then entered the Tzu-Wei Enclosure, approached Nu-Shih and trespassed against Shang-Shu. On the day of ting-yu-34 in the sixth month (July 10) it went out of sight.] [明史天文三 (Ming Shih, Celestial Phenomena), vol27, p408; Ho 1962, p208; Beijing Observatory 1988, p432]

明応九年五月四日、子時彗星見丑方、在内杵星長二尺所未方指光芒色白 [On the 4th day in the fifth month of the ninth year of the Mei-O reign period (May 31), at midnight, a comet appeared in the north-northeast. It was at the Naiki stars, and two syaku (2°) in length, pointing towards the south-southwest. Its ray was white.] [後法興院政家記 (Gohokoin-masaieki), Kanda 1935, p588]

Table 5. Orbital elements of Comet 1500 H1
derived from historical records.

Observations:

1500 TT	α (2000)	δ	$\Delta\alpha \cos\delta$	$\Delta\delta$
May 8.5	$23^h 50^m$	$0°$	$-3°.8$	$-0°.1$
May 19.5	23 40	$+30$	$+2.4$	-2.0
May 28.5	23 00	$+60$	$+2.8$	$+4.1$
June 24.5	17 30	$+73$	$+1.8$	-1.3
June 30.5	16 30	$+70$	$+0.7$	-2.4

Orbital Elements:

$$T = 1500 \text{ April } 25.9 \text{ TT}$$
$$q = 0.87352 \text{ AU}$$
$$\left.\begin{array}{l} \omega = 338°.7 \\ \Omega = 276°.7 \\ i = 81°.6 \end{array}\right\} 2000.0$$

* Residuals are calculated from the linked orbit given in table 6.

Table 6. Orbital elements for Comet 1861 J1
(1861 II) linked with Comet 1500 H1 .

	Comet 1500 H1	Comet 1861 J1(1861 II)
Epoch =	1500 April 18.0	1861 May 25.0 TT
T =	1500 April 20.98293	1861 June 12.00620 TT
q =	0.8273041	0.8223812 AU
e =	0.9843676	0.9850415
a =	52.9224374	54.9775567 AU
P =	385.00	407.64 yr
$\omega =$	$330°.19150$	$330°.08321$
$\Omega =$	$281°.12119$	$280°.90995$
$i =$	$85°.71463$	$85°.44241$
Number of Observations	5	87
r.m.s.	$\pm3°.1$	$\pm3''.16$

(The last three elements ω, Ω, i referred to 2000.0)

The orbit of Comet 1500 H1 was re-determined, and is given in table 5. After that, we immediately found that the orbit of Comet 1861 J1 = 1861 II resembled the orbit of Comet 1500 H1. The orbits of Comet 1861 J1 and Comet 1500 H1 have been successfully linked, and the osculating period of Comet 1861 J1 was derived to be 407.6 yr. Those results are given in table 6 along with the predicted orbital elements between −141 and 2265 in table 7 for further discussions.

The path of Comet 1500 H1 is shown in figure 2. In a similar way as in the case of Comet Pons-Gambart(D/1827 M1), the absolute magnitude and the observing conditions were estimated, and are presented in tables 7, 8, and 9.
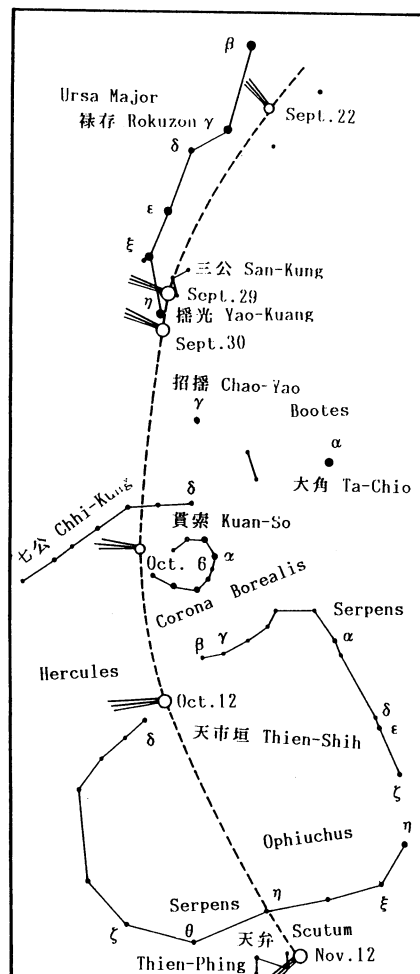

Fig. 4. The computed path of Comet 1468 S1 in 1468 during September 22 and November 12.

4. Comet 1337 M1 and Comet 1468 S1

Judging from the resemblance between the orbital elements, an identification of Comet 1337 M1 with Comet 1468 S1 has already been discussed (Hasegawa 1979). The historical records of these comets are as follows:

Comet 1337 M1:

忠肅王・後六年五月丙寅彗見長丈余自天船北至王良閣道 [On the day of ping-yin-3 in the fifth month of the late sixth year of Ch'ungsuk Wang (1337 June 25) a comet appeared. Its length was over 10 ft. It moved from the north of Thien-Chhuan to Wang-Liang and Ko-Tao.] [高麗史 (Koryo-sa); Sekiguchi 1917a, p191; Ho 1962, p196, Ho gives the wrong dates in his No.452 (Hasegawa 1979).]

Table 7. Predicted orbital elements of Comet 1861 J1(1861 II) between −141 and 2265.

T (TT)		q (AU)	e	ω	Ω (2000.0)	i	Epoch (TT)	
−141	Jan. 5.6	0.82613	0.98491	330°17	281°29	85°41	−141	Jan. 4.0
260	Jan. 8.5	0.82225	0.98586	330.26	281.46	85.11	260	Jan. 19.0
695	Oct. 16.9	0.82656	0.98564	330.30	281.42	85.26	695	Oct. 22.0
1110	June 4.0	0.82744	0.98508	330.25	281.28	85.45	1110	June 5.0
1500	Apr. 21.0	0.82730	0.98437	330.19	281.12	85.71	1500	Apr. 18.0
1861	June 12.0	0.82238	0.98504	330.08	280.91	85.44	1861	May 25.0
2265	Dec. 6.0	0.82881	0.98582	330.05	280.96	85.14	2265	Dec. 13.0

Table 8. Estimation of the absolute magnitude of Comet 1861 J1(1861 II) =Comet 1500 H1.*

Date	Elongation	δ_{2000}	Δm	m_1	H_{10}	Sources
1500 July 10	81°	+65°	+2.9	6.0	3.1	This paper
1861 June–July	—	—	—	—	3.9	Vsekhsvyatskii (1964)
Adopted value					3.5	

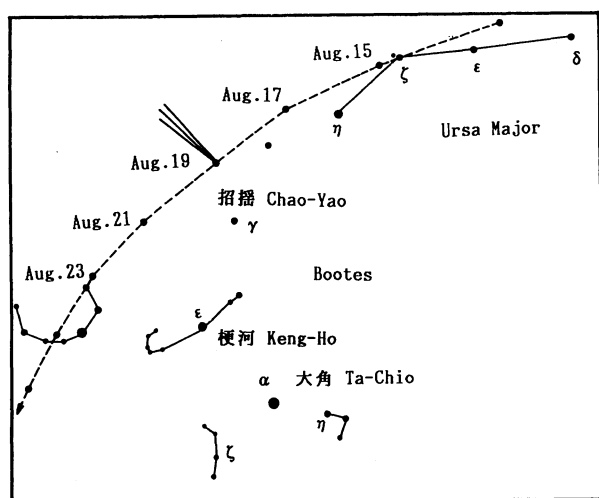* H_{10}, m_1, and Δm are the same as those in table 3.

Fig. 5. The computed path of Comet 1337 M1 = Comet 1468 S1 in −103 during August 15 and 23 (see note 1 to table 12).

順帝至元三年五月丁卯彗星見干東北如天船星大色白約長尺余彗彗指西南測在昴五度八月庚午（三日）彗星不見 其星自五月丁卯始見 戊辰往西南行日益漸速至六月辛未（二日）芒彗愈長約二尺余 丁丑上丞 己卯光芒愈甚約長三尺余入圜衛 壬午掃華蓋杠星乙酉掃勾陳大星及天皇大帝 丙戌貫四輔

経枢心 甲午出圜衛 丁酉出紫微垣 戊戌犯貫索掃天紀 七月庚子（二日）掃河間 癸卯経鄭晋入天市垣 丙午掃列肆 己酉（十一日）太陰光盛微弁芒彗出天市垣掃梁星至辛酉光芒微小瞻在房宿鍵閉之上罰星中星正西難測日漸南行 至是凡見六十有三日 自昴至房凡歷一十五宿而滅 [On the day of ting-mao-4 in the fifth month of the third year of the Chih-Yuan reign period (1337 June 26), a comet appeared at the northeast. It was as large as the star of Thien-Chhuan, white in color, and about one chih (1°) or more. The comet pointed southwest and was measured at the fifth degree in the Mao lunar mansion. On the day of keng-wu-7 in the eighth month (August 28) the comet went out of sight. Since the day of ting-mao-4 in the fifth month (June 26), it has been seen. On the day of wu-chhen-5 (June 27), it went to the southwest while increasing its speed daily. Until the day of hsin-wei-8 in the sixth month (June 30) its ray increased to more than two chih (2°). On the day of ting-chhou-14 (July 6) it swept past Shang-Cheng. On the day of chi-mao-16 (July 8) its rays grew to about 3 chih (3°) more and entered Huan-Wei. On the day of jen-wu-19 (July 11) it swept past Hua-Kai and Kang-Hsing. On the day of i-yu-22 (July 14) it swept past the large star of Kou-Chhen and Thien-Huang-Ta-Ti. On the day of ping-hsu-23

Table 9. Estimation of the observing conditions for Comet 1861 J1(1861 II) at latitude +35°.

Date	Twilight	Azimuth*	Altitude*	Elongation	Δm	m_1	Note
−141 Jan. 18	Morning	129°	+5°	21°	+0.5	4.0	
−141 Mar. 19	Morning	93	+53	59	+3.0	6.5	
260 Jan. 19	Morning	129	+4	20	+0.4	3.9	1
260 Mar. 22	Morning	88	+54	60	+3.1	6.6	
695 Nov. 30	Evening	256	+13	21	+2.2	5.7	
695 Dec. 20	Evening	270	+11	30	+3.2	6.7	
1110 June 20	Evening	280	+14	32	−4.5	−1.0	2
1110 Aug. 19	Evening	295	+64	70	+2.9	6.4	

* The horizontal coordinates of the comet are calculated for the beginning or the ending of the astronomical twilight. The azimuth is measured from north, as the 0° point, to east, south, west, and north (360°).

Notes

1. 260. 新羅沾解王十四年秋七月星孛東方二十五日而滅 [In the seventh month of autumn in the 14th year of the Chomhae Wang (260 July 25–August 23) a comet was in the east, and after 25 days, it disappeared.] [三国史記 (Samguk Sagi); Sekiguchi 1917a, p179; Ho 1962, p157]
This is not Comet 1861 J1 (1861 II).

2. 1110. During May 29 and June 28, Comet Pons-Gambart (D/1827 M1 = 1827 II) was seen in the north (see section 2).

(July 15) it penetrated Ssu-Fu and passed Shu-Hsin. On the day of chia-wu-31 (July 23) it left Huan-Wei. On the day of ting-yu-34 (July 26) it left the Tzu-Wei Enclosure. On the day of wu-hsu-35 (July 27) it trespassed against Kuan-So and swept Thien-Chi. On the day of keng-tzu-37 in the seventh month (July 29) it swept past Ho-Chien. On the day of kuei-mao-40 (August 1) it passed Cheng and Chin and entered the Thien-Shih Enclosure. On the day of ping-wu-43 (August 4) it swept past Lieh-Ssu. On the day of chi-yu-46 (August 7) its rays were barely seen under the brightness of the moon, and the comet left the Thien-Shih Enclosure and swept past the star Liang. On the day of hsin-yu-58 (August 19) its rays become smaller at the Fang lunar mansion above Chien-Pi and to the west of the central star of Fa-Hsing. Measurements became difficult. It moved daily southward. It has been seen for 63 days moving from the Mao lunar mansion to the Fang lunar mansion and went out of sight after passing 15 lunar mansions.] [元史・天文二 (Yuan Shih, Celestial Phenomena); Beijing Observatory 1988, p423; Ho 1962 p196; Pingré 1783, pp429,432]

Comet 1468 S1:

憲宗成化四年九月己未夜、客星見星五度、東北行

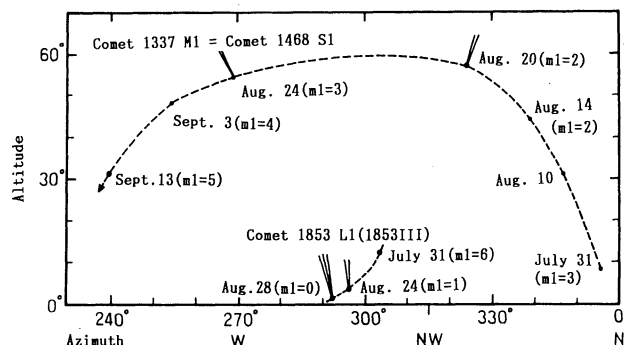Fig. 6. The computed paths presented in the horizontal coordinate of Comet 1337 M1 = 1468 S1 from July 31 to September 13 and of Comet 1853 L1 (1853 III) from July 31 to August 28 in 1853 (see note 2 to table 12).

癸亥夜、客星色蒼白光芒長三丈余、尾指西南、変為彗星　戊辰彗星晨見東北方　己巳彗星昏見西南方　庚午昏刻彗星犯三公星　辛未昏刻彗星犯北斗揺光星　丁丑昏刻彗星犯七公西第四星壬午昏刻彗星入天市垣　十月乙巳彗星出天市垣其体漸小　甲寅彗星犯天塀西第一星十一月庚申夜彗星滅 [On the day of chi-wei-56 in the ninth month of the fourth year of the Chheng-Hua reign pe-

Table 10. Linked orbital elements of Comet 1337 M1 and Comet 1468 S1.

Observations and residuals:

	TT		α (2000) δ			$\Delta\alpha\cos\delta$	$\Delta\delta$
1337	July	6.5	$4^h\,30^m$	$+65°$		$+1°\!.8$	$-0°\!.3$
	July	11.5	4 36	$+74$		$+1.0$	-2.1
	July	14.5	7 00	$+87$		$+2.4$	$+1.5$
	July	27.5	16 00	$+28$		$+0.3$	-0.4
	July	29.5	16 00	$+20$		$+0.1$	-0.1
	Aug.	1.5	16 00	$+13$		-0.2	$+2.9$
	Aug.	4.5	16 05	$+2$		$+0.8$	-0.7
	Aug.	7.5	16 10	-4		$+1.7$	-1.1
	Aug.	19.5	16 13	-18		$+1.1$	-2.3
1468	Sept.	22.5	11 36	$+53$		$+1.4$	$+2.8$
	Sept.	29.5	13 25	$+50$		-2.9	$+0.2$
	Sept.	30.5	13 50	$+49$		-2.3	$+0.3$
	Oct.	6.5	16 00	$+37$		$+1.8$	-0.8
	Oct.	12.5	17 10	$+23$		$+3.1$	-1.3
	Nov.	12.5	18 35	-8		-0.1	$+1.4$

Orbital Elements:

Epoch $=$	1337 June 13.0	1468 October 3.0 TT
$T =$	1337 June 18.328	1468 October 12.462 TT
$q =$	0.82901	0.83431 AU
$e =$	0.96833	0.96780
$a =$	26.177	25.910 AU
$P =$	133.93	131.89 yr
$\omega =$	$95°\!.022$	$94°\!.954$
$\Omega =$	$104°\!.972$	$105°\!.113$ } 2000.0
$i =$	$138°\!.039$	$137°\!.984$

r.m.s.$= \pm1°\!.61$ from 15 observations in 1337 and 1468.

Table 11. The absolute magnitude of Comet 1337 M1 = Comet 1468 S1.

TT		δ_{2000}	Elongation	Δm	m_1	H_{10}	Remarks
1337 June	25	$+52°$	$48°$	-0.7	3.8	4.5	η Per
June	25	$+52$	48	-0.7	1.8	2.5	α Per
Aug.	28	-21	73	$+2.5$	6	3.5	
Mean						3.5	
1468 Sept.	18	$+47$	59	-0.5	4	4.5	
Nov.	16	-11	32	$+1.4$	5	3.6	
Dec.	8	-19	12	$+3.0$	6	3.0	
Mean						3.7	

fourth star at the west of Chhi-Kung. On the evening of the day of jen-wu-19 (October 11) the comet entered the Thien-Shih Enclosure. On the day of i-ssu-42 in the tenth month (November 3) the comet left the Thien-Shih Enclosure and gradually diminished in size. On the day of chia-yin-51 (November 12) the comet trespassed against the first star at the west of Thien-Phing. On the night of the day of keng-shen-57 in the eleventh month (November 18) the comet disappeared. [明憲宗実録 (Ming Chheng-Hua Shih-lu); Beijing Observatory 1988, pp430-431; Ho 1962, p205]

応仁二年九月六日丑時彗星出丑方近北斗禄存星其間二尺芒光射貪狼星指未方至寅時軸星転東方光気指西其色白其長丈余同十一日猶止本所不去也 [On the sixth day of the ninth month of the second year of O-Nin reign period (1468 September 22) at 2 o'clock in the morning a comet appeared in the northeast near to the star Roku-zon in Hokuto (γ Ursae Majoris). Its distance from the star was 2 syaku (2°), and its rays pointed towards the star Donro (α Ursae Majoris), pointing towards the southwest. At 4 o'clock, the axis-star turned to the east, and its rays pointed towards the west. Its color was white and its length was more than 1 zyô (10°). On the eleventh day (September 27) it was still staying there.] [家秘要録仮第一冊 (Kahiyoroku, vol1); Kanda 1947, p40]

世宗十四年九月癸未入天市垣北東垣第一星西南三尺光芒可三十尺 [On the day of kuei-wei-20 in the ninth month of the 14th year of Sejo (1468 October 12) a comet entered the Thien-Shih Enclosure. It was at 3 chhih (3°) in the southwest

...riod (1468 September 18) a star appeared at the fifth degree of the Chhi-Hsing lunar mansion, and moved towards the northeast. On the night of the day of kuei-hai-60 (September 22) its color was white-blue and its rays were 3 chang (30 chih, about 30°) in length. Its tail pointed towards the southwest, and changed into a comet. On the morning of the day of wu-chhen-5 (September 27) the comet appeared in the northeast. On the evening of the day of chi-ssu-6 (September 28) the comet appeared in the southwest. On the evening of the day of keng-wu-7 (September 29) the comet trespassed upon the star of San-Kung. On the evening of a day of hsing-wei-8 (September 30) the comet trespassed against the star of Yao-Kuang in Pei-Tou. On the evening of the day of ting-chhou-14 (October 6) the comet trespassed against the

Table 12. Predicted orbital elements of Comet 1337 M1 = Comet 1468 S1 between −103 and 2117.

T (TT)	q (AU)	e	P (yr)	ω	Ω (2000.0)	i	Epoch (TT)	Note
−103 Aug.　8.4	0.8448	0.9670	129.7	96°.3	104°.2	138°.0	−103 July　23.0	1
26 Oct.　19.8	0.8381	0.9677	132.1	96.2	104.3	138.0	26 Oct.　14.0	
157 Dec.　16.4	0.8308	0.9683	134.3	96.2	104.5	138.0	157 Dec.　25.0	
291 May　24.6	0.8294	0.9683	133.9	96.0	104.5	138.1	291 May　16.0	
424 Feb.　1.3	0.8314	0.9682	133.7	95.8	104.5	138.0	424 Feb.　7.0	
555 Feb.　7.8	0.8379	0.9676	131.6	95.7	104.6	138.0	555 Jan.　30.0	
683 Sept.　28.1	0.8440	0.9670	129.2	95.6	104.6	138.0	683 Oct.　5.0	
811 Feb.　7.6	0.8419	0.9671	129.6	95.5	104.7	138.0	811 Feb.　15.0	
940 Feb.　17.5	0.8357	0.9678	132.1	95.5	104.8	138.0	940 Feb.　18.0	
1071 Feb.　21.9	0.8295	0.9684	134.4	95.5	105.0	138.0	1071 Feb.　10.0	
1204 Aug.　4.1	0.8285	0.9684	134.0	95.3	105.0	138.1	1204 Aug.　10.0	
1337 June　18.3	0.8290	0.9683	133.9	95.0	105.0	138.0	1337 June　13.0	
1468 Oct.　12.5	0.8343	0.9678	131.9	95.0	105.1	138.0	1468 Oct.　3.0	
1597 Aug.　3.4	0.8412	0.9671	129.5	94.9	105.3	137.9	1597 July　28.0	
1724 Nov.　28.1	0.8417	0.9671	129.2	94.8	105.3	137.9	1724 Dec.　9.0	
1853 July　21.3	0.8358	0.9677	131.7	94.7	105.4	138.0	1853 July　6.0	2
1984 Mar.　22.0	0.8274	0.9684	134.3	94.7	105.6	138.0	1984 Apr.　10.0	
2117 July　23.7	0.8250	0.9685	134.1	94.6	105.7	138.1	2117 July　22.0	

Note:

1. −103 to −100 太初中星孛於招搖星 [During the Thai-Chhu reign period (during −103 and −100), a comet appeared at the star of Chao-Yao (γ Bootis). [漢書天文志 (Han Shu, Celestial Phenomena) vol26, p1306; Ho 1962, p145. See the text and figure 5.]
2. 1853 咸豐三年七月二十五日彗星見于北方 [On the 25th day in the seventh month of the third year of the Hsien-Feng reign period (1853 August 29), a comet was seen in the north.] (Beijing Observatory 1988, p519. See the text and figure 6.)

of the first star in the northeastern part of the Enclosure. Its rays were about 30 chih (30°) in length.] [李朝列聖実録 (Sejo Sillok); Sekiguchi 1917b, p100]

The estimated positions of these comets with their residuals derived from the linked orbital elements are also given in table 10.

The mean value of the absolute visual magnitude was derived to be 3.7 from the estimated comet's brightness; it is shown in table 11 with osculating orbital elements of between −103 and 2117 in table 12. Due to the position of its perihelion point relative to the Earth's orbit, the observing conditions for this comet are always good upon its return to the perihelion. The historical records of comets between −200 and 1860 were examined in order to obtain an identifications with Comet 1337 M1. For these trials, the orbital periods of 132 yr, 66 yr, and 33 yr were assumed in the calculations of the comet's motion; hence, as a result, the period of 132 yr was derived as the most probable one.

The possible candidates identified with Comet 1337 M1 were found in the records of comets appeared in −103

and 1853. The calculated motion of a comet in −103 is presented in figure 5. Though the exact dates of the record are unknown, the comet passed near γ Bootis as a Chinese record had reported (see note 1 to table 12).

Another Chinese record in 1853 says that a comet was seen in the north on August 29 (see note 2 to table 12). In 1853, although another bright comet (C/1853 L1 = 1853 III) appeared in the end of August, it set in the western horizon at the end of evening twilight, as shown in figure 6. According to calculations using the orbital elements given in table 12, Comet 1337 M1 appeared at a high altitude above the horizon in 1853 August, as shown in figure 6. Thus, the comet given in the Chinese record on 1853 August 29 is considered to be Comet 1337 M1.

5. Concluding Remarks

Though we have only two apparitions for each periodic comet, the identifications of three comets given here are likely to be well established. We expect that the final confirmations for each comet will be made by re-observations in the future with the predictions given above, or with so far undiscovered historical records of the comets.

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