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Ancient Oriental Records of Novae and Supernovae

Written records by Chinese, Korean, and Japanese observers are of great value to radioastronomers.

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Translated from the Chinese by K. S. Yang

When a star explodes to become a nova, its luminosity may increase within a few days by a factor of from several thousands to several tens of thousands; when it explodes to become a supernova, its luminosity may increase as much as 10^{11} times within a few days. But the latter phenomena are rarely seen: within our Milky Way no supernova has appeared for 360 years since the appearance of one in 1604 in the constellation Ophiuchus (*1*). On the average, about 50 novae appear each year, but few can be seen by the unaided eye; only five were so visible during the 19th century and 16 during the first 50 years of the 20th century (*2*). Under such circumstances astronomers must rely on historical records for research on novae and supernovae.

More than 110 years ago a French expert on China, Biot, had already noticed the rich collection of such materials in the Chinese records. From *Wen Hsien Tung Kao* (*3*) and *Hsü Wen Hsien Tung Kao* (*4*) he collected all the Chinese written records concerning observed visiting stars (including novae, comets, and even meteors) before 1640, and in 1846 he published an account that attracted tremendous attention in Europe (*5*). From then on, Humboldt (*6*) and Zinner (*7*) of Germany, Lundmark of Sweden (*8*), and Shan-p'en I-ch'ing (*9*) of Japan all edited and published historical records of novae according to these data, along with additional bits of information. Nevertheless, their data were incomplete: for example, in Zinner's catalogue the three supernovae that appeared in the years 1054, 1572, and 1604 were missing, while Shan-p'en I-ch'ing did not even include observations by people in his own country.

In 1955 we published *A New Catalogue of Ancient Novae,* which was based on the histories of China and Japan; it listed 90 probable novae that were directly observed between the 14th century B.C. (recorded on tablets) and 1700 A.D. (*10*), and has been widely used by astronomers throughout the world. However, after 9 years this catalogue seems obviously incomplete: the wealth of the Korean records had not been included, and some of the novae listed turned out to have been comets. Ho Ping-yü (Ho Peng-yoke) also pointed out several errors in 1962 (*11*).

Realizing the value of ancient records of novae to modern astronomical research, we have recently started a program, based upon material gathered from many sources, to reexamine and compare the Chinese, Korean, and Japanese historical records. Because of the loose terminology used in these ancient records it is difficult to differentiate between novae and comets, but by applying modern astronomical knowledge we have set up several criteria for distinguishing between them:

1) Those whose positions changed and those having tails were considered to be comets and excluded from the list, no matter how they had been recorded—as nova or as comet.

2) Those that were recorded only by direction, with no definite positional information: for example, those "in the east before sunrise" or "in the west after sunset" (in other words, very close to the sun) were not listed because they may have been comets.

3) Those located far from the Milky Way but close to the ecliptic were not included as novae.

4) "Elongated stars," "fussy stars," and "candle-shaped stars" were not listed because they all described comets.

5) Whenever a star was directly registered as a "comet," it was examined in detail but generally excluded.

6) Those appearing within 6 months of a comet, in either direction, were examined rigorously.

7) Those passing these six criteria were considered to be probably novae, and their characteristics were checked against the more than 14,500 listings of the 1958 *General Catalogue of Variable Stars* (*12*) to determine whether they could be variable stars; if found to be such, they were excluded.

After application of these seven steps to almost 1000 items, only 90 items (Table 1) could be considered to be probable novae. Table 1 retains 53 of the entries in *A New Catalogue of Ancient Novae,* 37 being deleted. The deleted items either had no definite positions or were proven to be either comets or variable stars; in two instances two items were combined into one. Thirty-seven new entries are made, of which the Korean records contributed half. We should point out that: (i) some of the 53 original entries have new information added; (ii) of the 37 newly added entries (most from Chinese and Korean sources) one was contributed by Vietnamese records; and (iii) for the sake of completeness we have included related Arabic and European data listed chronologically, with Roman numerals used for numbering.

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Supernovae and the Origin of Radio Radiation

Of the 90 entries, the most interesting is the nova that appeared in 1054. In 1942 various workers (*13, 14*) proved that it was the origin of the Crab nebula in the constellation Taurus. During this century, 20 to 30 years of observations have proved that Crab nebula is expanding at a rate of 1100 kilometers per second. If we divide this nebula's (angular) diameter (about 5 minutes of arc) by its rate of expansion, we find that it originated from one point about 1000 years ago. At that time the Chinese and the Japanese registered a "new star" in the same position. The Crab nebula must be a supernova because of its huge expansion velocity. Chinese and Japanese astronomers discovered this supernova almost simultaneously; the Chinese records give more detail. According to these records, the light curve was very similar to that of the most clearly understood supernova, which appeared in NGC4182 in 1938; this point proves the reliability of ancient observations.

After the advent of radio telescopes, the Crab nebula was found in 1949 to be a radio source (*15*); it radiates strong radio waves whose wavelength ranges from 7.5 meters to 3.2 centimeters; the shorter the wavelength, the weaker the radiation intensity. If we plot this nebula's radio and light intensities as functions of radio frequency, we see immediately that the two are but two portions of the same curve. This is a tremendous discovery, showing that the radio and light radiations from Crab nebula have the same origin. This radiation is not the common thermal radiation resulting from a nebula's high temperature, but is the so-called synchrotron radiation caused by high-energy electrons accelerated in a magnetic field (*16*). Subsequently nebulosities were observed photographically in the positions in the sky in which novae were observed in 1572 and 1604 A.D. Radio sources also are observed in the same positions (*17, 18*). Thus an important hypothesis follows: Every nova explodes to form a nebula that gives rise to radio radiation.

Table 1 (pages 598 and 599). Revised catalogue of ancient novae. In column 1: brackets signify observation outside the Orient, an asterisk indicates that the nova was not listed in *A New Catalogue of Ancient Novae*, and Roman numerals indicate observation only outside the Orient.

No.	Origin of record	Date (B.C.–A.D.)	Position	R.A. (hr)	Decl. (deg)	Galactic coordinates (deg) Long.	Lat.	Listing: Lundmark	Shan-p'en I-ch'ing	Ho Ping-yü
1[a]	China, two (*77*)	Both about 14th cent.	Near α Scorpii	1630	−25	321	+13			1
2	China (*78*)	532	3, 5, μ, ϵ Aquarii							6
3[b]	China (*3, 62*)	204	Near α Bootis	1415	+20	346	+66			23
[4][c]	China (*62*)	134	β, δ, π, ρ Scorpii					1	1	40
5*	China (*62*)	108–107	Gemini							45
6	China (*62*)	77	Between Polaris and α Ursae Majoris	1145	+72	98	+50	2	2	50
7[d]	China (*62*)	48	East of τ Sagittarii	1820	−25	335	−7	4	3	57
8	China (*62*)	5	α, β, ϵ, ρ, π, o Capricorni							63
9*[e]	Korea (*37*), China (*62*)	4	α, β, γ Aquilae	1950	+10	17	−10			64
10[f]	China (*26*)	29	Close to α Herculis	1720	+15	5	+24			67
11*	Korea (*37*), China (*26*)	1 June 85	Circle of perpetual apparition							86
12	China (*63*)	13 Sept. 107	Southwest of κ Canis Majoris and π Puppis	0700	−35	214	−12	9	6	90
13	China (*3, 26, 63, 76*)	13 Dec. 125–11 Jan. 126	Ophiuchus, Hercules, Serpens Cauda, Aquila	1535, 1900	−15, +30				7	94
14*	Korea (*37, 38*)	18 March–15 April 158	Ursa Major	1114	+50–60					104
15[g]	China (*3, 26*)	7 Dec. 185–28 July 187	Between α, β Centauri	1420	−60	282	0	12	8	109
16*	China (*3, 26, 63, 64*)	6 Nov. 200		03–0500						115
17*	China (*3, 26, 63, 64*)	10 Nov. 207		1030–1300						119
18*	China (*3, 26, 63, 64*)	Jan. 213	Close to θ, τ, ι, ν, ϕ Geminorum	0700	+30	155	+18			120
19*	China (*3, 64–66*)	13 Oct.–10 Nov. 269	Circle of perpetual apparition							145
20*	China (*3, 65, 66*)	14 Jan.–12 Feb. 275	α, β, γ, δ, *et al.* Corvi							146
21	China (*3, 76*)	27 April–25 May 290	Circle of perpetual apparition					14		155
22	China (*3, 65, 66, 76*)	19 June–18 July 304	λ, γ, δ, ϵ, θ, α, *et al.* Tauri					16	10	163
23*	China (*3, 65, 66*)	11 Aug.–9 Sept. 329	Ursa Major	1114	+50–60					167
24	China (*3, 65, 76*)	24 March–22 April 369; 19 Aug.–17 Sept. 369	near α, κ, λ Draconis; Ursa Major 24; 43, α Camelopardalis	0310–0314	+65–70			17	11	174
25	China (*3, 65, 66, 76*)	15 April–14 May 386; 13 July–10 Aug. 386	near μ, λ, ϕ, τ, σ, ζ Sagittarii					18	12	177
I*[h]	Italy	389	Near α Aquilae	1950	+10	14	−4	19	13	
26	China (*3, 65, 76*)	27 Feb.–28 March 393; 22 Oct.–19 Nov. 393	Among ϵ, μ, ζ, η, θ, ι, κ, ν, λ Scorpii	1720	−40	316	−4	20	14	179
27	China (*67*)	396	Among η, λ, γ, *et al.* Tauri	0400	+20	141	−22			182
28*	China (*67*)	20 July 414	South of η *et al.* Tauri	0340	+20	137	−25			187
29*	China (*3, 65*), Korea (*37*)	17 Feb. 419	Near δ, θ, ι, σ, β Leonis	1110–1150	0–+20					192
30	China (*67*)	20 Jan.–17 Feb. 421	Orion, Hydra							194
31	China (*67*)	21 June 436	β, δ, π, ρ Scorpii							199
32[g]	China (*66, 67*)	26 Feb. 437	μ, λ, ϵ, ξ, *et al.* Geminorum	0640	+20	162	+9			200
33	China (*67, 79*)	11 Feb.–12 March 541	Circle of perpetual apparition							222
34	China (*68, 76*)	26 Sept. 561	Orion, Hydra					21	15	224
35[i]	China (*68, 76*)	27 April 575	Near α Bootis	1420	+20	346	+66			231
36	China (*3, 68, 76*)	22 Nov. 588	Near ξ, α, β, π, o, ρ Capricorni							235
37[g]	China (*3, 34–36*), Korea (*37, 38*)	18 May–6 June 668	Perseus	0430	+45	127	0			251
38[g]	China (*3, 34, 35*), Korea (*37*)	20 April–15 May 683; 25 Oct.–23 Nov. 683	Near α, β, θ, ι Aurigae; β Tauri	0520	+50	128	+4	23		257
39*	China (*3, 34–36*)	28 July 708	Among 35, 39, 41 Arietis; η Tauri	0310	+25	127	−25			262
40*	China (*3, 34–36*)	16 Sept. 709	Circle of perpetual apparition							263
41	Japan (*69–71*)	19 Aug. 722	Near ι, ϵ, δ, θ, ν, o Cassiopeiae	0140	+60	97	−1			266
42	Japan (*69–71*)	11 Feb. 725	Near 38 Cassiopeiae	0130	+70	94	+8			267
43*	China (*34*)	30 June–10 July 730	Among Taurus, Perseus, Auriga	0420	+30	136	−12			268
44	Japan (*69, 71*)	8 Jan. 745	γ, ϕ, ν, *et al.* Andromedae; β, γ, *et al.* Trianguli	0130–0210	+33–51					271
II[h]	Araby (*80*)	827	Among ϵ, μ, ζ, η, θ, ι, κ, ν, λ Scorpii	1650–1740	−43–33			24	17	
45*[g]	China (*3, 34*)	29 April–21 May 837	South of μ, ξ, ϵ, λ Geminorum; inside Monoceros			74	0			291
46*	China (*3, 34*)	3 May–17 June 837	Near ξ, ν, π, o Virginis	1200	+5	245	+65			291
47	Japan (*47, 69, 70*)	11 Feb. 877	Between α Andromedae, γ Pegasi							307
48*	China (*34*)	881	γ, δ, θ, η Cancri							

This hypothesis needs substantiation by more observations and by comparison with ancient records of observations. It is in this manner that the ancient Eastern records will prove valuable.

The supernova that appeared in the constellation Cassiopeia in 1572 *(19)* was discovered 3 days earlier and observed more than 2 months longer by the Chinese, according to *Ming Shih Lu* (*20*). The Chinese observations lasted from 8 November 1572 to June 1574, compared with Tycho's European observations from 11 November 1572 to 15 March 1574. The Koreans also recorded the supernova in the *Hsuan-tzu Shih Lu Hsiu Tseng* (*21*), which reads, "In the 10th month 5th year of the Hsuan-tzu reign, a new star bigger than the planet Venus appeared beside the Tse Hsing [α Cassiopeiae]."

The supernova that appeared in the constellation Ophiuchus in 1604 is now called Kepler's supernova after the German astronomer who published the results of his 12-month observations. According to *Ming Shih (22)*, the Chinese discovered it on 10 October 1604, only 1 day later than did an anonymous Italian doctor, and observed it for a full year (from 10 October 1604 to 7 October 1605)—just 2 days less than the period of observation in Europe (9 October 1604 to 8 October 1605). The Koreans discovered it 3 or 4 days later than the Chinese and Europeans, but for more than 5 months they observed it diligently every night, measuring its position and brightness; their record was so complete that it even included the dates on which observations were rained out (*23*). When we plot this star's light curve according to the Chinese and Korean records beside Baade's (*24*) light curve (from the European records) (Fig. 1) the two are obviously quite different. According to the Korean records, the maximum occurred on 28 October when the star was as bright as the planet Venus; while Kepler wrote that the maximum occurred on 17 October and that the star was brighter than Jupiter; the Korean records seem to be more accurate. On 17 October the Korean record was that the star was

No.	Origin of record	Date (B.C.–A.D.)	Position	R.A. (hr)	Decl. (deg)	Galactic coordinates (deg)		Listing		
						Long.	Lat.	Lundmark	Shan-p'en I-ch'ing	Ho Ping-yü
49	Japan (*47, 69*)	11 May 891	East of ϕ, χ, ψ, ω Ophiuchi	1640	−20	327	+15			313
50[g]	China (*3, 34*)	902–903	Among γ Camelopardalis; 48, 49, 50 Cassiopeiae	0130	+65	95	+3			320
51[j]	China (*3, 35, 72*)	31 May–28 June 911	Near α Herculis	1720	+15	5	+24	30		324
III*	Leoviticus [*sic*]	945	Cassiopeia					31	21	
52*[j]	Korea (*38*)	May–Aug. 980	Near α Herculis	1720	+15	5	+24			
[53][k]	China (*3, 51*), Japan (*47*)	3 April 1006; started 6 May 1006; 1 May 1006; started 1 May 1006	κ Lupi	1500	−50	292	+6	33	22	356
54	China (*3, 51*)	8 Feb. 1011	Near ϕ, σ, τ, ζ Sagittarii	1900	−30	335	−18	35	23	358
55*[l]	Korea (*73*)	26 Jan. 1020	Ophiuchus	1750	−5	350	+9			363
56*[m]	Korea (*38, 73*)	4 Oct. 1031	Among θ, η, γ, δ Cancri	0840	+20	174	+35			
57[n]	Japan (*47*), China (*51*)	Started 20–29 May 1054; ended 6 April 1056	Near ζ Tauri	0530	+20	154	−5	36	25	375
58	Korea (*73*)	1 Aug.–11 Sept. 1065	Among Hydra, Antlia, Vela	0920	−25	223	+19			379
59*	Korea (*73*)	9 Oct. 1073	South of γ Pegasi	0010	+10	78	−52			383
60*	Korea (*73*)	15 Aug. 1113	Near α, β Pegasi	2300						394
61*	Korea (*73*)	11 Aug. 1123	Ursa Major	11–1400	+50–60					395
62	China (*3, 51*)	9 June–8 July 1138	α, β, γ Arietis					38	27	402
63	China (*3, 51*)	23 March 1139	ϕ, ι, κ, λ Virginis					39	28	404
64	China (*3, 51*)	10–15 Aug. 1175	Among Bootes, Hercules, Draco	1600	+60	58	+44		29	413
65[o]	China (*3, 4, 51, 52*), Japan (*47, 50, 70*)	6 Aug. 1181–6 Feb. 1182	Cassiopeia	0130	+65	95	+3		29	415
66[h]	China (*3, 51*)	28 July–6 Aug. 1203	Near ϵ, μ, ζ, η, λ, θ, ι, κ, μ Scorpii	1700	−40	314	−1	40	30	419
67*	Korea (*73*)	Jan. 1221	Ursa Major	11–1400	+50–60					424
68	China (*51*)	11 July 1224	ϵ, μ, ζ, η, λ, θ, κ, ι Scorpii						31	427
69	China (*51*)	15 Dec. 1230–30 March 1231	South of 109 Herculis	1820	+20	16	+13	41		428
70	China (*4, 51*)	17 Aug. 1240	ϵ, μ, ζ, η, λ, θ, ι, κ, ν Scorpii						32	433
IV*	Stadeneis [*sic*]	1245	Capricornus						33	
V*	Leouticus [*sic*]	1264	Cassiopeia					42	34	
71*	China	5 Nov.–3 Dec. 1375	μ, λ, ϕ, σ, τ, ζ Sagittarii							
72	China (*22*)	29 March 1388	Between γ Pegasi and α Andromedae					43		482
73*	China (*74*)	3 Sept.–2 Oct. 1415	Near μ, λ, ϕ, σ, τ, ζ Sagittarii							494
74	China (*4, 20, 22*)	3 Sept. 1430	Near α, β, γ Canis Minoris	0730	+5	181	+13	44	53	500
75*	Korea	11 March 1437	Between μ and ζ Scorpii	1655	−40	314	0			508
76*	China (*4, 22, 74*)	21 March 1452	α, ϵ, δ, γ, λ, *et al.* Tauri							515
77*	Vietnam	22 Feb.–22 March 1460	Orion, Hydra							
78*	China (*22*)	13 July–10 Aug. 1523	Hercules, Ophiuchus, Serpens, Aquila, Sagittarius	1535, 1900	−15–+30					543
[79][p]	China (*20, 22*)	8 Nov. 1572–21 April–19 May 1574	Near 10 Cassiopeiae	0010	+65	90	−2			565
[80]	China (*4, 22*)	9 July–Nov. 1584	β, δ, τ, ρ Scorpii					48	37	572
81*	Korea	23 Nov. 1592–24 Feb. 1594	South of θ Ceti	0120	−10	120	−70		39	577
82*[g]	Korea	30 Nov. 1592–28 March 1593	Between β and κ Cassiopeiae	0020	+62	88	0		38	577
83*	Korea	4 Dec. 1592–4 March 1593	Near β Cassiopeiae	0020	+58	88	−4			577
VI*	*The Galactic Novae* (*41*)	1600–1621; reappeared 1655	ρ Cygni	2014	+38	44	0			
84*	Korea (*38*)	14 Dec. 1600	ϵ, μ, ζ, η, θ, ι, κ, ν, λ Scorpii							581
[85][q]	China (*4, 22*), Korea (*38*)	10 Oct. 1604–7 Oct. 1605; 13 Oct. 1604–2 May 1605	North of 44, θ, 36 Ophiuchi	1730	−21	334	+5			
86*	Korea (*38*)	26 Feb.–27 March 1645	Among θ, η, τ, δ Cancri	0840	+20	174	+35			
87*	Korea (*38*)	13 Dec. 1661–1 Jan. 1662	Near 3, 5, μ, ϵ Pyxidis							
88*	Korea (*38*)	19 Oct./17 Nov. 1664–13 June/12 July 1665	North of 44, θ, 36, *et al.* Ophiuchi	1730	−21	334	+5			
VII*	*The Galactic Novae* (*41*)	20 Dec. 1669	Vulpecula	1944	+27	31	0			
89	China (*75*)	18 Feb. 1676	Northeast of γ, π, δ, ϵ, ζ, *et al.* Eridani	0400	−10	169	−40			
90	China (*75*)	29 Sept. 1690	East of ϵ Sagittarii	1830	−34	327	−14			

[a] Lee believes these two were records of one nova. [b] Possibly explosion of nova AB Bootis. [c] Observed by Hipparchus. [d] Japanese recorded same position. [e] Could be explosion of nova V500 of Aquila. [f] Could be "recurrent nova." [g] Supernova; radio source. [h] Supernova. [i] Possibly explosions of nova AB Bootis. [j] Possibly reexplosion of the 29 A.D. nova. [k] Observed by Arabs; see (*69*). [l] Possibly reexplosion of RS Ophiuchi. [m] Possibly reexplosion of a nova. [n] Supernova; radio source, Taurus A. [o] Supernova; appears in Japanese literature. [p] Tyco's supernova; appears in Chinese, Japanese, and European literature. [q] Kepler's nova; daily Korean records.

"as bright as the planet Jupiter," agreeing with Kepler's observation, but from 17 October to 3 January the Europeans had no observational records.

These three are the widely recognized supernovae; on the basis of their characteristics we can probably establish these two standards to facilitate distinction of supernovae from novae in the historical records:

1) Supernovae are extremely bright and lasting; the three mentioned were all visible longer than 1 year, while the four brightest novae of the 20th century, except the 1934 nova in the constellation Hercules, were visible for less than 1 year. If a nova becomes as bright as Venus, it should be visible by the unaided eye before and after the change takes place; thus the ancients could have distinguished between the two types of event.

2) If there are radio sources in positions where novae exploded, and if the radiation is nonthermal in nature, these novae must be supernovae (*25*).

These two conditions can be used to each other's benefit. On one hand, we can seek radio sources in positions in which the first condition is satisfied; on the other hand, we can look for supernova remnants and records in positions in which radio sources have been found. Now let us discuss several probable supernovae in history and their relations to radio radiation.

"On 7 December 185 A.D. a 'guest star' appeared at Nan Men [β, ε Centauri]. It was as big as half of a *yin*, with fluctuating multiple colors, decreasing slightly in size, then disappearing in July 187." This extract (*26*) may be the world's earliest record of a supernova (*27*), which appeared between α and β [more likely β and ε] Centauri; the period of visibility lasted 20 months. Its 1950 position (all the following positions are for the year 1950) was right ascension, 14 hours; declination, -60 degrees. Its great southern declination places it just above the horizon (as seen from China). The description "with fluctuating colors" reflects the refraction and scintillation that affect stars close to the horizon. However, it is hard to place the term *yin*: a *yin* is a bamboo mattress; a star as big as a bamboo mattress would look like a comet. But this star stayed in the same position for more than 1 year, which fact rules out the possibility of its being a comet. Possibly the term *yin* may have been confused with *t'in*; a *t'in* was a kind of bamboo calculator

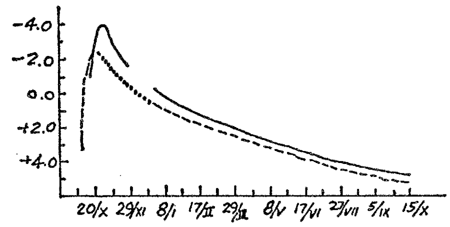

Fig. 1. Light curves of the 1604 nova in Ophiuchus. The solid curve is drawn according to the Chinese and Korean records; between 27 November and 25 December 1604, the nova was too close to the sun to be observed. The broken curve is drawn by Baade according to the European records; between 18 October 1604 and 2 January 1605 there were no European records (dots).

used by astronomers, and it seems very natural that astronomers should have used their instruments to convey size. In October, close to the autumnal equinox, Nan Men and the sun set almost simultaneously, but this star must have been visible throughout the entire period; being so bright and staying in one place for so long, it must have been a supernova. Shklovsky (*28*) believes that a moderately strong radio source (right ascension, $13^{h}\ 35^{m}$; declination, $-60°\ 15'$) could be the remnant of this supernova.

In 1954, Shklovsky, Shajn, and others proposed that nebula IC443 was the remnant of the visiting star that appeared in April 837 A.D., during the T'ang dynasty, just below Tung Ching [22nd Lunar Mansion; γ, ζ, λ, ξ Geminorum] (*29, 30*); this nebula is also a radio source. At that time, we believed that this "visiting star" was not a nova but Halley's comet; we now reverse

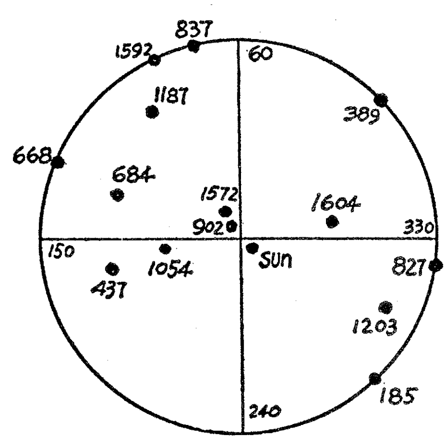

Fig. 2. Distribution of supernovae by galactic latitude. [Translator's comment: "Longitude" seems more appropriate than "latitude"; this was probably an error in the original Chinese.]

that opinion for two reasons: First, on 28 April the comet was in the constellation Leo, but on the 29th it moved to the constellation Gemini; that is, it moved 45 degrees in 1 day, which is impossible. Second, according to the orbit of Halley's comet for that year, its retrograde motion should have been in the latter portion of April and in the constellation Leo; it could not possibly have gone to the constellation Gemini.

But, if we say that this nova was the origin of IC443, problems remain: This nebula is situated between η and μ Geminorum, contrary to the recorded position which was south of ζ Geminorum. We might rather say that "On 26 February 437 a star-like object was seen between 1500 and 1700 hours in the northeast, around Tung Ching. It was orange-red in color and had the size of an orange." This was the origin of the nebula. Before 1500 hours it was seen in the northeast; therefore, it must have had a magnitude of about -4^{m}. Since we know that this nebula is at a distance of about 2000 parsec (*31*), we may calculate its absolute magnitude to be about -19^{m} during maximum brightness; this should be the biggest supernova on record.

On the other hand, the nova under Tung Ching may be related to another radio source, CTB-21 (*32*). The Rosette nebula (*33*), similar in fine structure to IC443, is in the position of this radio source; it could be the remnant of this supernova.

Both *Hsin T'ang Shu* (*34*) and *Wen Hsien Tung Kao* (*3*) recorded that "In May 667 there was a comet in the northeast, situated among Wu Ch'e [α, β, θ Aurigae], Pi [19th Lunar Mansion; ε, δ, π, α Tauri], and Mao [18th Lunar Mansion; Pleiades], and it disappeared in July." Both *Chiu T'ang Shu* (*35*) and *T'ang Hui Yao* (*36*) recorded that "In May 668 a comet appeared close to Wu Ch'e, . . . star seemed to stand out but not bright, . . . after 22 days the star faded." These two statements in fact referred to the same event.

The Koreans also have two records of this phenomenon. *Samguk Sagi* (*37*) and *Tseng Fu Wen Hsien Pei Kao* (*38*) recorded that "In the 4th month of the 8th year of Munmu Wang, a comet appeared to be guarding T'ien Ch'uan [η, γ, α, δ, μ Persei]"; and that "In the summer of the 27th year of Pao Tsang Wang, a comet was seen between Mao [Pleiades] and Pi [Taurus]." On the basis of these four Chinese and

Korean records, with special attention to the record in *Samguk Sagi* in which the term "guarding" was used, this object may have been a nova situated within the reference area between Pi, Mao, Wu Ch'e, and Tien Ch'uan and centered at 4 hours 30 minutes right ascension, + 45 degrees declination. One radio source, CTB-13, is near this position; its coordinates are right ascension, 4 hours 24 minutes; declination, + 47 degrees; its angular area is 5 by 2 degrees. Wilson and Bolton (*39*) described the structure of this radio source in 1960, indicating that it should be the remnant of a supernova; now this appears to be so.

Hsin T'ang Shu (*34*) and *Chiu T'ang Shu* (*35*) recorded that "In the 3rd month of the 2nd year of the Yung Shun reign, a comet appeared north of Auriga, which lasted 25 days and then disappeared in the 4th month." And *Samguk Sagi* (*37*) recorded that "In the 10th month of the 3rd year of Munmu Wang, a comet was seen outside Wu Ch'e [Auriga]"; these may be descriptions of the same phenomenon. From the 3rd month of the 2nd year of the Yung Shun reign to the 4th month corresponds to the period 20 April to 15 May 684.

After 15 May the sun gradually approached Auriga, causing the comet to disappear. Six months later, Auriga reappeared in the east at night. In October, because of the occurrence of a secondary maximum in its light curve, the object was observed by the Korean astronomers. Later, a strong radio source was apparent north of Auriga and was called Auriga A in 1960 by Steinberg and Lequeux (*40*). They pointed out that this source should be a type-II supernova remnant. A type-II supernova has a lower brightness than a type I, but it has secondary maxima in its light curve (*41*).

In 1963 Pokozhky (*42*) related CTA-1 to a supernova that exploded in 902, as was recorded by the Chinese; from the diameter of CTA-1's fine structure he estimated its distance (100 to 150 parsec) and found its magnitude at maximum brightness to be -18^{m}. On the basis of the light curve of Cassiopeia B, the supernova CTA-1 should have been visible for about 2 years. The Chinese recorded: "In the 1st month of the 2nd year of the T'ien Fu reign [902 A.D.] there was a visiting star, that looked like a peach, situated in Tzu Kun [Enclosure; Ursa Major, Draco, and Camelopardalis] beneath Hua Kai [21, 31, χ, 43, ω Cassiopeiae]. . . . In the following year it remained visible." This record showed its position, brightness, and period of visibility to accord with Pokozhky's conclusions (*42*).

In the 13th century, the Arab historian Barhebraeus wrote (*43*): "During the 396th year of the Mohammedan calendar, a star as bright as Venus appeared. Its brilliance illuminated the whole sky like the moon. It disappeared 4 months after it started to glow." Earlier another Arab, Ibn al-Athir, reported (*44*) "In the 8th month of the 396th year of the Mohammedan calendar, a very big and bright star, like the moon, appeared at the left side of Keepola [*sic*] of Ilac [*sic*], which lasted until the 11th month or 4 months altogether." The 396th year of the Mohammedan calendar corresponds to 1006 A.D.; "Keepola of Ilac" is in the direction of Mecca from Baghdad. Considering the season of the appearance of this star (3 May to 13 August), Schonfeld (*45*) concluded: "This was the record of the explosion of a nova in the constellation Scorpius." Shklovsky believed that this was a supernova and discussed its possible relations to several radio sources (*46*).

But the Chinese and Japanese historical records contain very detailed descriptions, according to which this star was not in the constellation Scorpius but rather in Lupus. It could have been the explosion of Che Chen Chian Ch'in [κ Lupi] itself, because the Japanese *Ming Yueh Chi* (*47*) reported: "Might be Che Chen Chian Ch'in changing state and pouring out light." The Chinese *Sung Hui Yao Tsi Kao* (*48*) reported: "A big star appeared east of K'u Lou [η, θ Centauri] and west of Ch'i Kuan [ψ', χ Lupi], and measured about 3 degrees from both"; this is exactly the position of the star κ Lupi. κ Lupi is now a double star, with the two components belonging to spectral classes B0 and A9, and with an absolute magnitude of 0.6^{m}. In recent years, many novae have been found to be double stars (*49*); after the explosion, their spectral class may be type B or type A. Thus κ Lupi could be one of those novae seen after explosion (as yet, this is the only one so recorded).

The Japanese *Matsuyama Kagami* (*50*) reported: "On 7 August 1181 A.D., a visiting star appeared in the northeast direction. It was as big as Tsung Hsing [110, 111 Herculis] and reddish-blue in color. There were spike-like structures. This was the first one since the one that appeared in 1006 . . . ." The Chinese *Sung Shih* (*51*) and *Chin Shih* (*52*) also registered

Translator's note. This paper was first read at the Scientific Panel Discussions, Peking, 1964. Many technical terms, both in astronomy and in the titles of the Chinese, Korean, and Japanese chronicles, were quoted directly in Chinese; they are often difficult to translate satisfactorily. Koreans and Japanese used Chinese characters for their names, calendars, and records, but pronounced them quite differently. In order to avoid confusion, most names and technical terms of Chinese origin are romanized as they are pronounced in Chinese. All dates have been converted to Gregorian.

Under the Chinese system of dividing the sky, there were three general broad regions called *yuan* (Enclosures): the Tzu Wei or Tzu Kun formed by stars in Ursa Major, Draco, and Camelopardalis; the T'ai Wei, by stars in Virgo, Leo, and Coma Berenices; and the T'ien Shih, by stars in Hercules, Serpens, Ophiuchus, and Aquila. In addition, there were 28 *hsiu* (Lunar Mansions) distributed approximately along the equator. Other stars were designated according to their positions relative to the three Enclosures and the 28 Lunar Mansions. Therefore the accuracies of positions reported in ancient records were more or less governed by the respective sizes of these "reference regions."

In the original, Table 1 included much more relevant information, which I have omitted because of difficulties with space and with readable translation of technicalities; interested readers should refer to the original.—K.S.Y.

Table 2. Twelve recordings of supernovae, made by the Chinese, Koreans, and Japanese, compared with Harris's 1962 list of 25 possible radio-emissive remnants of supernovae; agreement (A) is indicated in the last column. Abbreviations: Ch, Chinese; Ko, Korean; Ja, Japanese; Eu, European; TM, tenuous material; DORA, dim optical radial arc.

Supernova	Observer	A.D.	Remnant	Radio source	Galactic coordinates (deg.) Long.	Galactic coordinates (deg.) Lat.	Visible (days)	Visual magn.	Distance (parsec.)	Agreement
Centaurus B	Ch	185		13S6A	282	0	600			A
Gemini nova	Ch	437	1C443	06N2A	162	+9		−4	2000	A
Perseus nova	Ch, Ko	668	Observed TM	CTB–13	127	0	19			A
Auriga A	Ch, Ko	683		04N4A	130	+4	25		1900	A
Monoceros nova	Ch	837	Rosette nebula	CTB–21	74	0	23			
Cassiopeia nova	Ch	902	DORA	CTA–1	87	+10	730	−8	150	A
Taurus A	Ch, Ja	1054	Crab nebula	05N2A	155	−3	660	−5	1100	A
Cassiopeia nova	Ch, Ja	1181		?	94	+3	185	+1	2300*	
Scorpius nova	Ch	1203	Sharpless 51?	CTB–37	304	−1		+1	2300*	
Cassiopeia B	Ch, Ko, Eu	1572	Observed	00N6A	90	−2	540	−4	360	A
Cassiopeia nova	Ko	1592	TM	CTB–1	86	0	118			A
Ophiuchus nova	Ch, Ko, Ja	1604	Observed	CTB–41	332	+5	365	−4	1000	A

* Doubtful.

this visiting star: "On 6 August 1181, a visiting star appeared outside K'uei [β, μ, ν, π, δ, ϵ, ζ, η Andromedae and 65, ψ', χ, ϕ, ν, τ, σ, 121^{R} Piscium], nudging Ch'uan She [Cassiopeia, Camelopardalis]. It lasted until the 1st month of the next year for a total of 185 days." This may be the record of the appearance of a supernova in the constellation Cassiopeia.

"On 28 July 1203, a visiting star, blue-white in color, with no spike-like structure, and as big as Saturn, appeared situated in Wei [λ, κ, θ, η, ε Scorpii] in the southeast." This description *(3)* excluded the possibility that it was a comet, and so we may consider it to have been a nova. If one assumes that there was severe interstellar absorption, the intrinsic brightness of this star could have been much greater than the observed brightness; thus it could also have been a supernova. Close to this position there is now a radio source, CTB-37, having a spectral index of -0.3, characteristic of nonthermal radiation.

In 1592 the Koreans registered three novae simultaneously; one was close to θ Ceti; its galactic latitude was very high ($-70°$), and it was visible for 15 months. The other two novae were in Cassiopeia; the one between β and ε was visible for 4 months (30 November 1592 to 28 March 1593) and could be related to the radio source CTB-1; it could have been another supernova.

Altogether, the Chinese, Koreans, and Japanese recorded 12 supernovae; there may have been more, but these await verification by the radio astronomers. These 12, with galactic latitude and longitude, visual magnitude, period of visibility, and distance, appear in Table 2. Comparison of this table with Harris's 1962 list of 25 possible radio-emissive remnants of supernovae shows nine of them in agreement, which degree of agreement is very impressive. Unfortunately, we could find no ancient information on any event coinciding with the strong radio source Cassiopeia A, which is now considered to be the remnant of a supernova that exploded around 1700 A.D. *(54)*.

These 12 supernovae, plus the two *(55)* among the novae observed in Arabia and Europe, constitute the 14 supernovae in the Milky Way that have been recorded in history. Fourteen supernovae in 2000 years give an average frequency of one every 150 years —much higher than the rate of 1:356 years proposed by Zwicky *(56)*.

Looking at the distribution of these 14 supernovae (Fig. 2), we see that there are more toward the anticenter than there are in the direction of the center of the Milky Way. This fact is very strange, and may be because:

1) The portion of the Milky Way at great southern declinations (galactic latitudes from 240° to 300°) cannot be seen from China, Korea, or Japan.

2) The supernovae seen so far have all been fairly close to us. If a supernova exploded 10^4 parsec from us, with an absolute magnitude (M) of -16^{m}, its visual magnitude would be -1^{m} in the absence of interstellar absorption; this is as bright as T'ien Lang [Sirius] and should attract enough attention. But, if the correction for interstellar absorption is 1.5^{m} per 1000 parsec, under the same conditions M = $+14^{m}$—which could not be seen with a telescope less than 25 centimeters in diameter. If the distance is 5000 parsec and the amount of absorption is the same, visual magnitude is $+5^{m}$—just visible by the unaided eye. Let us suppose that the greatest distance (r') at which a supernova can be seen with the naked eye is 5000 parsec and that the greatest distance (r) from the center of the Milky Way at which a supernova can explode is 9000 parsec *(57)*. Because the galactic latitudes of supernovae are small, one may consider the galaxy as a circular plane, and so the proportion of the frequency of explosion of supernovae, f, to the visible frequency of explosion, f', is given by

$$f{:}f' = \pi r^2 : \pi r'^2$$

$$\text{or } f = (r/r')^2 f' = (9/5)^2(1/150)$$

$$= (1/50) \text{ time per year.}$$

This number may be correct. Shklovsky *(46)* and Opik *(58)* both believe that one supernova may explode in the Milky Way every 30 years on the average. During the 60 years of the 20th century there have been three such explosions in each of the spiral galaxies NGC 3184, 4321, and 6946. Recent results may indicate that the frequency of explosion of supernovae may be related to the type and size of a galaxy; the frequency of explosions should be high in a big galaxy like our Milky Way *(59)*.

Finally we should point out that the calculation of a frequency of occurrence of supernovae is important in three areas: Firstly, in radio astronomy, in the Milky Way the number (N) of radio sources with a lifetime less than T is Tf. Knowing f, we can estimate N *(46)*. Secondly, in the problem of the origin of cosmic rays in nuclear physics it is commonly believed that supernova explosions are the main suppliers of cosmic rays, according to the theory of radiation from the Crab nebula and the research on interstellar magnetic fields (*60*). Thirdly, it is related to stellar evolution. The problem of whether the evolution of a star necessarily includes the stage of supernova explosion can be studied, on the one hand, by the physics of the star; on the other hand, by the frequency of supernova explosions and the rate of change from stars to white dwarfs within the Milky Way. For the past 5 billion years there has been, on the average, 0.006 star per cubic parsec changing to a white dwarf, according to one calculation (*61*). If we take the frequency of supernova explosions to be once every 50 years, then for the past 5 billion years there has been only 0.0001 supernova explosion within a cubic parsec—only 1.7 percent of the earlier number. Thus it seems that not all stars have to pass through an explosive stage to become white dwarfs, and that it is possible for only very few of them to do so.

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