Observations of Meteors Probably Connected With the Pons-Winnecke's Comet in 1921.

By

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§1. Introduction.

The return of the Pons-Winnecke's comet in the present year aroused the special attention of meteor observers expecting to catch fine displays connected with the comet during the latter part of June. The matter was first introduced by Mr. Denning to the world, early in this year, to the effect that not only the meteors but the comet itself was thought to be of exceptional interest because of the great popularity, probably due to some misunderstanding of the matter, since sometime before its re-discovery by Prof. Barnard on April 10, 1921. Mr. Denning had seen meteors of this kind in 1916, whose own notes* we quote here:

"The meteors of Pons-Winnecke's Comet are due to appear on or about June 26-28, and there is the prospect of a striking display this year, as the parent comet will be near perihelion. There was a shower (probably the first observed from this comet) in 1916 June 28, when it was witnessed from Bristol, after 10h 25m, under rather unfavourable conditions. Half an hour later it was detected at Bournemouth and Birmingham. The meteors of this stream are individually not very noteworthy, but they are fairly bright, slow object, with short paths in the early part of the night, the radiant being not far W. of the zenith.

* Observatory, 44, 61. (1921).

"In 1916 the radiation seemed very diffused over the region of Ursae Majoris, Quadrans and Bootes. This shower should be very carefully observed in all its details next June. A special degree of interest attaches to the system, as it is quite a modern development, and owes its occurrence to the accumulated perturbations by Jupiter on one of the short-period comets. The orbit of this particular comet, though now nearly intersecting the Earth's path, was formerly placed at a distance sufficiently great to enable its particles (or debris) to avert collision with, and destruction by, our atmosphere."

According to Mr. R. T. Crawford's elements of the comet, which are based upon the observations of April 12, 19, and 29 of the present year:

$$
\begin{aligned}
T &= 1921 \text{ April } 12.95, \text{ G.M.T.},\\
\omega &= 170^\circ\ 34'\\
\Omega &= \ 97\ \ 51\\
i &= \ 18\ \ 50\\
e &= 0.6779\\
\text{Period} &= (5.80), \text{ assumed},\\
q &= 1.040,
\end{aligned}
$$

the earth was to pass the descending node of the cometary orbit on June 29 on or later, which was a little more than two weeks after its perihelion passage.

For the observation of the meteors we were making some preparations since the early part of June, preparing the necessary star maps and watching the weather conditions. It was to our deep regret that the time for our venture was the rainy season of our country, which comes on annually, beginning in the early part of every June, and lasting about one month in almost the whole area of central Japan. The northern part of the country, especially Hokkaido, is almost wholly excluded from the influence of the rain, so that that region was thought to be the best place for our astronomical observations of the time, whither, however, some observers from the Tokyo observatory were reported to be sent; accordingly we decided to remain here, in the "western" part, for our work in spite of some seeming disadvantages in weather.

§2. Method of Observations.

For our observations, the star maps of gnomonic projection were used. Each sheet covers a diametral arc of about 50° in all directions, and consequently the whole area of the celestial sphere is covered by 20 sheets in all, including abundant duplications with neighbouring ones in their peripheries, the depths of the duplication being about 20°.

During the observations, the time of the Central Standard Time of Japan, referring to the 135th meridian E. of Greenwich, was kept, and that with pocket watches, the rates of which being adjusted daily by the clocks of our observatory. In distant fields, as described in the following pages, the time of the post offices or that of the railway station near by was kept, since these are to be trusted within a minute usually in our country.

As for the observers, who are also the present writers, one (I. Y.) of them is near-sighted, compensating his natural power with a pair of spectacles to the usual ability. The another (K. N.) has good eyes, and rather an exceptionally sensitive efficiency for faint lights, which is sufficiently proved by the fact that he can see twenty stars in the Pleiades on a clear night. This rare circumstance has effected the present richness of our harvest.

§3. Plan and Programme of Observations.

As mentioned above, the latter part of June is still within the rainy season in Japan. Although the mean state of rainy weather was not experienced *in the present year* owing probably to some extraordinary meteorological conditions, it being relatively dry since the beginning of the month, yet constant attention toward the sky was necessary. A special watch upon the barometrical distributions of the atmosphere was kept with direct observations as well as by the weather charts reported daily by the central and the local authorities of meteorological observatories, whether visits were frequently paid.

After the middle of June, clouds prevailed over western Japan caused by a train of cyclones coming from central China. On the morning of the 25th, however, the writers caught a gleam of hope of clear weather which might come for a day or two at least follow-

ing a receding cyclone. Then we decided to follow closely on the heals of the cyclone, and in the afternoon we started from Kyoto Railway Station eastward.

One of us (K. N.) got an observing station by the kindness of Mr. E. Yoshida, in Hachiman, Omi Province, about ten miles NE of Kyoto. Here the weather was pretty good before sunset, but afterward SK-clouds appeared from the western sky, and night observations became almost hopeless, although the keen eyes of our observer indeed caught several glimpses of the meteors.

In the same afternoon, the other observer (I. Y.) extended his journey beyond Hachiman, hoping, if possible, to get a station at Tsuruga. But noticing on his way dirty weather coming on, he got off his train at Hikone, Omi Province, where he visited the meteorological observatory there immediately, and found that a new cyclone was speedily approaching, which in fact betrayed us all. In Kyoto Mr. R. Furukawa and others were watching the sky the same evening to catch the meteors if possible, and they had their useless vigil for their pains!

The next night, the 26th, the sky was less cloudy in many places near Kyoto, only covered with thin veils of cloud and several observers watched the meteors. But they gathered no crop. Mr. Nakamura stayed the same night still in Hachiman, and through gaps in the clouds, he happily got many stars, among which he actually found a number of the expected Winnecke Meteors for the first time.

The report of this discovery of the long-waited for meteors by Mr. Nakamura awakened a new impulse among our co-labourers on the morning of the 27th, and the next plan was made. After examining the annual results of meteorological observations many years ago, we learned that the San-in region, that is, along the coast of the Sea of Japan in the western part of the Main Land of Japan, was comparatively poor in mean quantity of precipitation. Therefore our most hopeful field was taken there. In the afternoon of the 27th, both writers started for the San-in; on the way thither, we fixed on a station at Fukuchiyama, a town about twenty miles NW of Kyoto, for our observations of the night. Mr. Y. Iwamori was so kind as to receive us and invited us to make use of the grounds of the Middle School, which was under his management, and proffered many facilities for which we were very thankful. At this place the weather was not perfectly clear, but during the moments of clearness we got

many meteors and fully confirmed the apparitions of the Winneckes.

Soon after midnight, we said good bye to Fukuchiyama, to continue our westward journey. On the morning of the 28th, we arrived at Tottori, and there we visited the Prefectural Normal School in the town, whose Principal, Mr. T. Idé, kindly offered the school ground, for our observation post. Here we stayed four days, two of which were entirely rainy, accompanied by storms. The other two days were also constantly threatened by clouds, whose temporary gaps, however, were diligently caught.

On the morning of July 2nd, we started from Tottori on our way back to Kyoto, because the climax phase of the meteoric display was ended. Our original plan was to get a night's observation at some place near Himeji, ten miles W. of Kobe. But rain prevented us.

After our arrival at Kyoto, a constant watch of careful observations of the meteors was kept mainly by Mr. Nakamura on the observatory grounds every night of sufficient clearness.

After the middle of July, we two made an excursion to a distance, which interrupted our observations of the heavens. After returning home, however, Nakamura found that the Winnecke meteors were still visible, radiating from displacing radiant points.

August 8th was our last night.

§ Results of our Observations.

In the following table, the results of the meteoric observations are arranged. Here, not only those of the Winnecke's Comet, but all others observed at the same time are included.

Let us now note some abbreviations used. The *weights* of individual observations are described by an arbitrary scale from zero to 10, where zero is the extremely poor, and 10 the best. As to the *velocity*,

vR : very rapid ;
R : rapid ;
*r*R : rather rapid ;
M : moderate velocity ;
*r*S : rather slow ;
S : slow ;
vS : very slow.

For the *colours*,

B : Bluish,
BW : Bluish-white,
W : white,
Y : yellowish,
YB : yellowish-blue,
RY : reddish-yellow,
C : Crimson.

For the *observers*, those marked with an asterisk* on the No. are stars of I. Yamomoto, and others of. K. Nakamura.

In the last column, R, those of Remarks,

W : meteor probably belonging to Winnecke's Comet,
A : meteor of α Bootids,
B : meteor of η Draconids,
C : meteor of Ophiuchids,
D : meteor of ε Bootids.

The approximate terrestrial coordinates of the observing stations are :

Stations.	Longitude E. of Greenwich	Latitude.
Kyoto University Observatory	$9^h\ 3^m\ 7^s$	$+35^\circ\ 1'.6$
Hachiman, Omi	9 4 20	+35 8
Fukuchiyama	9 0 36	+35 18
Tottori	8 56 56	+35 30

TABLE I.

Results of Observations of Meteors.

June 25, at Hachiman.

No.	Time.	Appearance.	Disappearance.	Weight.	Duration.	Magn.	Velocity.	Color.	R.
	h. m.	o o	o o		s.				
1	8 32.8	207.5+13	200.5+24.5	4	0.2	5	R		
2	39.8	212.5+19.5	205 +14.5	5	0.3	5	rR		A
3	40.2	202 +12.5	206 +24	3	0.2	5	R		
4	45.0	212 +19.5	205.5+21	4	0.2	4.5	rR		A
5	9 11.4	212 +20	207 +21.5	5	0.2	5.5	rR		A

June 26, at Hachiman.

1	8 34.2	213.5+46	225 +47	7	0.2	6	R		
2	35.4	211 +55	175.5+48.5	6	0.2	5.5	R		
3	37.1	165 +46	159 +55.5	8	0.3	5.5	R	B.W.	
4	39.0	201.5+48.5	199.5+58.5	6	0.2	6	R		
5	39.8	209 +50	199.5+58.5	5	0.2	5.5	R		W
6	40.7	211 +51.5	209 +52	7	0.2	5.5	R		W
7	42.2	211.5+51.5	211 +60	6	0.2	6	rR		W
8	43.4				0.3	5	rS	B.G.	
9	44.2	204 +50	242 + 7.5	5	0.2	6	M	B.W.	
10	47.0	239 +0	242 + 7.5	6	0.3	5	M	B.W.	W
11	47.8	209.5+50	216.5+45.5	5	0.2	4.5	M	W.	W
12	49.6	212 +53	207.5+56.5	8	0.2	5.5	M	B	W
13	49.6	210 +49	211.5+50	8	0.3	5	M	B	W
14	52.0				0.2	5.5	M		
15	52.8	213 +45.5	215.5+37.5	8	0.2	5.5	M		W
16	54.4	189 +54	181.5+59	6	0.3	5.5	M		A
17	55.8	219 +41.5	205 +11.5	9	0.5	5	R	B.W.	B
18	58.0	204.5+43.5	204 +32	6	0.2	5.5	rR		
19	58.8	206 +62	185 +60	8	0.3	4	R	B.W.	B
20	9 0.9	232 +35	227.5+41	7	0.2	6	rR		W
21	2.8	239 +22.5	235.5+30.5	7	0.2	5.5	rR		
22	4.9	235 + 6.5	137.5+ 3	7	0.2	6	rR		
23	12.0				0.3	5	rR		
24	14.2	201 +53	198 +53	5	0.3	5.5	M		A
25	15.8	198.5+41	202.5+22.5	7	0.3	5	vR		
26	16.8	209 +51	205.5+54.5	6	0.2	5.5	rS		W
27	18.2	236 + 8	241.5+65	6	0.2	5.5	R	B.W.	
28	21.2	212.5+49.5	214 +43.3	6	0.3	5.5	rR	B.	W
29	22.8	218.5+43.5	222.5+38	5	0.2	5.5	rR	W.	W
30	25.0	217 +33	225 +21	8	0.4	5	rR	W.	W
31	31.8	214.5+43.5	217.5+35.5	6	0.3	5.5	rR		W
32	10 1.2				0.3	4.5	R	B.W.	

June 27, at Fukuchiyama.

No.	Time.	Appearance.	Disappearance.	Weight.	Duration.	Magn.	Velocity.	Color.	R.
	h. m.	o o	o o		s.				
1	9 6	208 +50.5	204.5+55	6	0.2	5	*r*R		W
2	8.2	211 +33.5	211 +17	5	0.2	5	*r*R	B.W	W
3	11.1	225 +27.5	223 +32	8	0.2	5	R		
4	12.3	211.5+51.5	222.5+45	8	0.3	4.5	R	B	W
5	14.7	196 +62.5	214 +65	8	0.3	5.5	R		
6	15.0	220 +49	210.5+55.5	7	0.2	5	R	B	
7	15.6	210.5+51.5	219 +54.5	5	0.2	5.5	*r*R		W
8	18.1	262 +6	262 − 2	5	0.5	1.5	*r*R		
9	19.7	227 +42.5	217 +46	3	0.3	5	M		
10	20.8	212.5+48.5	227.5+40	9	0.4	4.5	M	B.W	W
11	23.0	205 +38	201 +33.5	7	0.2	5.5	R		W
*12	23	200 +45	187 +36	8	0.1	4	R	W	
13	24.8	208.5+50	208.5+62	3	0.2	5.5	R		W
14	26.3	204 +46	199.5+54	8	0.2	6	VR		A
15	28.0	224.5+41	203.5+33	4	0.2	5	R		B
16	30.2	217.5+41	220.5+35	6	0.3	5.5	M		W
17	31.2	211.5+47.5	208 +38.5	2	0.2	5.5	*r*R		W
18	33.7	201 +43	192.5+36	8	0.2	5.5	R		W
19	33.8	216 +54	229 +58	7	0.3	5.5	*r*R		W
20	35.2	231 +61.5	192.5+51	7	0.2	4.5	VVR	W	
21	37.0	209 +52	214 +57	7	0.2	5	R		W
22	37.8	212 +50	220.5+49.5	7	0.2	5	R		W
23	39.8	227.5+42.5	211 +47	8	0.3	5	R		
24	40.8	210 +70.5	228.5+76	9	0.2	5	R		
25	42.8	211 +51	222 +38	6	0.2	5	*r*R		W
26	44.0	262.5+79	7 +82.5	8	0.3	4.5	VR		B
27	45.0	221 +52	248 +59	6	0.3	5	R		
28	45.8	212 +53	230 +60	4	0.2	5.5	R		W
29	47.1	222 +41	227 +34.5	6	0.3	5	R		W
30	49.7	209.5+51	207.5+57	8	0.2	5	*r*R		W
31	51.8	204.5+56	194.5+63	3	0.2	5	*r*R		W
32	10 36.7	216 +70	222.5+76.5	5	0.3	3.5	*r*R		W
33	49.5	213 +24	216 +34	8	0.3	3.5	R	G.W.	A
*34	11 1	277 +75	272.5+35	6	0.2	3	R	W	
35	1.5	283.5+46	277 +33.5	3	0.2	4	R		
*36	8	287 +45	285 +34	7	0.1	3			
37	11.8	224 +76	248 +71	5	0.2	4	R		
38	14.0	211 +51	216.5+39.5	8	0.4	4	R	B	W
39	16.8	231 +59	229.5+51	5	0.3	5	*r*R		
40	18.7	129 +81.5	220 +75	6	0.3	5	R		
41	20.2	208.5+52	212 +57	5	0.2	4.5	VR		W
42	22.0	255 +71.5	285 +73	5	0.3	4.5	R		W
43	23.5	212 +51.5	225 +52.5	6	0.2	5			W
44	26.5	267.5+32.5	279 +33	6	0.2	4	R		A

June 28, at Tottori.

No.	Time.	Appearance.	Disappearance.	Weight.	Duration.	Magn.	Velocity.	Color.	R.
	h. m.	o o	o o		s.				
1	8 47.7	205 +49	212.5+57	8	0.3	5.5	rR	W	W
2	48.2	215 +42.5	220 +35	7	0.3	5	R	B.W.	W
3	49.2	207 +58.5	198 +67.5	7	0.4	5.5	rR	W	W
4	50.0	210.5+51.5	206 +54.5	9	0.2	5.5	rR		W
5	50.8	212.5+48	224 +43.5	7	0.4	5	rR		W
6	53.0	169 +16	162.5+26.5	9	0.6	5	R		
7	53.7	192.5+39	185 +42	10	0.3	5.5	rS	W	A
8	54.8	212.5+46.5	217.5+36	10	0.4	5.5	rR	B.W.	W
9	56.0	201 +32	195.5+22.5	7	0.5	5.5	rR	B.W.	W
10	57.2	210.5+65	204.5+56.5	10	0.4	5	M	B.W.	
11	57.5	194 +41	192.5+31	4	0.4	5.5	S		
12	58.2	208 +25	207.5+17.5	8	0.3	5	M	W	W
13	59.0	158 +61	168 +54.5	7	0.4	5.5	—	B.W.	
*14	59.0	219 +77.5	214 +72.5	7	0.2	2	Y	W	
15	59.8	211 +51	206 +58	6	0.4	4.5	rS	B	W
16	9 0.7	213.5+51.5	219 +55	6	0.2	5	M	W	W
*17	1	122.5− 5	127.5− 9.5	5	0.5	2	W	B	
18	1.5	209 +51	206.5+55	5	0.2	5	M	B.W.	W
19	2.4	242 +56.5	275 +72.5	10	0.6	4	vR	W	
*20	3	252 +58	236 +65	8	0.3	4	W		
21	3.7	218 +45	227.5+37.5	8	0.4	5.5	rR	W	W
22	5.0	211.5+48.5	216 +42.5	5	0.2	5	rR	W	W
23	5.7	212.5+48	217.5+44	7	0.3	4.5	rR	B.W.	W
24	6.8	213 +50	216.5+57	7	0.3	5.5	rR	B.W.	W
25	7.8	212.5+49	209 +56	9	0.3	5.5	rR	W	W
26	8.5	209 +42	206 +32	8	0.5	5	rR	B.W.	W
27	9.1	207.5+29.5	206 +20	7	0.5	5	rR		W
28	10.4	251 +68	225 +71.5	9	0.4	4	M	B.W.	
29	11.2	214.5+54.5	219.5+61.5	7	0.4	5	M	B.W.	W
30	11.8	212.5+48.5	214 +40	7	0.4	5.5	M	B.W.	W
31	12.9	206.5+52	200 +57	8	0.3	5	rR	W	W
*32	13	177 +59	171 +59	6	0.2	5			
33	13.8	208 +48	203 +40	7	0.4	5	rR	W	W
34	14.7	204 +54	195.5+57.5	8	0.3	5	rR	W	W
35	15.3	211 +52	212 +58	6	0.3	5.5	rR	B.W.	W
36	16.3	168 +53	155 +59	7	0.5	5.5	rR		
37	38.3	209 +51.5	207 +56	8	0.3	6	R		W
*38	39	167 +54	151 +51	8	0.3	2	Y	W	
39	41.2	173 +43	154 +40	4	0.6	3	M	W	W
40	46.8	213.5+29	214 +17	8	0.5	2	rR		W

July 1, at Tottori.

No.	Time.	Appearance.	Disappearance.	Weight.	Duration.	Magn.	Velocity.	Color.	R.
	h. m.	o o	o o		s.				
0	8 58	213 +46.5	217 +42	5	0.2	5.5	R		W
1	9 2	229 +29.5	232.5+24	5	0.3	4.5	rR	R	W
2	2	230 +60	227.5+71	3	0.4	4	R		
3	31	209.5+52	203.5+66.5	4	0.6	3.5	R		W
4	35	237.5+32.5	227 +21.5	5	0.5	3	rR		
5	37	234 +29	221 +31	5	0.6	4	R		
6	10 28	211 +24	212 +17.5	2	0.4	2	R		W
7	32	206 +52.5	193 +56.5	3	0.4	2.5	R		W
8	38	201 +42.5	192.5+34.5	3	0.5	3	R		W
9	40	181 +56.5	166 +59	4	0.4	3	R		W
10	41	192 +55.5	183 +58	4	0.2	4	rR		W
11	42	212.5+48.5	216.5+58.5	5	0.4	3	R		W
12	42.5	212.5+47.5	217.5+43	5	0.3	3.5	R		W
13	43	212.5+48.5	210.5+55.5	5	0.4	4	R		W
14	43.7	201.5+56.5	193 +62	4	0.2	4	rR		
15	44.8	212.5+47.5	217 +40.5	5	0.4	3	R		W
16	46.2	217.5+28.5	213 +20.5	6	0.5	3	rR		B
17	48.4	211 +47	210.5+42.5	2	0.3	3	M		W
18	50.3	207 +52	201.5+55	2	0.3	3.5	M		W
19	51.0	216 +84	28 +87	3	—	4	—		W

July 3, at Kyoto.

1	8 31.6	170° +56	165 +62	6	0.3	5.5	rR	Violet	
2	32.2	206.5+50	211 +42	7	0.4	4.5	rR	R	
3	32.8	172 +50	163 +48	8	0.3	5.5	R		W
4	33.5	194 +56.5	197 +61.5	5	0.4	5	M	RW	
5	34.2	200 +55.5	208.5+59	8	0.3	5.5	M	BW	
6	34.8	161 +59.5	166.5+54.5	6	0.3	5.5	M		
7	35.3	184 +66.5	169 +70.5	6	0.3	5.5	rR	W	W
8	37	196 +55.5	190 +64.5	5	0.4	5.5	M		
9	37.6	213.5+46.5	215.5+43	7	0.2	5.5	R		W
10	39.2	176 +54.5	163 +54	5	0.4	4	M	W	W
11	40.2	169.5+61	163.5+57	5	0.2	5	R	R	
12	41	171.5+41.5	162.5+47.5	7	0.3	5.5	rR	W	
13	42	176 +55.5	175 +61	4	0.3	5	R	RW	
14	42.2	164 +57	172 +58.5	7	0.2	5.5	rS		
15	42.7	175 +48.5	169.5+52.5	6	0.3	5.5	R		
16	44	199.5+52	187.5+54	3	0.3	3	R		W
17	45	168 +56	165 +62	3	0.2	5.5	rR		
18	46	199.5+56	194 +59	7	0.2	6	R		W
19	46.8	206 +50.5	201 +57.5	7	0.3	5	R	W	
20	48.2	202.5+52.5	193 +56.5	8	0.3	5	rR		W
21	49	191.5+57	180 +62	7	0.2	6	R		W

No.	Time.	Appearance.	Dis-appearance.	Weight.	Dura-tion.	Magn.	Velo-city.	Colour.	R.
	h. m.	o 8	o o		s.				
22	8 51	202 +54	190 +55.5	6	0.3	5.5	*R		
23	53	233 +58.5	244 +61.5	8	0.2	5.5	R		W
24	56	204 +50	194 +40.5	6	0.4	5.5	R		
25	58	192.5+56.5	194 +51.5	6	0.4	6	*S	W	
26	58.9	209 +51.5	204 +57	8	0.3	5	*R	BW	W
27	59.8	211.5+51	220 +64	7	0.4	3	*R		W
28	9 1	269 +44	279 +40.5	5	0.3	4	*R		W
29	1.9	221 +64.5	230 +71	7	0.4	5	*R	W	W
30	3.1	214 +46.5	217.5+42.5	6	0.2	5.5	*R		W
31	3.8	207.5+51	209 +56.5	5	0.2	5.5	M	RW	
32	5.7	171 +26	176 +17	4	0.2	5	R		
33	10.6	214 +48	220 +48	7	0.3	5.5	*S	W	W
34	12.2	272 +86.5	o +89	8	0.2	5	S	RW	
35	13.2	209 +47.5	202.5+48	7	0.3	5	S	W	W
36	14.8	208 +53.5	200 +64.5	6	0.3	5	R	W	W
37	15.2	207.5+51	202 +56	7	0.3	5	M	RW	W
38	22	211 +52	212.5+59.5	7	0.4	5.5	M	W	W
39	22.8	256.5+18	262.5+13	5	0.4	4	M	Y	W
40	24	211 +48	201 +51.5	7	0.3	5	*R	Y	W
41	36	228.5+48	207 +47.5	8	0.4	3	R	Y	
*42	36	205 +47	192.5+42.5	8	0.2	4	R	Y	W
43	42	236 +37.5	231 +22	8	0.6	4	*S	WY	B
44	46.2	212.5+45.5	213.5+15.5	9	1.0	5	R	W Streak	W
47	50.8	212.5+49	206 +60	8	0.4	5	*R	W Streak	W
48	52.3	230 +58	242.5+37.5	6	1.0	2	*S	Y	
49	54.8	213.5+47.5	214 +44.5	8	0.2	2.5	*S	Y	W
50	56.2	219 +47	212.5+52	7	0.3	4.5	M	BW	
51	10 2	181 +25	177.5+16	6	0.4	4.5	M	BW	W
			July 4, at Kyoto.						
1	8 38.2	168 +62.5	165 +57.5	7	0.2	5	R	Y	
2	39	165 +59	155 +56	4	0.2	4.5	R	B	
3	40	207.5+50.5	202 +55	8	0.3	5	M	W	W
4	40.2	152.5+55.5	146 +60	7	0.2	5.5	M	B	
5	41.4	152.5+68.5	164 +59	8	0.4	4	M	RY	
6	42.7	163.5+62	175 +67	6	0.2	5.5	*R	W	
7	44.3	212 +47.5	216 +41	8	0.3	4	M	B	W
8	48.4	217 +38.5	219.5+34	7	0.2	5	*R	W	W
9	50.4	205 +50	196.5+52.5	7	0.2	5	R		W
10	52.5	219.5+13.5	207.5+18.5	7	0.5	2	R	RY	C
11	58.4	227 +33	223 +40.5	8	0.3	5	S		
12	9 0	212 +47.5	200 +51.5	9	0.4	4.5	R		W
13	8	220.5+27	230.5+16	7	0.5	5	R		
14	11.2	232.5+10.5	225 + 7	7	0.2	5.5	R	Y	

No.	Time.	Appearance.	Dis-appearance.	Weight.	Duration.	Magn.	Velocity.	Color.	R.
	h. m.	o o	o o		s.				
15	12.8	245.5+ 3.5	236 +14.5	9	0.4	5	rR	B	C
16	13.6	238 −26.5	229.5−30	8	0.2	5	M	W	
17	14.8	239 −19.5	247.5−10.5	9	0.4	5	M	W	
18	15.7	240 +23	232.5+18	7	0.2	4	rR		
19	16.2	247.5+22	239 +26.5	8	0.3	4	M	WB	
20	17.4	265.5+ 2	260 − 4	6	0.3	4	M	R	
21	18.3	237 + 6.5	245 +11	7	0.3	5.5	R	W	
22	20.2	256 + 9	260.5+12.5	7	0.3	4.5	R		
23	21.4	244 +19.5	246.5+13	7	0.2	4.5	rR	W	
24	23.0	235 + 8.5	232.5+12.5	6	0.2	5.5	R	B	C
25	24.7	263 +12.5	270 +10	7	0.2	5	rR	WY	
26	26.8	245.5− 8	240.5−12	7	0.2	5	rS		C
27	28.5	234 + 7.5	232.5+10.5	7	0.2	5.5	R	W	
28	30.0	235.5+ 2.5	246 − 2.5	6	0.2	5	rR	W	
29	31.8	242.5− 3.5	246 − 2.5	6	0.2	5	rR	W	
30	33.2	240 −26	249 −26	6	0.2	4	R		
31	36.8	235.5+15.5	241 +16	5	—	5	rR	Streak	
32	38.0	224.5+27	217 +24.5	5	0.3	5	S	W	
33	41.0	235.5+ 9.5	239.5+ 4.5	7	0.2	5	R		
34	43.0	234.5+11	245 5+12	8	0.2	5.5	rR		
35	45.1	252.5+ 9	246 + 6	7	0.2	5	S	W	
36	49	253.5− 5.5	249 −14.5	8	0.5	4.5	S	Brown	
37	10 22.2	213.5+ 1.5	215 +55	7	0.3	4.5	R	B	W
38	24	213 +48.5	213.5+53	8	0.2	5	R		W
39	28.5	222 +32	218.5+40	4	0.2	4.5	R	W	
40	33.0	219 +12.5	207.5+17.5	8	0.5	4	rR	Y	C
41	35.3	213 +46.5	226.5+47.5	7	0.2	4.5	R	W	W
42	36.5	207 +26	205 +18.5	6	0.4	5	R	BW	W
43	38.0	226 +20.5	218.5+27	6	0.4	5	R	YW	C
44	39.7	225 +42	235 +38	8	0.2	4.5	R	BW S.	W
45	41.7	214 +48	218 +52.5	8	0.3	5.5	R	B	W
46	43.3	213.5+36.5	213.5+31.5	7	0.2	5	M	W	W
47	44.1	212 +48.5	204 +58	7	0.4	4.5	rR	B	W
48	51	211.5+56	202 +47.5	7	0.4	3	R	RY	
			July 5, at Kyoto.						
1	8 48	226 +40	212.5+39	7	0.6	5	S	B	
2	48.6	213 +48	212 +54	8	0.3	5	M	W	W
3	49.6	180 +52	173 +58	7	0.2	5.5	rR	W	
4	48.6	195 +39	200 +42	8	0.2	5.5	R	BW	
5	52	250 +21	252.5+10.5	5	0.2	4.5	rS	R	
6	53	214 +48.5	216 +53	8	0.3	5.5	rS	YB	W
7	54.8	228.5+33	224 +41	7	0.5	5	rS	W	
8	57	230.5+60.5	229 +69	8	0.6	5.5	M	—	

No.	Time.	Appearance.	Dis-appearance.	Weight.	Dura-tion.	Magn.	Velo-city.	Color.	R.
	h. m.	o o	o o		s.				
9	8 58	205 +48.5	194 +51	6	0.2	5.5	S	—	W
10	59	205 +49.5	192 +52.5	6	0.2	4	S	Y	W
11	9 1	213 +38	213.5+34	6	0.2	5.5	M	B	W
12	2.1	214 +43	217 +47.5	7	0.3	3	rR	B streak	W
13	3.3	213 +47	214 +55	—	0.4	5	—		W
14	4	213 +35.5	204.5+32	6	0.4	2	R	R.Y.	
15	10	207 +27	172 +37.5	6	0.5	4.5	R	Y	C
16	17	194.5+68	176 +76	7	0.4	4.5	rR	B	W
17	20	224.5+41	233 +36.5	6	0.3	5	rR	B.W.	W
18	21.6	200 +55.5	193 +59	6	0.3	5	rR	B streak	W
19	23.2	194.5+37	164 +65.5	9	0.4	6	R	B	
20	29.6	228 +33	220 +25	8	0.5	4	R	Y.W.	
21	34.6	239.5+ 5.5	231.5+17	4	0.4	1	R	Y	C
22	37.4	214.5+52.5	215.5+56.5	8	0.2	5	M	B	W
23	39.2	222 +19	223 +15.5	5	0.2	4.5	M	Y	W
24	43	213.5+46	191 +35.5	8	0.5	5.5	rR	B	W
25	44.2	189 +54.5	181 +62.5	7	0.4	2	S	Y	
26	46.8	213.5+48.5	214 +53.5	8	0.2	5	S	B	W
27		195 +44	172 +46.5	7	0.5	4	M	Y	
			July 6, at Kyoto.						
1	8 50	217 +47.5	225 +55	7	0.3	3	rR	Y	W
2	51	217 +49	213.5+52.5	8	0.2	5	M		W
3	51	214.5+48	214 +53	8	0.2	5.5	M		W
			July 11, at Kyoto.						
1	8 30	243.5−16	239.5−22	7	0.4	2	R	Y Curve	
2	9 6.4	181.5+54	169 +54.5	7	0.3	3.5	R	Brown	W
3	7.2	215 +47.5	213.5+53	7	0.2	5	rR	B.W.	W
4	9.2	171.5+45.5	162.5+44	6	0.3	4	rR	Y.W.	W
5	12.4	216.5+38	213 +36	6	0.2	4.5	rR	Y	
6	13.2	217 +38.5	211 +39	6	0.2	5	rR	Y	
7	15.5	201 +41	193.5+39	7	0.2	5	rR	W	W
8	20.4	194 +42	188 +41.5	5	0.1	3	R	Y	W
9	22.2	216 +54	213 +52	7	0.2	5.5	rR	W	
10	24.6	213 +47	213 +50	5	0.2	5	rS	B	W
11	25.2	184.5+38.5	176 +38.5	5	0.2	4.5	rR	B	W
12	27.2	238 +41	248 +39	7	0.3	4.5	rR	W	W
13	30.8	215.5+42.5	219.5+45	5	0.2	5	rS	B	W
14	33.2	213 +25	212.5+21	6	0.2	5	rR	B	W
15	36.0	205 +50	200 +53	5	0.2	5	rR	B	W
16	38.7	218 +42	224.5+40.5	6	0.3	5	rS	B	W

No.	Time.	Appearance.	Dis-appearance.	Weight.	Dura-tion.	Magn.	Velo-city.	Color.	R.
	h. m.	o o	o o		s.				
17	9 40.6	191 +55	174 +61.5	7	0.3	5	R	B.W.	W
18	42.4	212.5+52.5	201 +55	8	0.3	2	M	Y	
19	44.2	211.5+47.5	207.5+50.5	6	0.2	5	M	B	W
20	45.2	248 +21	239 +27	8	0.4	2.5	R	Y	
			August 2, at Kyoto.						
1	8 58	182 +45.5	172.5+48.5	8	0.3	6	S	B	W
2	9 1	219 +27.5	216 +29.5	7	0.2	5.5	rR	B	W
3	4	221 +50	208.5+47.5	7	0.3	1	rS	Y & Blue	
4	7	252 +11	242.5+ 2	7	0.8	−3	rS	Y & Blue	
5	10	218.5+30	217 +32.5	6	0.1	6	rS	B	W
6	12	225.5+41.5	226.5+48	7	0.2	5.5	M	B	W
7	17	220 +28.5	218 +30	6	0.1	6	rS	B	W
8	17.1	222.5+27.5	226 +27.5	7	0.1	6	rS	R	D
9	21	221.5+20	216 +28	6	0.4	5	M	Purple	
10	25	209 +34.5	203.5+37	6	0.2	6	M	B	W
11	26	219 +28.5	216 +32	6	0.1	6	rS	B	W
12	30	281 +40	262.5+12	8	0.8	5	rR	R	
13	10 5	221 +28	222 +29	6	0.1	6	M	R	D
14	8	219.5+27.5	214.5+31	6	0.2	5.5	M	B.W.	W
			August 3, at Kyoto.						
1	8 34	173 +53	166 +45.5	8	0.5	4.5	S	R curved	
2	39	207.5+19.5	204.5+16.5	7	0.2	4.5	rR	C	D
3	40	270 +37	220.5+42.5	5	0.2	5	rR	C	D
4	43	231 +28.5	216 +51.5	8	0.5	5.5	M	B	
5	46	267 +58.5	265 +67	6	0.4	5	M	C	
6	47	220 +28	217.5+32	7	0.2	6	M	B	W
7	50	220 +29.5	215 +39.5	6	0.4	6	M	B	W
8	51	219.5+27	219 +28.5	6	0.1	5.5	M	C	
9	53	232.5+45.5	216 +37.5	7	0.5	5	M	B.W.	
10	57	221 + 9.5	201 +12	6	0.5	4	M	B	
11	9 5	210 +66	175 +60	6	0.5	5	rR	R	
12	9	225 +41	226 +50	7	0.4	5.5	rR	C	D
13	10	243 +25	240 +21.5	5	0.2	2.5	S	Y	
14	35	224 +23.5	211.5+25	7	0.4	5	rR	R.W.	
15	37	222.5+24	229.5+23.5	5	0.3	6	rS	W	
16	39	219 +27.5	216.5+29	6	0.2	6	rS		W
17	40	216 +25	211.5+25	6	0.2	6	rS	W	W
18	42	229.5+28.5	238 +30	7	0.3	5.5	rR	C	D
19	47	242.5+27.5	245.5+22.5	6	0.2	5	rR	W	
20	47	221 +25	224 +25	6	0.2	5.5	M		W
21	49	218.5+28	215 +28	6	0.2	5.5	rS		W

No.	Time.	Appearance.	Dis-appearance.	Weight.	Dura-tion.	Magn.	Velo-city.	Color.	R.
	h. m.	o o	o o		s.				
22	9 50	244 +61	232.5+69.5	8	0.5	4	M	Y.W.	D
23	53	218 +39	197.5+40	9	0.6	3	*r*S	Y	
24	55	217 +22	215 +17.5	6	0.3	5	*r*S	C	
25	59	223 +45	211 +39.5	6	0.4	4.5	*r*R	Y	
26	10 00	225 +48.5	227.5+55	7	0.3	5	*r*R	C	D
			August 4, at Kyoto.						
1	8 23	224 +26.5	229 +25.5	7	0.2	5	*r*R	R	D
2	26	220 +26	216.5+27.5	6	0.2	6	M	B	W
3	27	217.5+41	207.5+35.5	6	0.3	5	M	W	
4	30	218 +17	220 +11	5	0.3	5	M	Y	
5	31	209 +33.5	202.5+37.5	7	0.4	6	M		W
6	33	219 +27	214.5+29.5	6	0.2	6	M	B.W.	
7	33	198 +31.5	187.5+22	6	0.5	4	*r*S	R.Y.	W
8	36	220 +28.5	216.5+32.5	6	0.2	6	*r*S	W	W
9	39	221.5+23.5	217.5+24	6	0.2	6	S	B.W.	W
10	41	236 +17.5	238.5+ 6.5	7	0.4	4.5	*r*S	R	
11	44	263 −14	258.5−25	8	0.6	4	*r*S	C	
12	45	219 +26	205 +26.5	6	0.2	6	*r*S		W
13	46	219 +27.5	214.5+29.5	5	0.2	6	*r*S		W
14	49	250 +40.5	240 − 2	10	0.8	2	*r*R	Y Tail	
15	53	220.5+26.5	218 +30	6	0.2	6	*r*S	B.W.	W
16	53	220 +26	218 +28.5	6	0.1	6	*r*S	B.W.	W
17	55	162 +61	175 +49	7	0.5	2	M	Y Tail	
18	56	231.5+10	236 + 3.5	6	0.3	5	*r*R	R	D
19	59	245 +32.5	231.5+37.5	7	0.3	3	*r*R	Y	
20	9 1	214 +21.5	210.5+20	5	0.2	6	M	B.W.	W
21	4	213 + 9	196 +10	9	0.6	3	M	C	
			August 5, at Kyoto.						
1	8 27	217.5+37.5	216.5+41	6	0.1	6	M	B.W.	W
2	27.2	223 +38.5	223.5+42	6	0.2	6	M	B.W.	W
3	27.3	214.5+35	211.5+38	6	0.2	5	M	R	D
3	37	196.5+27.5	193.5+ 9.5	6	0.6	3.5	R	B	
5	41	262 +58	243 +62	7	0.4	3	*r*R	Y Tail	
6	54	215 +31	219 +41	7	0.3	3	R	B	
7	55	227.5+32	231.5+36	6	0.2	5	*r*R	R	D
8	9 00	227.5+34.5	230 +37.5	6	0.1	5	M	R	D
9	1	221.5+23.5	222 +26.5	5	0.2	6	S	B	W
10	13	226 +26	215 +40	8	0.3	5.5	R	W	
11	16	240 +31	231 +26	8	0.5	5	*r*S	C	
12	18	261.5+27.5	262.5+10.5	6	0.6	4.5	R	Green	
13	30	212 +40	225 +42.5	6	0.5	4	S	C	

No.	Time.	Appearance.	Dis-appearance.	Weight.	Dura-tion.	Magn.	Velo-city.	Color.	R.
	h. m.	o o	o o		s.			•	
14	9 35	222 +21	221 +17.5	5	0.2	6	S	B.W.	W
14	36	224 +19	207.5+21	6	0.5	2.5	*r*R	Y	
16	41	222.5+22.5	227.5+22	5	0.2	6	*r*S	B.W.	W
17	46	277.5+75	231 +71.5	7	0.4	4.5	R	R	
			August 7, at Kyoto.						
1		220.5+22	217.5+24.5			6			W
2		222 +19.5	220.5+16			6			W
3		222 +22.5	224 +25			6			W
4		223 +25	223 +27			6			W
5		224.5+26	226 +27.5			6			W
6		224 +21	227.5+19.5			6			W
7		227.5+23	231 +24.5			6			W
			August 8, at Kyoto.						
1		214 +27	209 +28.5			6			W
2		213 +25	208.5+26			6			W
3		218.5+21	215.5+19			6			W
4		220.5+20	218.5+18			6			W
5		225.5+24.5	225.5+27.5			6			W
6		232.5+19.5	237.5+16			6			W

§5. Statistics of the Results.

Daily numbers of meteors observed are arranged in the next table. The third column shows those meteors belonging to Winnecke's Comet, as proved by their pass on the daily chart, and at the same time by their appearances. (See §6).

TABLE II

Statistical Review.

Date.	Total Meteors.	Winnecke Meteors.	Interval.	Place.
1921 June 25	5	0	$13^{m.}$	Hachiman
26	32	14	60	,,
27	44	23	94	Fukuchiyama
28	40	29	60	Tottori
July 2	19	15	27	,,
3	51	26	84	Kyoto
4	48	13	53	,,
5	27	14	61	,,
6	3	3	—	,,
11	20	14	41	,,
August 2	14	8	37	,,
3	26	6	86	,,
4	21	10	44	,,
5	17	5	39	,,
7	7	7	20	,,
8	6	6	18	,,

Beside these observations, there are numbers of the Winnecke Meteors only counted by Nakamura, not recording their positions because of their too abundant apparitions, as in Table III:

TABLE III.

Counted Meteors belonging to the Winnecke.

Date.	Duration of Observations.	Total Number.	Place.
1921 July 3	$9^h\ 26^m$ ... $10^h\ 1^m$	153	Kyoto
5	9 27 ... 9 48	91	,,

From these tables, we see that the total meteors *seen and recorded* during the period from the end of June till the first decade of August is 380, of which those belonging to the Winnecke's Comet is 193, with, moreover, 244 meteors of the latter kind only *counted*. Table IV gives more detailed summary of the Winnecke meteors exclusively.

From the above results, we see that the climax of the showery displays was between the 29th and the 30th of June, which is reasonably justified by the elements of the orbit of the comet.

TABLE IV.

Date.	Radiant Point.	Diffusion.	Hourly Number.	Weather.	Mean Magnitude
1921					
June 26	211°.5 + 52°	2°	14	Cloudy	5.4
27	210 + 50.5	2.5	15	Cloudy	5.0
28	212.5 + 49	5.5	29	Cloudy	5.1
July 1	212 + 48	5	33	Cloudy	3.5
3	213 + 47	4	19	Fine	4.8
4	213 + 46.5	1.5	15	Cloudy	4.8
5	213.5 + 46	2	14	Very Fine	4.8
6	214 + 45.5			Cloudy	4.5
11	215 + 42	2	20	Fine; Moon	5.0
Aug. 2	222.5 + 25		11	Fine	5.8
3	222 + 25		4	Very Fine	5.8
4	223 + 24		14	Fine	6.0
5	222.5 + 22.5		8	Cloudy	6.0
7	222.5 + 21		21	Fine; Moon	6.0
8	225 + 22.5		20	Fine; Moon	6.0

But the estimations of the hourly numbers is naturally influenced by the weather conditions, and that especially in this kind of very faint meteors. Consequently, the observations with special attention to the meteoric displays *sacrificing labours of recording* resulted in the following figures for hourly numbers on the nights of July the 3rd and 5th, as deduced from the data of Table III:

July 3, hourly number = 262,
„ 5, „ „ = 260.

The march of the radiant point during the period of observations is well shown. The total range actually observed is about 30° in six weeks. These radiant points were estimated in our maps used in the fields. Here we see that the radiant points are diffused to some extent, amounting more than five degrees in some instances. But, while counting only were made on July 3rd and 5th., some meteors

radiated from within 1.5 degrees of the radiant point, rarely, indeed, within half a degree.

§6. Characteristics of Apparitions.

Trail. The general feature of this kind of meteors belonging to Winnecke's Comet was its ash-like appearance, by which we could easily distinguish the present objects from other meteors. This is quite in accordance with Mr. Denning's description:

> "..... The meteors were rather slow, and the brighter ones left trains. In some cases the nuclei were resolved into streams of luminous ashes and presented essentially different aspects from the usual stellar meteors." (Observatory, Vol. 39, 356.)

These impressions made one of us (K.N.) recall a similar kind of apparitions seen on the night of June 23 through small gaps of clouds while watching the sky at Kyoto. He was little expecting at that time to see the Winnecke, because the date seemed too early for them. But, lately, by accumulated experiences, he has become assured in the belief that those that were seen that night were really meteors of the present shower. If it had been clear weather, his discovery must have been, thus, at least, three days earlier. Average velocities of the recorded meteors were found rather to be rapid. But as they were generally short, and the condition of appearance was peculiar, it was pretty hard to know their real velocities.

The curious fact was that the meteors were numerous in two regions of position angles, that is in 150°–180° and 330°–369°. These directions are opposite to each other. This may be probably due to some psychological effects, affected by the neighbouring configurations of bright stars.

Magnitude and Colour. Meteors of this shower were generally very faint; the brightest being of the 2nd magnitude, and that rarely. The recorded meteors were generally of the 5.5th magnitude and brighter. See the following table.

TABLE V.

Date	*Magnitudes.*								
	2	2.5	3	3.5	4	4.5	5	5.5	6
June 26	—	—	—	—	—	1	3	8	2
27	—	—	—	1	1	4	9	8	—
28	1	—	—	—	—	2	12	10	1

July	1	1	1	5	3	3	1	—	1	—
	3	—	1	2	—	4	1	9	7	2
	4	—	—	—	—	1	5	6	1	—
	5	—	—	1	—	1	2	6	4	—
	6	—	—	1	—	—	—	1	1	—
	11	—	—	1	1	1	—	2	9	—
Aug.	2	—	—	—	—	—	—	—	3	5
	3	—	—	—	—	—	—	—	2	4
	4	—	—	—	—	—	—	—	—	10
	5	—	—	—	—	—	—	—	—	5
	7	—	—	—	—	—	—	—	—	7
	8	—	—	—	—	—	—	—	—	—

The colour of the present meteors were generally of three kinds:— blue, bluish-white and white. But some fine meteors were yellow. The following table shows the distribution:

TABLE VI.

Colour-frequency of Winnecke meteors.

Date.	B	BW	W	Y	RW	YB	Brown
June 26	4	1	2	—	—	—	—
27	2	2	—	—	—	—	—
28	1	10	11	—	—	—	—
July 1	—	—	—	—	—	—	—
3	—	2	9	2	2	—	—
4	4	2	4	—	—	—	—
5	7	—	1	2	—	1	—
6	—	—	—	1	—	—	1
11	6	2	1	2	—	—	—
Aug. 2	7	1	—	—	—	—	—
3	2	—	1	—	—	—	—
4	1	5	1	—	—	—	—
5	1	4	—	—	—	—	—
7	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—
Sum	35	29	30	7	2	1	1
%	33	28	29	7	2	1	1

§7. Other Showers of Meteors.

In the observed meteors of Table I, there are many that do not belong to the Winnecke, of which the following four showers are found to have each its own radiant points:

TABLE VII.

Date.	Radiant Point.	Designation.	Number.
June 25–28	212°.5 + 19°.5	α Bootids	9
June 26–July 3	242° + 60°	η Draconids	6
July 3– 5	251 − 4	Ophiuchids	8
Aug. 2– 5	221 + 27	ε Bootids	13

The last one was very near the Winnecke in position. But we could detect the differential character by the peculiarities of the latter: for, these Bootids were very distinct with their red colour and with streaks of the usual stellar form. This shower showed a moving radiant point, thus:

August 2, 221° + 28°
„ 3, 220.5 + 27
„ 5, 221 + 25.5

§7. Summary.

Although much perturbed by peculiar weather conditions, owing to the annual rainy season, the expected returns of the meteoric displays probably belonging to the Pons-Winnecke's Comet were confirmed by actual discoveries and observations. They were generally very faint, of ash-like appearance, and left trains in the brighter ones. The progression of the radiant points was followed over some six weeks, which were pretty diffuse. Of colours, blue to white were predominating.

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I. Yamamoto.
K. Nakamura.

Kyoto University Observatory,
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