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Phoenicids in 1956 Revisited

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Abstract

The outburst of the Phoenicids observed in 1956 was investigated on the basis of the dust trail theory by using a newly linked orbit, which was estimated from the asteroid 2003 WY25 and comet D/1819 W1 (Blanpain). We found that a bundle of the trails formed from the late 18th through the early 19th centuries came close to the Earth's orbit at the epoch of the outburst in 1956. According to similar calculations for 1950–2030, the situation in 1956 was proven to be the best epoch for a strong display in the Phoenicids. This result shows not only a definite association of the objects to the Phoenicids, but also a clear reason for the sudden outburst in 1956. Although future activity is expected in 2014, it depends on the cometary activity of the parent object, because the related trails are expected to be relatively new.

Key words: interplanetary medium — meteors, meteoroids — meteor showers: individual (Phoenicids) — solar system

1. Introduction

The Phoenicids is one of the mysterious meteor showers. It suddenly appeared on 1956 December 5, which had been an unknown meteor shower until then. The many reports of witnessing this activity (the visual hourly rate was up to 100) were summarized by G. W. Kronk (2005).[1] J. Nakamura observed this outburst on a Japanese expedition ship, Soya, in the Indian Ocean on the way to the Antarctic while he was operating instruments for airglow observations. The activity was thought to have a maximum of about 300 in the visual hourly rate (Huruhata, Nakamura 1957). It is also mysterious that no other strong outburst at this level has been reported so far, except in 1956, while a few reports indicate the existence of small activity in the '70s and '80s. From a rough estimate of the radiant of the Phoenicids in 1956, Ridley (1957) pointed out that the comet D/1819 W1 (Blanpain) was a possible parent comet. However, this comet was observed only in 1819. Although the period of this comet was thought to be as short as 5–6 yr, no other apparition had been recognized. This situation also caused an uncertainty in the orbital elements of this comet, which prohibited any further study of not only this comet, but also its association to the Phoenicids. Recently, a newly discovered asteroid, 2003 WY25, was suggested to be the same object as the comet D/1819 W1 (Blanpain) (Foglia et al. 2005). This provided us a chance to revisit the outburst of the Phoenicids in 1956 on the basis of the dust trail theory by using new orbital elements of this object. In the present work, the characteristics of the observed outburst of the Phoenicids in 1956 was investigated using calculated results. The expectation of the future activity is also discussed.

2. Calculation of the Dust Trails

We applied the most simple approach of the dust trail theory (e.g., Asher 2000), which was described by Sato (2003). Each trail was assumed to be formed by meteoroids ejected during the passage of the perihelion of the comet. The trail was calculated by test meteoroids ejected toward and away from the comet motion. The ejection velocity was set at $\pm 20\,\mathrm{m\,s^{-1}}$ at first. Integration was carried out by using the Runge–Kutta–Fehlberg method together with Encke's method. We included three of the largest main-belt asteroids and the moon in addition to the nine planets to calculate the perturbation on the basis of DE406. We did not take the effect of the radiation pressure onto the meteoroids into account in our calculation. The applied orbital elements were those calculated by Nakano (2005). The non-gravitational force was not taken into account because we did not have enough information about it. The calculated trails in this study were those made during about 200 yr from 1743 through 1951. We set this period because much older trails should be too sparse to contribute to the outburst in 1956. This choice is justified in the next section.

[1] ⟨http://comets.amsmeteors.org/meteors/showers/phoenicids.html⟩.

Table 1. Data of trails related to the 1956 outburst.

Ejected year	Expected peak time Date (UT)	Time	LS (2000)*	Δr (AU)	Ejection velocity (m s^{-1})	fM	Expected position of radiant α (°)	δ (°)	V_g† (km s^{-1})	Notes
1.	Period in 1743–1754									
1754	1956/12/05.66	15:54	254.116	+0.00092	+0.28	0.010	3.63	−42.03	10.47	
2.	Period in 1760–1808									
1760	1956/12/05.69	16:37	254.147	+0.00054	+0.68	0.025	3.56	−41.95	10.47	
1766	1956/12/05.69	16:39	254.148	+0.00061	+0.62	0.023	3.55	−41.93	10.46	
1771	1956/12/05.69	16:40	254.149	+0.00065	+0.54	0.021	3.54	−41.91	10.46	
1776	1956/12/05.69	16:39	254.148	+0.00067	+0.52	0.020	3.54	−41.89	10.46	
1782	1956/12/05.69	16:38	254.148	+0.00067	+0.50	0.021	3.53	−41.87	10.46	
1787	1956/12/05.69	16:37	254.146	+0.00068	+0.49	0.021	3.53	−41.86	10.45	
1792	1956/12/05.69	16:35	254.145	+0.00068	+0.49	0.020	3.52	−41.84	10.45	
1797	1956/12/05.69	16:33	254.144	+0.00067	+0.49	0.021	3.52	−41.82	10.45	
1803	1956/12/05.69	16:30	254.142	+0.00065	+0.50	0.021	3.51	−41.80	10.45	
1808	1956/12/05.68	16:26	254.139	+0.00045	+0.73	0.031	3.50	−41.79	10.45	
3.	Period in 1814–1830									
1814	1956/12/05.67	16:08	254.127	−0.00022	+1.46	0.063	3.46	−41.73	10.47	‡
1819	1956/12/05.69	16:35	254.146	−0.0014	+2.21	0.095	3.23	−41.63	10.48	‡
1825	1956/12/05.70	16:51	254.157	−0.0021	+2.77	0.12	3.17	−41.61	10.49	
1830	1956/12/05.72	17:19	254.176	−0.0033	+3.85	0.20	3.07	−41.55	10.50	
4.	Period in 1861–1882									
1861	1956/12/05.71	17:02	254.165	+0.0049	−4.37	0.21	3.71	−42.04	10.34	
1866	1956/12/05.75	17:54	254.201	+0.0044	−3.69	0.20	3.63	−42.06	10.36	
1872	1956/12/05.82	19:41	254.276	+0.0044	−3.79	0.24	3.49	−42.14	10.36	
1877	1956/12/05.89	21:26	254.351	+0.0041	−3.97	0.22	3.32	−42.19	10.36	
1882	1956/12/05.96	22:57	254.414	+0.0050	−4.49	0.14	3.20	−42.33	10.35	
5.	Period in 1935–1940									
1935	1956/12/06.00	00:01	254.460	−0.0037	+18.83	0.29	2.42	−41.59	10.50	
1940	1956/12/05.99	23:44	254.448	−0.00013	+21.09	0.37	2.69	−41.69	10.44	§

* LS (2000) is the solar longitude (2000.0 Epoch) corresponding to the expected peak.
† V_g is the expected geocentric velocity.
‡ Possible contribution to subpeak of the outburst.
§ Included due to the small Δr value even in the larger ejection velocity (> 20 m s^{-1}).

3. Result of the 1956

Table 1 gives the situation of the dust trails at the epoch of the outburst in 1956. The date is the time when Earth passed at the ascending node of each trail. Δr is the difference of the heliocentric distance between Earth and each trail. The parameter fM is the degree of the extension of the trail, and was derived by $fM = \Delta t / \Delta t_0$, where Δt is the time needed for the trail passing the ecliptic plane, and Δt_0 is the same, but at the first return. In the absence of perturbations, the fM value is basically proportional to n^{-1}, where n is the number of returns. In reality, we calculate the effect of perturbations, and hence fM is a measure of the density of meteoroids within the trails.

The result is also summarized in figure 1, which shows the relation between the trails and the Earth's orbit. A bundle of the trails formed from the late 18th through the early 19th centuries came close to the Earth's orbit on December 5. The figure also includes the reported duration of the outburst activity, which clearly shows a coincidence of the position of the bundle. The bundle consists of the trails formed between 1743 and 1808. Especially the trails between 1760 and 1808 came close up to 0.00045 AU. The ejection velocity was small enough as 0.53–0.73 m s^{-1}, which means a strong concentration of the meteoroids. The epoch of the close approach is estimated to be between 16h 26m and 16h 40m, which coincides with the reported maximum time, 16h 30m, by Huruhata and Nakamura (1957).

Another part of the bundle is those trails formed between 1814 and 1830. The fM value is larger than the older trails. Especially the approach distance of the 1814 trail is 0.00022 AU, which is close enough to produce a strong display of a meteor shower. The ejection velocity in the case of these trails is a little larger than the first part, such as 1.46–3.85 m s^{-1}.

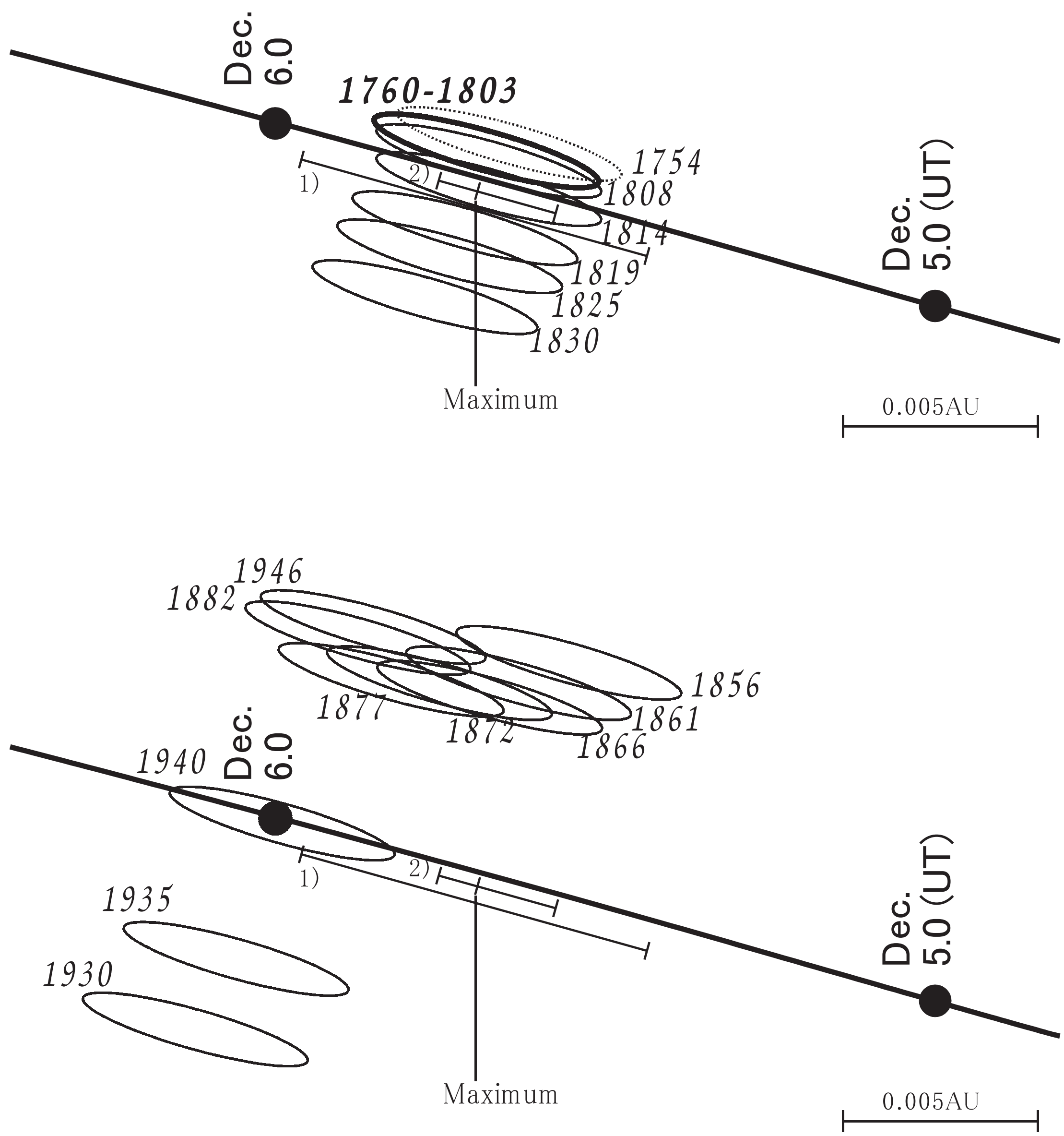

Fig. 1. Geometrical relation between the dust trails and the Earth's orbit in 1956. The upper panel shows those trails formed before 1830, while the lower panel shows those after 1856. The two lines indicate the duration of the outburst summarized by 1) Kronk[1] and 2) Huruhata and Nakamura (1957), including the epoch of the reported activity peak.

None of the trails later than 1814 came close to the Earth's orbit, except that of 1940. Although the trails older than 1754 actually came close, there may be no strong concentration of the meteoroids due to the smaller value of fM, which is less than 0.01. Hence, we did not consider the two trails of 1743 and 1749 in this study, and removed them from table 1.

It is also interesting to note that the 1940 trail just remained in the Earth's orbit. The closest distance was 0.00013 AU. However, the ejection velocity was much larger, $21.1\,\mathrm{m\,s^{-1}}$, which means a display of faint meteors, if any. The center of the cross section was located at around 0h UT on December 6, which is later than the observed activity period. If the comet was still active in 1940, then some more activity should have continued until December 6. This may give an important clue to clarifying the history of the cometary activity.

4. Comparison to the Observations

It should be noted that the above-mentioned result is a purely theoretical calculation based on the newly linked orbit of the parent candidate, 2003 WY25 and comet D/1819 W1 (Blanpain). The result indeed confirms the definite association of the parent object and the Phoenicid meteor shower. Moreover, the outburst observed in 1956 should be due to a bundle of several dust trails formed mainly between 1760 and 1808. If this bundle was the main source of the outburst in 1956, the maximum activity is estimated to be between 16h 26m and 16h 40m. Another expected characteristic is that the outburst should have included large meteoroids, namely bright fireball-class meteors, because the ejection velocity was as small as 0.53–$0.73\,\mathrm{m\,s^{-1}}$. These properties were actually

Table 2. Possible activities expected during 1950–2030.

Year	Estimated peak time	Expected activity	Main source trail
1951	12/5 4–7h	Middle level	1760–1808
1956	12/5 16–17h	Meteor shower	1760–1819
1961	12/4 11–14h	Low-Middle level	1782–1792
1977	12/3 1h	Low level	1830
1978	11/26 22h	Low level	1861
	11/27 9h	Low level	1861
1986	12/2 0h	Low level	1814
1988	12/5 2h	Low level	1749
1993	12/3 14–15h	Low-Middle level	1819, 1825
	12/4 0–1h	Low level	1835
2003	12/1 5h	Low level	1840
2008	11/8 0h	Low level	1866
2014	12/1 23–12/2 2h	High level	1909–1930
2019	11/23 0–1h	Low level	1877
	12/2 21–23h	Low level	1898, 1946
2024	11/14 9h	Low level	1866
2026	12/2 8–10h	Low level	1776
2030	12/2 18h	Low level	1903

recognized in several observation reports. The duration of the outburst has been described from 10h 10m through 22h 45m by Kronk,[1] while the maximum may have been 17h–19h, even if it was not clear. On the other hand, Huruhata and Nakamura (1957) reported that J. Nakamura first noticed the outburst at 13h 40m. They estimated the time profile of the activity as a visual hourly rate of ~ 100 at 14h, ~ 100 at 15h, ~ 200 at 16h, ~ 300 at 16h 30m, and ~ 100 at 17h, with the end at 18h. Especially the maximum time, 16h 30m, reported by Huruhata and Nakamura (1957) coincides with our calculation result. Another actual characteristic described in these reports is the abundance of fireball-class meteors at around the center of the outburst, which also coincides with the expected property. Huruhata and Nakamura (1957) wrote that many meteors were bright enough to produce bright persistent trains. Especially at around 16h 34m, several fireballs brighter than full moon appeared, and left persistent trains, which remained for several minutes. The basic properties of the outburst seem to be due to the bundle of dust trails formed between 1760 and 1808, while the enhancement of the activity at 16 h may have been partly due to the 1814 dust trail. Concerning the early phase of the outburst, there is no evidence of such bright meteors from the radio observation result (Weiss 1958). This is also consistent with the fringe of the bundle of trails due to the larger ejection velocity.

The problem is the radiant. The theoretical radiant derived by our dust trail theory is $\alpha \sim 3^{\circ}\!.5$ and $\delta \sim -41^{\circ}\!.8$ (1950.0) for 1808 dust trail. This position is different from those reported so far. Huruhata and Nakamura (1957) derived the radiant as $\alpha \sim 356^{\circ}$ and $\delta \sim -43^{\circ}$ at the Indian Ocean. On the other hand, the apparent radiant should have been $\alpha \sim 10^{\circ}\!.5$, and $\delta \sim -37^{\circ}\!.0$ (1950.0) by correcting the Earth's rotation and zenithal attraction. The difference is about 13°, which is not negligible. The large difference may have been caused by the fact that J. Nakamura was not familiar with the astronomical standard method, such as plots of the meteors in the star chart, as noticed by Huruhata and Nakamura (1957). On the other hand, Ridley (1957) derived the radiant by visual observations as $\alpha \sim 15^{\circ}$ and $\delta \sim -45^{\circ}$, while Shain (1957) derived as $\alpha \sim 15^{\circ}$ and $\delta \sim -58^{\circ}$. The apparent position of the radiant estimated at the observed location of Shain (1957) should have been $\alpha \sim 15^{\circ}\!.5$ and $\delta \sim -43^{\circ}$, which still shows a large difference with the observed position. Weiss (1958) also derived the radiant as $\alpha = 15^{\circ} \pm 2^{\circ}$, and $\delta = -55^{\circ} \pm 3^{\circ}$ from an analysis of the radar observation, which roughly coincides with that derived by Shain (1957). The results of both visual and radar observations seem to show systematic shifts to the south compared with the expected position. Unfortunately, at this stage we do not have any further materials to judge if this discrepancy is mainly due to the uncertainty of the observational determination or not.

5. Possibilities of the Other Epoch

We carried out similar calculations during 1950–2030, and surveyed the situation of the dust trails, which come close to Earth within 0.003 AU. The dust trails were calculated from 1743 through 1951, and the ejection velocity was confined to be between -20 and $+20\,\mathrm{m\,s^{-1}}$. As the result of our inspection, as shown in table 2, there is no other epoch for realizing the ideal condition of such a strong display as in 1956. The only two cases, in 1951 and 1961, may have been active, although the expected activity level should have been lower by one order of magnitude than that in 1956, because in both cases the fM values of the trails are smaller than that in 1956. On the other hand, in the future activity is expected in 2014. The predicted condition is better than those in 1951 or 1961. However, the activity in these years depends strongly on the cometary activity of the parent object, because the related trails are expected to be relatively new, such as in 1909–1930.

6. Conclusion

We confirmed the association of the object 2003 WY25 = comet D/1819 W1 (Blanpain) with the Phoenicid meteor shower, together with the outburst condition in 1956 on the basis of the dust trail theory by using new orbital elements. The 1956 outburst should have been caused by a bundle of the trails formed from the late 18th through the early 19th centuries. Inspecting similar calculations during 1950–2030, the 1956 has been proved to be the best epoch for the strong display. Although future activity is expected in 2014, it strongly depends on the cometary activity of the parent object, because the related trails are expected to be relatively new. We are able to constrain the history of the cometary activity by using meteor observations because we can predict the corresponding trails to the outbursts in any given year. Until now, the object 2003 WY25 has shown no cometary activity. We should carry out a physical observation on this object at its next return.

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