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Detection of the Phoenicids meteor shower in 2014

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ABSTRACT

An appearance of the Phoenicids meteor shower was predicted in 2014 by using a dust trail simulation of an outburst of 1956. We detected Phoenicids meteors on December 2 through multiple observation methods. The NASA All Sky Fireball Network and the Southern Ontario Meteor Network detected five meteors of Phoenicids via video observation. The Canadian Meteor Orbit Radar (CMOR) found fourteen candidate meteors, eight of which were confirmed as Phoenicids. The observed radiant point is consistent with that of our model predictions. In addition to the above observations, a visual observation was carried out by the Japanese team near the Observatorio del Roque de los Muchachos (ORM) of Instituto de Astrofisica de Canarias (IAC) in La Palma Island. The obtained zenithal hourly rate (ZHR) was 16.4 ± 4.9. The maximum ZHR was roughly estimated to be between 20 and 30, which indicates that the cometary activity of parent object 289P/Blanpain in the early 20th century was only about one fifth or one eighth as high as its activity in the late 18th and early 19th century. Accordingly, it seems to be the case that 289P/Blanpain is gradually transforming from a comet to a dormant object.

1. Introduction

The Phoenicids are one of the established meteor showers listed in the IAU database; their number is #254. A spectacular Phoenicids display was recorded only once in the past on December 5, 1956. J. Nakamura observed this outburst on a Japanese expedition ship, Soya, in the Indian Ocean on the way to the Antarctic. The activity was thought to have a maximum of about 300 in the visual hourly rate at about 16:30 UT (Huruhata and Nakamura, 1957). Ridley (1962) summarized this outburst which was widely observed in the southern hemisphere, and showed that it was started at 10:10 and ended at 22:45 UT, giving an observed duration of over 12 h. Jenniskens (1995) also suggested that it was a broad peak whose zenithal hourly rate (ZHR) was about 100 or less from observation reports in Australia and South Africa. Nakamura's observation was not included in both reports. It was indicated that the appearance witnessed by J. Nakamura was very strong and continuous. No other strong outburst has been reported so far.

The parent body of Phoenicids was suggested to be 289P/1819 W1 (Blanpain) by Ridley (1957) and Huruhata and Nakamura (1957). This comet was discovered in 1819; however, it was subsequently lost. A newly discovered asteroid, 2003 WY25, was identified to be comet 289P/1819 W1 (Blanpain) (Foglia et al., 2005; Jenniskens and Lyytinen, 2005). This provided us a chance to investigate the outburst of the Phoenicids in 1956 using a dust trail model simulation and the orbital elements of the recovered comet. Watanabe et al. (2005) reported that the strong Phoenicids display in 1956 was caused by a bundle of dust trails which were ejected from 289P between the 18th and the early 19th centuries. Jenniskens and Lyytinen (2005) also reported a similar result that the major contribution for the 1956 outburst of Phoenicids may have been an outburst or fragmentation of the parent body in 1819. This discovery confirmed that 289P/1819 W1 (Blanpain) was the parent body of the Phoenicids.

Furthermore, this also provided us with the chance to forecast the next Phoenicids appearance. Sato and Watanabe (2010) forecasted Phoenicids activity in 2008, 2014 and 2019. Among these predicted outbursts the detection of activity in 2014 was the most promising because several dust trails would approach the Earth within 0.001au. On the other hand, these trails were formed from dust ejected from the parent comet in the early 20th century, when there were no observations of 289P and its level of cometary activity was therefore unknown. Hence, it was important to observe the Phoenicids in 2014, not only for

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Table 1
Data of main dust trails in 2014.

Ejection year	Expected peak time Date (UT)	Time	LS (2000.0)	Δr* (au)	Ejection velocity (m/s)	fM	Expected position of radiant α (deg.)	δ (deg.)	Vg** (km/s)
1914	2014/12/01.96	23:03	249.472	−0.00094	−1.24	0.016	7.89	−27.25	9.79
1919	2014/12/01.97	23:15	249.480	−0.00070	−1.98	0.026	7.91	−27.27	9.78
1925	2014/12/02.00	23:59	249.511	−0.00020	−2.33	0.030	7.94	−27.36	9.77
1909	2014/12/02.02	00:27	249.531	−0.000037	−1.74	0.022	7.98	−27.49	9.78
1930	2014/12/02.05	01:07	249.559	+0.00064	−2.94	0.036	7.99	−27.52	9.76

* Δr is the difference in the heliocentric distance between the Earth and each trail in the ecliptic plane.
** Vg is the expected geocentric velocity before the gravitational focusing of the Earth.

the sake of studying the Phoenicids meteor shower, but also constrain the activity of this comet in the early 20th century. We therefore carried out a coordinated observation campaign for the 2014 Phoenicids. We combined the results of this campaign with Phoenicid observations from the NASA All Sky Fireball Network, the Southern Ontario Meteor Network (SOMN), and the Canadian Meteor Orbit Radar (CMOR), all of which were operating during the Phoenicid outburst.

2. Forecast of Phoenicids in 2014

The outline of predicted Phoenicid activity after 1956 is shown in Watanabe et al. (2005) and the details of the 2014 Phoenicid forecast is given by Sato and Watanabe (2010). After these papers were published, orbital elements of the parent (289P/Blanpain) were updated by Nakano (2013). Hence, we reran our simulations of the dust trails that were the most dense and close to the Earth using these updated elements. The simulation method of computation of dust trails was similar to Sato and Watanabe (2010), and was performed using the simplest dust trail model.

The results of the forecasts are summarized in Table 1. The new data are almost the same as results in Sato and Watanabe (2010). The expected peak time shifted 13 min earlier than in our older results and the distance changed by approximately 2×10^{-4}au. Therefore, most of the characteristics of the forecast did not change. The radiant lies at $\alpha = 8°$, $\delta = -27°$, in Sculptor, which is slightly north of the original position of the Phoenicids in 1956. The peak time was expected to be around 0:00 UT on December 2. It was thought that the appropriate site for observation was over the Atlantic. We called for observing it widely all over the world because observing sites in the Atlantic are very limited.

3. Observations

3.1. Video network observation

The NASA All Sky Fireball Network (Cooke and Moser, 2012) and the Southern Ontario Meteor Network (SOMN; (Weryk et al., 2008)) observed five double-station Phoenicids meteors on 1–2 December 2014. The networks consist of 15 (NASA) and 11 (SOMN) all-sky meteor video cameras operating in the United States and Canada, respectively, all having a similar design and running the All Sky and Guided Automatic Real-time Detection (ASGARD) software (Weryk et al., 2008) for automatic meteor detection and analysis. The Phoenicids are not part of the shower list that ASGARD uses to automatically classify meteors; rather, this group of five was extracted from the fireball dataset by a separate cluster analysis code (Burt et al., 2014). It was identified as a Phoenicids outburst by its close agreement with the radiant, velocity, and date predicted by Sato and Watanabe (2010).

The ASGARD software calculates meteor trajectories and orbits automatically. However, because a small number of Phoenicids were detected, we elected to perform a careful manual reduction of each meteor using the METeor AnALyze (METAL) tool (Weryk and Brown, 2012). Manual reductions ensure that the location of the meteor is chosen in a consistent manner in each frame. The meteor's trajectory and orbit were then calculated using MILIG (Borovicka, 1990) and MORB (Ceplecha, 1987).

Uncertainties were computed using the Monte-Carlo approach and code of Musci et al. (2012). We surveyed a set of existing manual reductions and found typical random and systematic differences between analyses of about a pixel each; these uncertainties in the location of the meteor's leading edge in our images were propagated through the trajectory calculations. As a final check, we compared the results of our manual reductions to the automatic solutions; the differences in derived parameters were comparable to our computed values. The results are summarized in Table 2 and the radiants are plotted in Fig. 1. The 2014 Phoenicid radiants and speeds are consistent with the predictions although meteor 5 has a slight larger uncertainty than others due to a small convergence angle.

Finally, we calculate the mean orbit of these five meteors using the methodology of Jopek et al. (2006). We again used a Monte-Carlo approach to calculate the corresponding standard deviation for each element. Table 3 contains the results of this calculation.

3.2. Radar Observation

The Canadian Meteor Orbit Radar (CMOR) is a multi-station, backscatter radar system operating at 29.85 MHz which is able to measure trajectories and speeds for individual meteors. Details of the basic system and operations are given in Jones et al. (2005); Brown et al. (2010), and Brown et al. (2008).

Phoenicids did not show up in regular wavelet processing, but normal processing only uses a probe size of 4 degrees which is probably too small for the extended radiant of the Phoenicids. Hence, we reran the wavelet search using a probe size of 15 degrees and a broader probe of velocity (20% of the speed rather than the usual 10%). In this modified wavelet run the Phoenicids are clearly visible near Solar Longitude = 250 degrees, exceeding the median background activity at the same radiant location averaged over the previous year by 7 standard deviations (Fig. 2). From this processing, 14 candidate Phoenicids meteors are found, the results are summarized in Table 4. However, there are many meteors whose errors are not shown because at these low speeds many of the solutions are below an apparent velocity of 13 km/s which is the lower bound our Monte Carlo routines can usefully run. Furthermore, we also did manual checks on all candidate meteors recorded by CMOR and got independent estimates for the speeds. The two meteors (H and I) did not have orbits because the Monte Carlo routine which estimates uncertainty does not work at the very lowest speeds when the uncertainty bounds overlap with the Earth escape speed.