Observation of April alpha Capricornids (IAU#752 AAC)

SonotaCo[1], Chikara Shimoda[2], Hiroyuki Inoue[3], T. Masuzawa[4], and Mikiya Sato[5]

A short duration outburst of 15 meteors was observed over 2 hours 34 minutes on 2014 April 7 from $16^{h}59^{m}$ to $19^{h}33^{m}$ UT by SonotaCo Network in Japan. Radiants of the 15 meteors were in the range of RA = $304^{\circ}.5 \pm 3^{\circ}.3$, Dec = $-12^{\circ}.7 \pm 1^{\circ}.1$, with $v_g = 69.1 \pm 0.9$ km/s at $\lambda_{\odot} = 16^{\circ}.65 \pm 0^{\circ}.6$. The orbit parameters of the brightest shower meteor with the least amount of observation uncertainty was RA = $303^{\circ}.80 \pm 0^{\circ}.04$, Dec = $-12^{\circ}.80 \pm 0^{\circ}.03$, $v_g = 69.4 \pm 0.2$ km/s, $1/a = 0.004 \pm 0.017$ 1/AU, $q = 0.80 \pm 0.01$ AU, $e = 0.9968 \pm 0.014$, $\omega = 126^{\circ}.5 \pm 0^{\circ}.5$, $\Omega = 17^{\circ}.63$, $i = 167^{\circ}.3 \pm 0^{\circ}.1$. There are no known nearby shower radiants so the IAU MDC assigned the name of this new shower as the April alpha Capricornids (IAU#752 AAC).

Received 2014 June 3

1 Introduction

SonotaCo Network began video meteor observations in 2003. After 4 years of experiments, continuous video observations using 50 to 60 hi-sensitivity video cameras with standard or narrow FOV lens at about 20 stations in Japan began in 2007. It has used the same setup and scale for nightly observations over 7 years up to now. It records 160 000 to 180 000 single station meteors per year and 19 000 to 27 000 multi-station simultaneous observation orbits per year. The resulting data sets are published annually on the internet as "SonotaCo Network Simultaneously Observed Meteor Data Sets (SNM20xx)" (SonotaCo, 2014a). This data base has been used for a variety meteor science purposes by multiple researchers around the world. The discovery of more than 30 new meteor showers from it have been reported (SonotaCo, 2009; Greaves, 2012; Šegon et al., 2013; Andreić et al., 2013). Continuous observation enables the recording of un-expected events such as bolides or new meteor shower. The observation of short time concentrated outburst from unknown radiant is especially important because it suggests the possible existence of an unknown hazardous comet (Jenniskens et al., 2011).

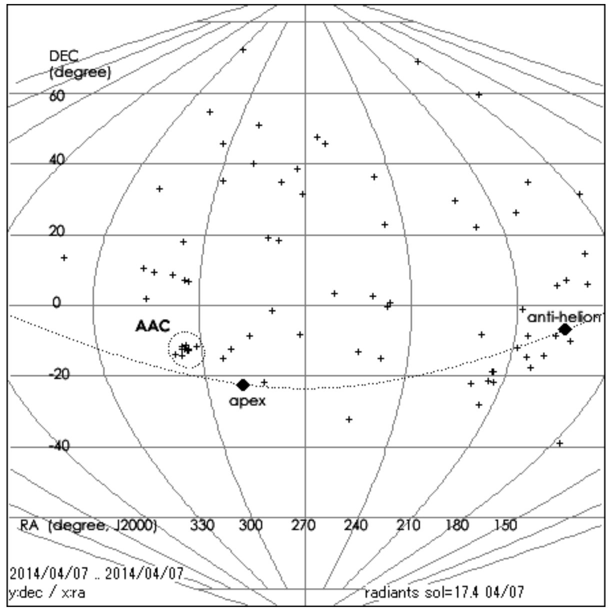

Figure 1 – 15 shower meteors relative to all 79 meteors observed on 2014 April 7.

2 Observation

On the night of 2014 April 7 UT, the Moon age was 7.3 days and the Moon had set 2 hours before the outburst. The network cameras were working as usual. 19 stations had clear sky and 53 cameras captured 357 single station meteors during the night. 79 orbits at $\lambda_{\odot}$ range of $17^{\circ}.33$ to $17^{\circ}.72$ were reduced from it. As is shown in Figure 1, a radiant of 15 meteors of the 79 total meteors was concentrated in a compact area of RA = $304^{\circ}.5 \pm 3^{\circ}.3$, Dec = $-12^{\circ}.7 \pm 1^{\circ}.1$. Also the geocentric velocity of the 15 meteors was in the range

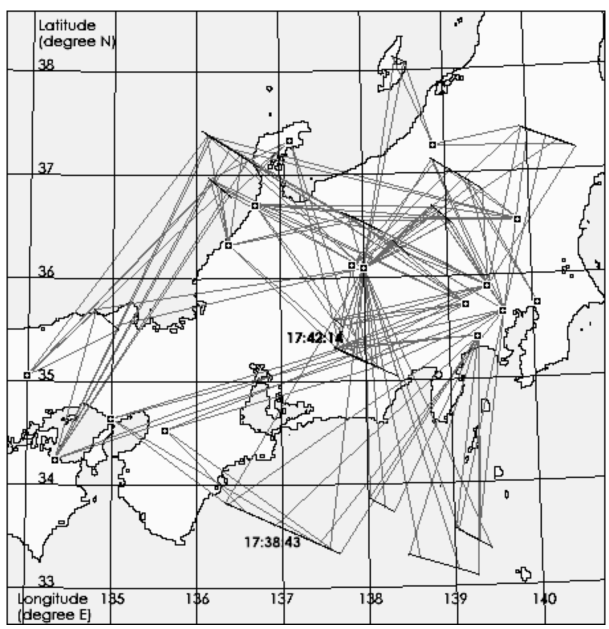

Figure 2 – Geometric relation between the 15 shower meteors and stations.

[1]SonotaCo Network, 3-20-4 Daita Setagaya-ku, Tokyo 1550033, Japan. Email: admin@sonotaco.jp
[2]Japan Fireball Network, 178 hario asahi-mura higashichikuma-gun nagano, Japan. Email: c-shimo@cnet.ne.jp
[3]589-1 Ishida Isehara-shi Kanagawa Japan. Email: fireballmsjp@gmail.com
[4]SonotaCo Network. Email: masuzawa@deepsky.xii.jp
[5]Kawasaki Municipal Science Museum. Email: mail@kaicho.net

IMO bibcode WGN-426-sonotaco-aac
NASA-ADS bibcode 2014JIMO...42..222S

Table 1 – Stations and observers that records AAC meteors. Nc: number of cameras on the station, Nm: number of meteors recorded on 2014 April 7, Nca: number of cameras that recorded AAC meteors, Nma: number of recorded AAC meteors.

Station	Observer	Nc	Nm	Nca	Nma
Nagano1	T. Masuzawa	8	68	7	18
Tokyo1	SonotaCo	8	25	5	9
Saitama1	Takashi Sekiguchi	4	34	2	7
Kagawa1	Sanbonmatsu High School	2	15	2	5
Kanagawa1	Hiroyuki Inoue	4	23	2	5
Tokyo6	Naoya Saito	1	12	1	5
Ishikawa5	Kazuhiko Yoneguchi	2	9	2	4
Tochigi1	Hidechika Ito	1	7	1	4
Ishikawa1	Hideaki Muroishi	1	10	1	3
Ishikawa2	Hiroshi Yamakawa	4	16	1	3
Nagano4	Chikara Shimoda	1	7	1	3
Okayama1	Junichi Yokomichi	1	8	1	3
Hyogo3	Yasuo Shiba	1	4	1	2
Niigata2	Toshio Kamimura	3	4	2	2
Osaka3	Masayoshi Ueda	4	10	1	2
Chiba3	Shinsuke Abe	1	7	1	1

of 69.1 ± 0.9 km/s. There was no known shower radiant around there. It was very clear that this is a new shower originating from the same body.

IAU MDC assigned the name of this shower as April alpha Capricornids (IAU#752 AAC). The AAC 15 meteors were observed by 31 cameras at 16 stations. Figure 2 shows the geometric relation among stations and the meteors, and Table 1 shows the observers at the stations. The average number of simultaneous observations per meteor was 5.1. The meteor observed by the most cameras occurred at $17^{h}42^{m}14^{s}$ UT. It was recorded by 15 cameras simultaneously.

3 Shower duration

All shower meteors occurred in the period of $16^{h}59^{m}$ to $19^{h}33$ UT, corresponding to $\lambda_{\odot}$ $17^{\circ}.60$ to $17^{\circ}.70$. It had a duration of 2 hours 34 minutes. The Sun rise time for Tokyo on that day was $20^{h}10^{m}$ UT so the end time of the shower can be hours later. On the previous and following nights, SonotaCo Network recorded 128 orbits from 2014 April 4 to 6 UT and 160 orbits from 2014 April 8 to 10 UT, but there are no similar orbits. During the past 7 years, there are two similar orbits in the 168 000 orbits on SNM2007-2013. But those two were in different year and no concentration was confirmed. Also, P. Jenniskens reports in CBET 3853 that no candidate shower members were detected in 2011–2012 by the California All-sky Meteor Surveillance project (Sato & Jenniskens, 2014).

From these, this outburst can be thought as the crossing of a very young and narrow dust tube such as a one-revolution dust trail of a long-period comet.

4 Orbit and uncertainty

A newly developed experimental program, which computes the orbit parameter and its uncertainty, was used for these shower meteors. It propagates the observation uncertainty to orbit parameter uncertainty using Monte Carlo simulation method. In the process, one thousand trials were done on each single station observation pole computation and another one thousand trials were done on the unified radiant and orbital parameter computation. Finally, the standard deviation among one thousand results was computed. Figure 3 and Table 2 show its result. The source uncertainty value is the direction measurement residual computed using reference stars on each event and the trajectory linearity error computed in the least square method of observation plane determination. Though, the precise evaluation of this method should be done in the near future, it successfully computed the uncertainty of the radiant of the AAC shower from the measured observation uncertainty.

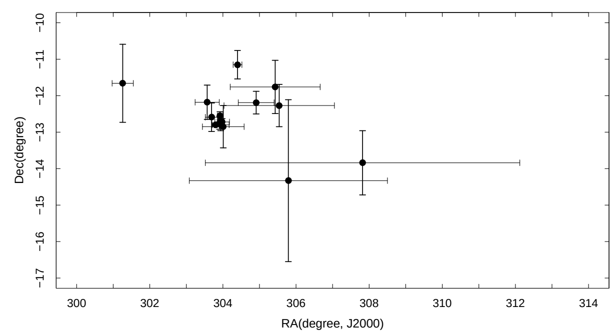

Figure 3 – AAC 15 meteor radiants with uncertainty.

As is shown in the Table 2, uncertainty differs very much among the meteors. It is because dominant factors, such as number of observed frames, distance between station and the meteor, number of observed cameras, and the observation cross angle, are quite different for each meteor. So taking a simple mean or median might not be appropriate for those. On the contrary, it means, there can be some very accurate results for meteors with very good observation conditions.

Hence, we would like to point out the orbit of the $17^{h}38^{m}43^{s}$ UT meteor as the most accurate data to be recorded. It is RA $= 303^{\circ}.80 \pm 0^{\circ}.04$, Dec $= -12^{\circ}.80 \pm 0^{\circ}.03$, at $\lambda_{\odot} = 17^{\circ}.629$, $v_g = 69.4 \pm 0.2$ km/s, $1/a = 0.004 \pm 0.017$ /AU, $q = 0.80 \pm 0.01$ AU, $e = 0.9968 \pm 0.014$, $\omega = 126^{\circ}.5 \pm 0^{\circ}.5$, $\Omega = 17^{\circ}.629$, $i = 167^{\circ}.3 \pm 0^{\circ}.1$. This orbit is obtained from the brightest and longest meteor in the shower. Its absolute magnitude was -3.5, duration time was 1.8 second, trajectory length 128.3 km and it was observed by 5 cameras simultaneously. Its period was computed as 4014 years. Though the orbit parameters of this meteor have very little uncertainty, the velocity was very close to the escape velocity of Solar system so the period can be any value in the range of several hundred years to infinite. The orbit parameter shows that it is a retrograde orbit and the meteor body collides with the Earth almost one month after its perihelion passage. It can be periodic or non-periodic either.

Table 2 – AAC meteor orbit parameters, Ncam: number of simultaneous observation, Nstar: number of reference starts, Qc: Simultaneous observation cross angle.

Time (UT)	$\lambda_\odot$ (°)	RA (°)	Dec (°)	V_g (km/s)	$1/a$ (1/AU)	q (AU)	e	ω (°)	Ω (°)	i (°)	A_{mag}	Dur (s)	H_1 (km)	H_2 (km)	L (km)	Ncam (°)	Nstar	Qc
$16^h59^m06^s$	17.602	305.43 ± 1.23	−11.76 ± 0.73	68.4 ± 1.3	0.044 ± 0.121	0.75 ± 0.03	0.9673 ± 0.0900	119.3 ± 4.9	17.60	165.7 ± 1.4	−1.3	1.1	112.6	104.6	80.0	2	72	4.6
$17^h16^m40^s$	17.614	304.40 ± 0.12	−11.15 ± 0.39	69.7 ± 0.8	−0.066 ± 0.076	0.79 ± 0.01	1.0520 ± 0.0600	125.7 ± 2.1	17.61	164.5 ± 0.7	−0.8	0.9	113.2	102.2	64.7	4	87	37.5
$17^h38^m43^s$	17.629	303.80 ± 0.04	−12.80 ± 0.03	69.4 ± 0.2	0.004 ± 0.017	0.80 ± 0.00	0.9968 ± 0.0137	126.5 ± 0.5	17.63	167.3 ± 0.1	−3.5	1.8	118.0	90.7	128.3	5	64	40.9
$17^h39^m25^s$	17.629	301.26 ± 0.29	−11.66 ± 1.07	67.3 ± 1.2	0.226 ± 0.108	0.82 ± 0.02	0.8138 ± 0.0858	127.3 ± 4.3	17.63	164.2 ± 2.0	−0.2	0.2	100.0	96.1	15.8	2	68	32.2
$17^h42^m14^s$	17.631	303.98 ± 0.20	−12.72 ± 0.09	69.1 ± 1.8	0.029 ± 0.165	0.79 ± 0.02	0.9769 ± 0.1295	125.2 ± 5.3	17.63	167.2 ± 0.3	−1.7	0.5	107.6	99.1	38.1	15	46	83.8
$17^h47^m48^s$	17.635	303.57 ± 0.33	−12.18 ± 0.47	68.5 ± 0.6	0.080 ± 0.057	0.79 ± 0.01	0.9366 ± 0.0447	124.7 ± 2.0	17.63	166.0 ± 0.9	−0.6	0.7	114.4	102.5	48.7	6	51	74.8
$18^h12^m13^s$	17.652	303.69 ± 0.17	−12.59 ± 0.39	69.5 ± 0.1	−0.008 ± 0.013	0.80 ± 0.00	1.0066 ± 0.0104	127.2 ± 0.5	17.65	166.9 ± 0.7	−1.9	1.0	119.6	98.0	68.1	6	93	54.4
$18^h16^m01^s$	17.654	304.91 ± 0.49	−12.19 ± 0.31	68.3 ± 1.0	0.075 ± 0.088	0.76 ± 0.02	0.9429 ± 0.0661	120.4 ± 3.2	17.65	166.3 ± 0.6	−2.7	0.7	115.7	100.1	44.7	3	66	13.3
$18^h18^m33^s$	17.656	305.54 ± 1.51	−12.27 ± 0.58	68.9 ± 0.7	0.010 ± 0.078	0.76 ± 0.03	0.9924 ± 0.0587	120.5 ± 4.4	17.65	166.8 ± 1.2	−0.5	0.5	113.2	102.2	33.0	2	74	11.3
$18^h25^m45^s$	17.661	303.92 ± 0.07	−12.55 ± 0.11	69.0 ± 0.5	0.038 ± 0.048	0.79 ± 0.01	0.9699 ± 0.0377	125.1 ± 1.5	17.66	166.8 ± 0.2	−2.3	0.9	117.6	97.6	62.7	9	52	87.8
$19^h02^m49^s$	17.686	304.01 ± 0.57	−12.85 ± 0.58	69.5 ± 0.8	−0.009 ± 0.075	0.80 ± 0.01	1.0073 ± 0.0598	126.5 ± 2.5	17.68	167.5 ± 1.1	−1.5	0.5	115.0	99.9	34.3	9	69	81.4
$19^h04^m45^s$	17.687	303.94 ± 0.23	−12.80 ± 0.16	68.8 ± 0.1	0.054 ± 0.013	0.79 ± 0.01	0.9571 ± 0.0099	124.8 ± 0.7	17.69	167.3 ± 0.3	−1.3	0.5	112.8	98.5	34.1	6	59	88.5
$19^h09^m20^s$	17.690	305.79 ± 2.71	−14.33 ± 2.22	70.0 ± 0.4	−0.077 ± 0.076	0.77 ± 0.06	1.0592 ± 0.0536	123.6 ± 6.8	17.69	170.8 ± 4.1	−0.1	0.3	111.4	101.3	23.9	2	93	38.2
$19^h12^m24^s$	17.693	303.91 ± 0.06	−12.75 ± 0.17	69.0 ± 0.7	0.037 ± 0.066	0.79 ± 0.01	0.9709 ± 0.0523	125.4 ± 2.0	17.69	167.2 ± 0.3	−2.2	0.5	114.5	98.1	37.4	3	73	78.5
$19^h33^m01^s$	17.707	307.82 ± 4.30	−13.84 ± 0.88	69.2 ± 0.4	−0.051 ± 0.117	0.72 ± 0.09	1.0363 ± 0.0735	116.2 ± 10.4	17.70	170.5 ± 2.4	+0.1	0.2	111.6	105.6	13.0	2	33	6.4

5 Discovery and report process

On the SonotaCo Network, nightly captured data was stored at each station individually. Typically it is analyzed the next morning and sent to the data hub of the SonotaCo Network after manual checks by the observers. The AAC outburst from 16^h59^m to 19^h33^m UT on 2014 April 7 corresponds to 1^h59^m to 4^h33^m April 8 local time in Japan. Before 8^h03^m LT, that night's data from 3 stations were uploaded to the hub by each observer (Chikara Shimoda, Hiroyuki Inoue, and SonotaCo). Inoue added a short comment "There were many meteors coming from east". SonotaCo also added a comment "Bright meteors appeared beyond my expectation for Japanese spring". Shimoda read these comments and ran the orbit computation program UFOOrbitV2 on those 3 station's data. There he discovered a sharp concentration of 5 meteors. At 8^h27^m LT Shimoda posted a new topic to the SonotaCo Network forum for discussion of this event with the title "Emerging fast meteor shower outburst from south of Aquila 20140408". That was 6 hours after the beginning of the shower. SonotaCo did the confirmation of this discovery by comparing with the latest IAU MDC data and at 10^h51^m LT SonotaCo issued a brief report of this discovery as "Possible new shower Report" to 10 relevant people, including IMO and MDC, by e-mail. Because it was already daytime in Japan, succeeding observations in other countries were expected, but did not happen. Roman Piffl of EDMOND reported in a personal mail with SonotaCo "we are looking for data from that night, in Central Europe was bad weather, but in UK was clear night, but UK is already very west". By April 10, all Japanese station data concerning this shower was uploaded to the hub and the 15 shower meteors were reduced from it. There was a station that is operated by T. Masuzawa, recorded 18 clips of 14 meteors of this shower by 7 cameras on one station. It contributed to the overall accuracy a lot. SonotaCo issued an update of the report on April 10. IAU MDC assigned the new shower name on April 11 and IAU CBET 3853 was issued on April 12.

In the prompt report, SonotaCo used code "1uky" as the short name of this shower. This code is named "Universal 4D meteor Shower Code"(U4SC). As is shown in the reference (SonotaCo, 2014b), it represents the shower peak position in the four dimensional space of [$\lambda_\odot$, RA, Dec, V_g]. It is 4 digits of 36 notation character [0-9a-z]. Each digit corresponding [$\lambda_\odot$: 0–360°, 10 g step], [RA: 0–360°, 10° step], [Dec: +90–−90°, 5° step], [Vg: 0–72 km/s, 2 km/s step]. So "1uky" means $\lambda_\odot = 15° \pm 5°$, RA $= 305° \pm 5°$, Dec $= -12\overset{\circ}{.}5 \pm 2\overset{\circ}{.}5$, $v_g = 69 \pm 1$ km/s. Originally, U4SC was invented for automated clustered showers by SonotaCo, but it universally points out most of the showers without ambiguity. It is useful for these reportings before an IAU name decision.

Table 3 – Distribution of one-revolution dust trail.

Approaching Time			R*
Year, Date	Time (UT)	$\lambda_{\odot}$ (°)	(AU)
1980, April 7	01^{h}	17.6	+0.0010
1990, April 7	13^{h}	17.6	+0.0011
2004, April 7	05^{h}	17.7	−0.0006
2014, April 7	18^{h}	17.6	0.0000
2025, April 7	13^{h}	17.6	−0.0019
2032, April 7	12^{h}	17.8	+0.0015
2039, April 7	05^{h}	17.7	−0.0008
2049, April 7	17^{h}	17.6	−0.0010

*R: The distance at plane of the ecliptic between dust trail and the Earth orbit.

6 Discussion

6.1 Dust Trail

In the case of a short period outburst like this shower, it was often brought about from the crossing of a one-revolution dust trail from a long-period comet. For example, the Aurigids (IAU #206, AUR) originated from parent body C/1911 N1 (Kiess). The outbursts of Aurigids occurred in 1935, 1986, 1994 and 2007, these are explained by approaching the one-revolution dust trail from C/1911 N1 (Lyytinen & Jenniskens, 2003; Jenniskens & Vaubaillon, 2007).

Moreover, the outbursts were explained by a dust trail from an undiscovered comet whose orbit is assumed to long-period comet like alpha Monocerotids (IAU #246, AMO) (Lyytinen & Jenniskens, 2003). Actually, it was shown that some meteors of AAC obtained by this observation have long period, they are over hundreds of years. Hence, we tried to investigate the distribution of a one-revolution dust trail from an undiscovered parent by assuming a long-period orbit. The assumed orbit of the parent was determine by integrating back in time from the orbit of the meteor which appeared on 2014 April 7 at $17^{h}38^{m}43^{s}$ UT. As a result of taking into account perturbations, it was assumed that its perihelion passage that priduced the one-revolution trail happened in −720 (721 BC).

Table 3 shows results for the approaching time and distance on the plane of the ecliptic between the dust trail and the Earth orbit. The possibility of observed meteors from this shower in 1980, 1990 and 2004 is shown in the past. However, observed meteors were not found. In the future, a possibility of appearance in 2025, 2032, 2039 and 2049 is shown. If outbursts are observed in these years, the cause of this meteor shower will become clear.

6.2 Candidate Parent Body

Roman Piffl reported in a personal mail to SonotaCo that "We have Jakub Algol Koukal and Mikhail Maslov's calculations that shows the link between the new shower and comet C/1917 H1 (Schaumasse)". The orbit of this comet was calculated as parabolic, however, it could be assumed to be a long-period orbit. Hence, we investigate the orbit at the time of perihelion in 1917 from the orbit with perihelion in −720. Table 4 shows a result of this simulation. The orbital element simulated from −720 was comparatively similar to the value of C/1917 H1. However, these two orbits were not linked completely. For example, the value of the ascending node is different about 7 degrees. It means that the appearance day of meteor shower differs for about seven days. Therefore, from this method, it was not able to conclude that the parent body was C/1917 H1. It will be necessary to study the parent of this new shower in more detail.

7 Conclusions

A new meteor shower was discovered and accurate orbits were obtained. It has a very compact radiant area and short time duration. The shower meteors were in retrograde orbits and collided with the Earth a month after their perihelion passage. Their geocentric velocity was very close to the escape velocity of Solar system and the period can be several hundred years to infinite. An encounter of a one-revolution dust trail of a long-period comet is most likely. There is currently no known probable parent body candidate. It means we should prepare for the encounter of an unknown object with a similar orbit.

Acknowledgements

The continuous observation of the SonotaCo Network is entering its 8th year. Though it nearly exceeds the standard life time of hardware components, systems are maintained by individual observers and have kept their overall sensitivity and accuracy. The constancy and continuity reduces the biases of optical observation and makes possible the determination of diffuse or minor shower. We have great respect for those pocket budget scientists who observe every night and publish the results. Also, we appreciate the researchers who use our observation results and produce scientific publications, listed in this reference. Scientific results are the most precious reward for non-professional observers, the progress encourage them a lot.

As for AAC confirmation, we are very grateful to Roman Piffl of EDMOND and Sirko Molau of IMO who responded quickly to our prompt report. We also acknowledge the effort of Tadeusz Jopek of MDC and Peter Jenniskens of SETI Institute, who assigns the IAU code and handled this discovery rapidly and properly.

References

Andreić Ž.., Šegon D., Korlević K., Novoselnik F., Vida D., and Skokić I. (2013). "Ten possible new showers from the Croatian Meteor Network and SonotaCo datasets". *WGN, Journal of the IMO*, **41:4**, 103–108.

Greaves J. (2012). "Four meteor showers from the SonotaCo Network Japan". *WGN, Journal of the IMO*, **40:1**, 16–23.

Jenniskens P., Gural P. S., Dynneson L., Grigsby B. J., Newman K. E., Borden M., Koop M., and Holman

Table 4 – Orbital elements simulated from −720 and C/1917 H1.

Data	Time of Perihelion Passage	q (AU)	e	ω (°)	Ω (°)	i (°)
Simulation (from −720)	1917 May 18.7	0.82	0.99	125.93	17.53	167.54
C/1917 H1 (Schaumasse)*	1917 May 18.7103	0.76	1	119.16	10.84	158.74

* : JPL Small-body Database Browser

D. (2011). “CAMS: Cameras for Allsky Meteor Surveillance to establish minor meteor showers”. *Icarus*, **216:1**, 40–61.

Jenniskens P. and Vaubaillon J. (2007). “Aurigid predictions for 2007 September 1”. *WGN, Journal of the IMO*, **35:2**, 30–34.

Lyytinen E. and Jenniskens P. (2003). “Meteor outbursts from long-period comet dust trails”. *Icarus*, **162:2**, 443–452.

Sato M. and Jenniskens P. (2014). “New Meteor Shower: April Alpha Capricornids”. *Central Bureau Electronic Telegrams*, **3853**.

SonotaCo (2007-2014a). “Sonotaco network simultaneously observed meteor data sets (snm20xx)”. `http://sonotaco.jp/doc/SNM/index.html` .

SonotaCo (2009). “A meteor shower catalog based on video observations in 2007 - 2008”. *WGN, Journal of the IMO*, **37:2**, 55–62.

SonotaCo (2014b). “Universal 4D meteor Shower Code (U4SC)”. `http://sonotaco.jp/doc/U4SC/index.html` .

Šegon D., Andreić Ž.., Korlević K., Novoselnik F., Vida D., and Skokić I. (2013). “8 new showers from Croatian Meteor Network data”. *WGN, Journal of the IMO*, **41:3**, 70–74.

Handling Editor: Javor Kac