Slovak Video Meteor Network—status and results: Lyrids 2009, Geminids 2010, Quadrantids 2011

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Since 2009, double station meteor observations by the all-sky video cameras of the Slovak Video Meteor Network (SVMN) resulted in hundreds of orbits. Thanks to several amateur wide field video stations of the Central European Meteor Network (CEMeNt) and despite a not-ideal weather situation, we were able to observe several Lyrid 2009, Geminid 2010, and Quadrantid 2011 multi-station meteors during their maxima. The presented meteor orbits derived by the UFOOrbit software may be qualified as quite precise.

1 Introduction

Recently, video observations with high-resolution digital cameras became more widely affordable, and several meteor detection networks started operations all over the world. Among them are the Slovak Video Meteor Network (SVMN), operated at the professional level by the Comenius University, and the Central European Meteor Network (CEMeNt), an amateur network consisting of several stations in the Czech and Slovak Republics. These networks cooperate closely with the Polish Fireball Network, the Hungarian Meteor Network as well as with other networks. Using video observations, we are able to detect fainter meteors than by classical photography and obtain a better time resolution for individual meteors. Thanks to available detection and analysis software, the data reduction is fast.

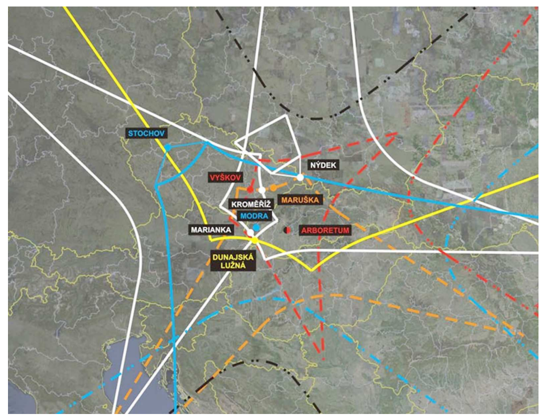

Figure 1 – Location of ground-based video meteor stations of SVMN (AGO, ARBO) and CEMeNt (Stochov, Vyškov, Kroměříž, Nýdek, Marianka and Dunajská Lužná).

2 Slovak Video Meteor Network and CEMeNt

The Slovak Video Meteor Network currently consists of two semi-automated all-sky video cameras, developed and constructed at the Astronomical and Geophysical Observatory of the Comenius University (AGO) in Modra. The first station is located at AGO, the second one, remotely controlled, at the Arborétum Mlyňany (ARBO), at a distance of 80 km. The network website is `http://www.daa.fmph.uniba.sk/meteor_network.html`.

Both stations are equipped with a Canon fish-eye lens (15 mm, $f/2.8$), an image intensifier Mullard XX1332, and a digital video camera DMK41AU02.AS (1280 × 960 pixels; angular resolution $8'\!.5$/pixel; stellar limiting magnitude +5.5; meteor limiting magnitude +3.5). The third station with the same configuration is being prepared for installation in Kysucké Nové Mesto, and another portable station is available for expeditions. The last one had been working at ARBO site during the Quadrantids 2011.

The CEMeNt network was developed at the initiative of amateur observers and currently operates simultaneously with SVMN. Observers of CEMeNt work independently (`http://cement.fireball.sk`).

Figure 2 – Image of the fireball from the all-sky video system of SVMN (Station ARBO) om September 6, 2011, at $23^{h}56^{h}13^{m}$ UT. North is down and West is on the left.

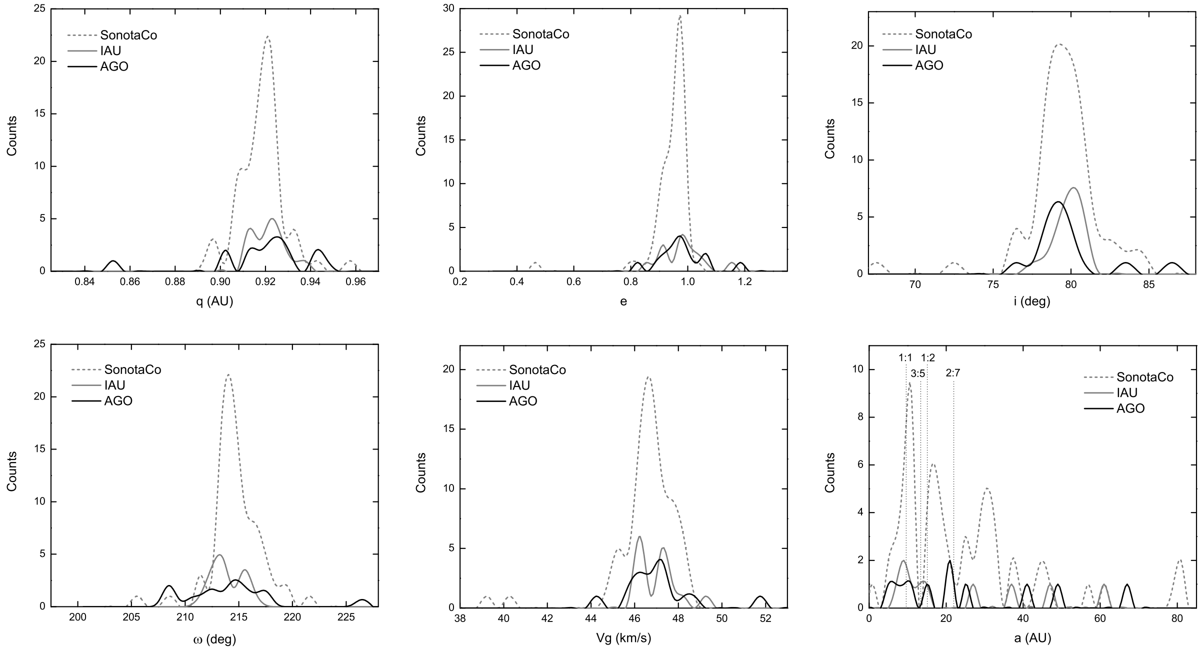

Figure 3 – Distribution of orbital elements (eq. 2000.0) of Lyrid meteors (q, e, i, ω, a) as well as geocentric velocity of precise IAU MDC photographic orbits (Lindblad et al., 2003), SonotaCo Japanese database records from 2007–2009 (SonotaCo, 2009), and observations from the baseline Modra–Arboretum in 2009 (marked as AGO). The semimajor axis graph also contains mean motion resonances with Saturn.

The station at Dunajská Lužná is equipped with a Watec 902H2 Ultimate camera and an XtendLan 2.8 mm lens. It uses a Canopus ADVC-55 AD converter. The field of view is $114° \times 85°$. The Stochov station has the same Watec camera and AD converter as the Dunajská Lužná station, but in combination with a Fujinon lens (3.6 mm). Its stellar limiting magnitude is +4.5 (for meteors approximately +1.5) and the field of view is $80° \times 60°$. The system of Kroměříž consists of a Watec 902 H2 camera (720×576 pixels), a Goyo GADN varifocal 3–8 mm lens. The field of view is $75° \times 60°$, the stellar limiting magnitude is +4.6 and the meteor limiting magnitude is +2.5. The Vyškov station is a mobile version of the Kroměříž station. The Marianka station consists of a Watec 902H2 Ultimate camera, a Fujinon 2.9–8 mm lens ($f/0.95$). The image is obtained by using an internal TV grabber. The locations of the SVMN and CEMENT stations are shown in Figure 1.

3 Observations and data analysis

The video signal is analyzed and detected by using the UFOCapture software, which is able to recognize meteors and fireballs. Meteor data have been processed with UFOAnalyzer and UFOOrbit (SonotaCo, 2009).

3.1 Lyrids 2009

The observation of the Lyrid meteor shower, in the night of April 21/22, 2009, from $19^{\mathrm{h}}15^{\mathrm{m}}$ to $2^{\mathrm{h}}20^{\mathrm{m}}$ UT, was the first observational test for double-station operation and subsequent orbit calculations within SVMN. We obtained reliable observational data covering a substantial part of the Lyrid's maximum in 2009. We detected 78 and 52 meteors from the first and the second station, respectively. Of these, 32 were simultaneously observed at both stations, and 17 of them were identified as Lyrids.

The orbits of Lyrids from Modra–Arboretum are consistent with those previously derived by several authors (Jenniskens, 2006, p. 702) and presented in Figure 3. The orbital element distributions are generated by using a B-spline technique. The 17 observed Lyrids are compared with 17 IAU MDC photographic orbits from Lindblad et al. (2003) and 75 Lyrids from the SonotaCo database of video orbits (SonotaCo, 2009) obtained in 2007–2009. The orbits from the SonotaCo database represent the most precise subset of Lyrids in the database selected by high quality criteria (Vereš & Tóth, 2010).

Nevertheless, there are some hyperbolic orbits in all three datasets. The IAU Meteor Database contains 35%, SonotaCo 8% and our data 35% Lyrids on hyperbolic orbits. However, the hyperbolicity of meteors might not be real. According to Hajduková (2008), the most probable reason is the uncertainty in velocity determination, shifting a part of the data through the parabolic limit. Therefore, we restricted ourselves to elliptic orbits in the graph showing the distribution of the semimajor axis in Figure 3 (Tóth et al., 2011a).

3.2 Geminids 2010 and Quadrantids 2011

These meteor observations were performed during the maximum activity of the Geminids (December 13–14, 2010) and Quadrantids (January 3–4, 2011), where 44, respectively 100, meteors were observed simultaneously. In the data of SVMN and CEMeNt, we have found 35 Geminids and 66 Quadrantids.

Table 1 – Mean orbit of Geminids from multi-station observations on December 13–14, 2010, by SVMN and CEMeNt. Orbital elements, geocentric radiant, and geocentric velocity are shown. They are compared with the SonotaCo mean orbit from the solar longitude interval $\lambda_\odot = 261°.49$–$261°.79$.

	a (AU)	q (AU)	e	i	ω	Ω	α	δ	V_g (km/s)	Orbits
Our data	1.268	0.148	0.883	21°.84	324°.30	261°.61	113°.07	+32°.13	33.30	10
St. dev.	0.048	0.007	0.008	1°.28	0°.76	0°.09	0°.49	0°.41	0.67	
SonotaCo	1.279	0.149	0.884	22°.69	324°.03	261°.69	113°.24	+32°.45	33.47	121
St. dev.	0.075	0.014	0.017	2°.49	1°.45	0°.08	0°.76	0°.78	1.16	

Table 2 – Mean orbit of Quadrantids from multi-station observations on January 3–4, 2011 by SVMN and CEMeNt. Orbital elements, geocentric radiant, and geocentric velocity are shown. They are compared with the SonotaCo mean orbit from the solar longitude interval $\lambda_\odot = 282°.88$–$283°.32$.

	a (AU)	q (AU)	e	i	ω	Ω	α	δ	V_g (km/s)	Orbits
Our data	2.547	0.981	0.611	70°.31	174°.55	283°.19	228°.88	+50°.44	39.91	8
St. dev.	0.264	0.003	0.044	1°.20	3°.93	0°.10	2°.12	1°.00	0.73	
SonotaCo	2.467	0.978	0.606	70°.162	169°.89	283°.30	230°.39	+49°.20	39.82	39
St. dev.	0.487	0.003	0.082	2°.59	2°.98	0°.16	2°.36	0°.93	1.79	

There are several UFOOrbit parameters that can evaluate the quality of the obtained meteor orbits. In order to separate high-quality orbits, we set multiple constraints on the data set. Due to the geometry of the incoming meteor trails, we selected individual meteor pairs in order to get the maximum precision of the orbital elements. For the Geminids, we set the general quality criterion for the orbits to Q2—an internal condition of the UFOOrbit software (SonotaCo, 2009). In this way, we obtained 10 Geminid meteor orbits. Also for Quadrantids, we selected the Q3 quality criterion and obtained 8 Quadrantid orbits.

The mean orbits of the Geminids (2010) and the Quadrantids (2011) obtained during the respective shower maxima are presented in Tables 1 and 2. The mean orbit is obtained by taking the arithmetic mean of each orbital element, with the corresponding standard deviation. In comparison, we used the SonotaCo data set of meteor showers observed above Japan during three years (2007–2009) and calculated the mean orbit of the Geminids (121 orbits) and Quadrantids (39 orbits) as well. Only SonotaCo orbits lying within the same range of the solar longitude as our observed meteors have been taken into account ($261°.49 \leq \lambda_{\odot,\mathtt{GEM}} \leq 261°.79$ and $282°.88 \leq \lambda_{\odot,\mathtt{QUA}} \leq 283°.32$). The comparison data were already filtered by the Q3 criterion in order to process only high-quality orbits. As can be seen in Tables 1 and 2, our mean orbits are very similar to the mean orbits obtained from the subset of high-quality SonotaCo data (Tóth et al., 2011b).

4 Conclusion

Video observations allow the detection of fainter meteors, hence a larger number of meteors can be detected in comparison with a photographic technics. Coordinated video observations of meteors with amateur astronomers yields a significant number of high quality heliocentric orbits. This cooperation has proved to be particularly fruitful due to unstable weather in Central Europe. In addition to both current professional stations, future observations with amateurs may yield more results, especially during active meteor showers or other observing campaigns.

Acknowledgements

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