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'European' activity of the τ-Herculid meteor shower

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The multi-station and multi-instrumental observation campaign of the τ-Herculid (TAH) meteor shower was carried-out in the Czech Republic in the night 30/31 May 2022. The shower became active earlier than predicted. During five hours of observation almost two hundred single- and multi-station TAH meteors were detected covering a wide range of the masses. The activity profile curve was relatively flat for several hours around midnight UT with few tens of meteors observed each hour.

1 Introduction

An enhanced activity or even an outburst of the τ-Herculid (TAH)[1] meteor shower was expected in the morning hours of 2022 May 31[2] according to several models (Lüthen et al., 2001), (Horii et al., 2008), (Rao, 2021), and (Ye & Vaubaillon, 2022) following the 1995 break-up of the 73P/Schwassmann-Wachmann 3 parent comet. As the number of the teams went to the United States, we decided to stay in Europe to cover possible earlier activity caused by the recent break-up material and/or activity connected with older material released from the comet at the end of 19th century (Wiegert et al., 2005).

Two mobile teams were prepared to reach an area with favourable weather across Europe and to establish double station video and photographic observations. The perfect forecast service was provided by the team of the Czech Hydrometeorological Institute (CHMI) on daily bases in the last days before 31 May (Figure 1). As the chances for clear sky were relatively high in central Europe, we finally decided to stay in the Czech Republic and to use a background of the Fireball Network within the country.

In this paper we introduce our observation campaign and some of the results. More data and analysis will follow in peer-reviewed paper in the near future.

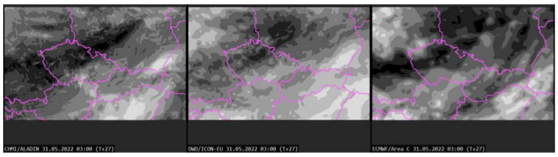

Figure 1 – Compilation of three different forecast models for 31 May, 3 UT provided 27 hours before the predicted peak by Pavel Šimandl, CHMI.

[1]061 code in the IAU MDC database

[2]Vaubaillon, 2022 at `https://www.imcce.fr/recherche/campagnes-observations/meteors/2022the`

2 Instrumentation and data processing

Routine automatic video observations are carried-out using Maia cameras (Koten et al., 2011) on a daily basis. These cameras covered western field of the multi-station video experiment. The cameras aim at a fixed elevation of about 100 km above the surface. The eastern field was covered by the manually operated video cameras DMK (Koten et al., 2020). Because of very low TAH meteor velocity, the aiming point of the cameras was set at 80 km elevation.

Both sets of the cameras employ Mullard XX1332 image intensifiers. In the case of Maia cameras, the 50 mm lenses are used providing a field-of-view of about 52°. The DMK cameras were equipped with 135 mm lenses providing field-of-view of about 22°. A limiting meteor magnitude is about $+5.5^{m}$ for Maia cameras and $+7.0^{m}$ for DMK. Moreover, a spectral video camera was operated at Ondřejov station. Each double-station experiment was accompanied by another station using 4 Mpx Dahua cameras and mobile photographic cameras. Finally, all the instruments of the fireball network (Spurný et al., 2017) were also in operation.

As usual, following the observations all the records were searched for the meteors. The meteors were catalogued and double/multi-station cases identified on the bases of time correlation. Subsequently, the records were measured using FishScan software and the trajectories and orbits were computed by the Boltrack program using standard procedures (Borovička, 1990). For the single station meteors a shower membership was estimated depending on their movement direction and angular velocity. These meteors were used just for the activity profile calculation.

The Ondřejov – Kunžak base is traditionally used for the double station video experiments. To increase the chances to carry out a successful video experiment, two different double station fields based on these stations were prepared. Another mobile station was established for each of the fields. Altogether, two three station video experiments were planned as Figure 2 shows.

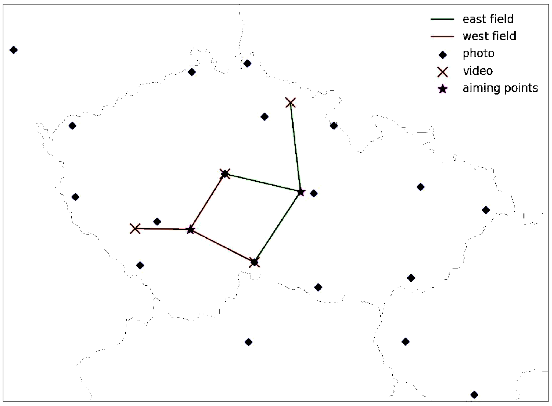

Figure 2 – Map of two triple-station video experiments inside the Czech part of the European fireball network. Fireball network stations are marked by blue diamonds, stations with video cameras with red crosses, and aiming points for video experiment by magenta stars.

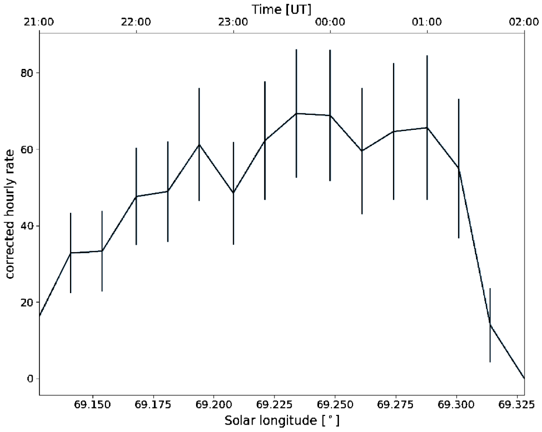

Figure 3 – Activity profile of the TAH meteor shower based on the video data. The meteors were counted in 20 minute intervals.

3 Activity profile

Video observations started at 20 UT and finished at 1:30 UT. Firstly, it is necessary to note that the forecast was fulfilled quite well. The observational conditions were good for the majority of the night. Note that the southern station was overcast at the beginning of the observations. Also there the sky became clear around 23 UT.

Alltogether, 57 double/multi station TAH meteors were found in the video data. Additional 120 TAH meteors are only single station cases. Moreover, 13 multi-station photographic meteors also belong to the TAH meteor shower. Even this total number shows that the meteor shower was very active during the night, many hours before the predicted outburst maximum.

To construct an activity profile curve all the TAH meteors were used. They were counted in 20 minute intervals and corrected only on the zenith distance of the radiant. The resulting value called corrected hourly rate (cHR) is not directly comparable with the visual ZHR.

The activity started to increase after 21 UT. Note that the contribution from the southern part of the experiment is missing at the beginning. From 23 to 1 UT the activity was the highest with cHR fluctuating between 60 and 70 (Figure 3). It started to decrease later. This was caused mainly by the beginning of the dawn. More detailed look at the data after 1 UT when the lightening of the sky was not still significant shows decrease of the numbers of the meteors. It seems that the activity decrease was really observed.

The activity profile derived from the visual observations (Rendtel & Arlt, 2022) also shows a broad maximum before midnight with a peak around 23 UT followed by descent. The width of this maximum was about 3 hours. The lowest activity occurred about 0:30 UT and then started to rise again. In case of video observations the activity profile is slightly shifted by about one hour and the maximum is not as prominent as it was from visual observations. According to Figure 6 in (Wiegert et al., 2005) there were two intersections with material released from the comet in 1892 and 1897 before and after midnight. From this point of view it seems that these encounters were indeed observed.

4 Meteor radiants

Calculated radiants and heliocentric orbits of multi-station meteors were compared with a catalogue radiant and orbit of the τ-Herculid meteor shower[3] and also with the orbit of the 73P/Schwassmann-Wachmann 3 parent comet[4] using the Southworth-Hawkins D_{SH} criteria (Southworth & Hawkins, 1963).

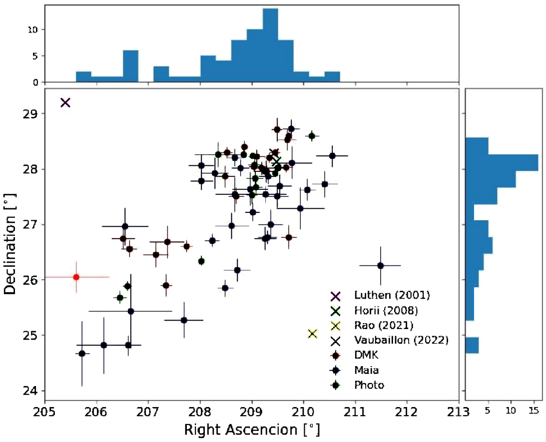

Figure 4 – Geocentric radiants of the TAH meteors, the comparison with several modelled radiants and histograms of distribution in right ascension and declination.

Geocentric radiants of τ-Herculid meteors are shown in Figure 4 together with their error bars. The modelled radiants are added, too. We can see two features

[3] https://www.ta3.sk/IAUC22DB/MDC2022/
[4] https://ssd.jpl.nasa.gov/

from this plot. There is relatively compact area around $\alpha_G = 209°.5; \delta_G = 28°.0$ which is consistent with the models of Horii and Vaubaillon and the area of scattered radiants in east-southern direction. We checked whether these two areas contain meteors with specific characteristics but did not find any dependance. The photometric mass, semimajor axis, perihelion distance, solar longitude and D_{SH} criterion were among analysed parameters. As an example a distribution based on the photometric mass of the meteoroids is shown in Figure 5. It was found that no group prefers meteors with certain values of these parameters.

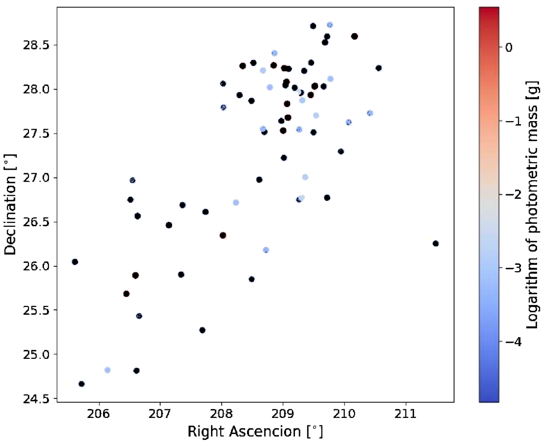

Figure 5 – Distribution of the geocentric radiants based on the photometric masses of the meteoroids. No dependence on the mass is observed.

Figure 6 shows comparison with the catalogue radiant of the shower. The observed radiants are significantly shifted from this catalogue one. The angular distance between the centre of compact radiant area and catalogue radiant is almost 20°.

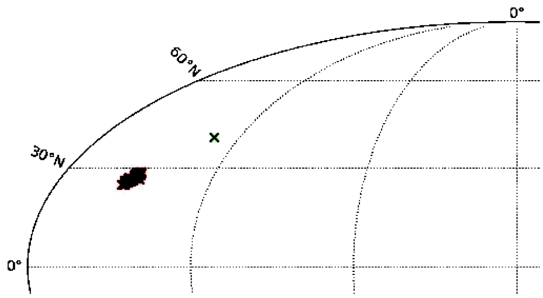

Figure 6 – This global map shows a comparison with the catalogue τ-Herculid radiant.

This fact together with an agreement between observed and modelled radiants, which were produced for the meteoroids released from the parent comet break-up in 1995, suggests that the observed meteors were actually caused by the material ejected in 1995.

5 Summary

A significantly higher than the annual τ-Herculid meteor shower activity was observed many hours ahead of the predicted outburst. Although the timing of the activity is consistent with modelled encounters with the 1892 and 1897 ejected material, other properties suggest that the fresh material originated from 1995 parent comet break-up was observed.

It was again confirmed that it is important to be prepared for unexpected meteor shower activity. While most teams observed the main peak of the shower activity, we were able to obtain valuable data on earlier activity and contribute to the further development of meteor stream modelling.

Acknowledgements and diclaimer

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