New meteor shower in Draco

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A new meteor shower on a JFC-type orbit has been detected in 2023 by the Global Meteor Network during the time interval 295.0° < λ_{O} < 299.0° (January 15–19) from a radiant at R.A. = 235° and Decl.= +61° with a geocentric velocity of 32.8 km/s. This radiant position is east from the known gamma-Ursae Minorids (GUM#0404) meteor shower which has its strongest activity when the new shower activity ends. The new meteor shower has been listed in the Working List of Meteor Showers under the temporary identification M2023-D2.

1 Introduction

The Global Meteor Network radiant map for January 16–17 2023 (*Figure 1*) showed a remarkable concentration at a distinct distance east from the known gamma-Ursae Minorids (GUM#0404). This possible new shower appears earlier in time than the gamma-Ursae Minorids and disappears once GUM reaches more significant activity. This is also visible on the radiant plot obtained by CAMS where a concentration of unidentified radiants appears east from the early GUM-radiants well in advance before the gamma-Ursae Minorids appear as a strong concentration on the map. However, most of the radiants shown on the CAMS map (*Figure 11*) are in fact taken from the Global Meteor Network data and display the same radiants.

2 Meteor shower search methodology

Once a group of meteoroid orbits has been detected on GMN plots, the method used for the determination of the shower parameters consists of the following steps.

At first, radiant positions are being roughly estimated in Sun-centered geocentric ecliptic coordinates $\lambda_g - \lambda_O, \beta_g$. Also, the solar longitude range during which the radiant can be seen on plots, as well as a rough radius of radiant dispersion are determined. The radius is usually taken to be a couple of degrees larger than the actual size in order to cover all contributing radiants.

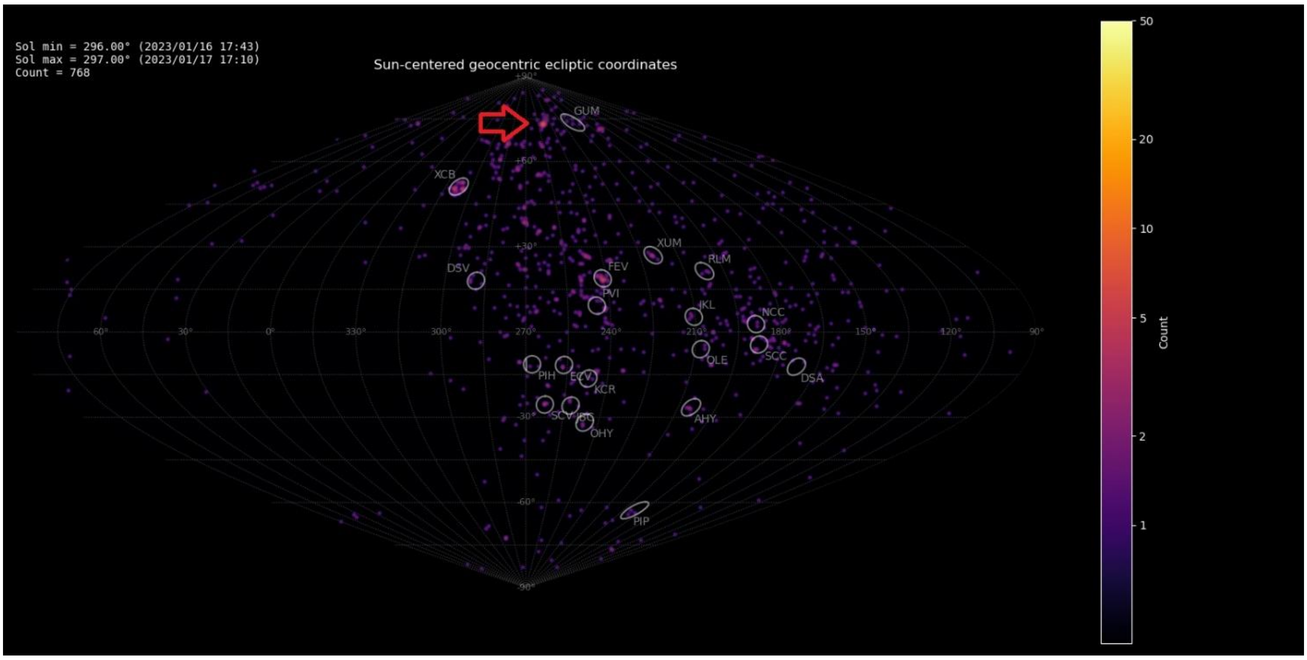

Figure 1 – Radiant plot of the Global Meteor Network data for 2023 January 16–17 in Sun-centered geocentric ecliptic coordinates. The new radiant is visible left of the GUM radiant and is marked by a red arrow.

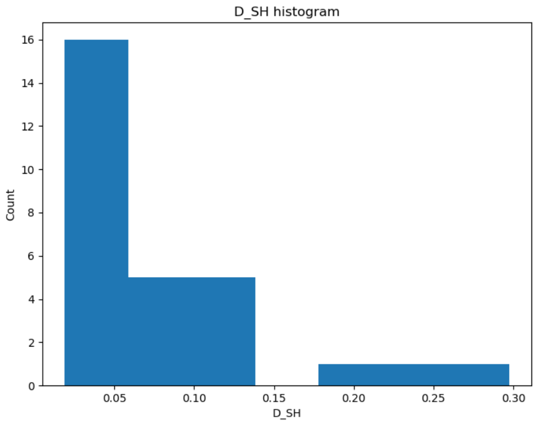

Figure 2 – Histogram of the distribution of the values of the D_{SH} criterion valid for the first mean orbit estimate.

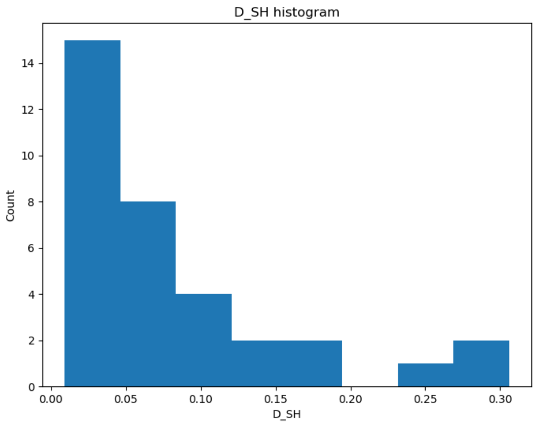

Figure 3 – Histogram of the distribution of values of the D_{SH} criterion valid for the final mean orbit.

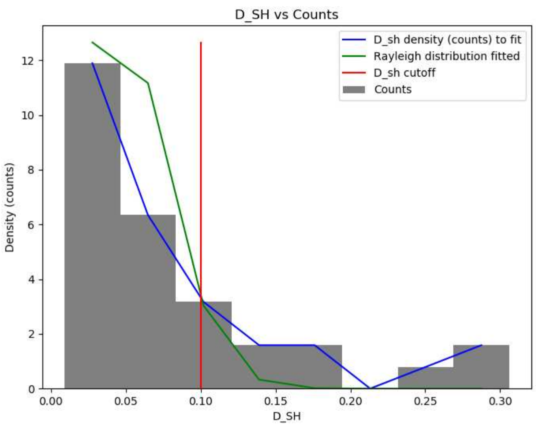

Figure 4 – Rayleigh distribution fit and D_{SH} cutoff.

The numeric average orbit of the radiants that satisfy the criteria is computed and we calculate the Southworth and Hawkins (1963) *D*-criterion for each selected orbit and the reference mean orbit. The resulting distribution of *D*-criteria plotted as a histogram (*Figure 2*) allows us to select the histogram bin containing most meteors. This bin is often not the bin with the smallest *D*-criterion value, indicating that it follows a Rayleigh distribution.

Next, we recompute the mean orbit using only these core orbits and the updated *D*-criterion distribution is shown in *Figure 3*. We then fit a Rayleigh distribution to the computed offsets and choose a *D*-criterion cutoff value at the 95th percentile (*Figure 4*). In case the fit fails, we estimate the *D*-criteria cutoff in a manual way, by picking the smallest *D*-criteria value covering the left part of the distribution down to local minima count. The Raileigh distribution may not be the correct choice of the *D*-criteria distribution for all cases, but the estimated *D*-criteria cutoff in this case shows that the remaining non-shower orbits are not affected by the extraction from the dataset of new shower ones (see *Figure 5*). This *D*-criteria cutoff is then used to isolate only orbits satisfying it, and from this set of orbits the mean orbital parameters and radiant positions are calculated using the method of Jopek et al. (2006). On the radiant and $\Pi - i$ plots, circles represent the part of the radiants we want to emphasize while pale diamonds represent alternative ones, both solar longitude color-coded. Dimensions of circles/diamonds represent the estimated magnitudes (smallest being faintest), while error bars represent a 2-sigma error of the plotted parameter.

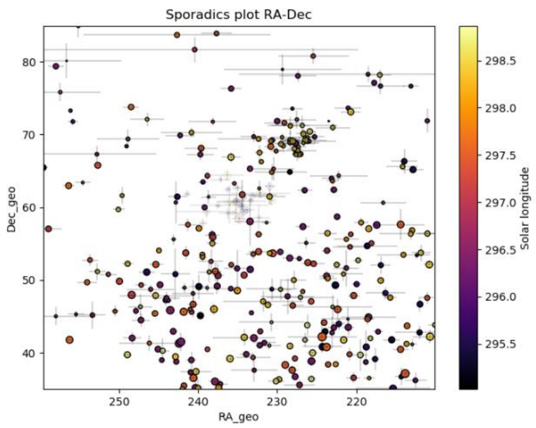

Figure 5 – All radiants in geocentric equatorial coordinates during the shower activity. The gray crosses are the new shower radiants, you can see the GUM radiants in the upper right.

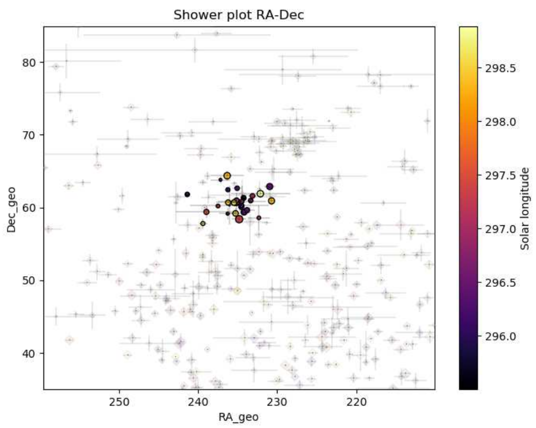

Figure 6 – The reverse of *Figure 5*, where the background radiants are now grayed out, all radiants in geocentric equatorial coordinates. The GUM shower radiants may be clearly seen as a separate group of orbits at their expected radiant positions (up and right from the new shower).

The shower radiants are compared to the sporadic background in *Figures 5 and 6*. The concentration of the orbits is also shown in the diagram of the inclination *i* against longitude of perihelion Π (*Figure 7*). The activity period appears within the time interval 295.0° < $\lambda_{\odot}$ < 299.0° (*Figure 8*).

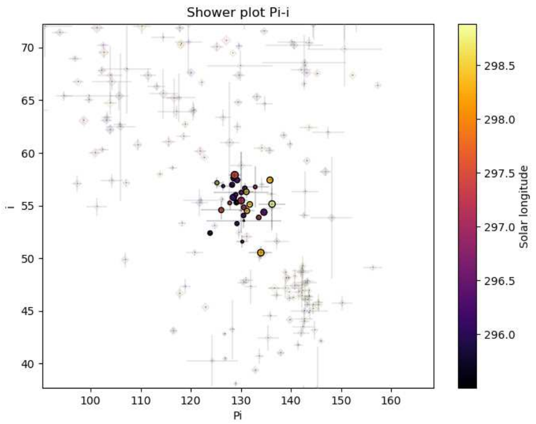

Figure 7 – The diagram of the inclination i against longitude of perihelion Π. The GUM shower radiants may be clearly seen as a separate group of orbits (down and right from the new shower).

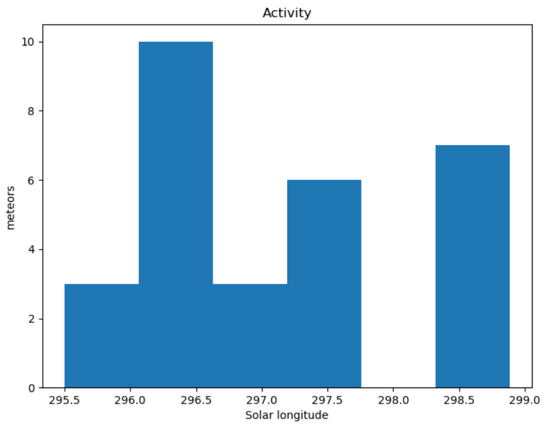

Figure 8 – The activity period with the number of orbits identified as new shower members.

3 New shower or existing shower?

Before making claims that the detected activity qualifies to be listed as a new meteor shower, the known existing meteor showers active around this time from this part of the sky have to be checked. The first suspect candidate is the afore mentioned gamma-Ursae Minorid meteor shower. In equatorial geocentric coordinates, the radiant concentrations appear as close neighbors as well as in Sun-centered ecliptic geocentric coordinates. As the new shower activity appears east and earlier than the bulk of the GUM-activity, the off-set in radiant positions cannot be explained by radiant drift. The Tisserand relative to Jupiter proves both are JFC-type orbits (*Table 1*). The orbits differ mainly by ~7° in inclination and ~12° in longitude of perihelion.

Further verification of the IAU MDC Working List of Meteor Showers (Jenniskens et al., 2020; Jopek and Kaňuchová, 2014; 2017; Jopek and Jenniskens, 2011; Neslušan et al., 2020) reveals two more candidate meteoroid streams, about 10 days earlier in time from a radiant position close to that of the possible new meteor shower, in equatorial as well as in Sun-centered ecliptic coordinates. However, these two showers appear to be an erroneous duplicated entry, listed as the January eta-Draconids (JED#1099) and January iota-Draconids (JID#1107) by Jenniskens (2022). Both orbits have a Tisserand value relative to Jupiter typical for long period comet type orbits with a distinct different eccentricity e compared to the possible new shower. The longitude of perihelion differs by ~15°. The different nature of this orbit compared to the one of the possible new shower, which has a JFC-type orbit, excludes that JED or JID represent the same meteoroid stream.

Table 1 – Known neighboring showers, gamma-Ursae Minorids (GUM#0404, Shiba, 2022), January eta-Draconids (JED#1099), Jenniskens, 2022), January iota-Draconids (JID#1107), Jenniskens, 2022) and the new meteor shower.

	GUM	JED	JID	New
$\lambda_{\odot}$ (°)	299.7	287.6	286.9	296.3
$\lambda_{\odot b}$ (°)	296.2	–	–	295.5
$\lambda_{\odot e}$ (°)	304.9	–	–	298.9
α_g (°)	229.0	237.3	236.3	235.2
δ_g (°)	+67.7	+62.6	+62.3	+60.7
$\Delta\alpha_g$ (°)	0.99	–	–	–
$\Delta\delta_g$ (°)	–0.70	–	–	–
v_g (km/s)	29.4	37.3	37.3	32.8
λ (°)	157.1	180.5	180.6	184.2
$\lambda_g - \lambda_{\odot}$ (°)	217.4	252.9	253.7	247.1
β_g (°)	+74.3	+75.6	+75.1	+73.7
a (A.U.)	2.79	25.6	19.4	2.73
q (A.U.)	0.952	0.979	0.979	0.973
e	0.659	0.962	0.950	0.644
i (°)	48.0	59.5	59.6	55.3
ω (°)	203.1	187.4	187.7	193.1
Ω (°)	299.7	287.5	286.9	297.1
Π (°)	142.8	114.9	114.6	130.2
T_j	2.60	0.82	0.88	2.54
N	60	28	21	29

4 Another search method

Another method has been applied to check this new meteor shower discovery. The starting point here can be any visually spotted concentration of radiant points or any other indication for the occurrence of similar orbits. The method has been described before (Roggemans et al., 2019). The main difference with the method described in *Section 2* is that three different discrimination criteria are combined in order to have only those orbits which fit different criteria. Instead of using a cutoff value for the D-criteria these values are considered in different classes with different thresholds of similarity. Depending on the dispersion and the type of orbits, the most appropriate threshold of similarity is selected to locate the best fitting mean orbit as a result of an iterative procedure.

Applying this search method, the same orbits are found as with the higher described method. *Figure 9* shows the radiants in Sun-centered geocentric ecliptic coordinates with the sporadic background (black), the gamma-Ursae Minorids (blue) and two similarity classes for the new shower (yellow and red). The average radiant of the new shower is east of that of the gamma-Ursae Minorid radiants.

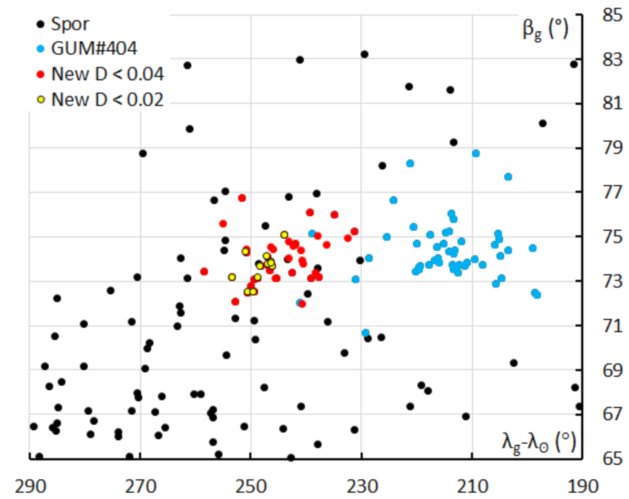

Figure 9 – Close up of the Sun-centered ecliptic geocentric coordinates for the possible new shower and the orbits identified as gamma-Ursae Minorids.

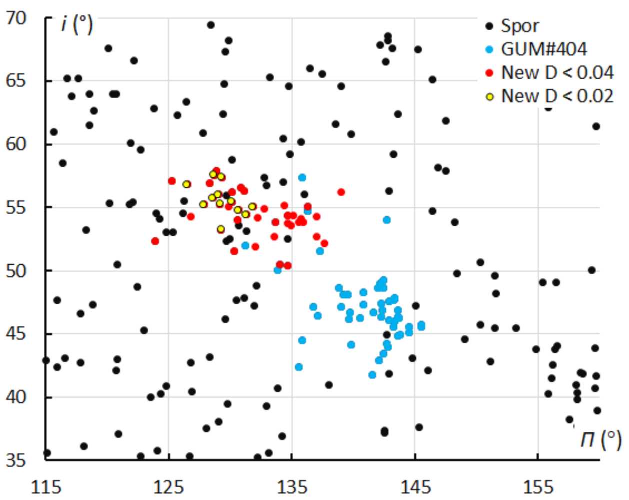

Figure 10 – Diagram of the inclination i against the longitude of perihelion Π for the new shower and the gamma-Ursae Minorids.

The offset in the concentration of orbits is also very obvious in the diagram showing the inclination i against the longitude of perihelion Π (*Figure 10*). The 12 best fitting orbits within the interval 295.0° < λ_O < 299.0°, according to this method yield a mean orbit which is in perfect agreement with the results presented in *Table 1*.

- a = 2.75 AU
- q = 0.974 AU
- e = 0.6465
- i = 55.6°
- Ω = 296.80°
- ω = 192.52°

5 Comparing older data and other datasets

Looking up past years orbit data for Global Meteor Network, we find only 16 similar orbits with D_{SH} < 0.1 and D_D < 0.04 for the period 2019 to 2022. Checking the CAMS data for 2011–2016 we also find 16 similar orbits with D_{SH} < 0.1 and D_D < 0.04. The SonotaCo data for 2007–2021 yield 12 orbits with D_{SH} < 0.1 and D_D < 0.04. And EDMOND data for 2006–2016 had only 6 similar orbits with D_{SH} < 0.1 and D_D < 0.04. 2023 appears to be the first year with noticeable activity for this new shower.

As mentioned in the introduction, the new shower appears also as a group of unidentified radiants on the CAMS map for January 16–17 (*Figure 11*). However, this data consists meanly of GMN data and it is not possible to select only CAMS data in this display.

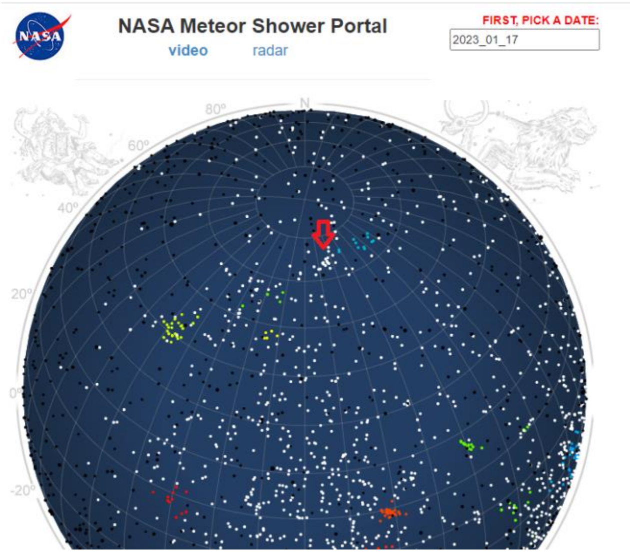

Figure 11 – Radiant plot for CAMS on 2023 January 17. The radiant concentration is indicated with a red arrow.

6 Conclusion

A new meteor shower radiant has been discovered in Global Meteor Network data around 2023 January 16–17 with a radiant close but still distinct from the known gamma-Ursae Minorids. A mean orbit could be established based on 29 orbits. The new shower and the GUM orbits being of the same type and relatively close apart in space, may be somehow related and belong to a small complex of common origin.

The new meteor shower has been reported to the IAU and has been listed in the Working List of Meteor Showers[2] under the temporary identification M2023-D2.

[2] https://www.ta3.sk/IAUC22DB/MDC2022/Roje/pojedynczy_obiekt.php?lporz=01595&kodstrumienia=01215

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