

Possible dust trail encounters of the October Draconids and the Leonids in 2025

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We provide details for possible dust trail encounters of the October Draconids and the Leonids in 2025 derived from modelling. Enhanced activity of the October Draconids is possible on 2025 October 8 between 15^hUT and 16^hUT. Model calculations indicate an encounter with dust released from comet 21P/Giacobini-Zinner in 2012. There may be also some activity of the Leonids on 2025 November 17 between 18^hUT and 23^hUT caused by dust ejected from 55P/Tempel-Tuttle in 1699. Further, there are encounters with very old dust of 55P. Observations on 2025 November 09 and 15 are of interest because there are essentially no data of such old dust trails.

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1 Introduction

Modelling meteoroid streams from the ejection of meteoroids from the parent object to their possible encounter with the Earth has allowed observers on Earth to record peculiar returns of meteor showers. Evidence from observations may also help to improve the modelling of future events. Here we provide details for two shower returns in 2025 which may cause interesting events as announced in the 2025 IMO Meteor Shower Calendar (Rendtel, 2024).

2 Draconids

The October Draconids (009 DRA) – often shortened to Draconids – are observable around October 8–9 with highly variable activity. In most years the rates are close to the detection limit, but outbursts with visual ZHR > 100 occurred repeatedly. Such outbursts have proven difficult to predict in the past (Egal et al., 2019). For example, the 2012 Draconid return produced storm-level activity with ZHR ≈ 9000 in radio meteor sizes (Ye et al., 2014). Observations collected from the 2024 return of the shower have been summarised by (Rendtel et al., 2024).

The observing conditions for optical methods during the 2025 return are very poor as the gibbous Moon less than 2 days after full is in Aries at the moment of the expected dust trail encounter. It is most interesting because it is a very young dust trail of meteoroids released from the parent comet 21P/Giacobini-Zinner in 2012 and the event happens only shortly after the comet’s perihelion on 2025 March 25.

The associated peak is probably very difficult to observe optically because of the very large ejection velocity which is necessary to bring the meteoroids close enough to the Earth. Like the 2012 return mentioned above, it may be detected by radar or other observations covering recording meteors.

There are more dust trails not described here which are too far from the Earth to cause observable activity. While there are no clear peaks to be expected from these individually, there may be a slightly enhanced general activity over some time.

For the 2025 return we expect an encounter with the 2012 dust trail on October 8. The **calculated peak times** were given in the 2025 IMO Meteor Shower Calendar and are summarised here:

$\lambda_{\odot} = 195^{\circ}269$ (15^h52^mUT; (Jenniskens, 2006)).

$\lambda_{\odot} = 195^{\circ}238$ (15^h07^mUT; Maslov, 2024).

$\lambda_{\odot} = 195^{\circ}257$ (15^h34^mUT; Sato, 2024).

The estimated prospects concerning the **activity level** are:

1. In Table 6d (Jenniskens, 2006) gives a ZHR ≤ 50.
2. Maslov calculated that the number density is about 8 times higher than of a 1-revolution Leonid trail. However, the Earth crosses this unperturbed trail at the end which is dominated by small meteoroids. For these a high ejection velocity is required. As a result, there may be a very short outburst with a ZHR of 100–150 from a radiant at $\alpha = 262^{\circ}8, \delta = +55^{\circ}9$ which is essentially identical to the known position.
3. Sato also emphasizes that the trail is dominated by small meteoroids and therefore may be limited to radar observations.

The time of the closest approach favours observing sites roughly east of 40°E in the northern hemisphere (Figure 1).

For the Draconids, Vaubaillon’s model requires a stretch of the impact parameters quite a bit to find an encounter with the 2005 trail of 21P/Giacobini-Zinner. These modelling results show both the 2005 dust trail and the whole stream far from the Earth. The closest approach is found on 2025 October 08, 15:56 UT and therefore very close to the time of the above mentioned 2012 trail. Since the distance to the 2005 trail is so large, the chance to observe (and distinguish) meteors of the 2005 trail is negligible.

3 Leonids

The parent comet of this shower, 55P/Tempel-Tuttle, currently returns into the inner Solar System. Its next perihelion is due on 2031 May 20. Meteoroids we observe now are ahead of the comet. The knowledge of the dust ejection mechanisms and trail evolution allowed us to predict and verify variable activity in numerous years until recently.

The (“regular”) nodal Leonid maximum at the known position at $\lambda_{\odot} = 235^{\circ}27$ should occur on 2025 November 17 shortly before 18^h UT. In (Maslov, 2007) we find

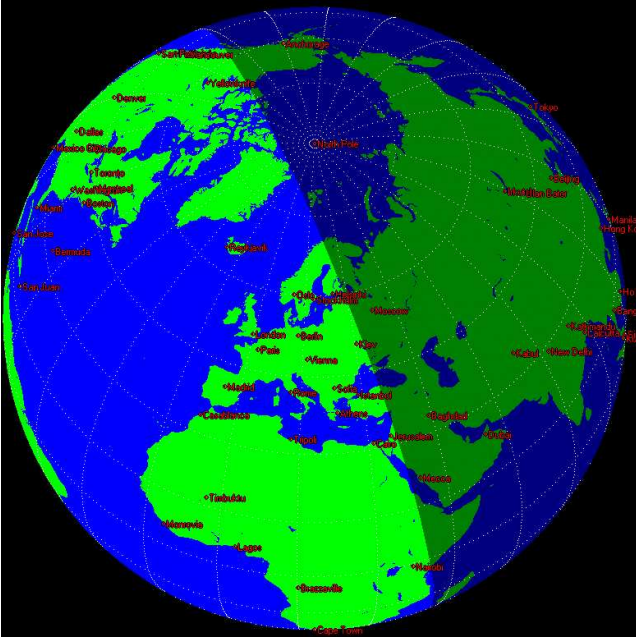


Figure 1 – The Earth as seen from incoming Draconid meteors ($\alpha = 262^\circ.8, \delta = +55^\circ.9$) at the time of the expected maximum time of outburst from the 2012 dust trail on 2025 October 8 at 15:07 UT. (Figure created using Xearth 1.1.0 by G. Hewgill, 2003).

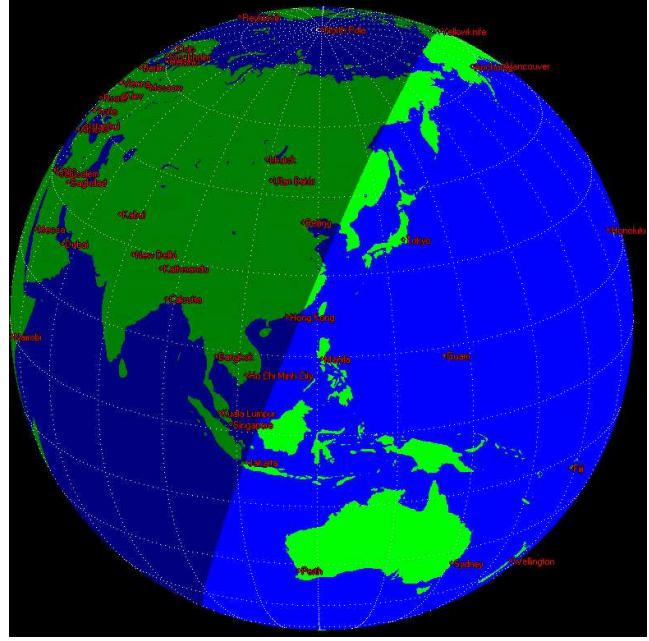


Figure 2 – The Earth as seen from incoming Leonid meteors ($\alpha = 154^\circ, \delta = +22^\circ$) at the time of the expected maximum time of outburst from the 1699 dust trail on 2025 November 17 at 19^h UT. (Figure created using Xearth 1.1.0 by G. Hewgill, 2003).

a slightly earlier time for this maximum: 2025 November 17, 10^h UT, corresponding to $\lambda_\odot = 234^\circ.95$ with an expected ZHR of about 10–15. Additionally, the Earth will encounter the 1699 dust trail and perhaps some much older trails as well.

Modelling by Sato:

There are two segments of this trail approaching the Earth in 2025 (Table 1). The parameters indicate that the 2nd peak may be detectable. However, there is some uncertainty because there is little experience about the appearance of dust returning prior to the parent comet.

Modelling by Maslov:

The same 1699 dust trail is modelled here as well (Table 2). As already pointed out above, the activity level is difficult to estimate because the particles which come close to the Earth must have left the comet at relatively high negative (backwards) ejection velocities. The Earth encounters relatively regular (undisturbed) parts of the trail.

Since smaller meteoroids are expected to be blown away by solar radiation pressure in such a trail, the results suggest that there will be only a small increase of the ZHR. However, the meteor brightnesses may be higher than the average level.

The event should be best visible from most parts of Asia except the eastern and southeastern regions (Figure 2). For European observers the radiant is just rising at the predicted encounter time.

Modelling by Vaubaillon:

Two encounters of even older dust trails can be found in the model. Slightly loosened parameters for the 1633 trail are applied to include the encounter. That is an interesting case, since the plot (Figure 3) shows that the trail is close to the path of the Earth, but the number density of particles is low: the densest part lies still a bit far from the Earth to cause significant activity. Therefore we are curious to see how or if this can be detected. Observers should be alert to monitor possible activity on 2025 November 15, around 03^h UT.

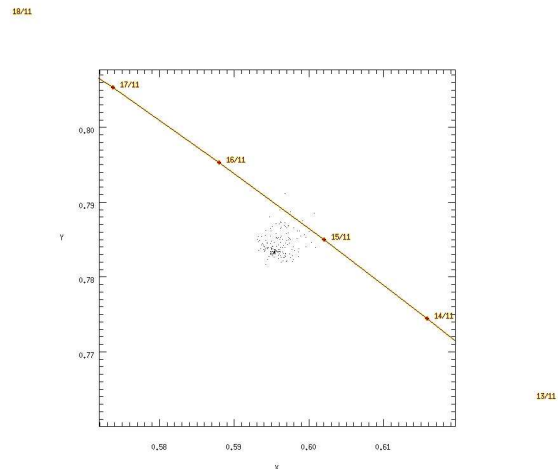


Figure 3 – Encounter of the dust trail ejected from comet 55P/Tempel-Tuttle in 1633.

Table 1 – Two segments of the 1699 Leonid dust trail to be encountered in 2025 and the calculated data. The minimum distance between the dust and the Earth is $\Delta r = rD - rE$. The expected radiant position is $153^\circ 86', +22^\circ 14'$ for the first segment and $153^\circ 88', +21^\circ 90'$ for the second one. The geocentric velocity is 70.6 km/s.

Expected peak time			Δr (AU)	Ejection vel. (m/s)	fM
Date	Time (UT)	$\lambda_\odot$			
2025-11-17	19:18	$235^\circ 341'$	−0.0019	−21.91	0.38
2025-11-17	22:40	$235^\circ 482'$	−0.00072	−17.31	0.44

Table 2 – Segments of the 1699 Leonid dust trail to be encountered in 2025 and the calculated data. The minimum distance between the dust and the Earth is $\Delta r = rD - rE$.

Expected peak time			Δr (AU)	Ejection vel. (m/s)	fM
Date	Time (UT)	$\lambda_\odot$			
2025-11-17	18:27	$235^\circ 301'$	−0.00182	−22.01	0.229
2025-11-17	18:27	$235^\circ 301'$	−0.00174	−21.92	−0.359
2025-11-17	19:05	$235^\circ 327'$	0.00015	−19.54	0.060
2025-11-17	19:15	$235^\circ 334'$	0.00020	−19.42	−0.165
2025-11-17	22:33	$235^\circ 473'$	−0.00062	−17.31	−0.423

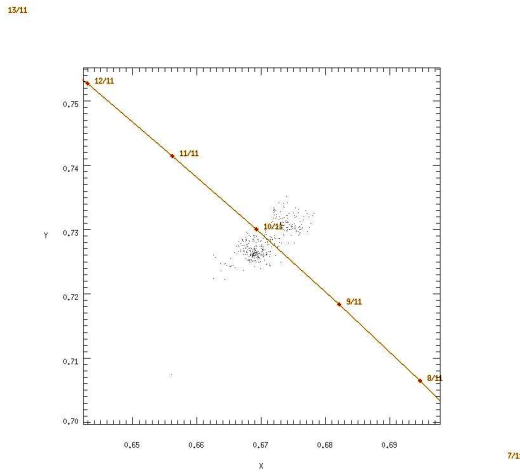


Figure 4 – Approach of the Earth with the 1167 dust trail of the Leonids in 2025.

Another extremely old and split dust trail – ejected in 1167 – comes close to the Earth already on 2025 November 9, around 22^hUT. The minimum distance is a bit less than for the 1633 trail (Figure 4). Nevertheless, we are not confident that it will be observable at all. But who knows, the Leonids are full of surprises, and it is worth monitoring the activity around this position. Unfortunately, there is some moonlight interference at this time.

4 Summary and Conclusions

Here we summarise the possible 2025 Leonid dust trail encounter times in chronological order:

- Nov 09, 22^hUT (1167 dust trail)
- Nov 15, 03^hUT (1633 dust trail)
- Nov 17, 10^hUT (nodal maximum at $\lambda_\odot = 234^\circ 95'$)
- Nov 17, 18^hUT (nodal maximum at $\lambda_\odot = 235^\circ 27'$)
- Nov 17, 19^hUT (1699 dust trail at $\lambda_\odot = 235^\circ 341'$)
- Nov 17, 22^h40^mUT (1699 dust trail at $\lambda_\odot = 235^\circ 482'$)

Except the first of the listed trail encounters, all others are observable without moonlight interference. As pointed out in the descriptions above, there are numerous unknowns and there are essentially no data of very old dust trails. Therefore all observational data is important, also covering other periods around the given times. This also includes reports which document that there is no detectable activity in or around any of the given intervals.

References

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