Australian Astronomy

**ASA Factsheet No. 6** **The Leonid Meteor Shower**

Over the next few years, there are significant prospects for strong displays of Leonid meteors in mid-November. Prediction of Leonid activity has had a rather chequered history, not helped by the events in 1998, but a new theory is able to explain the historical events and should thus be able to make sound predictions for the near future. Whilst these predictions don't suggest Leonids raining from the sky, as in the "storms" of 1833 and 1966, **prospects appear good for a moderate storm visible in dark skies from Australia and eastern Asia in 2001, and in moonlit skies over Europe, west Africa and North America in 2002.**

**What is a meteor?**

A meteor results when a small particle (typically millimetres in size for a visual meteor) of dust orbiting the Sun collides with the Earth's atmosphere. The speed of collision is determined by whether it is a head on collision or otherwise and also the acceleration due to the Earth's gravity. Velocities of collision are between 11 and 72 km/sec (40,000 - 260,000 km/hr). At these immense speeds, the particles are intensely heated in collision with atoms and molecules in the upper atmosphere causing both the particle and air surrounding it to glow. This phenomenon is known as a meteor. From this explanation it is clear why the phrases "falling star" or "shooting star", whilst descriptive, can be seriously misleading. Meteors typically "burn up" at heights around 90 km but for a typical Leonid meteor having a near head-on collision speed of 71 km/sec, the height is typically over 100 km.

**Meteor storms**

On an average night, around 5 to 10 meteors can be seen in an hour from a dark country location. The term "storm" is thus most apt for the 1966 Leonids, when a peak rate of over 100,000 meteors/hr was estimated by observers in western North America. For about quarter of an hour either side of maximum, the rates were over half this value. Eyewitness accounts of the 1966 storm, for which only vague predictions existed, were typically expressions of awe and great excitement. It is no wonder therefore that throughout history, many cultures across the world have clearly documented the occurrence of meteor storms.

**History of the Leonid shower**

One of the first scientific accounts of a Leonid storm was by Alexander von Humboldt, a Prussian aristocrat, explorer and polymath. He witnessed the 1799 storm from South America during his exploration of the Orinoco. His account of meteors pouring from the sky is but one tiny part of the multi-volume report of his expeditions.

It was the 1833 Leonid storm witnessed over North America that resulted in the modern study of meteors. This event led to the recognition of Leonid storms in historical records going back to 902 AD and to the 33 year periodicity in their occurrence. High activity from the Leonids can happen over several years every 33 years or so, but away from these years, the Leonid rates are typically only a few tens of meteors per hour at best.

In 1866 a Leonid storm came on cue, with good activity also in 1867 and 1869. Around this time another major advance in meteor science took place. Comet searchers found two bright comets, one became named Swift-Tuttle and the other Tempel-Tuttle after their discoverers. In both cases, the orbits of the comets around the Sun were shown to be basically identical to known meteor showers, the August Perseids in the case of comet Swift-Tuttle and the Leonids in the case of Tempel-Tuttle. It was clear that shower meteors were directly related to comets.

**Showers and radiants**

Meteor showers occur at the same time each year because the orbits of the dust and the

Earth form a sort of celestial crossroads. Once a year, at the same point (the dates can differ by a day from year to year due to the nature of the calender and the gravitational pull of the planets on the orbiting dust) the Earth goes through the crossroads. The number of meteors seen from that shower will depend on the amount of "traffic" at the time. The number of particles encountered is related to the way the dust comes off the comet and how long ago it was ejected. With all the dust particles from a particular shower having closely similar motions, their paths in the atmosphere are parallel. Parallel lines, like railway lines converging towards the horizon, appear to radiate from a central point. For a meteor shower, this point is called the radiant and the constellation in which the radiant lies gives its name to the shower. The particles from comet Tempel-Tuttle radiate from the constellation Leo and are therefore called the Leonids.

**Predicting Leonid activity**

The orbital period of comet Tempel-Tuttle is 33.2 years, and with the major Leonid activity being in the years just following the passage of the comet it appeared that the debris formed a cloud that lagged the comet. The stage was then set for the 1899 Leonids and astronomers had enthusiastically predicted a major event. When very little happened in that or subsequent years, astronomy suffered a major blow to its credibility in the eyes of the public. This simple adding of 33 years to the last period of high activity was shown to be rather naive. Irish astronomers Johnstone Stoney and Arthur Downing were amongst a few scientists that pointed out the effect of the gravitational attraction of the planets (particularly Jupiter, Saturn and Uranus) on the orbit of the comet and the dust. By 1899, the orbits had been shifted away from Earth intersection and prospects were no better around 1932. Indeed very little happened from the Leonids in the early 1930's.

When 1966 came around, astronomy was a much more vibrant science with increased amateur participation. Whilst little was specifically predicted for that year, mostly due to no calculations having being made, the huge Leonid storm that took place was very well observed by hundreds of amateur and professional astronomers in North America. This led to new attempts to calculate future storms.

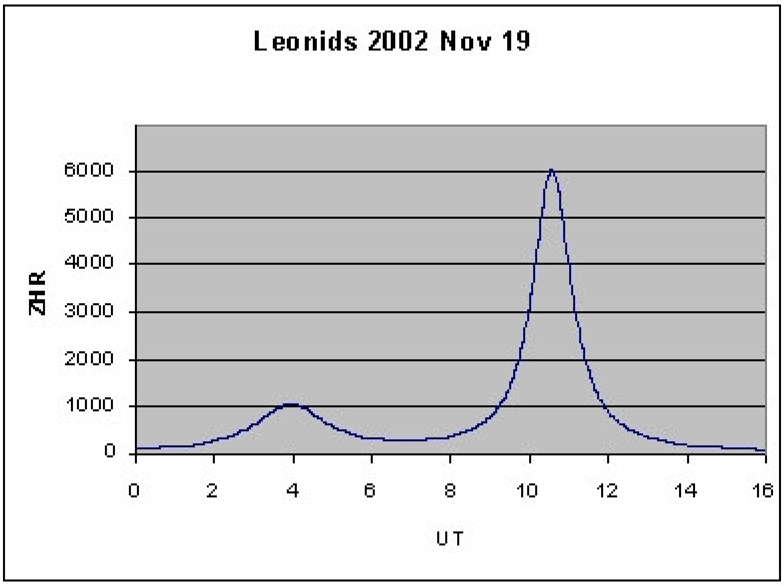
**Modern predictions**

David Asher of Armagh Observatory in Northern Ireland and myself have carried out detailed calculations to predict the visibility of the Leonid meteors over the next few years. In our calculations we took account of the dust ejected by Comet Tempel-Tuttle on its past approaches to the Sun. For more details of our calculations and that of other astronomers who have done similar studies previously, read David Asher's explanation of dust trails or read my article in the Oct/Nov 1999 or Oct/Nov 2001 issues of *Sky & Space*. The table below includes some additional trails calculated since the original work was published. In comparing various predictions, it should be noted that those not involving rigorous orbital calculations for the orbiting dust are likely to be little better than first approximations. An excellent summary of other predictions of the 2001 Leonids appears in the Nov 2001 issue of *Sky & Telescope*. Note however that when that issue was published, the results of our latest calculations were not available and should be replaced by the values given here.

Although our predictions have been carefully validated against historical data, these young dust trails are not all there is to the Leonids. There is also a "background" of dust ejected in the distant past that can peak more that a day away from the times below, and can produce strong activity, but probably nothing approaching the stronger displays given in the table. This background activity is present between around Nov. 14 - 21.

The detailed predictions for the dust trail encounters are given below.

| Date/Time | Revs | Rate | Moon | Visibility map |
|---|---|---|---|---|
| 2002 Nov 19 03:56 UT | 7 | 1000 | Bad | 2002 map a W.Africa, W.Europe, N.Canada, NE S.America |
| 2002 Nov 19 10:34 UT | 4 | 6000 | Bad | 2002 map b N.America |




The ZHR (Zenithal Hourly Rate). It will be substantially less due to the moonlight, city lights, haze, radiant elevation, etc. Expect the observed rate at maximum along the east coast of the US to be more like 1000 per hour, as dawn starts.

### Explanation of the Table and Visibility Maps

- Eastern Australian daylight saving time is UT +11 hours. The predicted times for these dust trail encounters is uncertain by around 5 minutes.
- **Revs**, indicates the number of revolutions the dust has made around its orbit since the dust was ejected.
- The **rates** quoted are approximations (revised 10 Oct. 2002). They give an indication of the number of meteors seen from a dark location with no moonlight and Leo high in the sky. A bright sky, or the constellation Leo being close to the horizon, will result in much lower rates being seen. The rates quoted are based on a technical definition called a ZHR; rates actually seen will be less, except in excellent observing conditions.
- The full moon will seriously lower the observed rates in 2002.
- **The visibility maps** show the region of the Earth that will experience the Leonid meteors at the predicted peak time. The region to the right is daylight and only very bright meteors could be seen. To the left is the night region, with the various lines from top right to bottom left (reading right to left) being the day/night boundary and the civil, nautical and astronomical twilight boundaries. To the public, the sky shows a touch of blue between astronomical and nautical twilight and this results in the faintest meteors being missed. The concentric circles show the angle of the Leonid meteor radiant above the horizon. The higher the radiant the more meteors will be seen. The phase of the Moon is displayed at the top right, as seen from the southern hemisphere. The Moon rise/set boundary is plotted as a thick dashed line, and the 'lunar civil twilight' with a thin dashed line.

### What happened in 1998?

Despite some predictions of high activity in 1998, rates were moderate. The greatest activity occurred some 18 hours before these rough predictions and comprised mostly very bright Leonids. David Asher and his colleagues have shown that in 1998 the Earth ran into a trail of exceptionally large particles ejected by the comet back in 1333. For more details, see David Asher's explanation of the 1998 "fireball" activity.

### Circumstances from Australia

Other than the 2001 encounters, which are probably the best of the present epoch, there will be no encounters visible from Australia. This doesn't imply there will be nothing of interest for Australians to observe. These young dust trails are embedded in a background of Leonid particles that are old and have lost their dust trail structure. It is possible that quite high rates of up to 500 meteors per hour could occur, but there has been no adequate modelling of this, so no predictions as to the time or rate of maximum can be made. In the years from 1999 onwards, the peak of this background activity could occur on the nights of Nov 17/18, 18/19 or even 19/20. Northern Australia is favoured, having the Leonid radiant in the sky for three hours or more before dawn. When the Leonid radiant is below the horizon, the Leonids won't be visible. In southern Australia the period of visibility is the two hours before dawn. With Leo rising in the north east (see map), Leonids could be recognised as very swift meteors coming from the north east.

### Observing meteors

The most important factor in observing meteors is a dark sky. There are many more faint meteors than bright ones, so trying to observe from the light polluted skies of a moderate to large town can dramatically lessen the number of meteors seen. Reclining on a camp bed makes looking at the sky more enjoyable and less of a strain on the neck. Look at any part of the sky, especially the clearest and darkest part with the least obstructions although it is interesting to have Leo in your field of vision, to show the effect of the meteor radiant. General information on visual observing of meteors can be found here.

To photograph meteors, a fast film (400 ISO or faster) and a fast standard to wide angle lens (f/1.4 to f/2.8) are the best combinations. Exposures should be of the order of 20 minutes to one hour depending on the specific film/camera and sky brightness combinations. You are well advised to try some test shots well in advance and have them processed to allow suitable adjustments to be made before the critical nights. Try to include some foreground features for the most photogenic effects.

For more information on photographing meteors as a science project, see the IMO notes on photography.

**Books**

"*The Heavens on Fire: The Great Leonid Meteor Storms*" by Mark Littman
Cambridge University Press
Paperback (1999) 0 521 779799 0
Hardback (1998) 0 521 62405 3
A most lucid and fascinating read. Strongly recommended.

**Links**

**Comet Tempel-Tuttle**
Orbit of 55P/Tempel-Tuttle

**Leonids**
Visibility of Leonids in Australia in 2001 Peter Anderson - Astronomical Association of Queensland
Armagh Observatory Leonid meteors page
NASA Ames Leonid Page
Gary Kronk's Leonids Page

**Meteors in general**
International Meteor Organisation
Two Australian meteor groups are located in Victoria

**Leonid Images**
Images and links from Timo Leponieni, Finland
Leonids live on the web from Alice Springs, courtesy of Swinburne University's Centre for Astrophysics and Supercomputing.

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