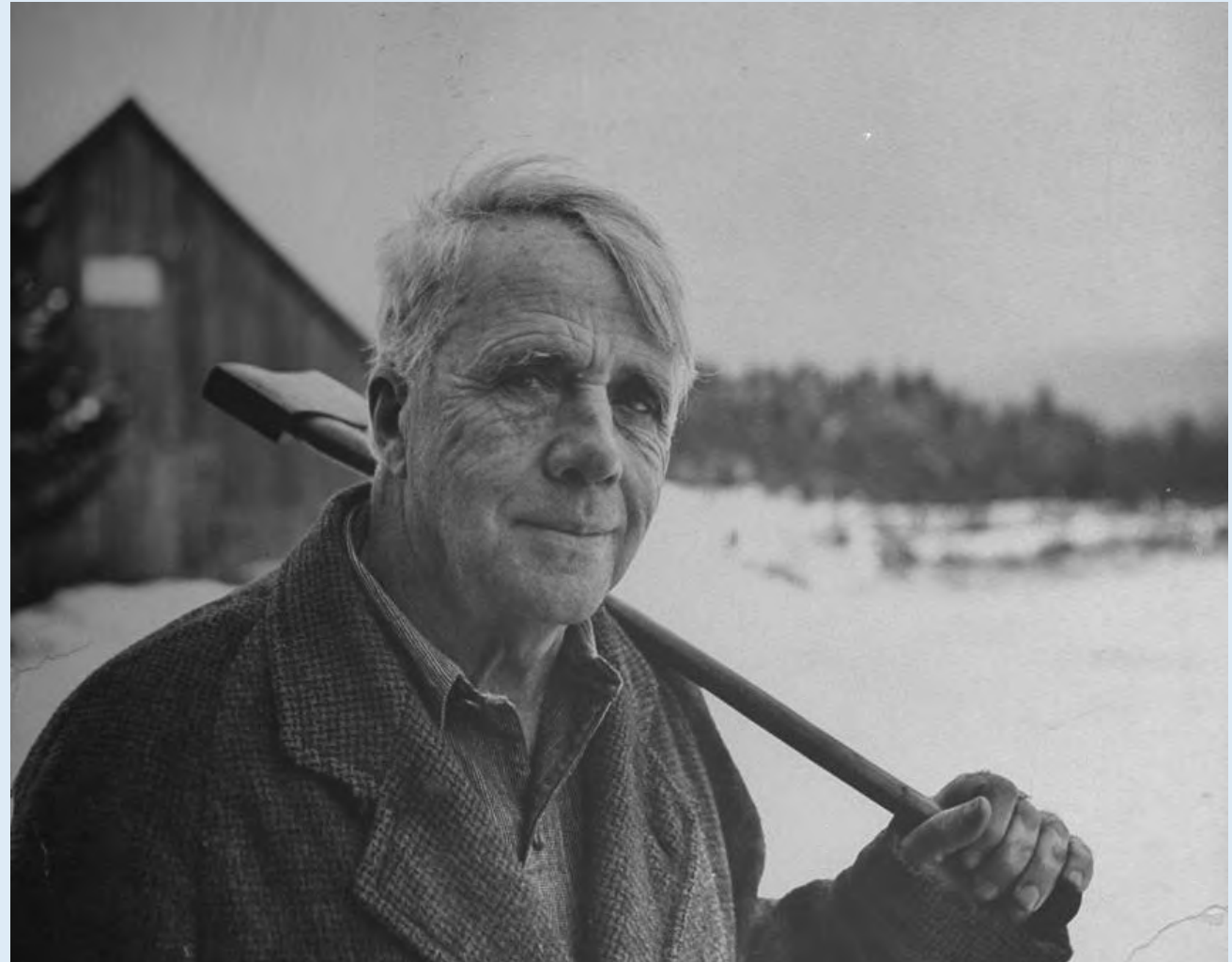
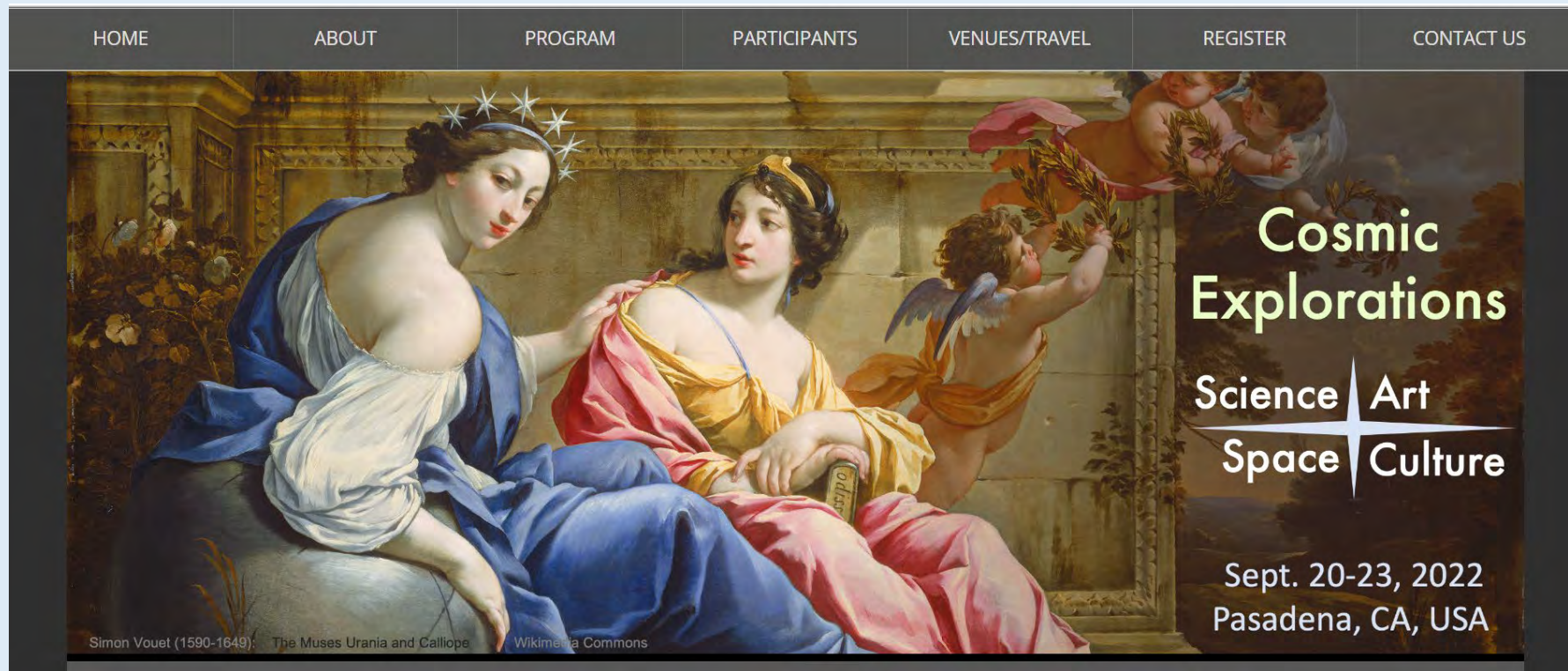


Robert Frost  
and the  
Leonid meteor shower

Leila Belkora (Ph.D., astrophysics)  
Cosmic Explorations 2022

Photo Credit: Eric Schaal





Hoffmann on art/science: both value economy and intensity.

Frost poem: scientific ideas in a compact and relatable form;  
makes us think about our relationship with the natural world

# Robert Frost (1874-1963)

Photo Credit Tony Spina, <http://reuther.wayne.edu/node/9001>





# The Leonid meteor shower

Particles about size  
of grain of sand

- Everyday meteors: a few per hour
- Leonid shower (mid-Nov.): 10-15 per hour
- Leonid “storm” (rare): could be 10 PER SECOND!



2002 storm; 30 1-min exposures

Photo credit: Casado & Graboleda.

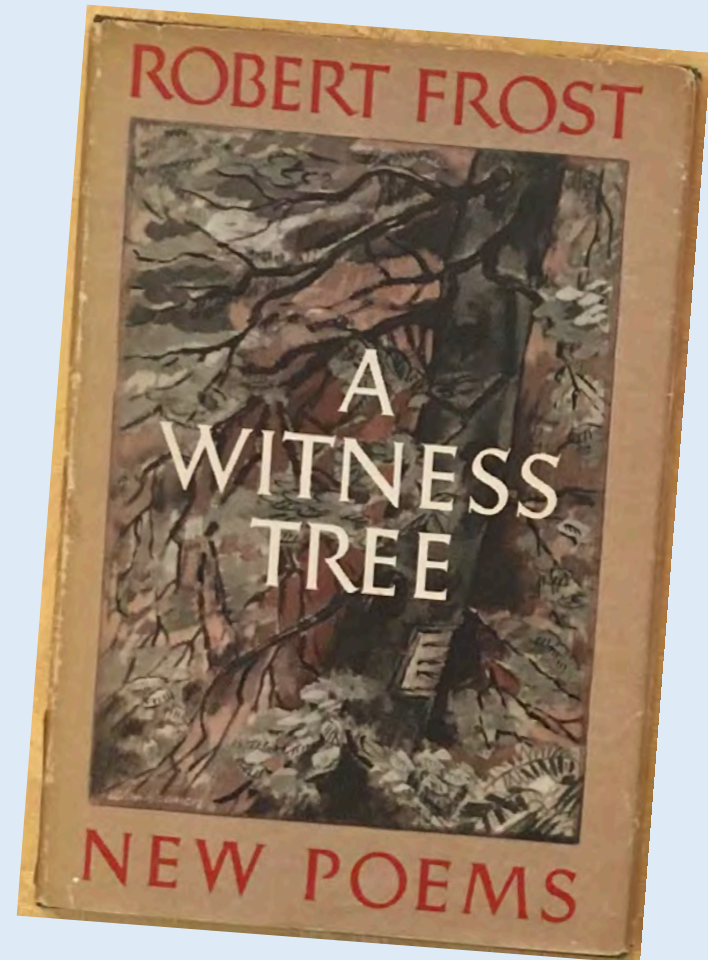
# “A Loose Mountain (Telescopic)”

First published in

*A Witness Tree*, 1942

but likely inspired earlier.

A rhyming poem about Leonids...





# A Loose Mountain (Telescopic) language colloquial/humorous

Did you stay up last night (the Magi did)

To see the star shower known as Leonid

That once a year by hand or apparatus

Is so mysteriously pelted at us?

It is but fiery puffs of dust and pebbles 5

No doubt directed at our heads as rebels

In having taken artificial light

Against the ancient sovereignty of night.

A fusillade of blanks and empty flashes,

It never reaches earth except as ashes 10

Of which you feel no least touch on your face

Nor find in dew the slightest cloudy trace.

Nevertheless it constitutes a hint

That the loose mountain lately seen to glint

In sunlight near us in momentous swing 15

Is something in a Balearic sling

The heartless and enormous Outer Black

Is still withholding in the Zodiac

But from irresolution in his back

About when best to have us in our orbit 20

So we won't simply take it and absorb it.



# A Loose Mountain (Telescopic) slight air of punishment

Did you stay up last night (the Magi did)  
To see the star shower known as Leonid  
That once a year by hand or apparatus  
Is so mysteriously pelted at us?  
It is but fiery puffs of dust and pebbles 5  
No doubt directed at our heads as rebels  
In having **taken artificial light**  
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In sunlight near us in momentous swing 15  
Is something in a Balearic sling  
**The heartless and enormous Outer Black**  
Is still withholding in the Zodiac  
But from irresolution in his back  
About when best **to have us** in our orbit 20  
So we won't simply take it and absorb it.

# A Loose Mountain (Telescopic) rhyme & rhythm

Did you stay up last night (the **Magi did**)

To see the star shower known **as Leonid**

That once a year by hand or **apparatus**

Is so mysteriously **pelted at us?**

It is but fiery puffs of dust and **pebbles** 5

No doubt directed at our heads as **rebels**

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# Balearic Slingers

- From Balearic Islands in Western Mediterranean;
- Hannibal (218 BC)

“... the loose mountain lately seen to glint  
In sunlight near us in momentous swing  
Is something in a Balearic sling”

Credit: <https://imperiumromanum.pl/en/curiosities/best-slingers-came-from-balearic-islands/>

# A Loose Mountain (Telescopic) not take for granted; uncertainty

Did you stay up last night (the Magi did)

To see the star shower known as Leonid

That once a year by hand or apparatus

Is so mysteriously pelted at us?

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# 1899: Frost; anticipation of Leonids

## ON THE WATCH FOR METEORS.

Yerkes Observatory Astronomers Will Try to Obtain Photographs.

WILLIAMS BAY, Wis., Nov. 10.—The astronomers of the Yerkes Observatory are already on the lookout for meteors, although none of the Leonides is expected before Sunday morning. The twenty-four-inch reflecting telescope, which has just been completed in the instrument shop of the observatory, has been set up temporarily on the roof of the building. It is supplied with a temporary equatorial mounting, which has been tested and found to work satisfactorily.

Sixteen or eighteen photographic cameras are being prepared, varying in size from 2 to 6 inches. They are to be attached to the mounting of the telescope in such a way as to cover as much as possible of the sky where the meteors are expected to appear. It is hoped that a large number of meteor photographs will be secured, and the position of the radiant determined with greater accuracy than ever before.

Prof. Bannard considers from 2 to 5 o'clock in the morning of Nov. 13 the most favorable time for making observations of the meteors.

## FIRE ALARM TO ANNOUNCE METEORS

If the Leonid Shower Tonight Is Worth Seeing Cambridge People Will Be Notified by Five Blows Sounded Twice

At the instance of the school committee, Mayor Champlin of Cambridge has made arrangements with Professor Pickering of the Harvard Observatory, so that if the Leonid meteor shower appears, as expected, the people of that city can be made aware of the fact without sitting up all night. Provided the shower is good enough to make it worth while, Professor Pickering will notify the central office of the fire-alarm system, and the no-school signal, consisting of five blows sounded twice, will be rung. If this signal is

# Leonids of 1899—why the buzz?

- 1799 Nov. shower, Humboldt + (100s/sec)
- 1833 another November shower

*In the eastern part of Pennsylvania, where I was, they began to fall about eleven o'clock in the evening, increasing in frequency until, in a few hours, they became a perfect shower. They could no more be counted than one can count the fast falling flakes of snow in a hard storm.*

*They continued to fall without any diminution of numbers until the dawn of day obscured them [...].*

*—J.H. Waggoner, of 1833 event*

# Leonids of 1899—why the buzz?

- 1799 Nov. shower, Humboldt +
- 1833 another November shower
- H.A. Newton correctly predicted return in 1866 (2000-5000 per hour)
- Tied to comet 55P/T-T
- Expectation of “storm” about every 33 years

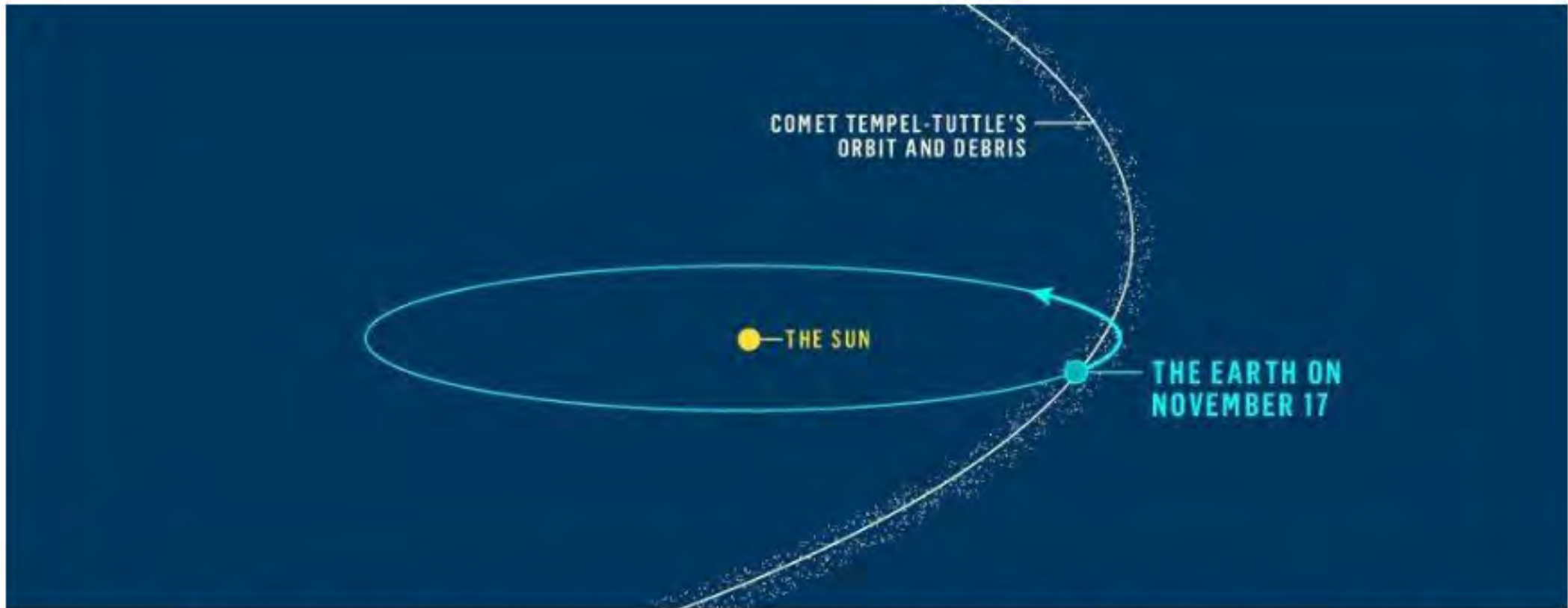
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*They continued to fall without any diminution of numbers until the dawn of day obscured them [...].*

*—J.H. Waggoner, of 1833 event*

Earth yearly encounter with comet trail;

Every 33 years, encounter with “freshly enriched” trail



The comet's orbit and debris stream where it intersects the Earth's orbit. Credit Katie Peek, Popular Science.



Anticipation of 1899 Leonids high

BUT ...

1899 No  
“blizzard of fire”!

Only a few meteors were  
seen.

The comet itself had been a  
no-show.

Why?

## The Fiasco of the Leonid Meteors.

Written for THE NEW YORK TIMES

By Prof. CHARLES A. YOUNG  
of Princeton University.

AS AN intelligent gentleman said the other day, “astronomy is on its defense.” The public want to know why they were humbugged into staying up through “the wee, sma’ hours” and watching the skies for several nights to see a celestial display that did not come off. The astronomers must frankly concede that as a spectacle the affair was a total failure, and that as a verification of their predictions it was very far from satisfactory.

It is true that a good many meteors were seen between Nov. 13 and 16, of which a large proportion—more than one-half—were Leonids, and had it not been for the overpowering moonlight, at least ten times as many would have been visible; for, under the circumstances, only the brilliant meteors could be seen, and the fainter ones are always vastly more numerous. If the sky had been clear and moonless the twenty or thirty which were actually observed at

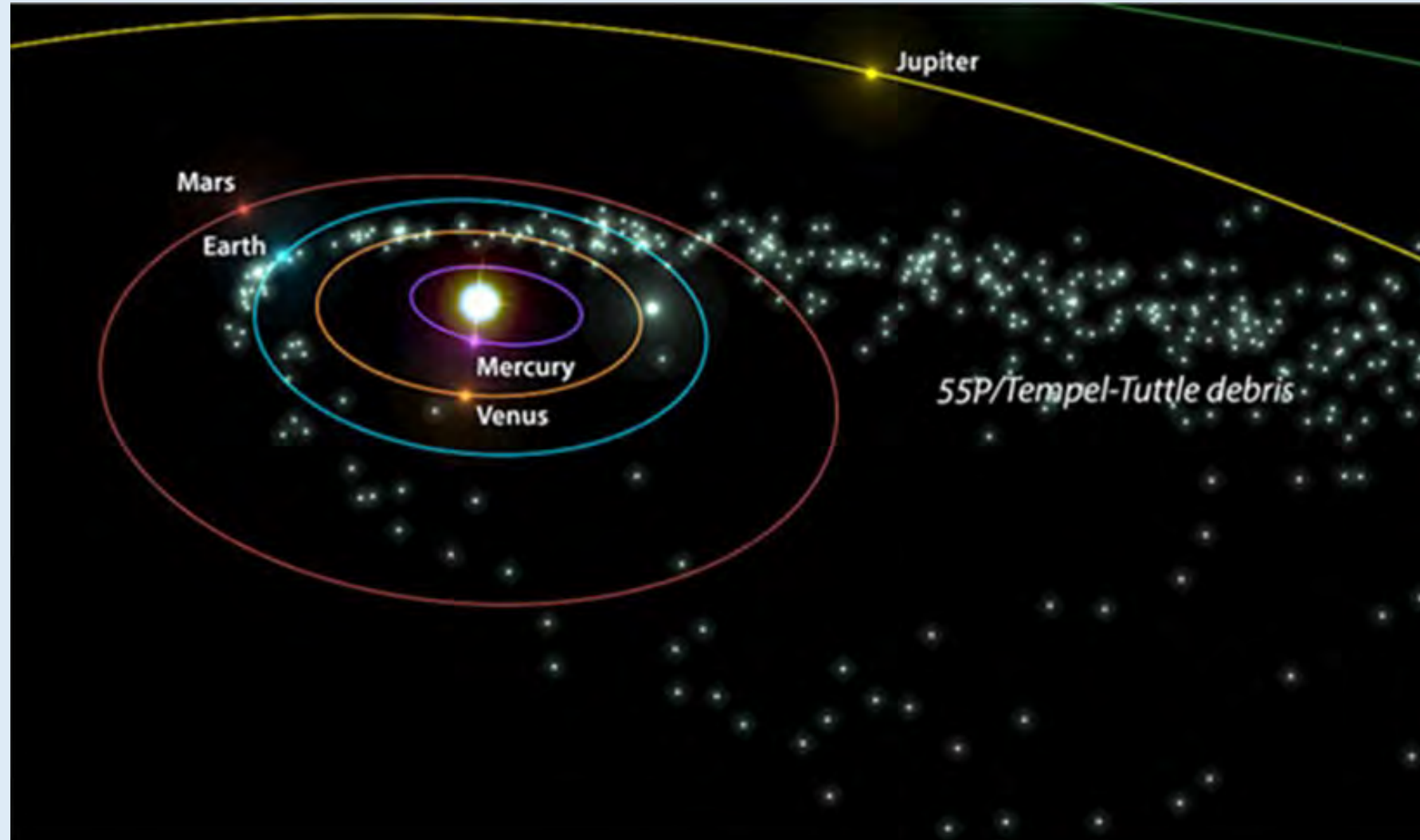
is enormously enhanced when we are dealing with a disorderly procession more than a thousand millions of miles long, composed of little meteoroids which travel in irregular streams and groups, with stragglers before, behind, and all around, and with the great planets Jupiter and Saturn disturbing them for thirty years—to say nothing of the confusion and havoc produced by the earth herself in 1866-7. While it is to be regretted that the calculations proved to be erroneous by an amount which caused the failure of the prediction founded upon it, it is nothing to wonder at.

All things considered, however, it seems rather probable that the computation may have been all right so far as concerns the date at which the earth should cross the meteor track, and that the failure to encounter the meteors was due to a shift of their orbit upward or downward, converting the former “grade crossing” into a

1) Meteor-causing particles “like an army on the march” and “this year, the earth may have cut through between two brigades, and so have failed to strike any considerable mass of the enemy, meeting only some of the stragglers...”

2) Perturbations by gravity of planets

Illustration credit: Illustration credit: Jenniskens/Webster/S&T



# Historical context of poem

1899—failure of Leonids; Jupiter/planets blamed

increased use of streetlights in cities (gas, arc, incandescent)

1931-1933—disappointing to many; Jupiter blamed again

1942— “A Loose Mountain (Telescopic)” appeared in print

1963—Frost died; next big storm would have been expected 1966

Re-read poem in this light...

# A Loose Mountain (Telescopic) uncertainty/history

Did you stay up last night (the Magi did)

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So we won't simply take it and absorb it.

“Did you stay up last night?”

1966 storm—brief but  
very intense. Viewers had  
impression of moving  
through space



# Art / science / space / culture



poem: mankind's connection to night sky.  
Story about Leonids.



Assignment: watch the skies!

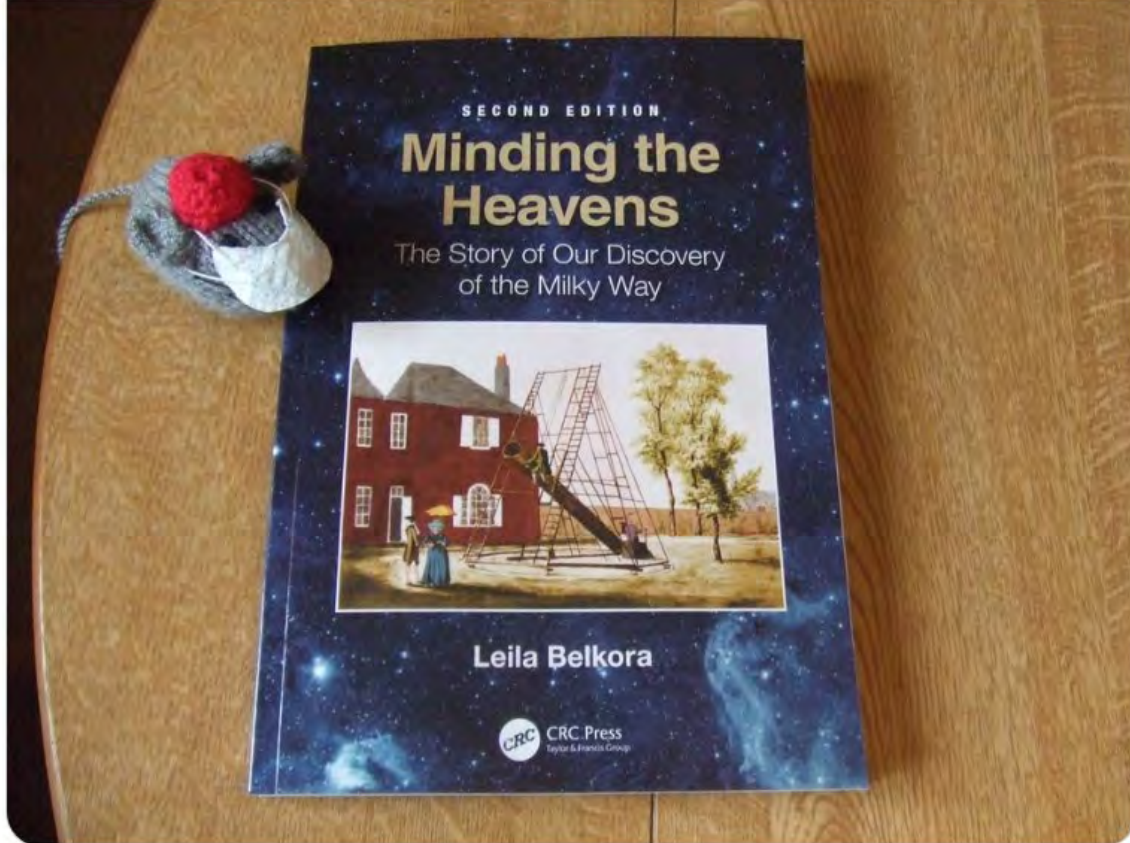
November 2022 forecast (M. Maslov): 1733 trail outburst possible 17<sup>th</sup>, and another peak 19<sup>th</sup>

Image credit: Tunc Tezel 2016



# Book (2021) history of astronomy

 **Astronomical Mouse** @Astronimouse · May 14, 2021  
Pleased to receive this great new edition of Leila Belkora 'Minding the Heavens'!



work in progress: Frost

*Out for Stars: Robert Frost  
and the Astronomy of His Time*

Also forthcoming, two articles in the  
*Robert Frost Review* (Fall 2022)

Belkora@cox.net

A question for the audience...

What do you make of the title of Frost's poem,  
“A Loose Mountain (Telescopic)” ?

# “A Loose Mountain (Telescopic)”

Credit: Alan Dyer (with permission)



© Amazing Sky Photography  
Astrophotography by Alan Dyer / [amazingsky.com](http://amazingsky.com)

# A Loose Mountain (Telescopic)

Did you stay up last night (the Magi did)  
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# Meteor facts

- 2 to 7 meteors each hour (“sporadic” meteors)
- During a quiet Leonid year, 10-15 per hour
- During a Leonid storm, 50,000 to 150,000 per hour est for 1833
  
- Seen at 50-75 miles (80-120 km) altitude
- Hundreds of named showers; about a dozen really prominent

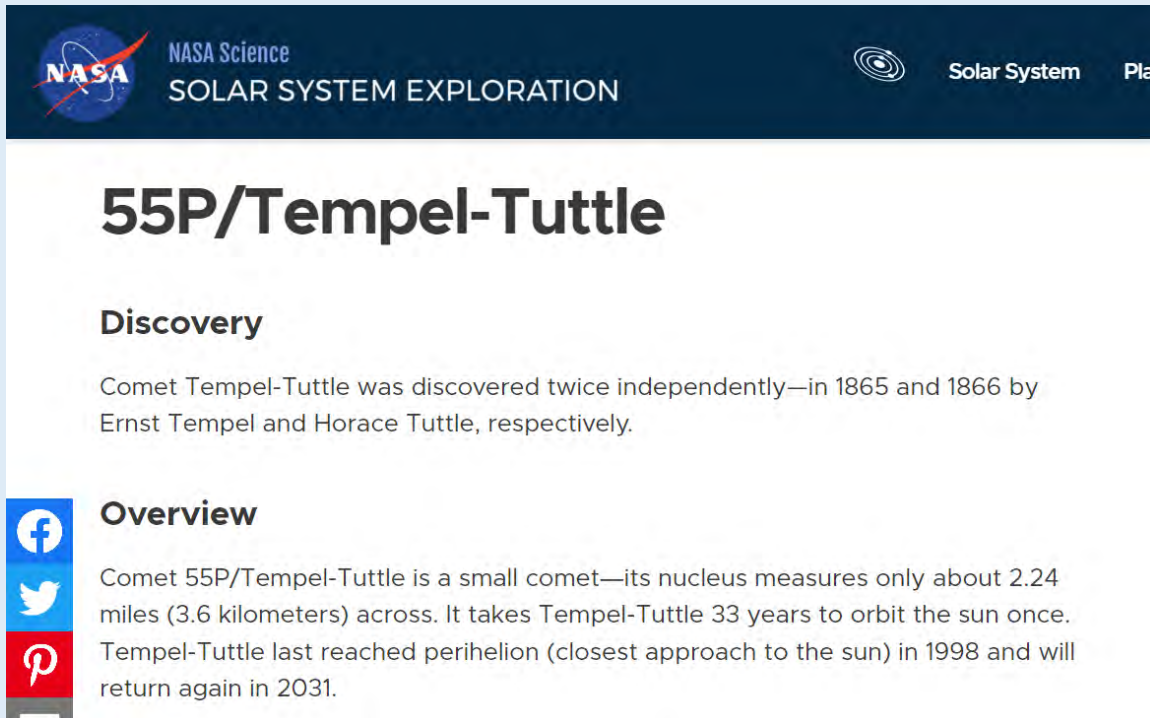
# List of Major Meteor Showers (2022)

2022 Major Meteor Showers (Class I)

Shower	Activity Period	Maximum		Radiant		Velocity	r	Max.	Time	Moon
		Date	S. L.	R.A.	Dec.	km/s	ZHR			
Quadrantids (QUA)	Dec 26-Jan 16	Jan 04	283.3°	15:20	+49.7°	40.2	2.1	120	0500	02
Lyrids (LYR)	Apr 15-Apr 29	Apr 22	032.4°	18:10	+33.3°	46.8	2.1	18	0400	21
eta Aquarids (ETA)	Apr 15-May 27	May 05	046.2°	22:30	-01.1°	65.5	2.4	60	0400	05
Southern delta Aquarids (SDA)	Jul 18-Aug 21	Jul 31	127.6°	22:42	-16.3°	40.3	3.2	20	0300	03
Perseids (PER)	Jul 14-Sep 01	Aug 13	140.0°	03:13	+58.0°	58.8	2.6	100	0400	17
Orionids (ORI)	Sep 26-Nov 22	Oct 21	207.5°	06:21	+15.6°	66.1	2.5	23	0500	27
Leonids (LEO)	Nov 03-Dec 02	Nov 18	236.0°	10:17	+21.6°	70.0	2.5	15	0500	24
Geminids (GEM)	Nov 19-Dec 24	Dec 14	262°0	07:34	+32.3°	33.8	2.6	120	0100	21
Ursids (URS)	Dec 13-Dec 24	Dec 22	270°5	14:36	+75.3°	33.0	3.0	10	0500	29

Information and Table Template Courtesy the International Meteor Organization and Masahiro Koseki.

# Comet 55P/Tempel Tuttle



The screenshot shows the NASA Science website page for Comet 55P/Tempel-Tuttle. The header includes the NASA logo, 'NASA Science', and 'SOLAR SYSTEM EXPLORATION'. Navigation links for 'Solar System' and 'Planets' are visible. The main title is '55P/Tempel-Tuttle'. Below it, the 'Discovery' section states that the comet was discovered twice independently in 1865 and 1866 by Ernst Tempel and Horace Tuttle. The 'Overview' section describes the comet's nucleus as 2.24 miles (3.6 kilometers) across, with a 33-year orbital period, and notes its last perihelion in 1998 and next in 2031. Social media icons for Facebook, Twitter, and Pinterest are on the left.

<https://www.astro.umd.edu/~farnham/tt/tthist.html>

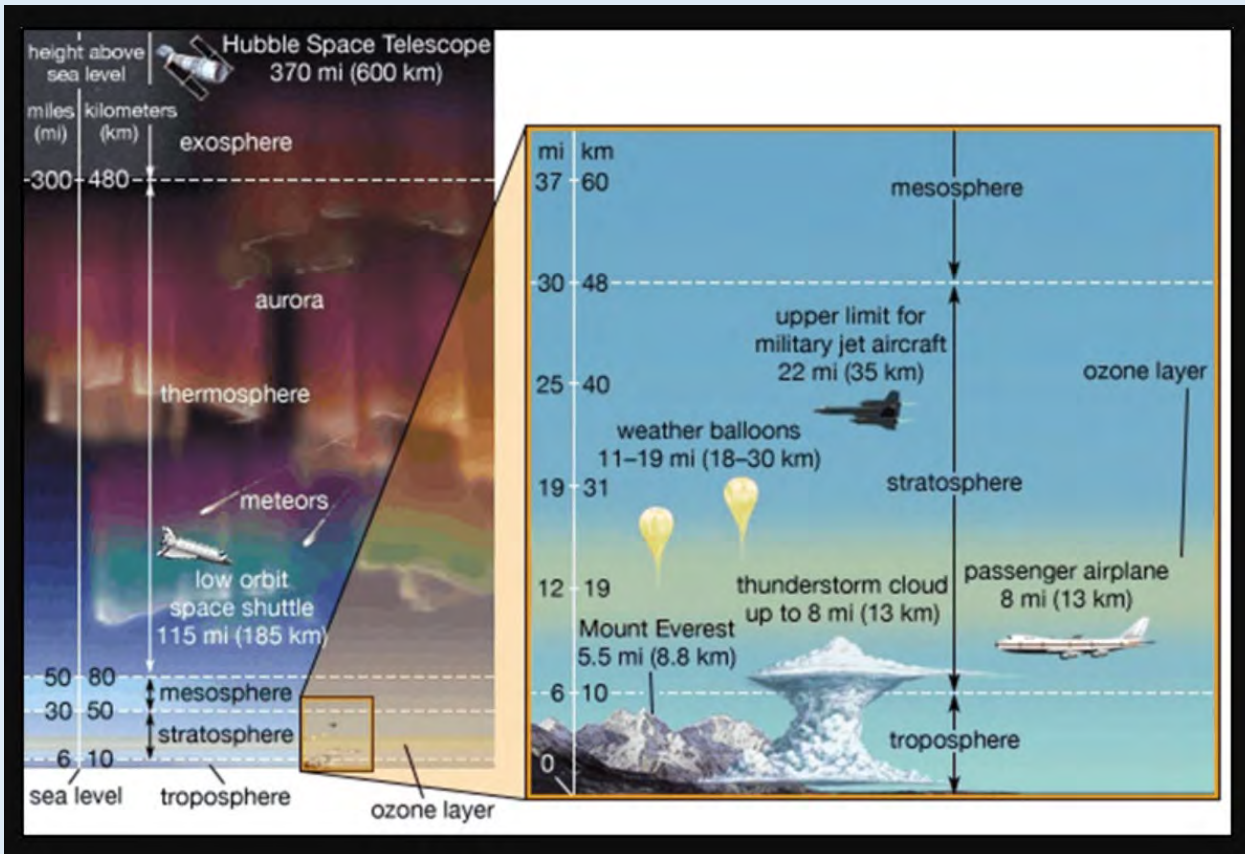
## History (from *Comets, A Descriptive Catalog*, 1984)

Comet Tempel-Tuttle was "discovered" independently by William Tempel in December 1865 and by Horace Tuttle in January 1866. After this apparition, calculations showed that the comet was in an elliptic orbit with a 33-year period. This information was then used to prove that Tempel-Tuttle was the same comet that had been observed in the year 1366 and again in 1699. The orbit determination was also used to show that T-T was associated with the Leonid meteor shower that occurs every year in November.

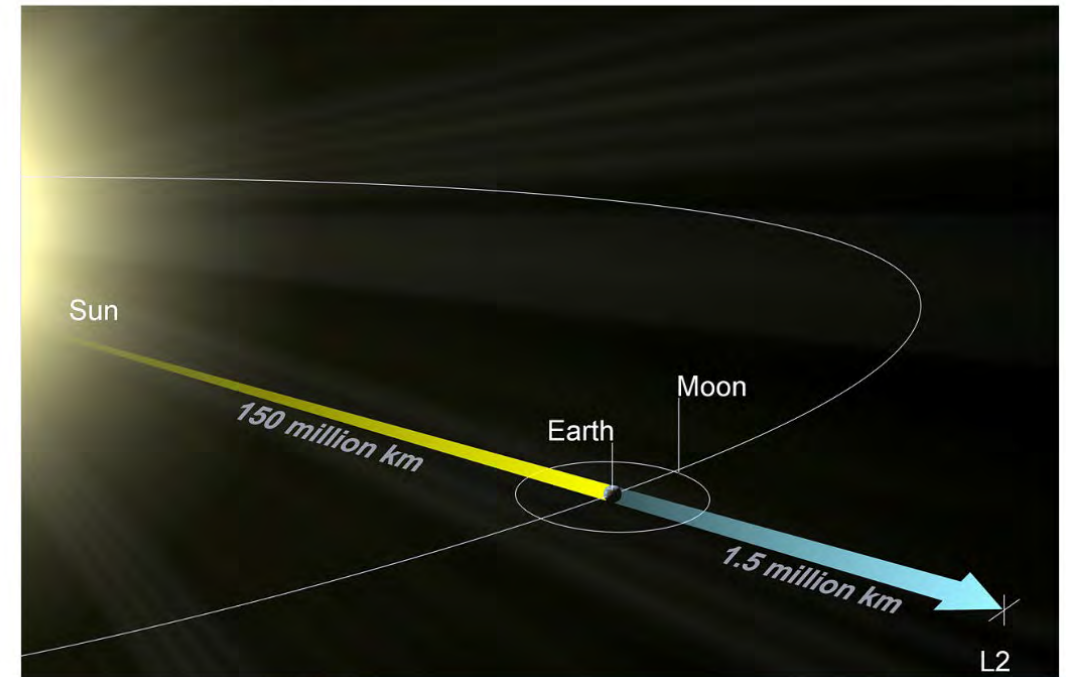
Even though astronomers searched for it in 1899 and again in 1932, Tempel-Tuttle was not seen again until 1965, when it was observed as a faint, 16th magnitude object.

Comet Tempel-Tuttle was recovered on March 4, 1997 by Karen Meech, Olivier Hainaut and James Bauer at the University of Hawai'i. At the time it was very faint (22.5 mag), but the recovery proved that it was returning on schedule and that its orbit was very well determined.

# Relative altitudes or distances




L2 orbit of JWST





Impacts on earth (meteorites) usually from sporadic falls of asteroid bits, not meteor showers

 **BARRINGER**  
**METEOR CRATER**  
AND ITS ENVIRONMENTAL EFFECTS

**INTRO**

Forty-nine thousand years ago, a large 30 to 50 meter diameter iron asteroid impacted the Colorado Plateau in northern Arizona. The resulting massive explosion excavated 175 million tons of rock, forming a crater nearly a mile wide and 570 feet deep. ([Click here to learn about the geology of the region](#)). While the Meteor Crater\* impact event was too small to cause global environmental effects, its regional damage would have been significant.

**EFFECTS MAP**


**MEGAFUNA OF THE COLORADO PLATEAU**

Reconstructing the environment at the time of the impact is important to understanding the context of the devastation. Palynological (fossil pollen) and paleontological studies have provided a partial record of the paleoenvironment including the flora (vegetation) and fauna (animals) that lived in the region ~50,000 years ago.

**BACK TO CRATERING ENVIRO EFFECTS**

The current data suggests that a juniper-pinyon woodland or forest covered the gently rolling countryside. Large mammals such as [mammoths](#), [large ground sloths](#), [bison](#), [camels](#), tapirs and horses may have lived in the vicinity and been victims of the 20 to 40 megaton blast.

**LINKS**



# Other “astronomical” poems of Frost’s

- The Literate Farmer and the Planet Venus
- A Star in a Stone-boat
- Canis Major
- I Will Sing You One-O
- Lost in Heaven
- Skeptic
- The Freedom of the Moon
- The Star-Splitter
- Two Leading Lights

**In 2022** a moderate traditional maximum is expected. At 16<sup>h</sup> UT 17 November activity will rise to 10–15 meteors on the ZHR scale. Also, a strong outburst from the 1733 trail is possible. At 06<sup>h</sup> UT 19 November activity can reach 250–300 meteors on the ZHR scale and brightness will be much higher than the average level. Another small enhancement to 5–10 meteors on the ZHR can occur at 15<sup>h</sup> UT 21 November due to the 1800 trail. Meteor brightness will be again much higher than average level.

**In 2023** a moderate traditional maximum is expected.