

# The Heliophysics Big Year

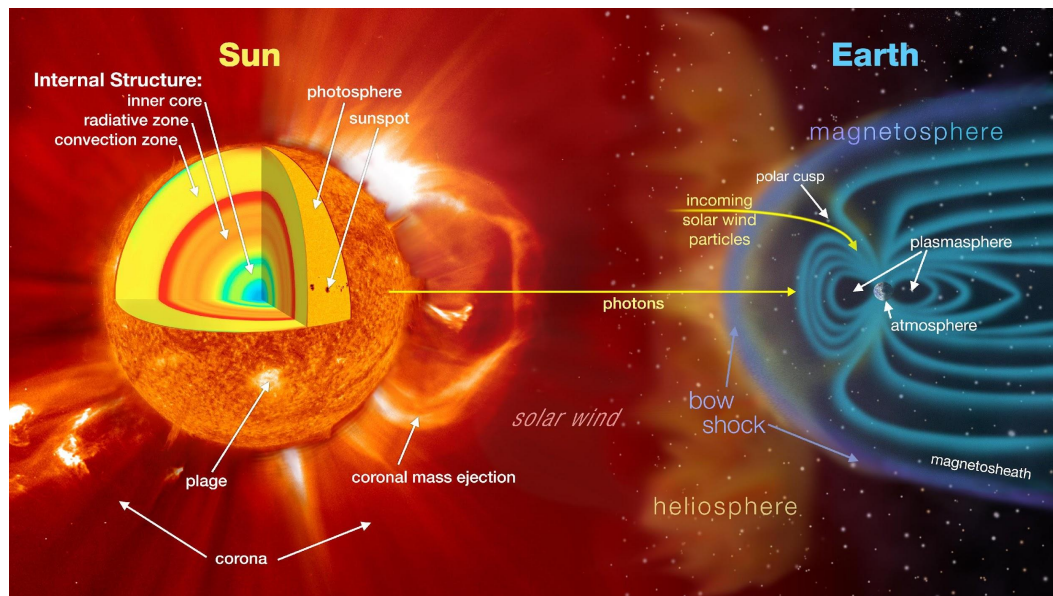
Dr. Sten Odenwald, Astronomer



# October 2024: What is Heliophysics?

Heliophysics is the discipline in space science that deals with the matter and energy of our Sun and its effects on the solar system.

It also studies how the Sun varies over time and how those changes can sometimes pose a hazard to humans on Earth and in space.



# Heliophysics Big Year Timeline

**Annular Eclipse**

October 14, 2023



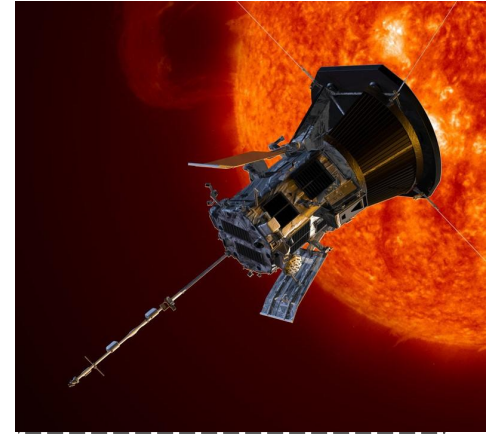
**Total Eclipse**

April 8, 2024



**Solar Parker  
Probe Perihelion**

December 24, 2024



# Heliophysics Big Year Themes

## 2023

- ✓ **October**- Annular Solar Eclipse
- ✓ **November**- Mission Fleet
- ✓ **December**- Citizen Science

## 2024

- ✓ **January**- Sun Touches Everything
- ✓ **February**- Fashion
- ✓ **March**- Experiencing the Sun
- ✓ **April**- Total Solar Eclipse
- ✓ **May**- Visual Art
- ✓ **June**- Performance Art

✓ **July**- Physical and Mental Health

✓ **August**- Back to School

✓ **September**- Environment

**October – Solar Cycles**

**November**- Bonus Science

**December**- Parker's Perihelion

<https://www.nasa.gov/science-research/heliophysics/nasa-announces-monthly-themes-to-celebrate-the-heliophysics-big-year/>

# October 2024 : NASA's Big Questions

1. What causes the Sun to vary?
2. How do the Earth and the heliosphere respond?
3. What are the impacts on humanity?

These Big Questions form the basis for the

## **Framework for Heliophysics Education**

<https://science.nasa.gov/learn/heat/big-ideas/>

# How to Teach Heliophysics

## Framework for Heliophysics Education

3 Heliophysics  
Investigatory Questions



3 NGSS-aligned  
Big Ideas per Question



3 Guiding Questions per  
Idea  
-1 Question per Level-



Heliophysics  
Resource Database

### 1. What causes the Sun to vary?

1.1 The Sun is really big and its gravity influences all objects in the solar system. (PS2, ESS1)

1.2 The Sun is active and can impact technology on Earth via space weather. (PS1, PS2, PS4, ESS2, ESS3)

1.3 The Sun's energy drives Earth's climate, but the climate is in a delicate balance and is changing due to human activity. (PS1, PS2, PS3, LS4, ESS2, ESS3)

### 1. How do Earth, the solar system, and the heliosphere respond to changes on the Sun?

2.1 Life on Earth has evolved with complex diversity because of our location near the Sun. It is just right! (PS3, PS4, LS1, LS2, ESS2)

2.2 **The Sun defines the space around it, which is different from interstellar space. (PS2, ESS1, ESS2)**

2.3 The Sun is the primary source of light in the solar system. (PS1, PS2, PS3, PS4, ESS1)

### 1. What are the impacts of changes on the Sun on humans?

**3.1 The Sun is made of churning plasma, causing the surface to be made of complex, tangled magnetic fields. (PS1, PS2, ESS1, ESS2)**

3.2 Energy from the Sun is created in the core and travels outward through the Sun and into the heliosphere. (PS1, PS3, PS4, ESS1, ESS2, ESS3)

3.3 Our Sun, like all stars, has a life cycle. (PS1, LS1, ESS1)

# October 2024: Solar Cycles

We are now at ‘sunspot maximum’ when the sun is at its stormiest and aurora borealis light up the skies every few months.

This is not a random process, but follows an 11-year cadence called the sunspot cycle.

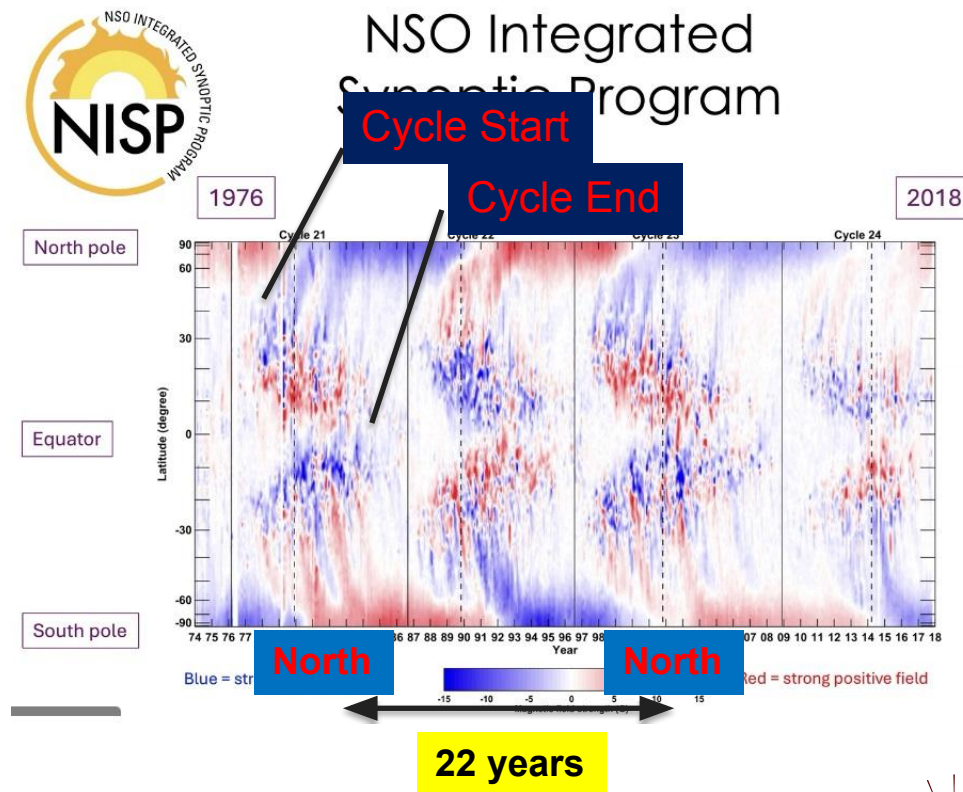


October 10-12, 2024 Aurora

# October 2024: Solar Cycles

Sunspots appear in the northernmost latitudes of the sun at the start of each cycle, and form at lower latitudes as the cycle progresses.

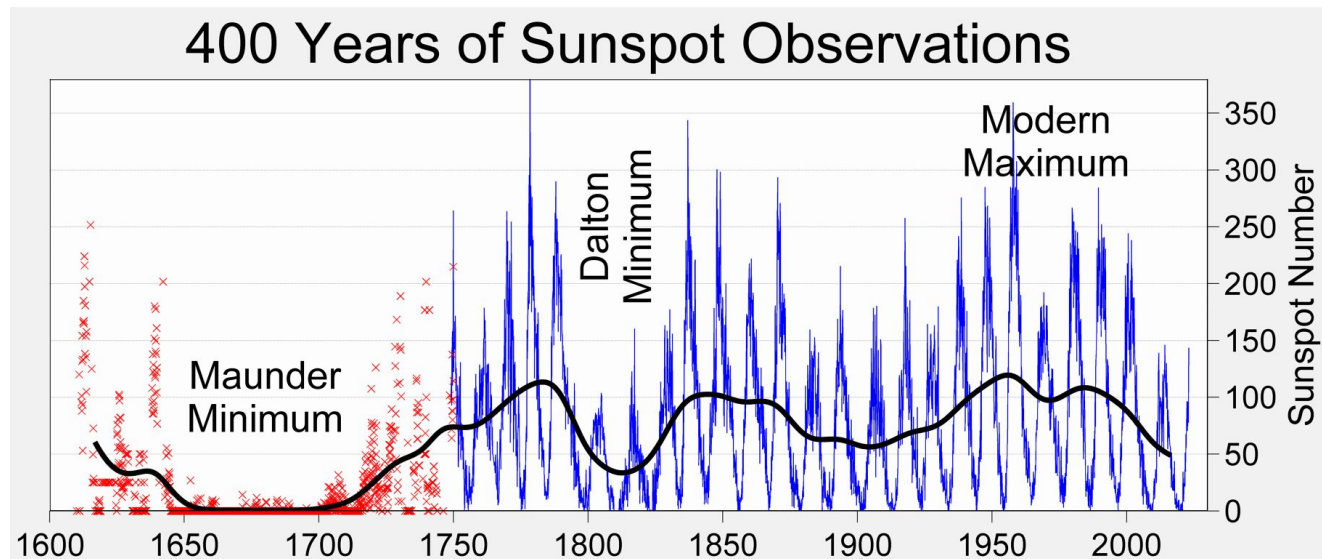
The global magnetic field of the sun reverses polarity every cycle, so that after two cycles (22-years) it has returned to its original polarity in each hemisphere. This is called the Hale Magnetic Cycle.





# October 2024: Solar Cycles

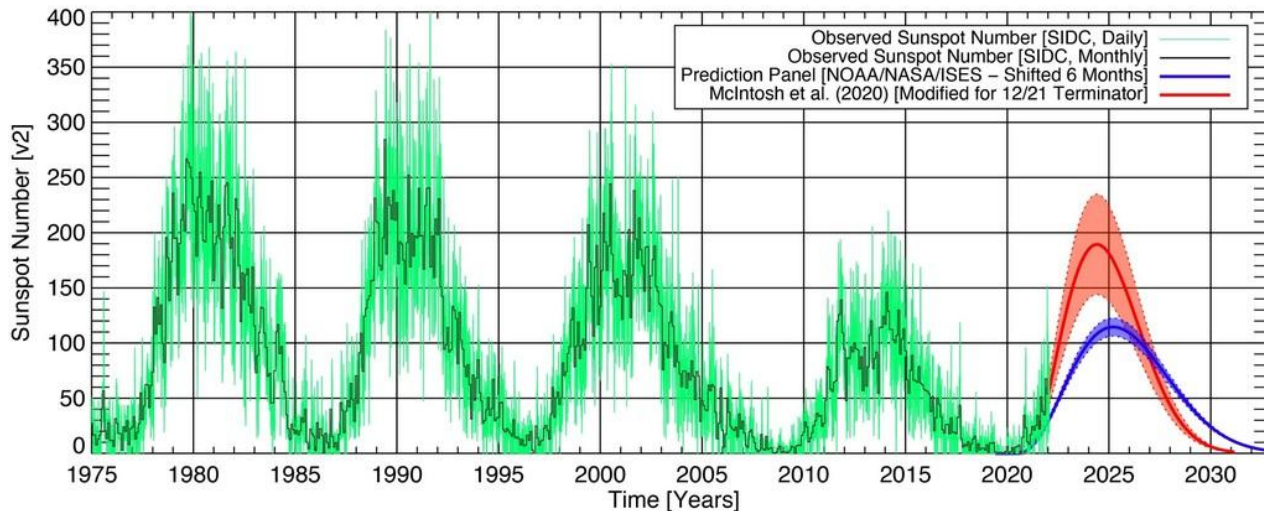
The most famous solar cycle is due to the rise and fall of the number of sunspots on its surface, first discovered in the early-1800s.



Wikipedia: Robert A. Rohde - the Global Warming Art project.

# October 2024:

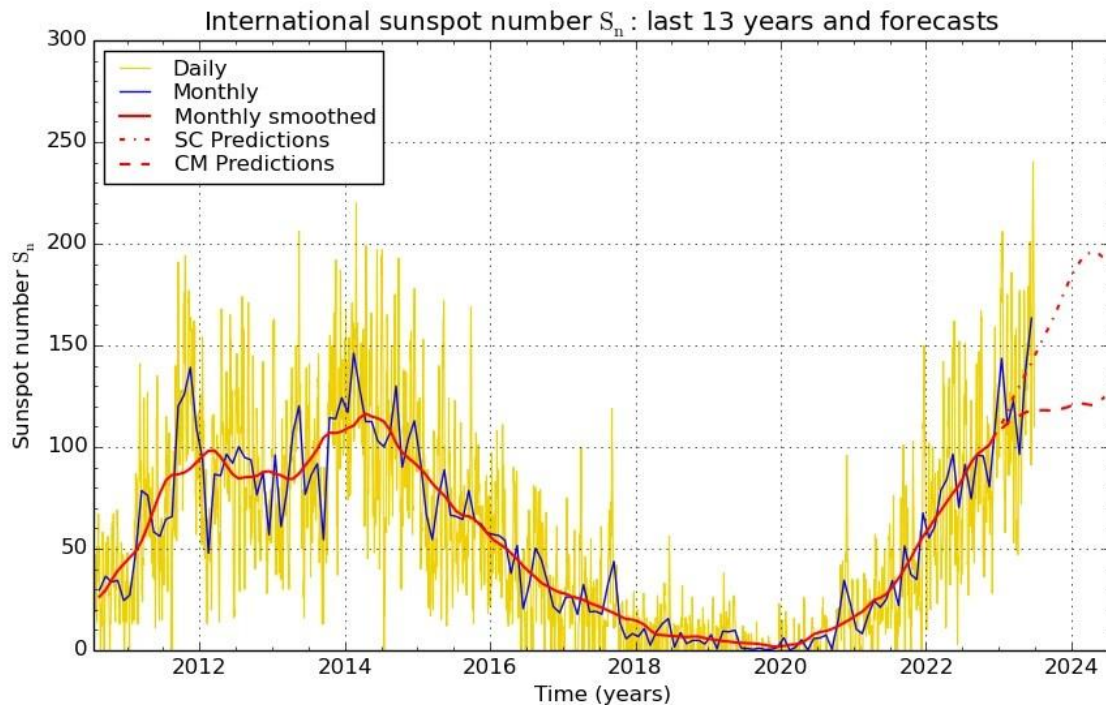
The last few cycles are likely ones that you might have recalled from news reports.



McIntosh, 2020: <https://swling.com/blog/tag/solar-cycle-25/>

# October 2024:

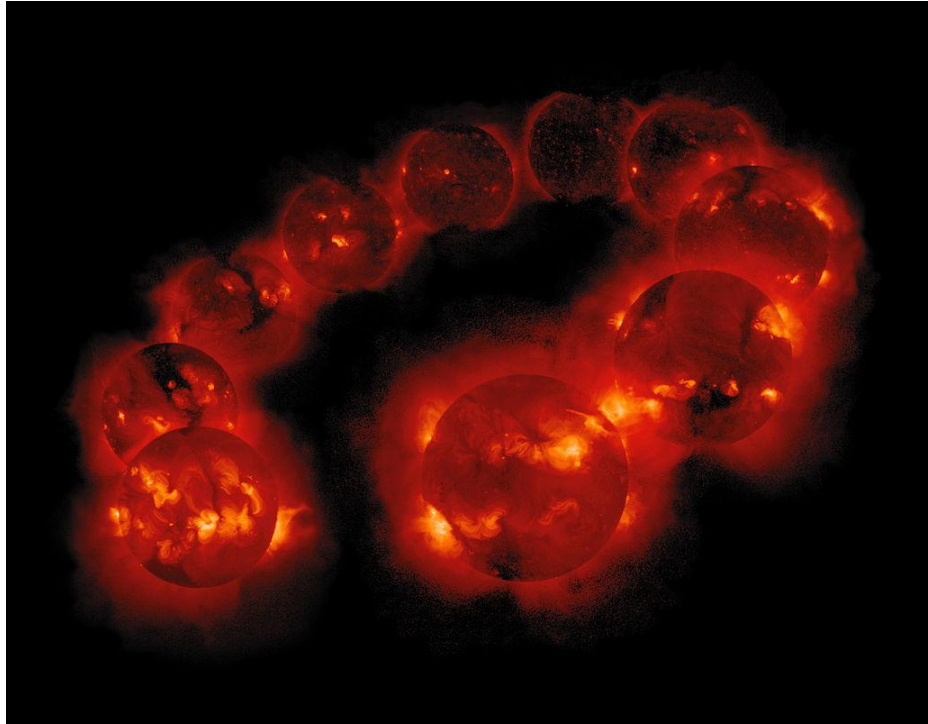
The current  
NOAA prediction  
for Cycle 25 looks  
like this:



SILSO graphics (<http://sidc.be/silso>) Royal Observatory of Belgium 2023 July 1

# October 2024:

Keeping track of solar storminess protects us from unexpected satellite and power grid damage, along with astronaut health issues.



David Chenette, Yohkoh/Lockheed Martin.

# October 2024: Beginning – The next sunspot cycles

Assume the sunspot cycles obey the following rules:

Period = 11 years.

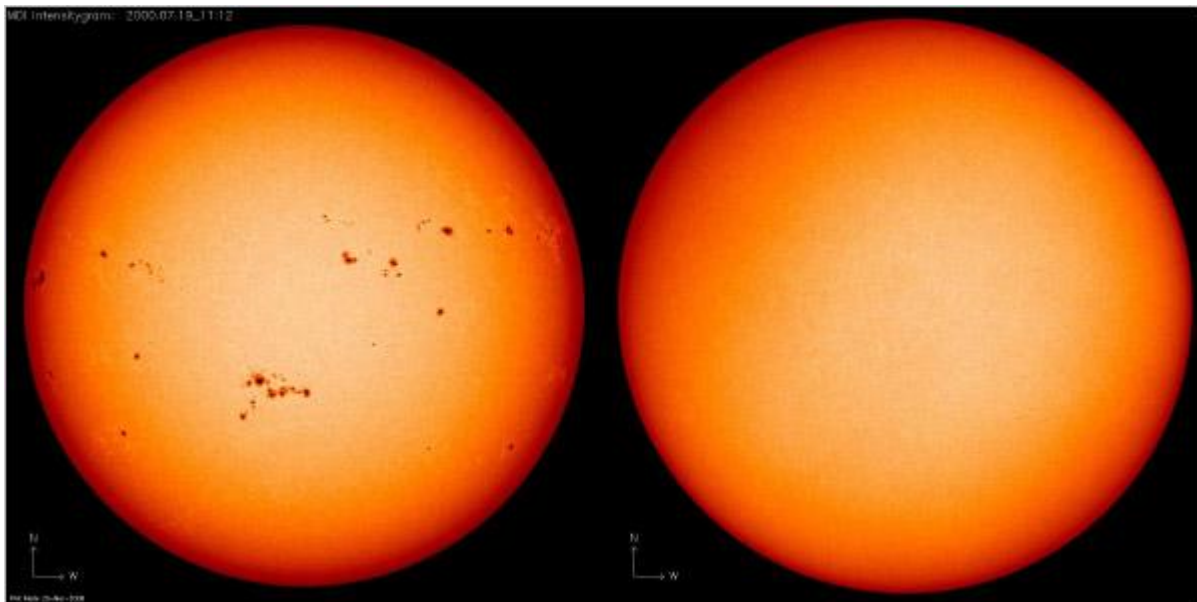
Maximum = July 2024.

Minimum = January 2020.

Height = ??????

When will the next 3 sunspot cycles occur?

Tabulate and plot. Assume all peaks have equal heights to Cycle 25.



Credit: NASA

# October 2024: Beginning – The next sunspot cycles

Assume the sunspot cycles obey the following rules:

Period = 11 years.

Maximum = July 2024.

Minimum = January 2020.

Height = ?????

When will the next 3 sunspot cycles occur?

Tabulate and plot.

**Assume all peaks have equal heights to Cycle 25.**

Cycle 25: Maximum: July 2024 = 2024.6  
Minimum: January 2020 = 2020.1

Cycle 26: Maximum =  $2024.6 + 11 = 2035.6$   
Minimum =  $2020.1 + 11 = 2031.1$

Cycle 27: Maximum = 2046.6      Minimum = 2042.1

Cycle 28: Maximum = 2057.6      Minimum = 2053.1

# October 2024: Beginning – The next sunspot cycles

Assume the sunspot cycles obey the following rules:

Period = 11 years.

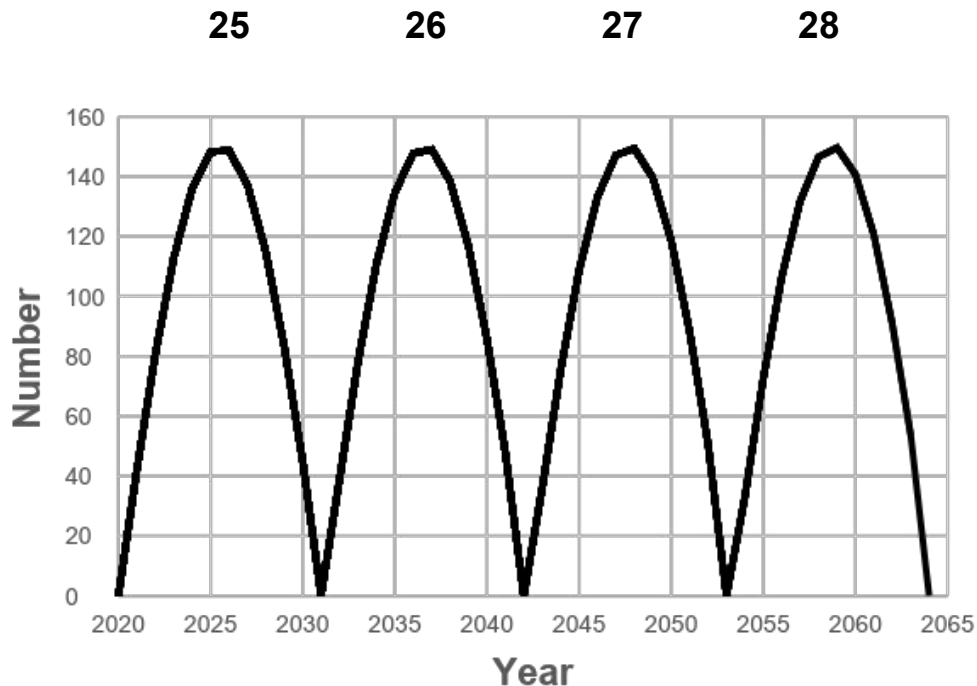
Maximum = July 2024.

Minimum = January 2020.

When will the next 3 sunspot cycles occur?

Tabulate and plot.

If you live 80 years, what is the most distant sunspot cycle you will hear about?

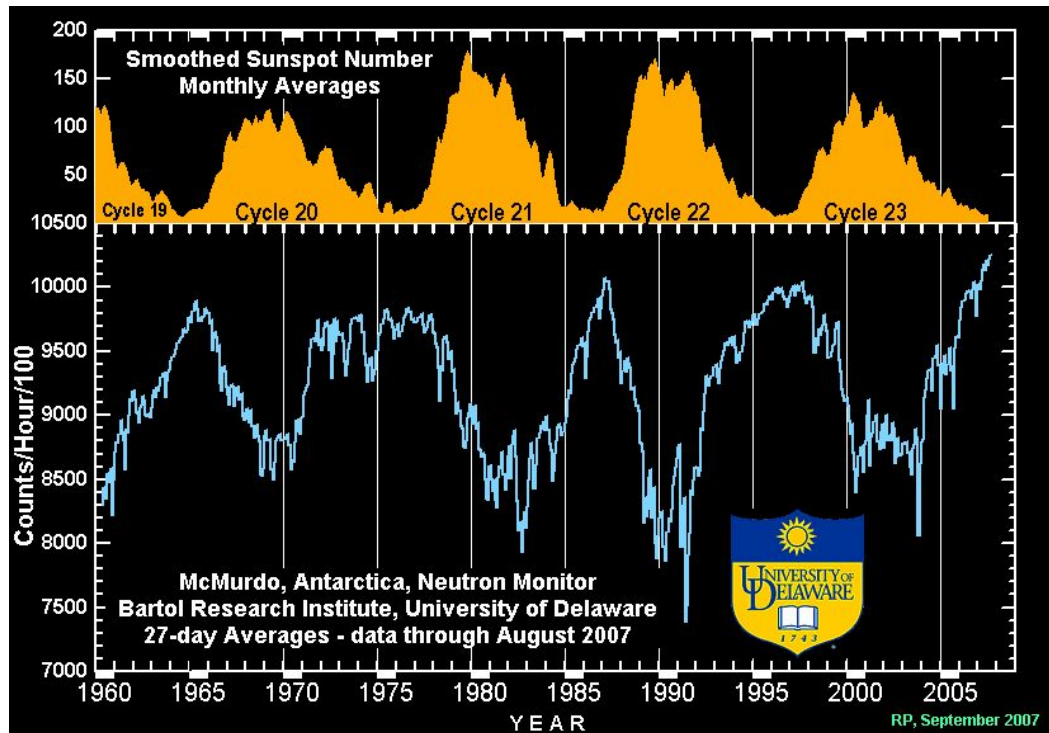




# October 2024: Intermediate – The Cosmic Ray Cycle

Cosmic rays are blocked when our sun's magnetic field is at maximum during sunspot maximum.

They can enter the inner solar system when the sun's field is more concentrated near the solar surface at sunspot minimum.





# October 2024: Intermediate – The Cosmic Ray Cycle

Math 2: Draw a second curve on top of the sunspot cycle curve that shows the next three cosmic ray cycles.

Assume

Minimum = July 2024.7

Maximum = June 2020.1

Maximum height = 150 units.

Cycle 25: Minimum: July 2024 = 2024.6  
Maximum: January 2020 = 2020.1

Cycle 26: Minimum =  $2024.6 + 11 = 2035.6$   
Maximum =  $2020.1 + 11 = 2031.1$

Cycle 27: Minimum = 2046.6    Maximum = 2042.1

Cycle 28: Minimum = 2057.6    Maximum = 2053.1

# October 2024: Intermediate – The Cosmic Ray Cycle

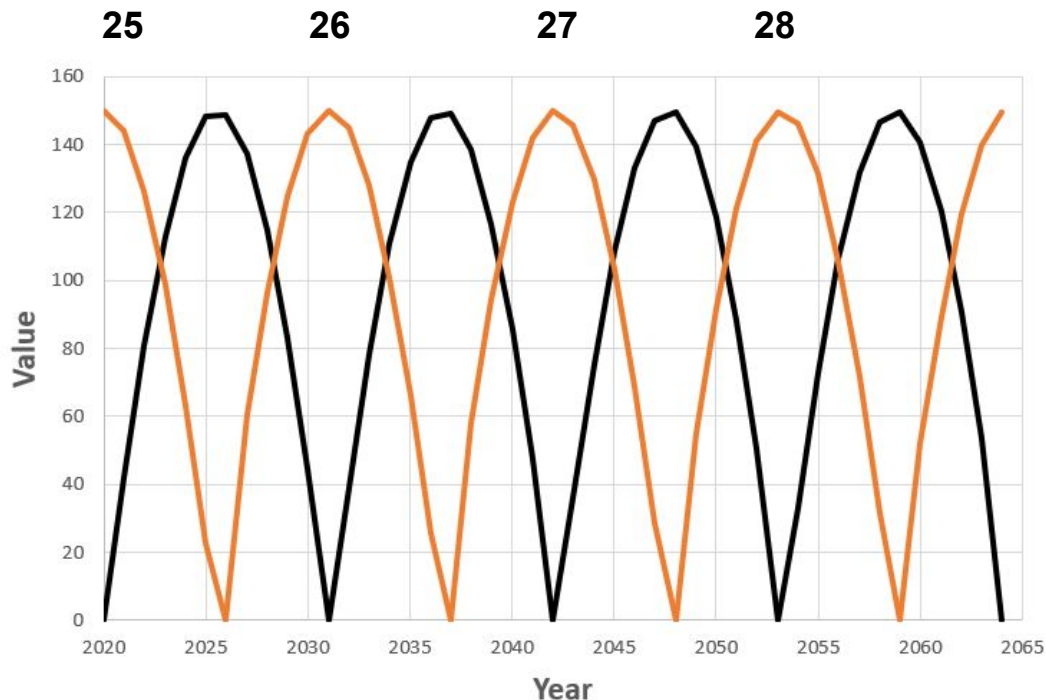
Draw a second curve on top of the sunspot cycle curve that shows the next three cosmic ray cycles.

Assume

Minimum = July 2024.7

Maximum = June 2020.1

Maximum height = 150 units.



# October 2024 – Advanced – The Journey to Mars

When are the best times to go?

Opposition dates come every 770 days (2.1 years)

Next opposition is in January 2025.

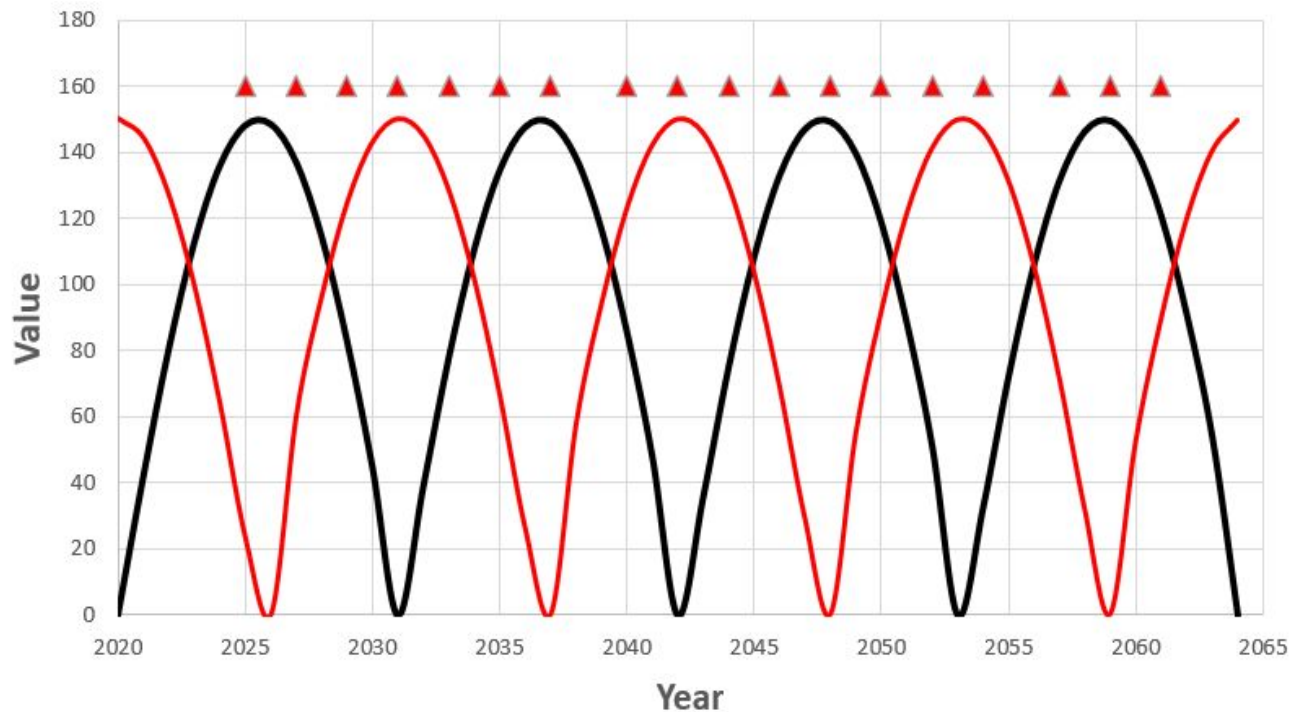
Use the table and show these opposition years on the sunspot and cosmic ray cycle plot.

Opposition Date(UT)	Ls <sub>o</sub>	Dec <sub>o</sub>	Dia. <sub>v</sub>	Closest Approach (UT)	Dec <sub>o</sub>	Dia. <sub>v</sub>	Distance A.U.
2025 Jan 16 (0232)	30.9	+25.1	14.6	2025 Jan 12 (1338)	+24.8	14.6	0.64228
2027 Feb 19 (1545)	65.4	+15.4	13.8	2027 Feb 20 (0014)	+15.4	13.8	0.67792
2029 Mar 25 (0743)	99.5	+1.1	14.4	2029 Mar 29 (1256)	+1.6	14.5	0.64722
2031 May 04 (1157)	138.4	-15.5	16.7	2029 May 12 (0350)	-15.0	16.9	0.55336
2033 Jun 27 (0124)	190.7	-27.8	21.8	2033 Jul 05 (1119)	-28.3	22.1	0.42312
2035 Sep 15 (1933)	267.3	-0.0	24.5	2035 Sep 11 (1421)	-7.7	24.6	0.38041
2037 Nov 19 (0904)	331.9	+20.3	18.7	2037 Nov 11 (0800)	+20.5	19.0	0.49358
2040 Jan 02 (1521)	16.3	+26.7	15.3	2039 Dec 28 (1447)	+26.3	15.3	0.61092
2042 Feb 06 (1159)	52.3	+19.8	13.9	2042 Feb 05 (0757)	+19.7	13.9	0.67174
2044 Mar 11 (1244)	86.0	+6.9	14.0	2044 Mar 14 (0607)	+7.3	14.0	0.66708
2046 Apr 17 (1801)	122.3	-9.0	15.6	2046 Apr 24 (0433)	-8.3	15.7	0.59704
2048 Jun 03 (1445)	168.1	-24.7	19.5	2048 Jun 12 (0141)	-24.8	19.8	0.47366
2050 Aug 14 (0746)	236.1	-20.7	25.0	2050 Aug 15 (1255)	-20.8	25.0	0.37405
2052 Oct 28 (0628)	309.9	+12.0	13.9	2052 Oct 20 (0512)	+12.4	21.2	0.44103
2054 Dec 17 (2209)	0.5	+26.3	14.0	2054 Dec 11 (1144)	+26.2	16.4	0.57032
2057 Jan 24 (0126)	38.3	+23.2	15.6	2057 Jan 01 (0903)	+23.2	14.3	0.65552
2059 Feb 27 (0525)	72.8	+12.3	19.5	2059 Feb 28 (1032)	+12.5	13.8	0.67681
2061 Apr 02 (1247)	107.5	-2.6	25.0	2061 Apr 07 (1354)	-2.0	14.8	0.63109



# October 2024 –Advanced – The Journey to Mars

When might be the best times to travel?

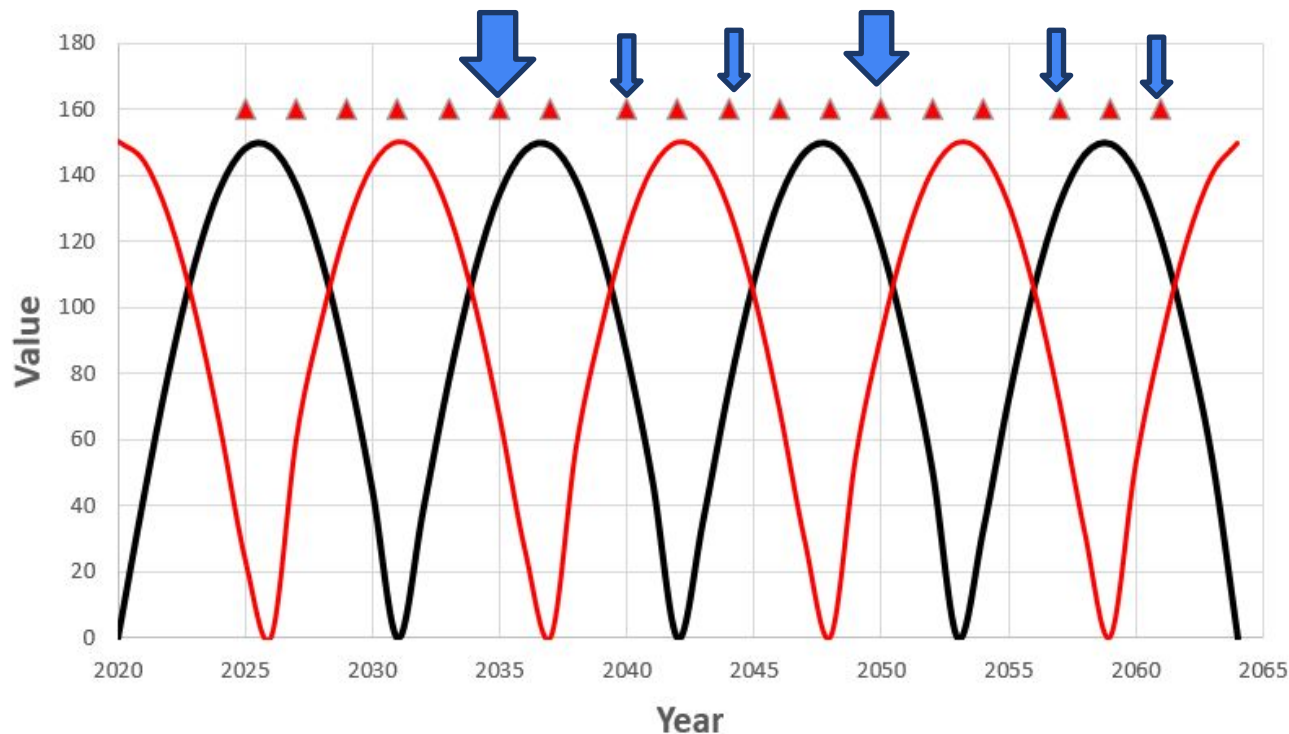


# October 2024 –Advanced – The Journey to Mars

When might be the best times to travel?

There might not be any right answer but each opposition has its advantages and disadvantages.

Here's one set of possibilities. The long arrows are when the opposition distances are at their minimum for the 21<sup>st</sup> century.

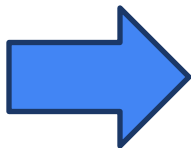


Red = solar flares    Black = cosmic rays

# October 2024 – Ask ChatGPT

**Query:** Between now and 2065, given the sunspot cycles, **the cosmic ray cycles**, and mars opposition distances, when would be the best years for astronauts to travel to Mars?

ChatGPT did  
NOT  
factor in cosmic  
rays



To find optimal years, you need to align these factors:

**Mars Oppositions:** The best years for missions to Mars will be when Mars is at opposition. Some upcoming oppositions are in 2025, 2027, 2033, 2035, 2040, 2042, 2048, 2050, 2056, and 2058.

**Sunspot Cycles:** To minimize sunspot activity, you would prefer to launch during or near solar minimum phases. The next solar minima are expected around the early 2020s, mid-2030s, mid-2040s, early 2050s, and late 2060s.

Based on these factors, **2027, 2033, 2040, 2048, and 2056** would be some of the best years to send missions to Mars. Each of these years balances proximity to Mars with minimized exposure to solar and **cosmic radiation**.



# November 2024 – Bonus Science!

Next Time!

*Unexpected  
discoveries!*



Cover art for "Alien #1" from Marvel Comics. (Image credit: Marvel Comics)

# Slides and Recordings

Slides: <https://rb.gy/qsgmbr>

Previous webinar recordings

[https://www.youtube.com/watch?v=lwf8Y\\_fOOIs&list=PL5mpEj48YwXntxhPvZBgJn0ZG5MRm4UIS](https://www.youtube.com/watch?v=lwf8Y_fOOIs&list=PL5mpEj48YwXntxhPvZBgJn0ZG5MRm4UIS)