

Presentatie Space Weather en het Noorderlicht

Versie 2024-03-29

# Space Weather en het Noorderlicht

## Metius

Alkmaarse Weer- & Sterrenkundige Vereniging

2024-03-29



# Space Weather en het Noorderlicht

## Metius

Alkmaarse Weer- & Sterrenkundige Vereniging

2024-03-29

*Cees Ooms*















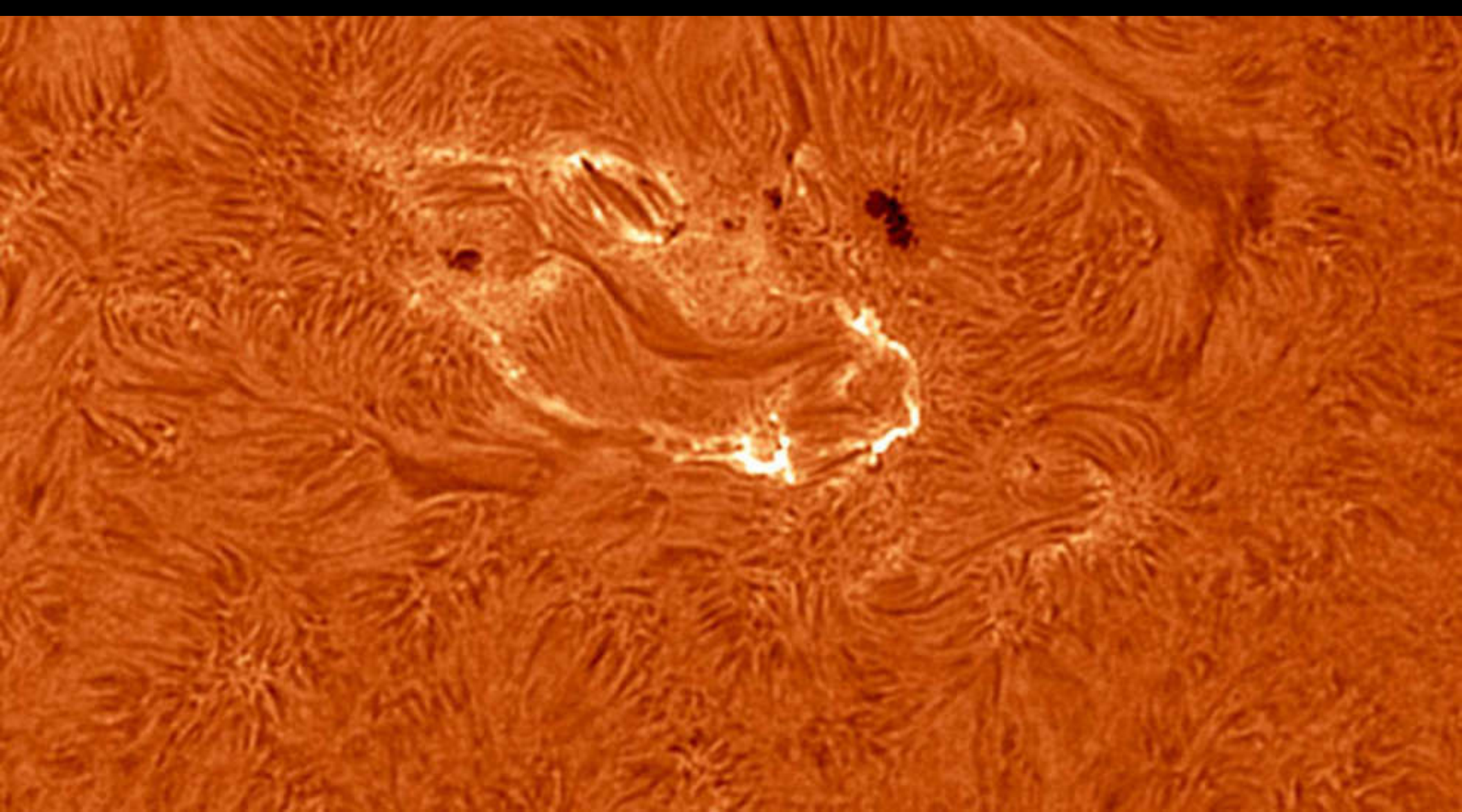


Noorderlicht op 200 km hoogte aan nachtkant aarde.  
Door geladen deeltjes van de zon?

# Ruimteweer *Space Weather*

- Processen in:
  - ARs (Active Regions) zon;
  - Magnetosfeer & atmosfeer aarde.
- *Geladen deeltjes van de zon veroorzaken Noorderlicht, maar botsen niet.....*
- Zon in H-alpha.



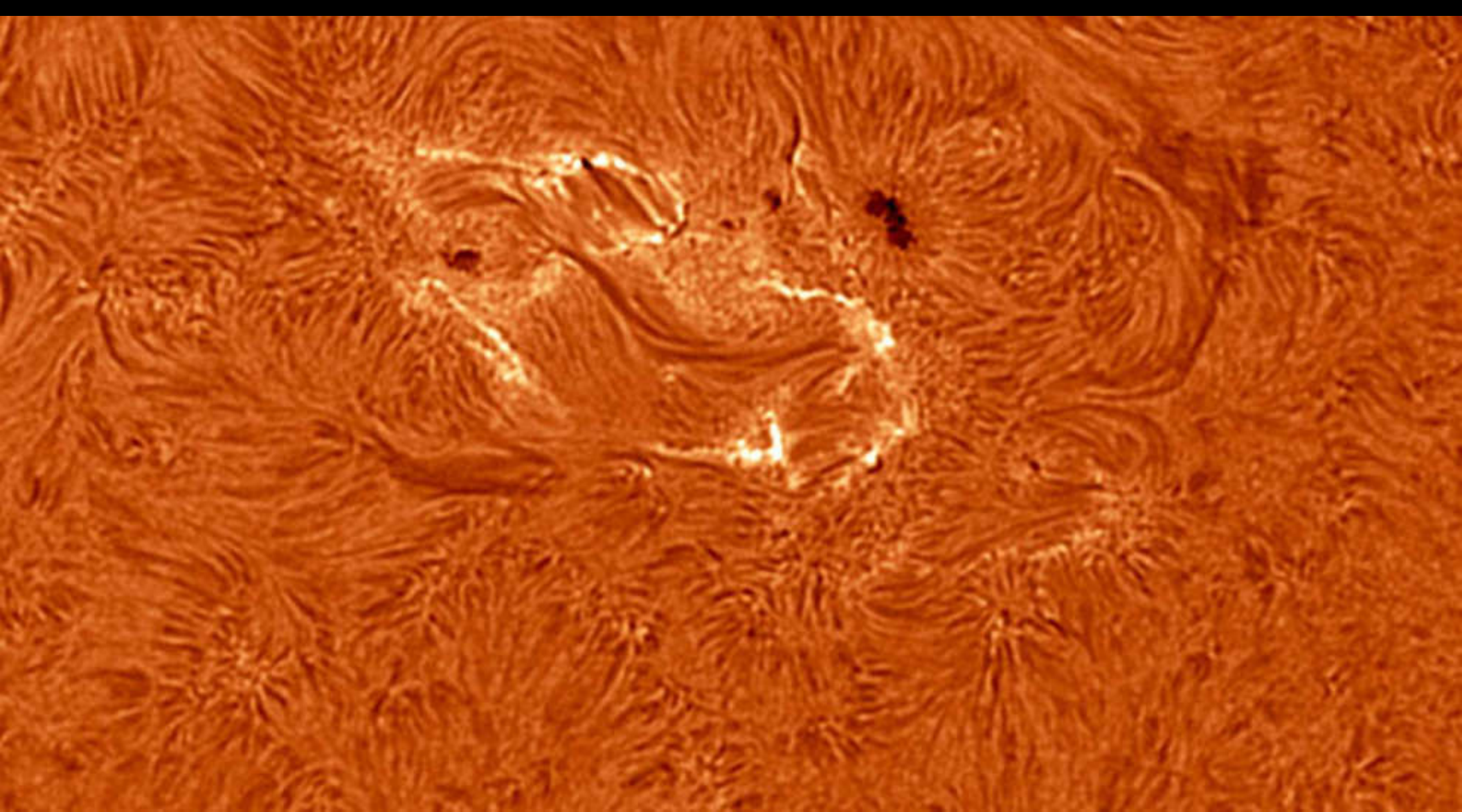


2023-06-24

Zon H-alpha

12:05 uur



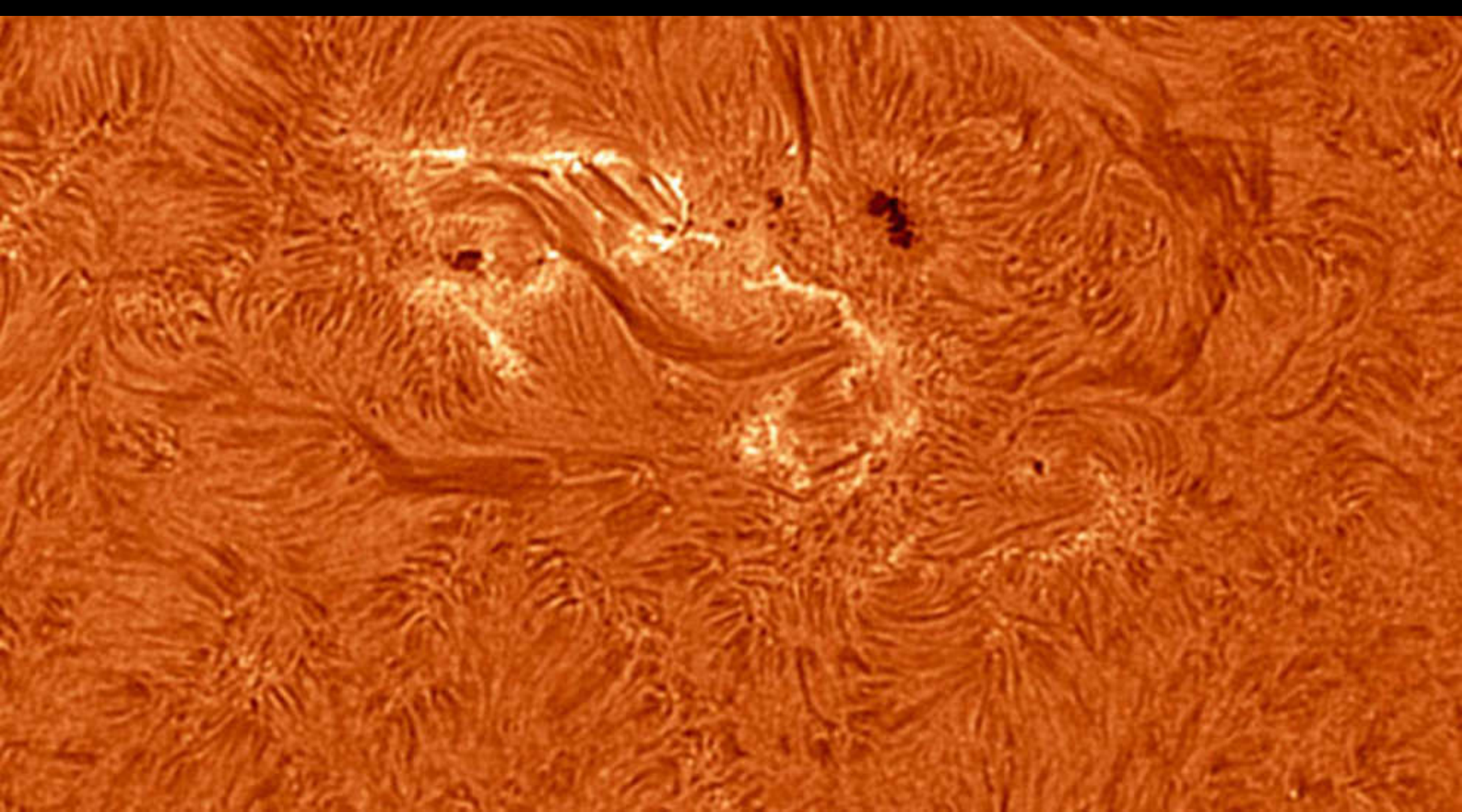


2023-06-24

Zon H-alpha

12:20 uur





2023-06-24

Zon H-alpha

12:35 uur

# Definitie

The term space weather generally refers to conditions on the sun, in the solar wind, and within Earth's magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health.

NASA - 2017-08-03



# AGENDA

## 1 Inleiding

Actueel ruimteweerbericht  
Space Weather onderdelen

## 2 Processen zon & aarde

Magnetische reconnectie  
Zon  
Aarde  
Werking Noorderlicht

## 3 Ruimteweerbericht

2023-10-15 voorbeeld 3-Day Forecast  
Noorderlicht voorspellen  
Noorderlicht NL 2023-02-27  
2022-10-09 ARs 3112 & 3116

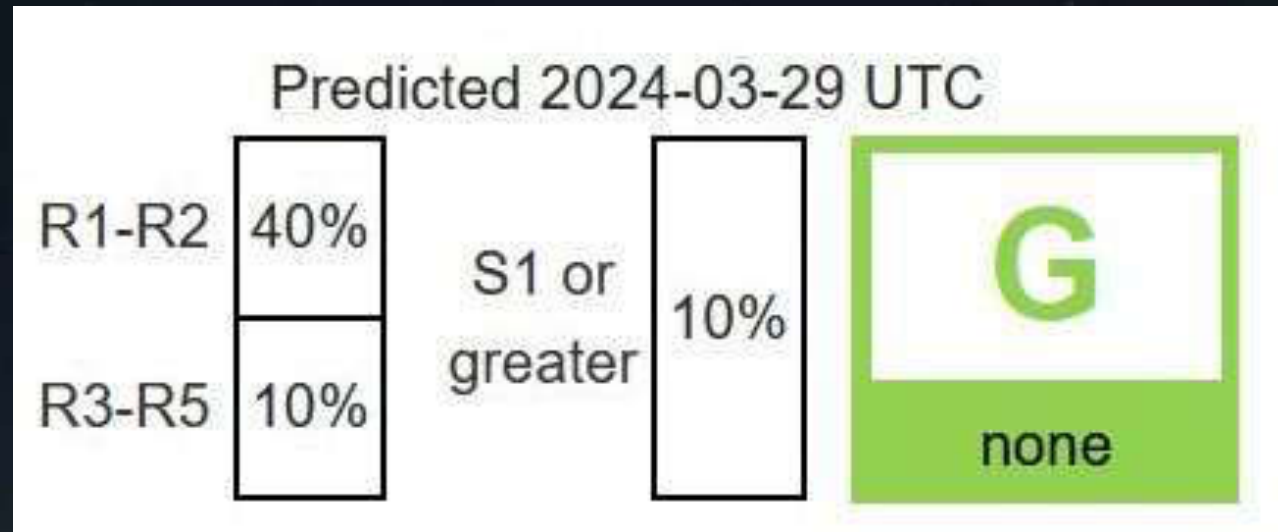


# 1 Inleiding

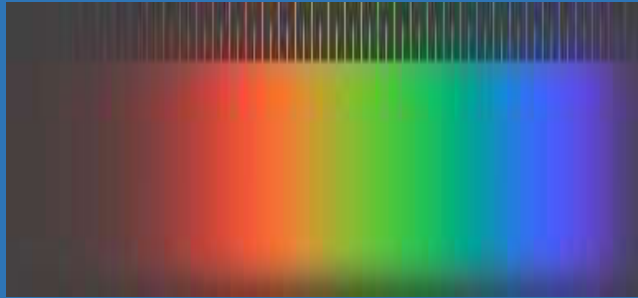
Ruimteweerbericht 2024-03-29



# Ruimteweerbericht 2024-03-29

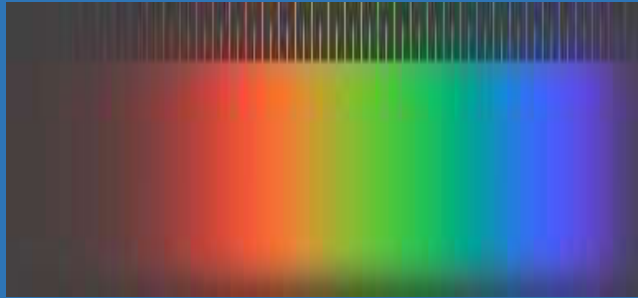


# Straling van de zon



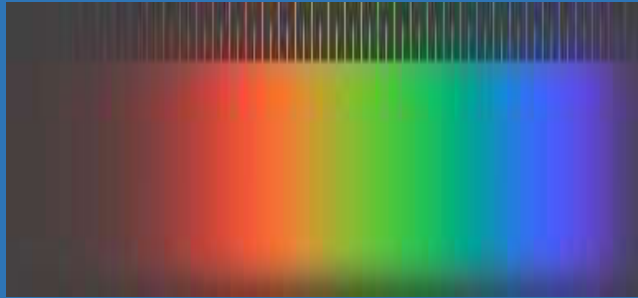
Radio IR Zichtbaar licht UV

# Straling van de zon



Radio IR Zichtbaar licht UV X-ray

# Straling van de zon

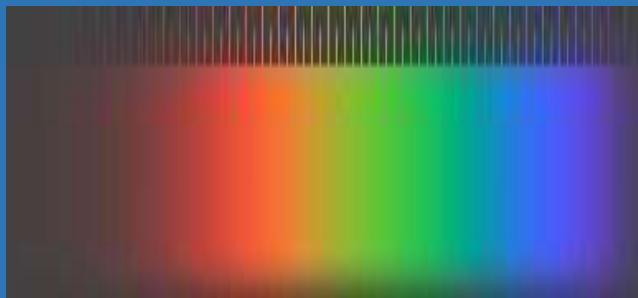


Radio IR Zichtbaar licht UV X-ray



R

# Straling van de zon



Radio

IR

Zichtbaar licht

UV

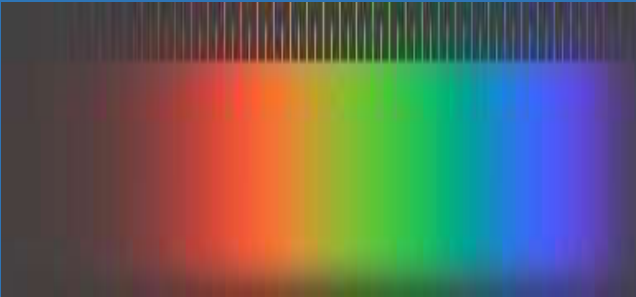
X-ray

SEPs



R

# Straling van de zon



Radio

IR

Zichtbaar licht

UV

X-ray

**SEPs**

*Solar  
Energized  
Particles*

50.000

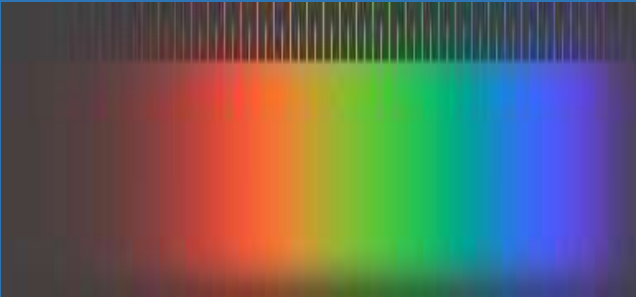
km/sec



R



# Straling van de zon



Radio

IR

Zichtbaar licht

UV

X-ray

**SEPs**

*Solar  
Energized  
Particles*

50.000

km/sec

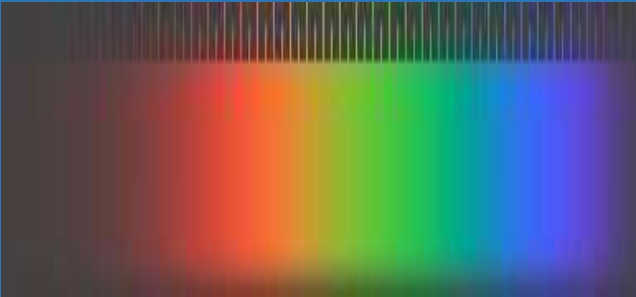


R



S

# Straling van de zon



Radio

IR

Zichtbaar licht

UV

X-ray

**SEPs**

**Zonnewind**

*Solar*

*Energized*

*Particles*

50.000

500 km/sec

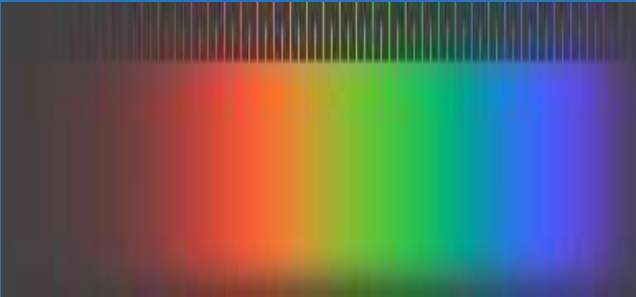


R



S

# Straling van de zon



Radio

IR

Zichtbaar licht

UV

X-ray

**SEPs**

**Zonnewind**

*Solar  
Energized  
Particles*

50.000

500 km/sec



R



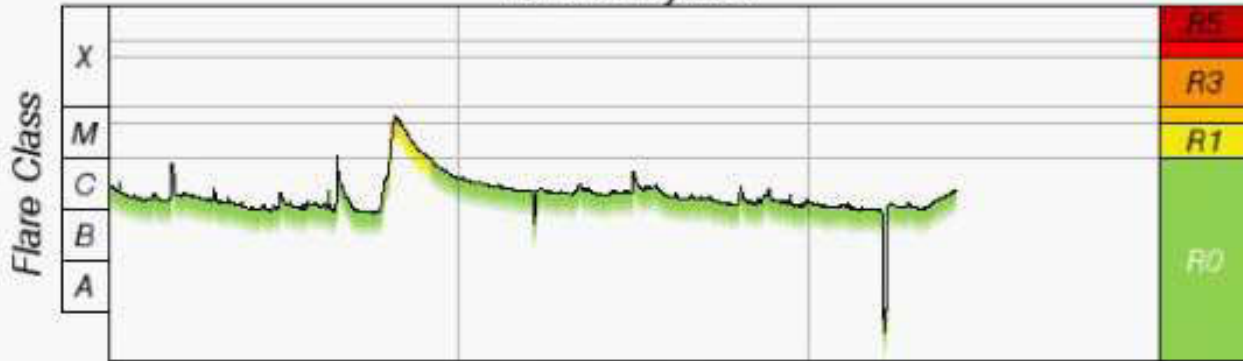
S



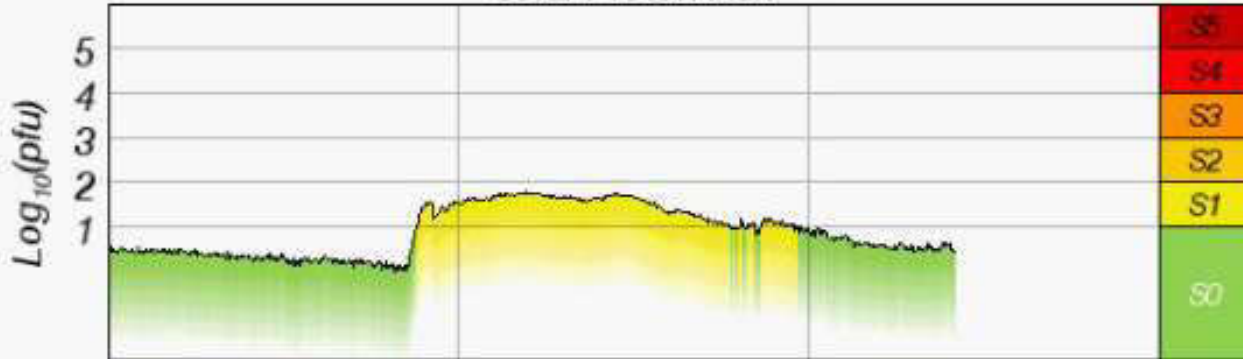
G

# SPACE WEATHER OVERVIEW

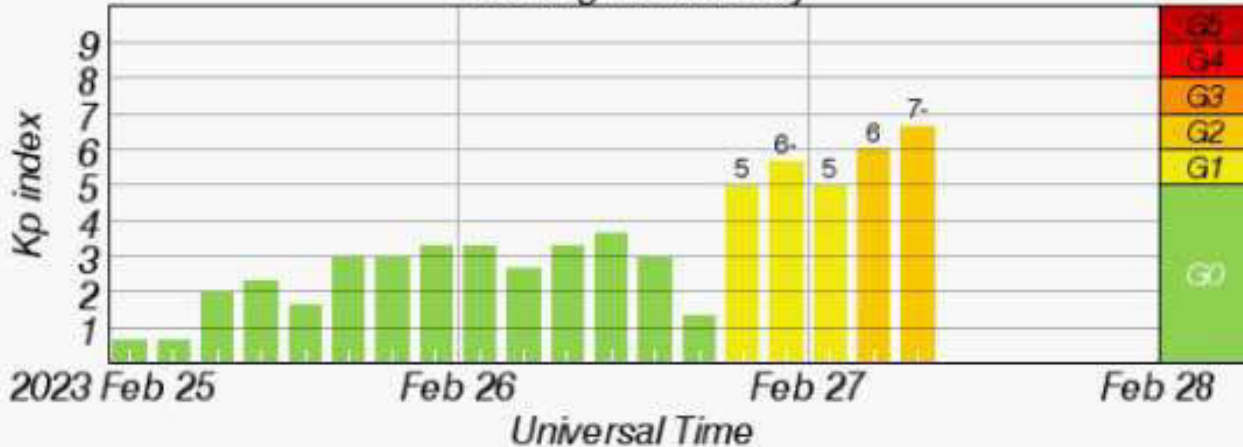
## Solar X-ray Flux



## Solar Proton Flux

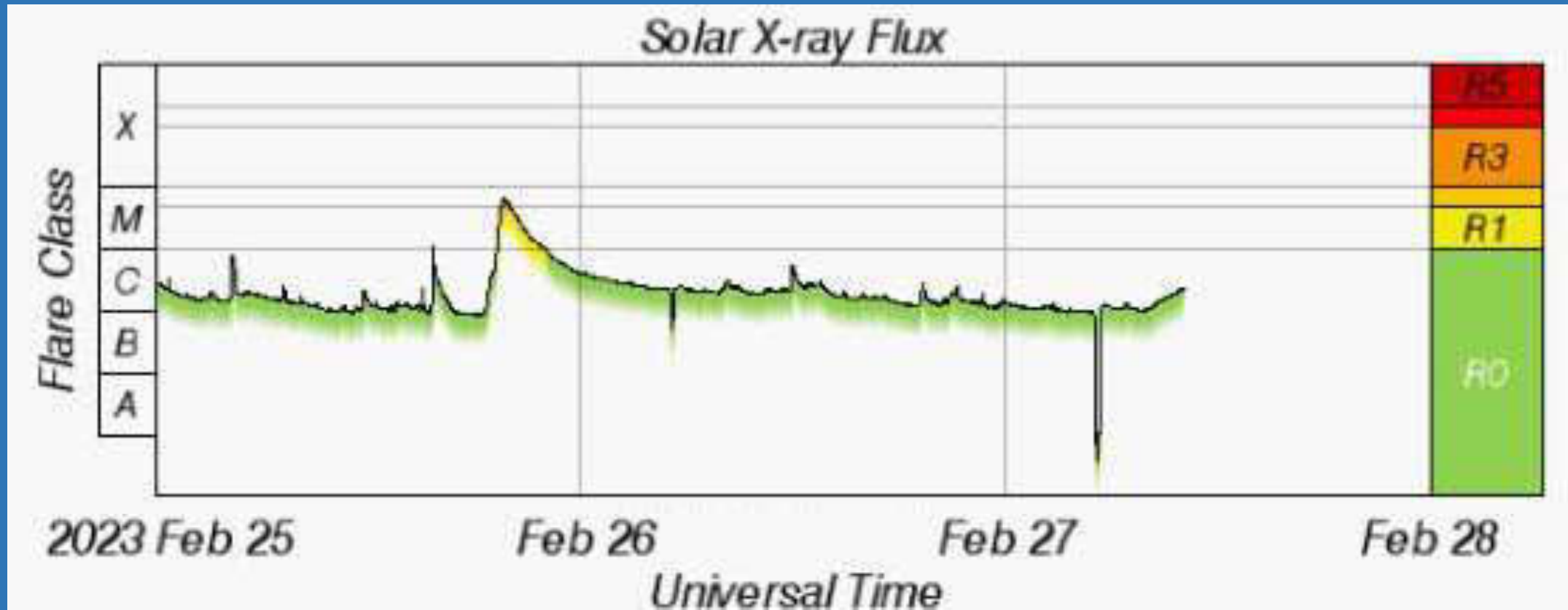


## Geomagnetic Activity



Ruimte weerbericht 2023-02-27

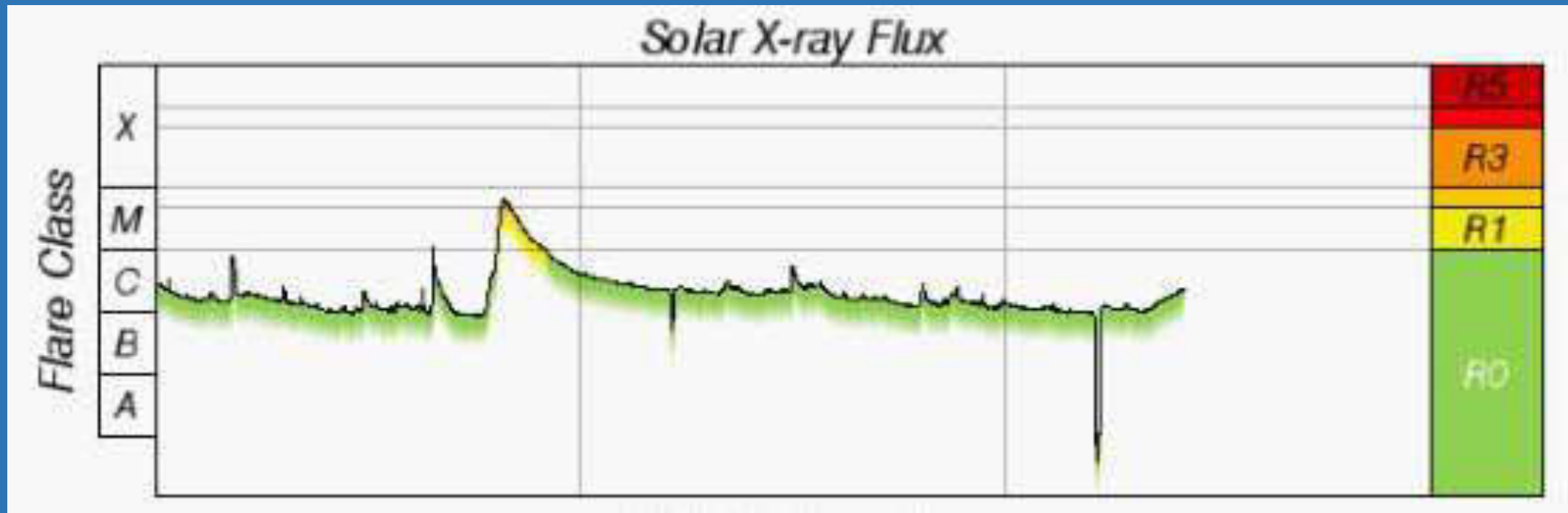
R



Atmosfeer aarde beschermt 100 %.

Hoog in de atmosfeer en in de ruimte: ionisatie.

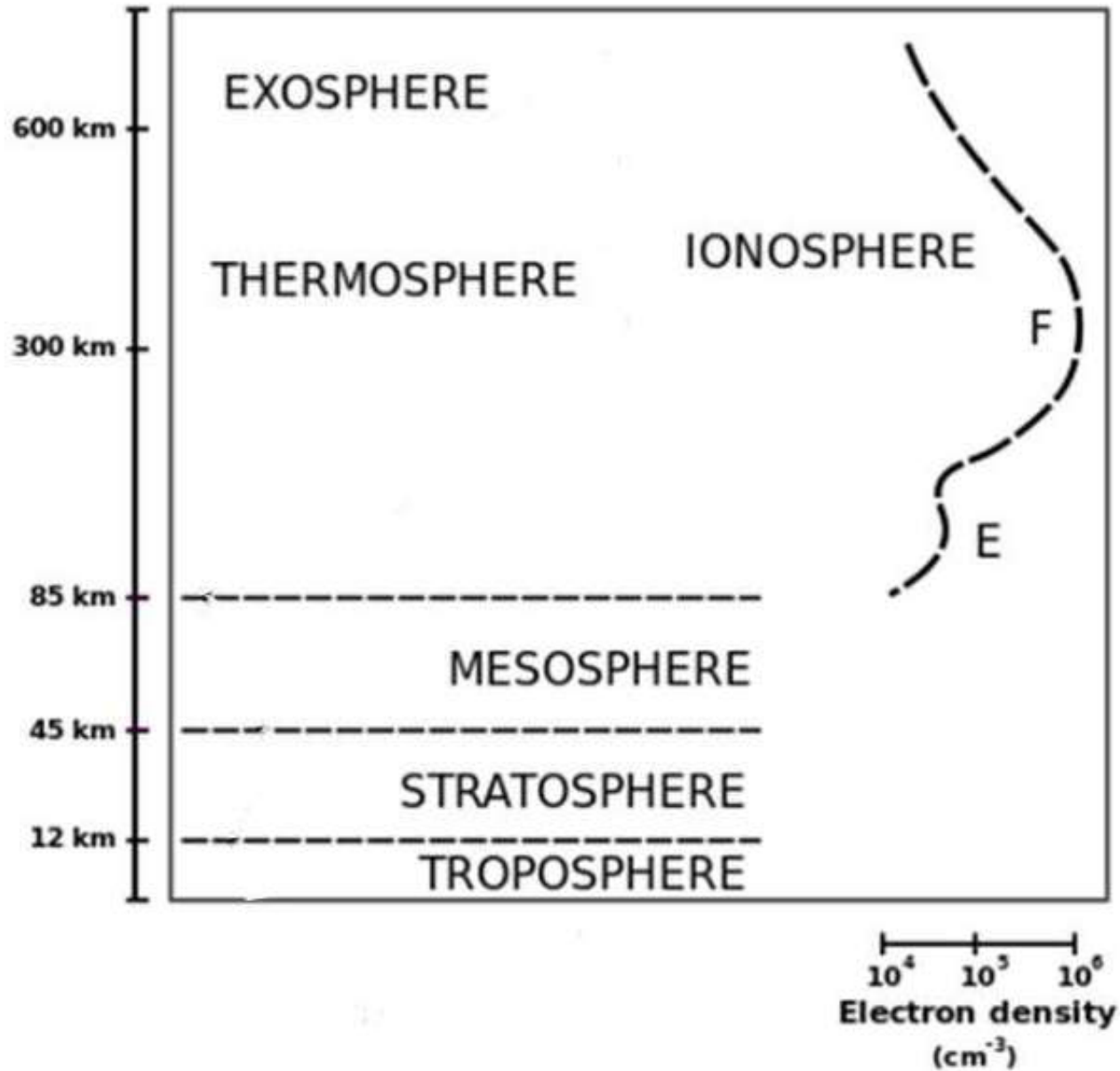
R



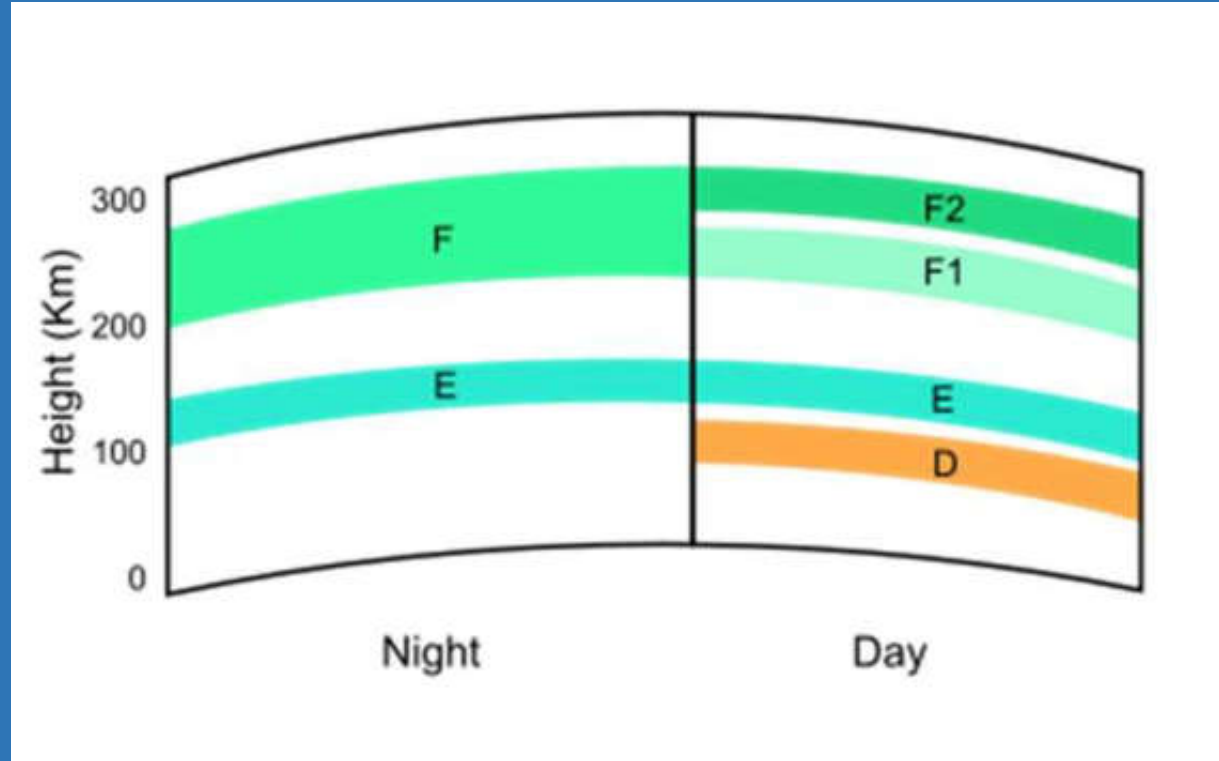
Max peak soft X-rays:

| X-Ray Flare | Severity Descriptor |
|-------------|---------------------|
| X20         | R5 Extreme          |
| X10         | R4 Severe           |
| X1          | R3 Strong           |
| M5          | R2 Moderate         |
| M1          | R1 Minor            |

R



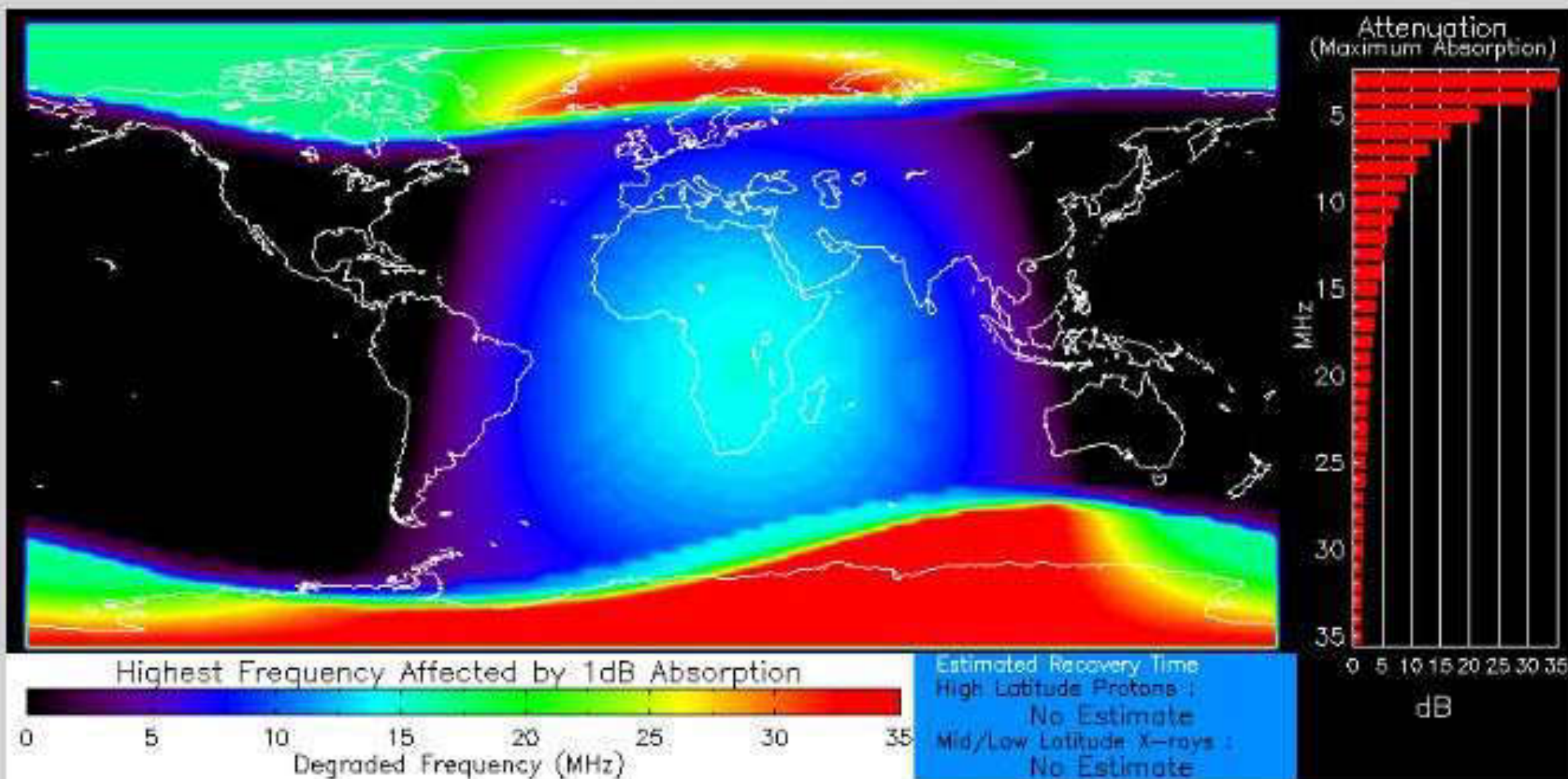
# Ionosfeer



D Region Absorption



# D REGION ABSORPTION PREDICTION



Elevated X-ray flux  
Product Valid At : 2023-02-27 10:15 UTC

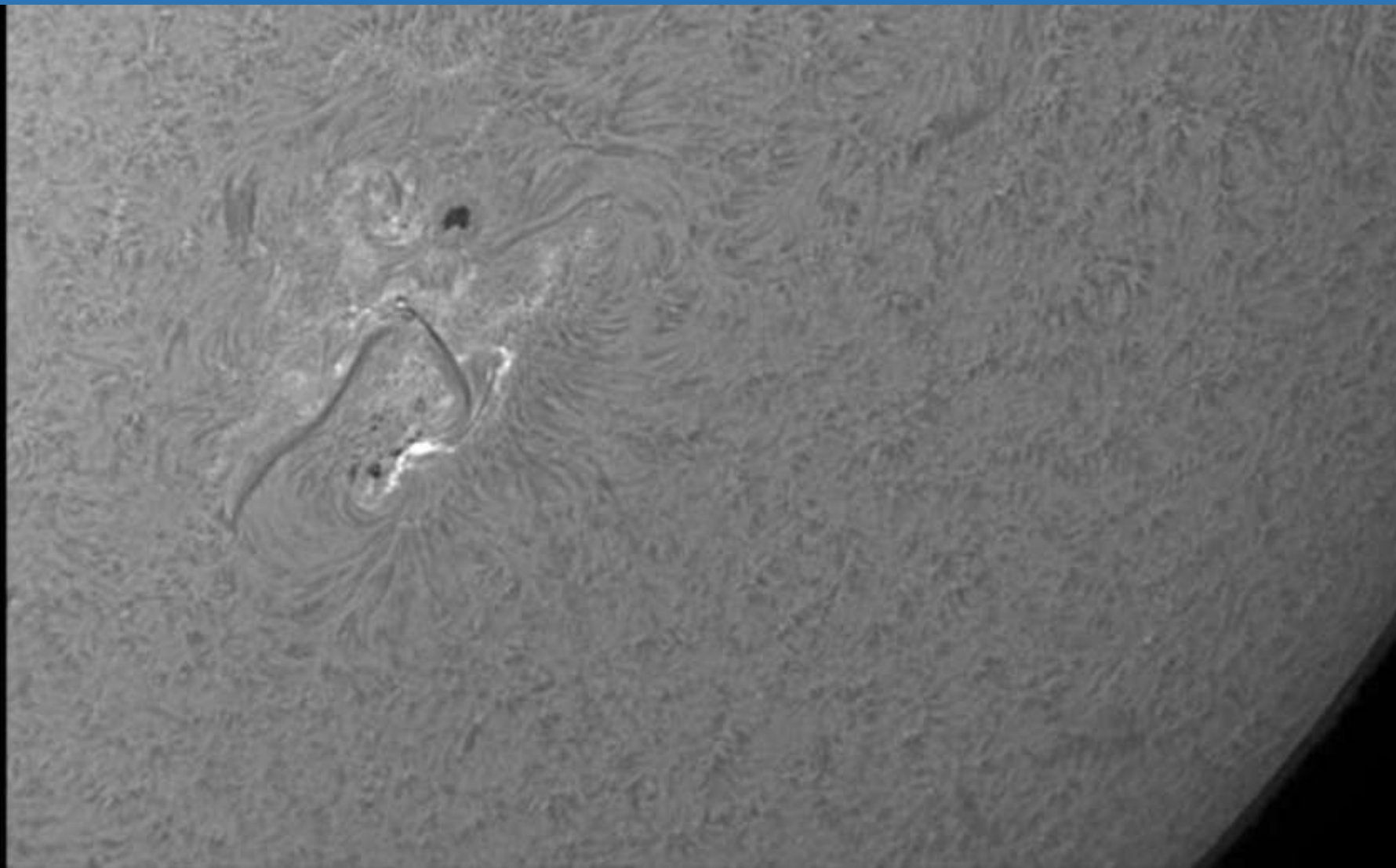
Normal Proton Background  
NOAA/SWPC Boulder, CO USA

# Effecten R

Astronauten;  
Satellieten;  
GPS;  
Satelliet verbindingen;  
Radio verbindingen.

***R-storm: enkele keren per week.***

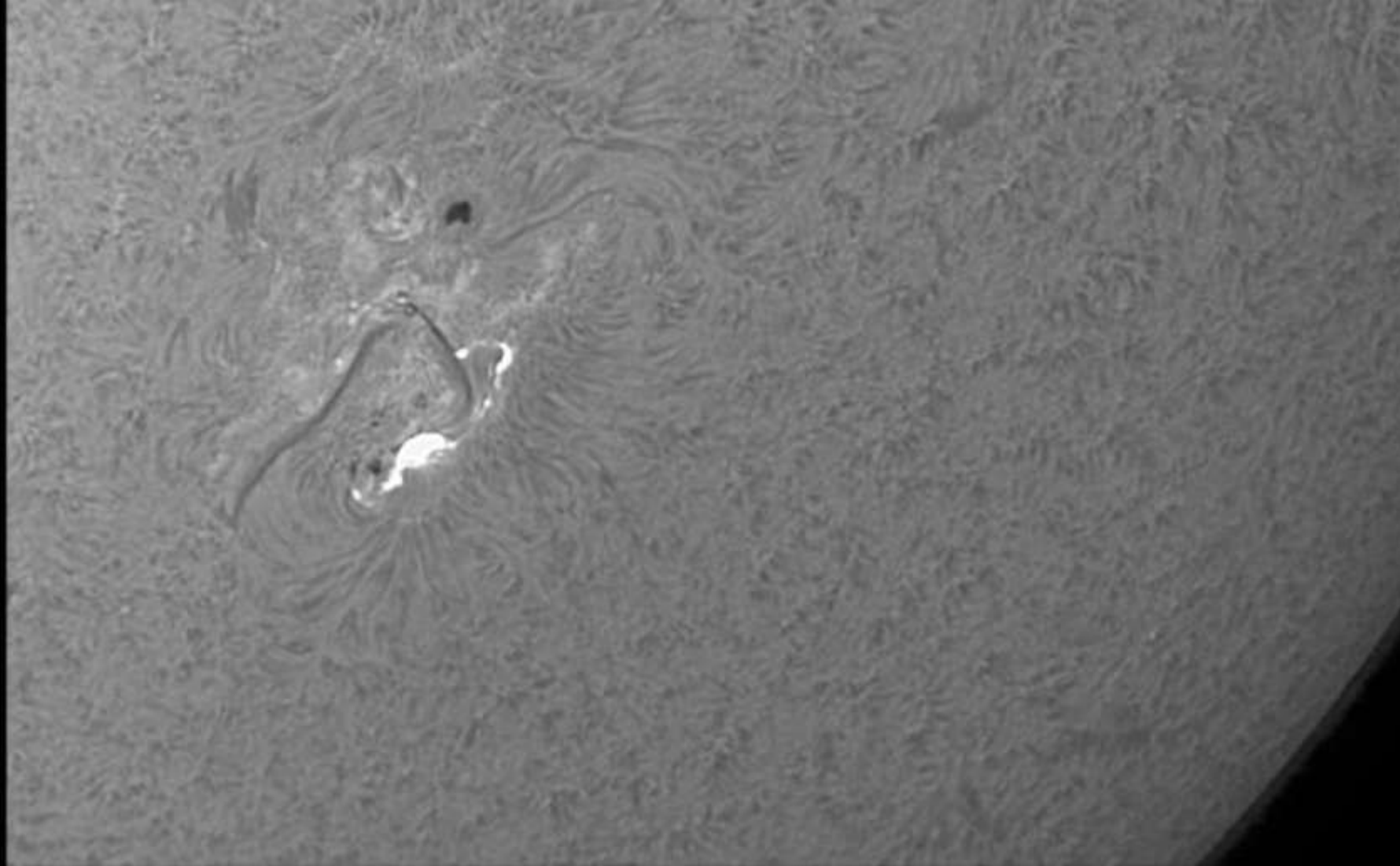
R-flare 2021-10-28



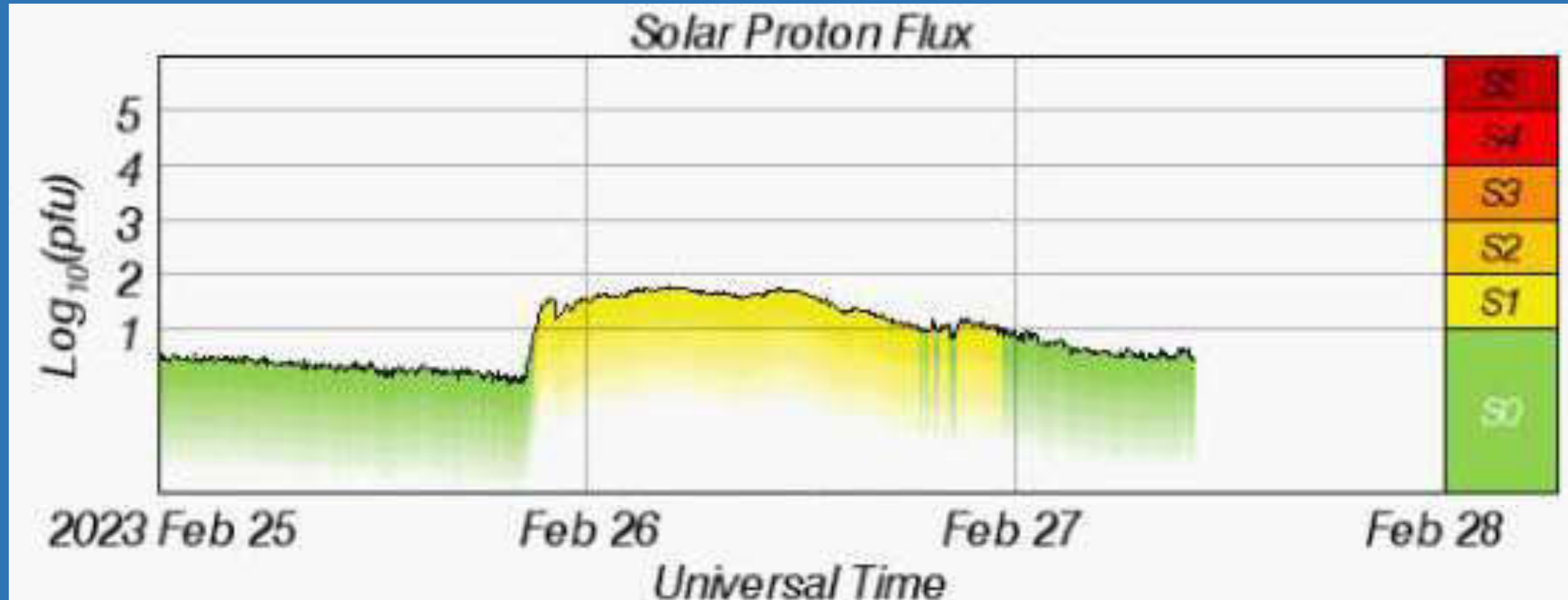
*Volgende H-alpha foto is 30 sec later.*



R-flare 2021-10-28



S



Atmosfeer aarde beschermt niet volledig.

Kettingreactie met fonteynen van hoog energetische deeltjes.

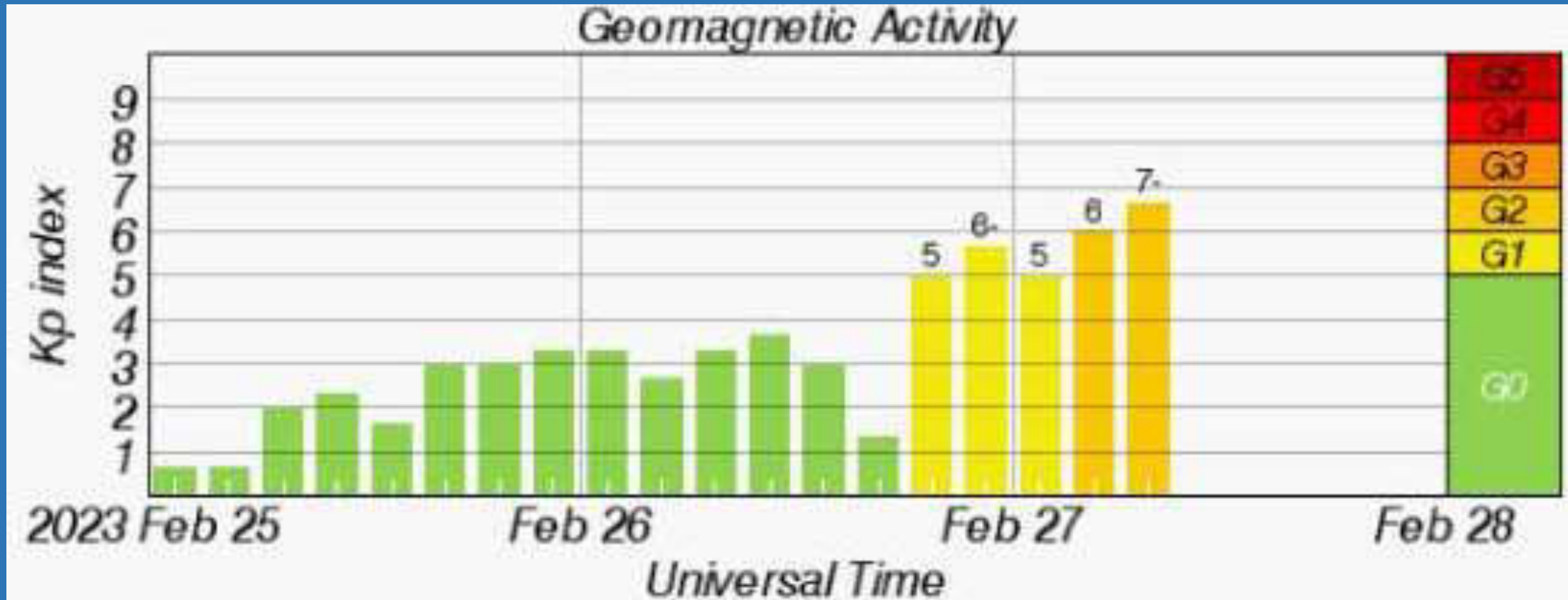
Hoogste flux secundaire deeltjes op 18 km hoogte.

## Effecten S

Astronauten;  
Satellieten;  
Bemanning vliegtuigen.

*S-storm: enkele keren per jaar.*

Dark 2019-02-23



Magneetveld aarde beschermt niet altijd.

Door **G-storm** wordt het magneetveld van aarde aan de dag-kant verder gecomprimeerd én ontstaan **Sub-storms**.

## Effecten G

Satellieten;  
Hoogspanning systemen;  
Noorderlicht.

*G-activiteit ( $K_p > 3$ ): enkele keren per week.*



## Hoofdstuk 2 – Processen zon & aarde

### Magnetische reconnectie



# Plasma

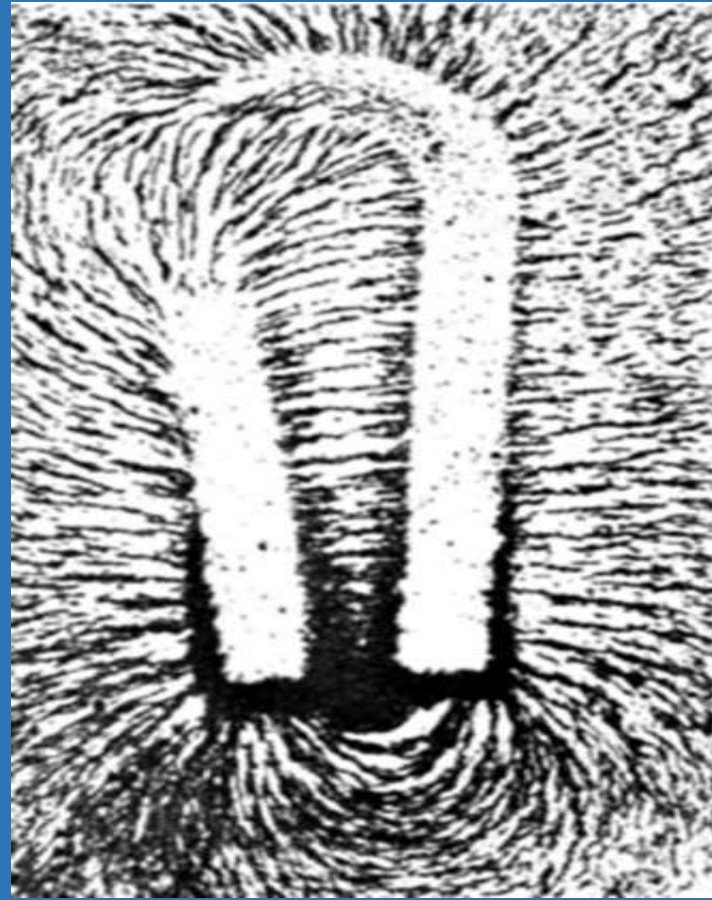
Aggregatietoestanden:

- Vast;
- Vloeibaar;
- Gas;
- Plasma.

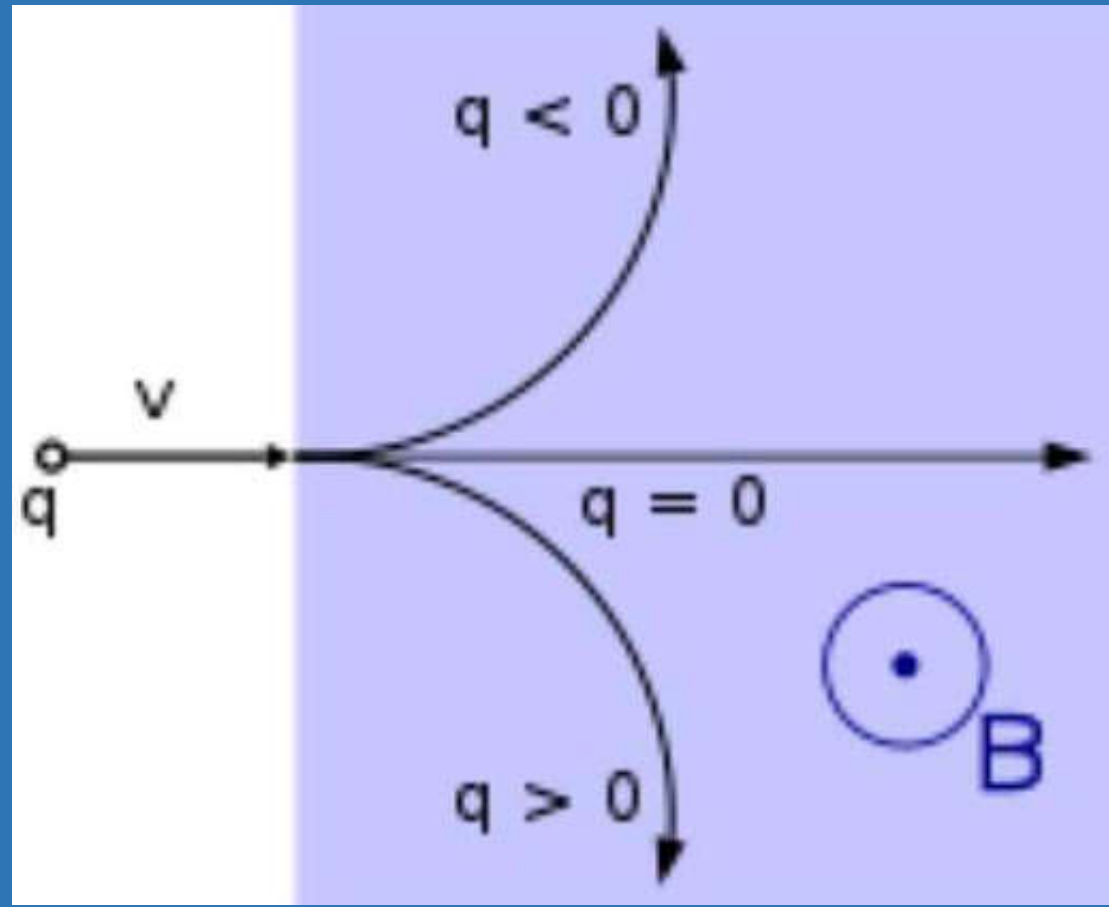
Plasma is een elektrisch geleidend gas met positieve ionen en elektronen.



# Magnetische velden



Magnetische veldlijnen



Lorentz kracht

# Magnetische velden

|                              |                      |
|------------------------------|----------------------|
| Hersenactiviteit:            | 0,001 nT (nanotesla) |
|                              | 25                   |
| Magneetveld aarde (evenaar): | 50.000               |
| Koelkastmagneet:             | 5.000.000            |
| Buitenkant zon               | 150.000.000          |
| Zonnevlekken                 | 500.000.000          |
| Magneet grote luidspreker    | 1.000.000.000        |
| 1 G (gauss)                  | = 100.000            |

**Magnetohydrodynamica (MHD)** beschrijft beweging elektrisch geleidend gas (plasma) óf vloeistof in een magnetisch veld.

Grondlegger is Hannes Alfvén - 1970 Nobelprijs natuurkunde.

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Grondlegger is Hannes Alfvén - 1970 Nobelprijs natuurkunde.

“Frozen-in flux” benadering van Alfvén:

- Magnetische veldlijnen behouden hun identiteit;
- Magnetische veldlijnen kunnen niet breken;
- Wanneer plasma beweegt, wordt magnetisch veld meegenomen en wanneer magnetisch veld beweegt wordt plasma meegenomen;
- Wanneer twee plasma hoeveelheden op een moment door een magnetische veldlijn zijn verbonden, dan blijven ze dat altijd.



“Frozen-in flux” geldt wanneer geleidbaarheid plasma oneindig is:  
Ideaal MHD (weerstand = 0).

Plasma moet ook ijl zijn, zodat onderlinge ionenbotsingen van ondergeschikt belang zijn.

*Volgens “Frozen-in flux” blijft het plasma altijd binnen een klein gebied rond de magnetische veldlijnen.*

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*Volgens “Frozen-in flux” blijft het plasma altijd binnen een klein gebied rond de magnetische veldlijnen.*

Peter Sweet en Eugene Parker hebben in de jaren 1950 gewerkt aan een theorie die het wel mogelijk maakt magnetische veldlijnen met verschillende oorsprong te openen en weer te sluiten tot een magnetisch veld met andere samenhang en oriëntatie.

SP-theorie was 50 jaar bepalend voor “Magnetic reconnection”, een verschijnsel dat zich overal in de ruimte voordoet.

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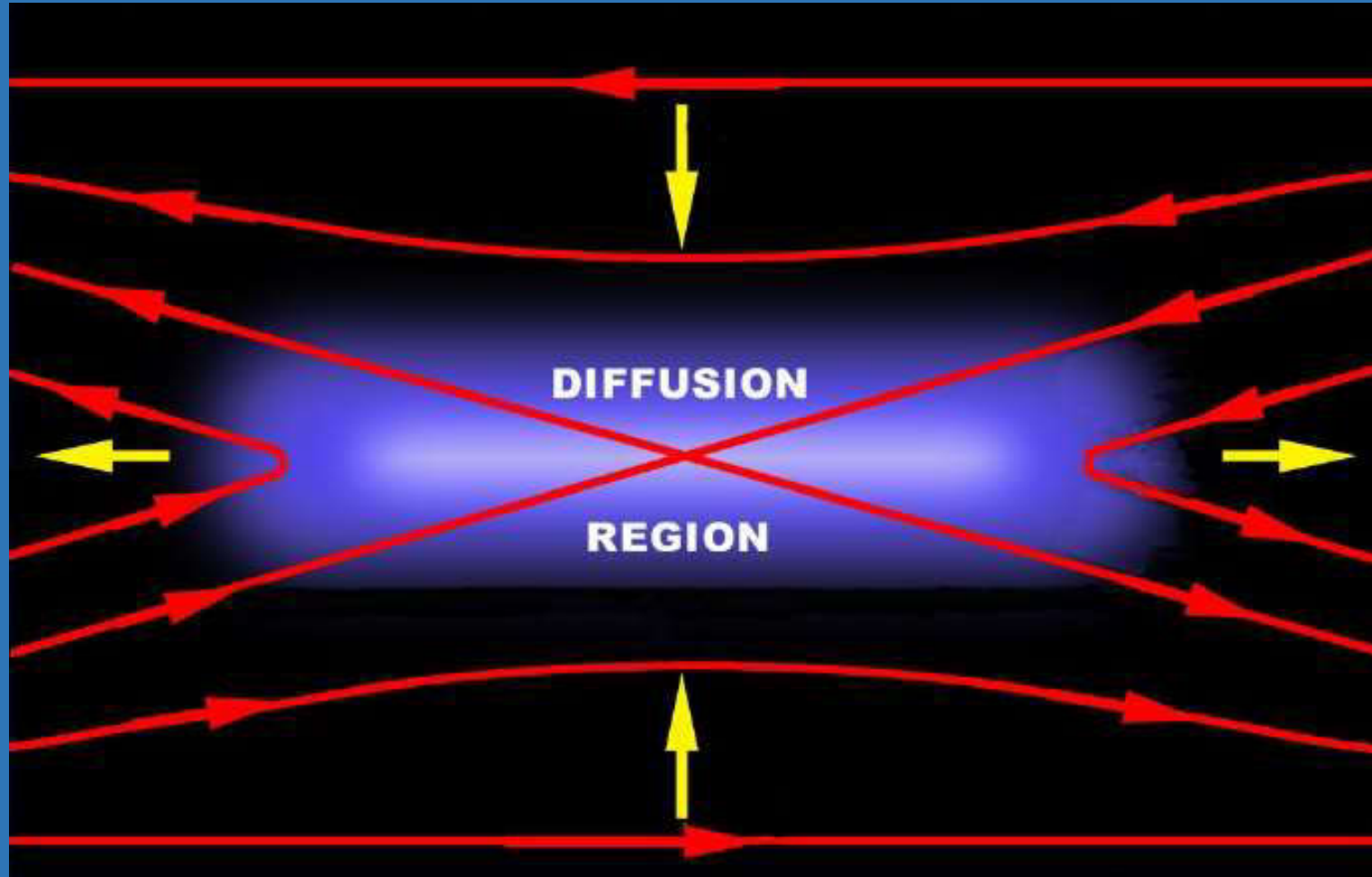
## **Magnetic reconnection:**

- Reconfiguration of magnetic field in a plasma;
- Violent release of energy;
- Particle acceleration.

&

- Breaking of the frozen-in flux constraint of Ideal MHD.

## Magnetische reconnectie volgens SP:

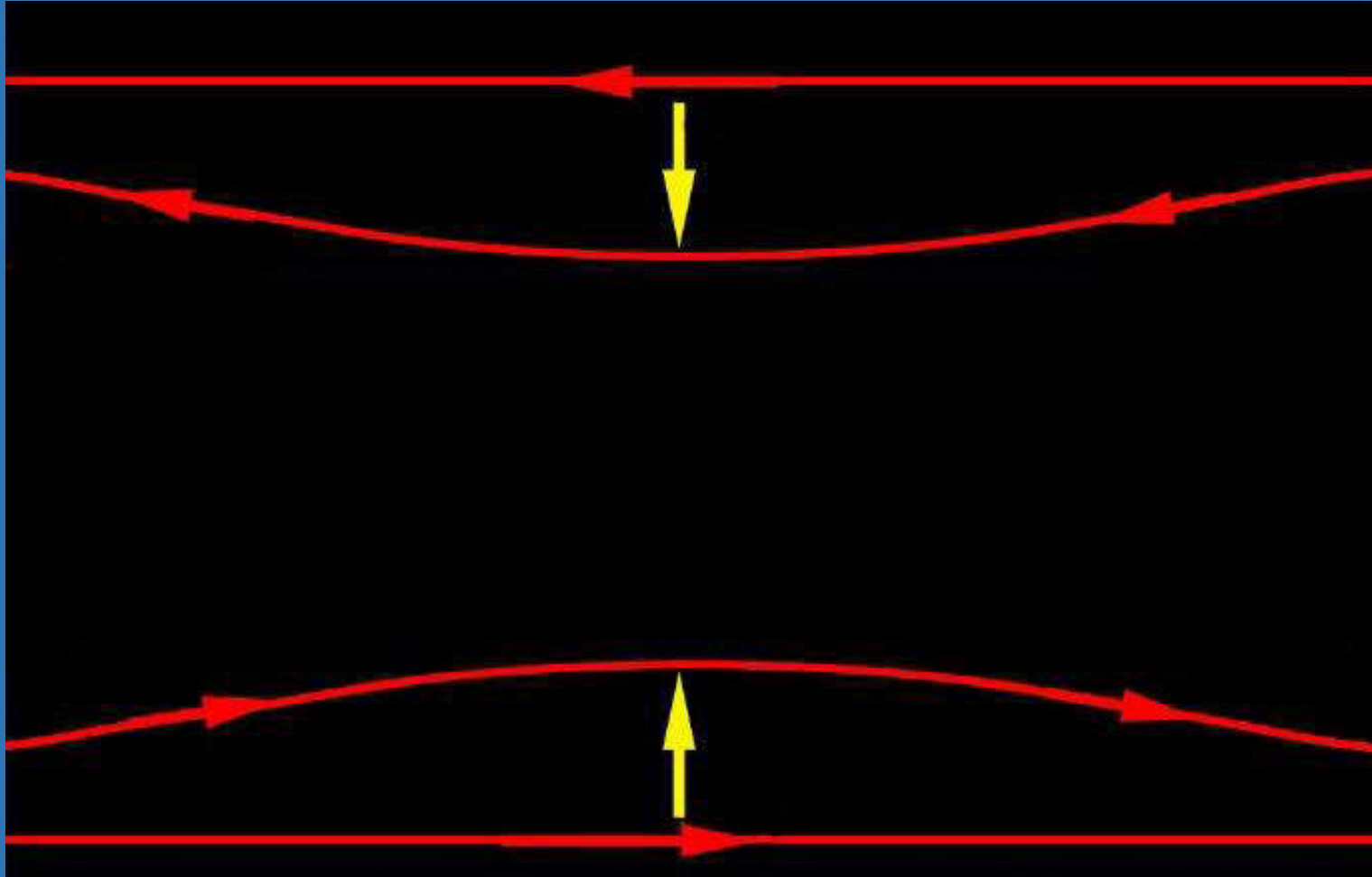


Uitgangspunten:

Systeem is stabiel (ideaal MHD);

Elektronen stromen in een richting loodrecht op de tekening (plasma).

## Magnetische reconnectie volgens SP:

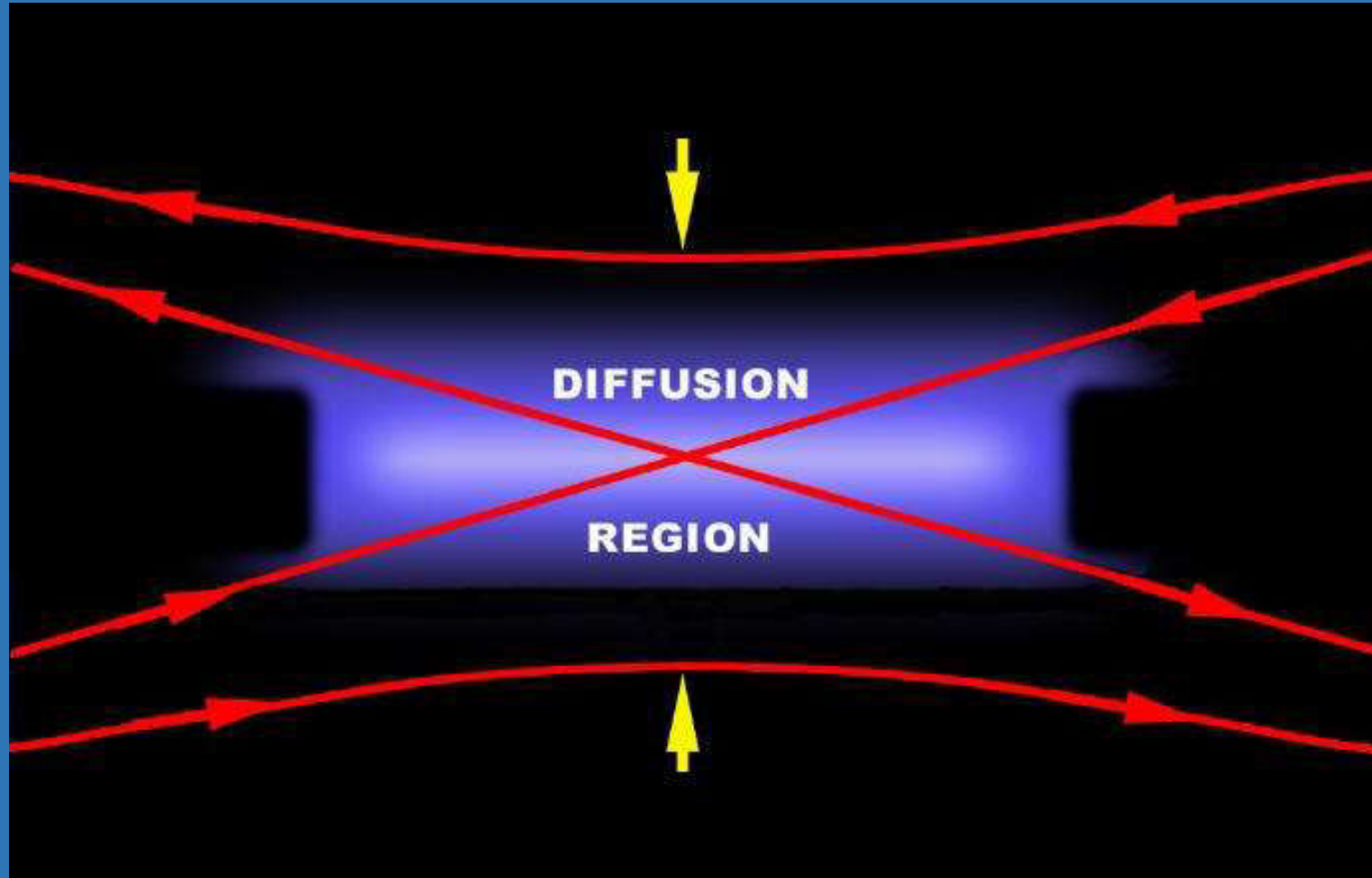


Stap 1:

Parallele magnetische veldlijnen, met tegengestelde veldrichting, bewegen naar elkaar.



## Magnetische reconnectie volgens SP:

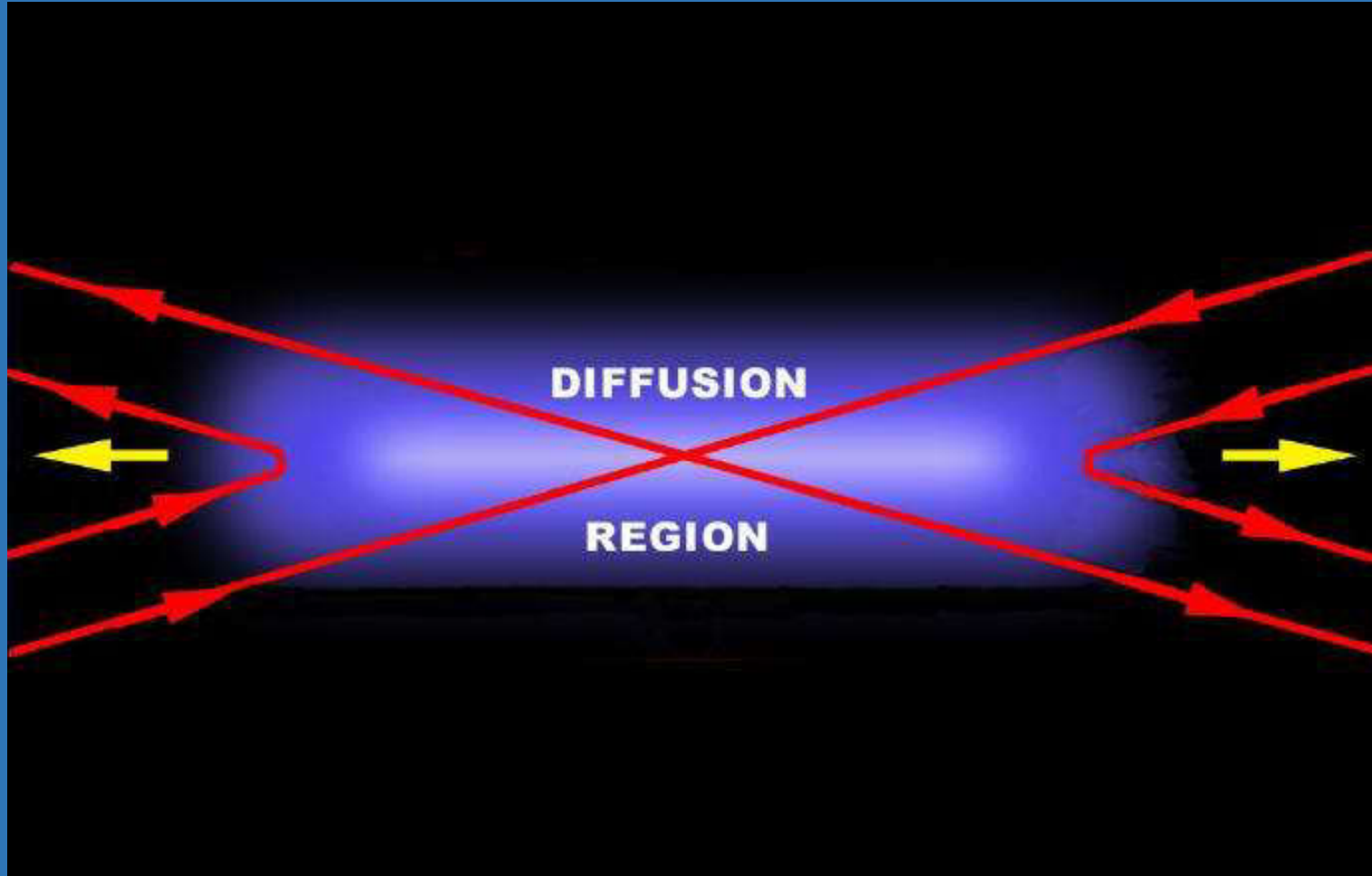


Stap 2:

Sterkte magnetisch veld wordt 0 in diffusiegebied.

Magnetische veldlijnen gaan open en sluiten kruislings.

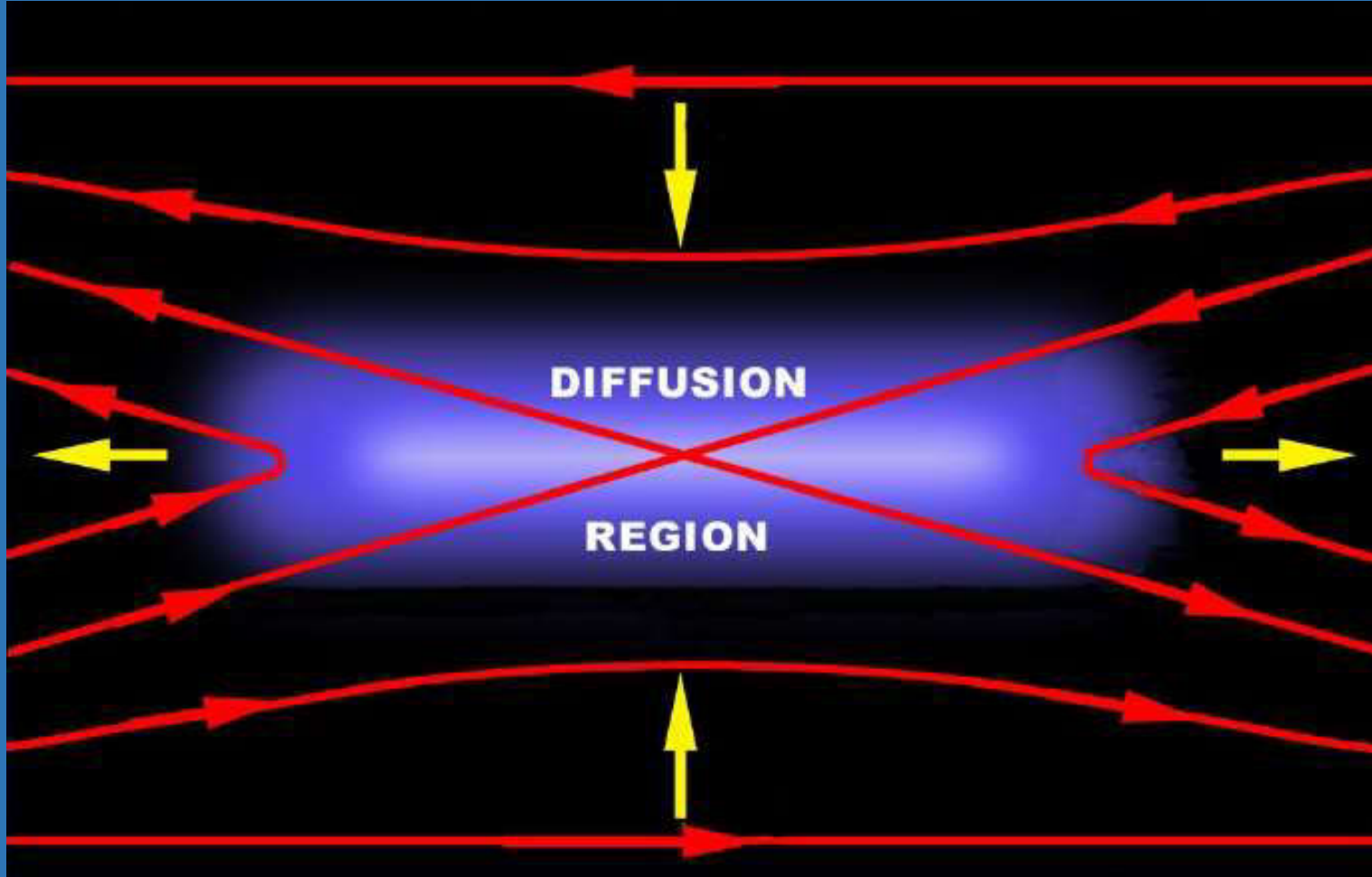
## Magnetische reconnectie volgens SP:



Stap 3:

Elektronen volgen de gesloten magnetische veldlijnen en worden, door energie uit het magneteveld, sterk versneld afgevoerd.

## Magnetische reconnectie volgens SP:

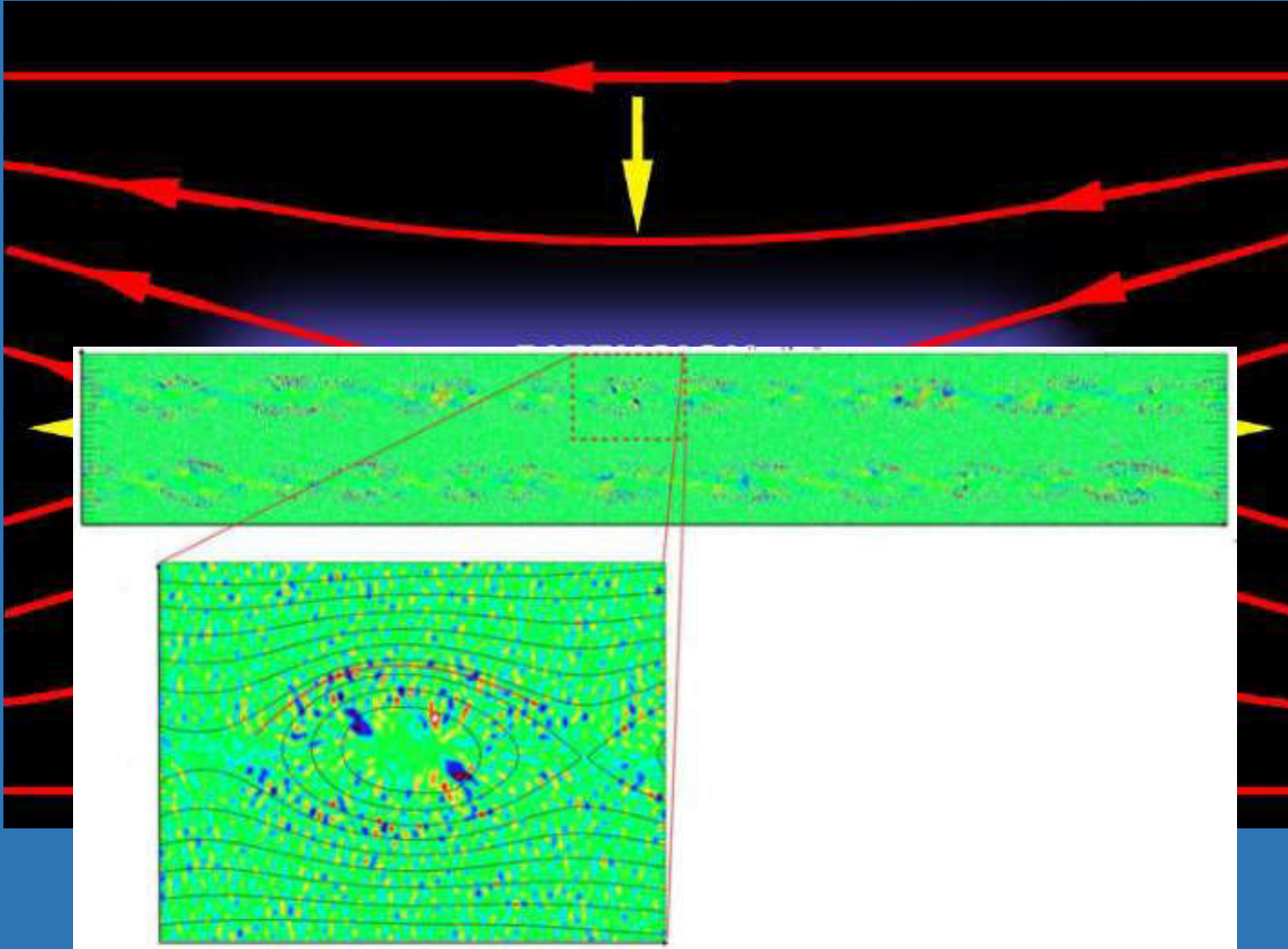


### Probleem:

Volgens berekeningen met het SP-model duurt een zonnevlam weken.

In de praktijk gaat het in minuten.

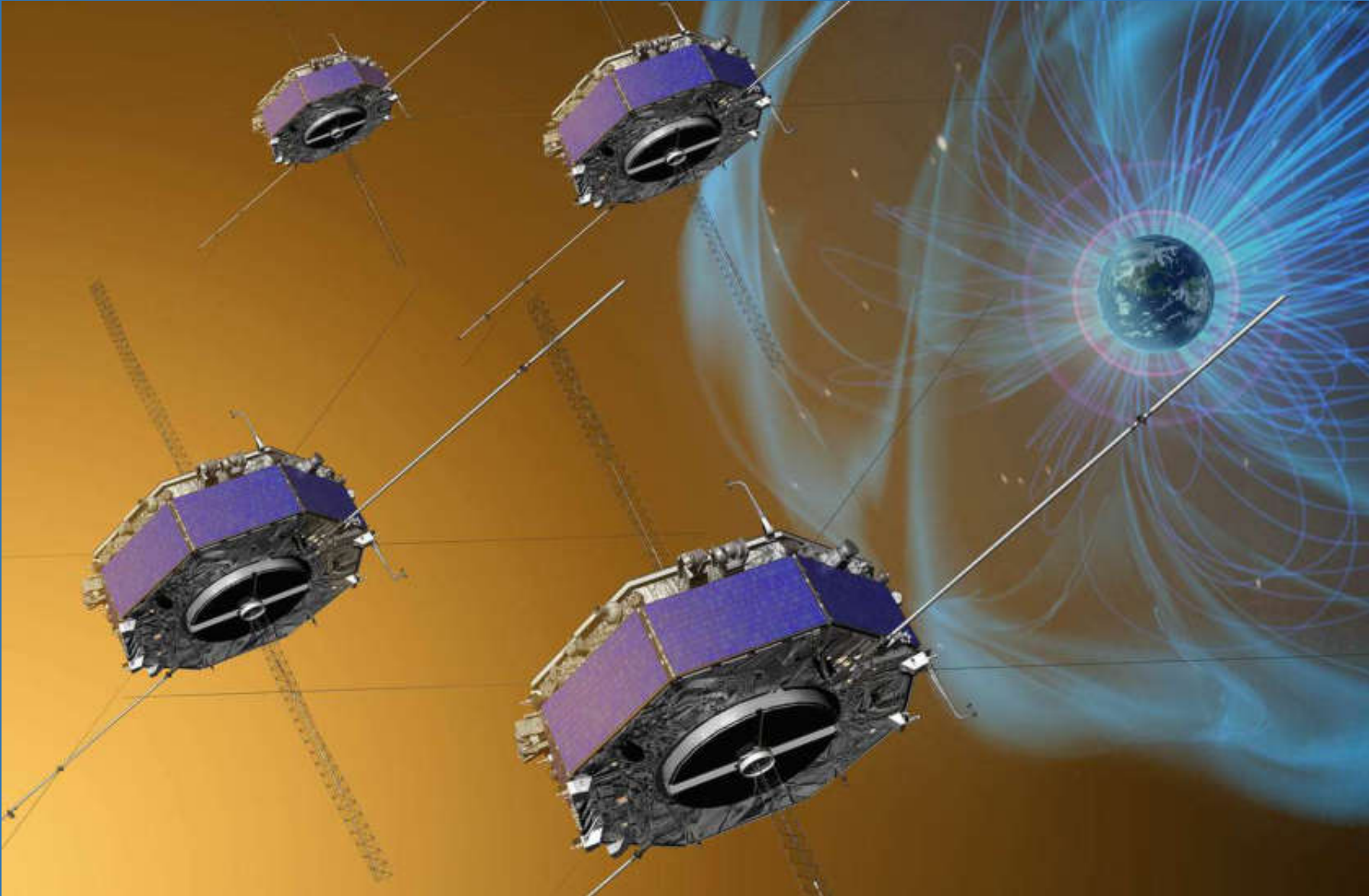
## Magnetische reconnectie – variant op SP:



Oplossing: **Stochastic  
Plasmoid Chains**

Plasmoids ontstaan, spatten uiteen en vormen zich opnieuw. Elektronen worden opgenomen en versneld via de kruislings gesloten magnetische veldlijnen afgevoerd.





Magnetospheric  
Multiscale Mission  
(MMS) 4 Probes

*2015-03-13*

2016: magnetische  
reconnectie aange-  
toond.

Tot 2040 in bedrijf.

Zon





Zonsverduistering  
2017 - USA

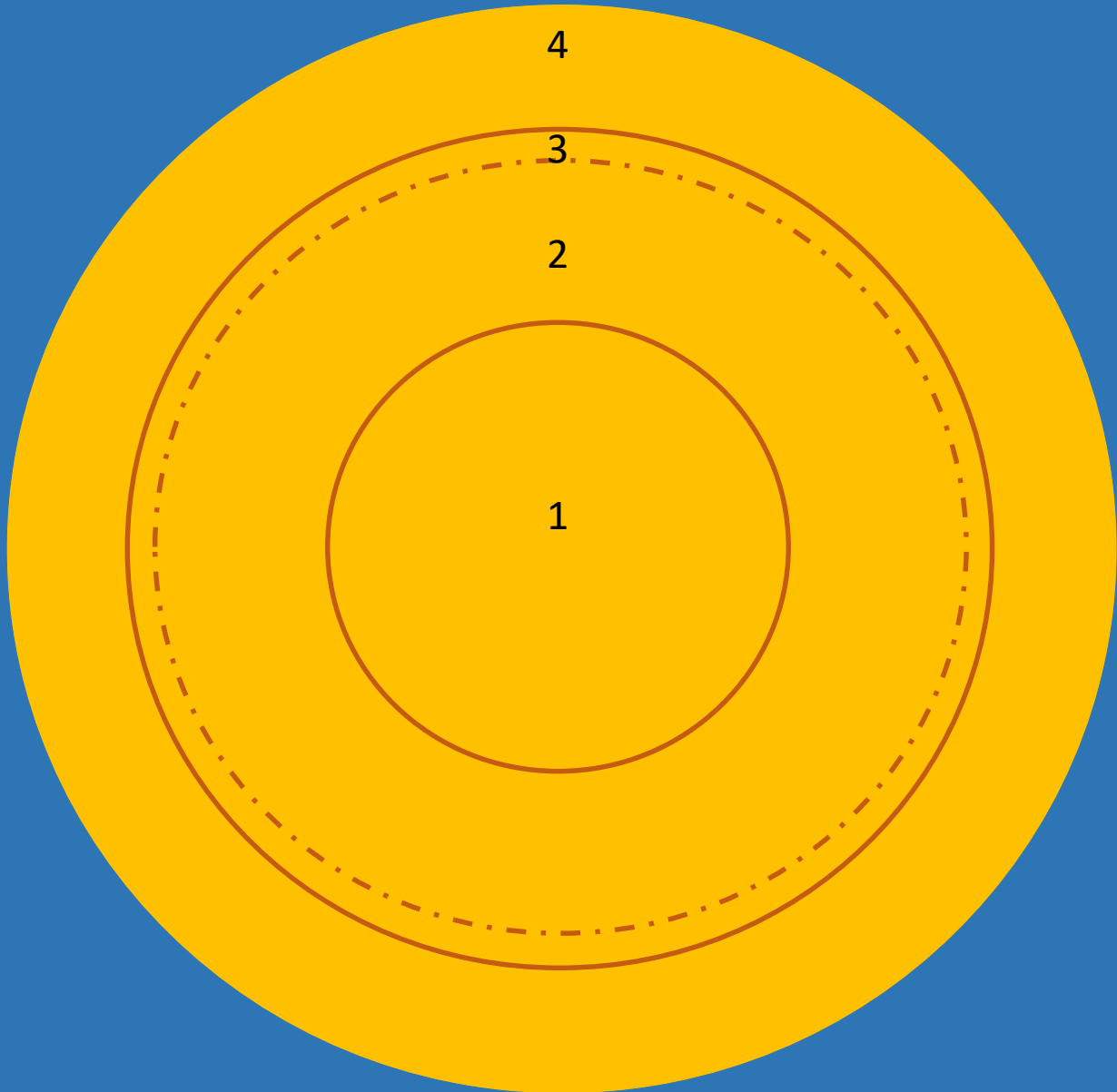






Zonsverduistering  
2019 Chili

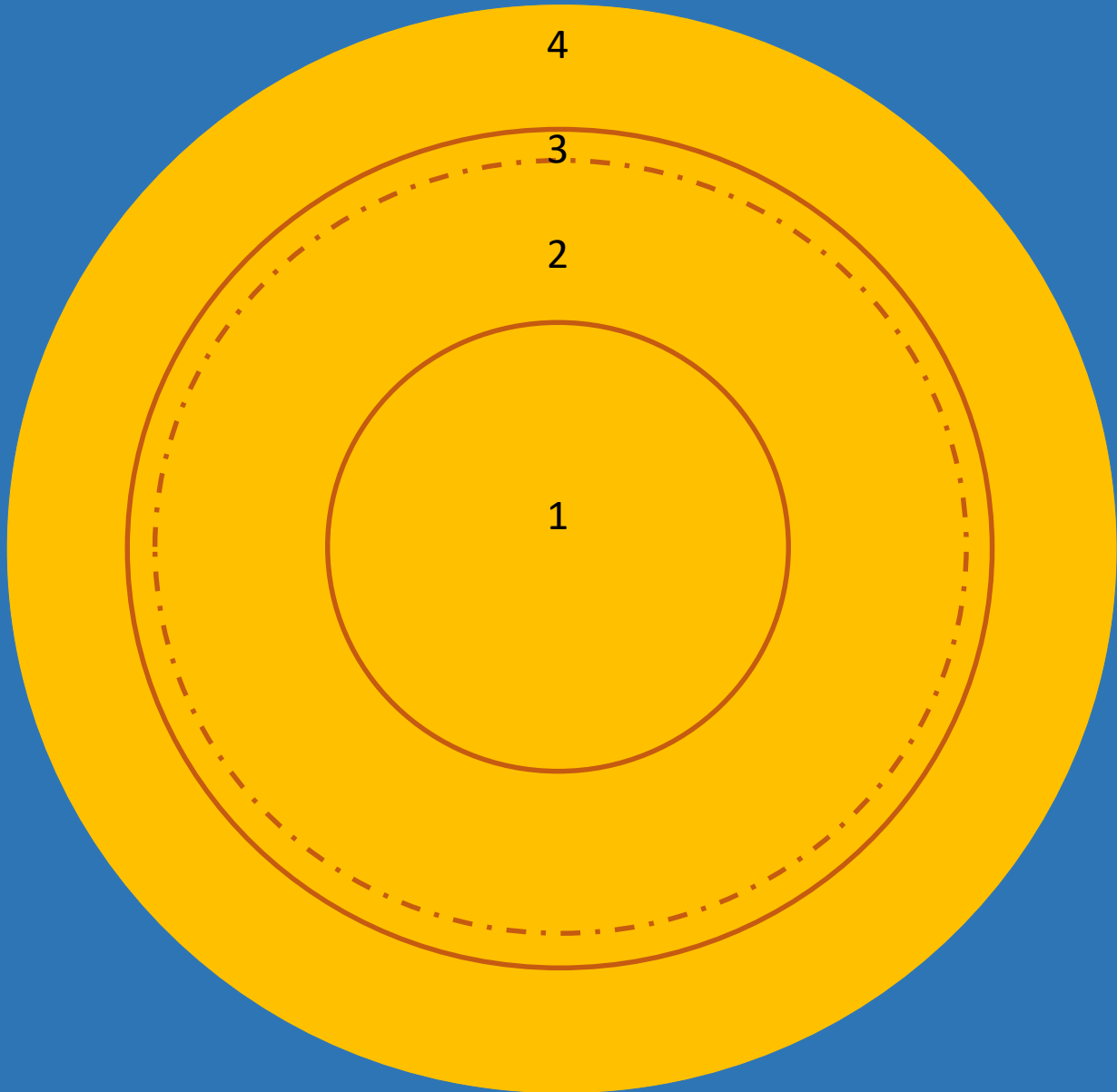




1 – Kern

Waterstoffusie.

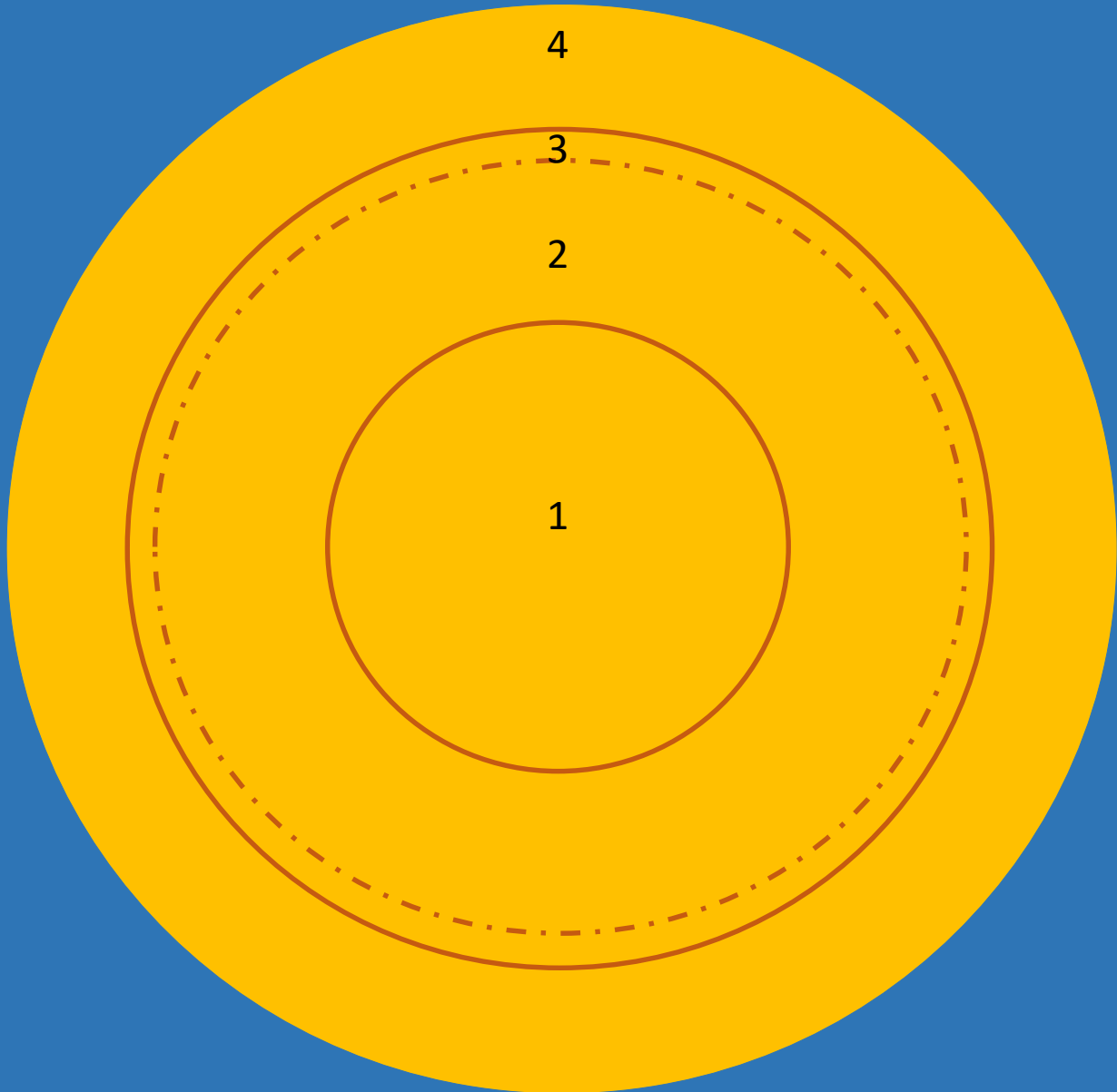
15 miljoen K.



2 – Stralingszone (geen convectie)

Dichtheid 0,25 Rzon: 20 g/cm<sup>3</sup>;  
0,7 Rzon: 0,2 g/cm<sup>3</sup>.

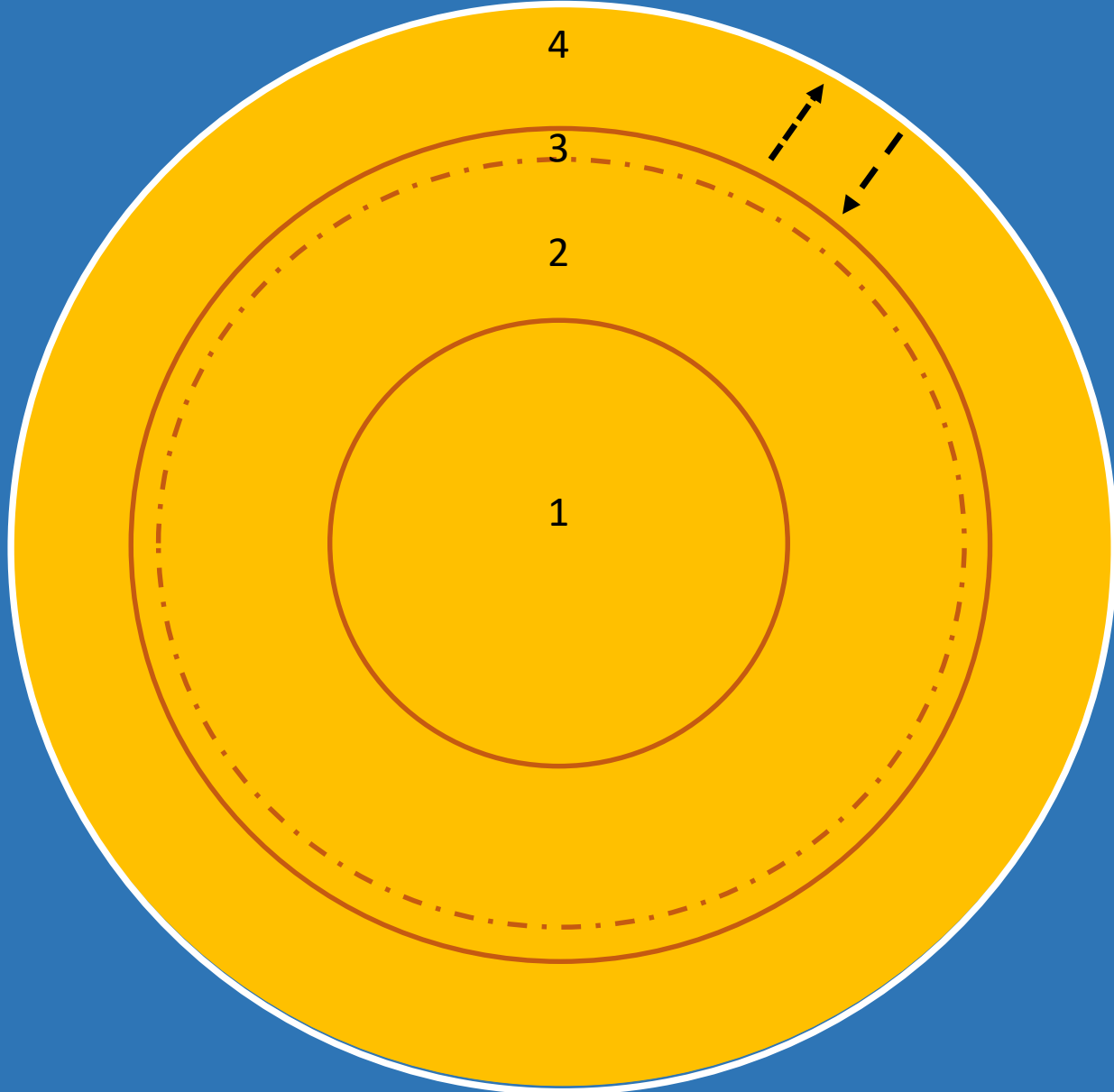




3 – Tachocline (overgangsgebied)  
100.000 km onder zonsoppervlak

Magnetisch veld van de zon ontstaat,  
waarschijnlijk, in de Tachocline.

***Nog heel veel onbekend.***



4 – Convectiezone en fotosfeer

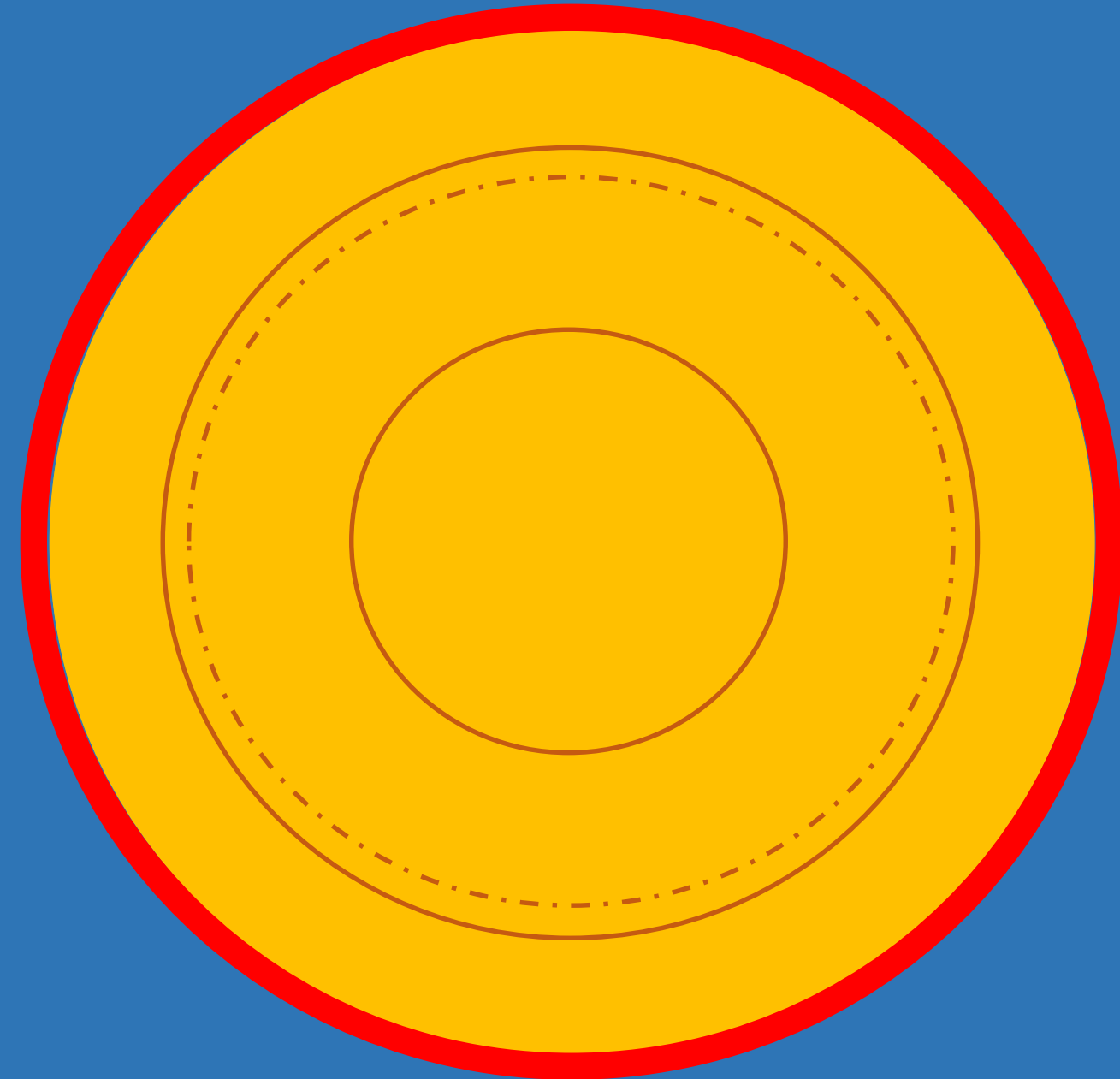
Onderste laag: 2 miljoen K;

Buitenste laag: 5.700 K – **Fotosfeer.**

Fotosfeer:

Zichtbaar oppervlak zon.  
Doorzichtig - 450 km dik

0,0000002 g/cm<sup>3</sup>;  
(1/10.000 van lucht 1 bar).



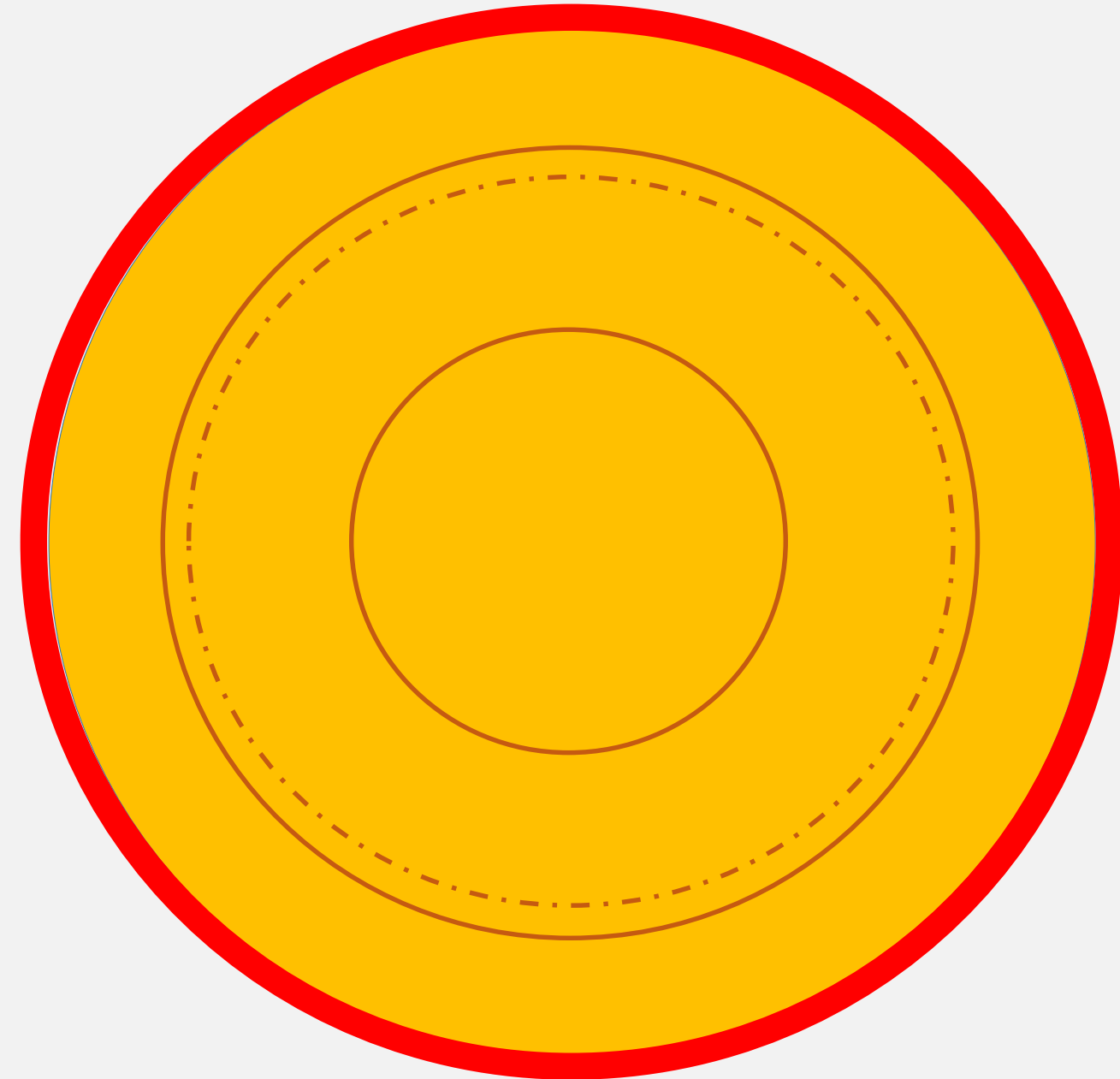
## Chromosfeer

Onderste laag: 6.000 K;

Buitenste laag: 20.000 K.

Zichtbaar in H-alpha (656 nm) 2.500 km dik.

Onregelmatige beweeglijke structuren die magnetische veldlijnen volgen.



## Corona

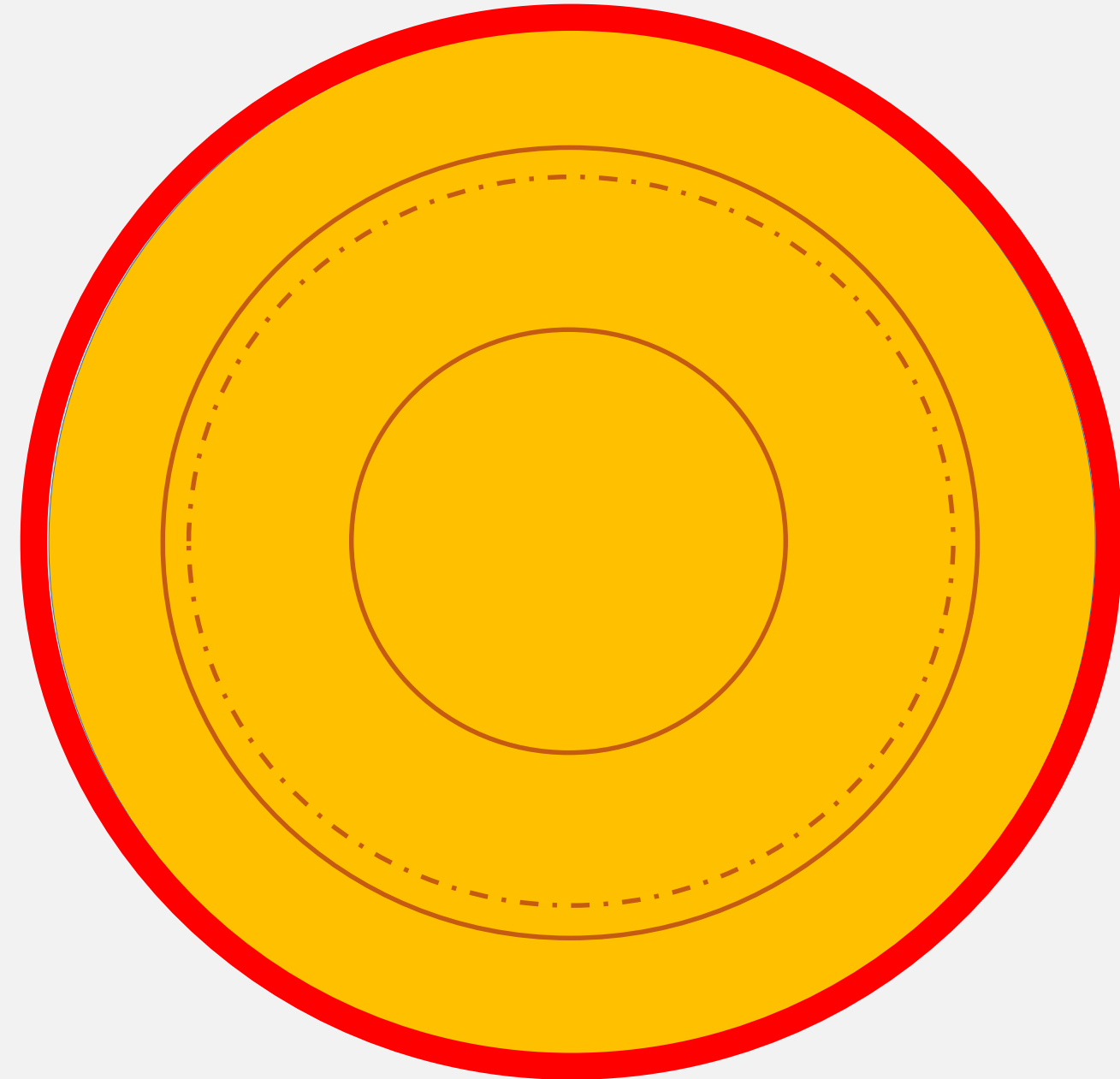
> 1 miljoen K.

Zichtbaar in zichtbaar licht (eclips) en X-Ray.

Plasma waarin H t/m O alle elektronen kwijt zijn.

Dichtheid: heel laag.

Diameter: miljoenen kms.



## Corona

Materiaal stroomt uit Corona de ruimte in:  
de **zonnewind**.

2 miljoen ton/sec (0,02 % zonmassa in  
9 miljard jaar).

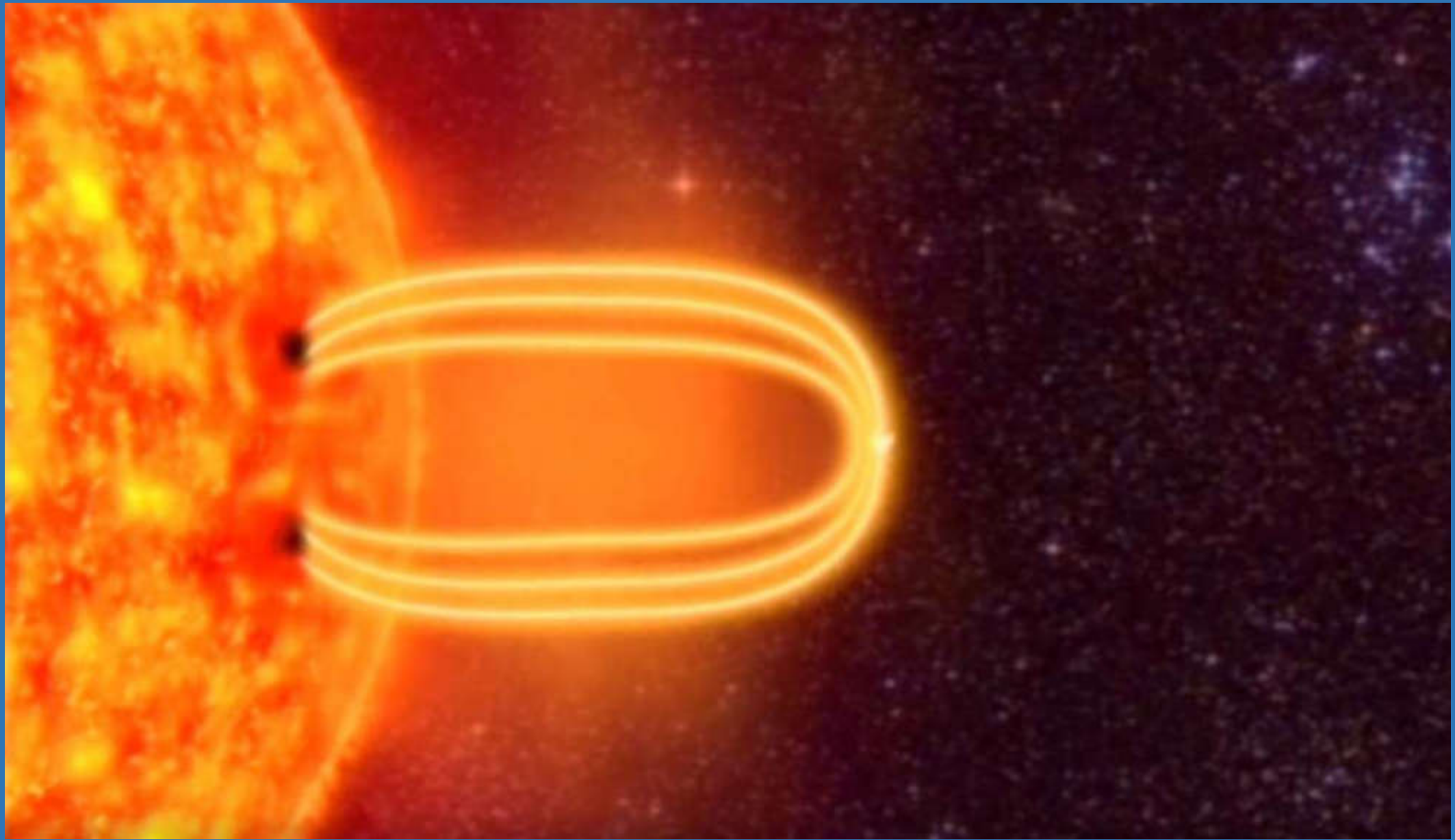
Door zonnewind ontstaat het IMF.

**IMF – Interplanetary Magnetic Field**

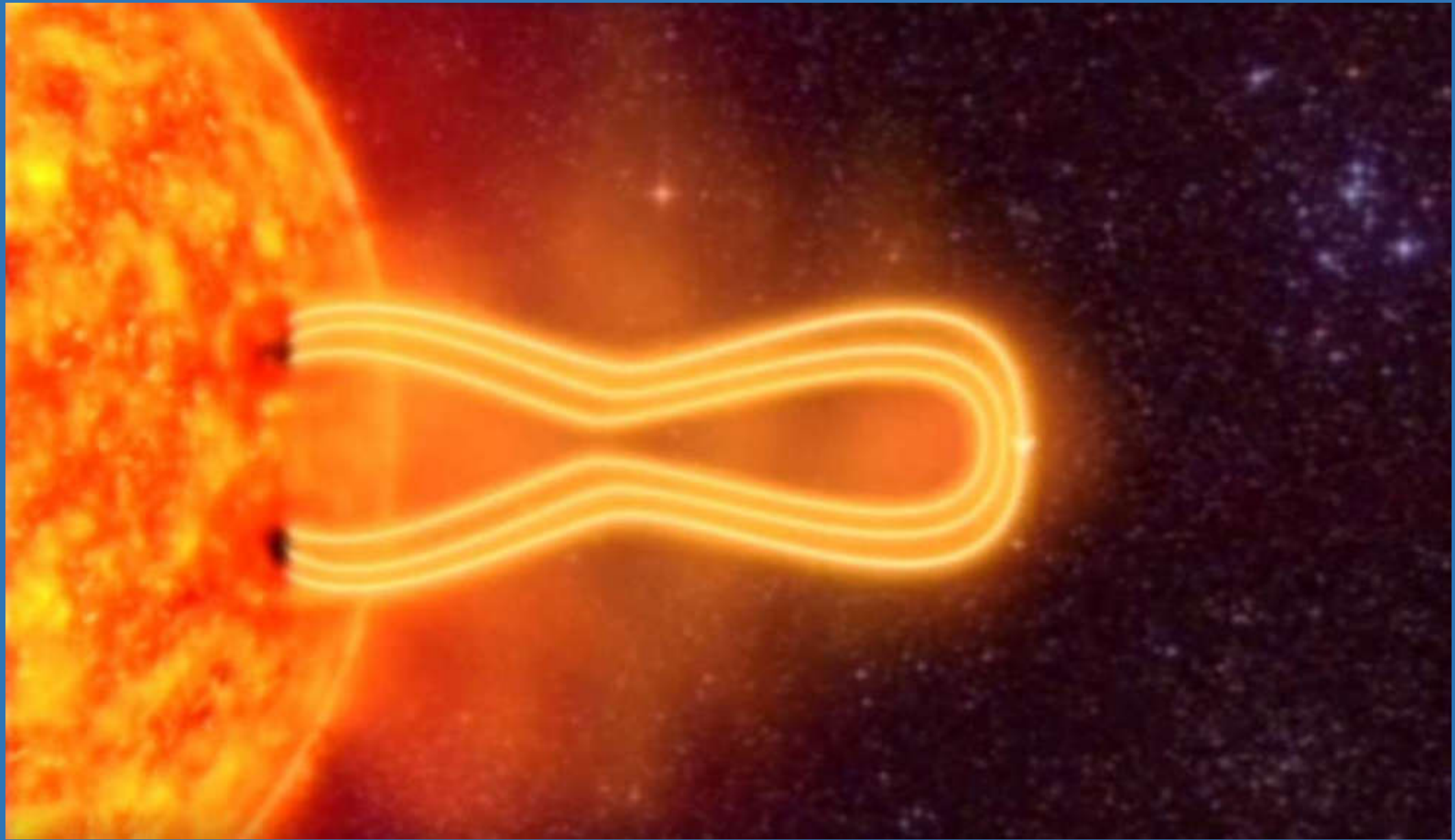
Soms wordt de zonnewind een  
**zonnestorm:**

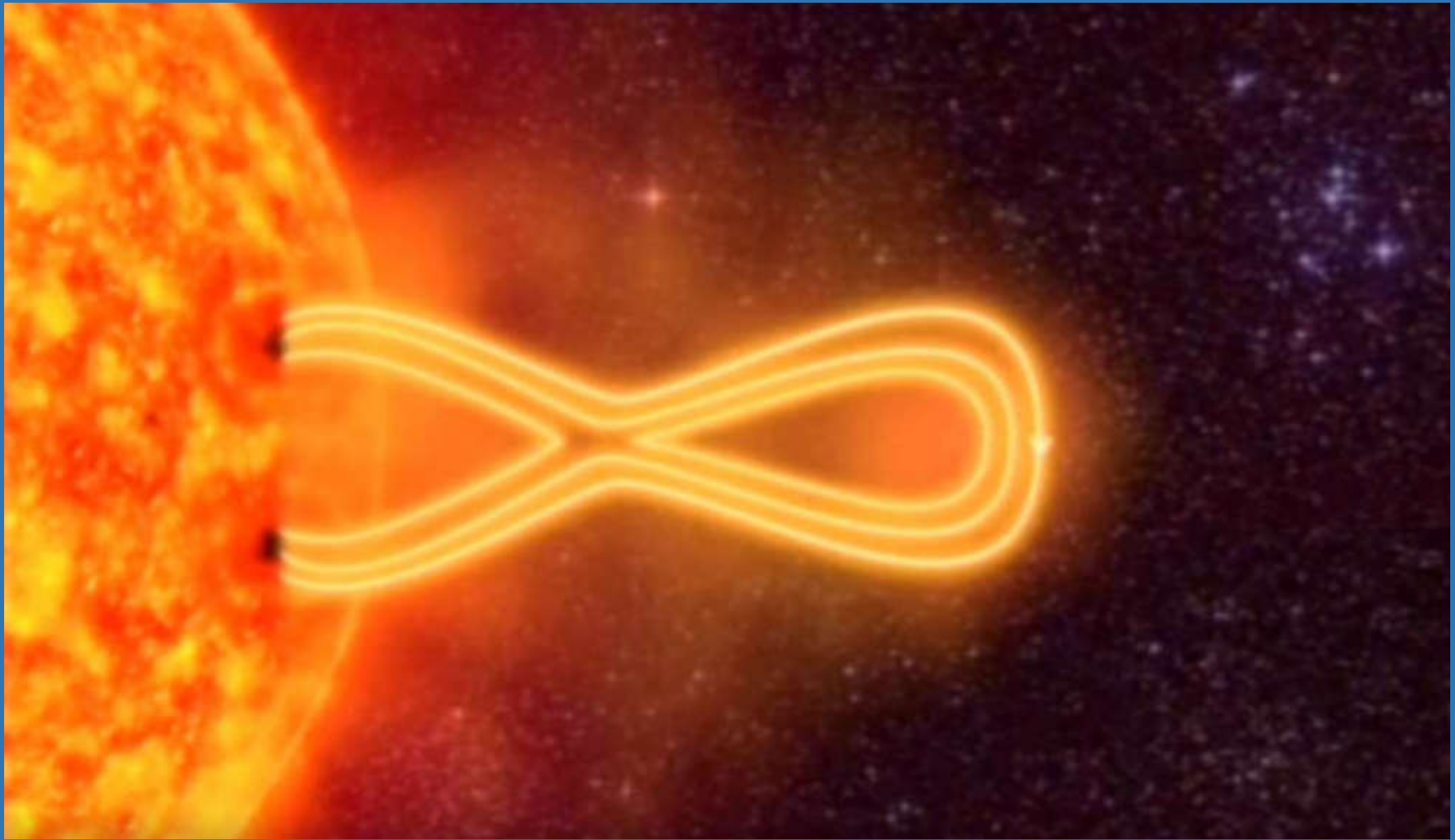
**CME = Coronal Mass Ejection.**

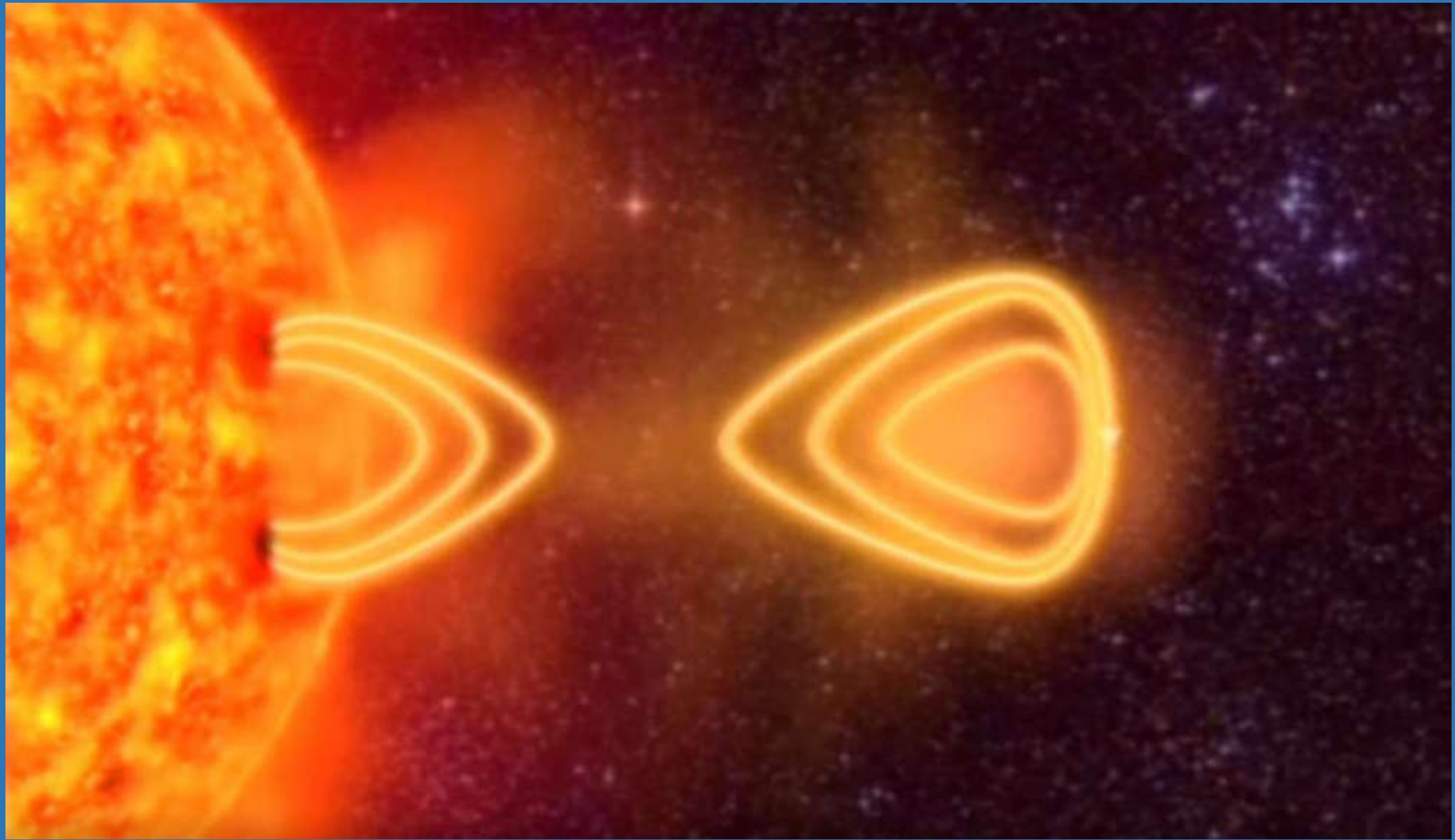
# CME's ontstaan door magnetische reconnectie



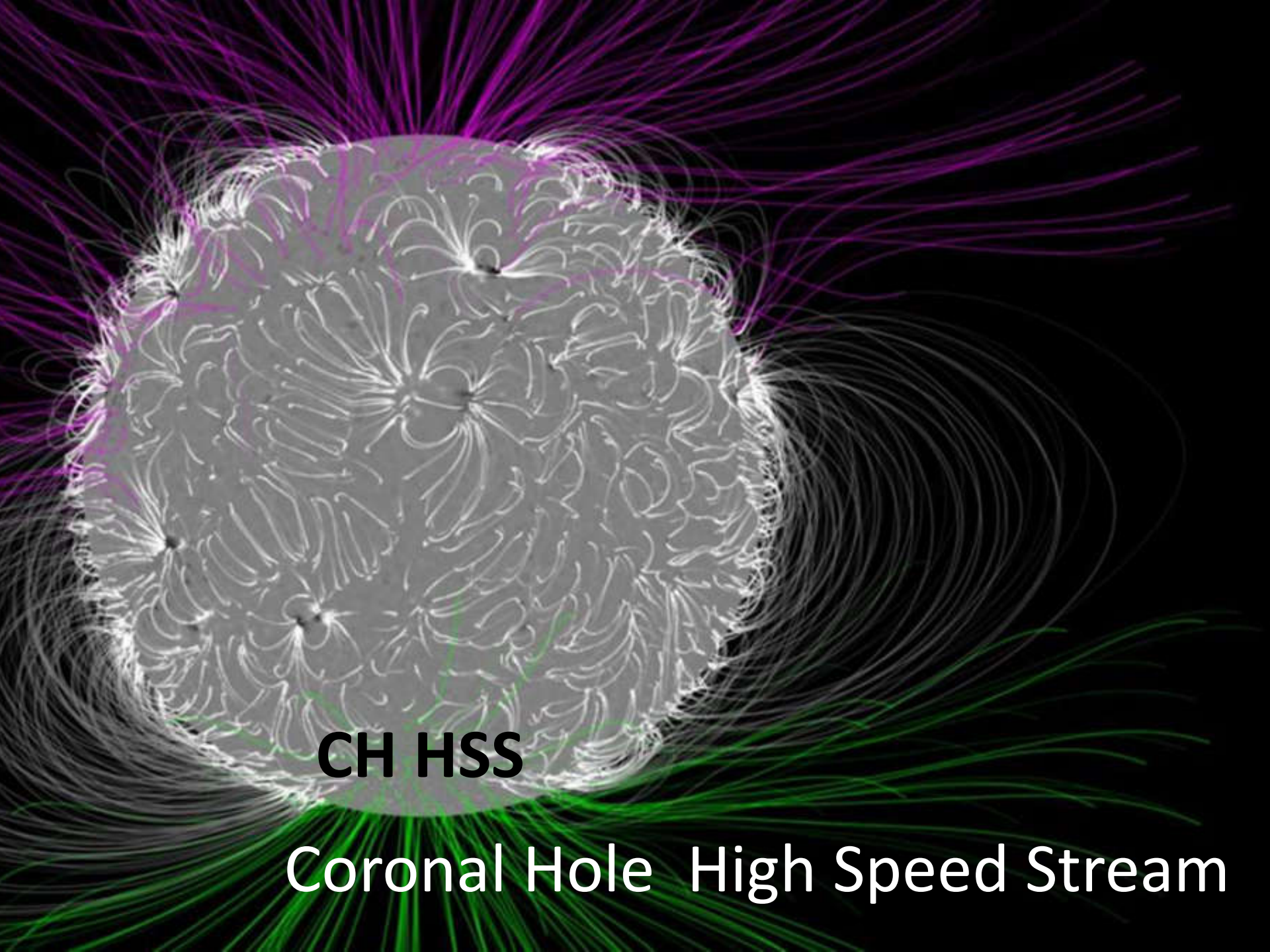
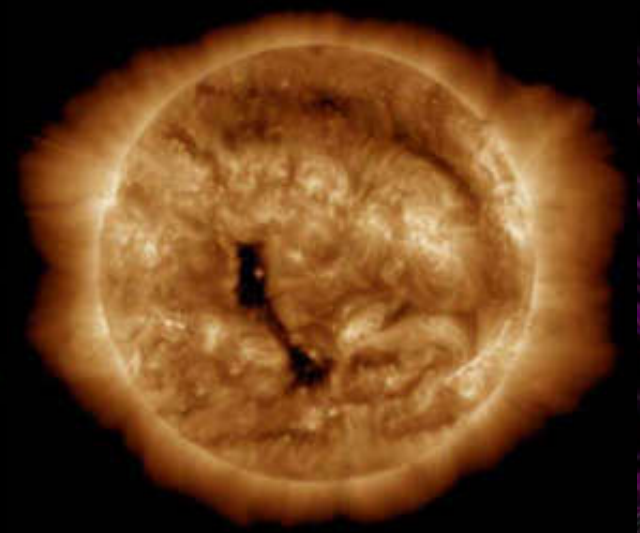








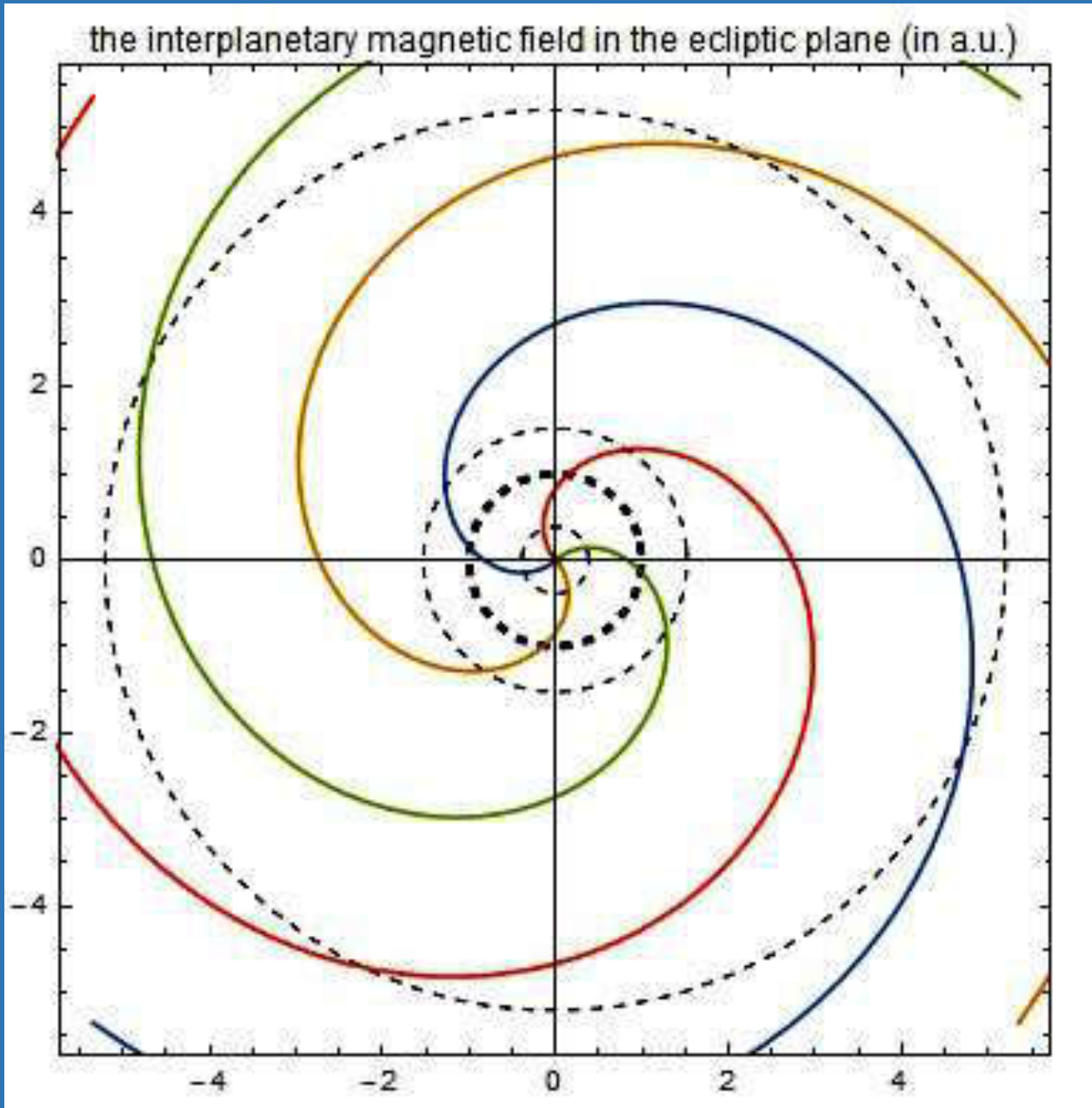




**CH HSS**

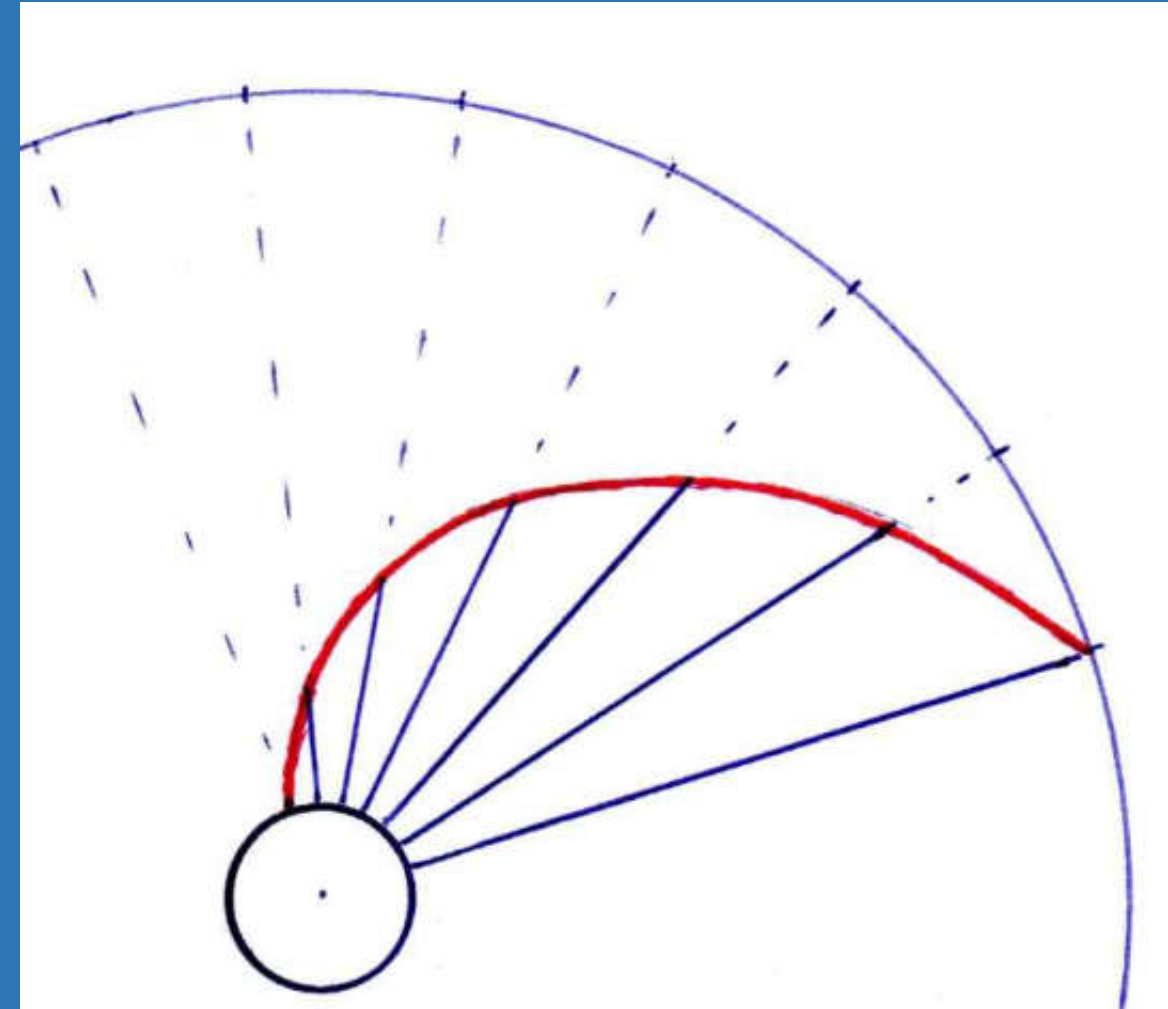
Coronal Hole High Speed Stream

# Parker Spiral

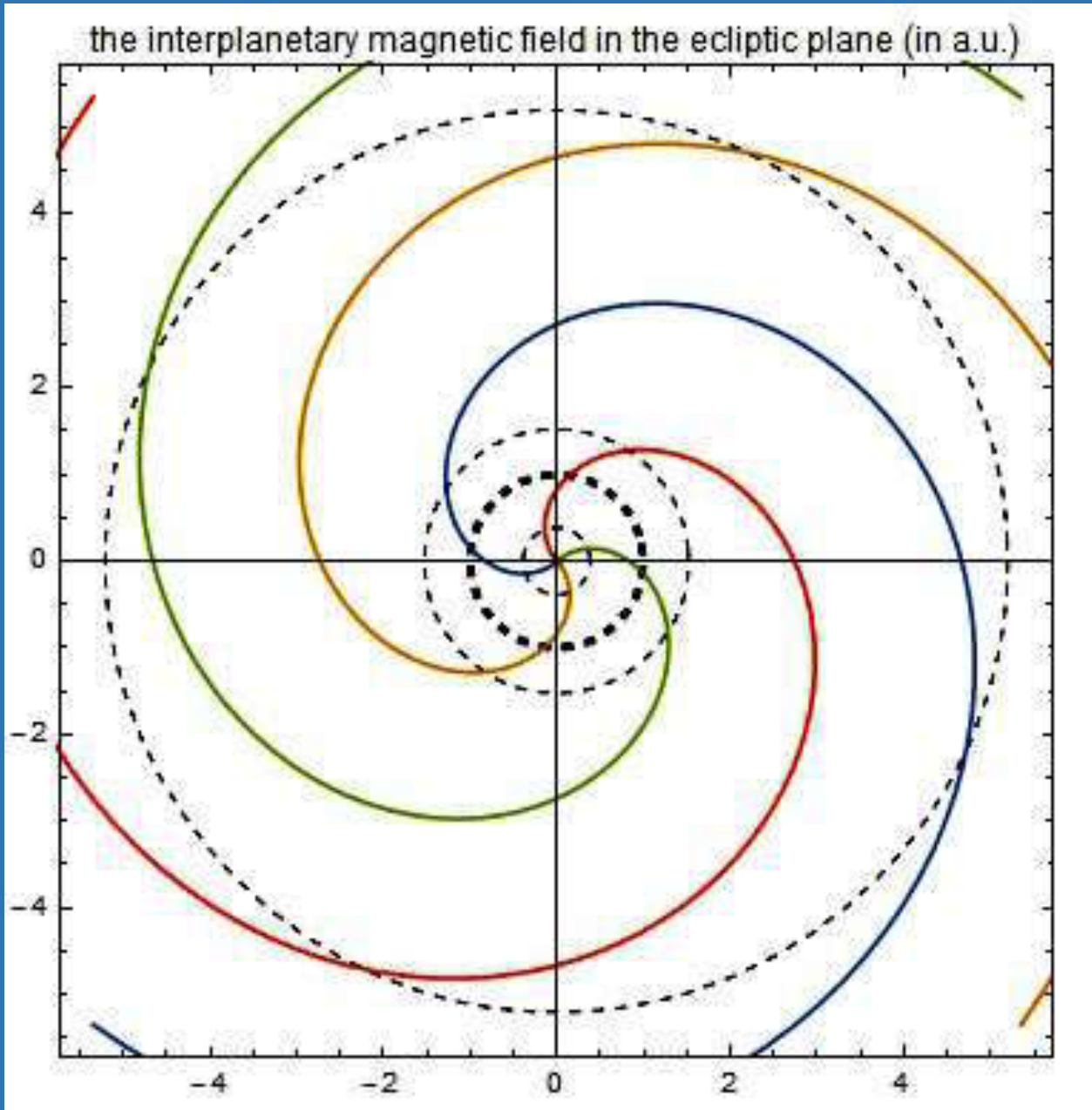




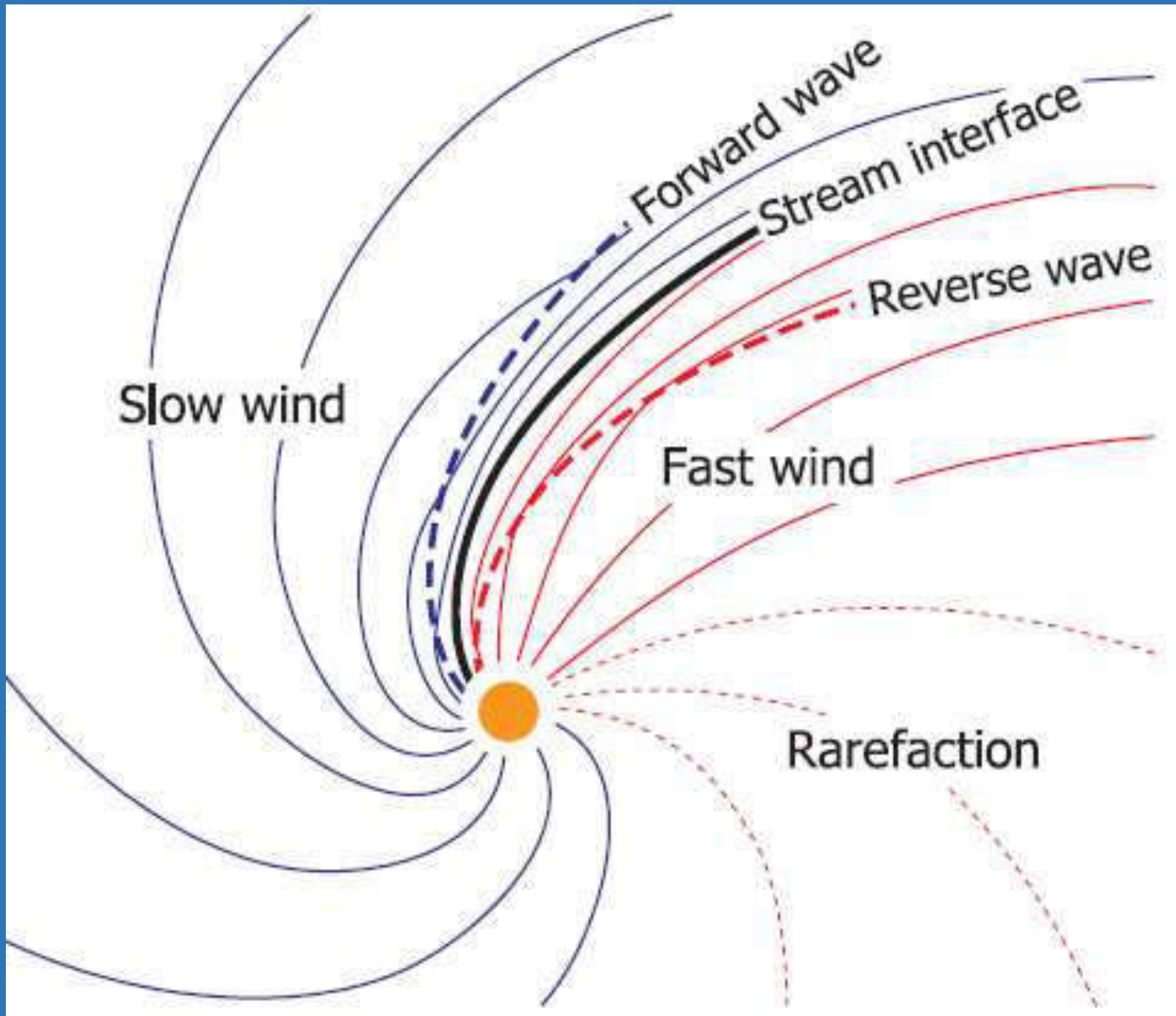
# Parker Spiral



Constructie magnetische veldlijn (7 dagen).

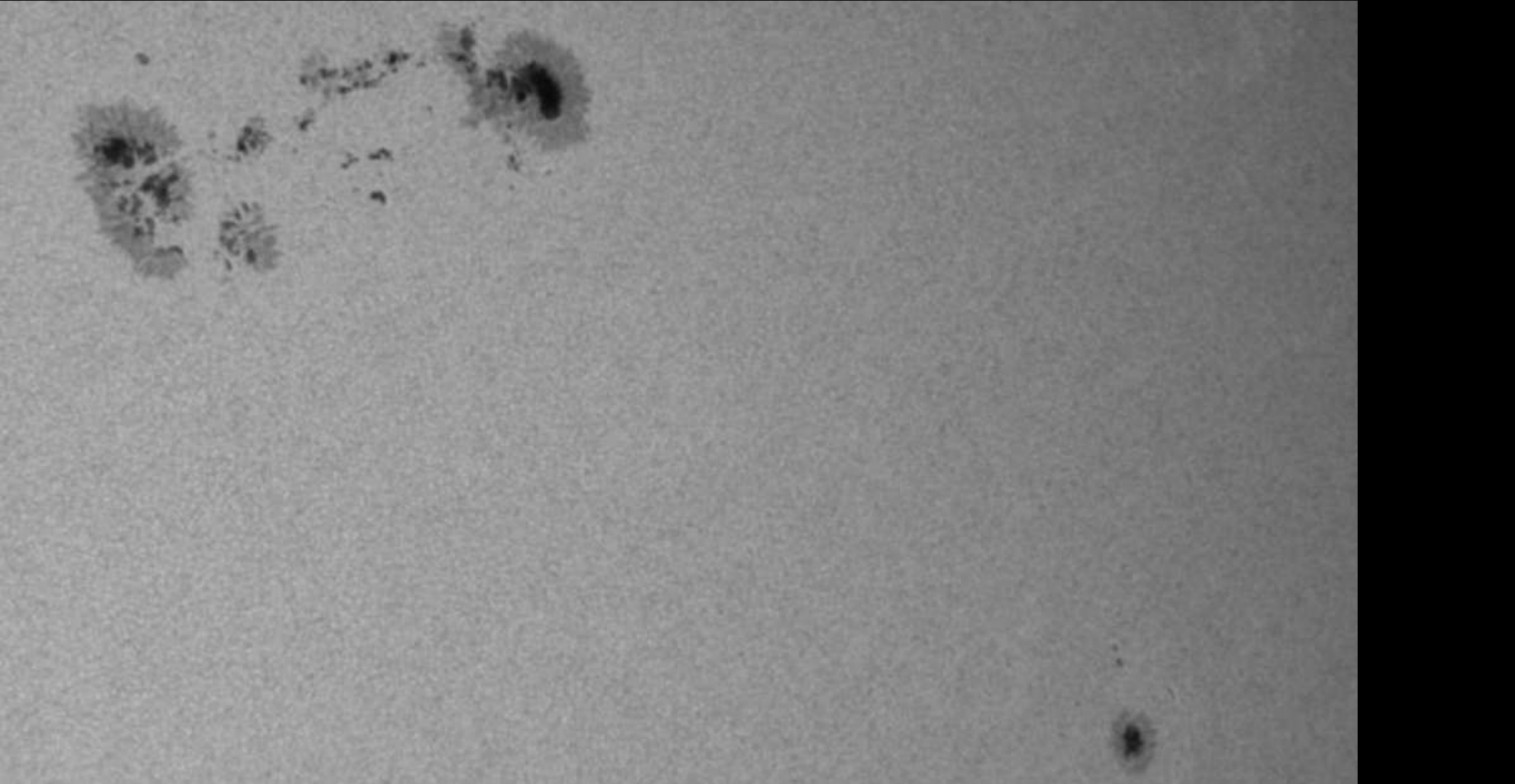




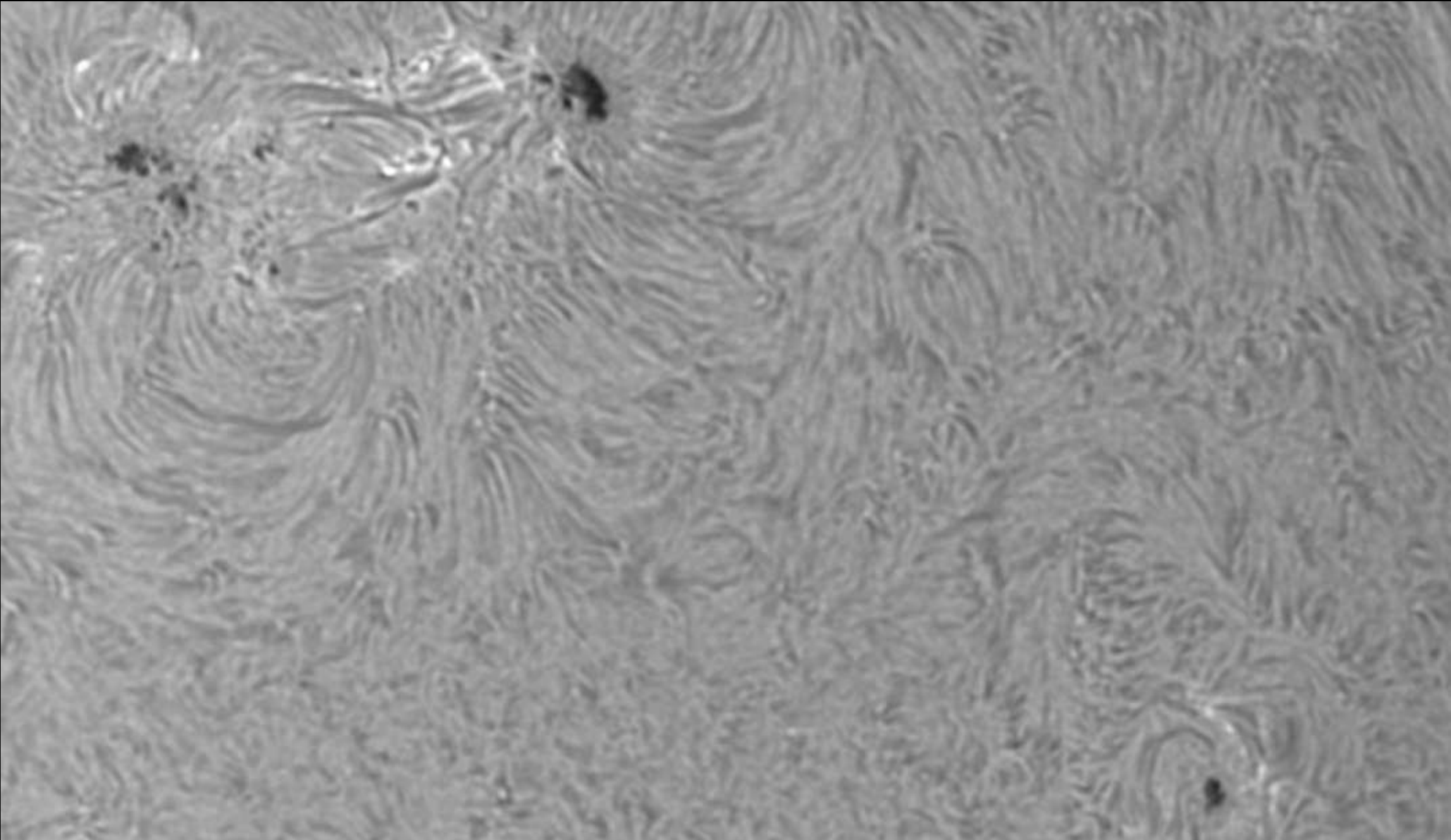


CIR / CH HSS

CIR: Co-rotating  
Interaction Region

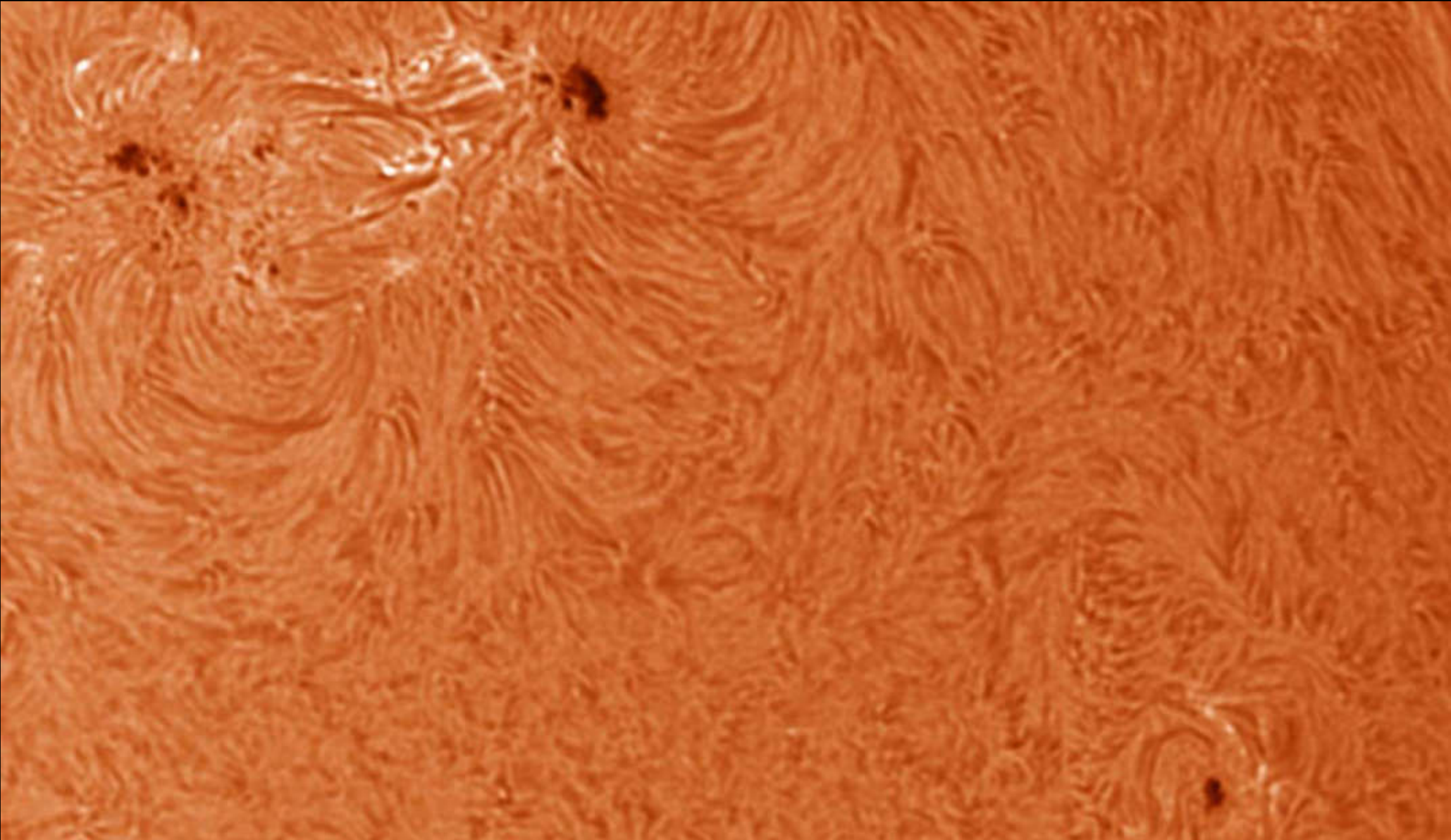


2022-06-22 Fotosfeer Groen filter – B&W

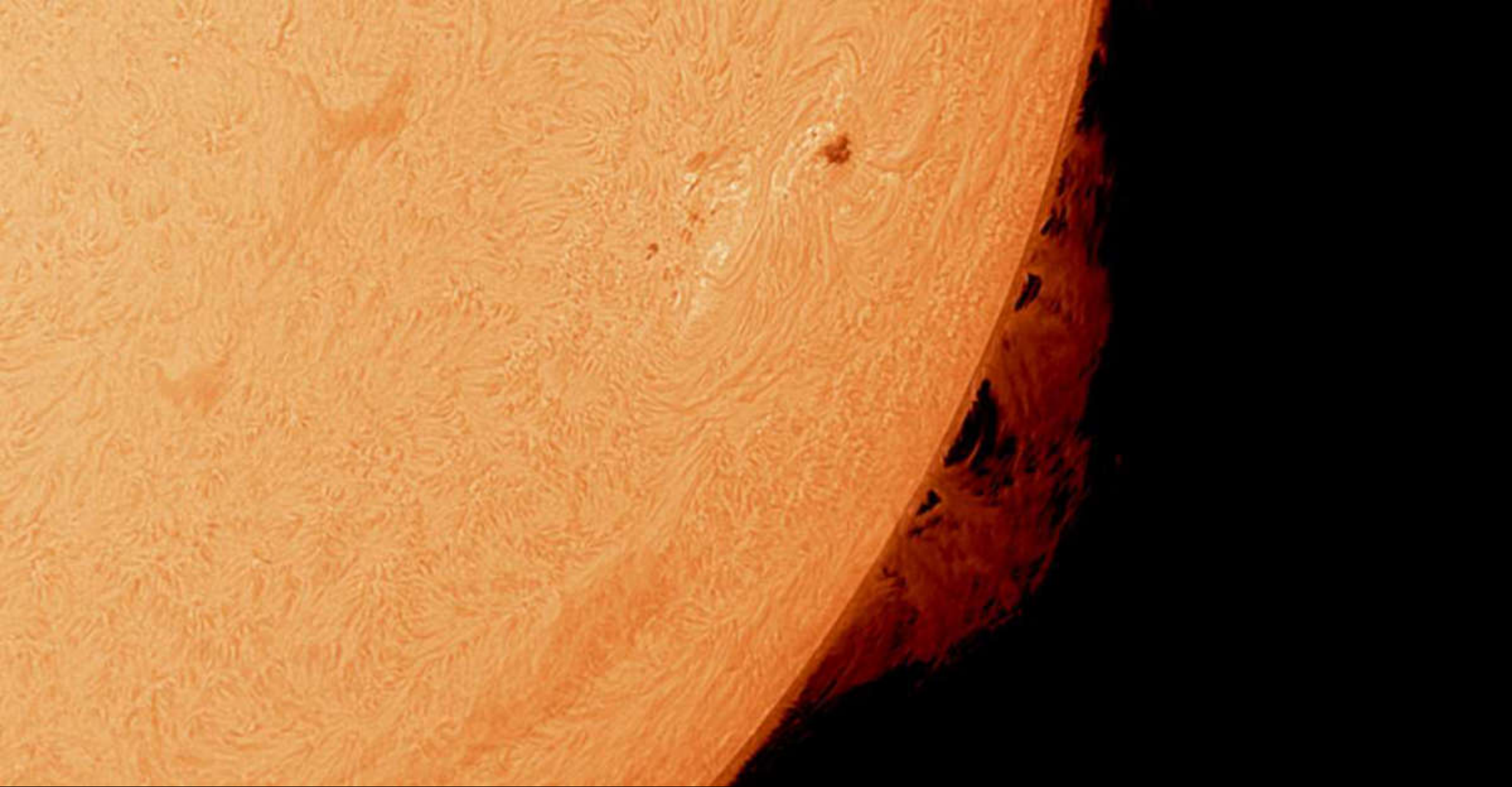


2022-06-22 Chromosfer Quark H $\alpha$  – B&W





2022-06-22 Chromosfeer Quark H $\alpha$  - valse kleuren



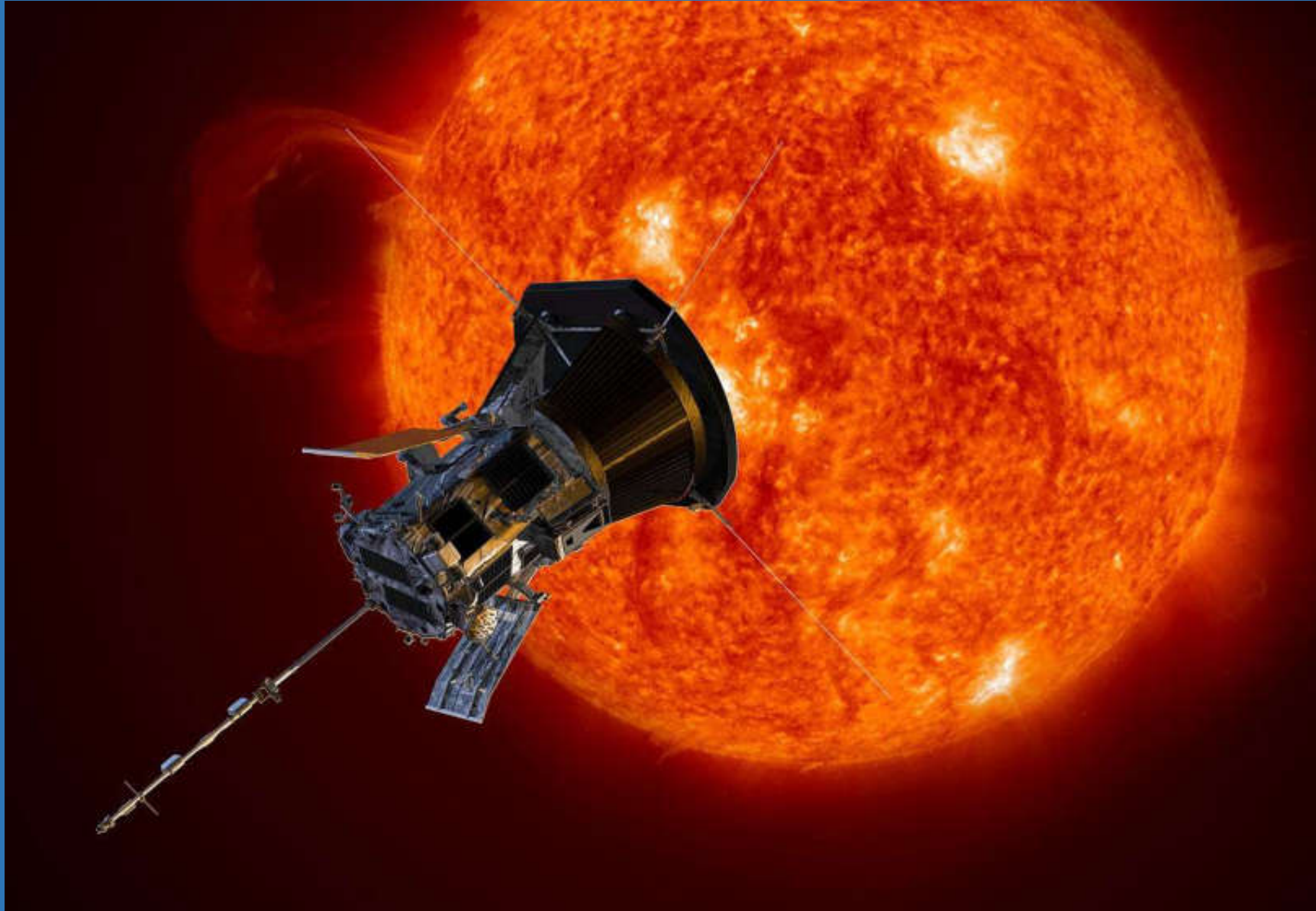
2022-07-16 Quark H $\alpha$  - valse kleuren





2022-08-28 Quark H $\alpha$  - valse kleuren





Parker Solar Probe

NASA

*2018-08-12*

SCIENCE & EXPLORATION

# solar orbiter

Taking the closest ever images of the Sun, observing the solar wind and the Sun's polar regions like never before, unravelling the mysteries of the solar cycle

ESA

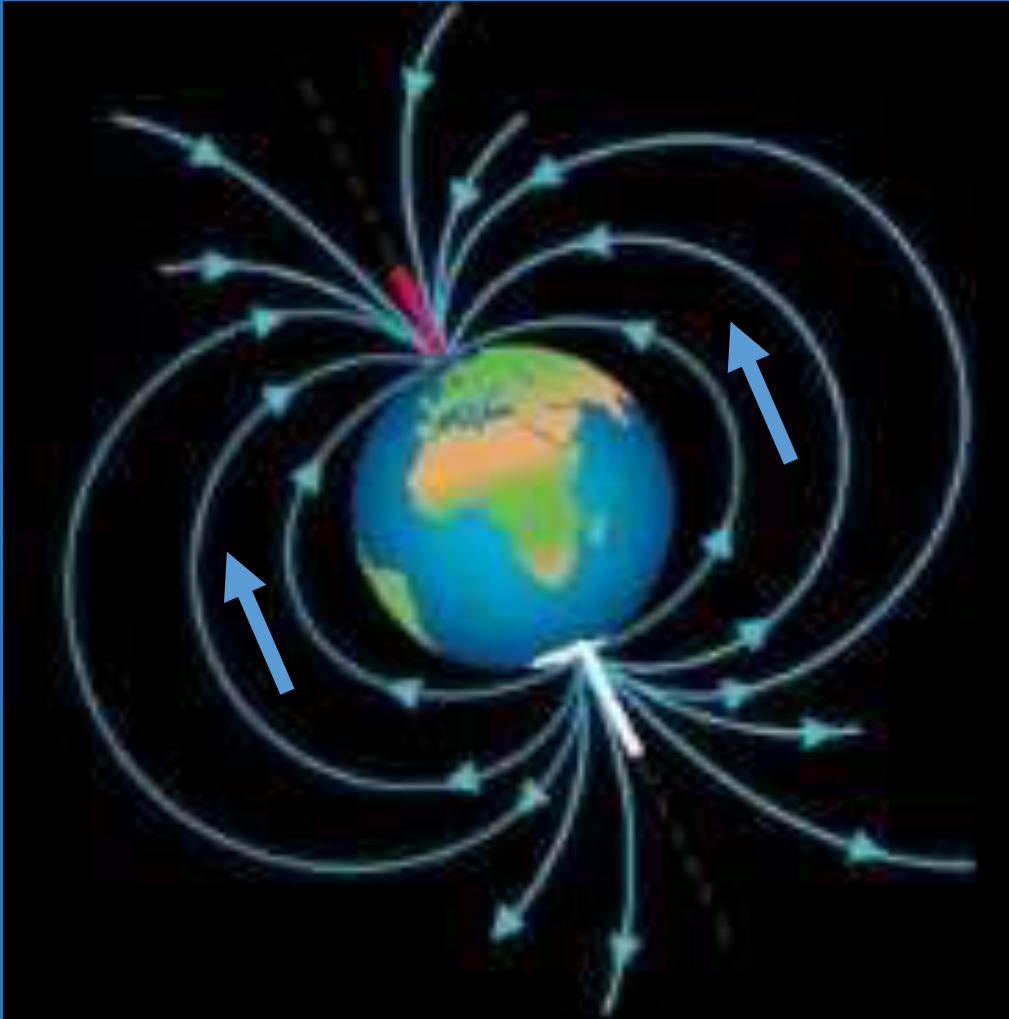
*2020-02-10*



Aarde

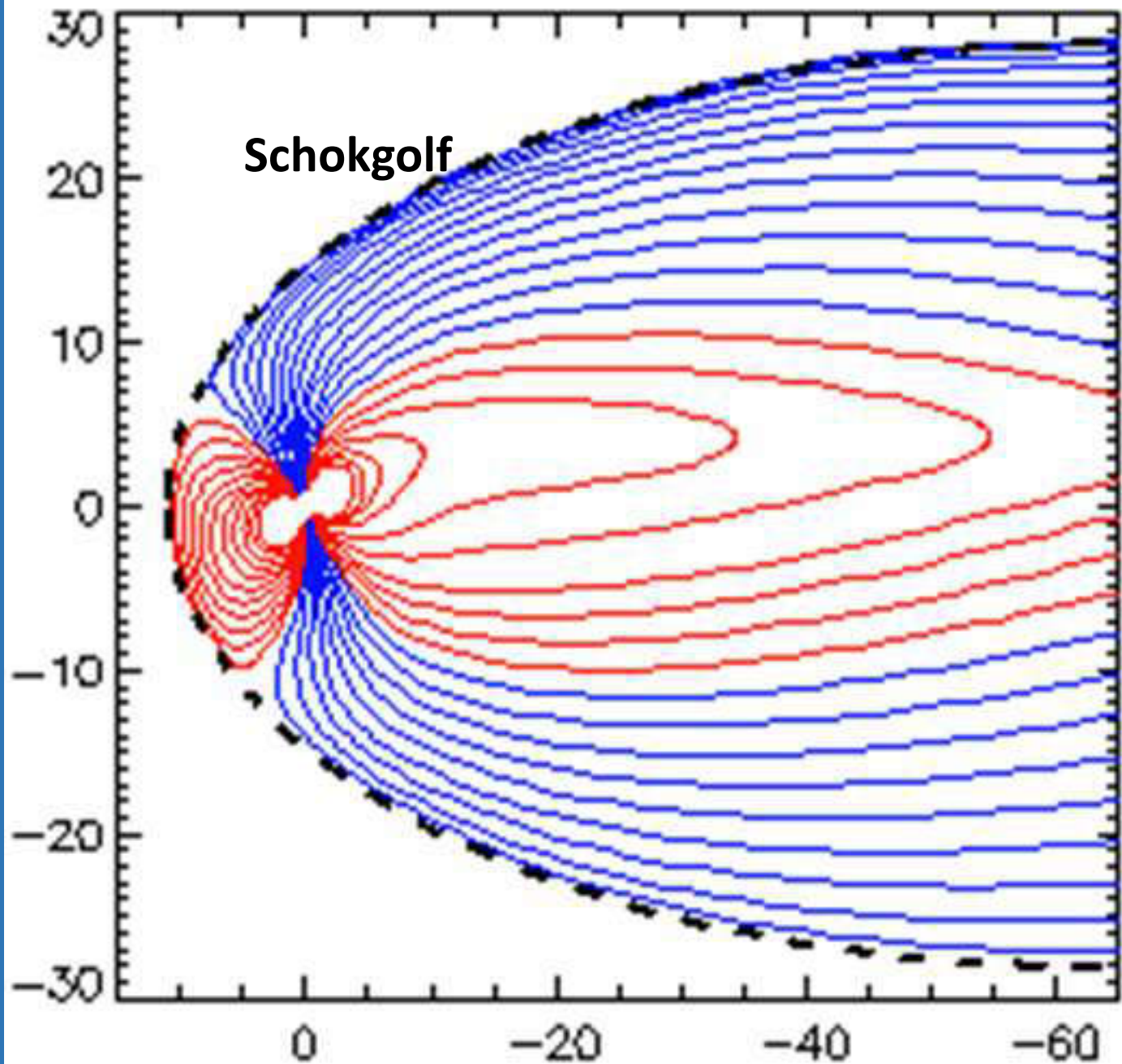


## Magnetisch veld aarde



Richting magnetisch veld  
aarde in de atmosfeer is  
van Zuid naar Noord.



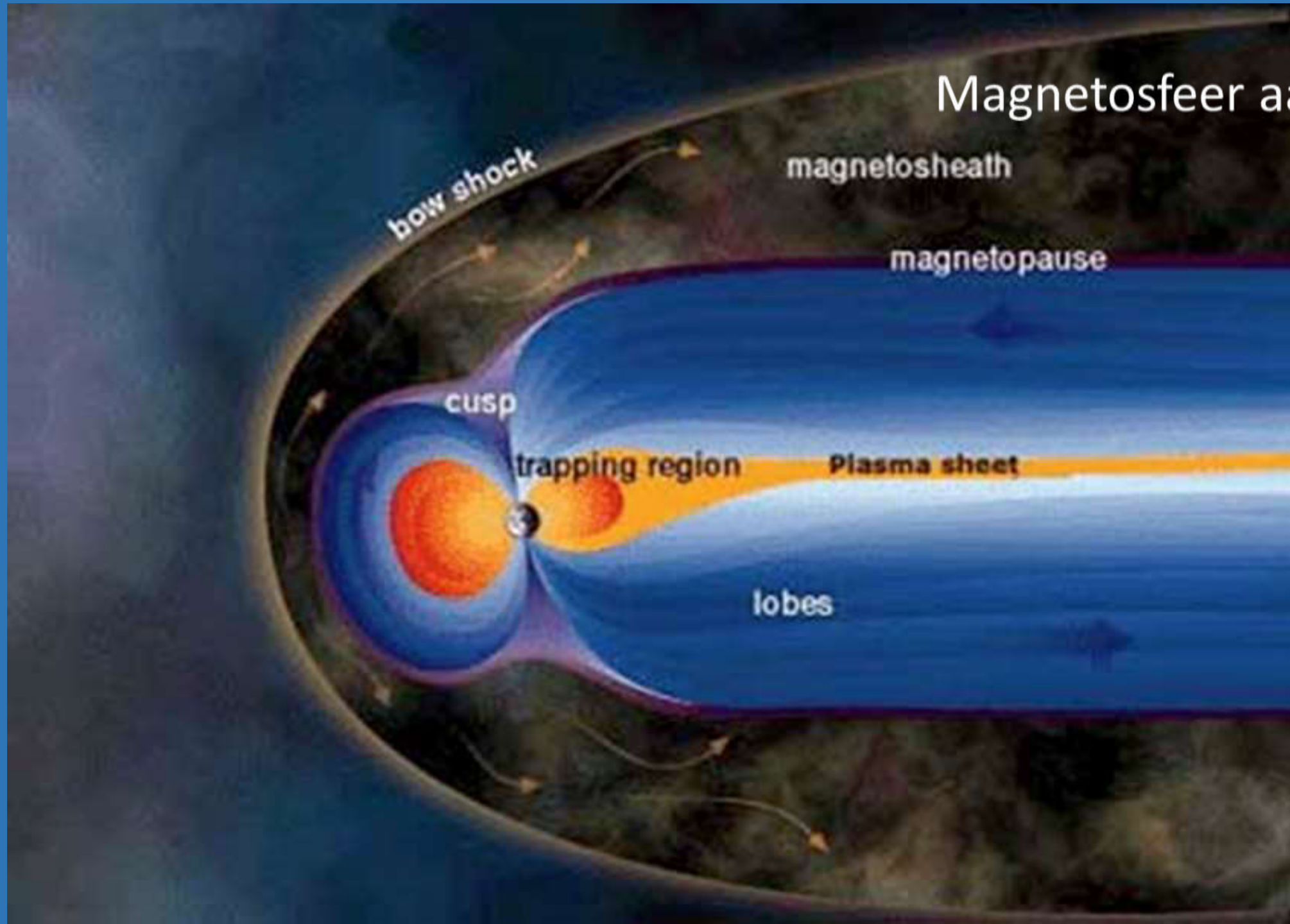


## Magnetosfeer aarde

Effect zonnwind:

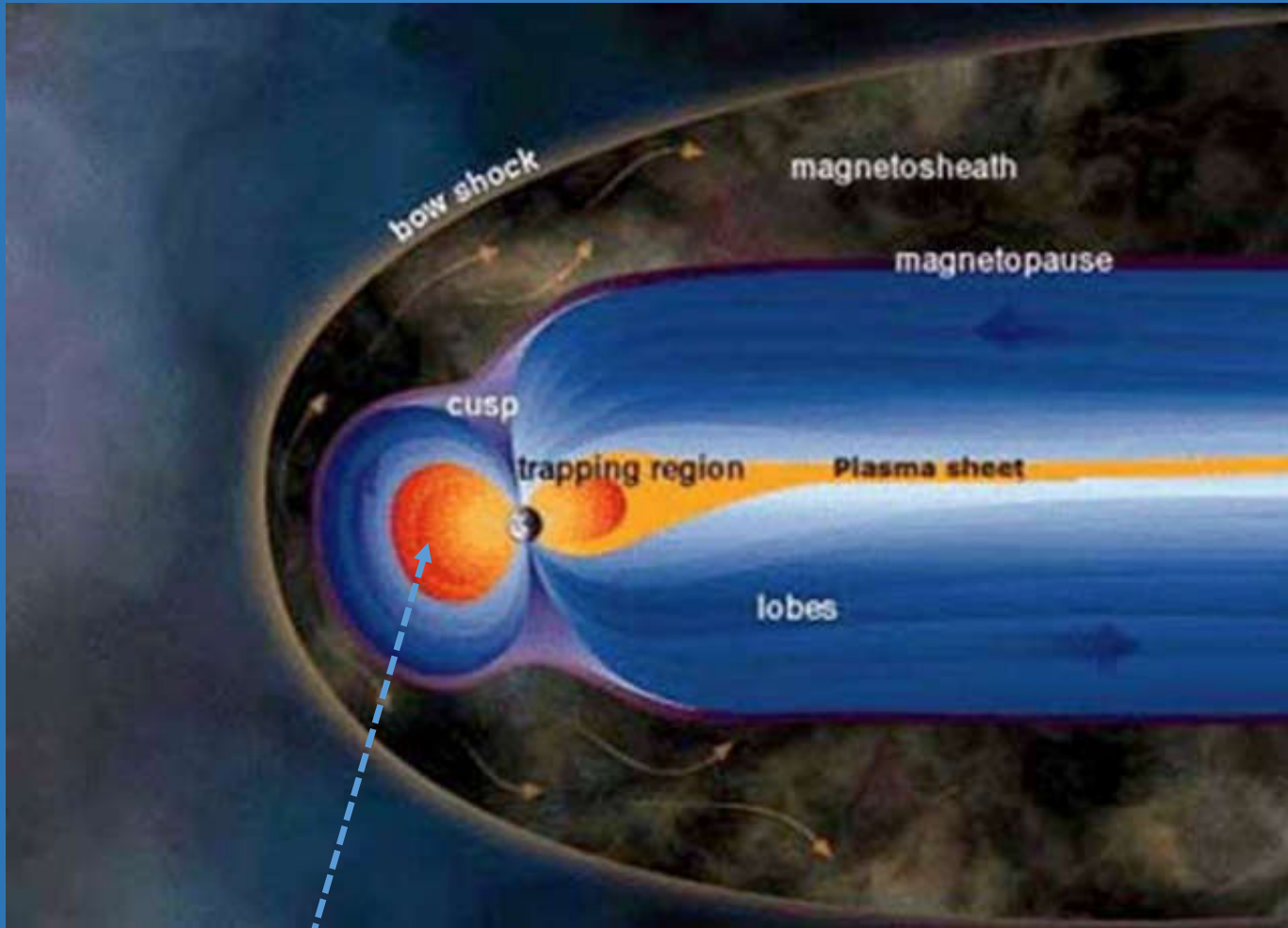
- Constante vervorming;
- Veel opgeslagen energie.

# Magnetosfeer aarde

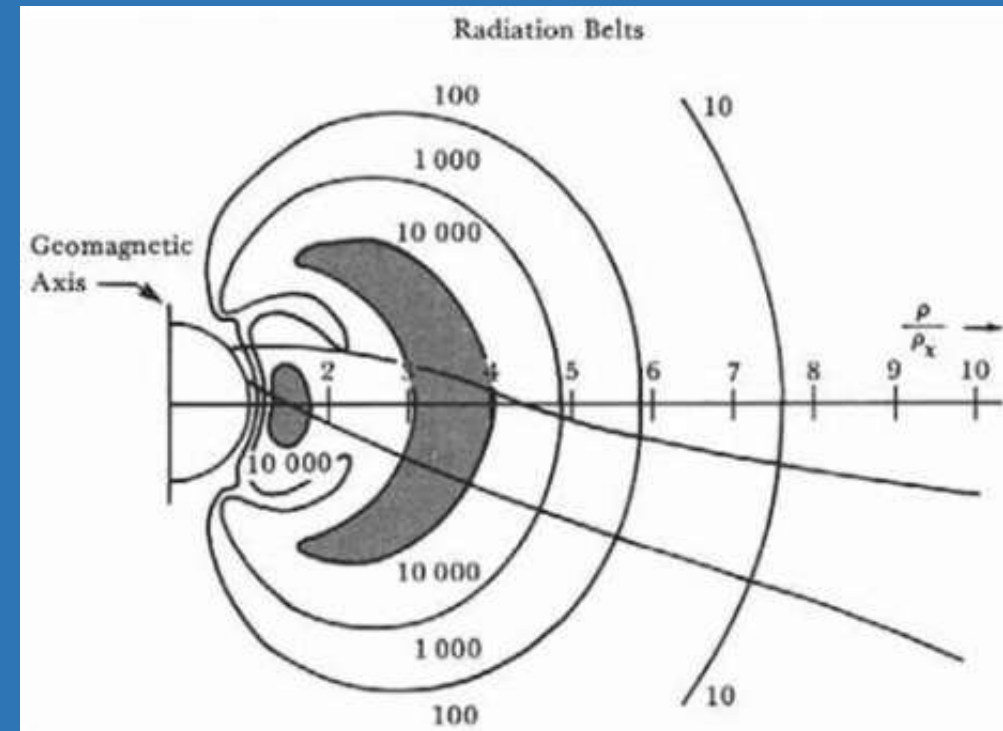


# Magnetosfeer aarde

James van Allen: 1958  
Geigerteller Explorer 1.

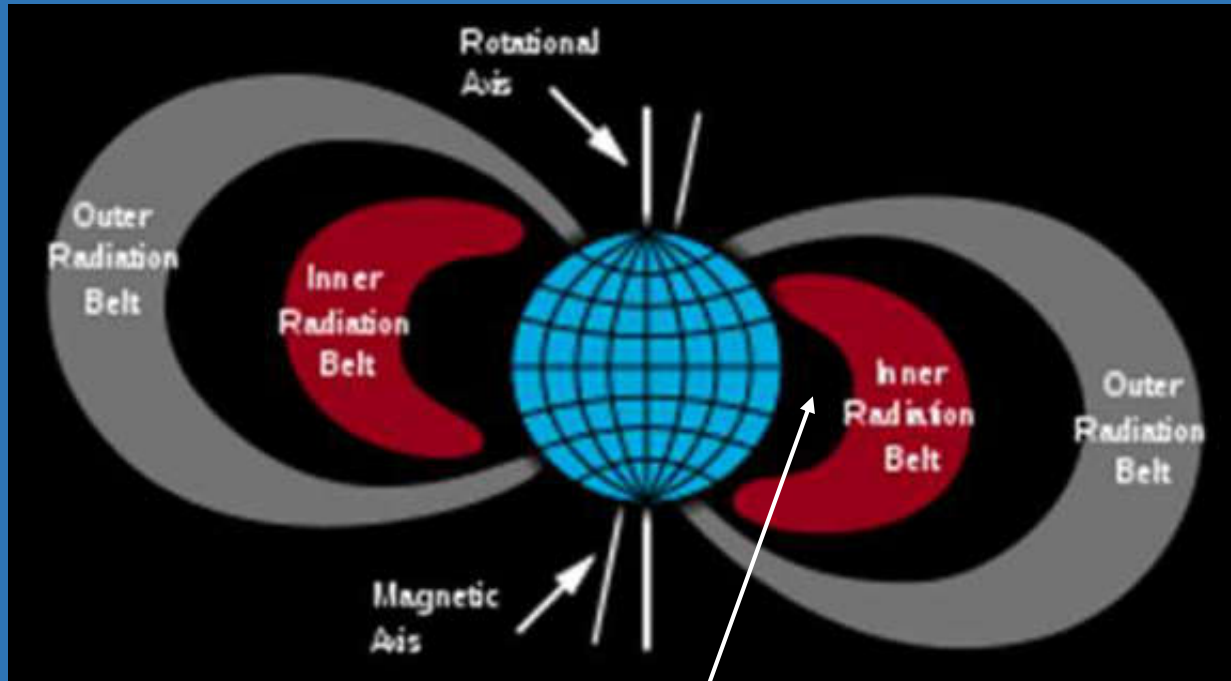


Van Allen Radiation Belts





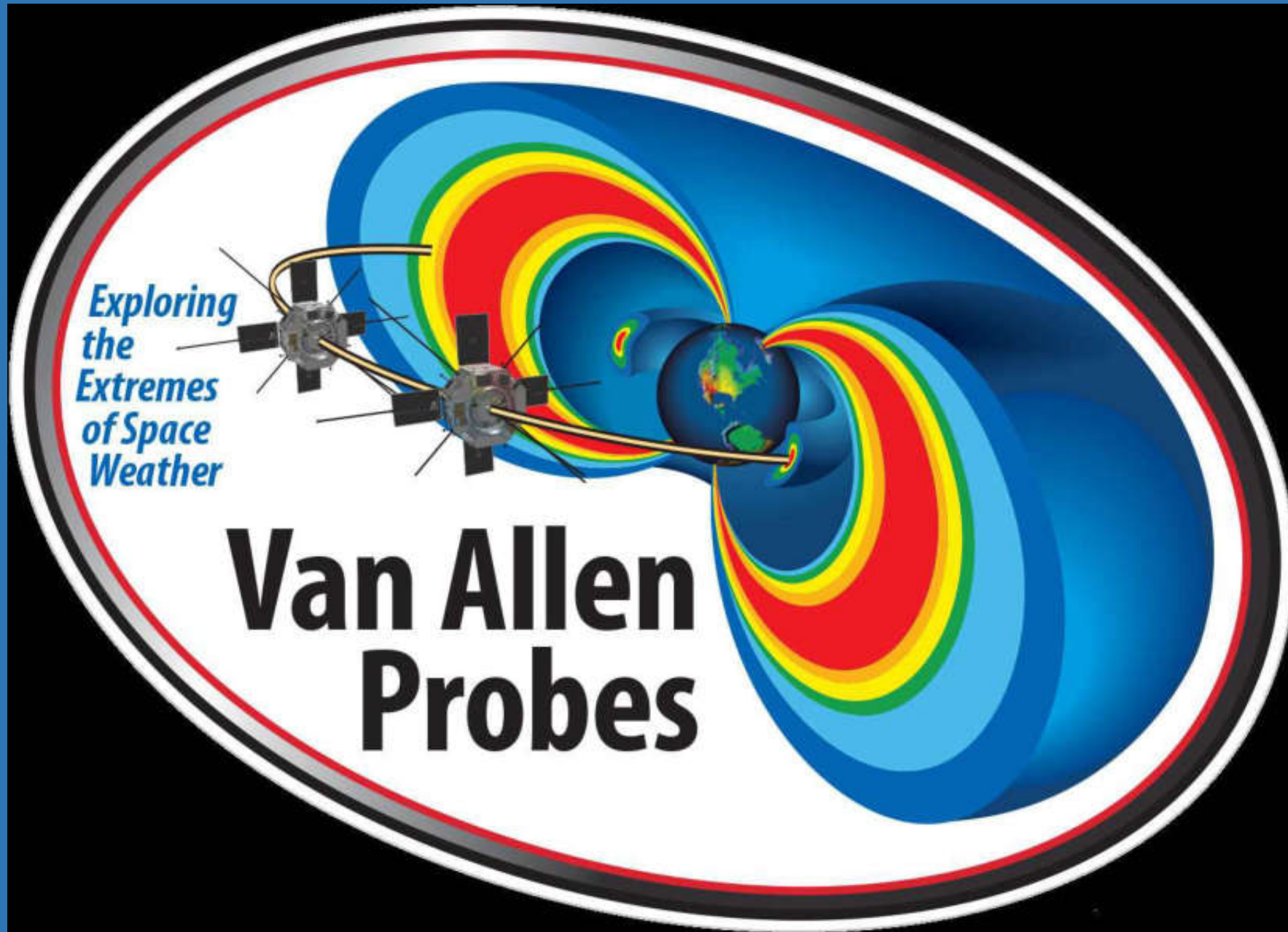
# Van Allen Radiation Belts



ISS & Hubble

Inner:  
Protonen (kosmische straling)

Outer:  
Elektronen (zonnwind)



Van Allen Probes

Probe A & Probe B

*2012-08-30*

2019 uit bedrijf.

Werking Noorderlicht.



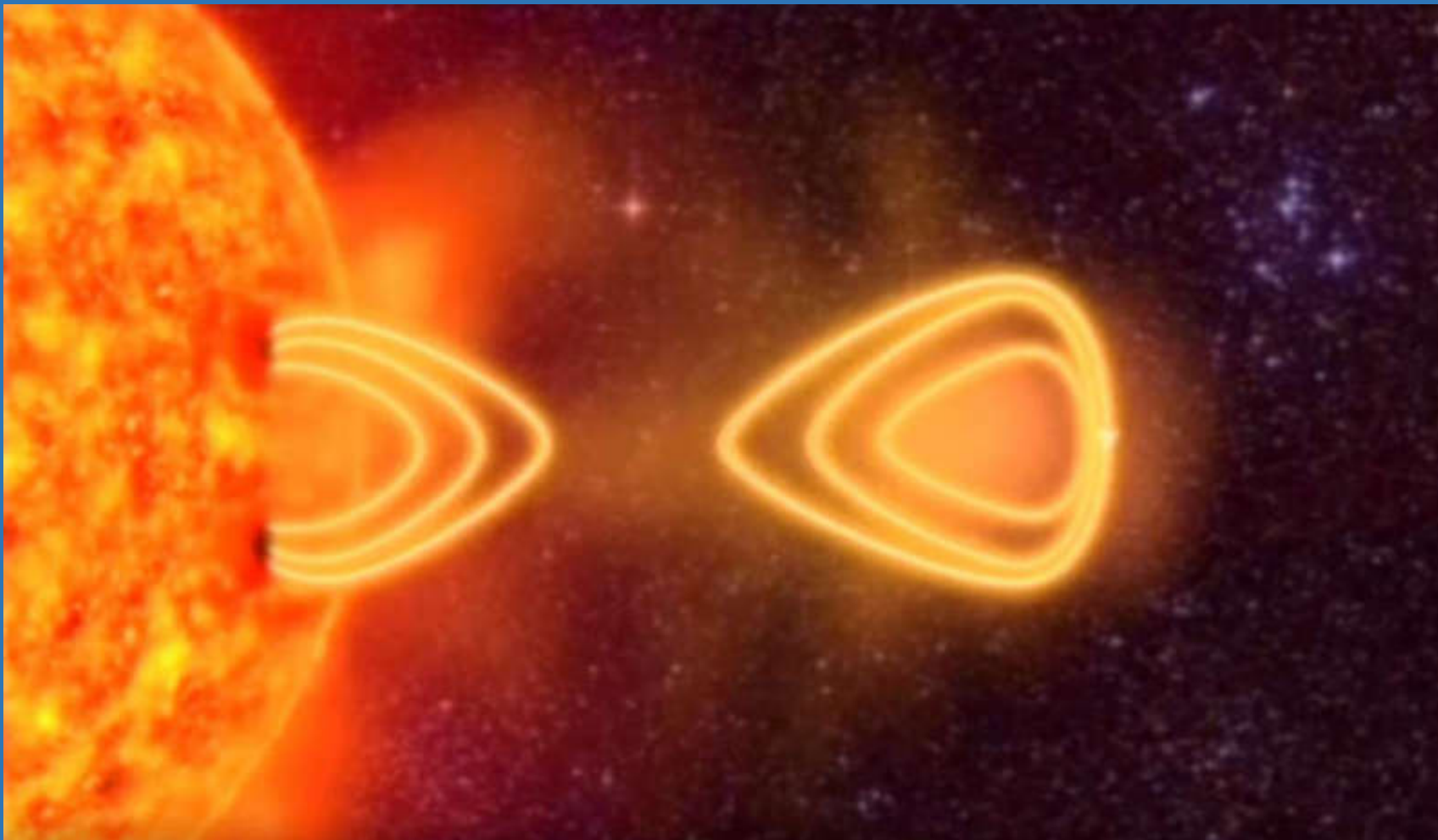
## Dungey cycle - 1961

James Dungey

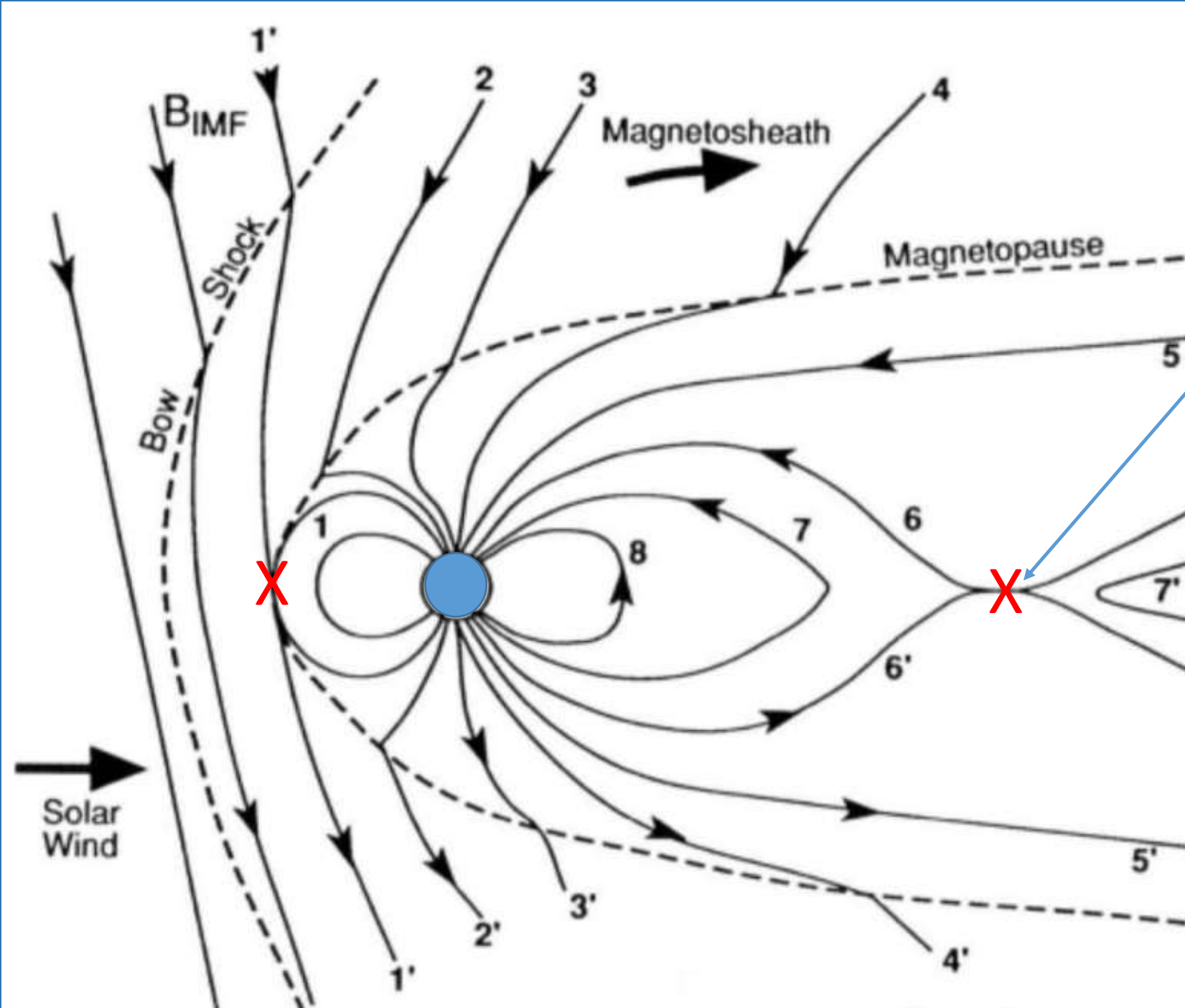
Zonnestorm én IMF met magnetische veldrichting tegengesteld aan aarde.

Magnetische reconnectie

- Dagkant aarde;
- Nachtkant aarde.







# Dungey cycle

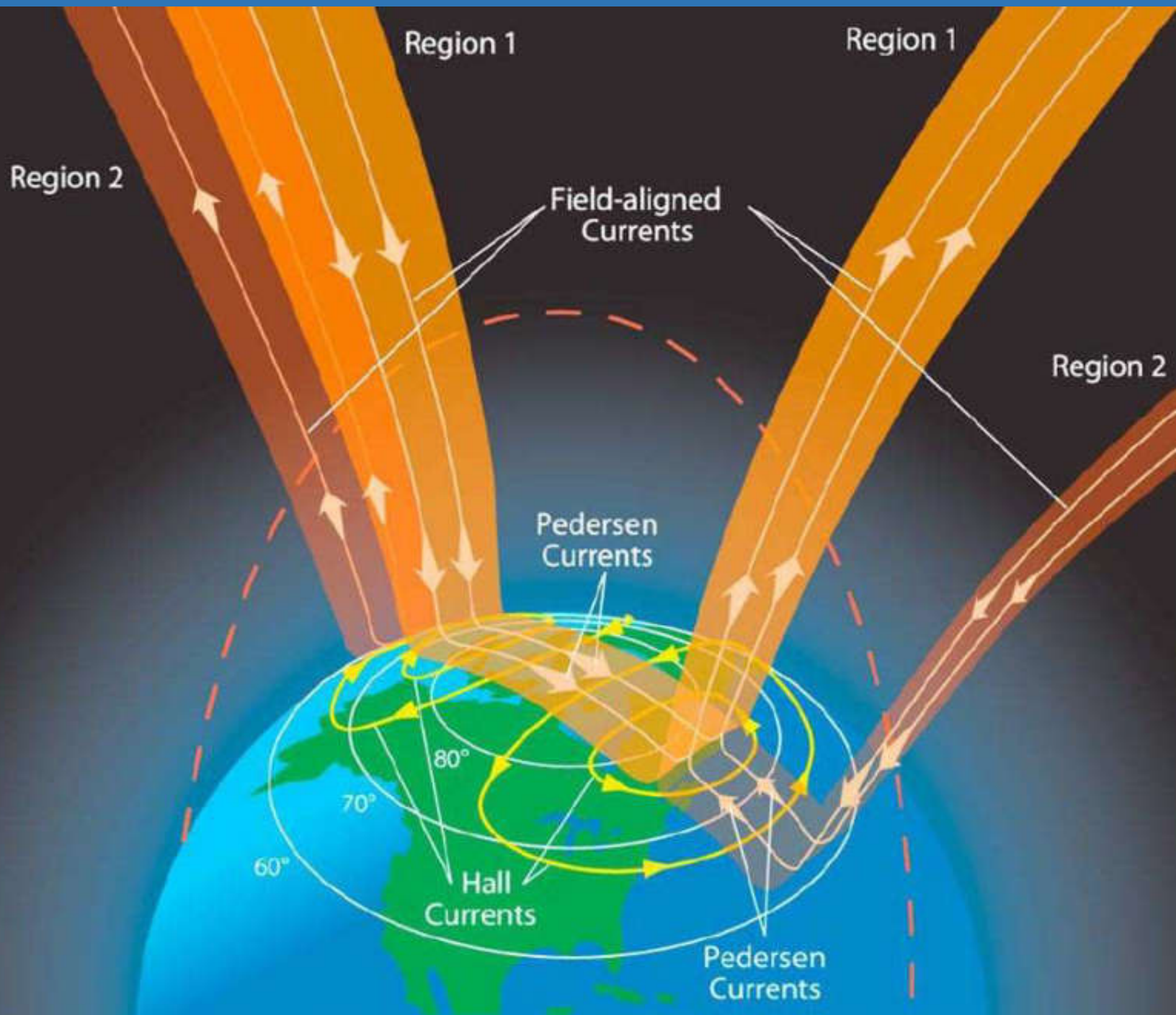
**X** Magnetische reconnectie

Nachtkant aarde:

*Elektronen* worden versneld richting N & Z pool en botsen op atmosfeer:

***Noorderlicht & Zuiderlicht;***

*Plasma* verdwijnt de ruimte in.



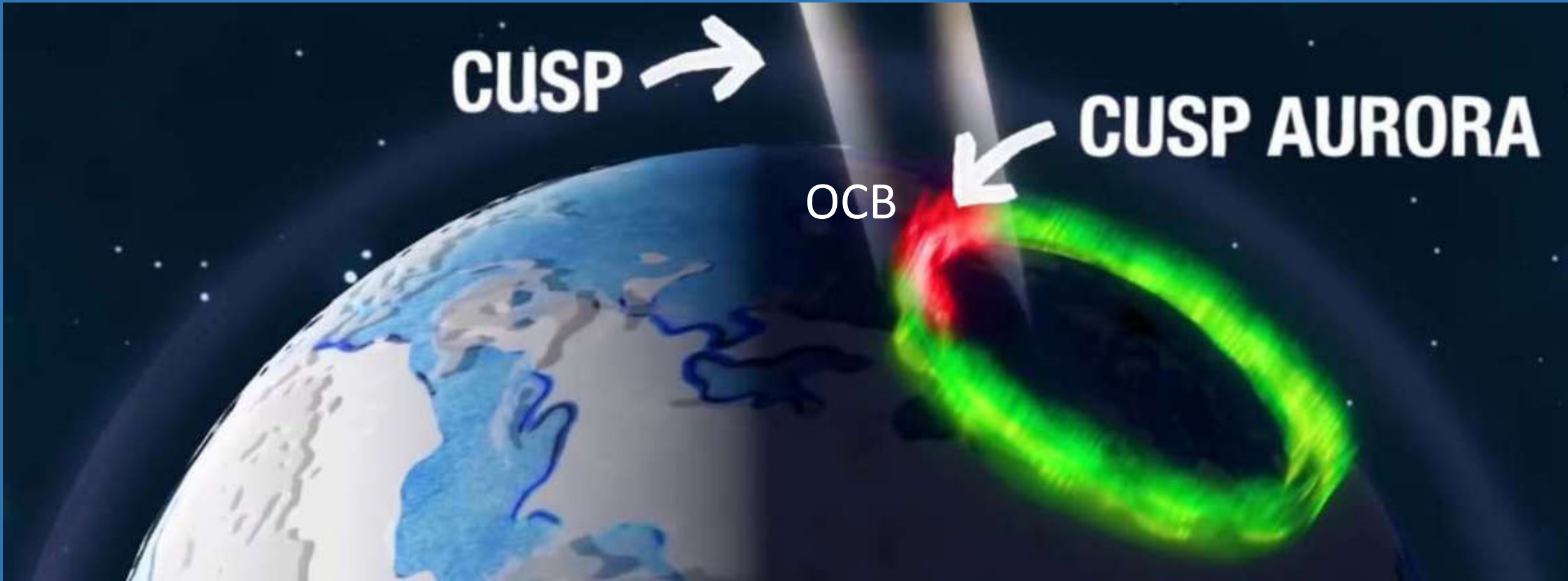
Birkeland currents  
of  
Field-aligned Currents

Elektrische stromen die  
de Magnetosfeer met de  
Ionosfeer verbinden.

**CUSP** →

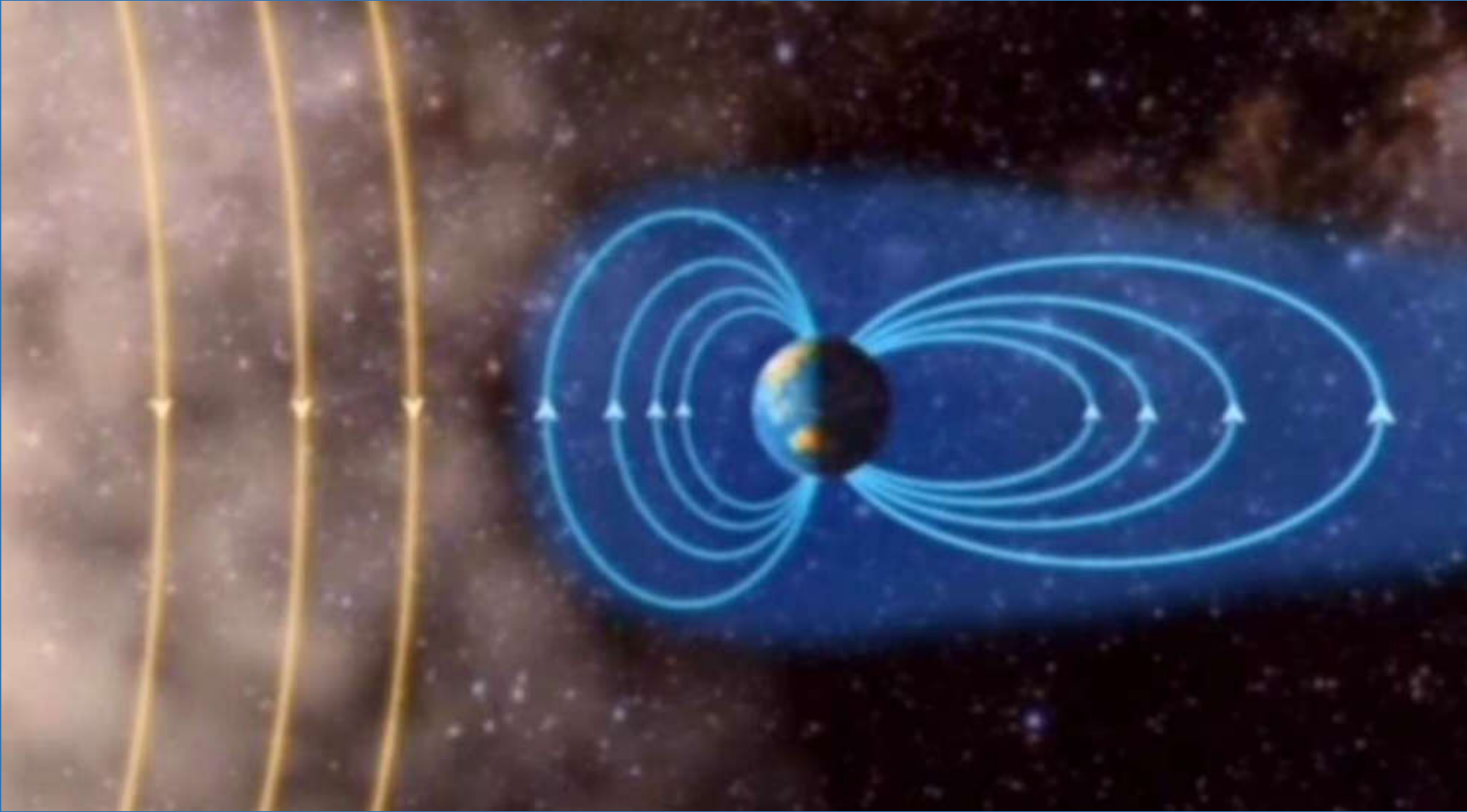
**CUSP AURORA**

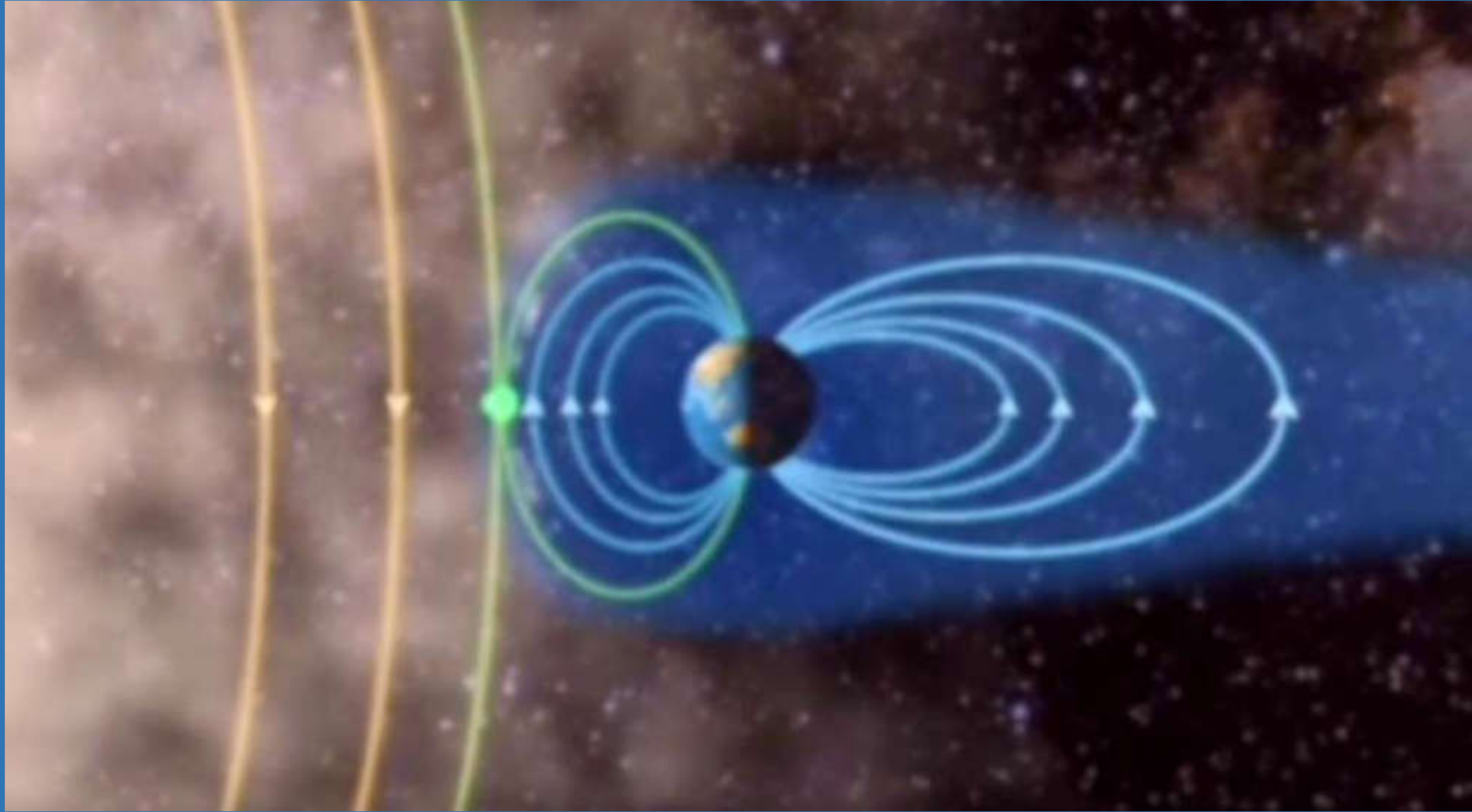
OCB

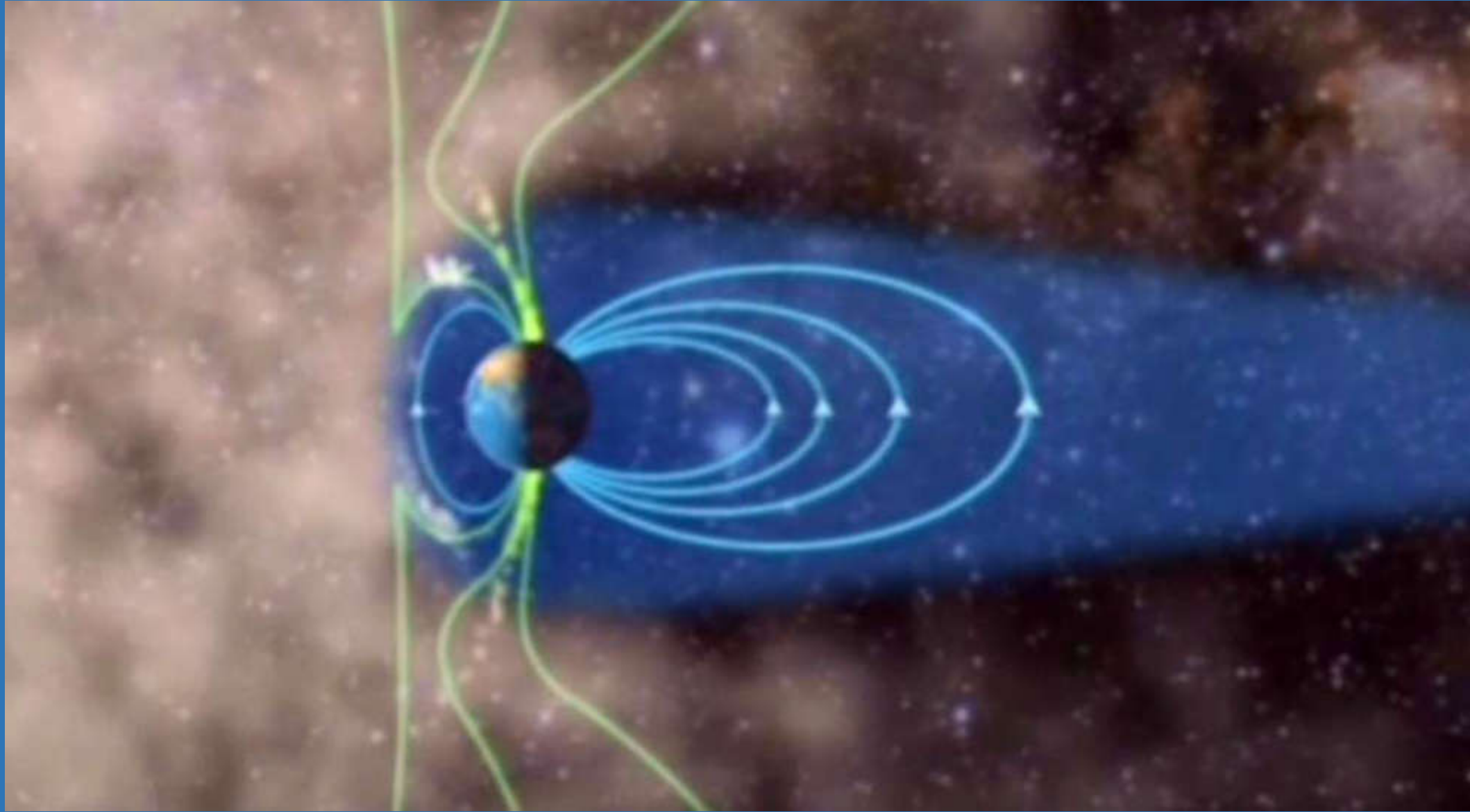




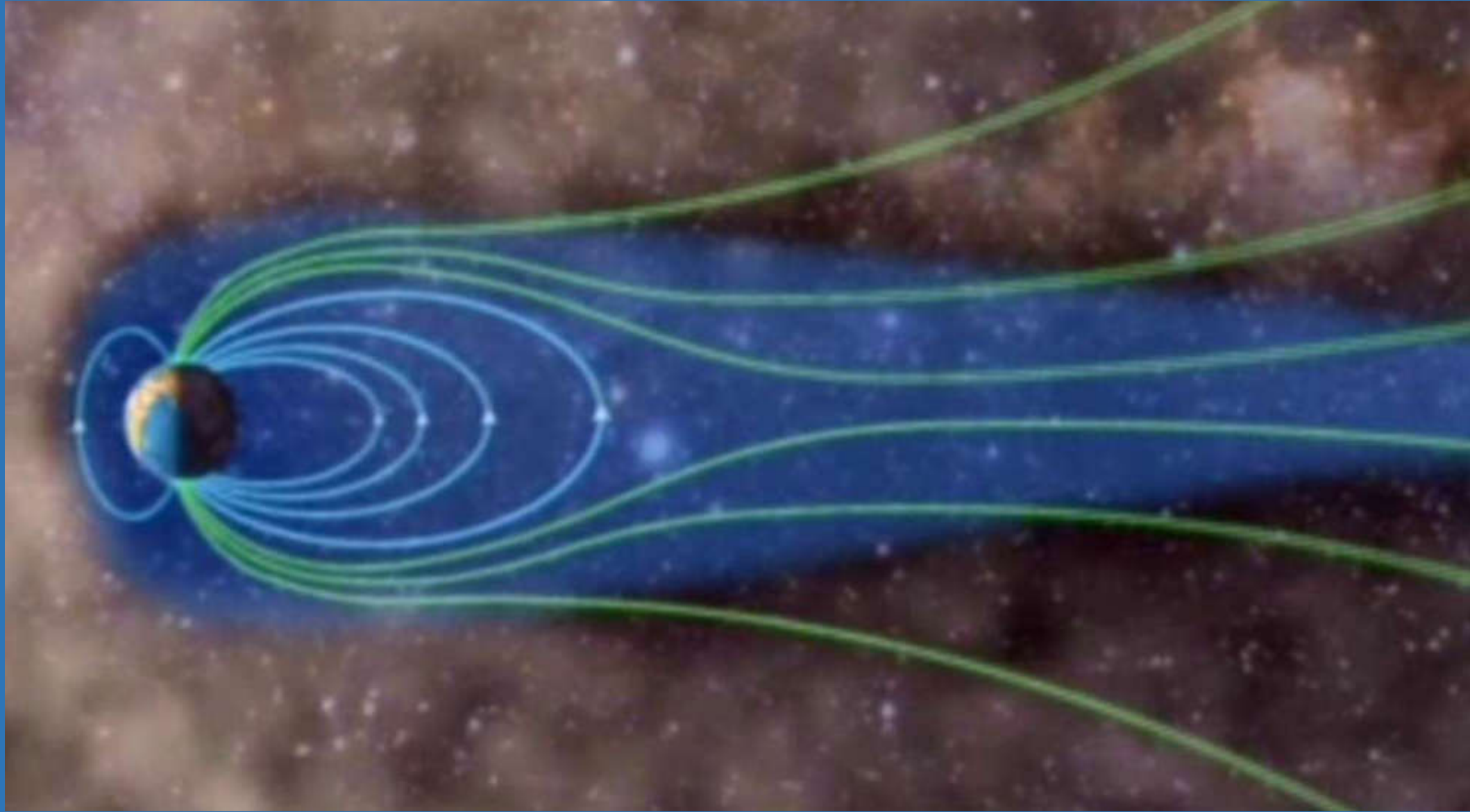
# Dungey cycle

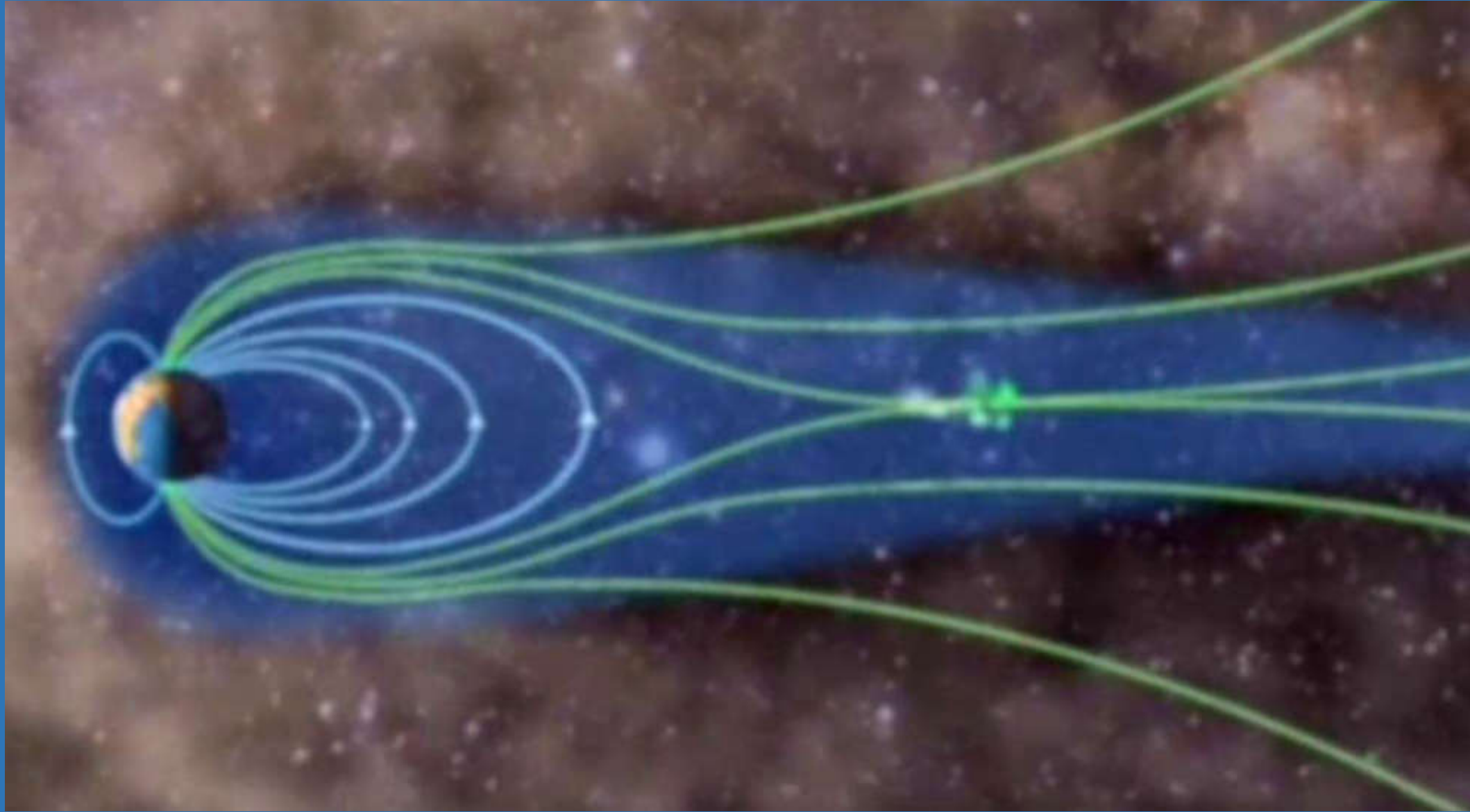




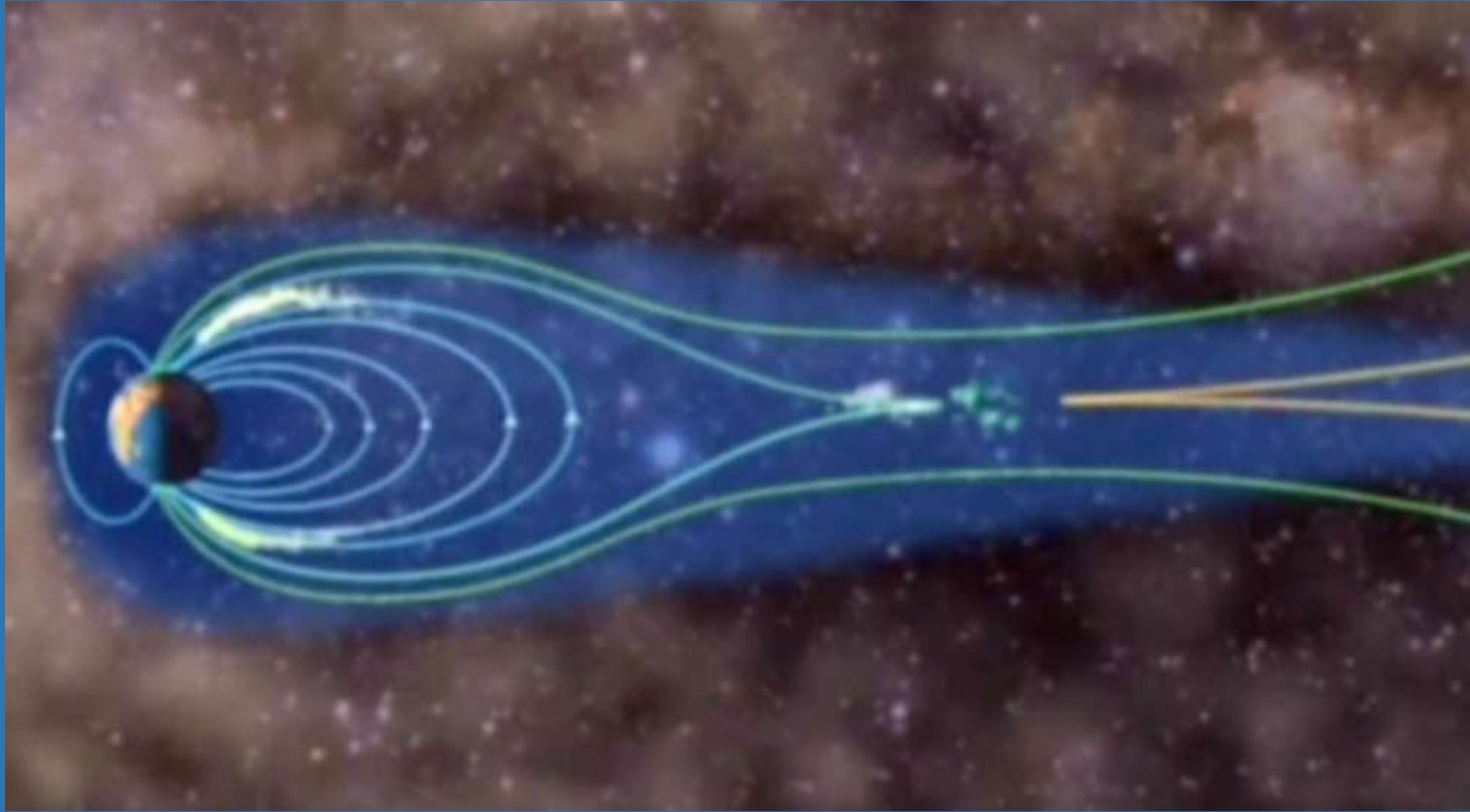
















# Hoofdstuk 3 – Ruimteweerbericht





NOAA – National Oceanic and Atmospheric Administration

<https://www.swpc.noaa.gov/>

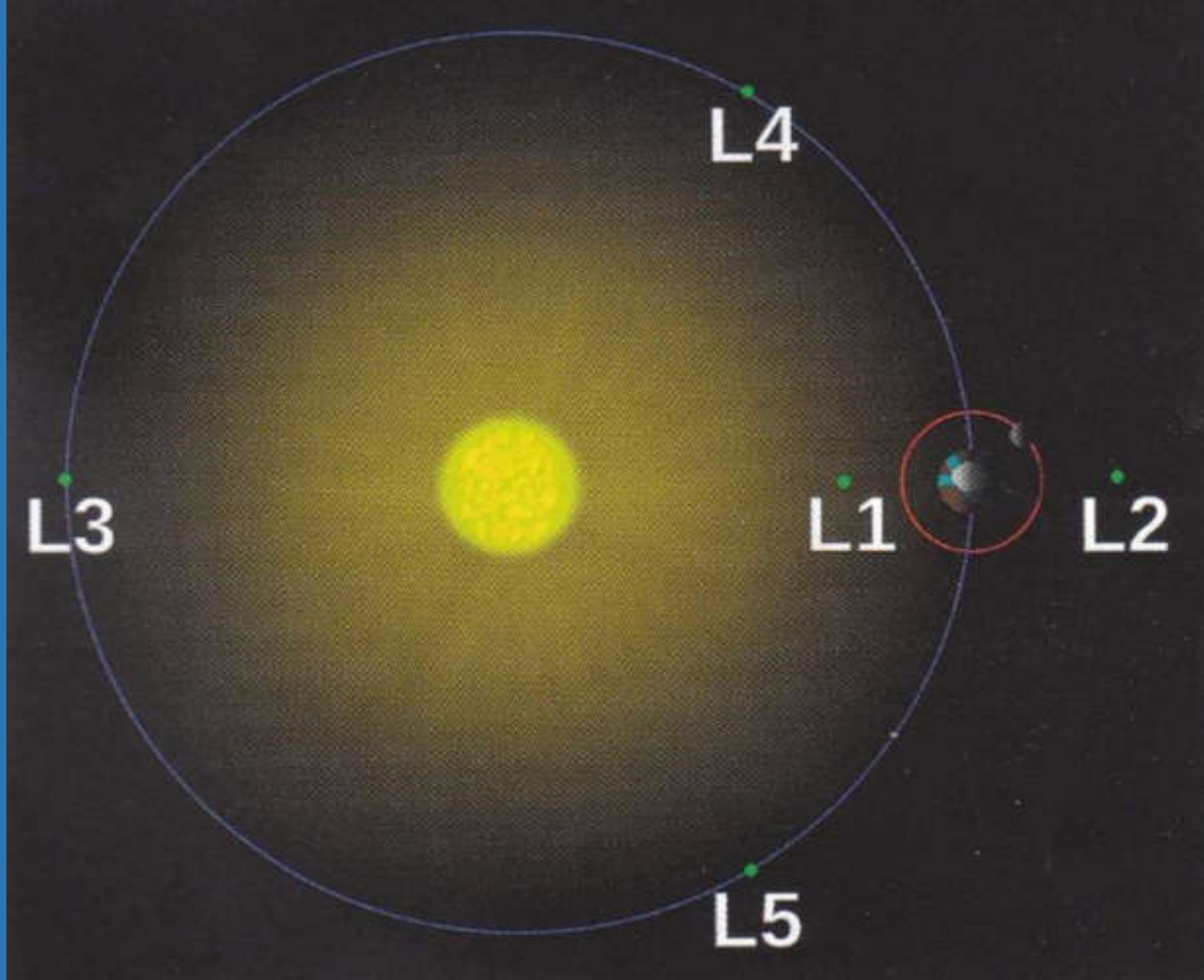


**SWPC**

Space Weather  
Prediction Center

Boulder  
Colorado





## Satellieten in L1

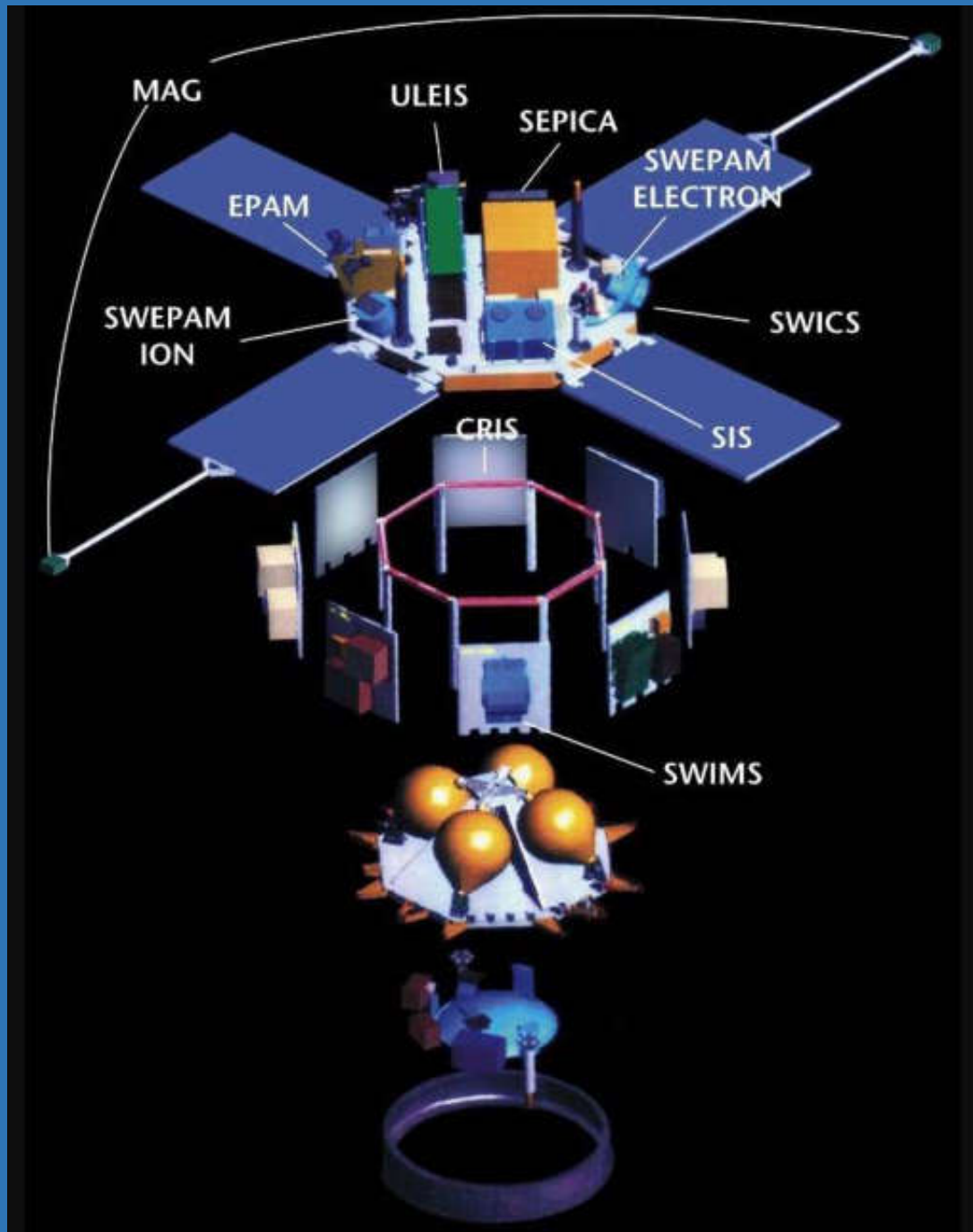
Zon – L1 = 0,99 AU

L1 – aarde = 0,01 AU

Na 30 – 60 min is zonnewind van L1 bij aarde.

**SEPs te snel om op te reageren.**

**X-Ray komt zonder vertraging aan.**



## Satellieten in L1

ACE                      Advanced Composition Explorer

NASA

*1997-08-25*

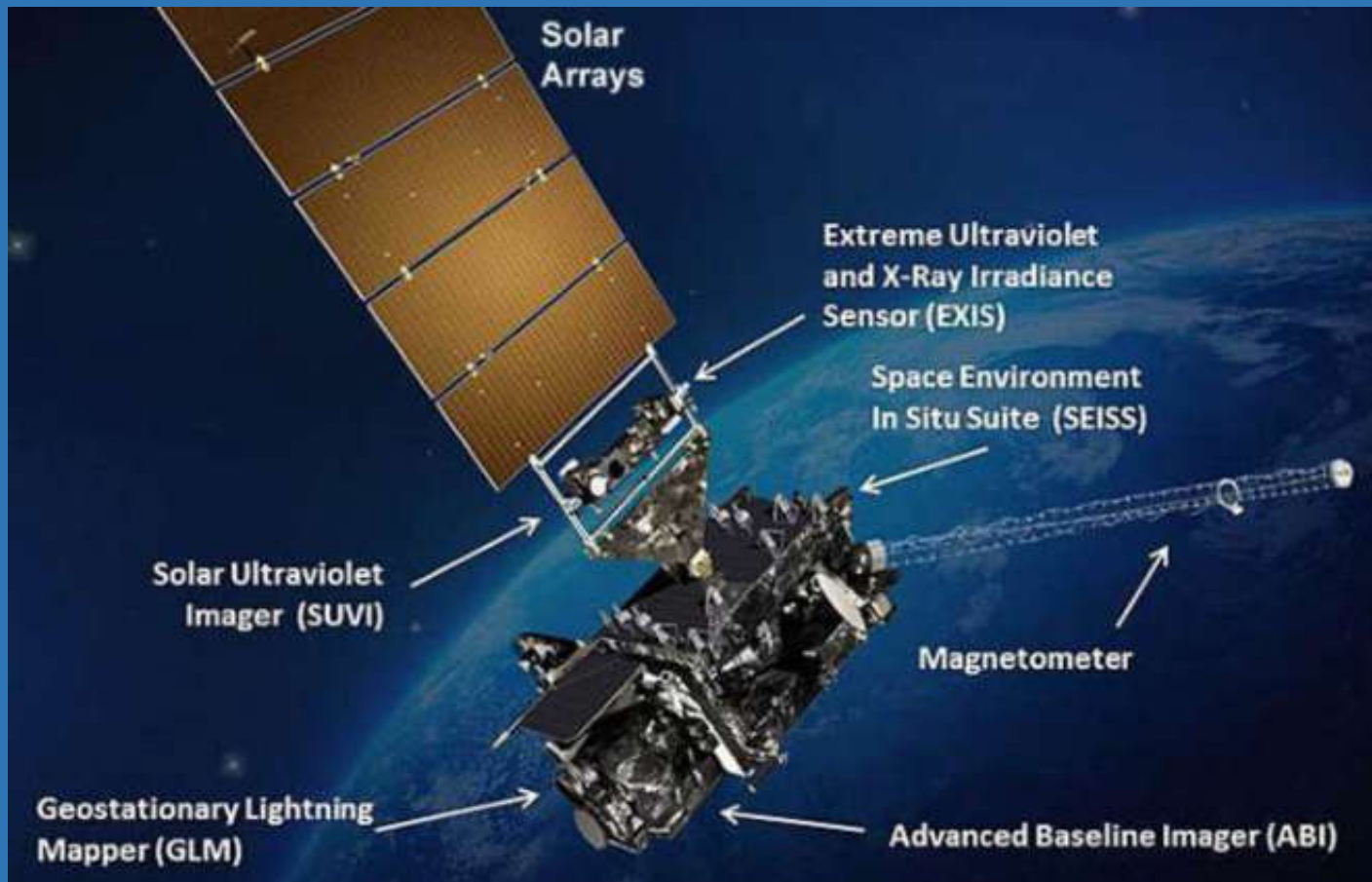
SWEPEAM – Solar Wind Electron, Proton and Alpha Monitor.

# Satellieten in baan om aarde

GOES Geostationary Operational Environmental Satellites

NOAA

GOES 16 2016-11-19 East  
GOES 18 2022-03-01 West



2023-10-15 Voorbeeld 3-Day forecast





## SPACE WEATHER CONDITIONS on NOAA Scales

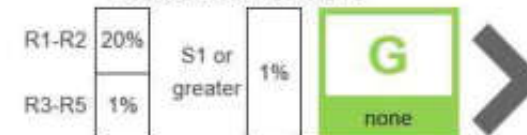
24-Hour Observed Maximums



Latest Observed



Predicted 2023-10-15 UTC



Solar Wind Speed: **403** km/sec

Solar Wind Magnetic Fields: Bt **2** nT, Bz **-1** nT

Noon 10.7cm Radio Flux: **148** sfu

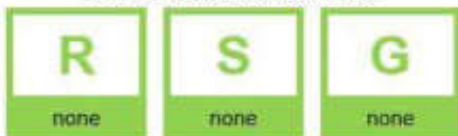
## SPACE WEATHER ENTHUSIASTS DASHBOARD





SPACE WEATHER CONDITIONS on NOAA Scales

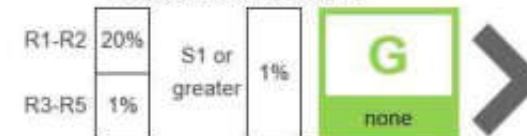
24-Hour Observed Maximums



Latest Observed



Predicted 2023-10-15 UTC

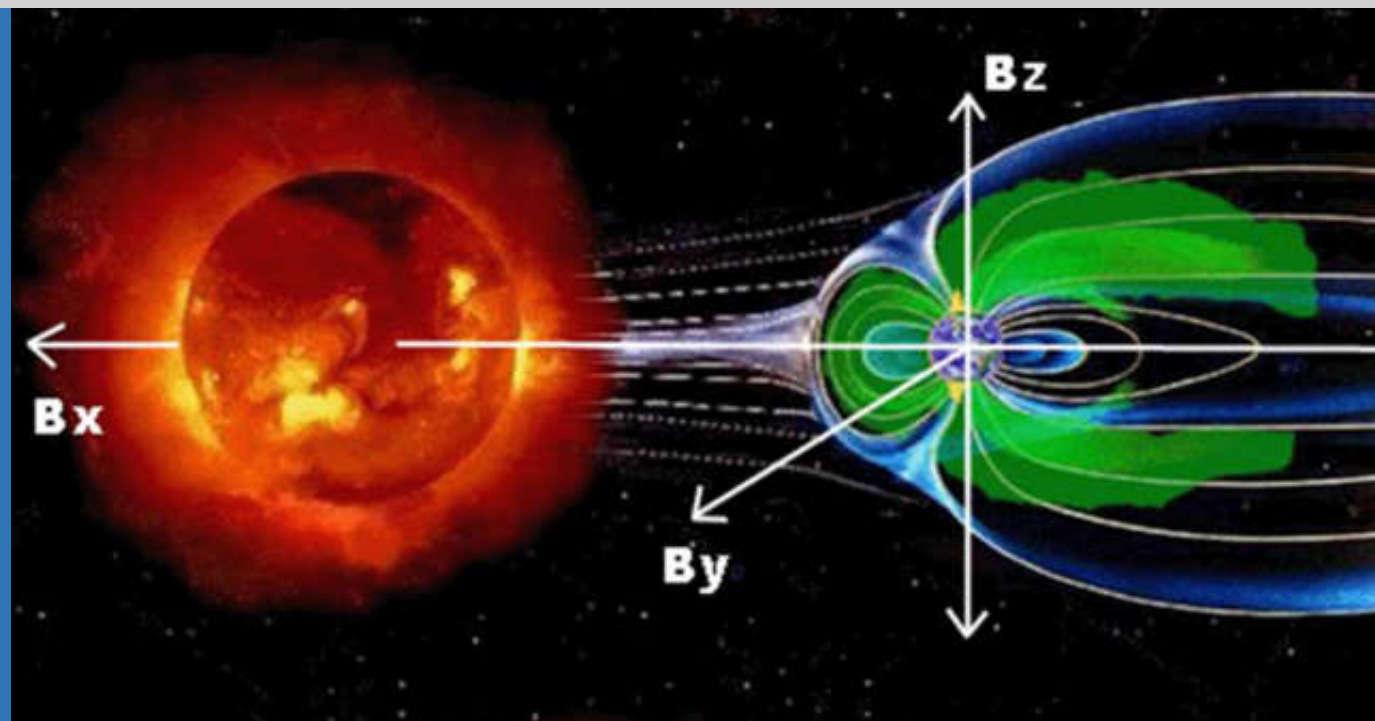
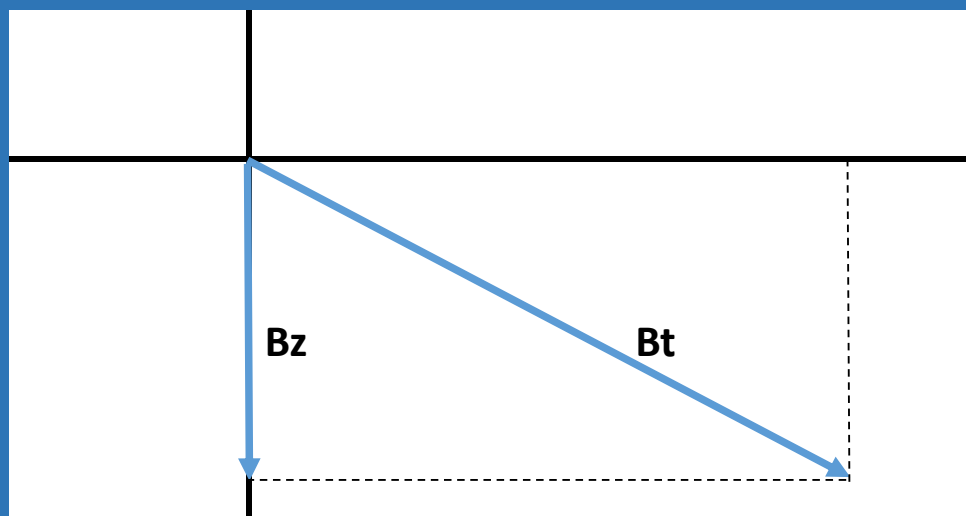


Solar Wind Speed: **403** km/sec

Solar Wind Magnetic Fields: Bt **2** nT, Bz **-1** nT

Noon 10.7cm Radio Flux: **148** sfu

SPACE WEATHER ENTHUSIASTS DASHBOARD

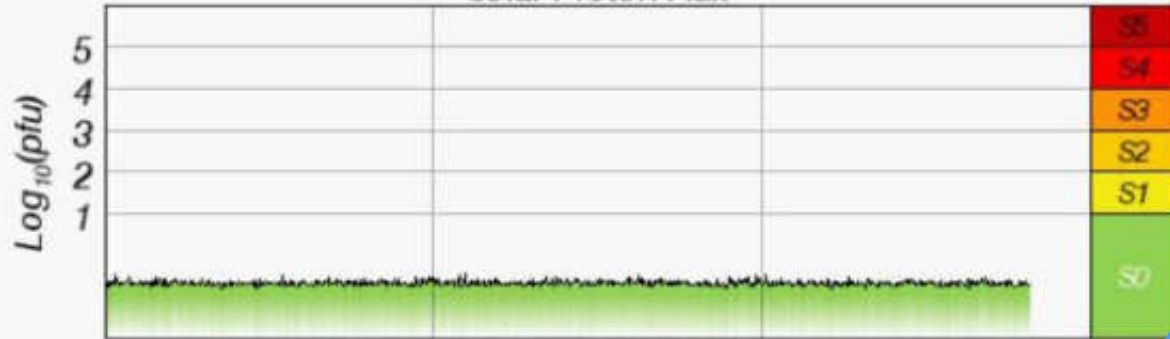


# SPACE WEATHER OVERVIEW

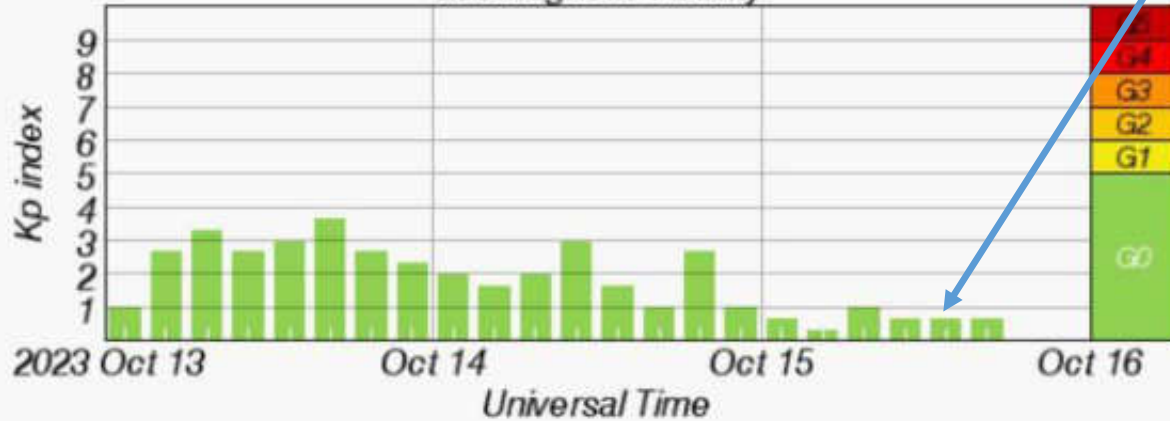
Solar X-ray Flux



Solar Proton Flux



Geomagnetic Activity



:Product: 3-Day Forecast

:Issued: 2023 Oct 15 1230 UTC

# Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center

#

A. NOAA Geomagnetic Activity Observation and Forecast

The greatest observed 3 hr Kp over the past 24 hours was 3 (below NOAA Scale levels).

The greatest expected 3 hr Kp for Oct 15-Oct 17 2023 is 3.67 (below NOAA Scale levels).

NOAA Kp index breakdown Oct 15-Oct 17 2023

|         | Oct 15 | Oct 16 | Oct 17 |
|---------|--------|--------|--------|
| 00-03UT | 0.67   | 1.67   | 2.67   |
| 03-06UT | 0.33   | 1.67   | 2.67   |
| 06-09UT | 1.00   | 1.33   | 3.67   |
| 09-12UT | 0.67   | 1.33   | 2.67   |
| 12-15UT | 2.67   | 1.67   | 1.67   |
| 15-18UT | 2.33   | 1.33   | 1.67   |
| 18-21UT | 2.33   | 1.33   | 2.67   |
| 21-00UT | 2.33   | 1.33   | 3.00   |

Rationale: No G1 (Minor) or greater geomagnetic storms are expected. No significant transient or recurrent solar wind features are forecast.

B. NOAA Solar Radiation Activity Observation and Forecast

Solar radiation, as observed by NOAA GOES-16 over the past 24 hours, was below S-scale storm level thresholds.

Solar Radiation Storm Forecast for Oct 15-Oct 17 2023

|               | Oct 15 | Oct 16 | Oct 17 |
|---------------|--------|--------|--------|
| S1 or greater | 1%     | 1%     | 1%     |

Rationale: No S1 (Minor) or greater solar radiation storms are expected. No significant active region activity favorable for radiation storm

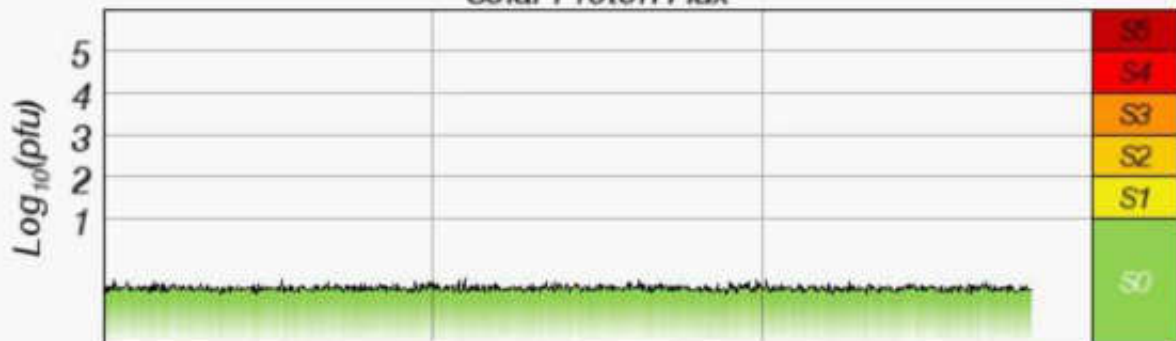


# SPACE WEATHER OVERVIEW

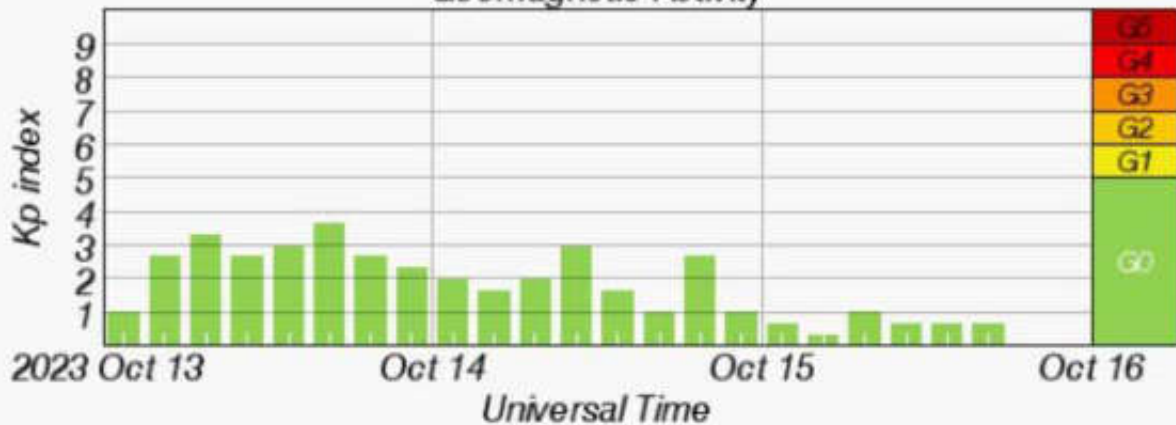
## Solar X-ray Flux



## Solar Proton Flux



## Geomagnetic Activity



|         | Oct 15 | Oct 16 | Oct 17 |
|---------|--------|--------|--------|
| 00-03UT | 0.67   | 1.67   | 2.67   |
| 03-06UT | 0.33   | 1.67   | 2.67   |
| 06-09UT | 1.00   | 1.33   | 3.67   |
| 09-12UT | 0.67   | 1.33   | 2.67   |
| 12-15UT | 2.67   | 1.67   | 1.67   |
| 15-18UT | 2.33   | 1.33   | 1.67   |
| 18-21UT | 2.33   | 1.33   | 2.67   |
| 21-00UT | 2.33   | 1.33   | 3.00   |

Rationale: No G1 (Minor) or greater geomagnetic storms are expected. No significant transient or recurrent solar wind features are forecast.

### B. NOAA Solar Radiation Activity Observation and Forecast

Solar radiation, as observed by NOAA GOES-16 over the past 24 hours, was below S-scale storm level thresholds.

#### Solar Radiation Storm Forecast for Oct 15-Oct 17 2023

|               | Oct 15 | Oct 16 | Oct 17 |
|---------------|--------|--------|--------|
| S1 or greater | 1%     | 1%     | 1%     |

Rationale: No S1 (Minor) or greater solar radiation storms are expected. No significant active region activity favorable for radiation storm production is forecast.

### C. NOAA Radio Blackout Activity and Forecast

No radio blackouts were observed over the past 24 hours.

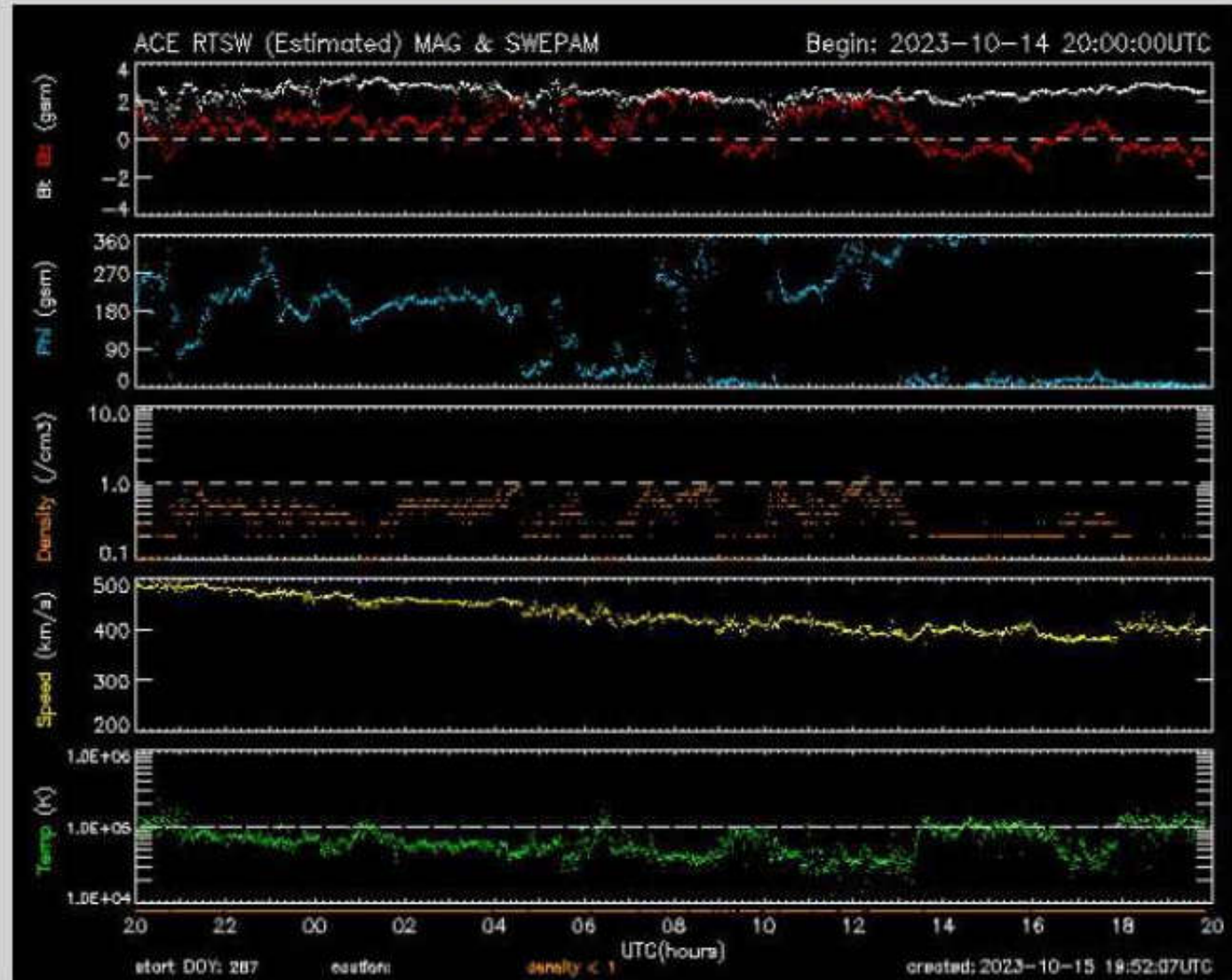
#### Radio Blackout Forecast for Oct 15-Oct 17 2023

|               | Oct 15 | Oct 16 | Oct 17 |
|---------------|--------|--------|--------|
| R1-R2         | 20%    | 20%    | 20%    |
| R3 or greater | 1%     | 1%     | 1%     |

Rationale: There is a slight chance for R1-R2 (Minor-Moderate) radio blackouts over 15-17 Oct.

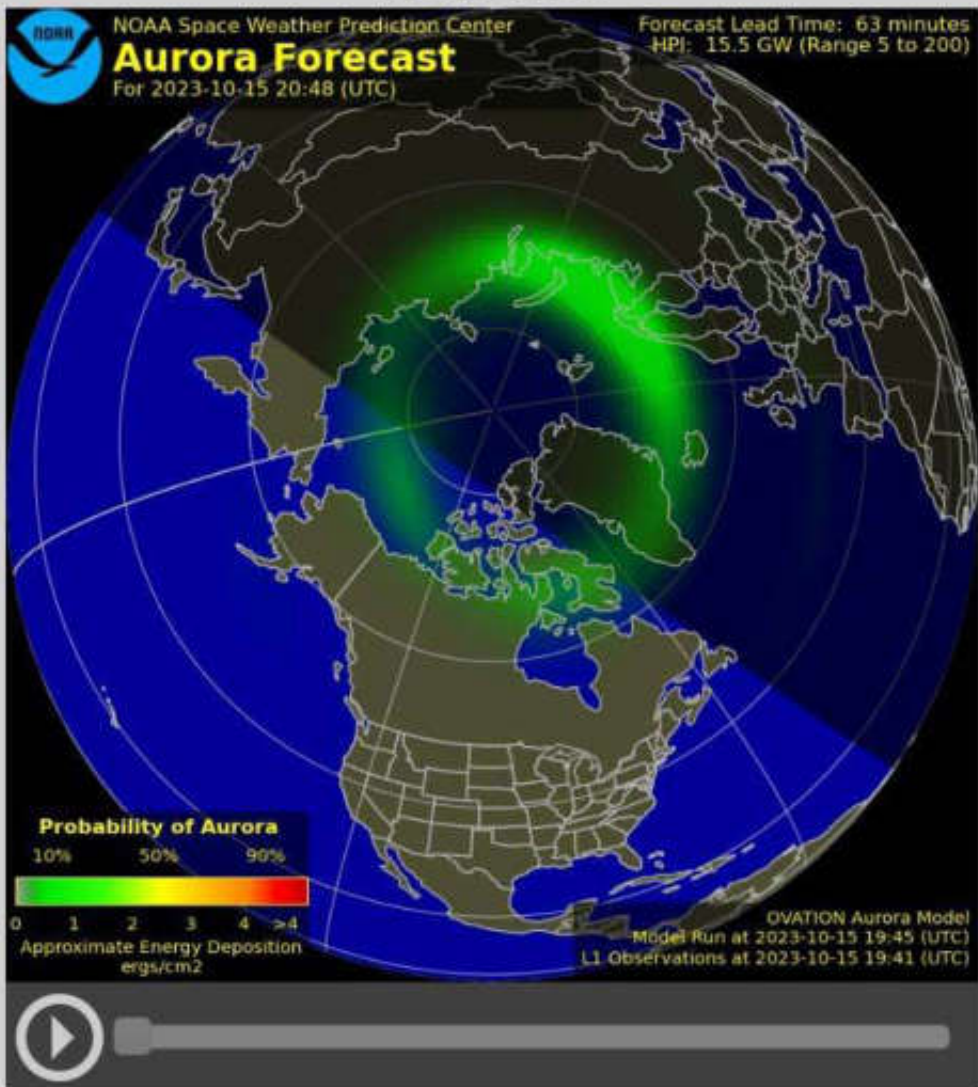
# Solar Wind

## ACE MAG AND SWEAPAM

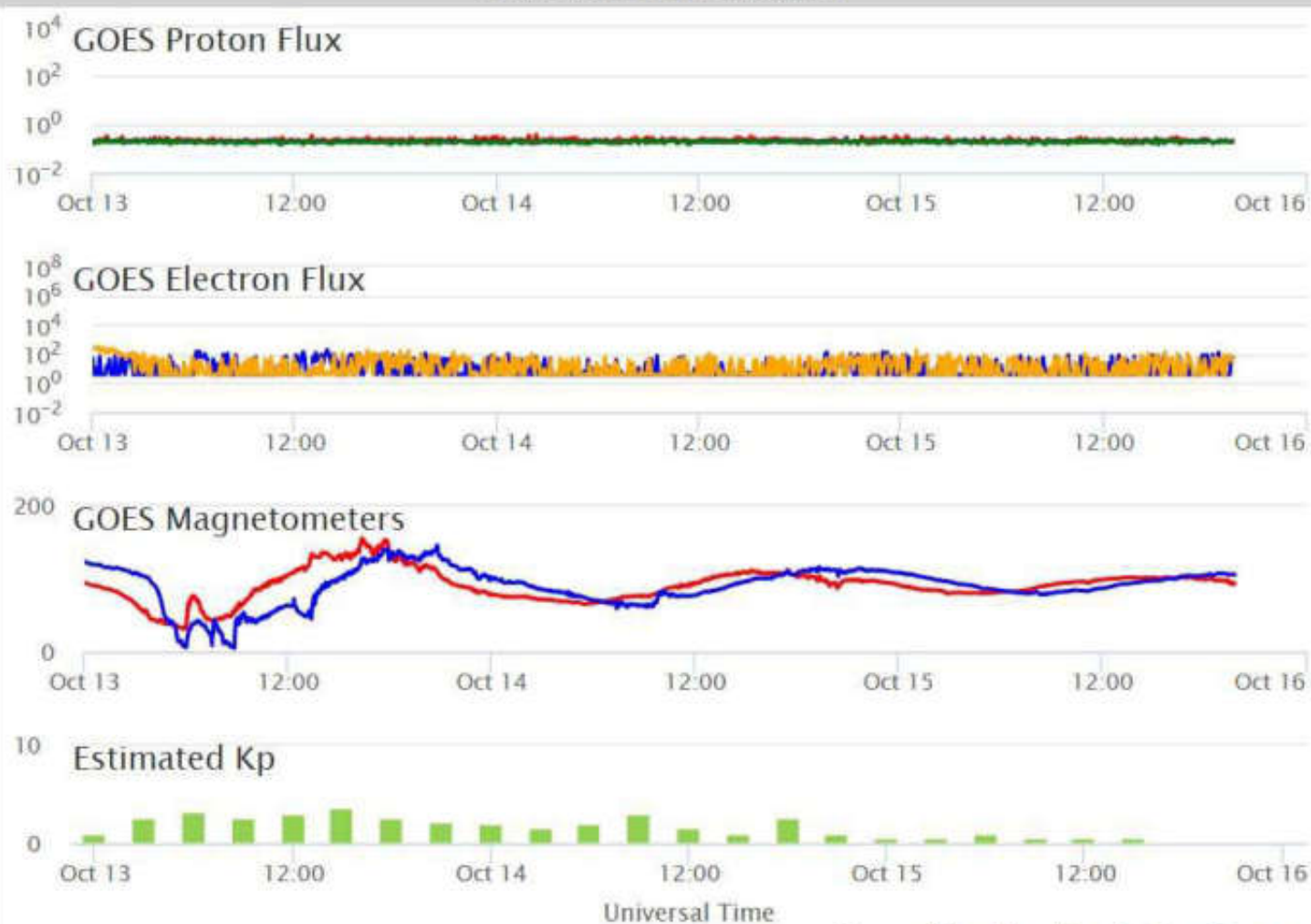




## AURORA FORECAST



## 3-DAY SATELLITE ENVIRONMENT

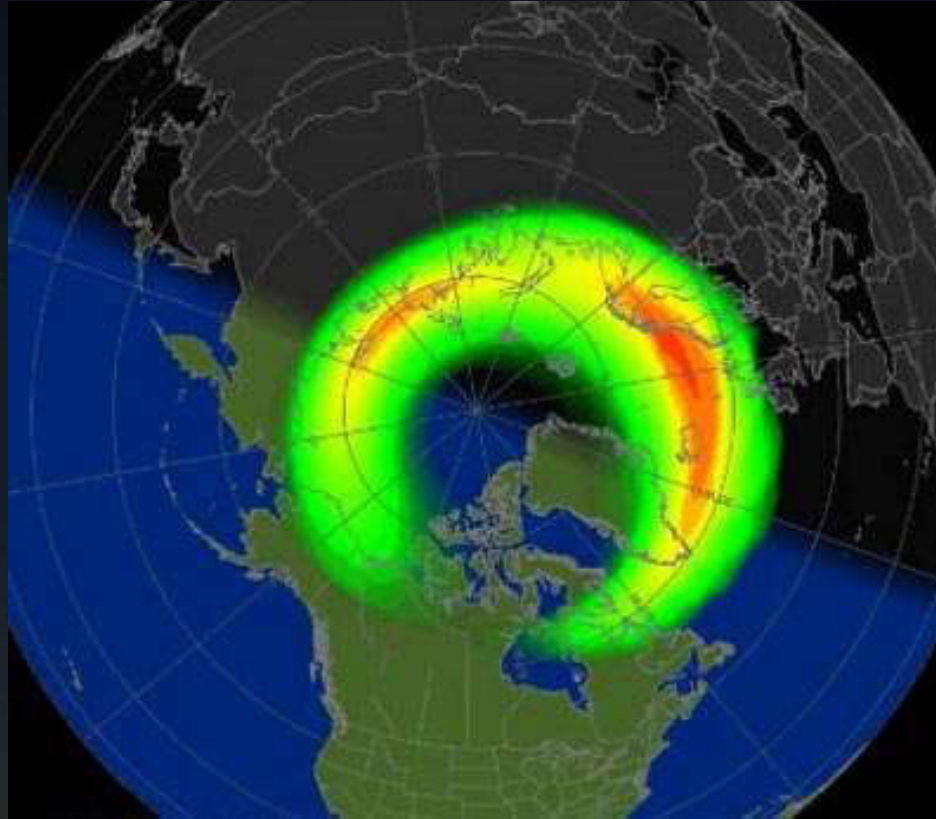


Space Weather Prediction Center

Updated Time: 2023-10-15T19:49:00.000Z

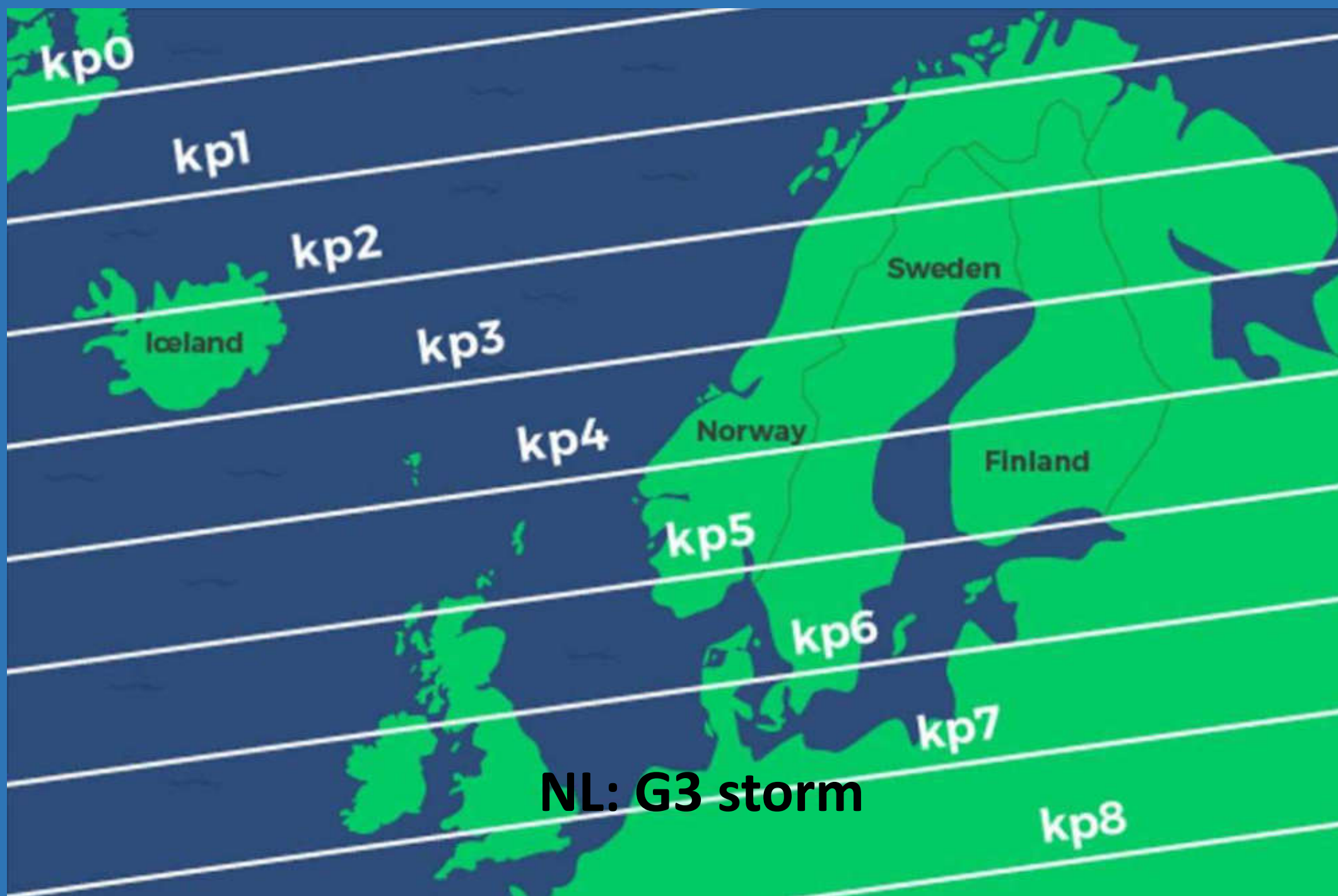


## Noorderlicht voorspellen



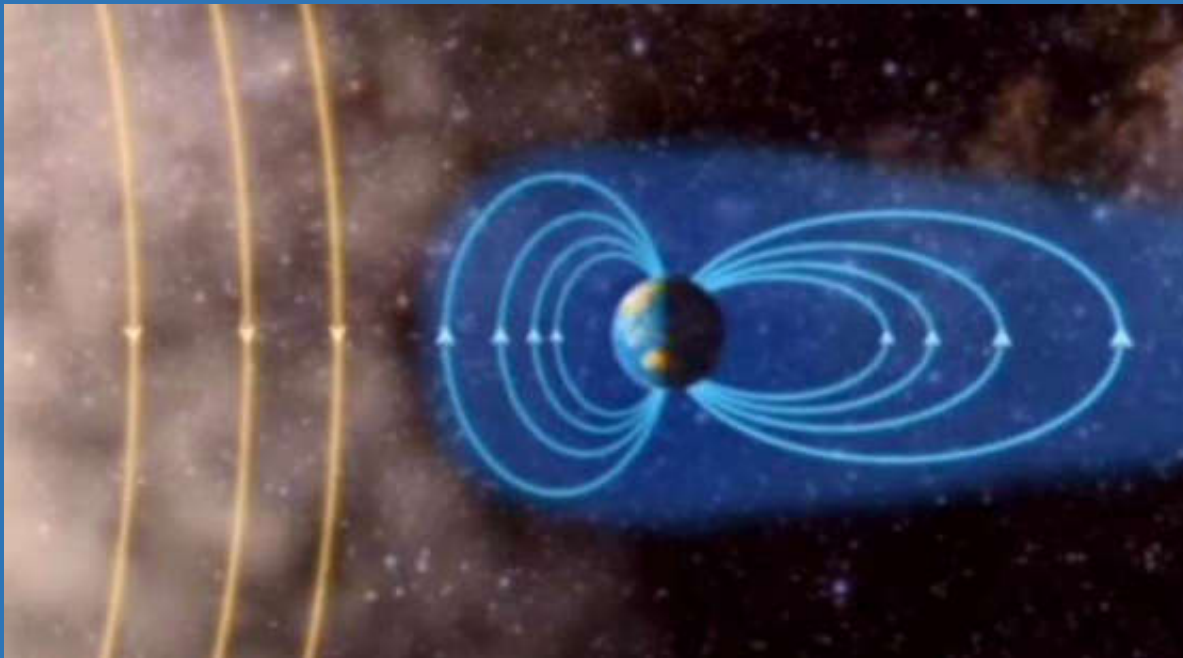
<https://www.swpc.noaa.gov/communities/space-weather-enthusiasts>

<https://www.spaceweatherlive.com/en/news.html>



# Noorderlicht voorspellen

|                            | Omgeving<br>Poolcirkel |                    | NL    |
|----------------------------|------------------------|--------------------|-------|
| • Zonnewind snelheid:      | > 400                  | ****               | > 550 |
| • Bt:                      | > 5                    | **                 | > 10  |
| • Bz Negatief:             | < -1                   | **                 | < -5  |
| Langer dan 1 uur positief: |                        | $-(2 \times Bz)^*$ |       |
| • Zonnewind dichtheid:     | > 2                    | *                  | > 4   |



# Noorderlicht voorspellen

|  | Omgeving<br>Poolcirkel |          | NL    |
|--|------------------------|----------|-------|
| • Zonnewind snelheid:                      | > 400                  | ****     | > 550 |
| • Bt:                                      | > 5                    | **       | > 10  |
| • Bz Negatief:                             | < -1                   | **       | < -5  |
| Langer dan 1 uur positief:                 |                        | -(2xBz)* |       |
| • Zonnewind dichtheid:                     | > 2                    | *        | > 4   |
| • Datum rondom Equinox (Equinox Aurora):   |                        | * - ***  |       |
| • Gunstige trend snelheid/Bt/Bz/dichtheid: |                        | * - **   |       |
| • Hoge Kp: Afgelopen 3 uur:                | > 3                    | **       | > 5   |
| Afgelopen 12 uur:                          | > 2                    | ***      | > 4   |





**SPACE WEATHER PREDICTION CENTER**  
 NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Sunday, October 02, 2022 15:22:04 UTC

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**SPACE WEATHER CONDITIONS** on NOAA Scales

24-Hour Observed Maximums

**R2**  
moderate

**S**  
none

**G**  
none

Latest Observed

**R**  
none

**S**  
none

**G**  
none

Predicted 2022-10-02 UTC

|       |     |               |    |
|-------|-----|---------------|----|
| R1-R2 | 40% | 31 or greater | 1% |
| R3-R5 | 10% |               |    |

**G1**

➔

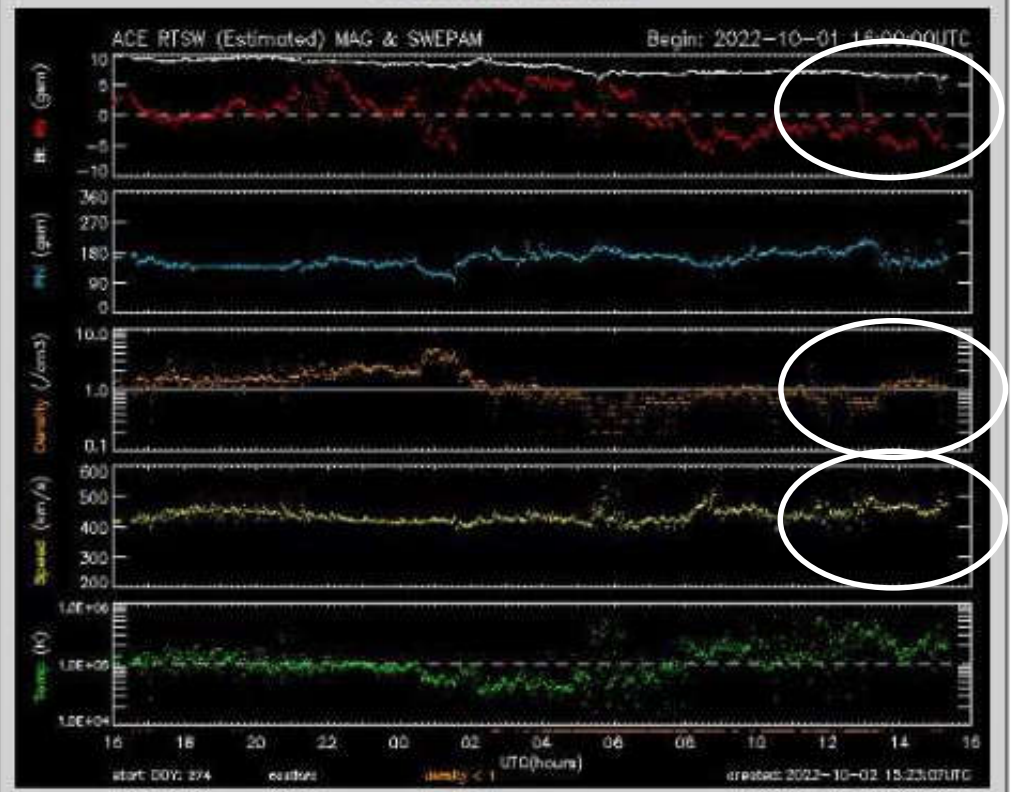
Solar Wind Speed: **476** km/sec
Solar Wind Magnetic Fields: Bt **6** nT, Bz **-5** nT
Noon 10.7cm Radio Flux: **148** sfu

2022-10-02  
 15:22 UT

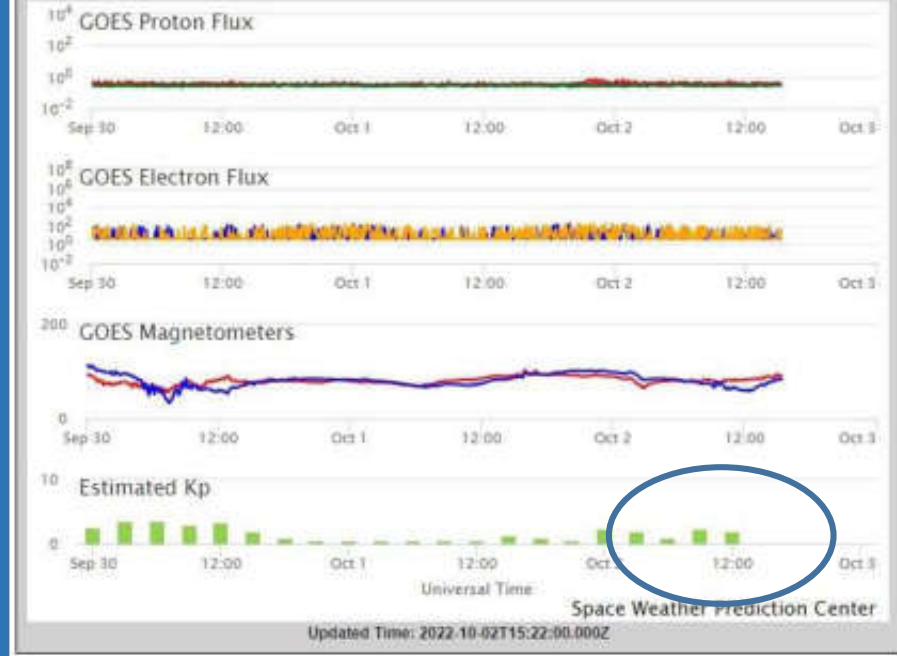
## Solar Wind

## Geospace

### ACE MAG AND SWEPAM



### 3-DAY SATELLITE ENVIRONMENT





NOAA SPACE WEATHER PREDICTION CENTER  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Sunday, October 02, 2022 15:22:04 UTC

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SPACE WEATHER CONDITIONS on NOAA Scales

24-Hour Observed Maximums: **R2** (moderate), **S** (none), **G** (none)

Latest Observed: **R** (none), **S** (none), **G** (none)

Predicted 2022-10-02 UTC: R1-R2 40%, R3-R5 10%, 31 or greater 1%, **G1** (minor)

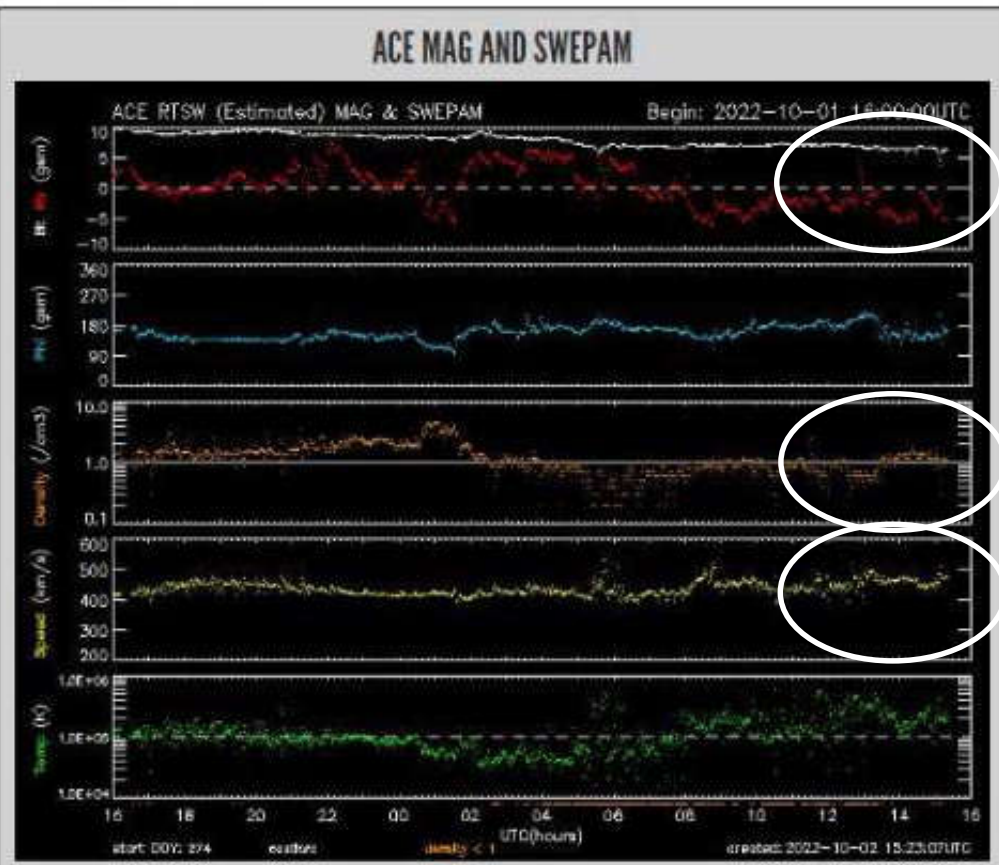
Solar Wind Speed: **476** km/sec

Solar Wind Magnetic Fields: Bt **6** nT, Bz **-5** nT

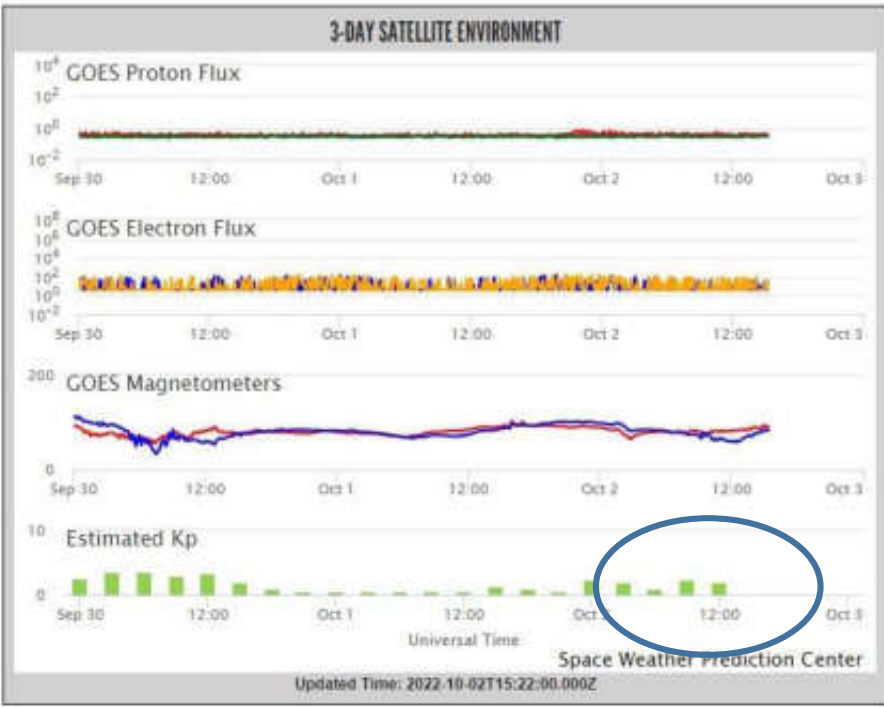
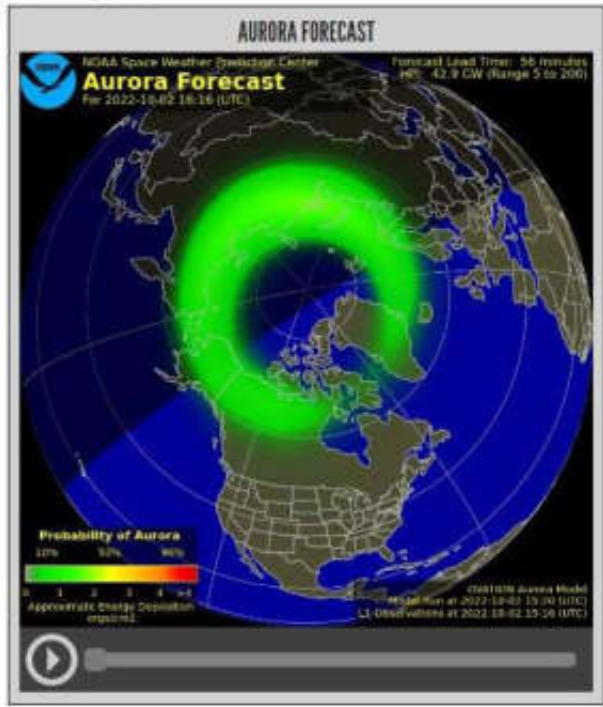
Noon 10.7cm Radio Flux: **148** sfu

2022-10-02  
15:22 UT

## Solar Wind



## Geospace



# Noorderlicht NL 2023-02-27



Noorderlicht NL  
2023-02-27

10:25 UTC

458 km/sec

Bt 20

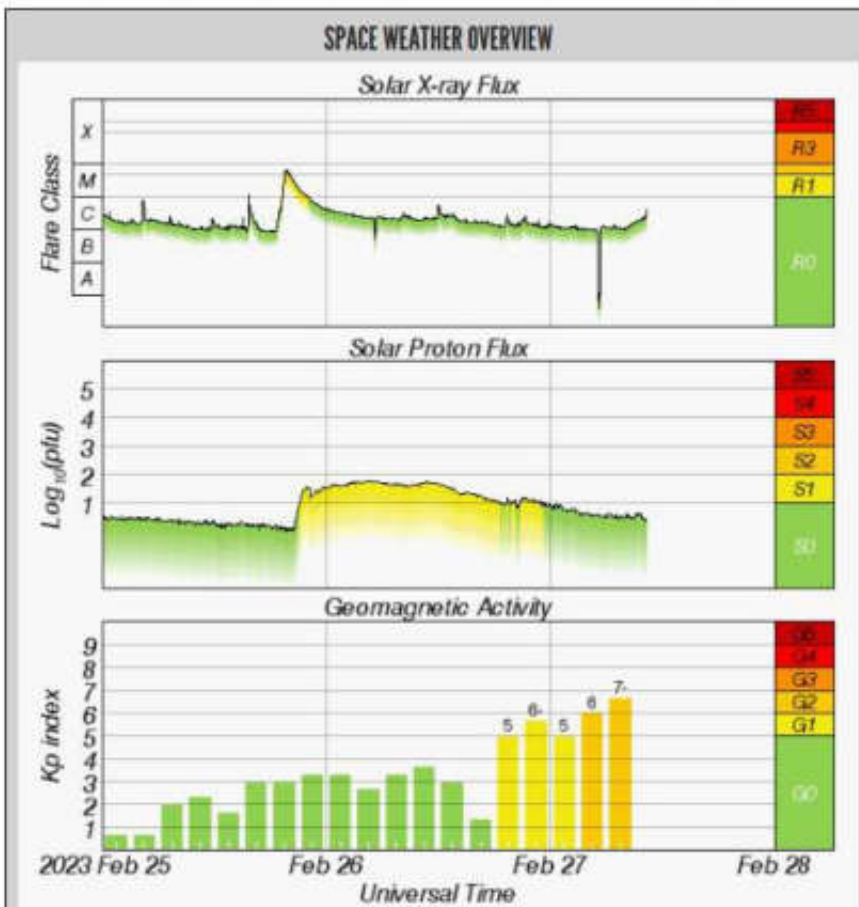
Bz -15

SPACE WEATHER CONDITIONS on NOAA Scales



Solar Wind Speed: **458** km/sec      Solar Wind Magnetic Fields: Bt **20** nT, Bz **-15** nT      Noon 10.7cm Radio Flux: **159** sfu

SPACE WEATHER ENTHUSIASTS DASHBOARD



:Product: 3-Day Forecast  
:Issued: 2023 Feb 27 0030 UTC  
# Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center  
#  
A. NOAA Geomagnetic Activity Observation and Forecast

The greatest observed 3 hr Kp over the past 24 hours was 6 (NOAA Scale G2).  
The greatest expected 3 hr Kp for Feb 27-Mar 01 2023 is 6.67 (NOAA Scale G3).

NOAA Kp index breakdown Feb 27-Mar 01 2023

|         | Feb 27    | Feb 28    | Mar 01 |
|---------|-----------|-----------|--------|
| 00-03UT | 5.67 (G2) | 5.67 (G2) | 4.00   |
| 03-06UT | 5.00 (G1) | 5.00 (G1) | 3.67   |
| 06-09UT | 5.67 (G2) | 4.33      | 3.00   |
| 09-12UT | 4.67 (G1) | 4.00      | 3.00   |
| 12-15UT | 4.67 (G1) | 4.00      | 2.67   |
| 15-18UT | 4.33      | 3.00      | 2.67   |
| 18-21UT | 5.00 (G1) | 3.00      | 2.67   |
| 21-00UT | 6.67 (G3) | 3.67      | 3.00   |

Rationale: G3 (Strong) geomagnetic storms are likely on 27 Feb, and G2 (Moderate) storms are likely on 28 Feb, due to negative polarity CH HSS influences and CME effects.

B. NOAA Solar Radiation Activity Observation and Forecast

Solar radiation, as observed by NOAA GOES-16 over the past 24 hours, was above 5-scale storm level thresholds.

Solar Radiation Storm Forecast for Feb 27-Mar 01 2023

|               | Feb 27 | Feb 28 | Mar 01 |
|---------------|--------|--------|--------|
| S1 or greater | 99%    | 50%    | 25%    |

Rationale: Ongoing S1 (Minor) solar radiation storm conditions are expected to continue on 27 Feb.



**SPACE WEATHER CONDITIONS** on NOAA Scales

24-Hour Observed Maximums

R

S1

G3

none minor strong

Latest Observed

R

S

G2

none none moderate

Predicted 2023-02-27 UTC

R1-R2 85%

S1 or greater

90%

G3

➔

R3-R5 15% strong

Solar Wind Speed: **836** km/sec

Solar Wind Magnetic Fields: Bt **9** nT, Bz **-2** nT

Noon 10.7cm Radio Flux: **159** sfu

**SPACE WEATHER ENTHUSIASTS DASHBOARD**

### SPACE WEATHER OVERVIEW

**Solar X-ray Flux**  
Flare Class: X, M, C, B, A

**Solar Proton Flux**  
Log<sub>10</sub>(pfu): 5, 4, 3, 2, 1

**Geomagnetic Activity**  
Kp index: 9, 8, 7, 6, 5, 4, 3, 2, 1

2023 Feb 25      Feb 26      Feb 27      Feb 28  
Universal Time

**Product:** 3-Day Forecast  
**Issued:** 2023 Feb 27 1230 UTC  
**# Prepared by:** the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center  
**#**

**A. NOAA Geomagnetic Activity Observation and Forecast**

The greatest observed 3 hr Kp over the past 24 hours was 7 (NOAA Scale G3).  
The greatest expected 3 hr Kp for Feb 27-Mar 01 2023 is 7.00 (NOAA Scale G3).

**NOAA Kp index breakdown Feb 27-Mar 01 2023**

|         | Feb 27    | Feb 28    | Mar 01 |
|---------|-----------|-----------|--------|
| 00-03UT | 5.00 (G1) | 5.67 (G2) | 4.00   |
| 03-06UT | 6.00 (G2) | 5.00 (G1) | 3.67   |
| 06-09UT | 6.67 (G3) | 4.33      | 3.00   |
| 09-12UT | 7.00 (G3) | 4.00      | 3.00   |
| 12-15UT | 4.67 (G1) | 4.00      | 2.67   |
| 15-18UT | 4.33      | 3.00      | 2.67   |
| 18-21UT | 5.00 (G1) | 3.00      | 2.67   |
| 21-00UT | 5.00 (G1) | 3.67      | 3.00   |

**Rationale:** The geomagnetic field is expected to be at active to severe storm levels (G3-Strong) on day one (27 Feb), unsettled to major storm levels (G2-Moderate) on day two (28 Feb) and unsettled to active levels on day three (01 Mar). Combined influence of the recurrent negative polarity CH HSS and effects from the 24 and 25 Feb CMEs is the source for these enhanced geomagnetic conditions.

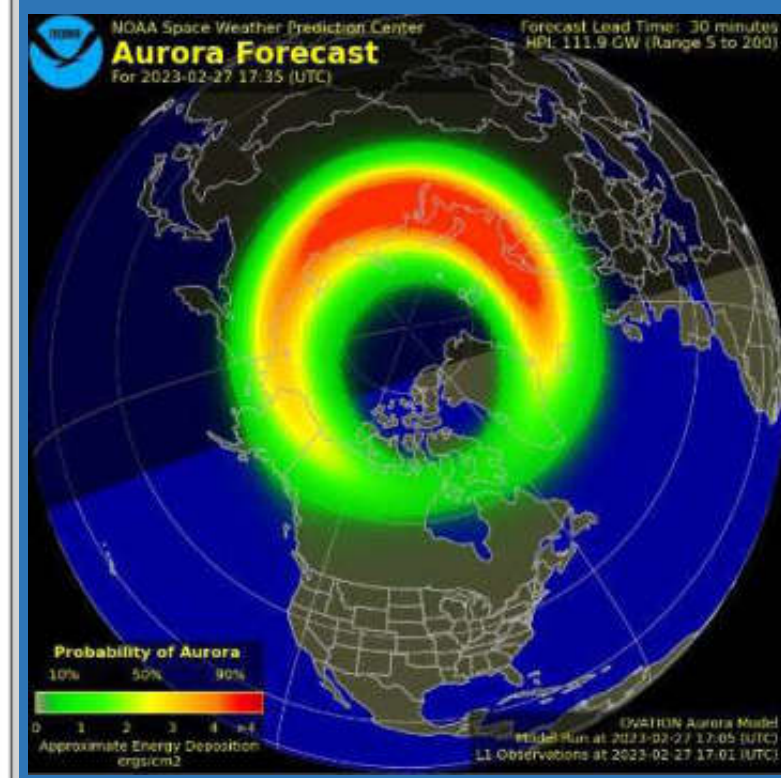
**B. NOAA Solar Radiation Activity Observation and Forecast**

Solar radiation, as observed by NOAA GOES-16 over the past 24 hours, was above S-scale storm level thresholds.

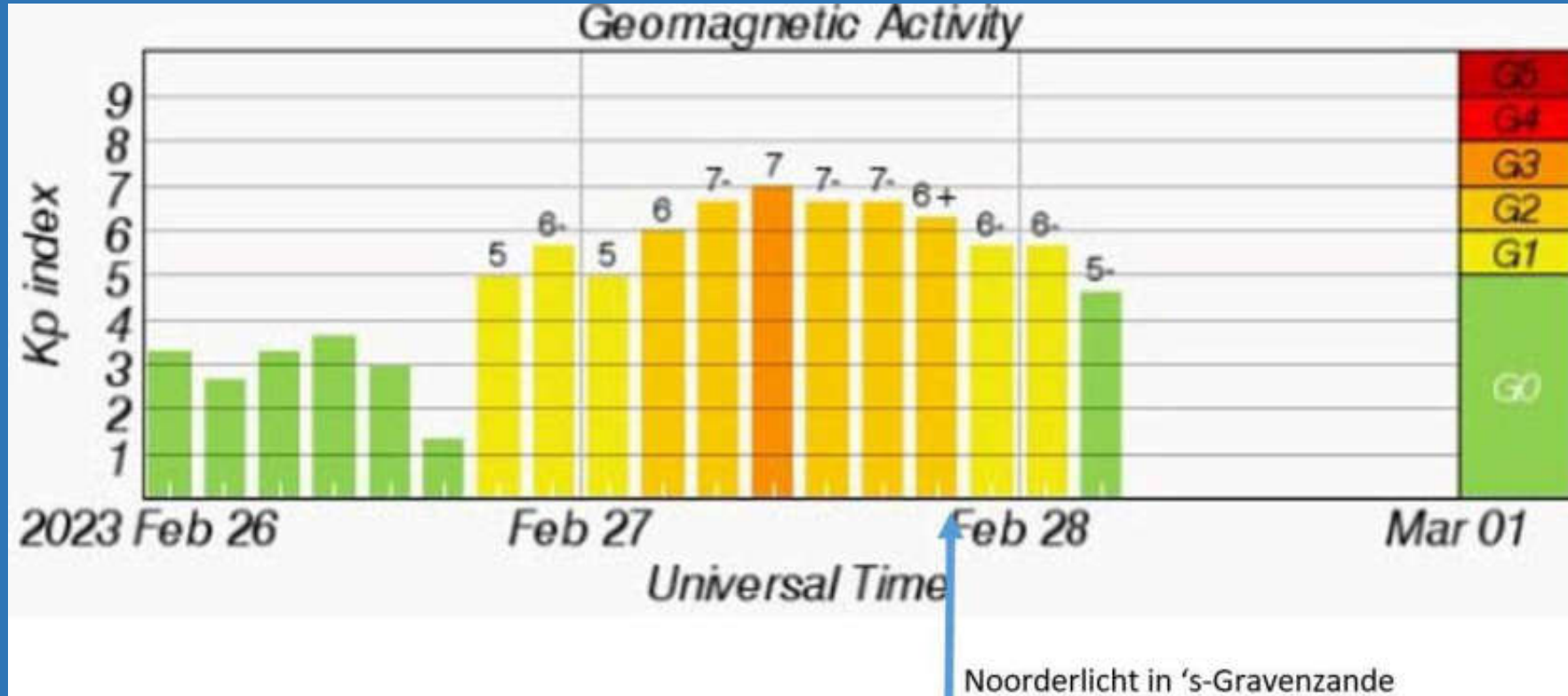
**Solar Radiation Storm Forecast for Feb 27-Mar 01 2023**

Feb 27    Feb 28    Mar 01

**Noorderlicht NL**  
**2023-02-27**  
**17:04 UTC**  
**836 km/sec**  
**Bt 9**  
**Bz - 2**



# Noorderlicht NL 2023-02-27



:Product: 3-Day Forecast: Issued: 2023 Feb 27 1230 UTC

The geomagnetic field is expected to be at active to severe storm levels (G3-Strong) on day one (27 Feb), unsettled to major storm levels (G2-Moderate) on day two (28 Feb) and unsettled to active levels on day three (01 Mar). Combined influence of the recurrent negative polarity CH HSS and effects from the 24 and 25 Feb CMEs is the source for these enhanced geomagnetic conditions.



2022-10-09 ARs 3112 & 3116



**SPACE WEATHER CONDITIONS** on NOAA Scales



Solar Wind Speed: **565** km/sec

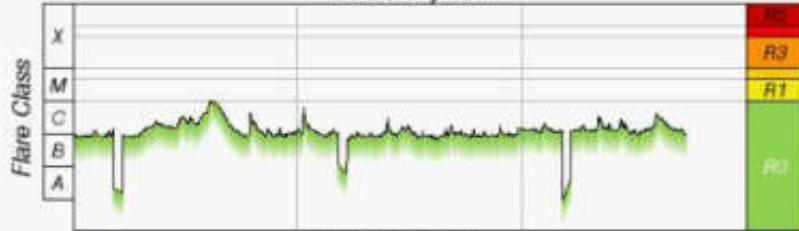
Solar Wind Magnetic Fields: Bt **4** nT, Bz **1** nT

Noon 10.7cm Radio Flux: **157** sfu

**SPACE WEATHER ENTHUSIASTS DASHBOARD**

**SPACE WEATHER OVERVIEW**

*Solar X-ray Flux*



*Solar Proton Flux*



*Geomagnetic Activity*



2022 Oct 07      Oct 08      Oct 09      Oct 10

Universal Time

:Product: 3-Day Forecast  
 :Issued: 2022 Oct 09 1230 UTC  
 # Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center  
 #  
 A. NOAA Geomagnetic Activity Observation and Forecast

Radio Blackout Forecast for Oct 09 2022:

Oct 09

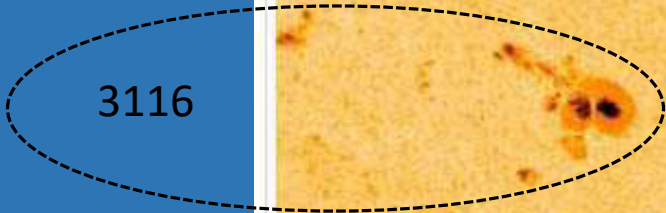
- R1-R2      50%
- R3 or greater      10%

Rationale: A chance for R1-2 (Minor-Moderate), with a slight chance for R3 (Strong), radio black-outs will persist through the forecast period mainly due to the configurations exhibited by regions 3112 and 3116.

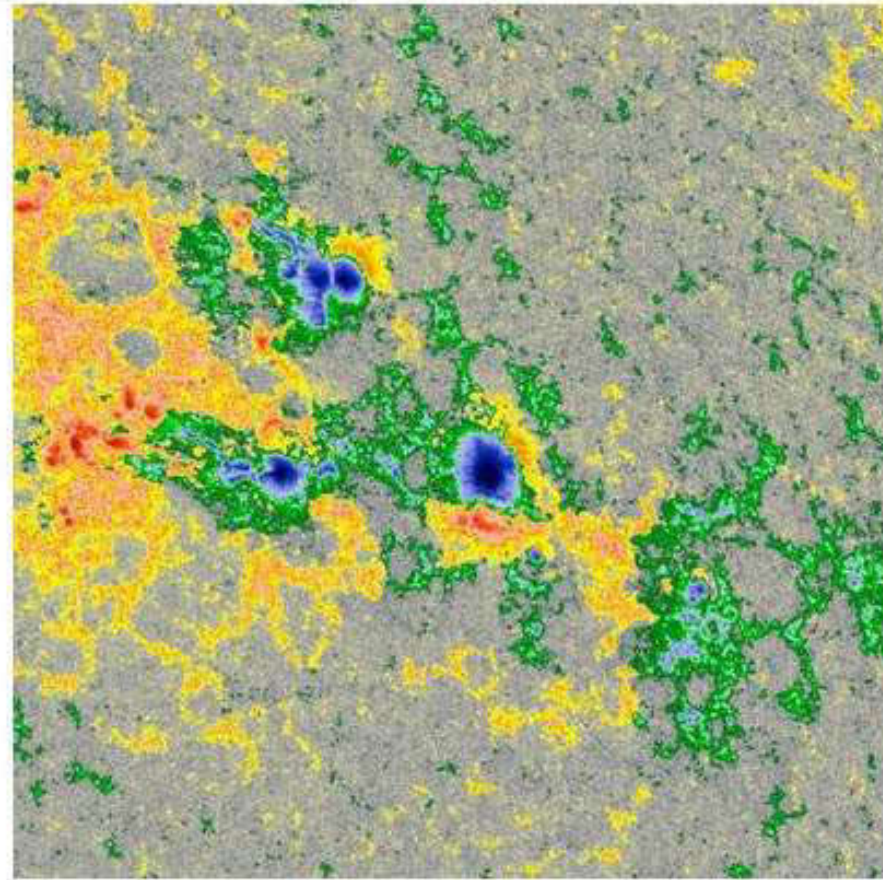
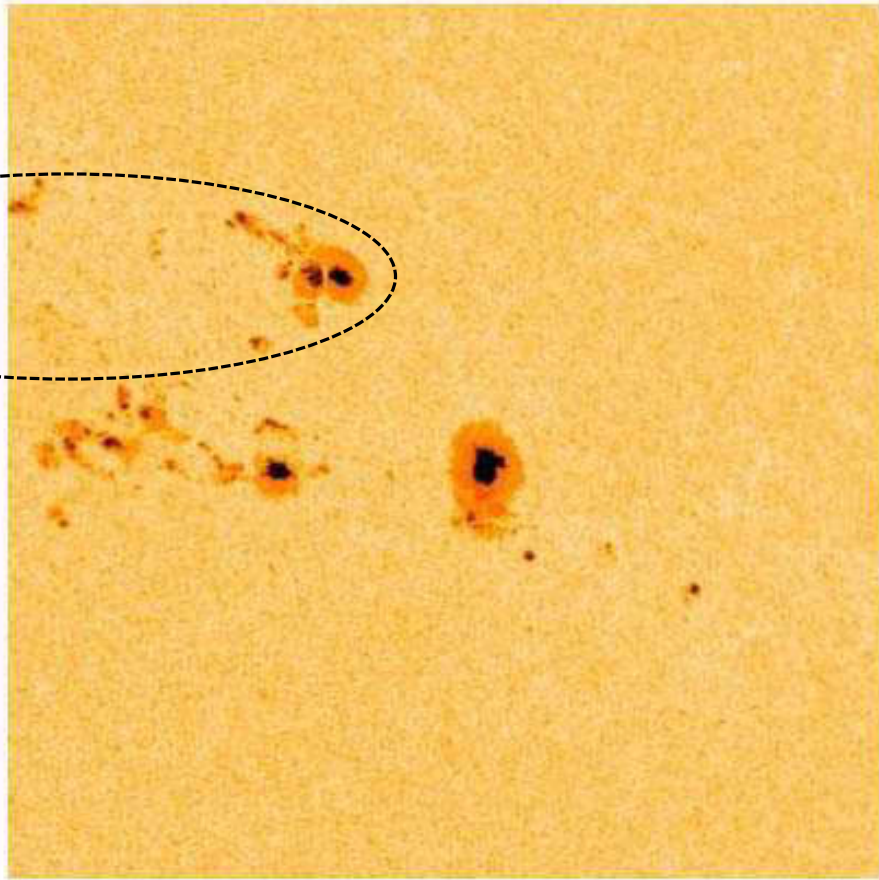
# Region 3112



| Number of sunspots    | Size ?                 | Class Magn. ?      | Class Spot ? | Location |
|-----------------------|------------------------|--------------------|--------------|----------|
| 14 <span>↓ -18</span> | 400 <span>↓ -70</span> | $\beta$ - $\delta$ | FKI          | N22W28   |



3116



Solar flares on this day

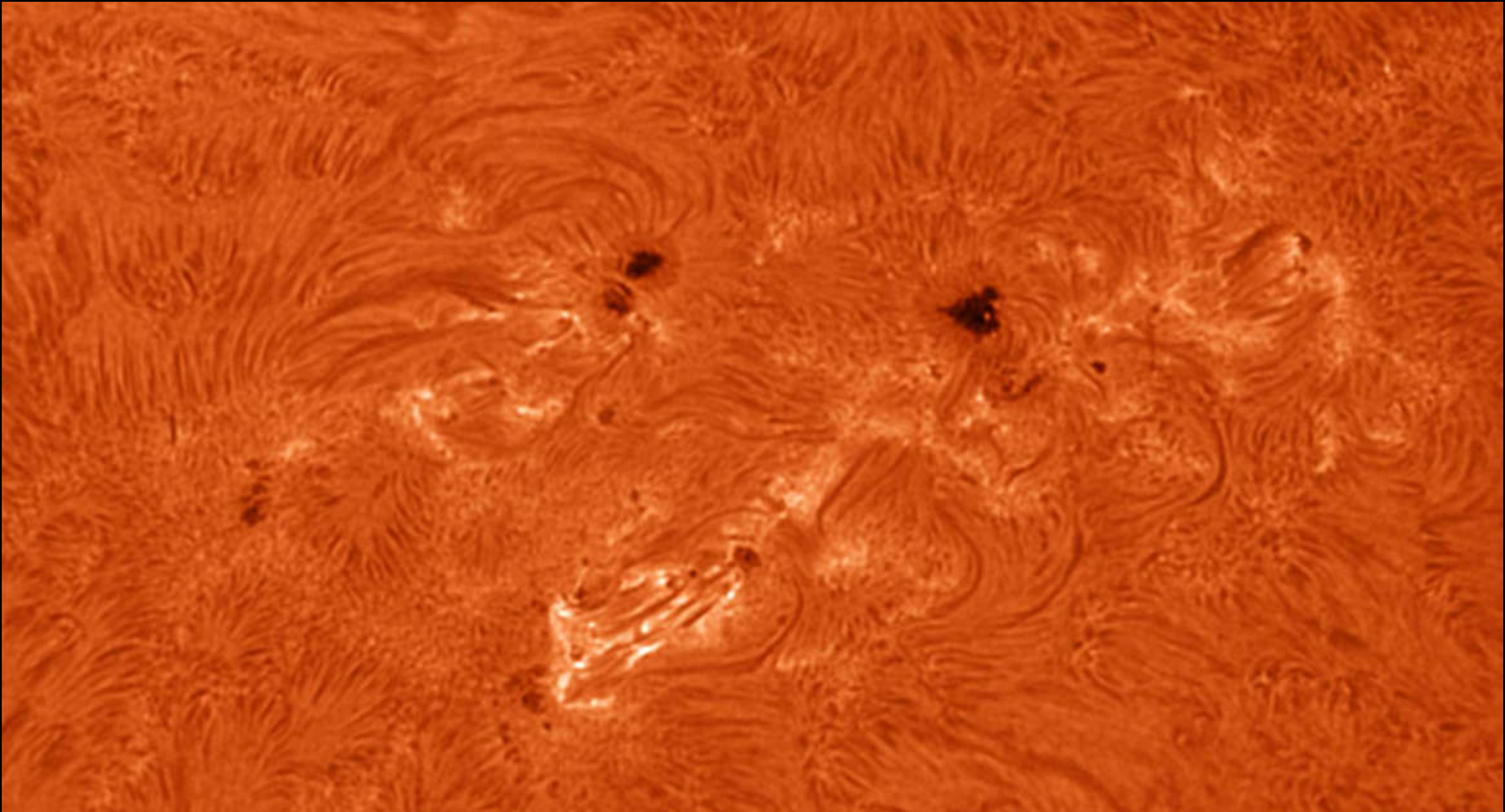
- C2.1
- C3.3
- C2.9
- C2.0
- C1.6
- C2.9
- C2.3
- C3.9
- C2.0
- C3.6



## Solar flares

| Region |      | Start | Maximum | End   |
|--------|------|-------|---------|-------|
| 3112   | C2.1 | 02:08 | 02:25   | 02:35 |
| 3112   | C3.3 | 08:05 | 08:13   | 08:20 |
| 3112   | C2.9 | 08:20 | 08:25   | 08:30 |
| 3112   | C2   | 09:15 | 09:21   | 09:30 |
| 3112   | C1.6 | 10:17 | 10:24   | 10:27 |
| 3112   | C2.9 | 10:27 | 10:34   | 10:46 |
| 3112   | C2.3 | 10:58 | 11:01   | 11:06 |
| 3112   | C3.9 | 14:10 | 14:27   | 14:56 |
| 3112   | C2   | 18:37 | 18:47   | 19:03 |
| 3119   | C3.6 | 21:46 | 21:57   | 22:05 |
| 3119   | C4.2 | 22:11 | 22:16   | 22:24 |
| 3112   | C3.6 | 23:43 | 23:57   | 00:03 |

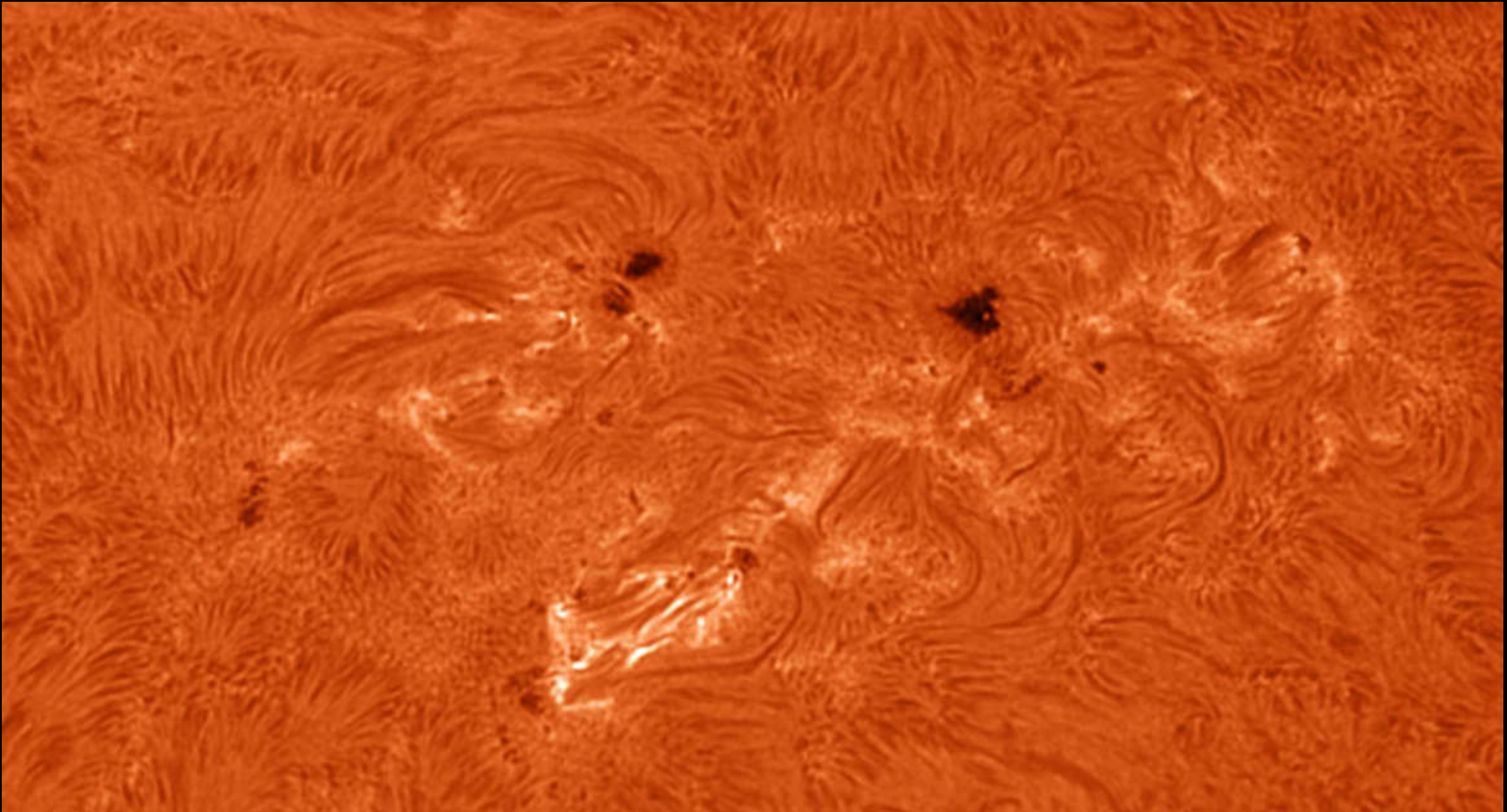




2022-10-09 Quark H $\alpha$  - valse kleuren

10:17 UT ARs 3112 & 3116

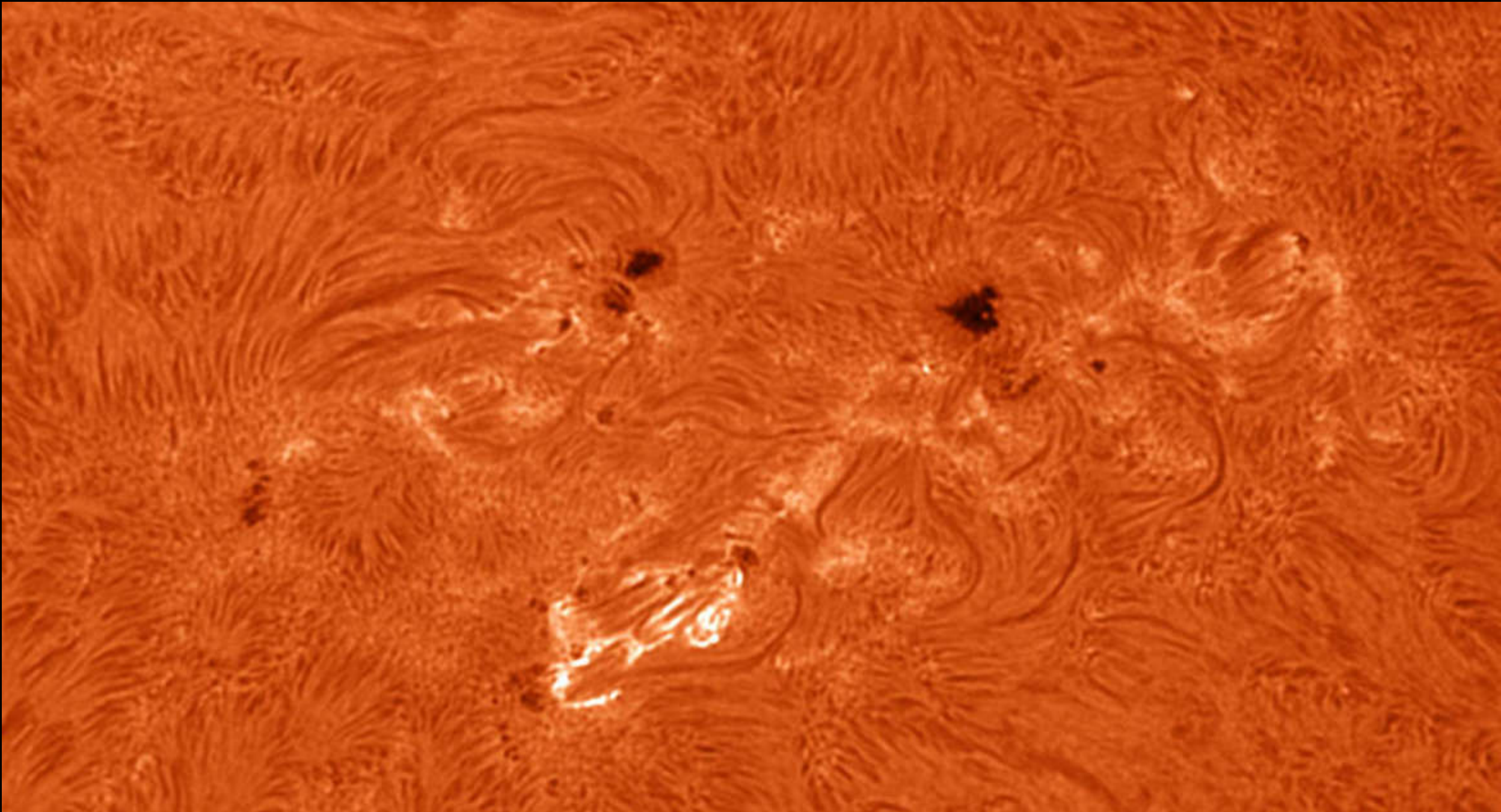




2022-10-09 Quark H $\alpha$  - valse kleuren

10:20 UT ARs 3112 & 3116





2022-10-09 Quark H $\alpha$  - valse kleuren

10:23 UT ARs 3112 & 3116





**SPACE WEATHER CONDITIONS** on NOAA Scales

24-Hour Observed Maximums

R1

S2

G4

minor moderate severe

Latest Observed

R

S1

G

none minor none

Predicted 2024-03-25 UTC

|       |     |               |     |
|-------|-----|---------------|-----|
| R1-R2 | 85% | S1 or greater | 99% |
| R3-R5 | 25% |               |     |

G2

➤

moderate

**SPACE WEATHER ENTHUSIASTS DASHBOARD**

### SPACE WEATHER OVERVIEW

Solar X-ray Flux

Solar Proton Flux

Geomagnetic Activity

**Product:** 3-Day Forecast  
**Issued:** 2024 Mar 25 0030 UTC  
**# Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center**  
**#**  
**A. NOAA Geomagnetic Activity Observation and Forecast**

The greatest observed 3 hr Kp over the past 24 hours was 8 (NOAA Scale G4).  
The greatest expected 3 hr Kp for Mar 25-Mar 27 2024 is 6.67 (NOAA Scale G3).

**NOAA Kp index breakdown Mar 25-Mar 27 2024**

|         | Mar 25    | Mar 26    | Mar 27 |
|---------|-----------|-----------|--------|
| 00-03UT | 6.00 (G2) | 5.00 (G1) | 1.67   |
| 03-06UT | 6.67 (G3) | 4.00      | 1.33   |
| 06-09UT | 6.00 (G2) | 4.00      | 1.33   |
| 09-12UT | 5.00 (G1) | 3.67      | 1.33   |
| 12-15UT | 4.00      | 3.00      | 1.33   |
| 15-18UT | 3.00      | 2.33      | 1.33   |
| 18-21UT | 3.00      | 2.33      | 1.67   |
| 21-00UT | 4.00      | 3.33      | 1.67   |

**Rationale:** G1 (Minor) or greater (G3 Strong) geomagnetic storms are expected in response to CME passage.

**B. NOAA Solar Radiation Activity Observation and Forecast**

Solar radiation, as observed by NOAA GOES-18 over the past 24 hours, was above S-scale storm level thresholds.

**Solar Radiation Storm Forecast for Mar 25-Mar 27 2024**

|               | Mar 25 | Mar 26 | Mar 27 |
|---------------|--------|--------|--------|
| S1 or greater | 99%    | 78%    | 50%    |

2024-03-24  
Heavy Space Weather

**Rationale:** S1 (Minor) or greater solar radiation storms are expected as the space radiation event from March 23 continues to decay.

**C. NOAA Radio Blackout Activity and Forecast**

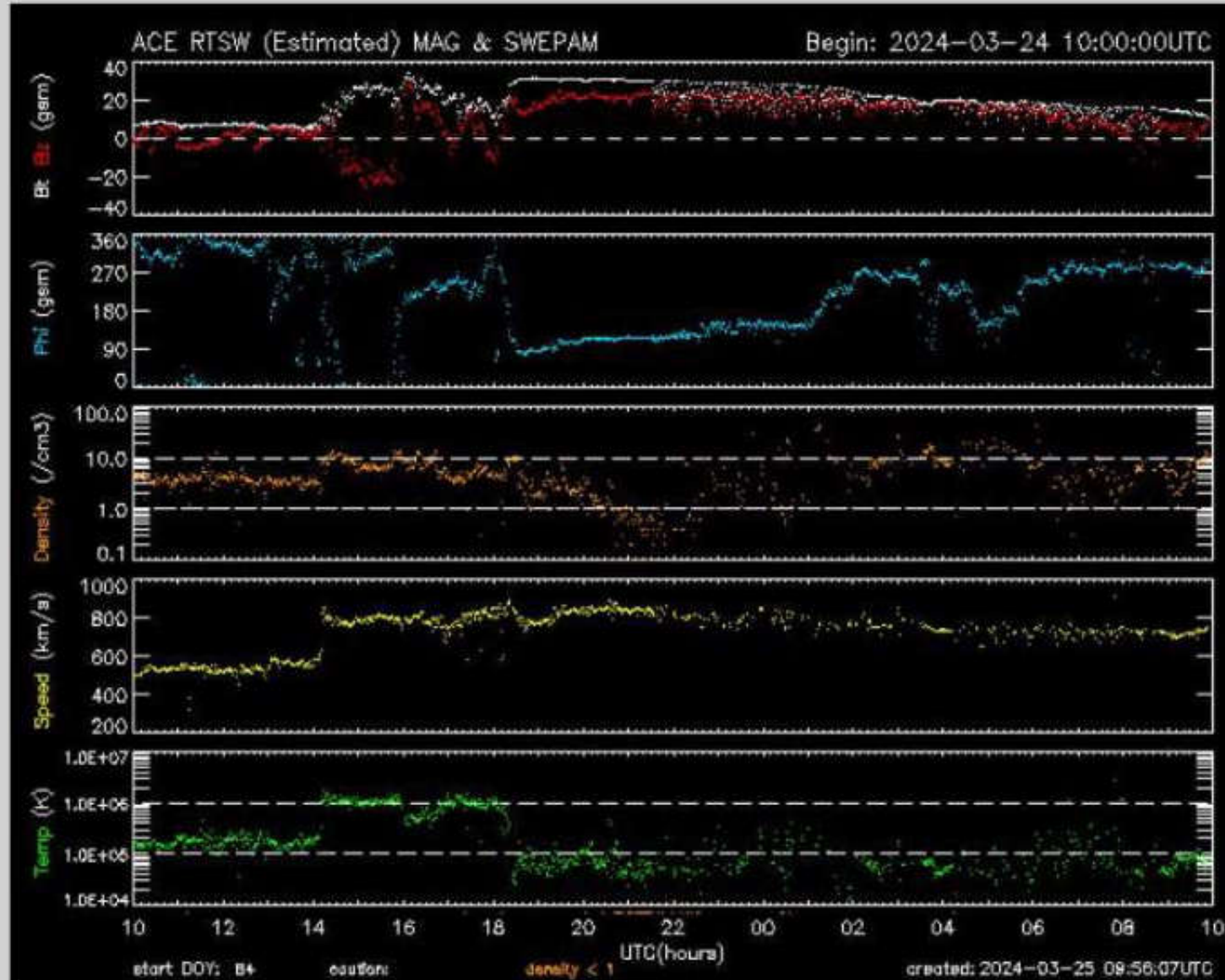
Radio blackouts reaching the R1 levels were observed over the past 24 hours. The largest was at Mar 24 2024 0218 UTC.

**Radio Blackout Forecast for Mar 25-Mar 27 2024**

|               | Mar 25 | Mar 26 | Mar 27 |
|---------------|--------|--------|--------|
| R1-R2         | 85%    | 85%    | 85%    |
| R3 or greater | 25%    | 25%    | 25%    |

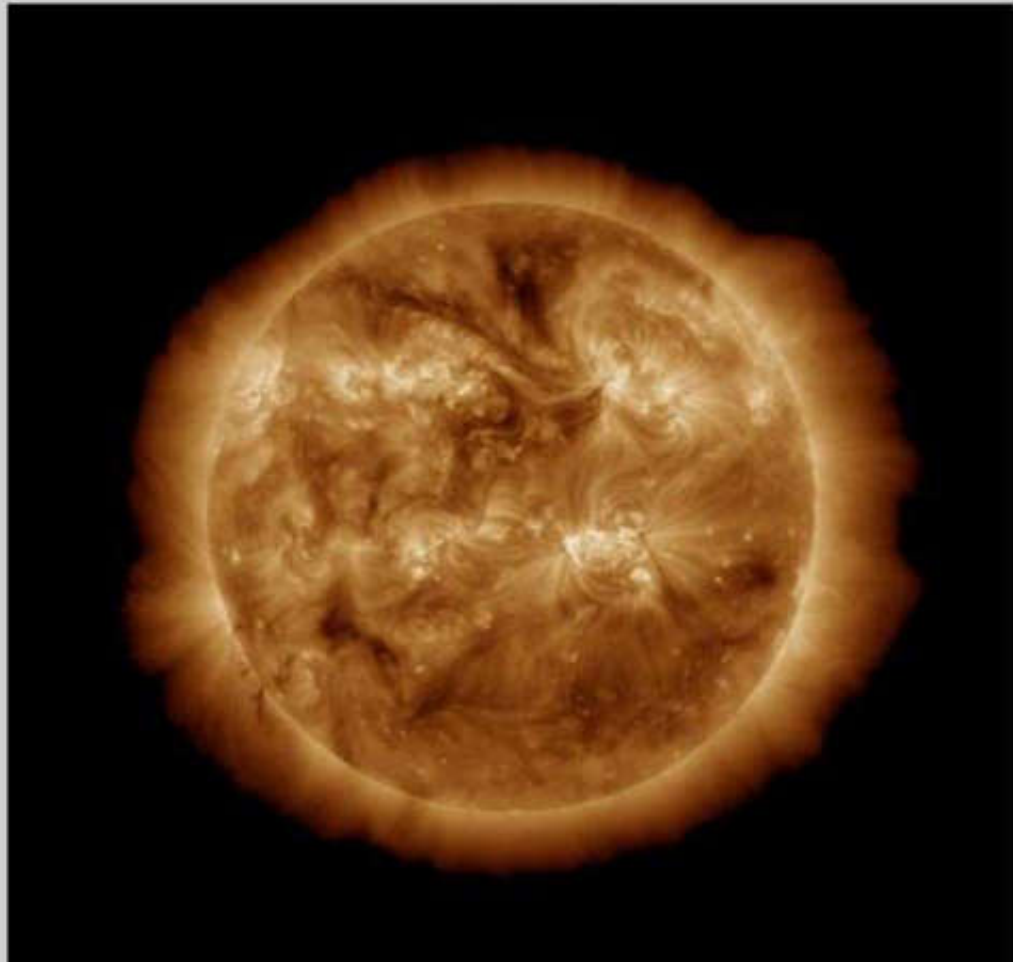
**Rationale:** R1-R2 (Minor-Moderate) or greater radio blackouts are expected, with a chance for an R3 (Strong) event from significant sunspot regions.

# ACE MAG AND SWEPAM

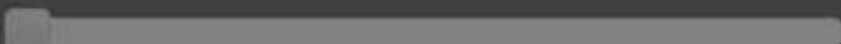


# Solar

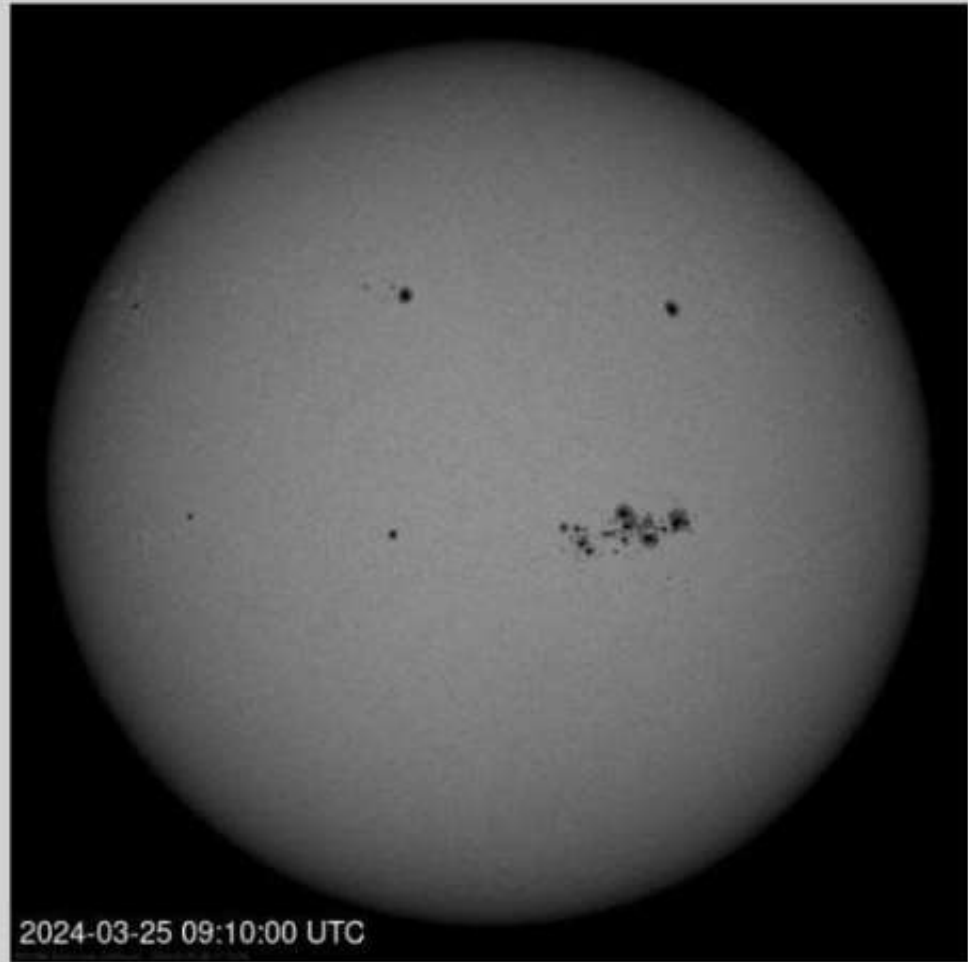
GOES SOLAR ULTRAVIOLET IMAGER



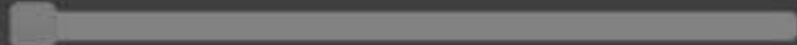
GOES-16 SUVI Composite 195 Angstroms 2024-03-25 09:44:03



SOLAR VISIBLE LIGHT



2024-03-25 09:10:00 UTC







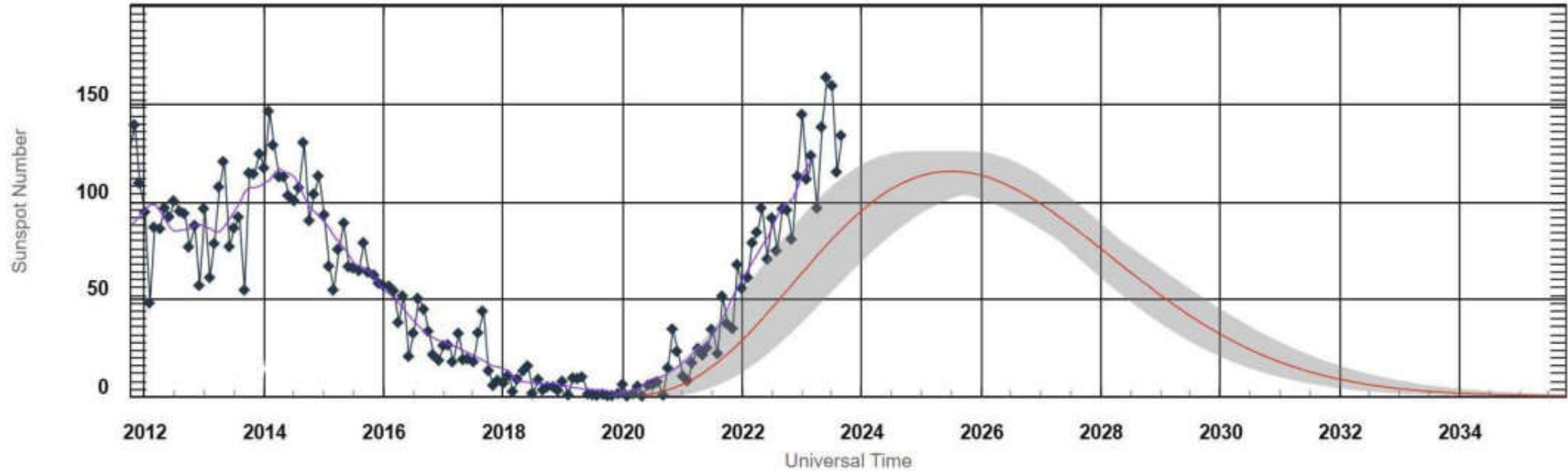


# Solar Cycle

## SUNSPOT NUMBER PROGRESSION

### ISES Solar Cycle Sunspot Number Progression

Zoom:



◆ Monthly Values    — Smoothed Monthly Values    — Predicted Values    ● Predicted Range

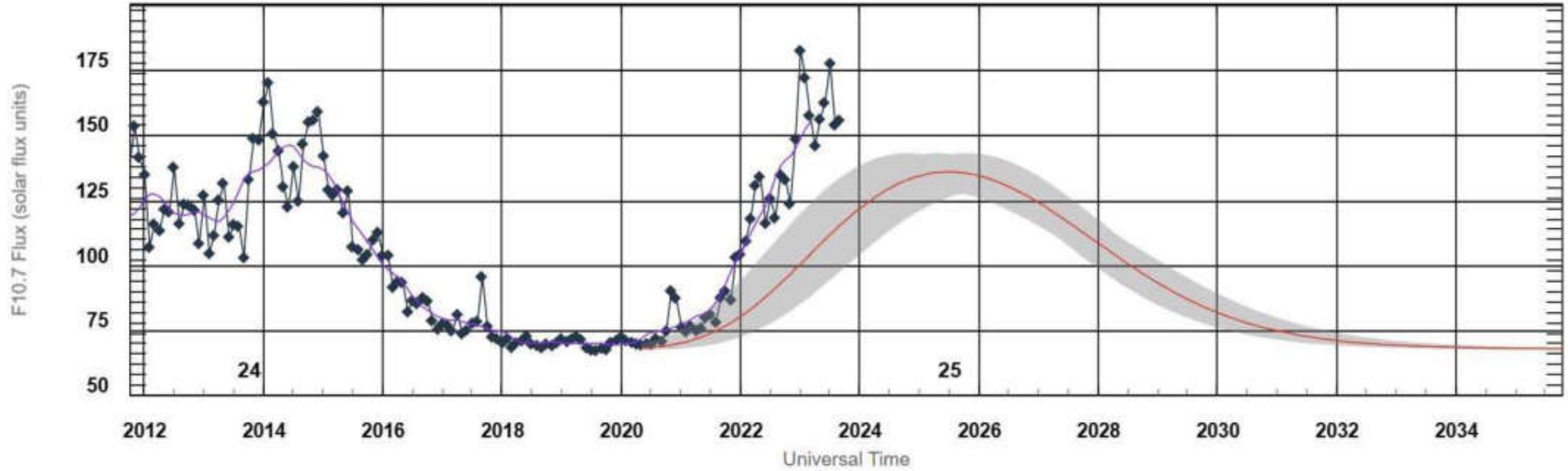
▾

Space Weather Prediction Center

# ISES Solar Cycle F10.7cm Radio Flux Progression



Zoom:



◆ Monthly Values    — Smoothed Monthly Values    — Predicted Values    ● Predicted F10.7 Range

▾

Space Weather Prediction Center

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<https://www.poollicht.be/>

