THE 2017 TOTAL SOLAR ECLIPSE

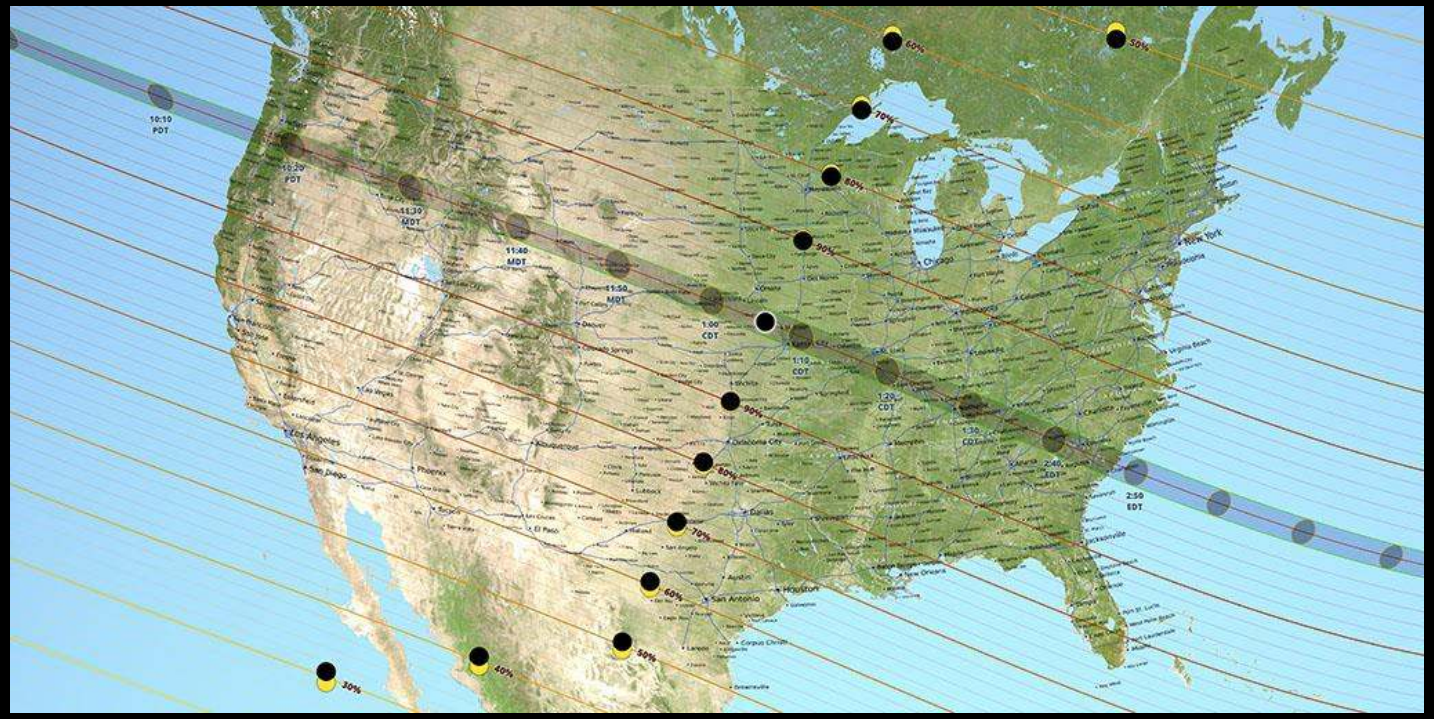
ESAC Seminar, 14 Sep 2017

M. Breitfellner, D. Cabezas, M. Castillo, A. de Burgos, B. Gonzalez, S. Martínez, D. Merritt, M. Pérez-Ayúcar, J. Zender, …

Event organized by CESAR and ESA Comms

THE GREAT AMERICAN ECLIPSE !

- First eclipse in 38 years in continental USA
- Covers USA from coast to coast from Oregon to South Carolina
- ONLY 2min 30 sec!



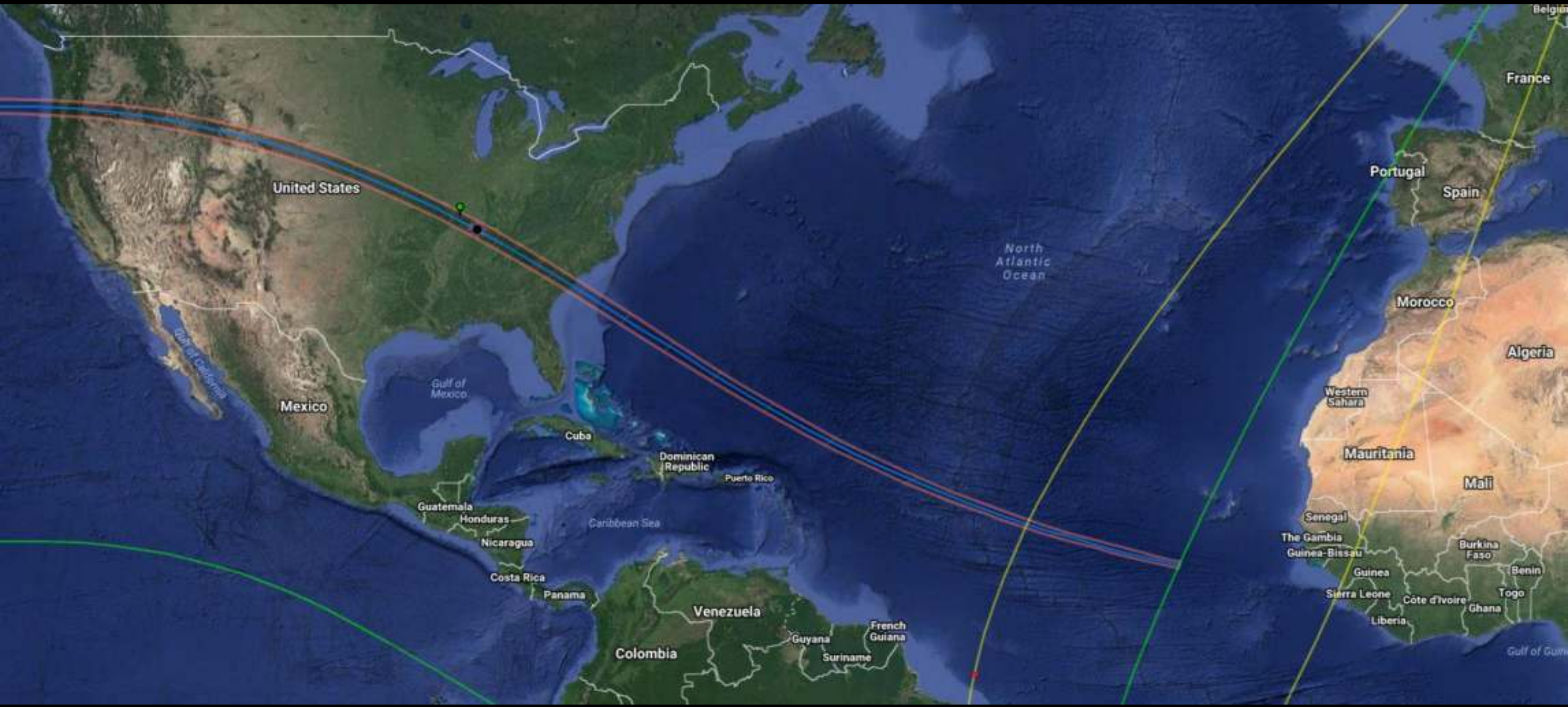
Credits: NASA eclipse pages

47.0
MILLION
AMERICANS

14.4% OF
THE NATION

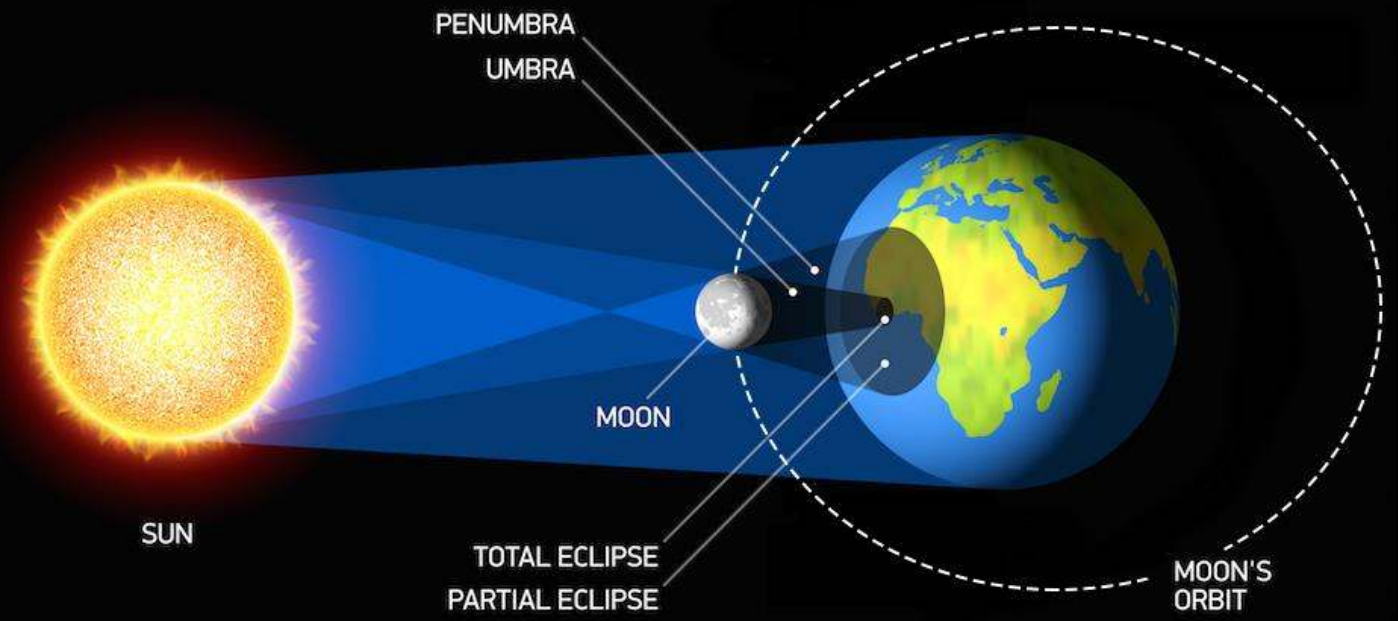
LIVES WITHIN
100
MILES OF
TOTAL ECLIPSE

Great
American
Eclipse.com


United States
Mexico
Gulf of Mexico
Gulf of California
Cuba
Dominican Republic
Puerto Rico
Guatemala
Honduras
Nicaragua
Costa Rica
Panama
Caribbean Sea
Venezuela
Colombia
Guyana
Suriname
French Guiana
North Atlantic Ocean
Portugal
Spain
France
Morocco
Algeria
Western Sahara
Mauritania
Mali
Senegal
The Gambia
Guinea-Bissau
Guinea
Sierra Leone
Liberia
Côte d'Ivoire
Ghana
Burkina Faso
Benin
Togo

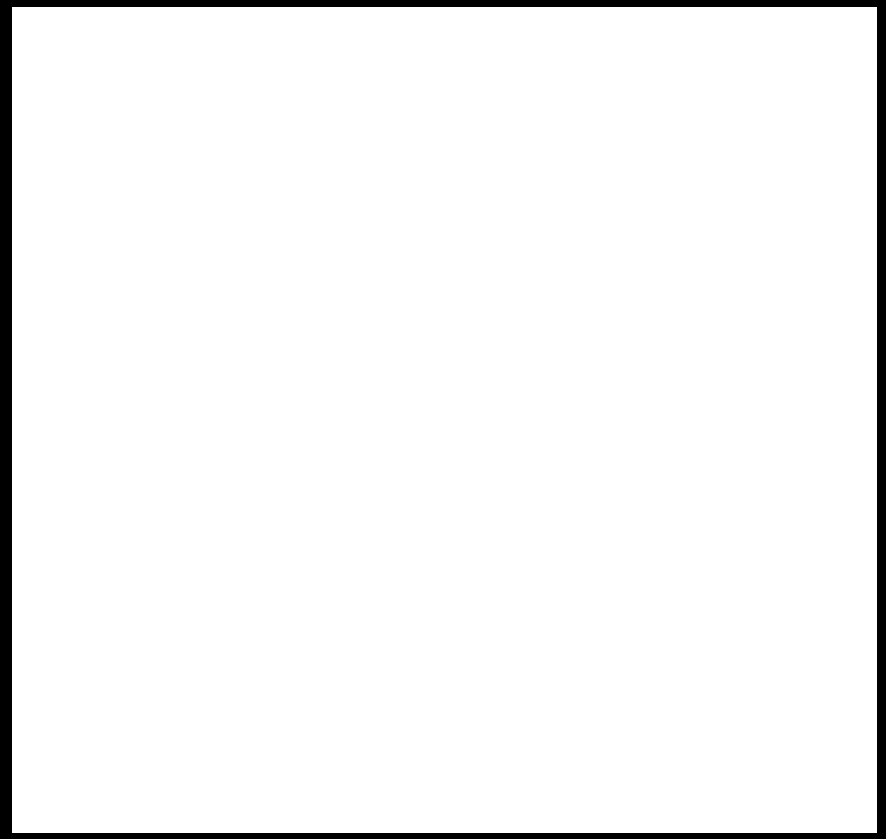
WHY ECLIPSES OCUR

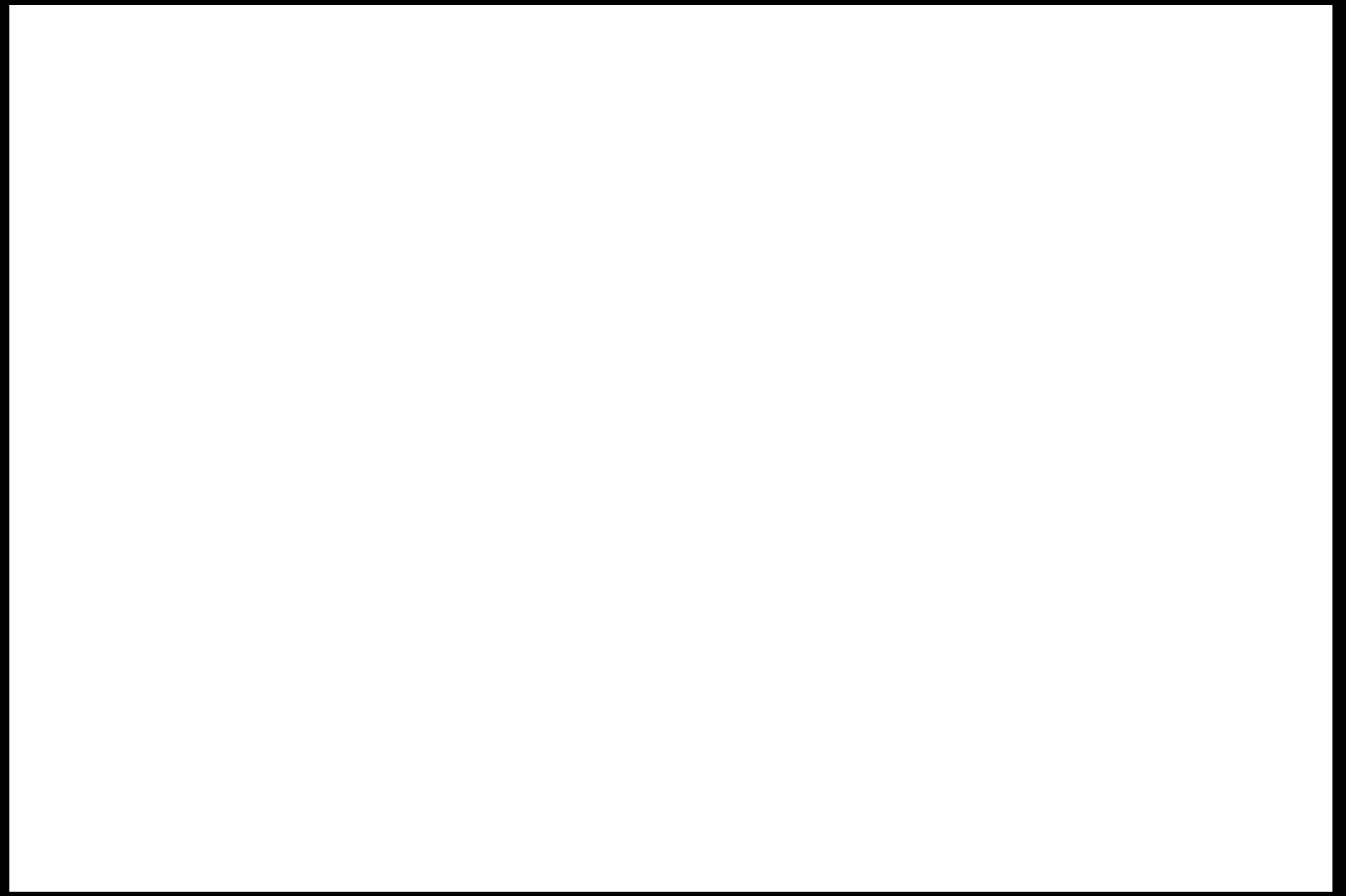
- Eclipses occur when the Moon orbits between the Earth and the Sun, covering the latter.
- Despite the Moon being nearly 400 times smaller than the Sun, it is also 400 times closer to Earth, which causes its size to be similar.
- Eclipses can only happen at new moon.
- During a total eclipse, the Moon does not block the Sun’s outer atmosphere (*corona*), which remains visible.
- The Moon casts two shadows over the Earth: the Umbra and the Penumbra.



Credits: Mrs. Stefanisin's Page

Eclipses: not in every new moon …

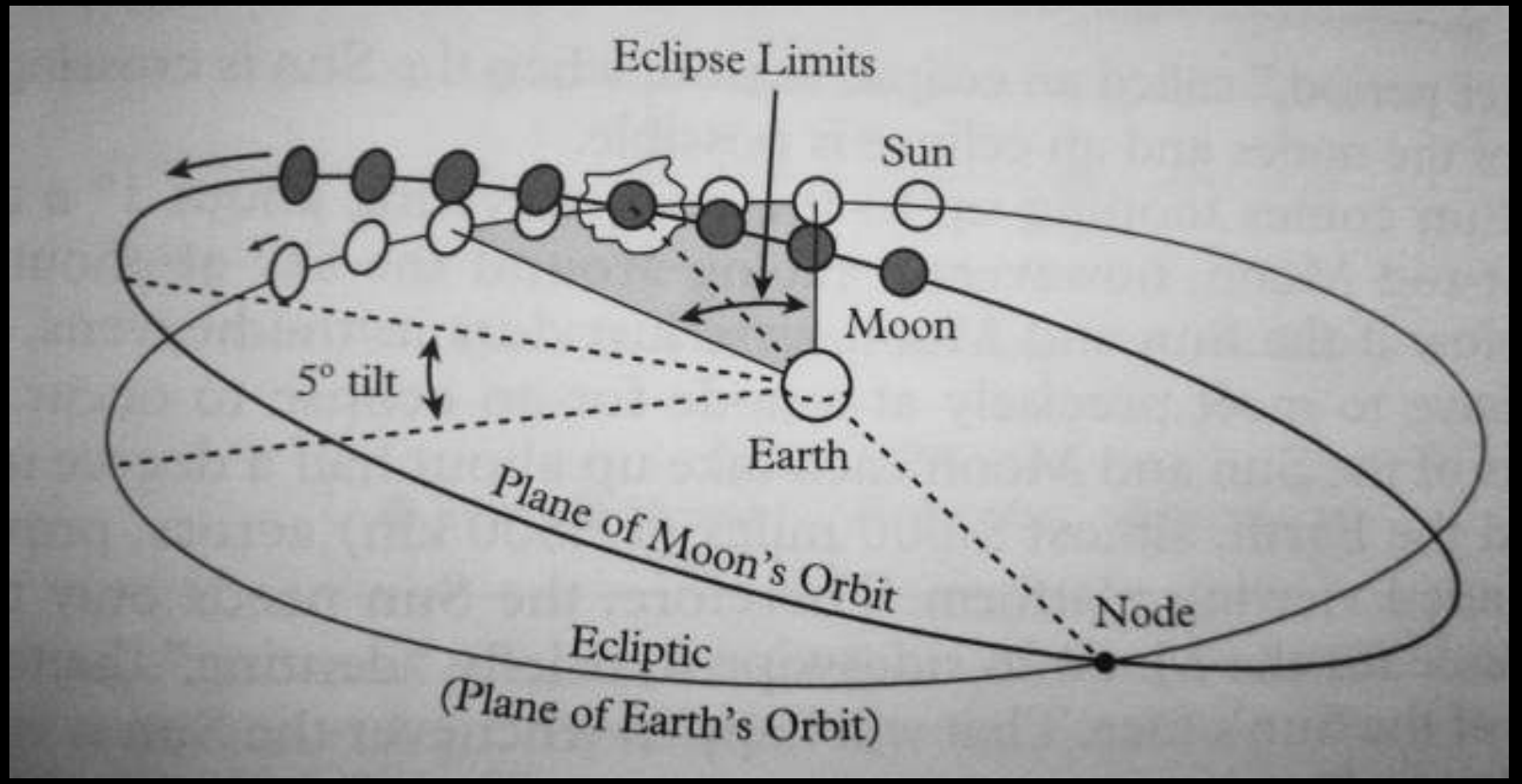




hyperphysics.phy-astr.gsu.edu/hbase/Solar/lunecl.html

Eclipses: not in every new moon …

- When can it occur? In the 31 days (DANGER ZONE) where the Sun crosses the nodes of the Moon.



INTERESTING FACTS on ECLIPSES

- Duration ? Up to 7 min 32 sec (total eclipse)
- Can it happen in other planets? Yes, but they are either partial (Mars), or Total (Saturn, Jupiter, Pluto…). We also can consider transits (partial eclipse) of other planets.
- Why are they so particular for the EARTH-MOON ? It is just a celestial coincidence that the relative size is so close that we can actually see the chromosphere / inner corona

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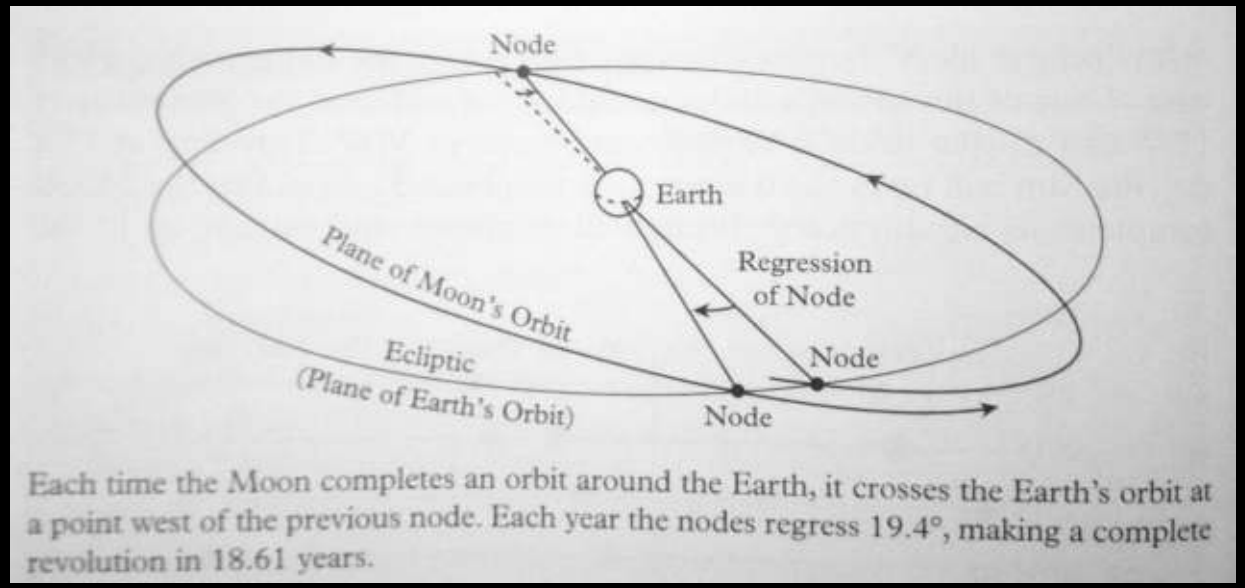
PREDICTING NEXT ECLIPSES

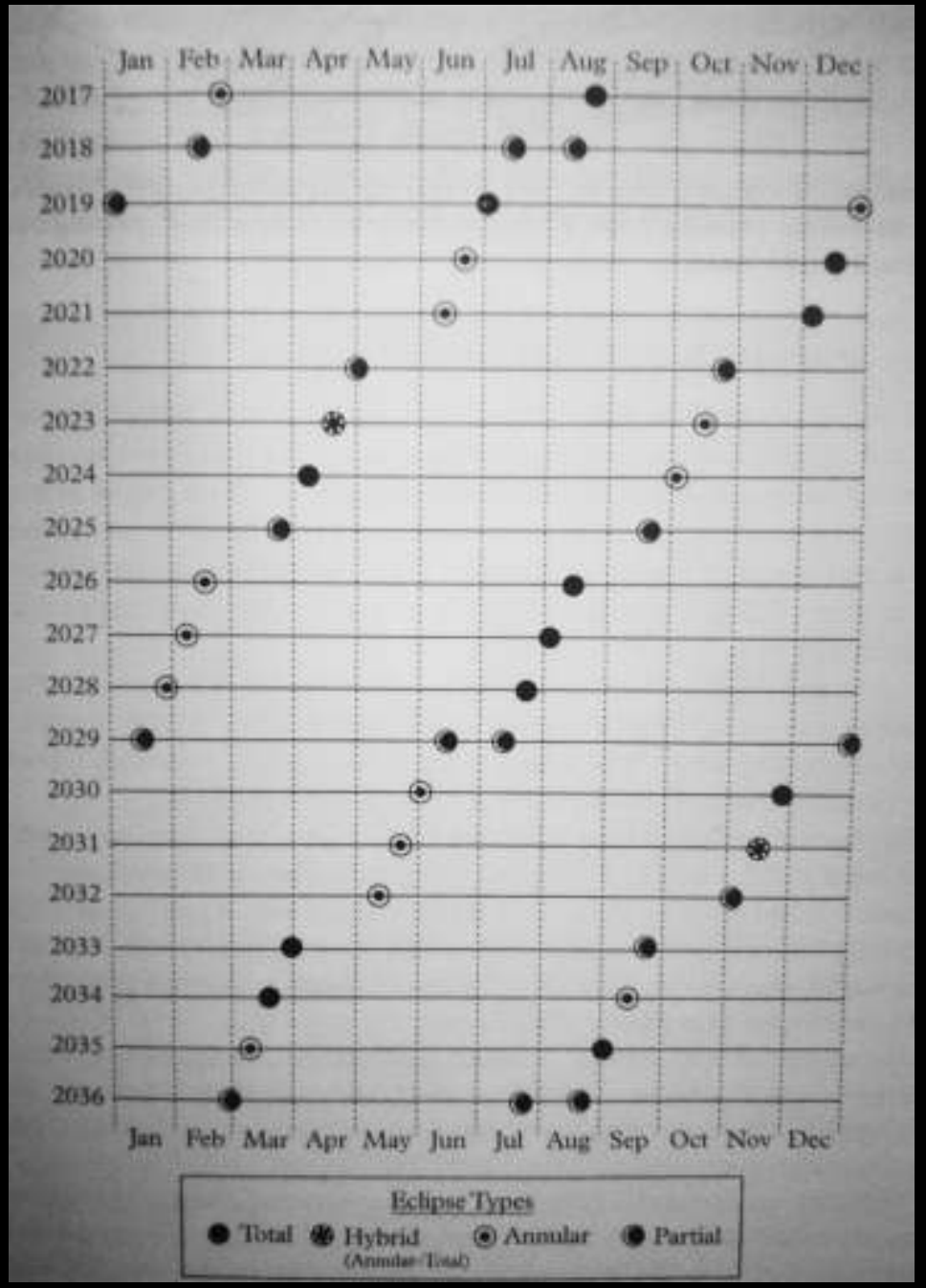
- The eclipse repetition is not HALF year exactly, as the Moon orbit nodes regress 19.4 deg per year. Sun eclipse year is 346.62 days

- Saros cycle = 18 years 11.3 days ~ 6585 days
  - 223 synodic months (29.53 days) = 6585.32 days
  - 19 eclipse years = 6585.78 days

- How many eclipses per year ? 2 – 5



Each time the Moon completes an orbit around the Earth, it crosses the Earth's orbit at a point west of the previous node. Each year the nodes regress 19.4°, making a complete revolution in 18.61 years.



TYPES

Partial

Annular
(ring of fire)

Credits: Daniel Lynch

Credits: Hong Kong Observatory

Hybrid

TOTAL

Credits: Luc Viatour / https://Lucnix.be

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PHASES

THE TEAM

- CESAR expedition @ USA: Miguel Perez Ayucar-ESAC, Abel de Burgos Sierra-ESAC, Manuel Castillo-ESAC, Joe Zender-ESTEC, Silvia García Soto-external, Dario Perez-external
- CESAR team @ ESAC: Michel Breitfelner-ESAC, David Cabezas-ESAC, Santa Martinez-ESAC, Roberto Prieto-ESAC, Donald Merritt-ESAC, Daniel Barrado, Anick de Groof
- Communications and Education ESA @ ESTEC: Emily Baldwin-ESTEC, Markus Bauer-ESTEC, Emmet Fletcher-ESAC

→TOTAL SOLAR ECLIPSE

21 August 2017, USA

Image: Proba-2, ESA

Follow the eclipse LIVE, from our expedition team in Wyoming USA, and from the European Space Astronomy Centre in Madrid ! We will also be talking about eclipses and solar space missions.

#eclipse2017

CASPER MOUNTAIN - WYOMING

42° 45' 09.21" N <–>	42.75256°	2m 25.1s (total solar eclipse)	Help
106° 18' 52.91" W <–>	-106.31470°	2m 27.8s (lunar limb corrected)	

Umbral depth : 86.73%
7.2km (4.5mi)
Path width : 108.5km (67.4mi)
Obscuration : 100.00%

Magnitude at maximum : 1.01272
Moon/Sun size ratio : 1.02934
Umbral vel. : 0.766km/s (1713 mph)

Event (ΔT=68.8s)	Date	Time (UT)	Alt	Azi	P	V	LC
Start of partial eclipse (C1) :	2017/08/21	16:22:15.5	+42.7°	118.1°	288°	13.0	
Start of total eclipse (C2) :	2017/08/21	17:42:41.0	+54.0°	142.6°	117°	07.2	-1.8s
Maximum eclipse (MAX) :	2017/08/21	17:43:53.5	+54.1°	143.1°	019°	10.5	
End of total eclipse (C3) :	2017/08/21	17:45:06.1	+54.2°	143.5°	282°	01.6	+0.9s
End of partial eclipse (C4) :	2017/08/21	19:09:30.9	+59.1°	180.6°	111°	08.3	

42° 04' 25.72" N <–>	42.07381°	2m 30.5s (total solar eclipse)	Help
102° 49' 06.49" W <–>	-102.81847°	2m 30.9s (lunar limb corrected)	

Umbral depth : 95.05%
2.7km (1.7mi)
Path width : 110.0km (68.4mi)
Obscuration : 100.00%

Magnitude at maximum : 1.01414
Moon/Sun size ratio : 1.02976
Umbral vel. : 0.729km/s (1631 mph)

Event (ΔT=68.8s)	Date	Time (UT)	Alt	Azi	P	V	LC
Start of partial eclipse (C1) :	2017/08/21	16:27:11.9	+46.0°	122.4°	289°	01.0	
Start of total eclipse (C2) :	2017/08/21	17:49:19.1	+56.6°	150.1°	107°	07.7	-1.0s
Maximum eclipse (MAX) :	2017/08/21	17:50:34.4	+56.8°	150.7°	200°	04.6	
End of total eclipse (C3) :	2017/08/21	17:51:49.7	+56.9°	151.2°	293°	01.5	-0.6s
End of partial eclipse (C4) :	2017/08/21	19:16:50.3	+59.4°	190.9°	112°	08.6	

40° 26' 39.43" N <–>	40.44429°	(partial solar eclipse)	Help
3° 57' 11.29" W <–>	-3.95314°		

Obscuration : ???

Magnitude at maximum : 0.26153
Moon/Sun size ratio : 1.01320

Event (ΔT=68.8s)	Date	Time (UT)	Alt	Azi	P	V
Start of partial eclipse (C1) :	2017/08/21	18:45:21.2	+02.7°	283.3°	240°	05.6
Sunset (SET) :	2017/08/21	19:02	-00.3°	285.9°		8.25%
Maximum eclipse (MAX) :	2017/08/21	19:21:39.6*	-03.9°	289.2°	197°	07.0
End of partial eclipse (C4) :	2017/08/21	19:56:30.7*	-10.1°	295.2°	154°	08.4

WHAT WE WANTED TO CAPTURE

- The Expedition wanted to capture several aspects of the eclipse
    - Fully capture the moon transit as image sequences from the start to end of the eclipse (~3h), including the totality (2min 30sec)
    - Totality: Baily beads (moon's valleys)
    - Totality: Diamond ring
    - Totality: Inner and outer corona images and video
    - Totality: Chromosphere (red)
    - Totality: Emission spectra of chromosphere and corona elements (H, Fe, Mg..)
    - Totality: polarization of corona
    - Landscape scene
    - Pinhole projection
    - First person experience

EQUIPMENT – cameras, mounts, telescopes, etc..

Eclipse Observation and Recording Equipment												
Optics	**Who**	**Diametre**	**Mount**	**Camera**	**Equivalent focal length**	**Target**	**Spectral Range**	**Real-time Distribution**	**Off-line distribution**	**Eclipse coverage**	**Shutter**	**Description**
Telescope	MPA	90mm	CGEM	Canon 550D or QHY		Photosphere + Inner corona	Visible	YES	YES	All	SW	Eclipse evolution in visible Imaging in 16 bits for HDR
Coronado Telescope	MPA	90mm	CGEM	Canon 550D or QHY		Chromosphere	H-alpha	YES	YES	All	SW	Eclipse evolution in H-alpha
300mm	MC	58mm	Star Adventurer	Canon 60D	480mm	Photosphere + Extended Corona	Visible	NO	YES	All	timer	Eclipse evolution in visible Extended Corona in 16bits for HDR
500mm	MC	72mm	Star Adventurer	Olimpus E240	1000mm	Photosphere + Chromosphere Limbs	Visible+NIR	NO	YES	Totality	manual	Eclipse Limb spectres in 16 bits
400mm	Abel	77mm	Star Adventurer	Canon 6D	400mm	Photosphere + Inner corona	Visible	NO	YES	All	timer	Short exposure time images
250mm	Silvia	58mm	Star Adventurer	Canon700D	400mm	Photosphere + Outter corona	Visible	NO	YES	All	timer	Long exposure time images
300mm	Joe	58mm	Star Adventurer	Canon 5DMII	300mm	extended corona	visible+540nm filter	NO	YES	All	timer	short and long exposures
18-55mm	MPA	52mm	none	Nikon 3100D	28-86mm	context sun	visible	NO	YES	All	timer	sun context image, wider angle, landcape, sky
wide lens	AdB		none	GO-pro	-	local obs site	visible	NO	NO	All	internal time-lapse	first person record of the eclipse (video)
Webcam for computer	MPA		none	Webcam	-	local obs site	visible	YES	NO	All	internal time-lapse	live images of the observation site for real-time upalod to web (1/1min or so)

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EQUIPMENT - telescopes

Coronado Solarmax II 90

Aperture : 90mm
Focal Length : 800mm
Bandwidth : <0.7Å (0.5 with double stack)

Bresser AR-102

Aperture : 102mm
Focal Length : 1000mm
Filter : BAADER AstroSolar™ Safety Film

Celestron CGEM

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TOTAL SOLAR ECLIPSE
21 August 2017, USA
cesar.esa.int

INSTRUMENTS – cameras on tripods

INSTRUMENTS - summary

- 12 cameras to cover the event (8 DSLR, 3 go-pro, 1 webcam)
- 2 telescopes
- 4 tracking mounts
- 2 tripods
- 1 diffraction network
- two polarizers
- two pin-hole projection masks

EQUIPMENT - transport

EQUIPMENT - transport

EQUIPMENT - transport

EQUIPMENT - extra

EQUIPMENT – on site

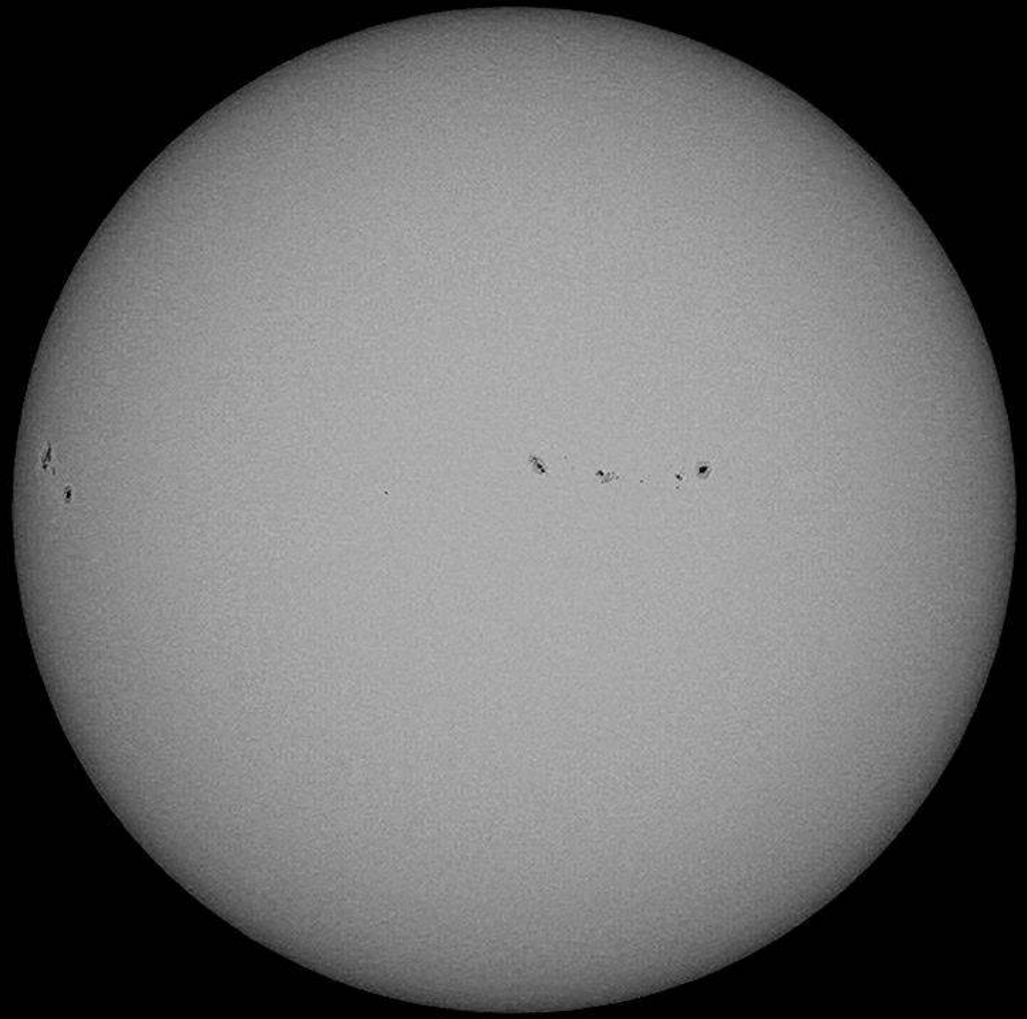
EQUIPMENT – on site

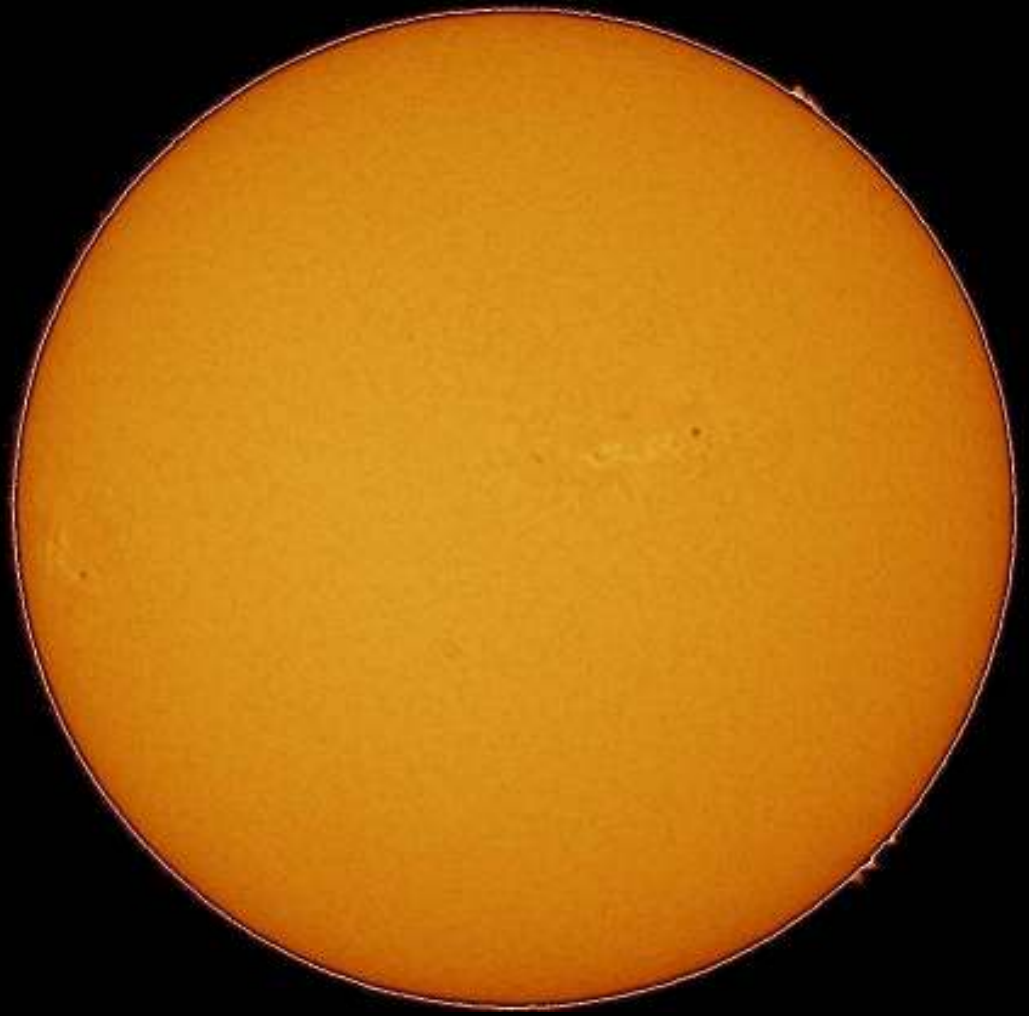
RESULTS

LIVE IMAGES

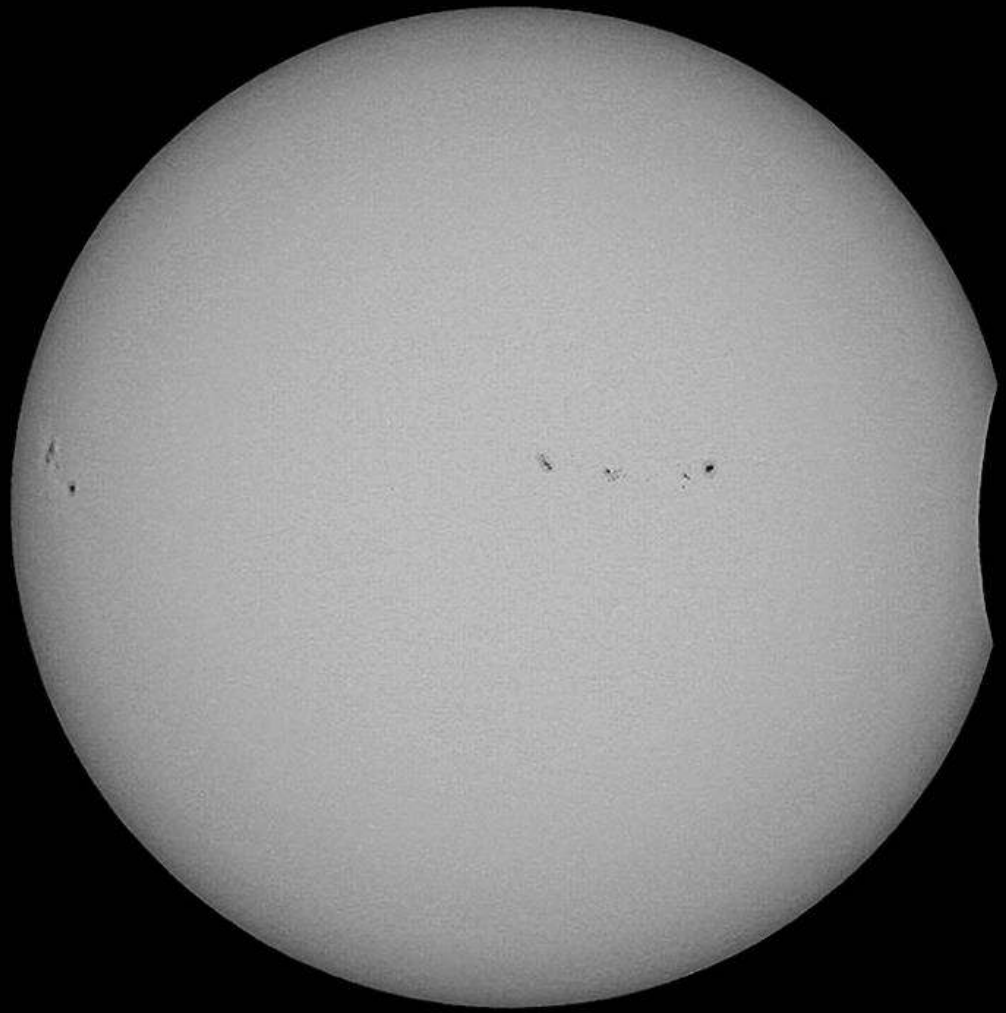
- H-alpha and Visible (monitoring from the two telescopes)
- Work in progress to center all the images and correct brightness (when clouds)

LIVE IMAGES





LIVE IMAGES



LIVE IMAGES

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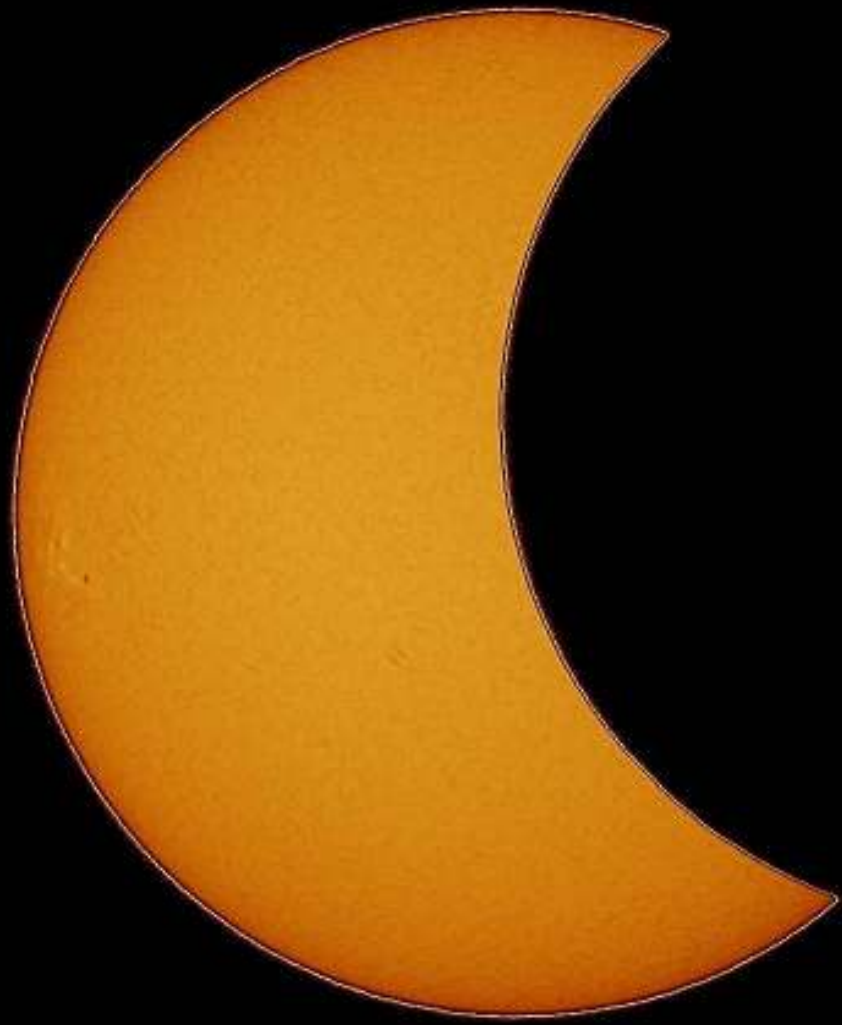
LIVE IMAGES



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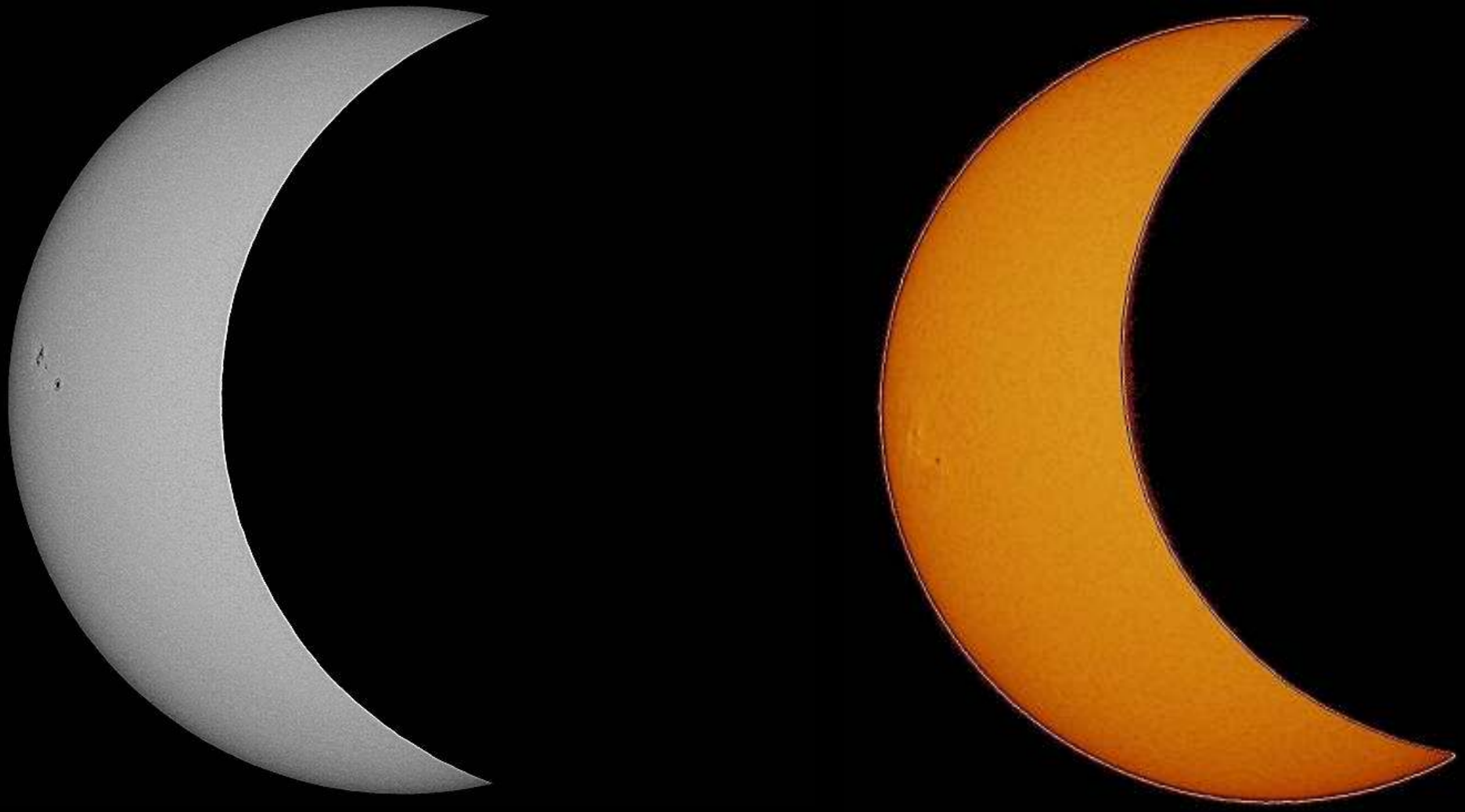

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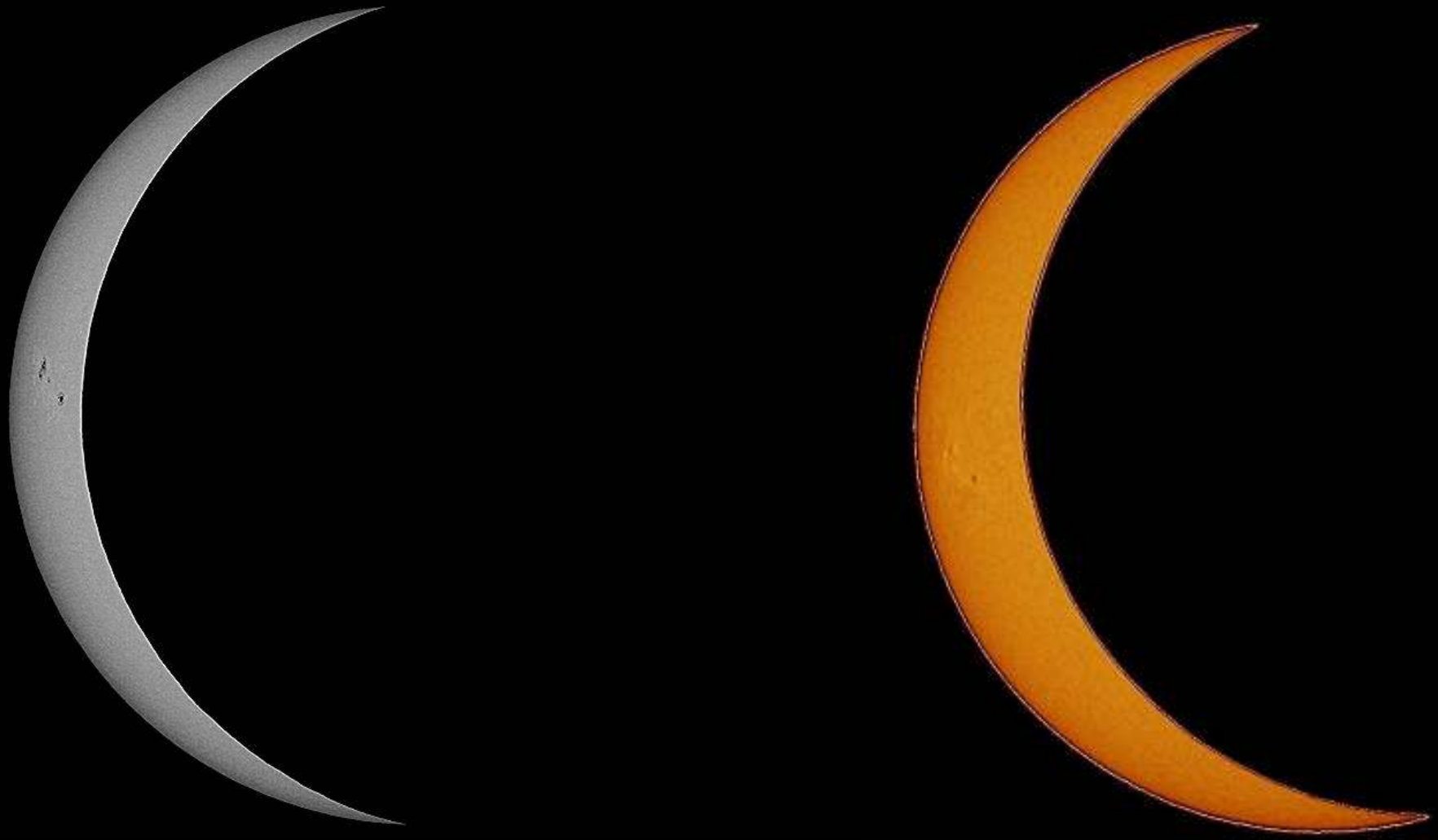

LIVE IMAGES

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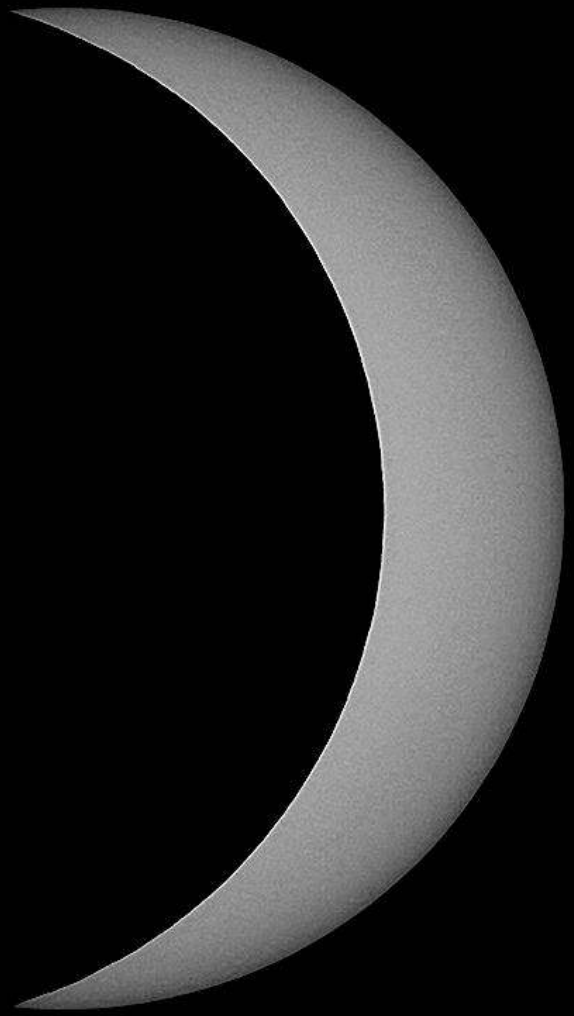

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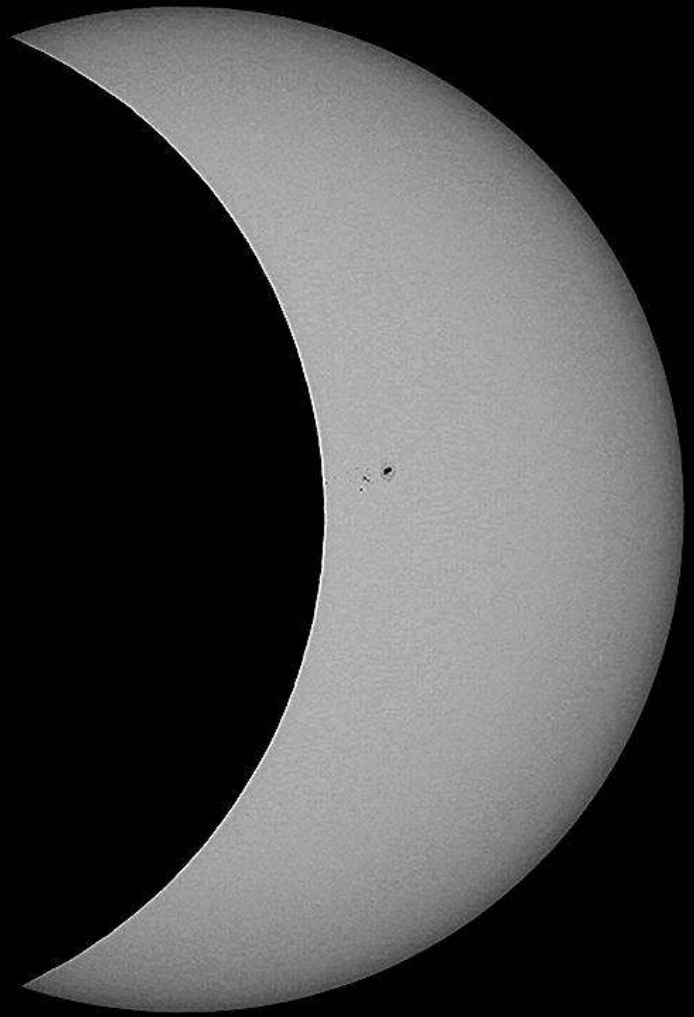

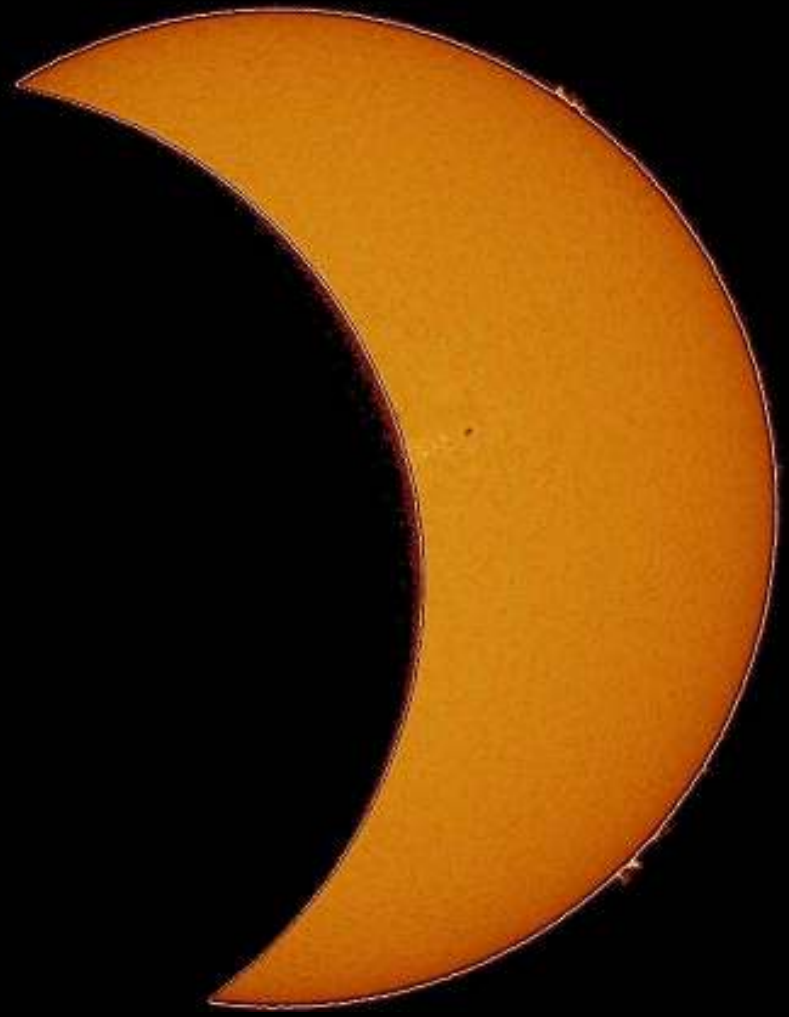

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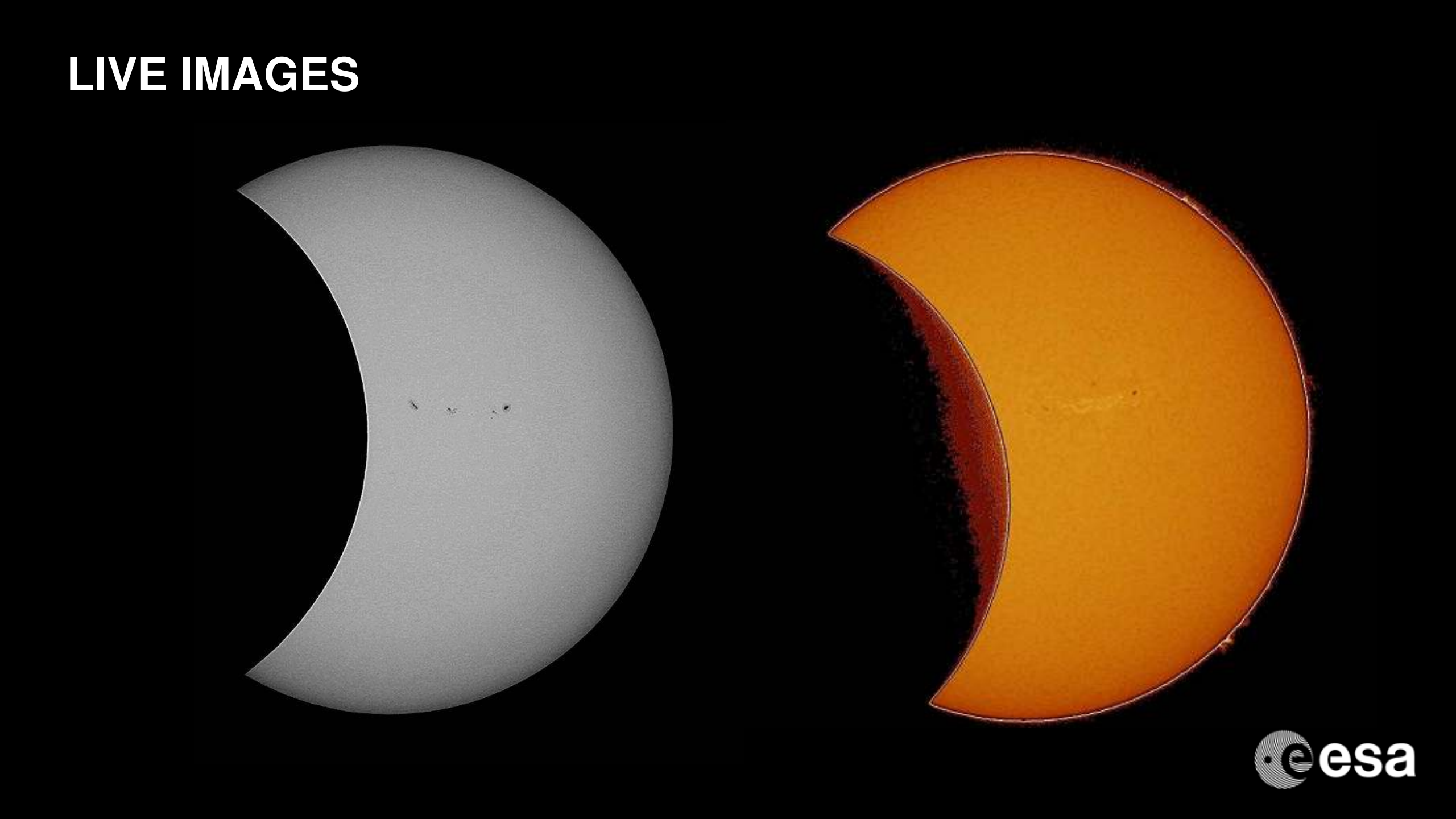

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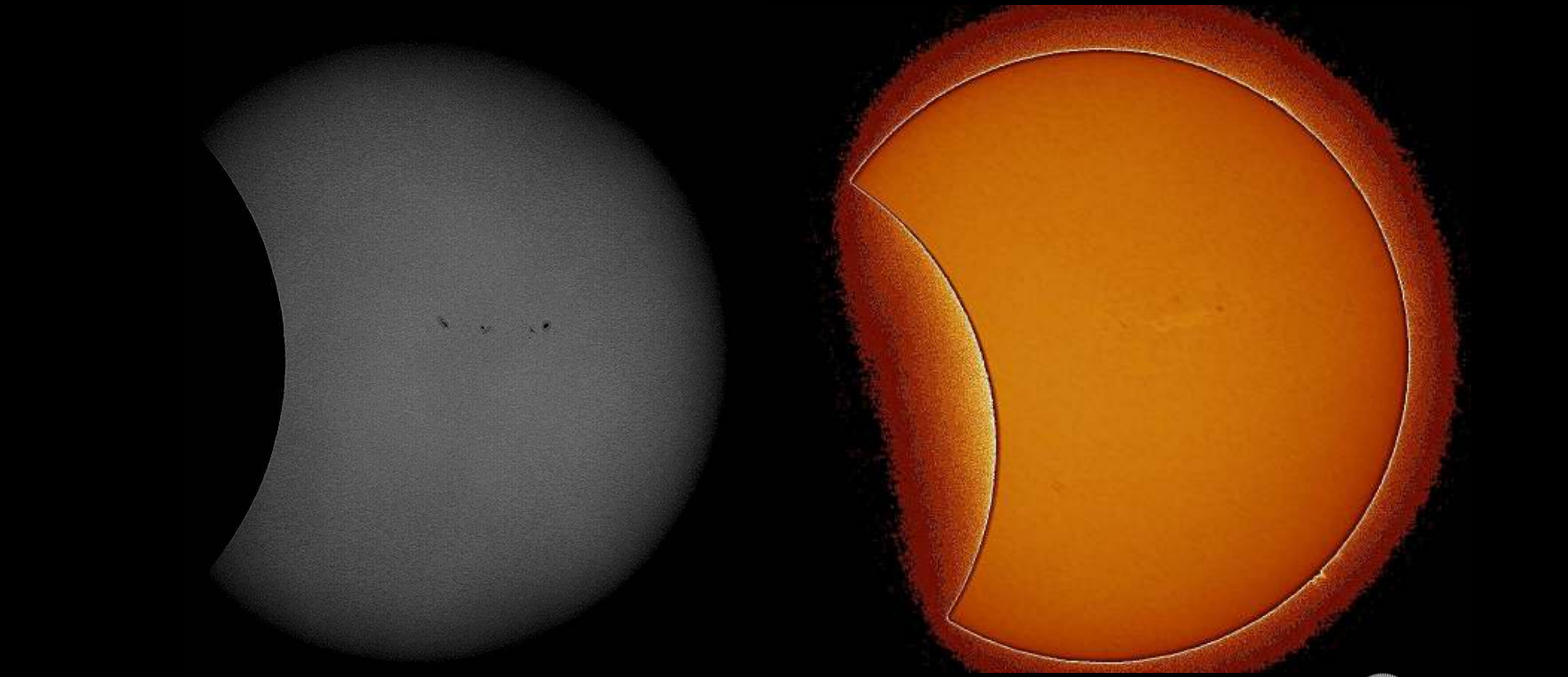

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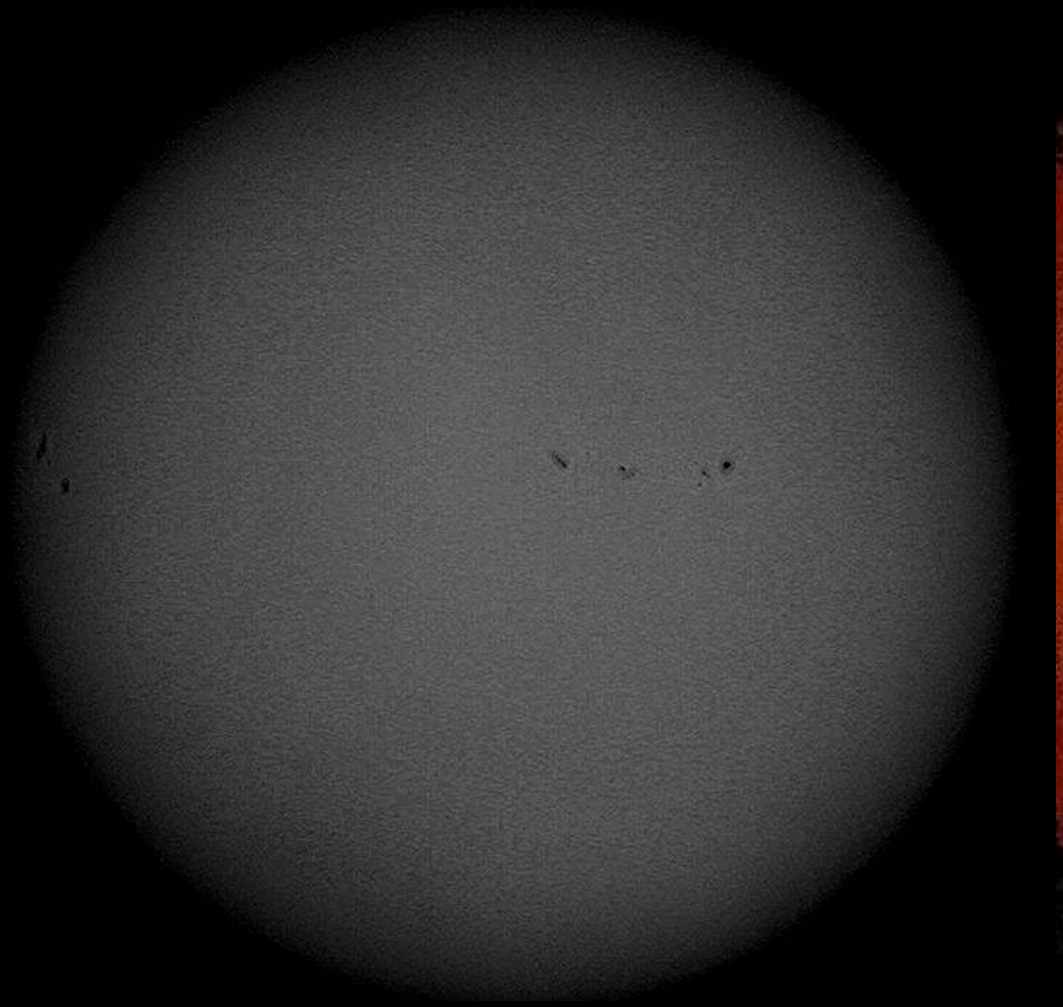

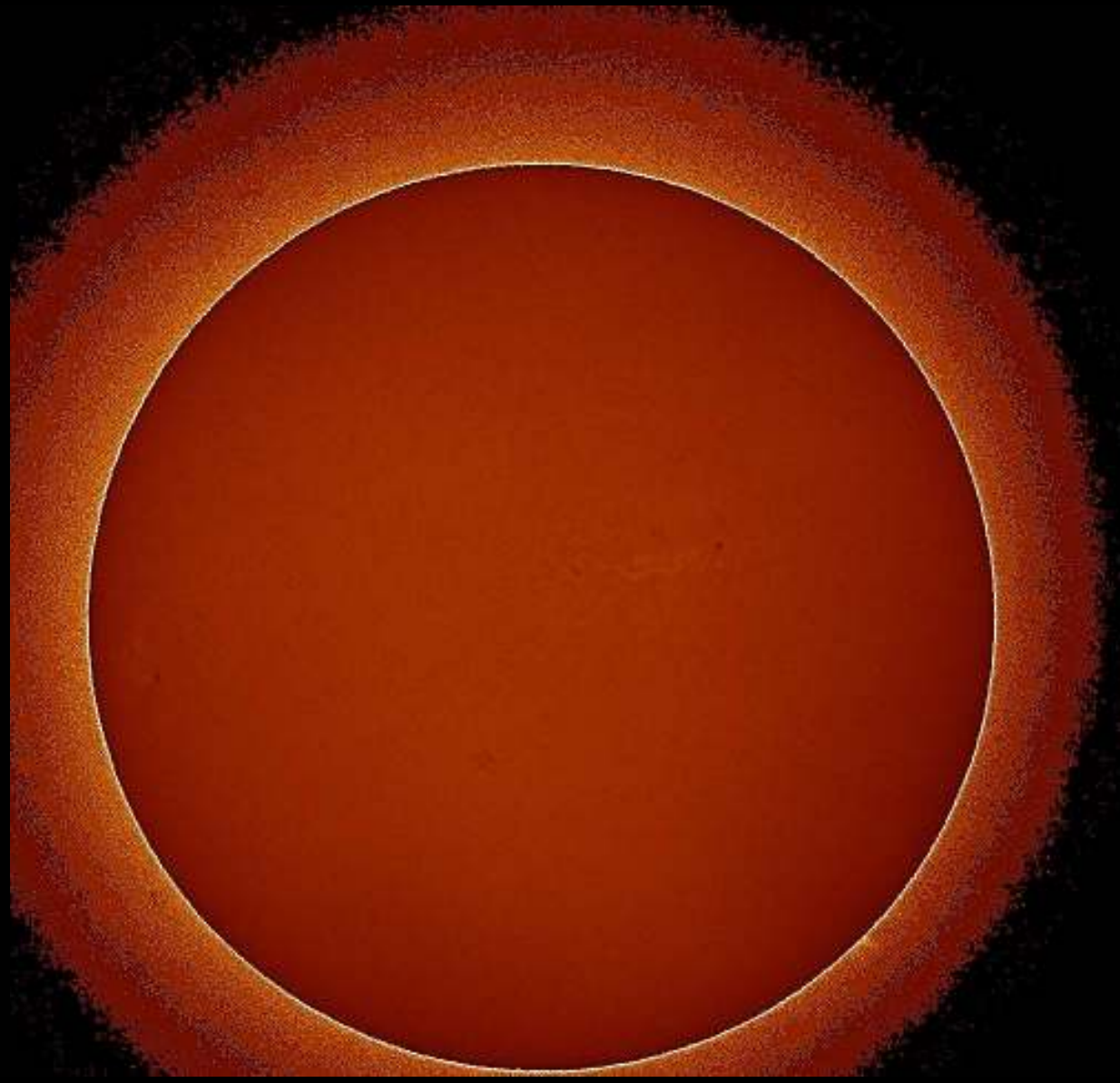

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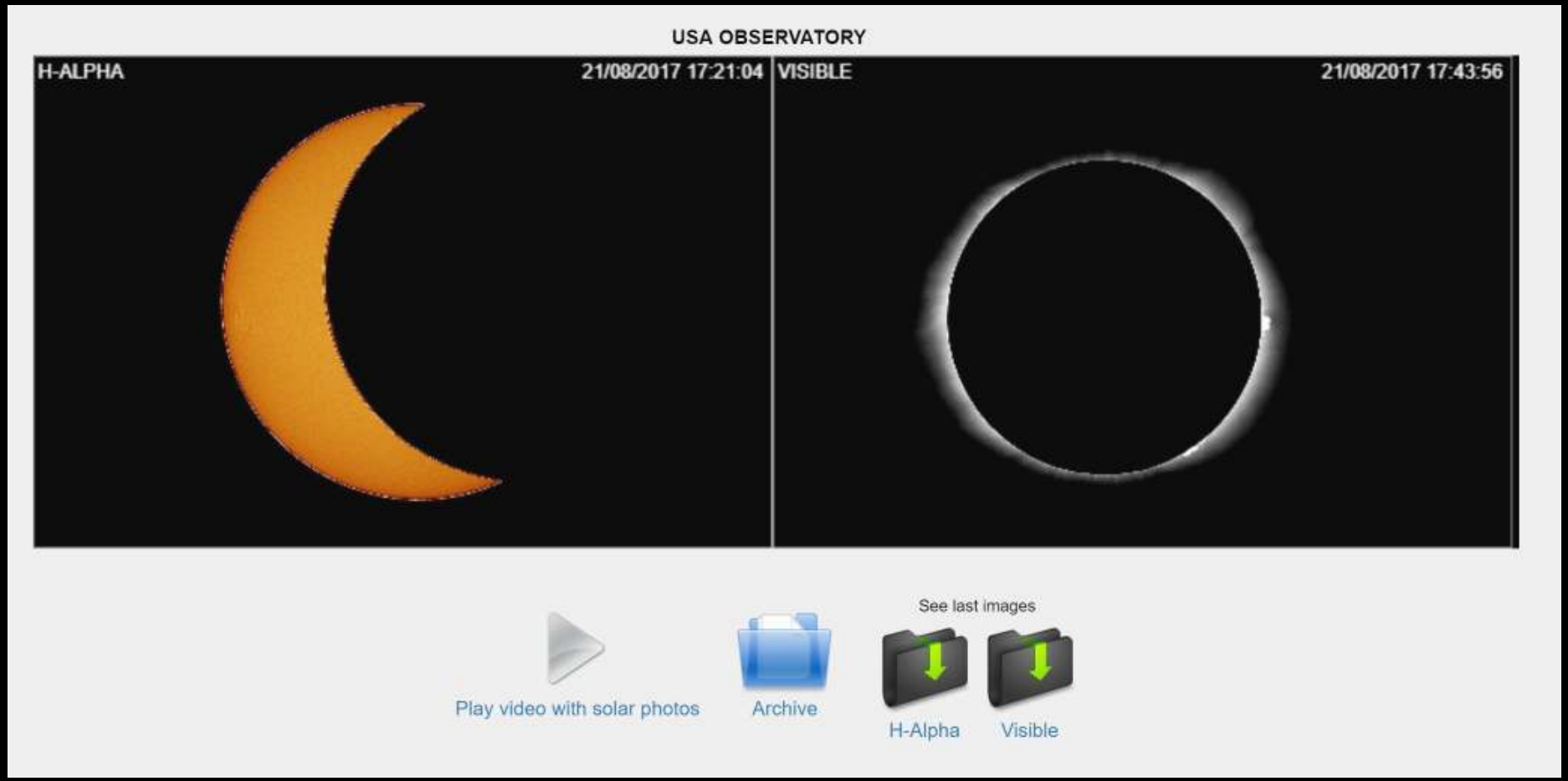
LIVE IMAGES video

- Work in progress

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THE CHROMOSPHERE

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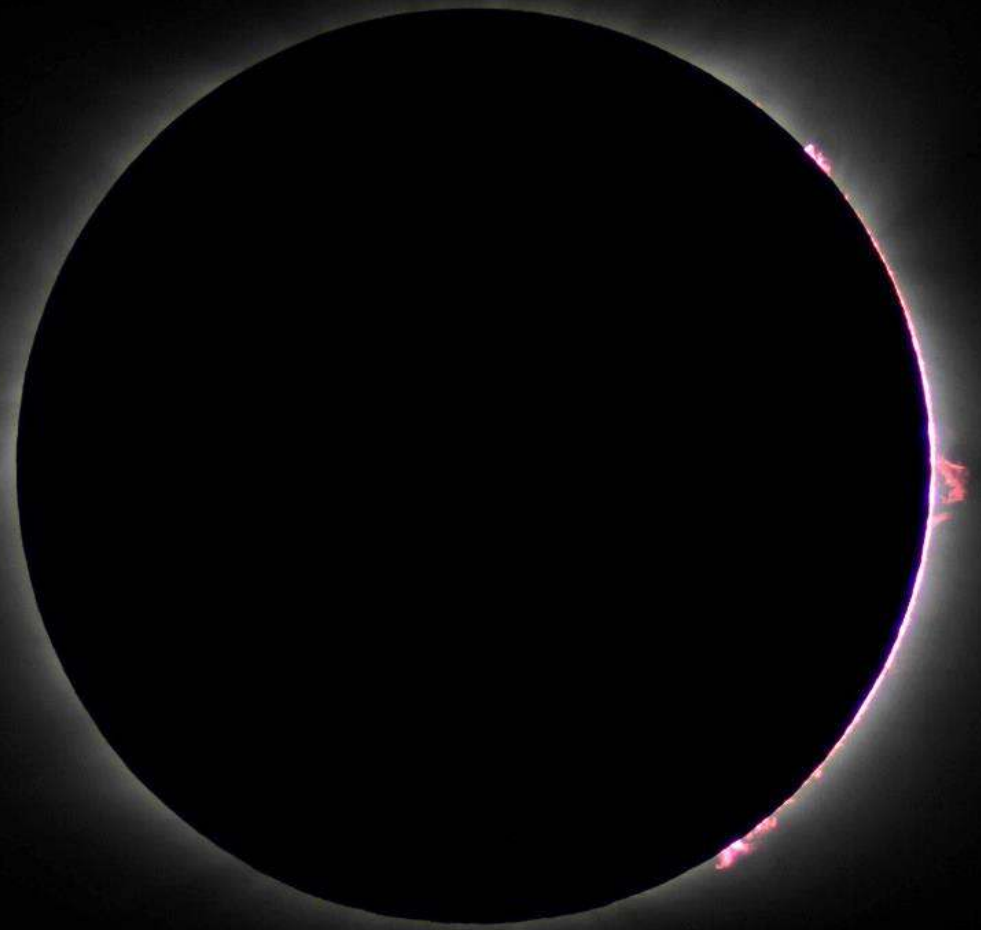
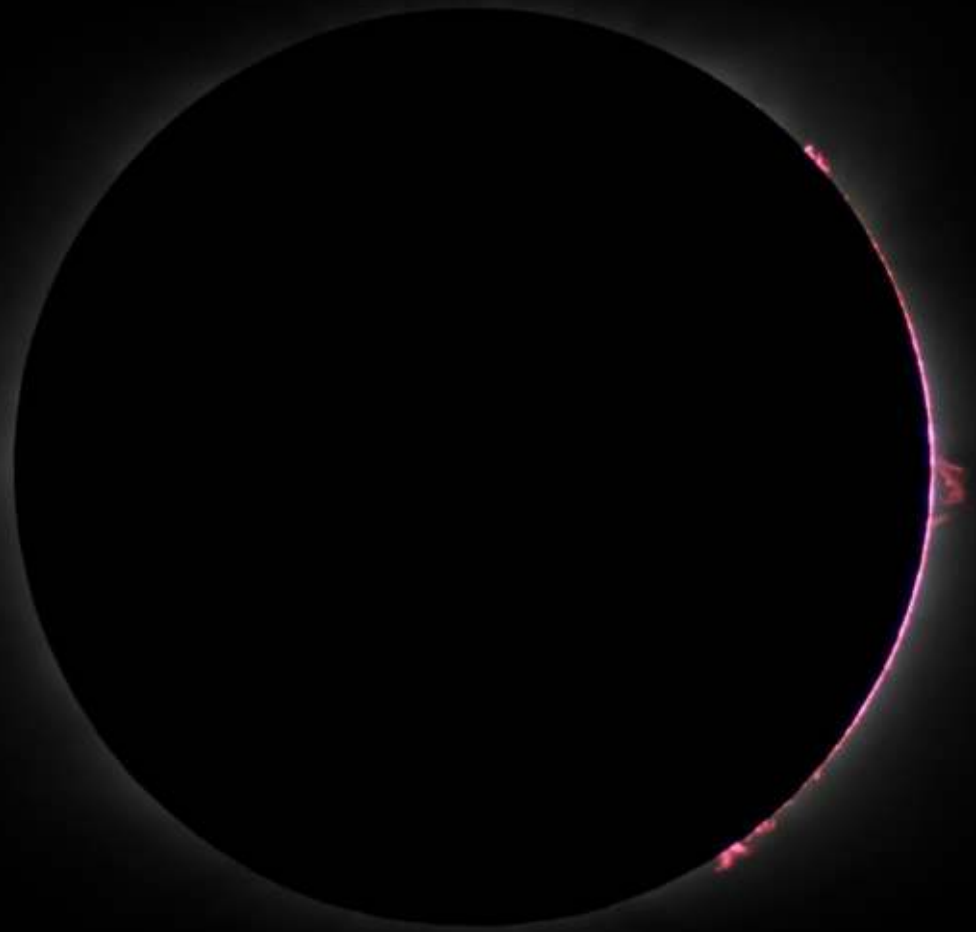
THE CHROMOSPHERE



THE CHROMOSPHERE

THE BAILY'S BEADS



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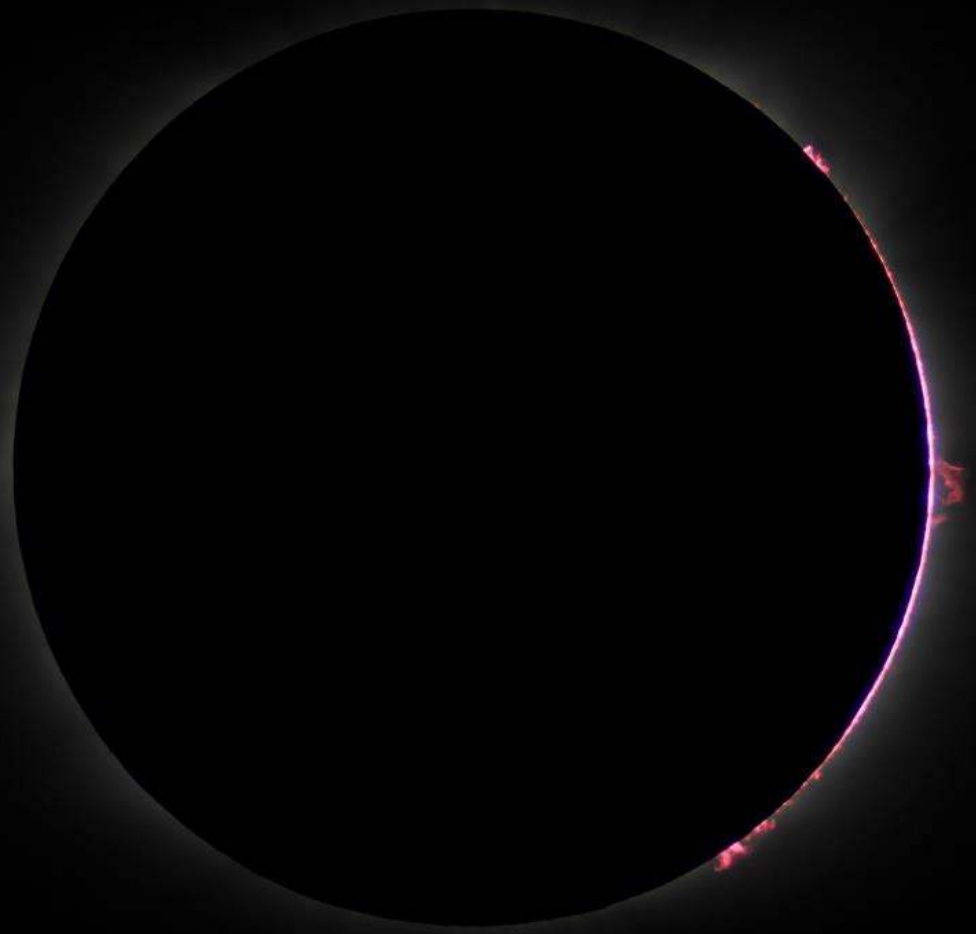

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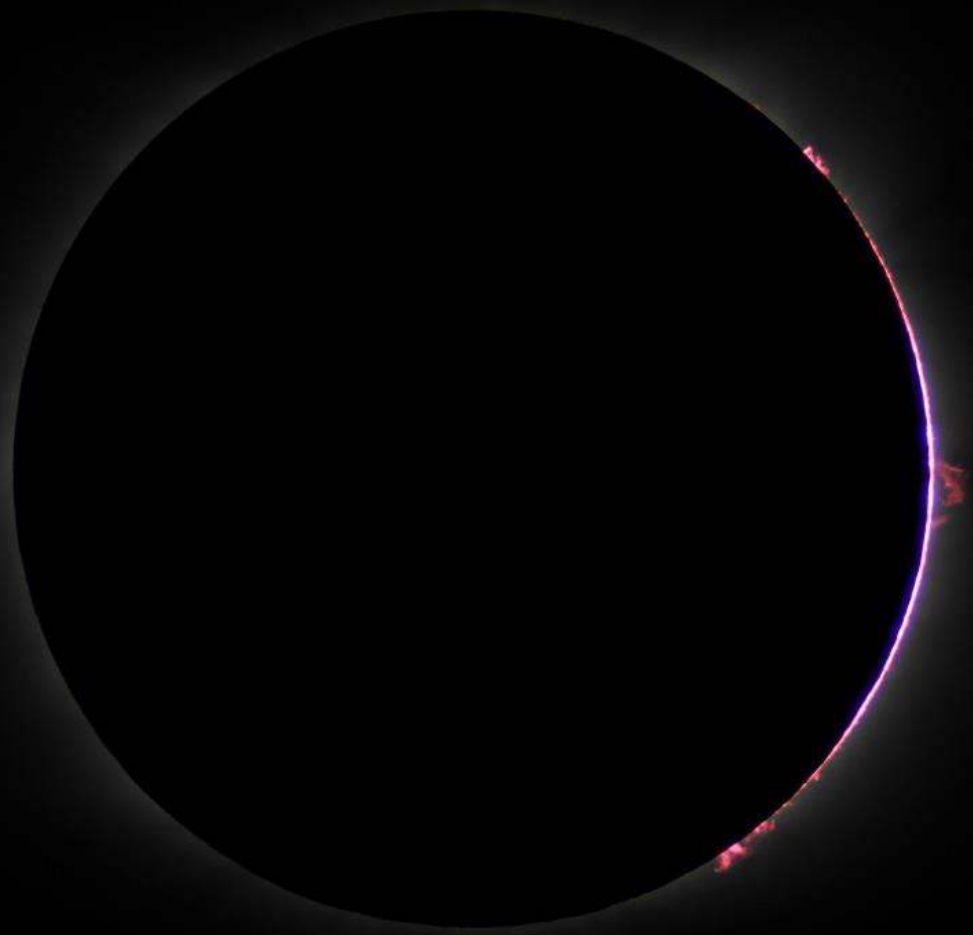

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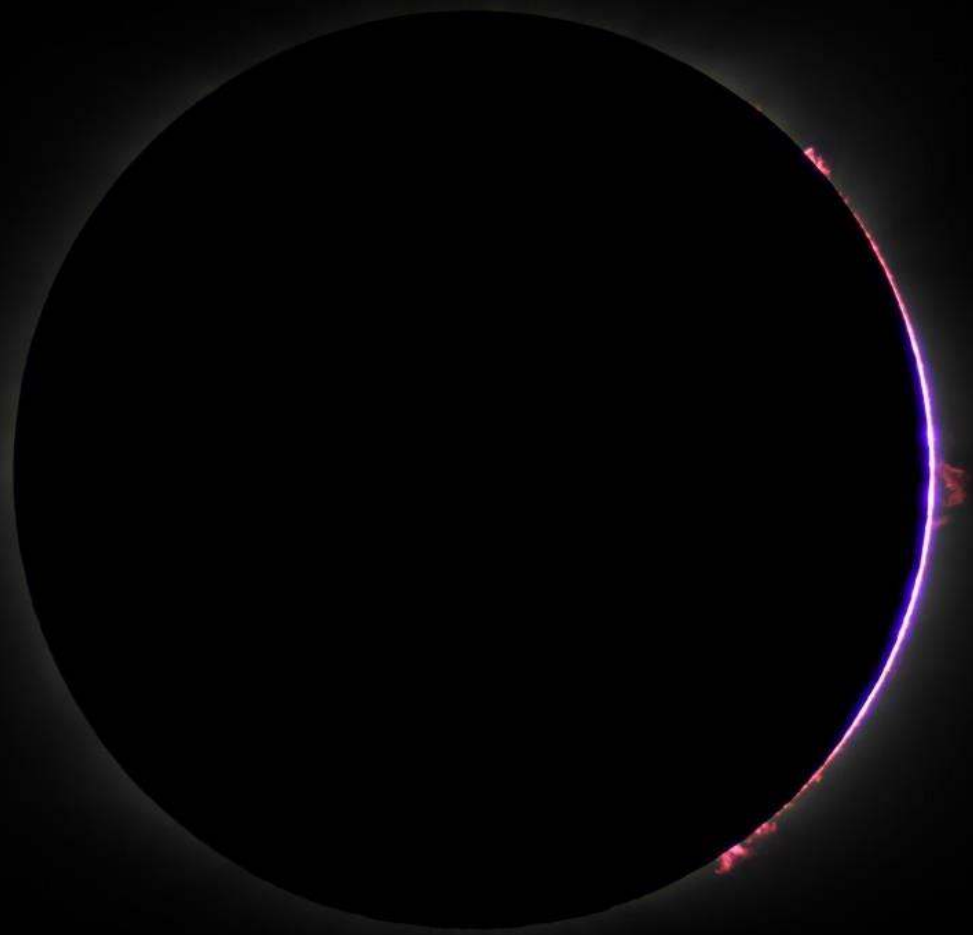

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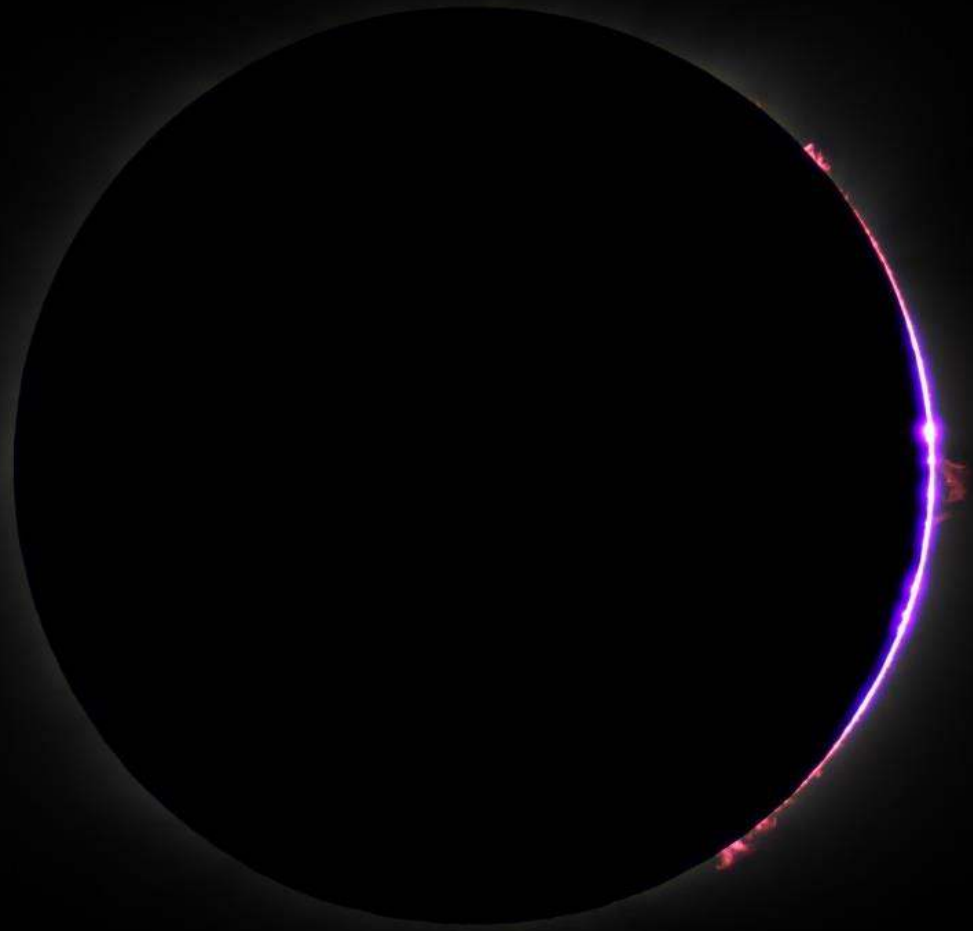

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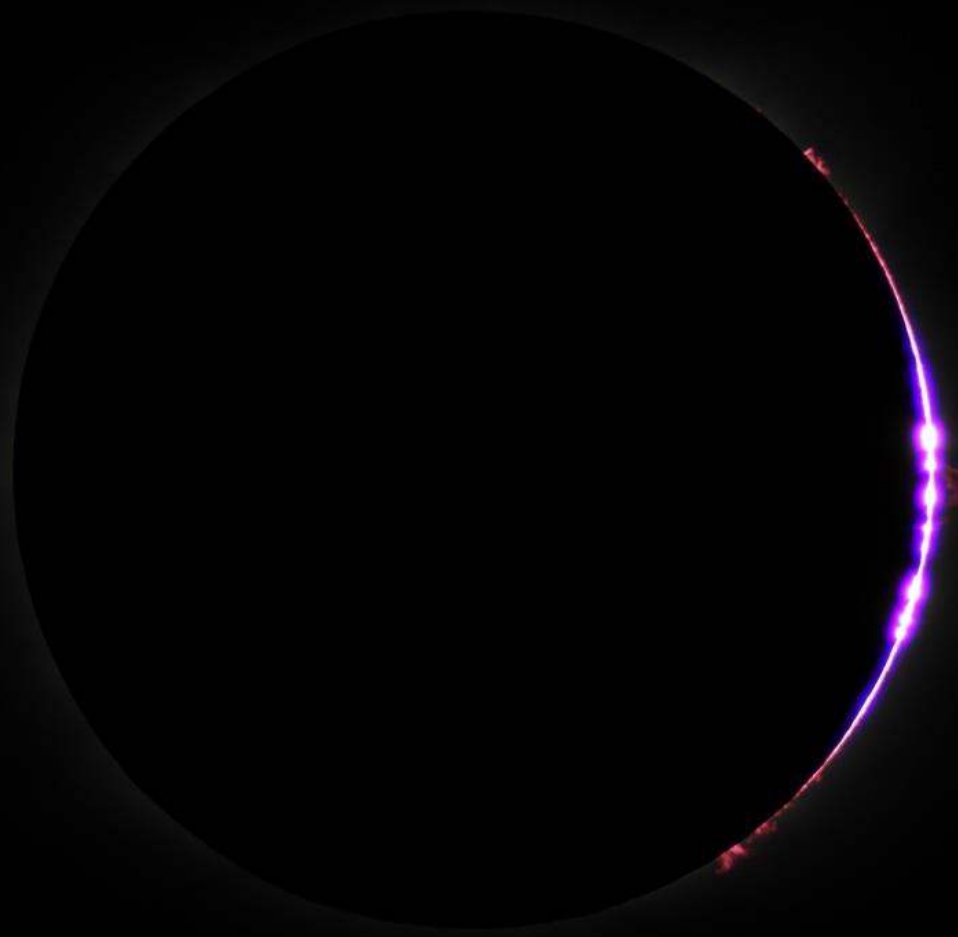

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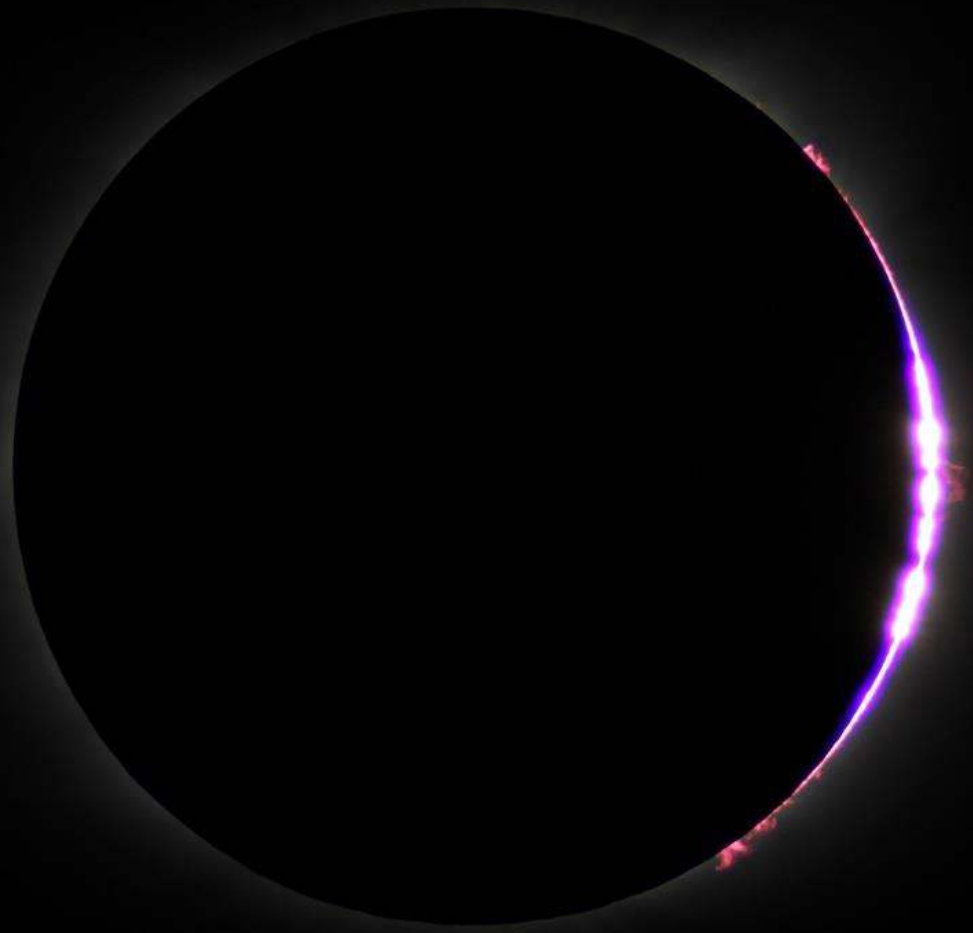

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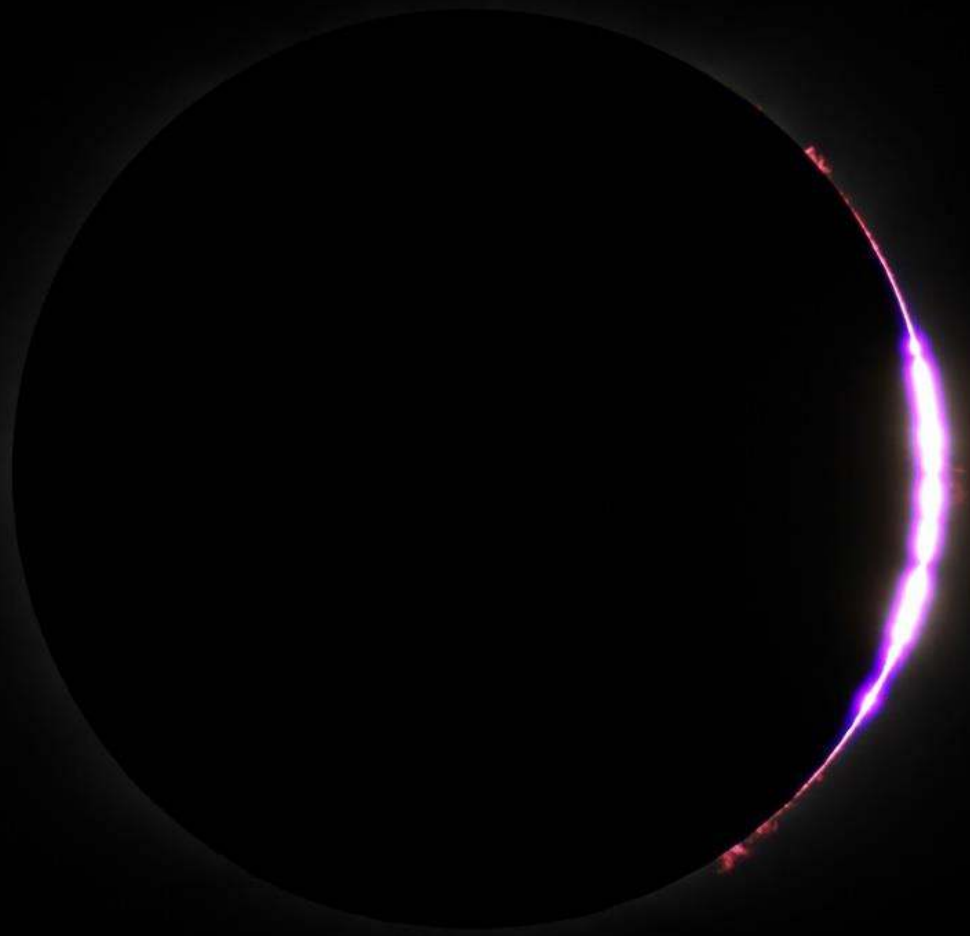

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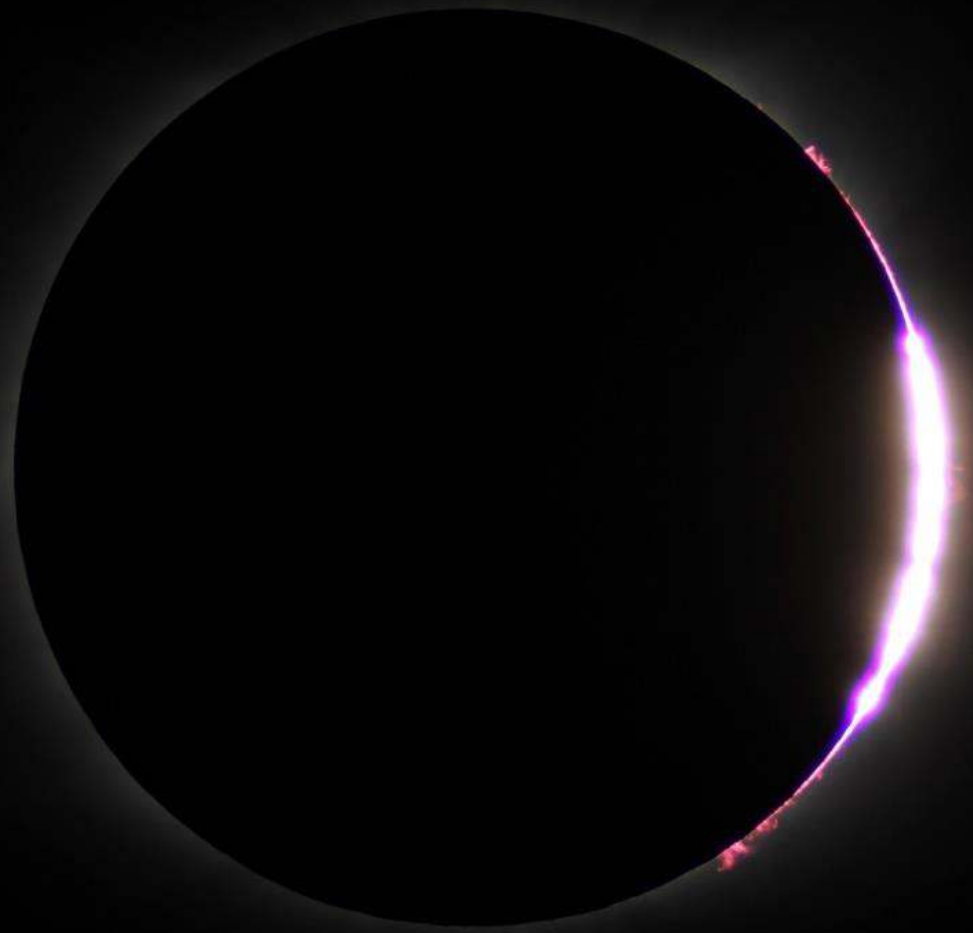

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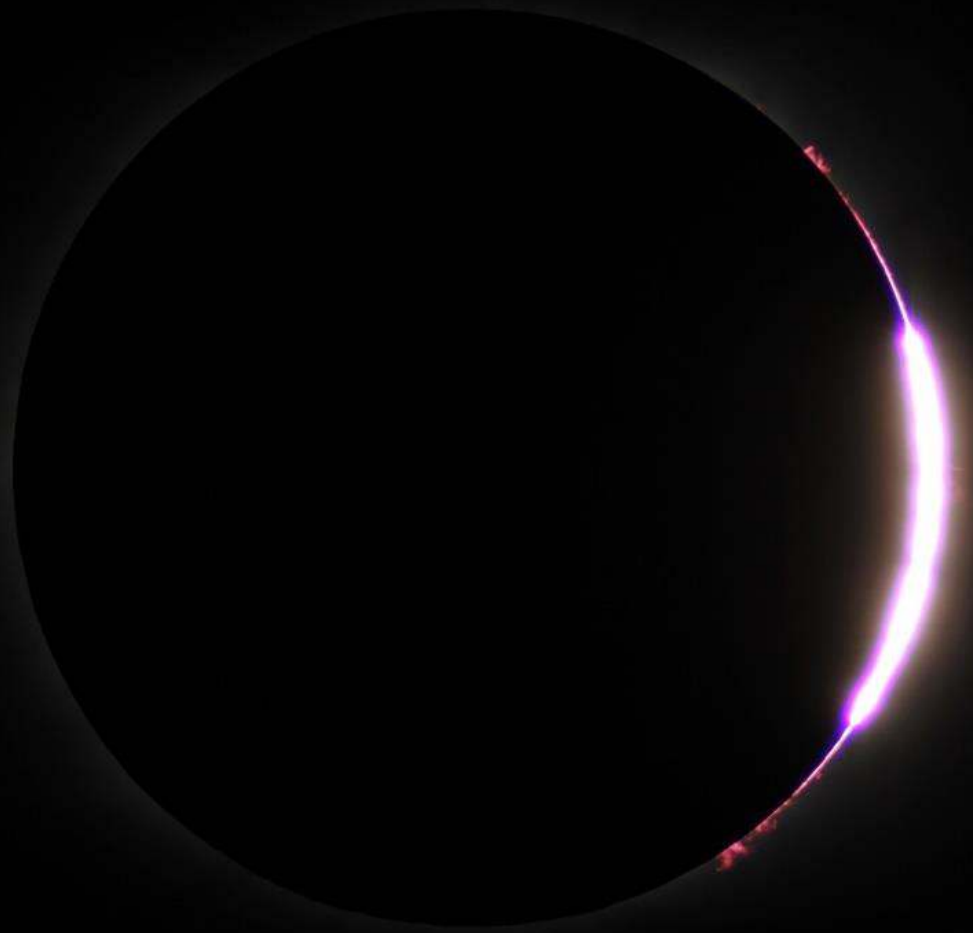

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THE CORONA in HDR

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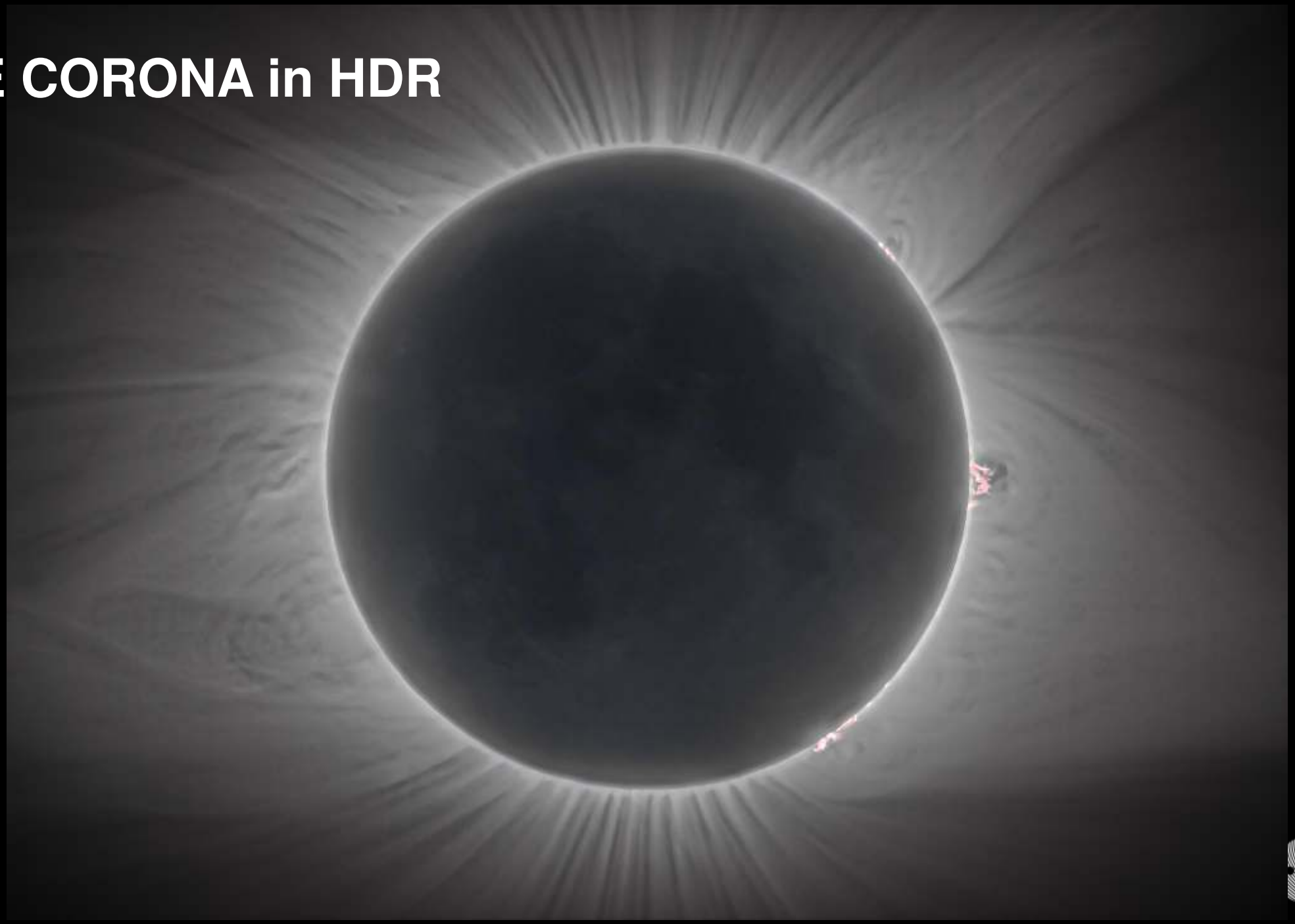
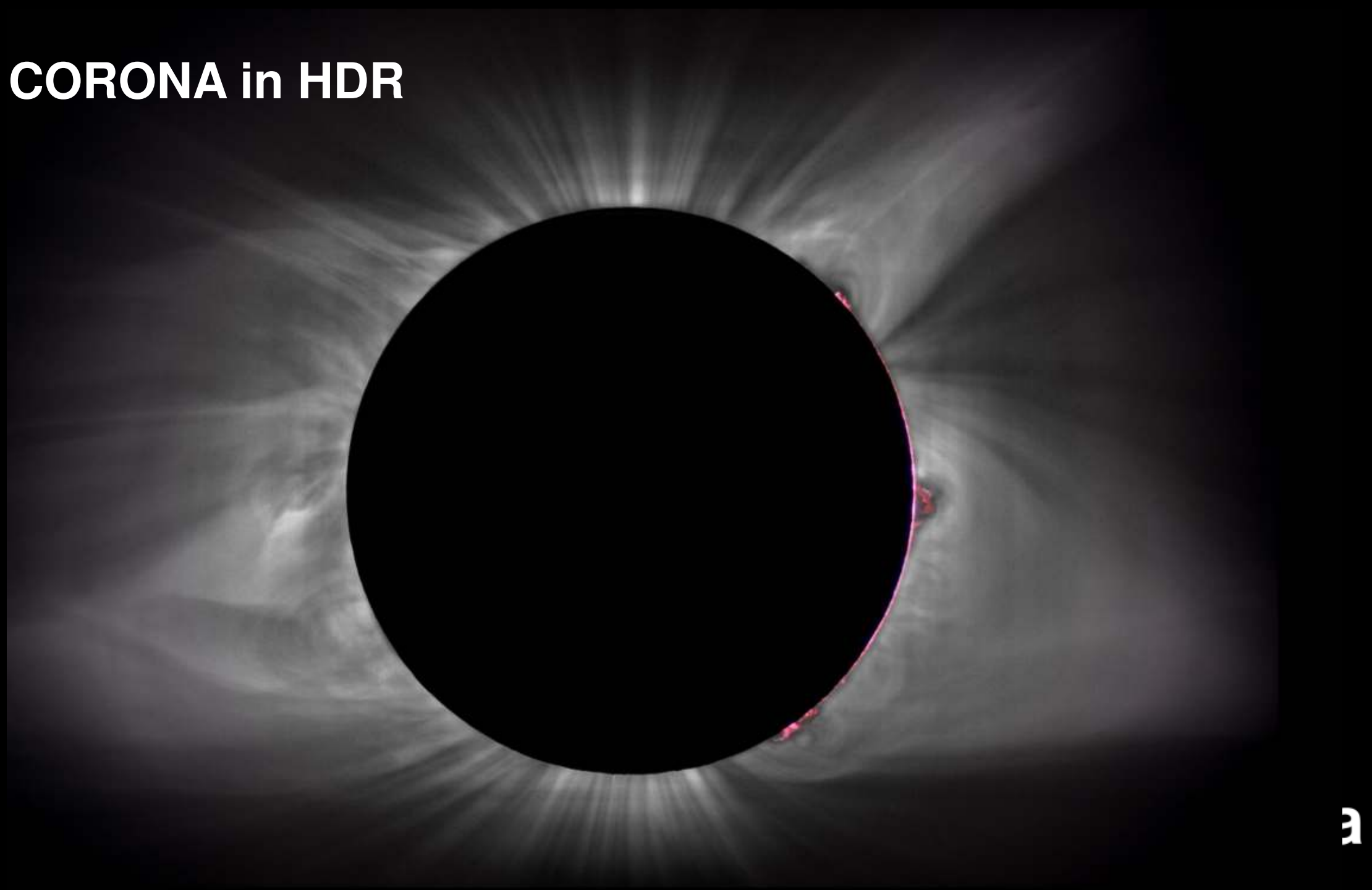


THE CORONA in HDR



THE CORONA in HDR

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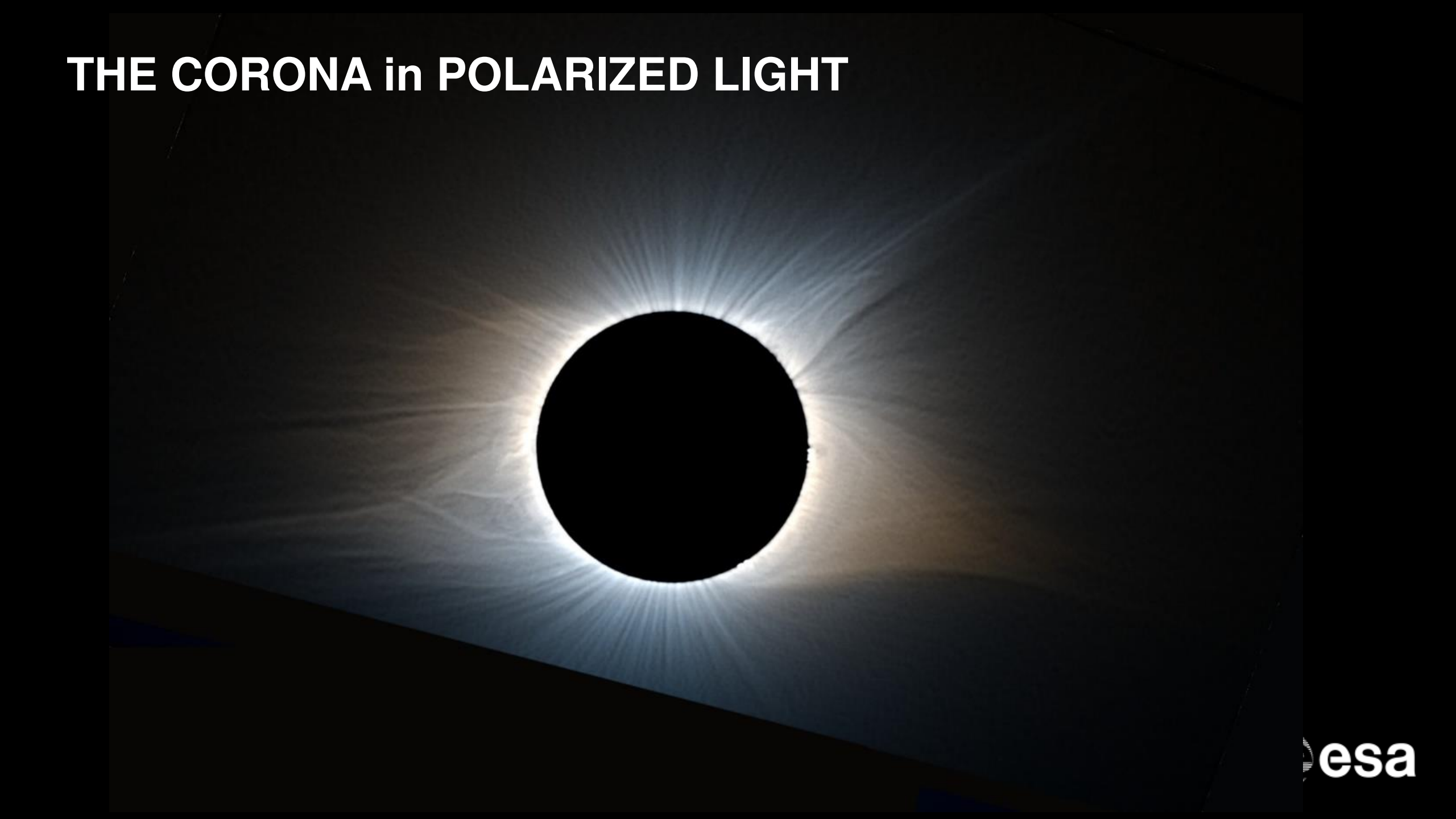
THE CORONA in POLARIZED LIGHT



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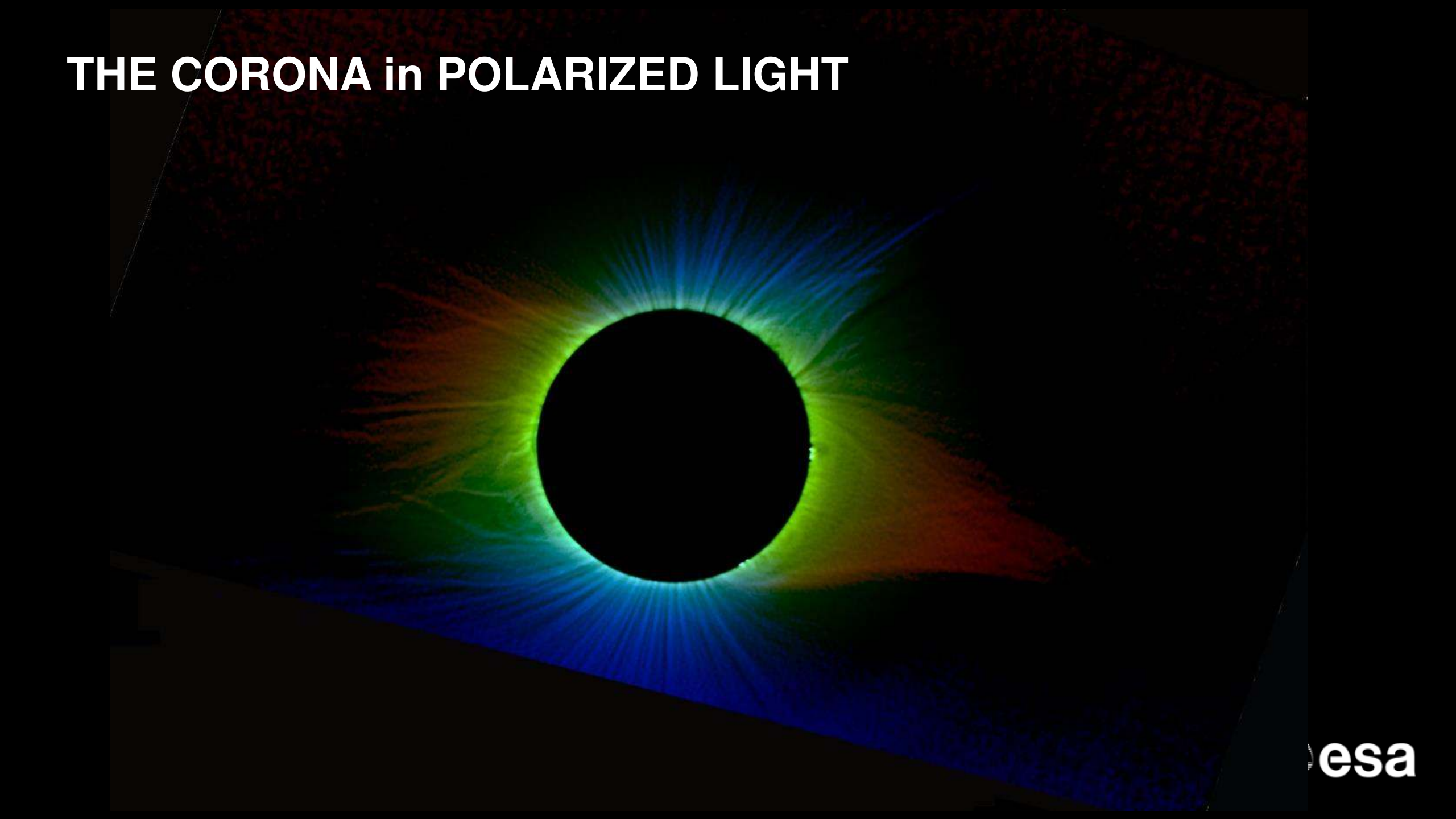
THE CORONA in POLARIZED LIGHT



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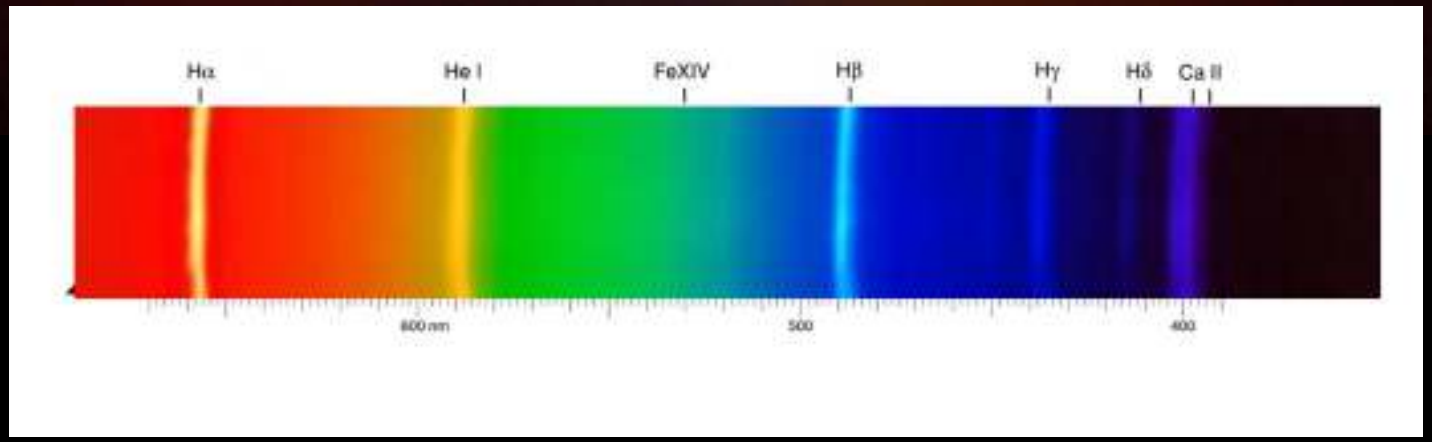
SPECTRAL DATA



Chromosphere Flash Spectrum

- Total Solar Eclipses have been used historically to observe and measure separately different Sun regions (chromosphere, prominences , corona).
- Chromosphere Flash Spectrums are captured with the last and first light of the solar limb just before and after the eclipse totality.
- It was performed by Janssen and others from India during the Total Eclipse on Aug. 18, 1868 trying to measure the spectrum of the prominences. The event marks the first discovery of an “extraterrestrial” element, the Helium, as it had not yet been found on Earth. It was found in 1895.

Chromosphere Flash Spectrum

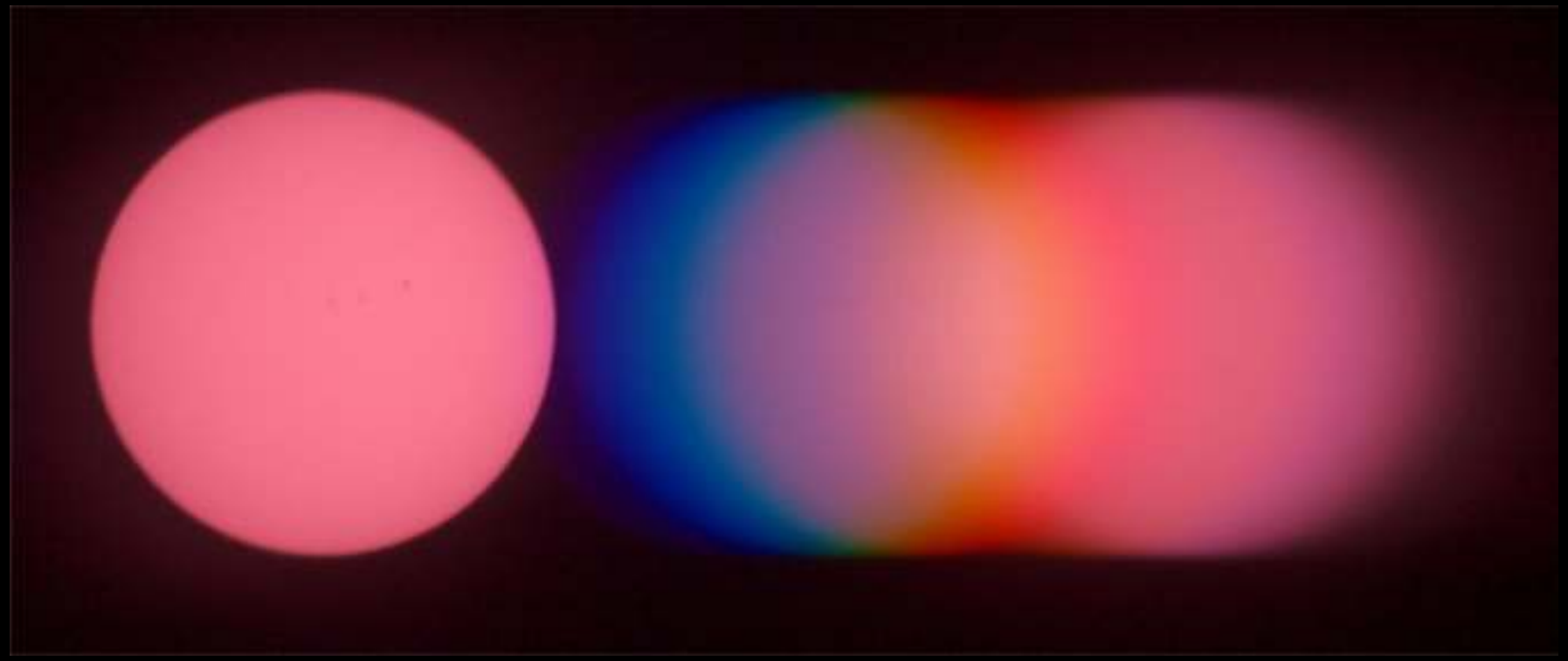
Spectrographic Camera

- Maksutov-Cassegrain Teleojective 500mm
- Blazed Difraction Grating 207 lines/mm
- Olympus E-420 DSLR with NIR Blocking Filter Removed

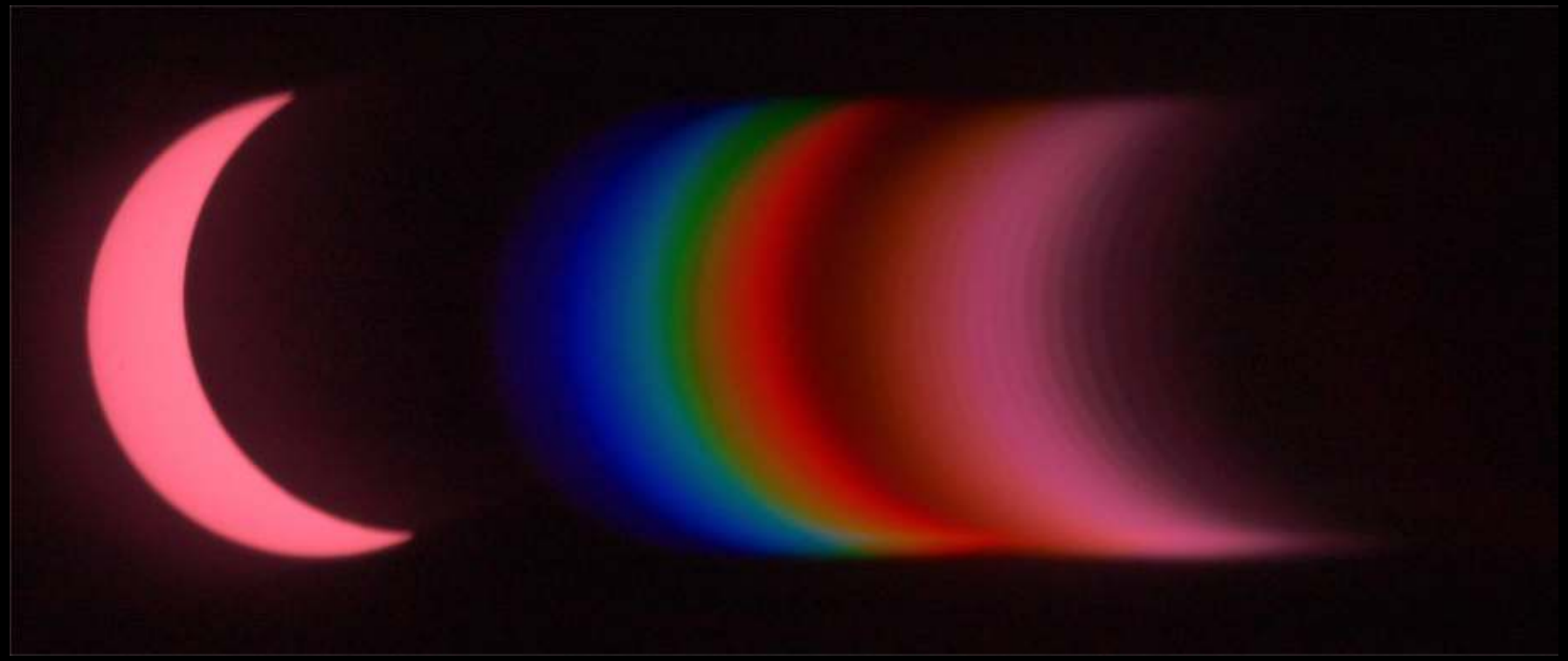
Chromosphere Flash Spectrum

Spectrographic Camera

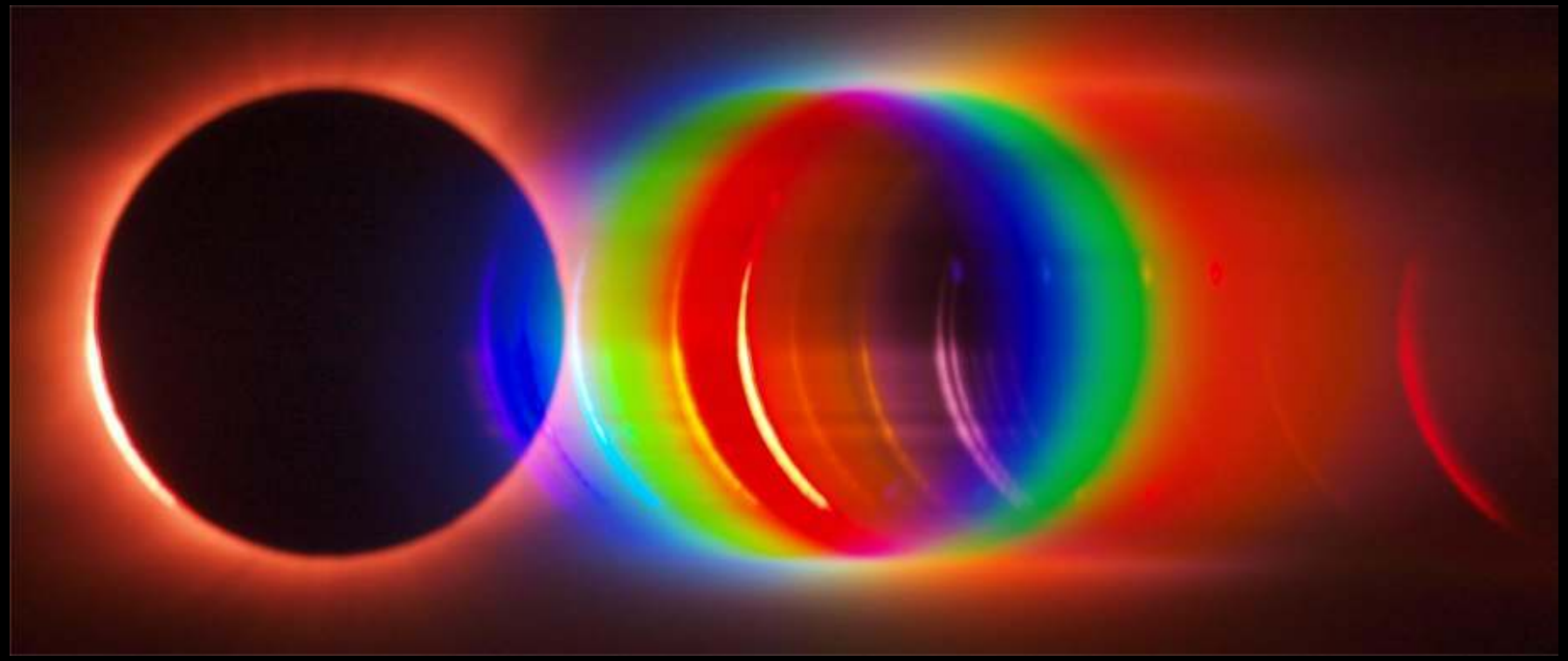
Chromosphere Flash Spectrum



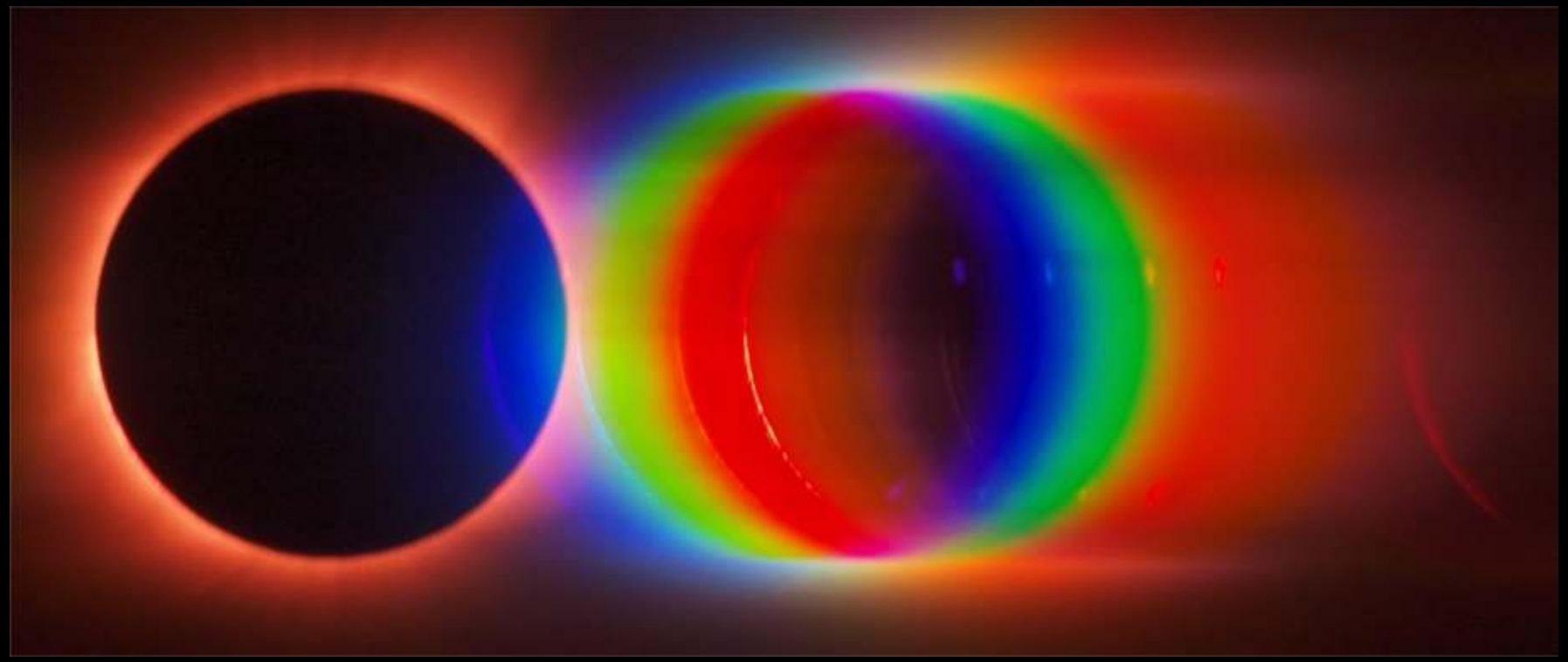
Chromosphere Flash Spectrum



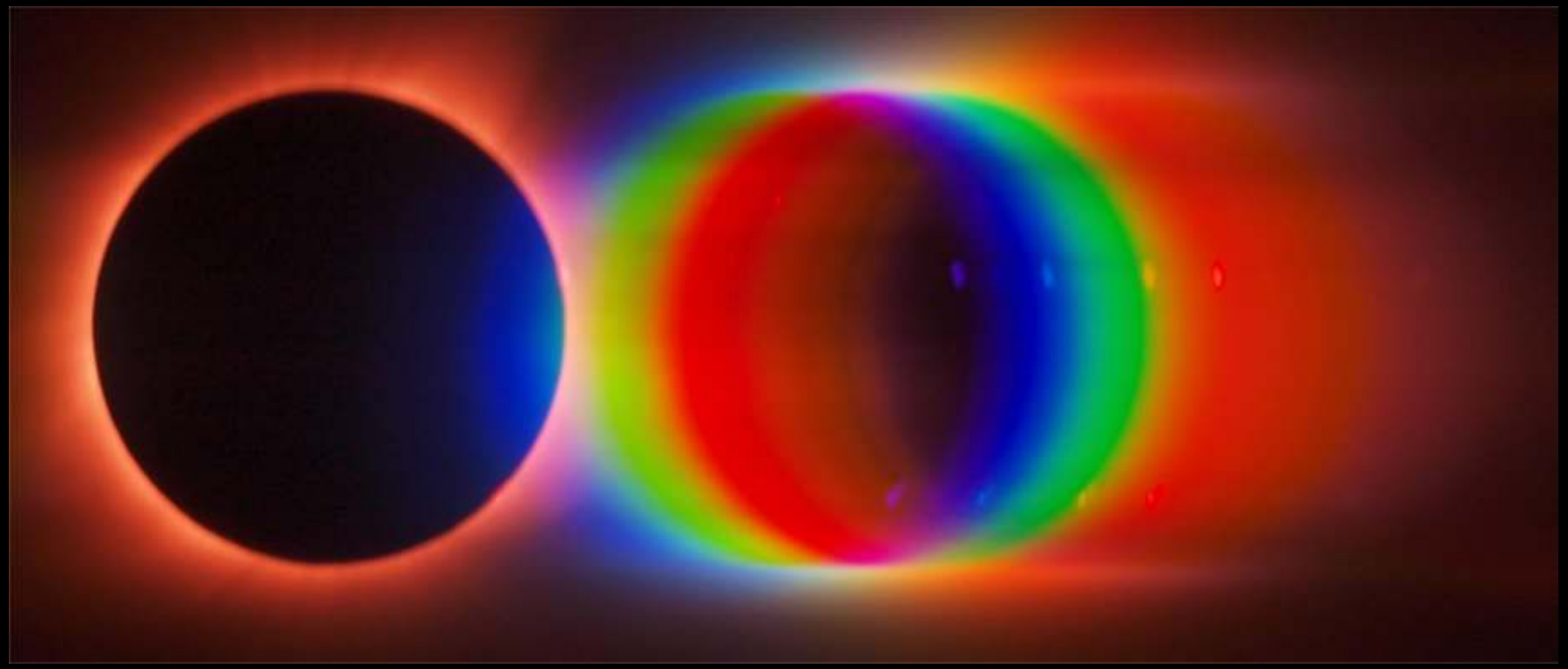
Chromosphere Flash Spectrum



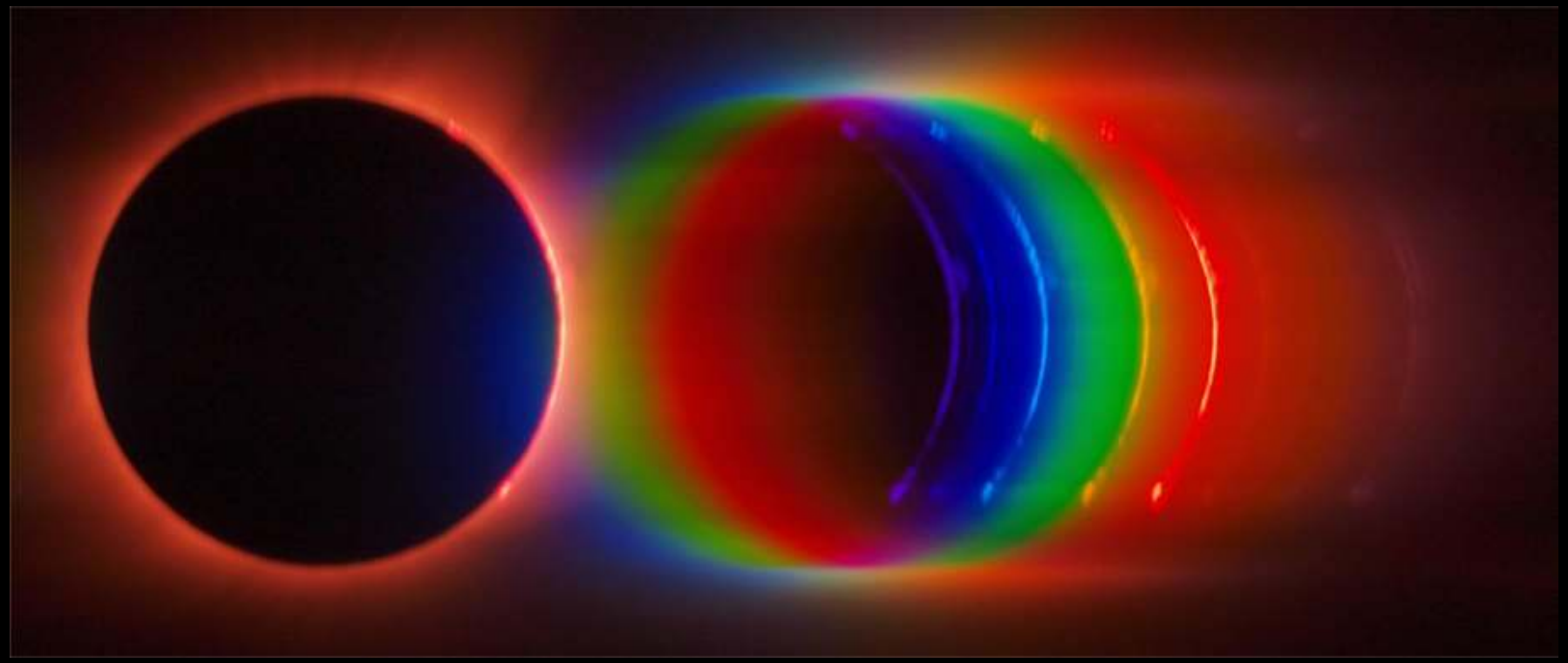
Chromosphere Flash Spectrum



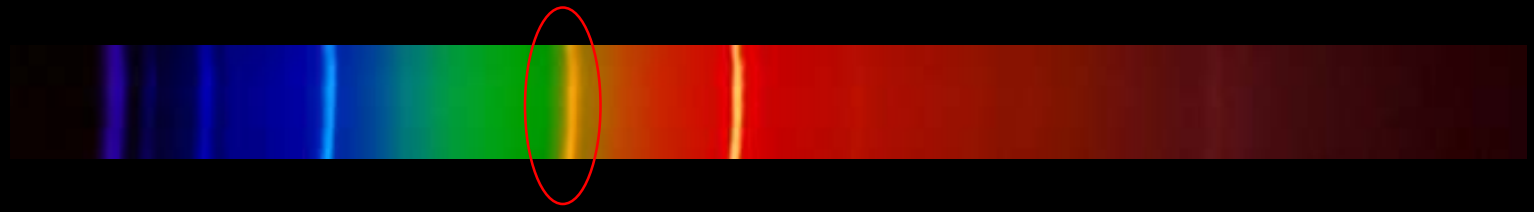
Chromosphere Flash Spectrum



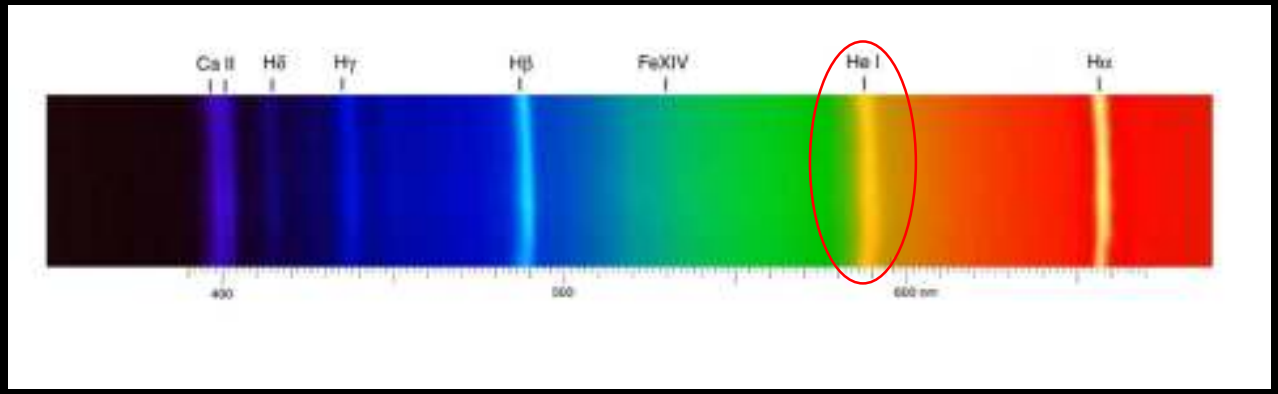
Chromosphere Flash Spectrum



Chromosphere Flash Spectrum



The yellow line was thought to be produced by Sodium. However, Janssen captured the line with more accuracy and he concluded that it had to belong to some other Element. It was named Helium.



Corona Polarization

- The corona displays a continuous emission spectrum and is found to be strongly polarized (K-corona) . It arises out of photosphere light that is scattered by the free electrons (Thomson scattering) of the coronal gas.

- Other contributions to corona brightness is produced by diffraction of dust near the observer (F-corona) and hence it is un-polarized

- The polarization of coronal emissions is an excellent tool to diagnose key plasma parameters (e.g., magnetic fields, densities, temperatures, velocities, etc.) to better understand complex coronal phenomena, such as the solar activity, coronal heating and the acceleration of the solar wind.

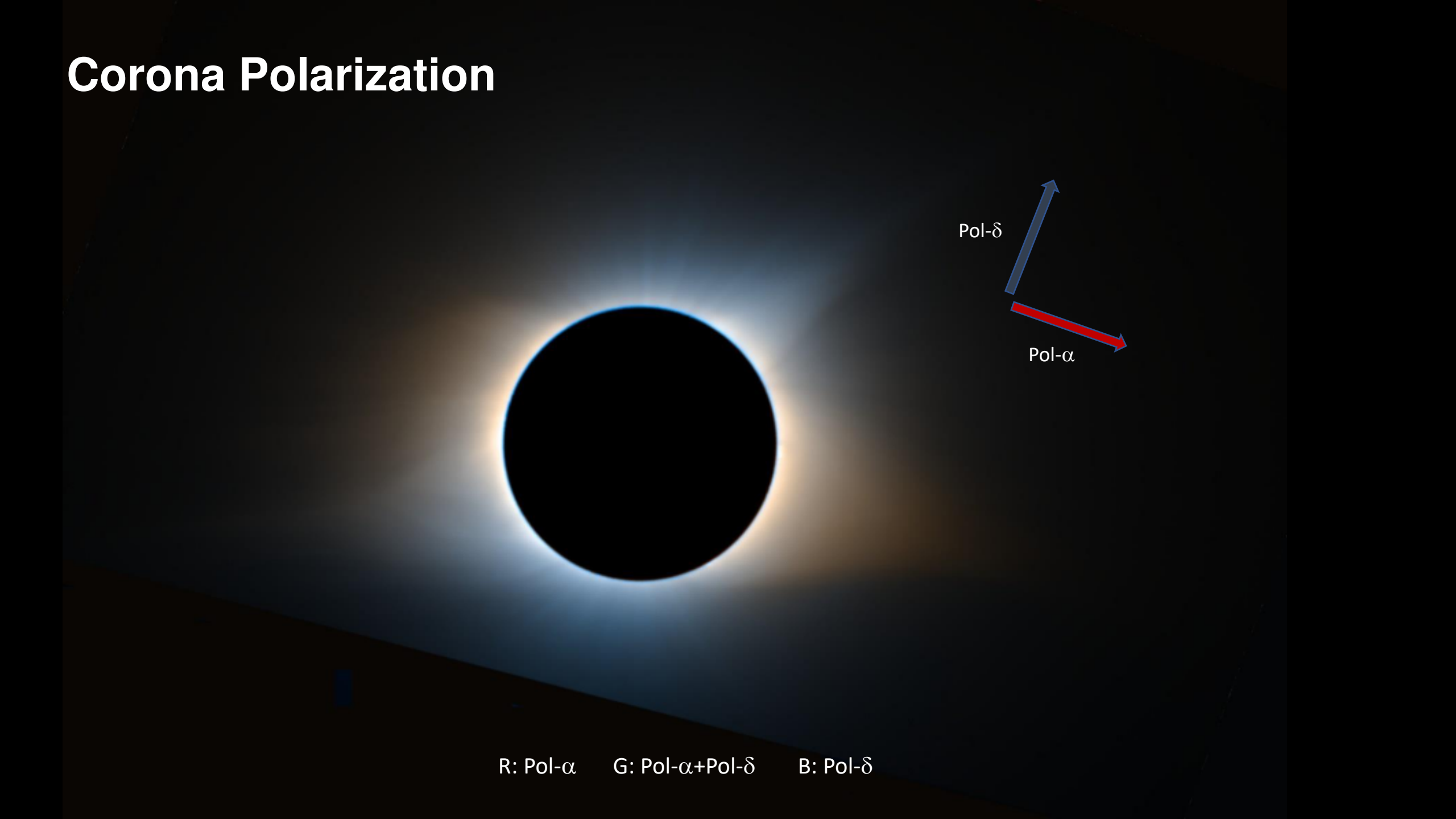
Corona Polarization

Pol-δ: Linear Polarization in Declination

Pol-α:
Linear Polarization
in Right Ascension

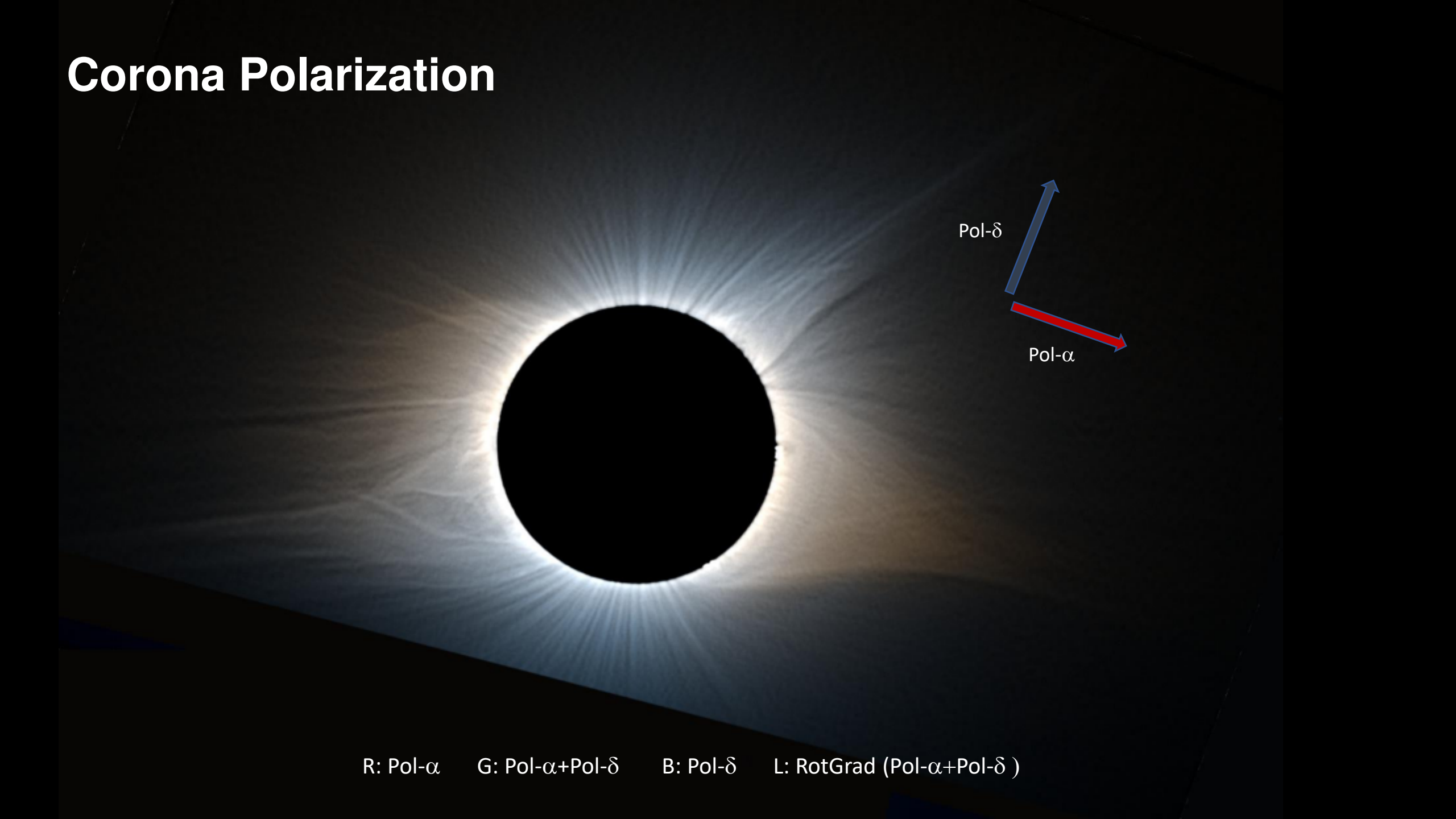
- Pol-α: Canon 5D + Tele 300 mm
- Pol-δ: Canon 60Da + Tele 300 mm

Corona Polarization



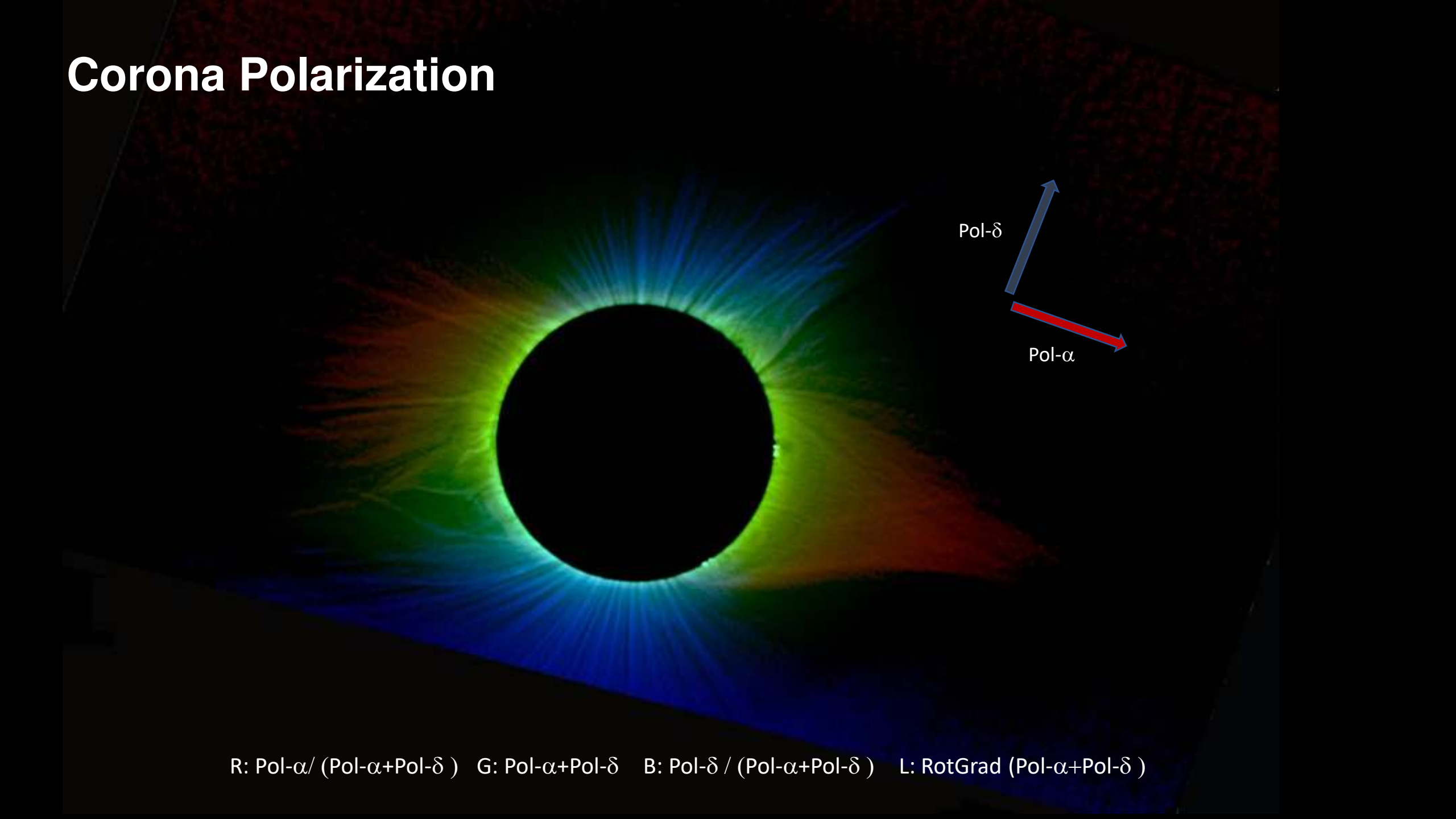
R: Pol-α G: Pol-α+Pol-δ B: Pol-δ

Corona Polarization



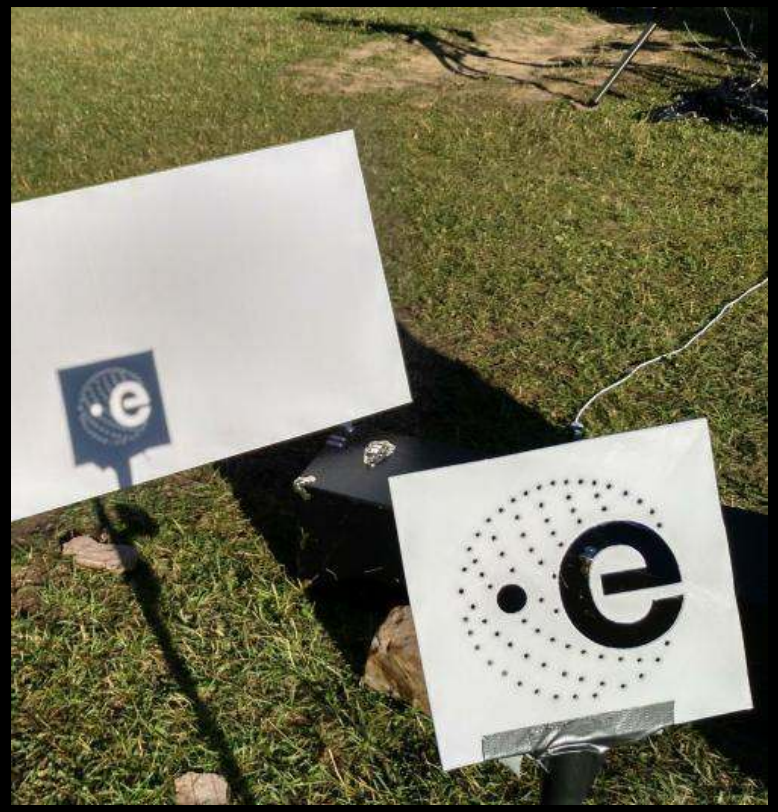
R: Pol-α G: Pol-α+Pol-δ B: Pol-δ L: RotGrad (Pol-α+Pol-δ)

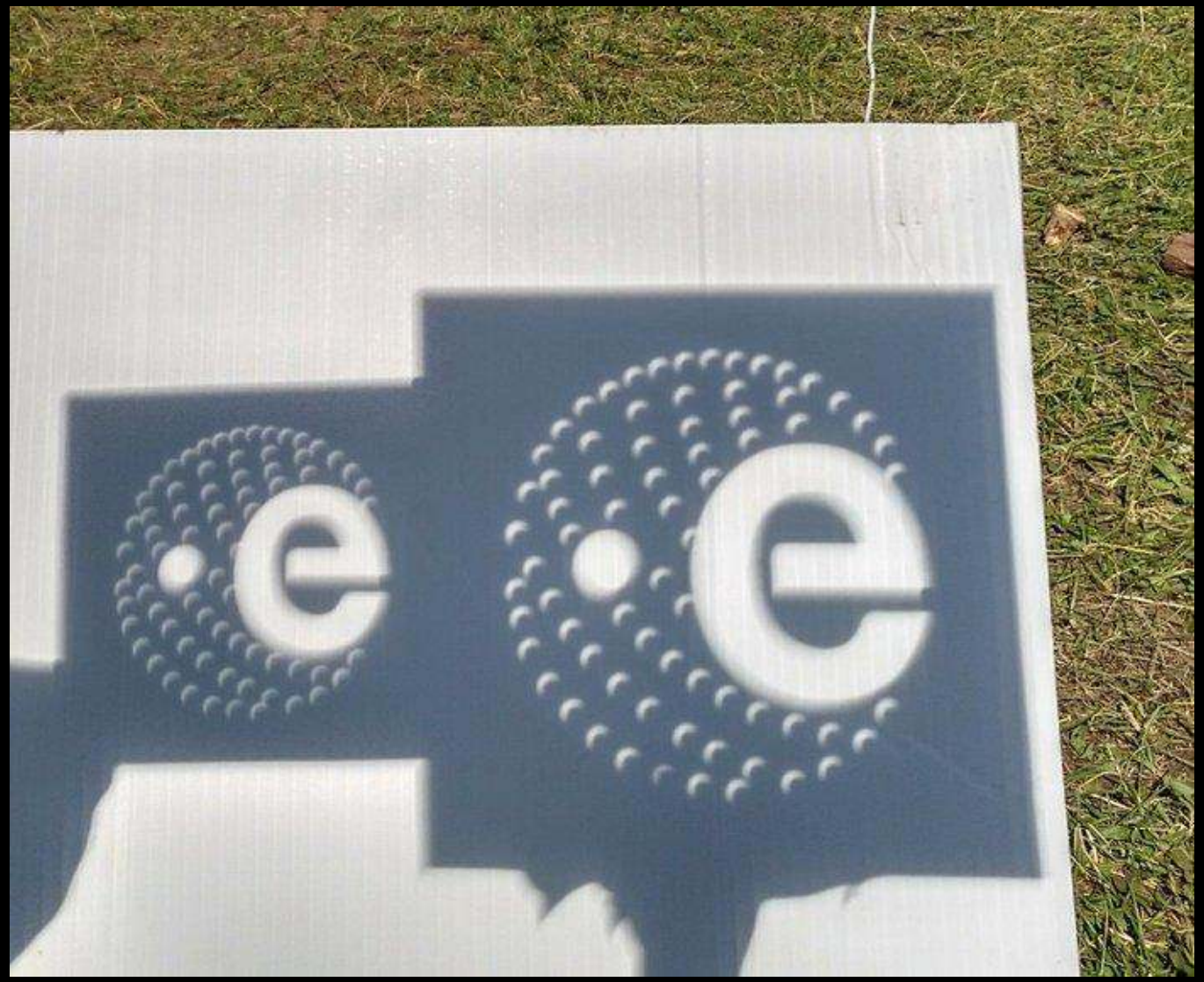
Corona Polarization



R: Pol-α/ (Pol-α+Pol-δ) G: Pol-α+Pol-δ B: Pol-δ / (Pol-α+Pol-δ) L: RotGrad (Pol-α+Pol-δ)

PINHOLE PROJECTION





MOON

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STARS


v Leo - 27 Leo - HIP 48883 - SAO 98876
Type: star
Magnitude: 5.25 (after extinction: 5.41)
Absolute Magnitude: -0.68
Color Index (B-V): -0.03
31 Leo - HIP 49637 - SAO 98964
Type: double star
Magnitude: 4.35 (after extinction: 4.52)
Absolute Magnitude: -0.44
Color Index (B-V): 1.45
Regulus
α Leo - 32 Leo - HIP 49669 - SAO 98967
Type: double star
Magnitude: 1.38 (after extinction: 1.51)
Absolute Magnitude: -0.59
Color Index (B-V): -0.09

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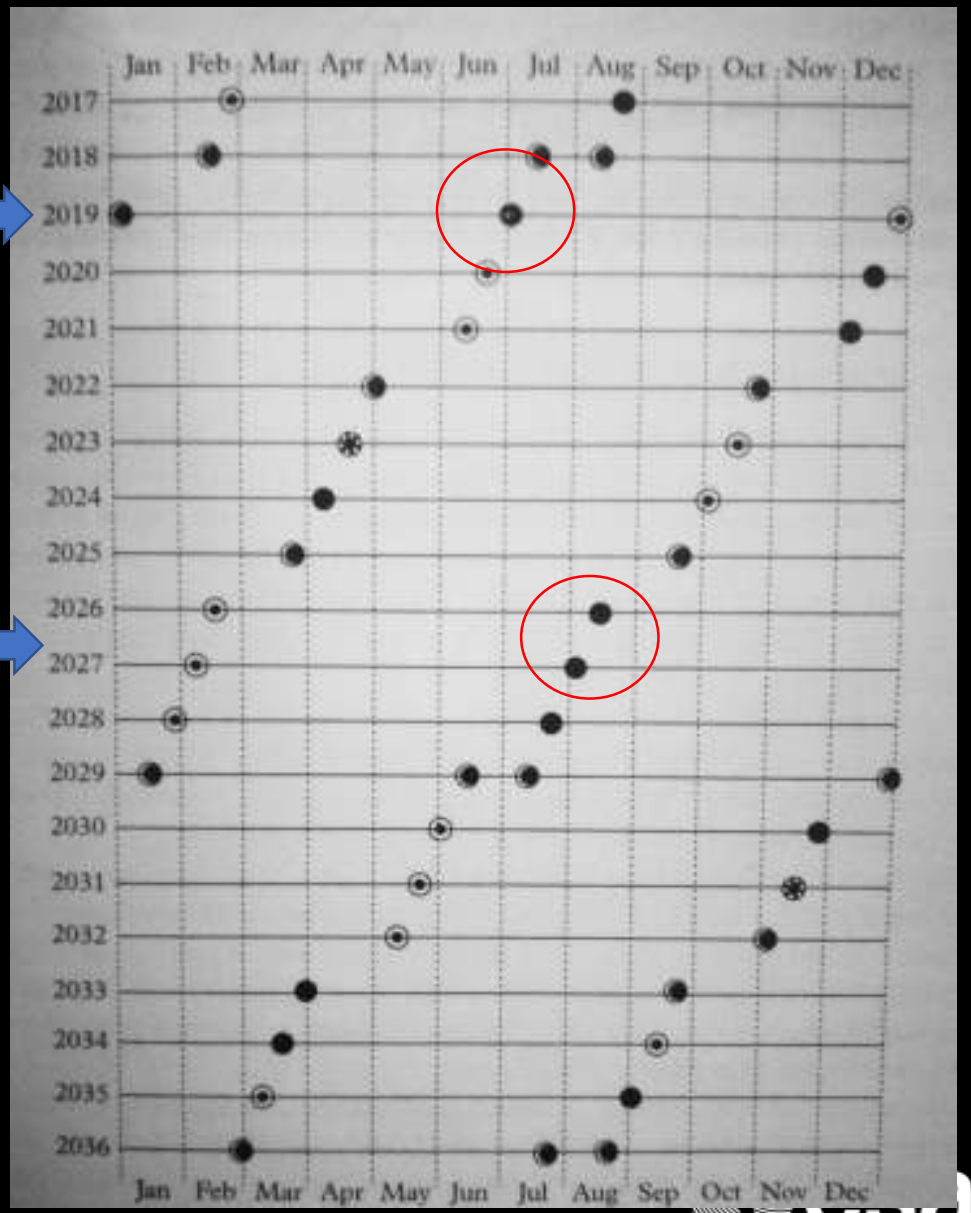
NEX

- Nex
- In S
  -
  -


Portugal
Spain


Portugal
Spain


Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
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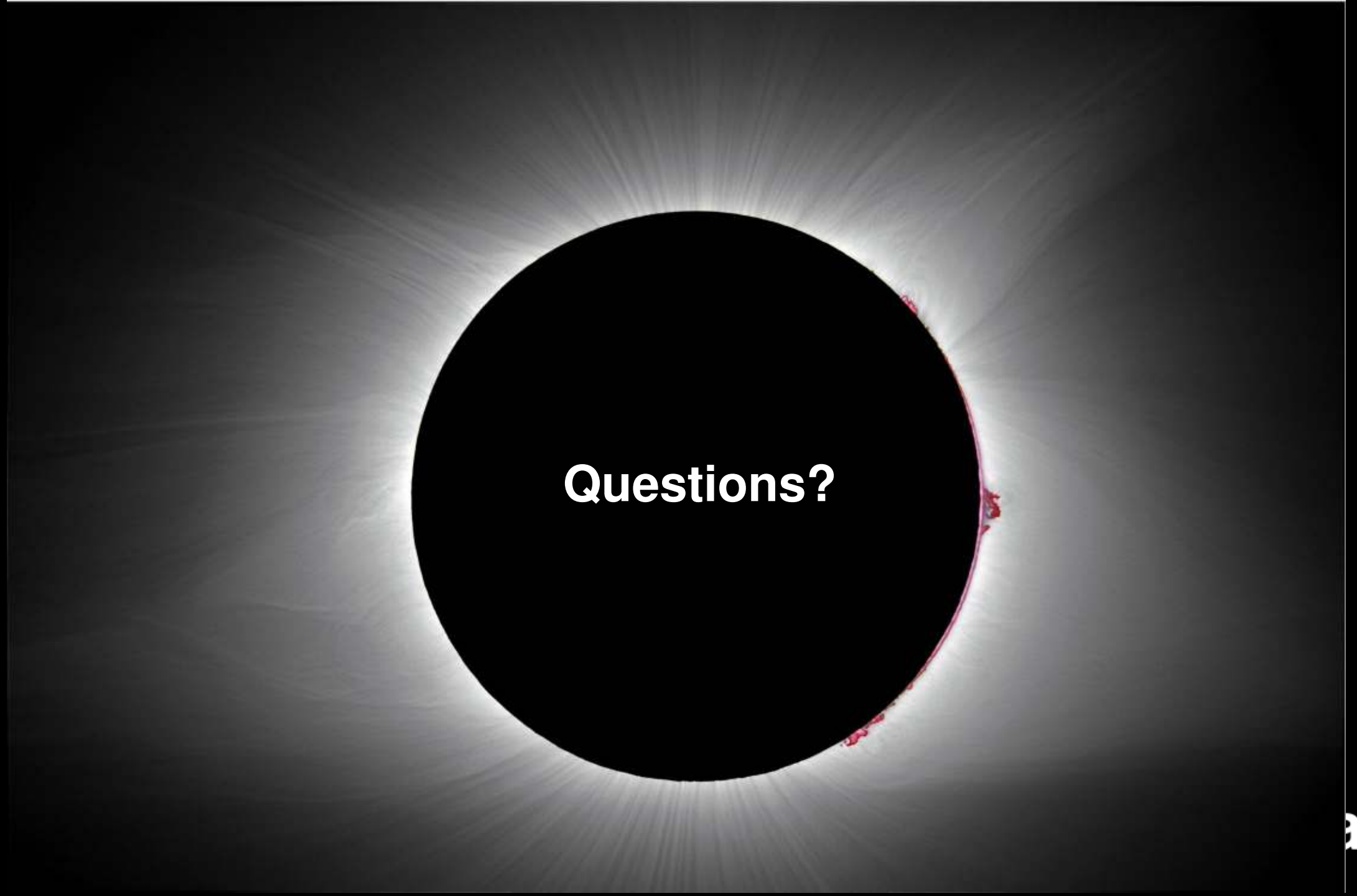
Questions?

COOPERATION THROUGH EDUCATION IN SCIENCE AND ASTRONOMY RESEARCH

→ European Space Agency (ESA) Spanish National Institute for Aerospace Technology (INTA) ISDEFE

→ hands-on experiences in Astronomy research

→ real scientific results

→ promote Space Science

→ Four telescopes on-line

→ http://cesar.esa.int





50cm optical telescope

30cm optical telescope

Two sets of 9cm Hα and 10cm white light

15m satellite tracking antenna

radio telescope

esa


cesar
esa
Cooperation through Education in Science and Astronomy Research

→

→

→

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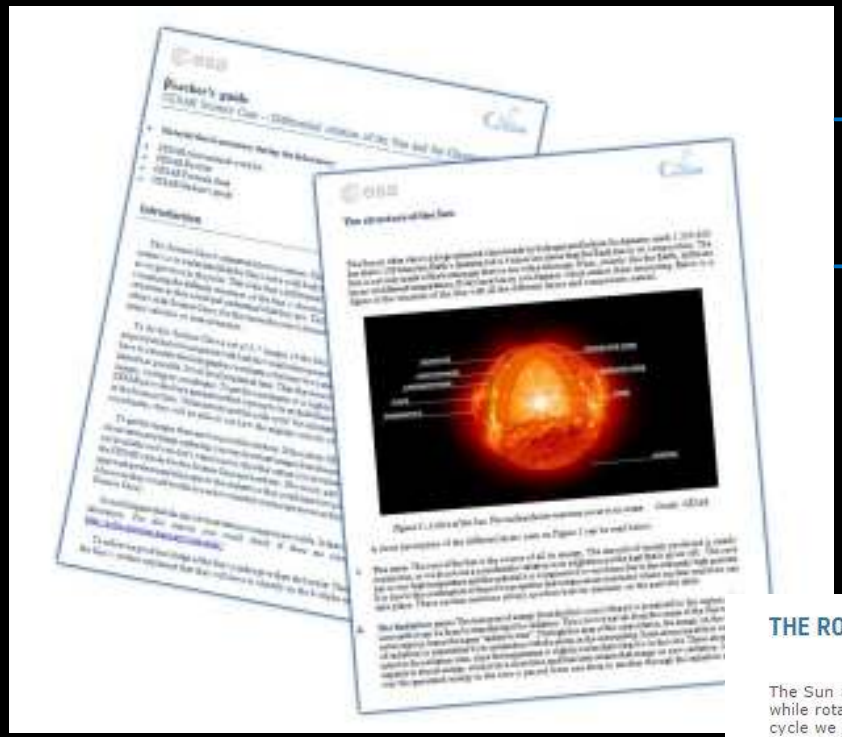
→ class of university students Space Astronomy related subject

→ Introduction to Space Science and ESA for school classes.

→ lecture videos can be streamed school classes coming to ESAC every week different scientific topics

→ 4 x 4 day training courses about Space Science for 65 school teachers



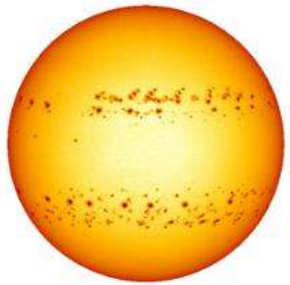
→ Science Cases

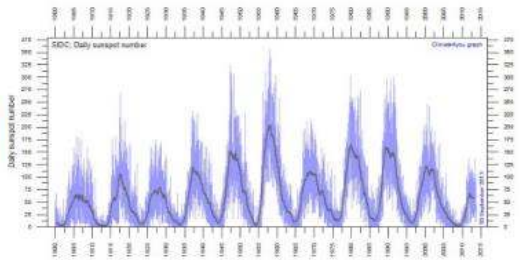
→ Science Cases
hands-on experiences in astronomy and astrophysics

→ Sun, Planets, Moons Binary stars, Exoplanets…

THE ROTATION PERIOD OF THE SUN AND THE SUNSPOT ACTIVITY

The Sun as every star is an active and dynamic object. It rotates at a very high speed that we can calculate tracking the sunspots while rotating. Using the number of sunspots we can determine how active the Sun is at that moment and estimate where in the solar cycle we are.





THE DOCUMENTS:

- The booklet
- Student's guide
- Teacher's guide
- Formula sheet

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→ CESAR ESAC Solar Observatory

Day	H-Alpha	Visible
01/09/2016	418	426
02/09/2016	397	428
05/09/2016	292	333
06/09/2016	417	424
07/09/2016	440	461
08/09/2016	420	440
09/09/2016	396	408
12/09/2016	159	329
16/09/2016	193	187

Day	H-Alpha	Visible
19/09/2016	479	488
20/09/2016	148	146
21/09/2016	405	488
22/09/2016	338	310
23/09/2016	363	363
24/09/2016	302	314
26/09/2016	227	234
27/09/2016	398	405
28/09/2016	333	338

Day	H-Alpha	Visible
29/09/2016	454	449
30/09/2016	404	404
03/10/2016	343	389
04/10/2016	396	406
05/10/2016	308	327
06/10/2016	308	321
07/10/2016	369	367
11/10/2016	66	88

Calendar						
«	October					»
					1	2
3	4	5	6	7	8	9
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17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

→ download live images of the Sun

→ We provide students the tools

The CESAR COSMOS website

http://www.cosmos.esa.int/web/cesar

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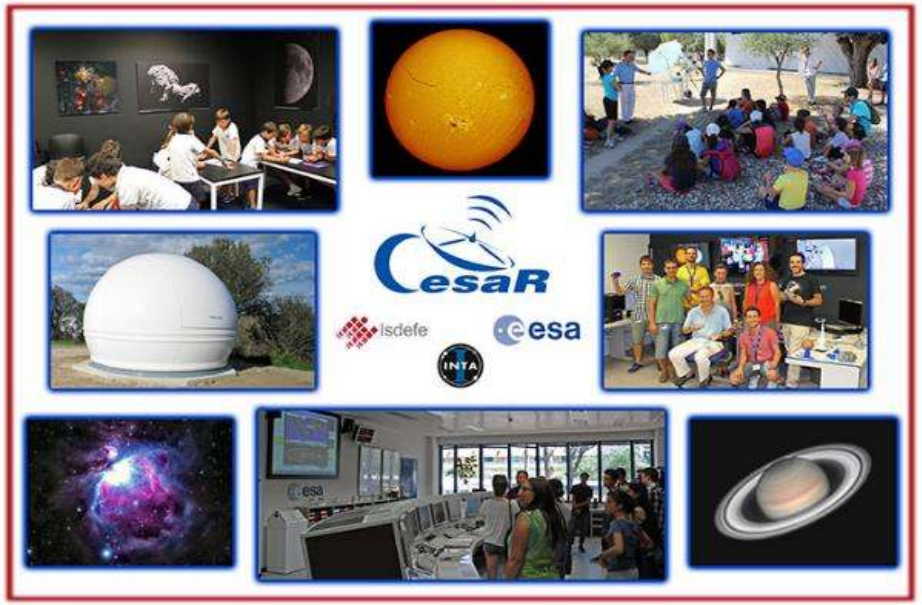
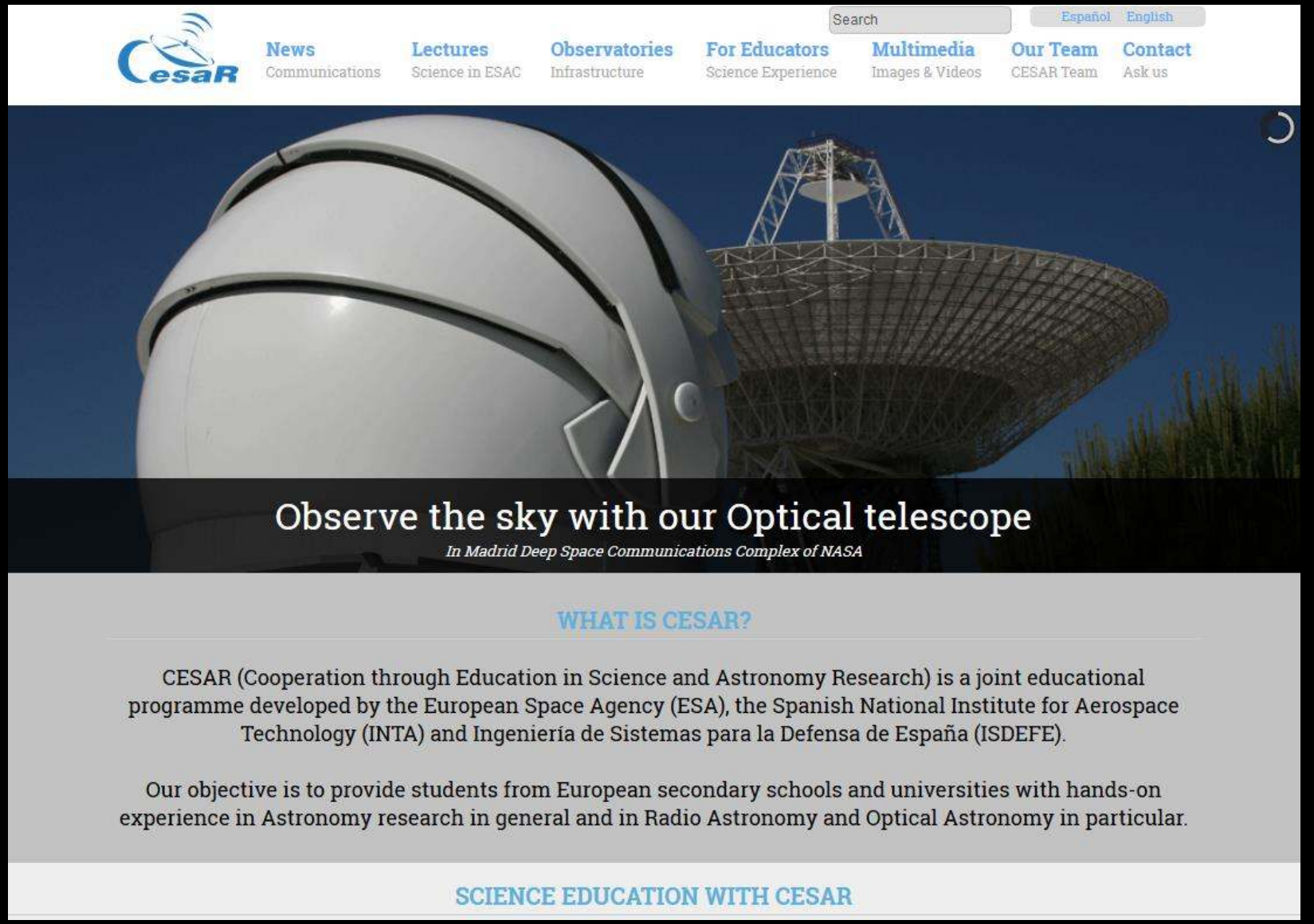
WELCOME TO THE CESAR COSMOS HOMEPAGE

CESAR (Cooperation through Education in Science and Astronomy Research) is a joint educational programme developed by the European Space Agency (ESA), the Spanish National Institute for Aerospace Technology (INTA) and Ingeniería de Sistemas para la Defensa de España (ISDEFE).

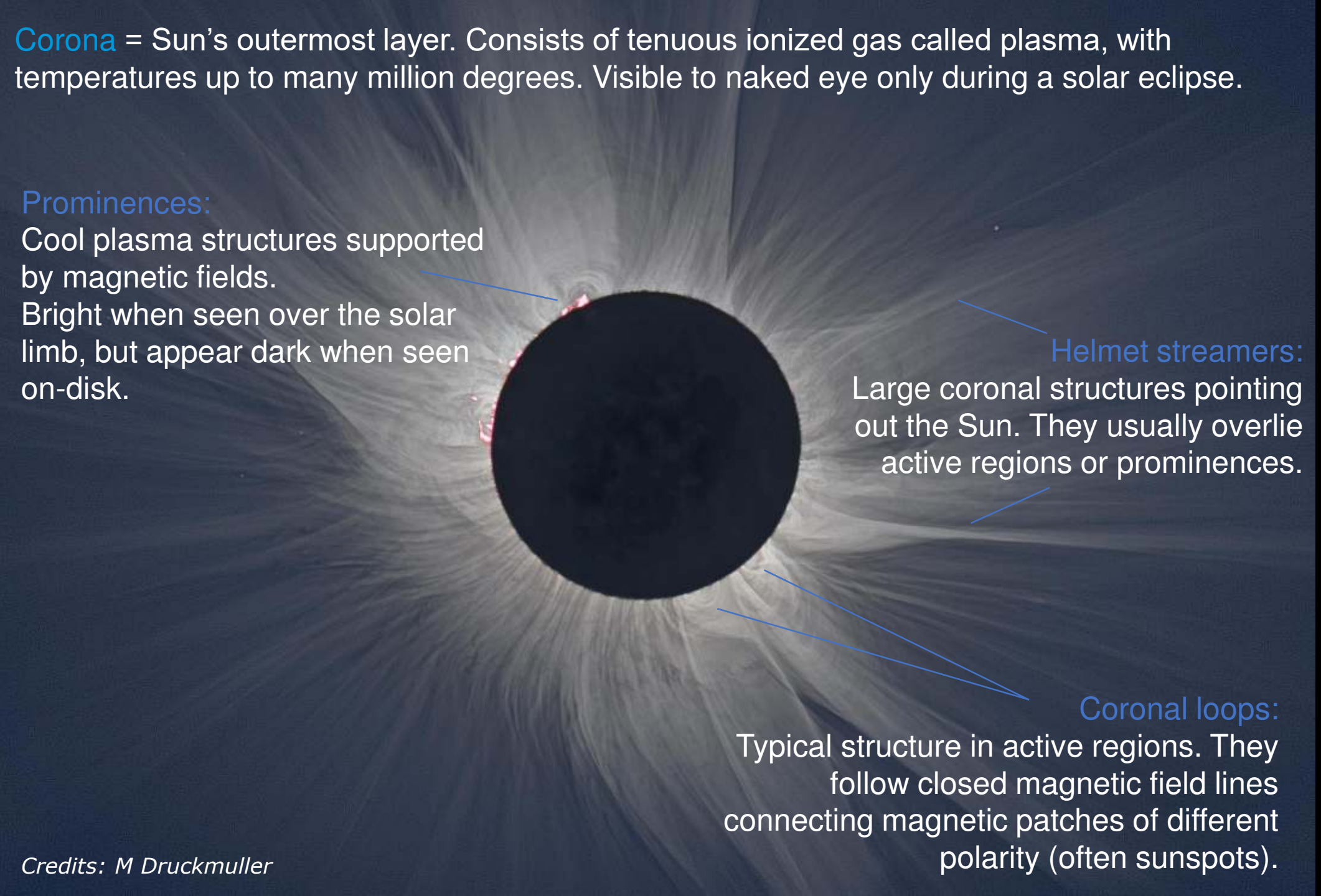
Our objective is to provide students from European secondary schools and universities with hands-on experience in Astronomy research in general and in Radio Astronomy and Optical Astronomy in particular. CESAR´s educational projects should not only be of didactic value but should also produce real scientific results within the framework of its limited resources. In addition, as a secondary objective, CESAR shall contribute with outreach activities to promote Space Science and to stimulate European student´s interest in Science and Technology in general and Astronomy in particular.



http://cesar.esa.int



Corona = Sun's outermost layer. Consists of tenuous ionized gas called plasma, with temperatures up to many million degrees. Visible to naked eye only during a solar eclipse.



Prominences:
Cool plasma structures supported by magnetic fields.
Bright when seen over the solar limb, but appear dark when seen on-disk.

Helmet streamers:
Large coronal structures pointing out the Sun. They usually overlie active regions or prominences.

Coronal loops:
Typical structure in active regions. They follow closed magnetic field lines connecting magnetic patches of different polarity (often sunspots).

Credits: M Druckmuller

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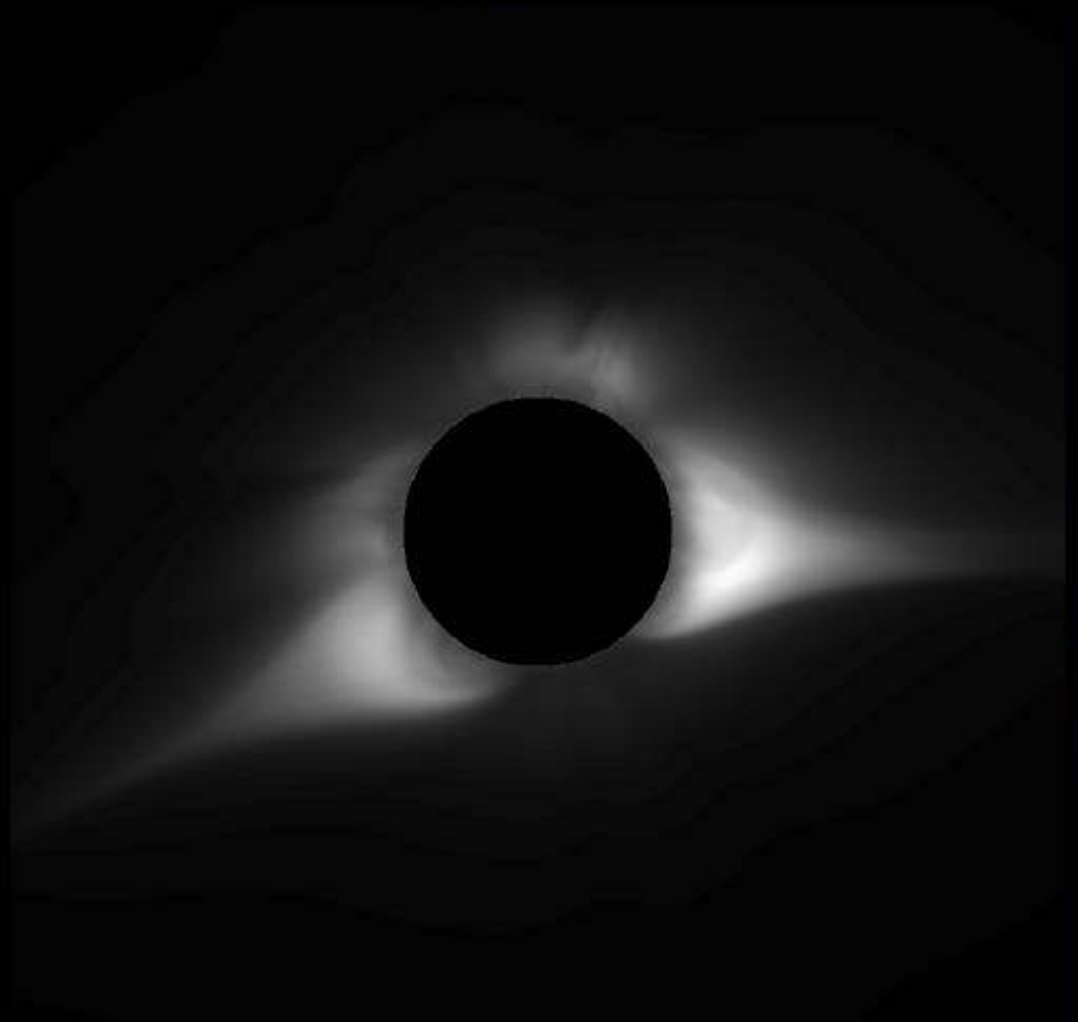
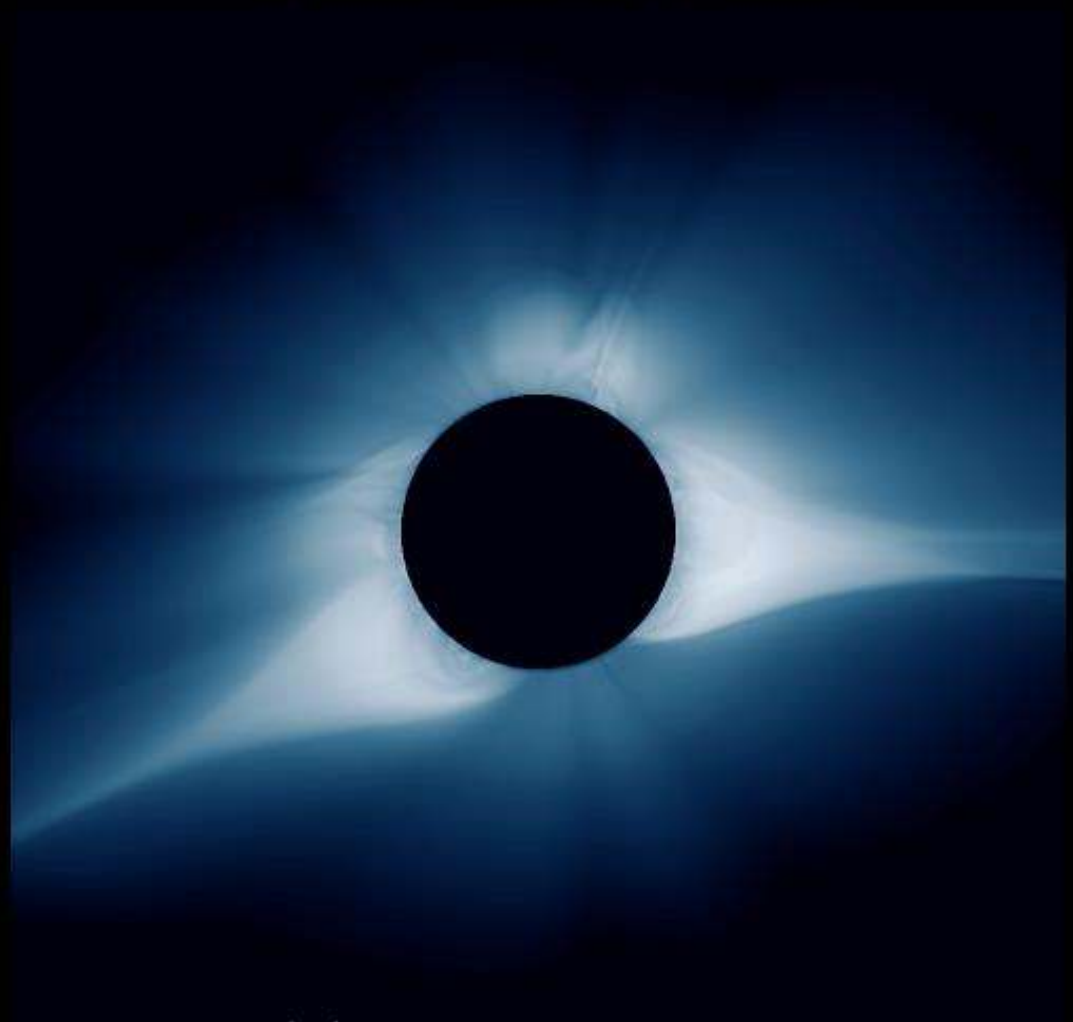
Polarized Brightness (Newkirk Filter)

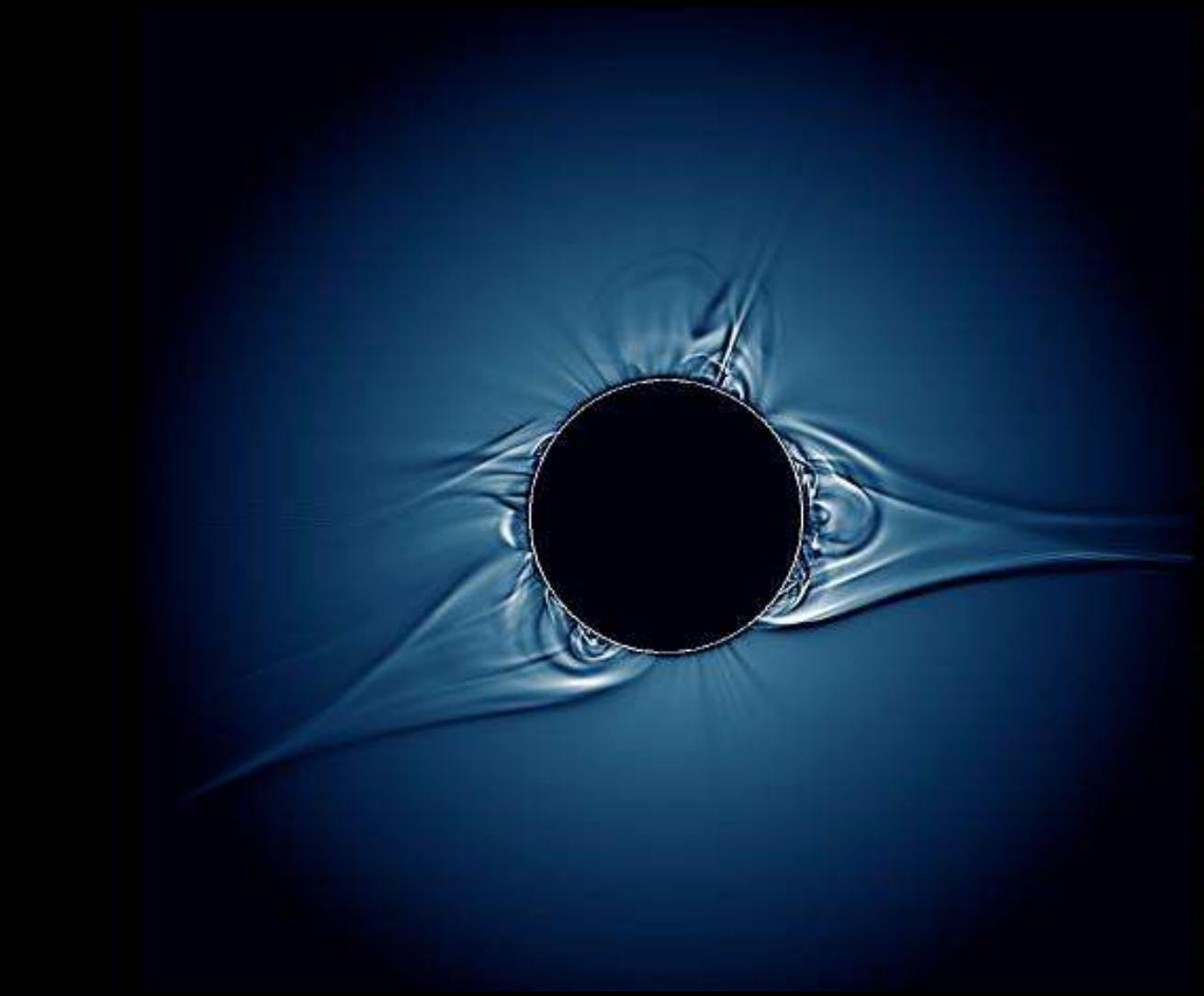


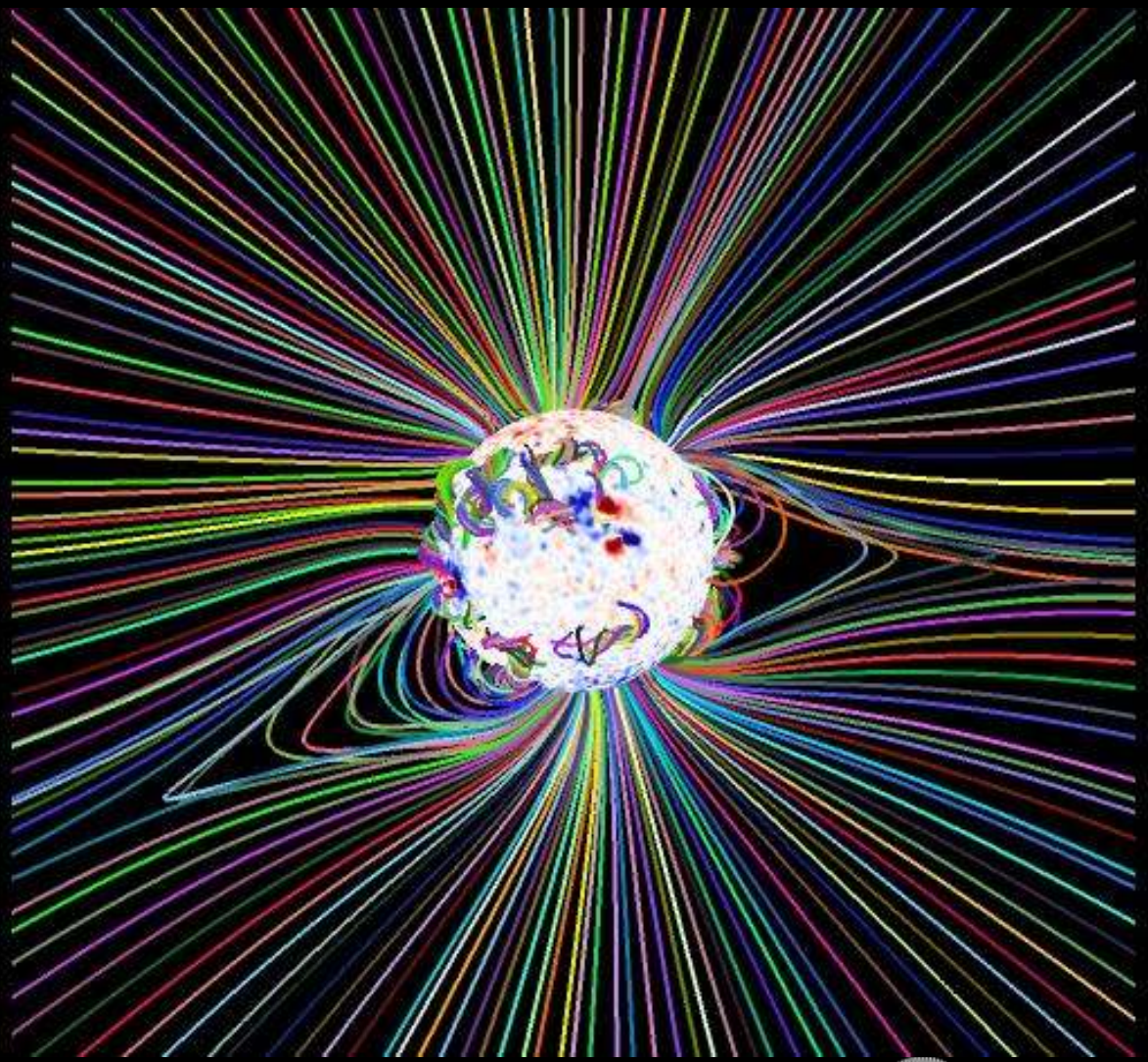
PSI Prediction 08/14/2017 · Terrestrial North up

Log Polarized Brightness (Unsharp Masked)



PSI Prediction 08/14/2017 · Terrestrial North up





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