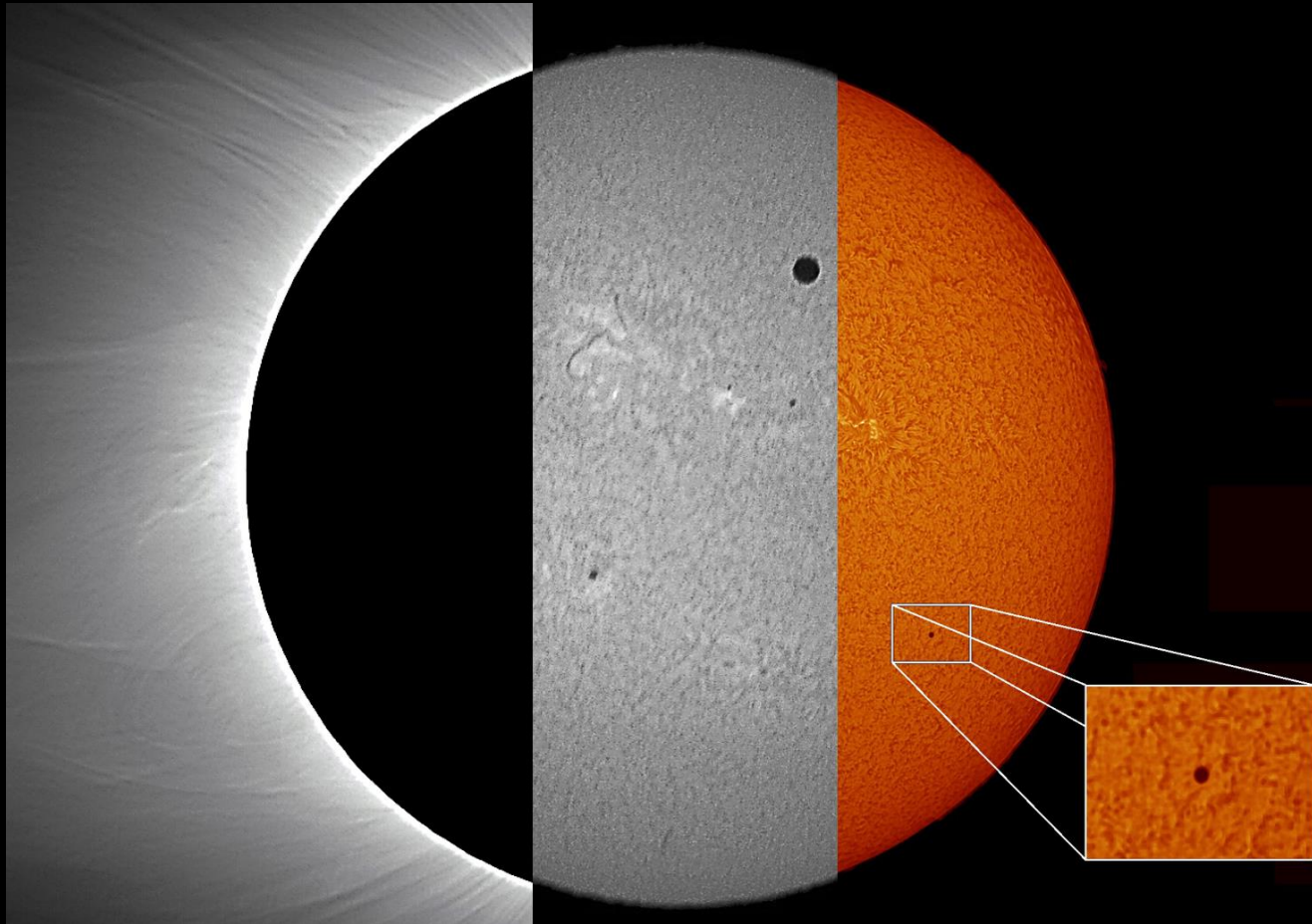


Transits in our Solar System for educational activities

Venus Transit 2012, Mercury Transit 2016 and Total Solar Eclipse 2017



Miguel Pérez-Ayúcar, M Breitfellner, M. Castillo
On behalf of the CESAR Team, EPSC2017, 21 Sep 2017



EDUCATION PROJECT CESAR

"The EUROPEAN SPACE AGENCY as a didactic resource"

EDUCATION

TECHNOLOGY

SCIENCE

COOPERATION



RESEARCH

ASTRONOMY

STUDENTS

cesar.esa.int



Education Project CESAR



RESOURCES IN THE CLASS

Using our
observatories

SPACE SCIENCE EXPERIENCE

School visits to
ESAC

SPECIAL EVENTS

Scientific
expeditions,
transits,
eclipses,
hangouts ..

TEACHERS COURSES

Teachers CTIF
C. Madrid

www.cesar.esa.int



Education Project CESAR



RESOURCES IN THE CLASS

Using our
observatories

SPACE SCIENCE EXPERIENCE

School visits to
ESAC

SPECIAL EVENTS

Scientific
expeditions,
transits,
eclipses,
hangouts ..

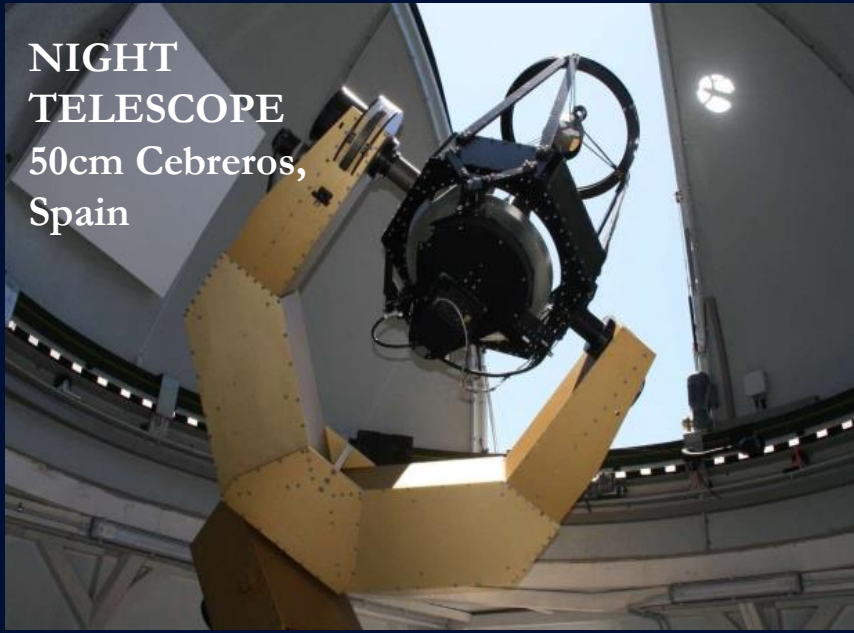
TEACHERS COURSES

Teachers CTIF
C. Madrid

www.cesar.esa.int

CESAR - RESOURCES

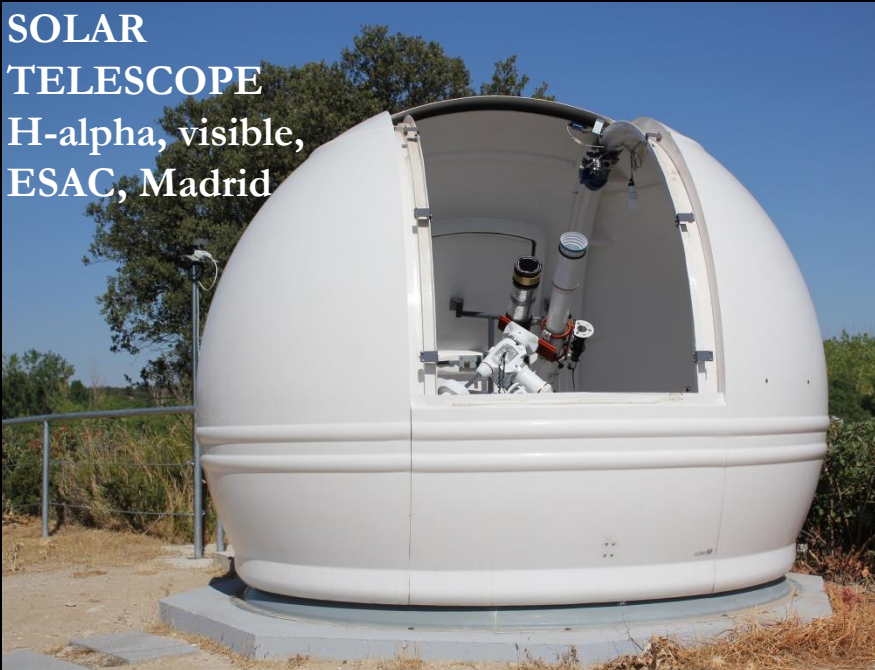
**NIGHT
TELESCOPE**
50cm Cebreros,
Spain



**NIGHT
TELESCOPE**
30cm Robledo de
Chavela, Spain



**SOLAR
TELESCOPE**
H-alpha, visible,
ESAC, Madrid



**RADIO
TELESCOPE**
15m ESAC,
Madrid





Education Project CESAR



RESOURCES IN THE CLASS

Using our
observatories

SPACE SCIENCE EXPERIENCE

School visits to
ESAC

SPECIAL EVENTS

Scientific
expeditions,
transits,
eclipses,
hangouts ..

TEACHERS COURSES

Teachers CTIF
C. Madrid

www.cesar.esa.int

Education Project CESAR



News

Communications

Lectures News

Science at ESAC

For Educators

Science Experience

Events

Special events

Observatories

Infrastructure

Multimedia

Images & Videos

Contact

Contact us

Home » Lectures

Lectures

Page: [1](#) [2](#) [3](#) [4](#) ... [8](#) [9](#) (8 Lectures each page) - [See all lectures news](#)



The colour of the Stars - German School
4th year of Primary School - 36 students [See more](#)



Travel through Solar System - CEIP El Pradillo de Ávila
70 studens - 2º Primary
From Ávila- Spain [See more](#)



Javier Ventura & Topographic Study with Augmented Reality - Lycée fra
26 Students - CM2A [See more](#)



Topographic Study with Augmented Reality - Jesús Maestro School
80 Students 2ºESO [See more](#)



Solar Mass Ejections - J.L.López Aranguren school
Solar Mass Ejections
3 ESO + 1 Bachillerato - 48 students [See more](#)



Hertzsprung-Russell diagram - IES Francisco Giner de los Rios school
4 ESO - 50 students [See more](#)



Topographic Study - IES Francisco Giner de los Rios school
110 students - 4th year of ESO [See more](#)



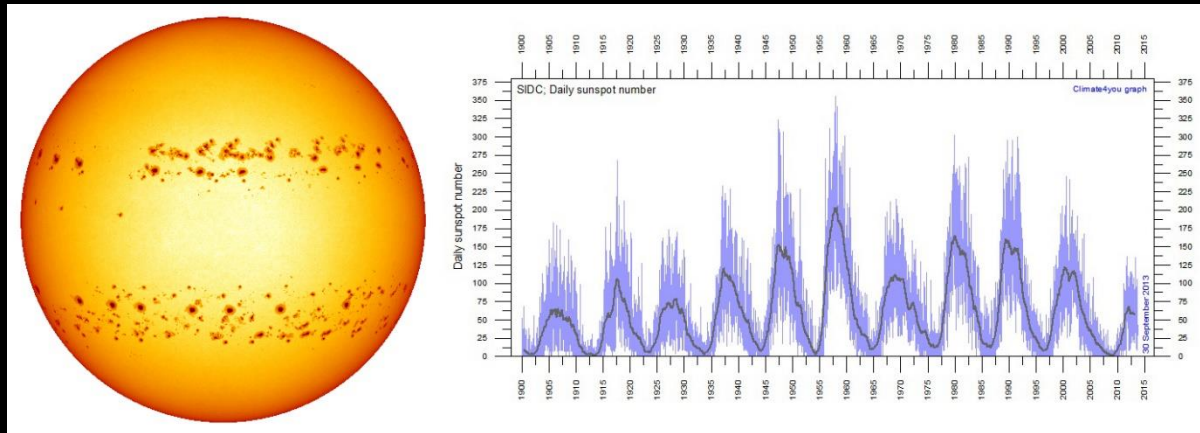
Mission to the Moon - CRA Elena Fortún school
Third & Fourth year of primary school - 54 students [See more](#)



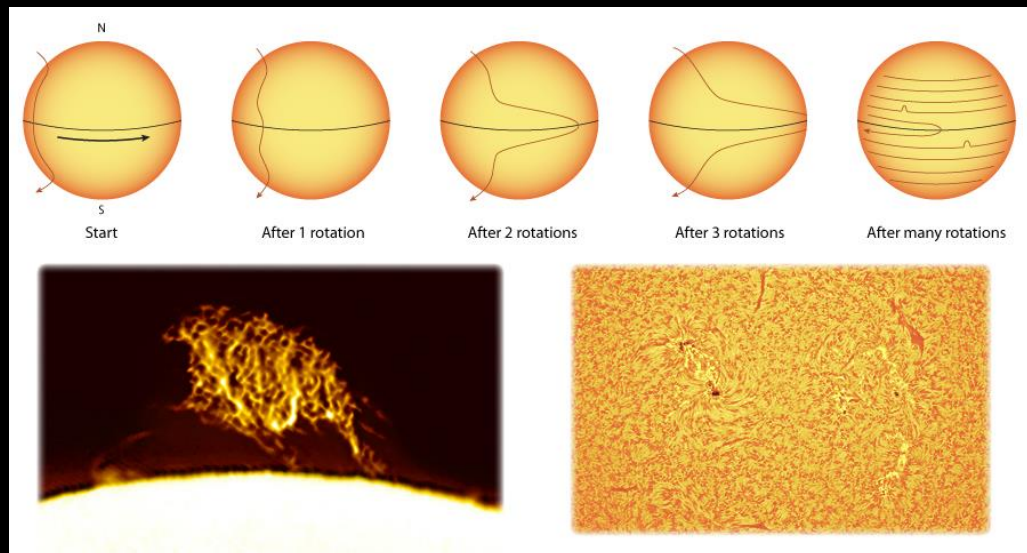
www.cesar.esa.int

SCIENCE CASES: examples

1 - THE ROTATION PERIOD OF THE SUN AND THE SUNSPOT ACTIVITY



2 - THE DIFFERENTIAL ROTATION OF THE SUN AND ITS CHROMOSPHERE





Education Project CESAR



RESOURCES IN THE CLASS

Using our
observatories

SPACE SCIENCE EXPERIENCE

School visits to
ESAC

SPECIAL EVENTS

Scientific
expeditions,
transits,
eclipses,
hangouts ..

TEACHERS COURSES

Teachers CTIF
C. Madrid

www.cesar.esa.int



FACE
ENCE
RIENCE

visits to
SAC

E
S
exp
t
e
ha



CESAR - ESAC

Control Room & Theatre



RADIO
telescope



SOLAR
observatory



Image Landsat / Copernicus

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

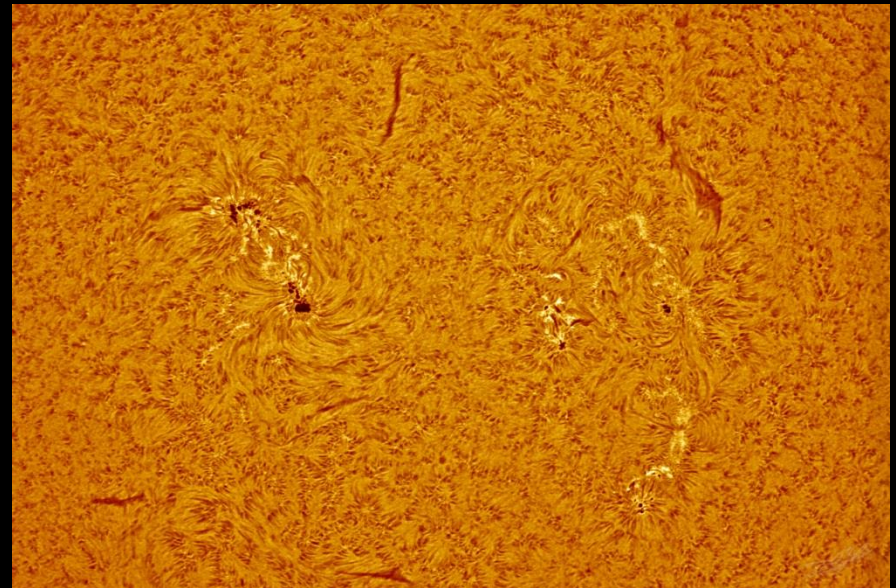
Google Earth

Calle Madrid de Fala

CESAR Control Centre & Theatre



HELIOS (ESAC) – SOLAR OBSERVATORY





Education Project CESAR



RESOURCES IN THE CLASS

Using our
observatories

SPACE SCIENCE EXPERIENCE

School visits to
ESAC

SPECIAL EVENTS

Scientific
expeditions,
transits,
eclipses,
hangouts ..

TEACHERS COURSES

Teachers CTIF
C. Madrid

www.cesar.esa.int

Scientific expeditions are organized to engage students with **awesome rare exotic events**

- Super rare: Venus transits (not anymore in our lifetime)
- Mildly Rare: Mercury transits
- Normal Rare BUT AWE: solar eclipses

EXPEDITIONS EVENTS – main parts (1/2)

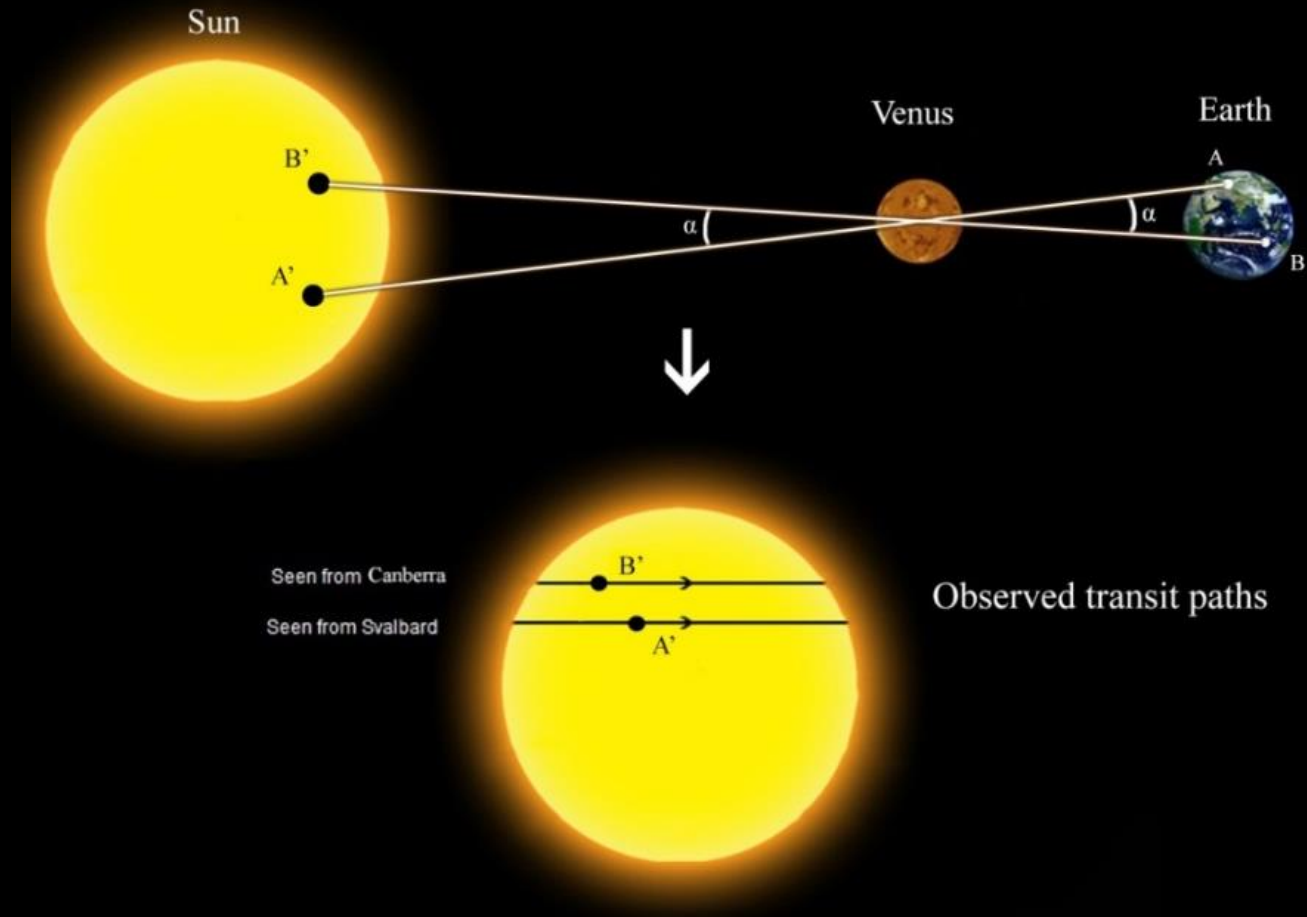
(1) Interactive LIVE transmission:

- Live images via ESAC servers in the web
- LIVE hangout with presentations from experts and LIVE connections to expeditions



EXPEDITIONS EVENTS – main parts (2/2)

(2) Creation of Offline Science Cases for students



CESAR – SCIENTIFIC EXPEDITIONS GOALS

- Expeditions are organized not just for obtaining the **scientific data** used in the cases for the classroom activities
- They serve mainly to **engage** students with **appealing**, RARE awesome EVENTS – **LIVE**
- Events are **interactive**: students can Q&A with the experts
- They can be followed from the School – University in a special event: the team will **connect** with them in the live transmission
- In the future we want students to be active part of the team:
 - prepare them via specific **training** courses
 - **come** along and have their own instruments in charge

CESAR EXPEDITIONS – COLLABORATION

- Promote **ESA** science **satellite** projects

- Venus Express
- Solar Orbiter
- Proba 2 – Proba 3
- Bepi Colombo



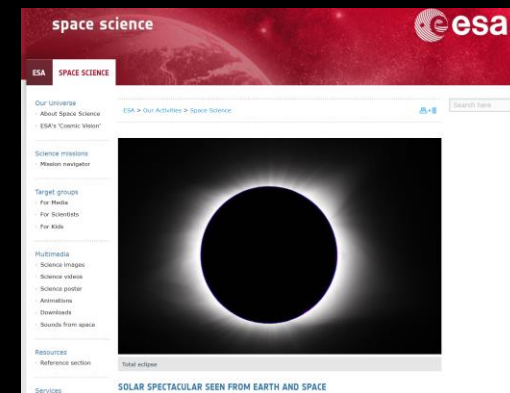
- **ESA communications**

- ESAC Comms – Intranet, Press
- ESTEC Comms – ESA main portal, ESA TV, Science Image of the Week



- Support from **local hosts**

- ESO, Paranal
- NASA Canberra Deep Space Network
- Izana Observatory Teide, Canary Islands
- Casper University



- **Education** with

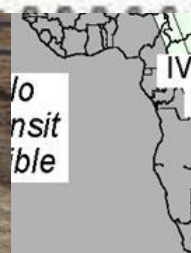
- ESA Education Office – ESTEC (science cases)



The EXPEDITIONS – results

CESAR – SCIENTIFIC

VENUS TRANSIT 2012. SV



F. Espenak, NASA's GSFC

- * Region X - Beginning and end of Transit are visible, but the Sun sets
- * Region Y - Beginning and end of Transit are NOT visible, but the Sun



CESAR – SCIENTIFIC EXPEDITIONS I

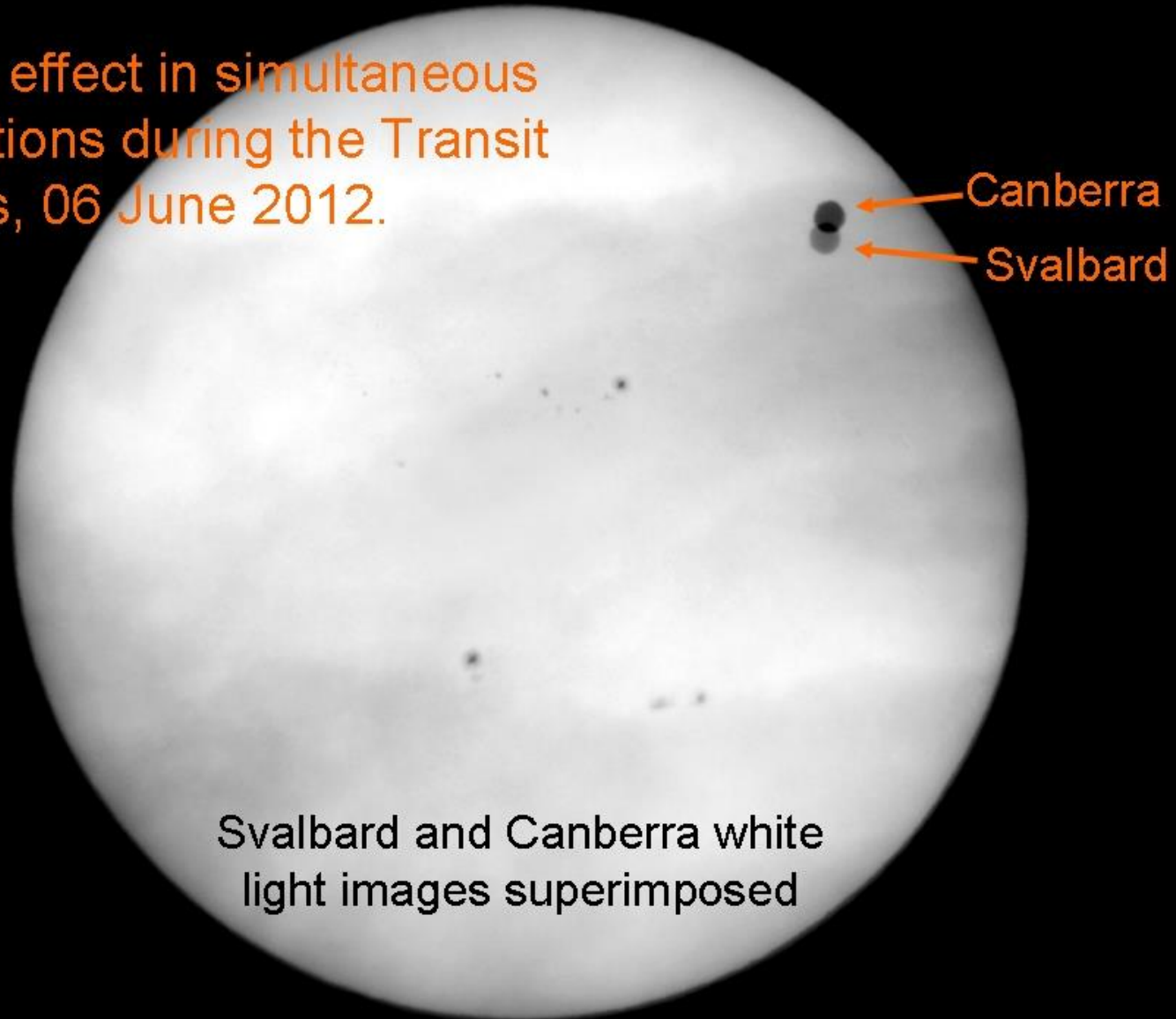
VENUS TRANSIT 2012. SVALBARD - CANBERRA



CESAR – SCIENTIFIC EXPEDITIONS I

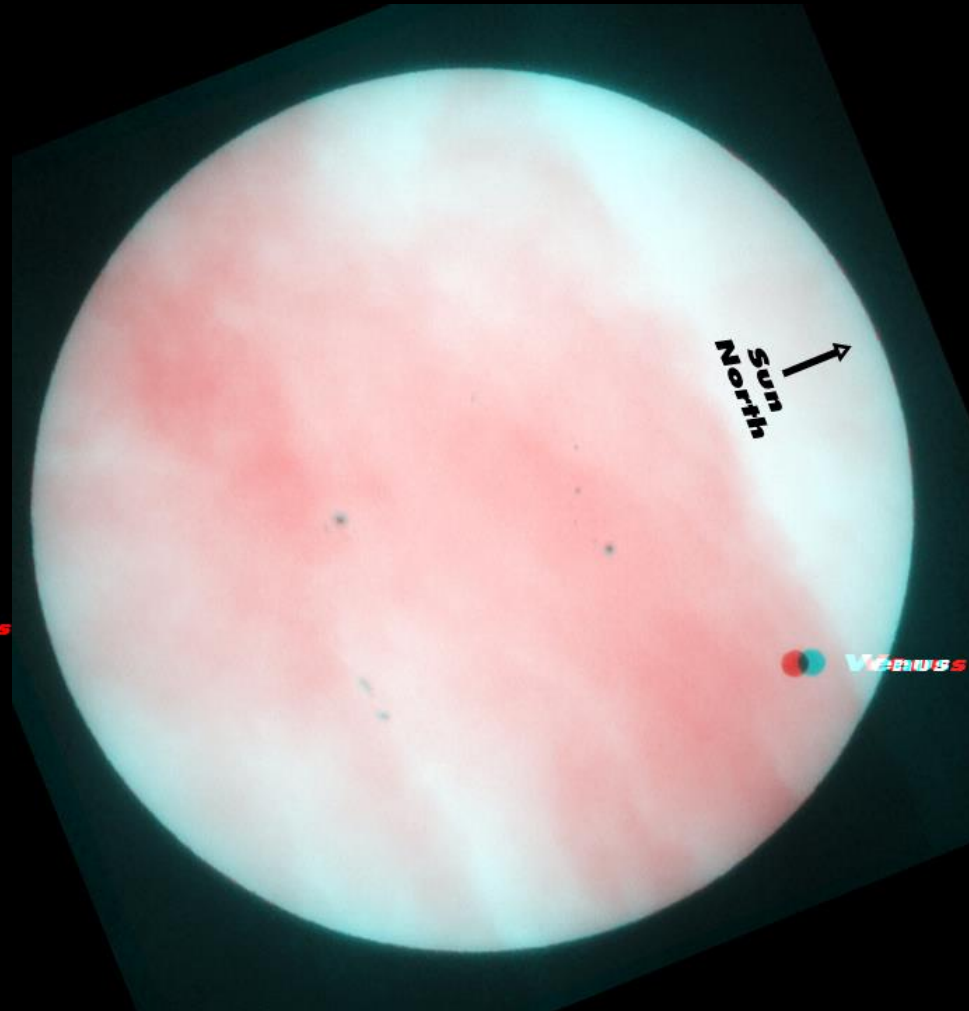
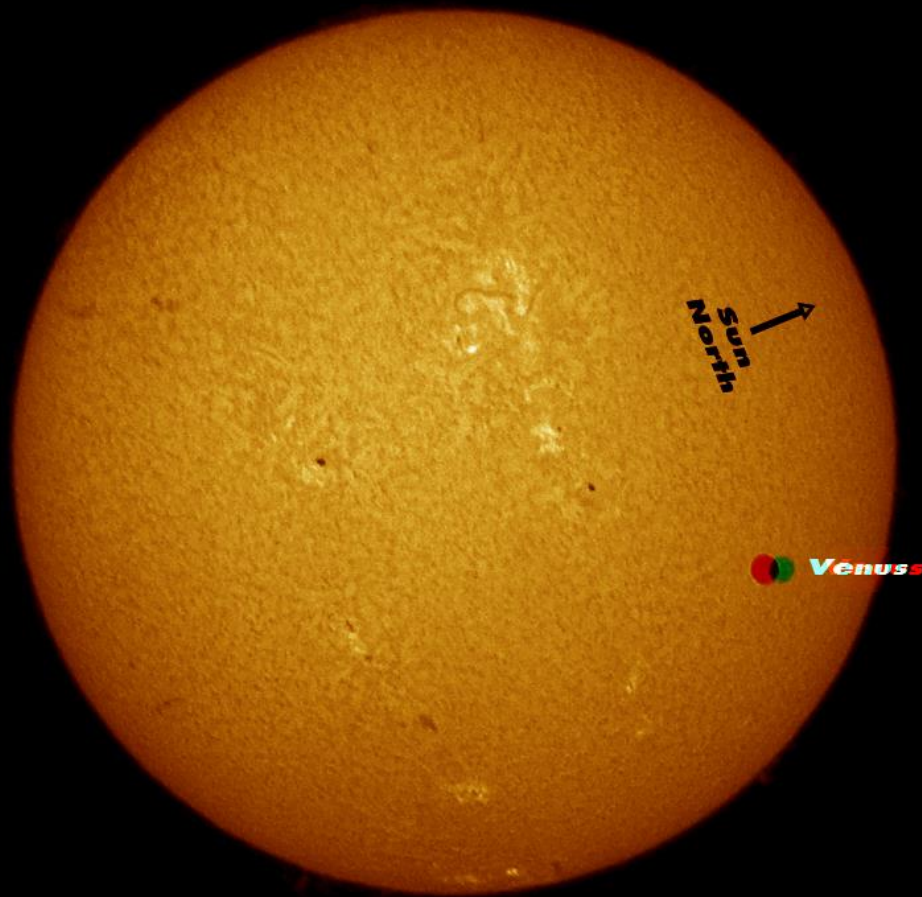
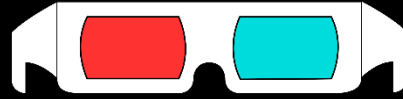
VENUS TRANSIT 2012. SVALBARD - CANBERRA

Parallax effect in simultaneous observations during the Transit of Venus, 06 June 2012.



CESAR – SCIENTIFIC EXPEDITIONS I

VENUS TRANSIT 2012. SVALBARD - CANBERRA

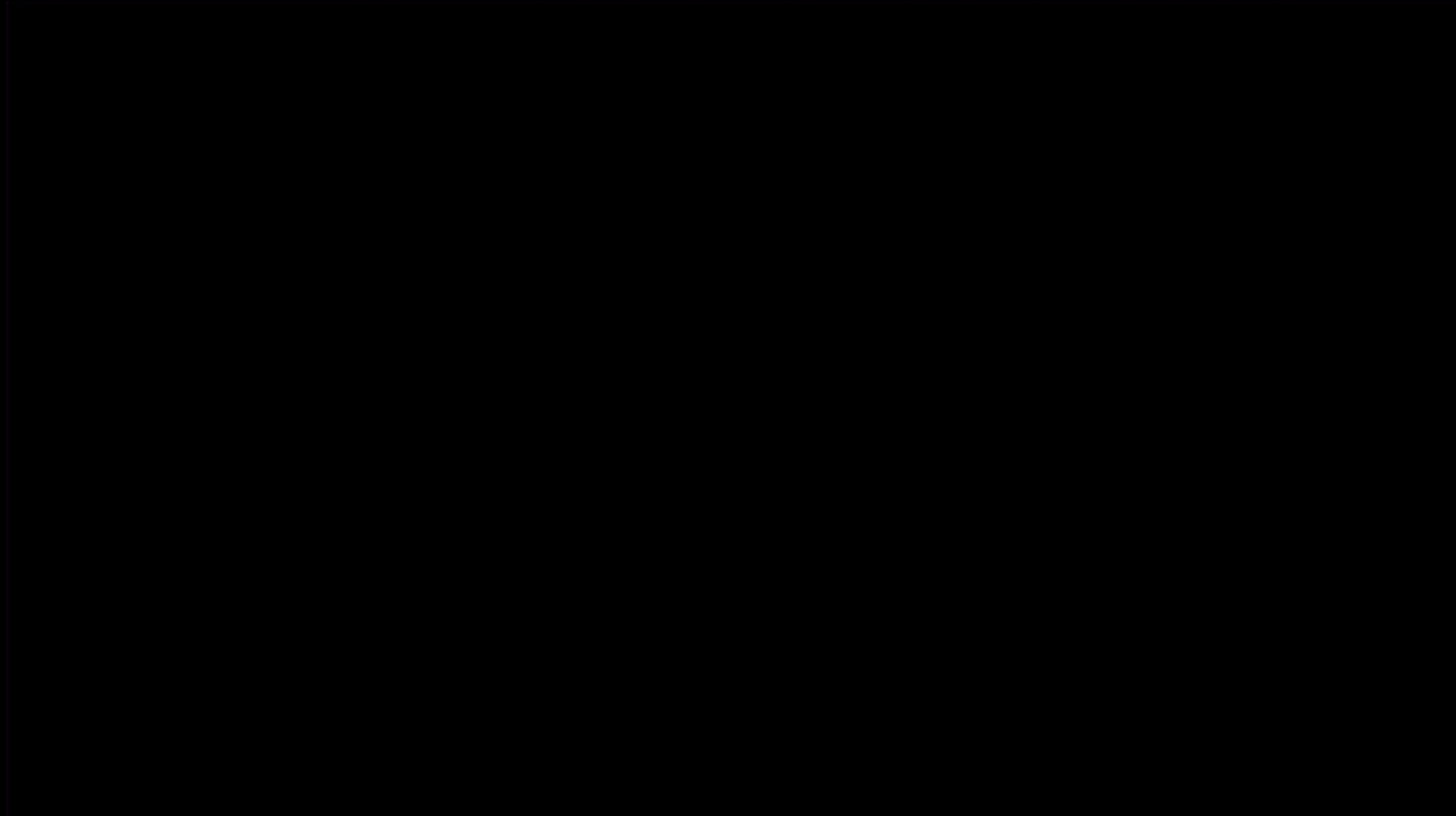


CESAR – SCIENTIFIC EXPEDITIONS I

VENUS TRANSIT 2012. SVALBARD - CANBERRA

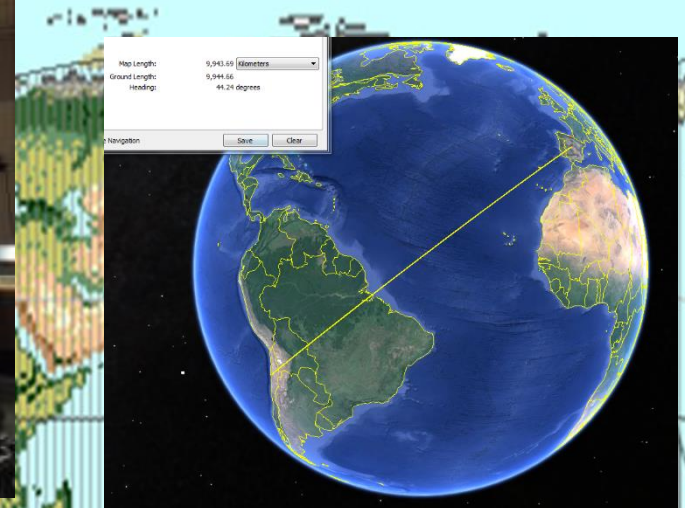
CESAR – SCIENTIFIC EXPEDITIONS I

VENUS TRANSIT 2012. SVALBARD - CANBERRA



CESAR – SCIENTIFIC EXPEDITIONS II

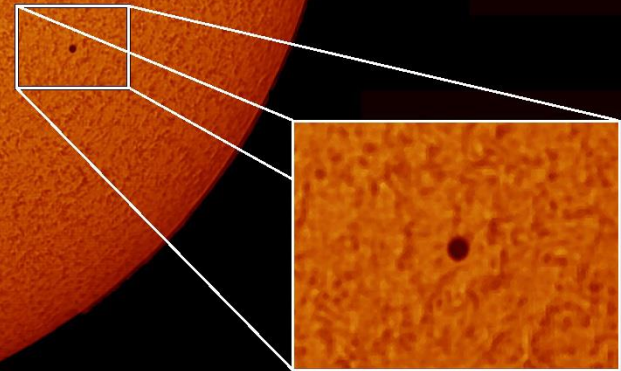
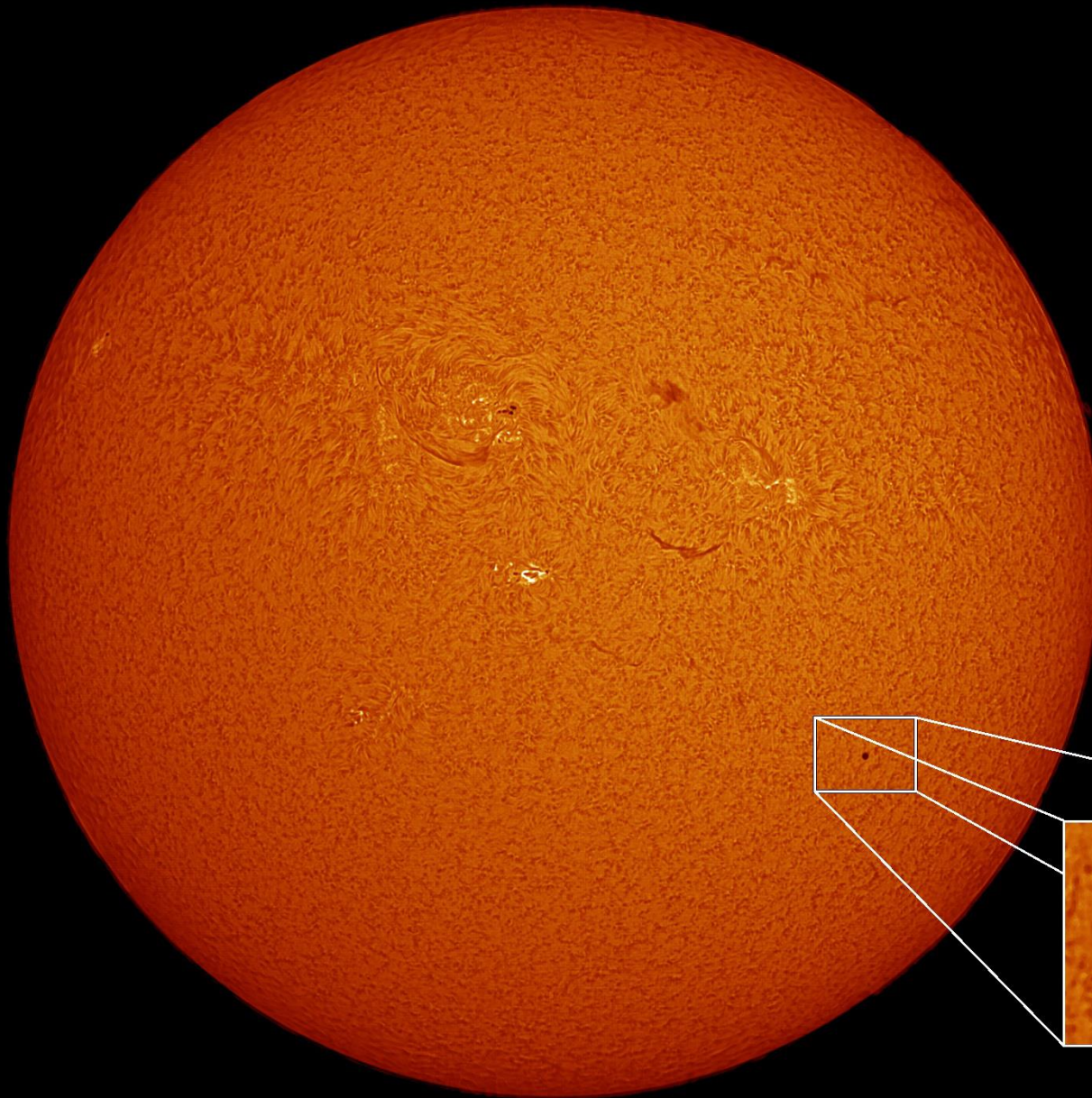
MERCURY TRANSIT 2016. CHILE - SPAIN



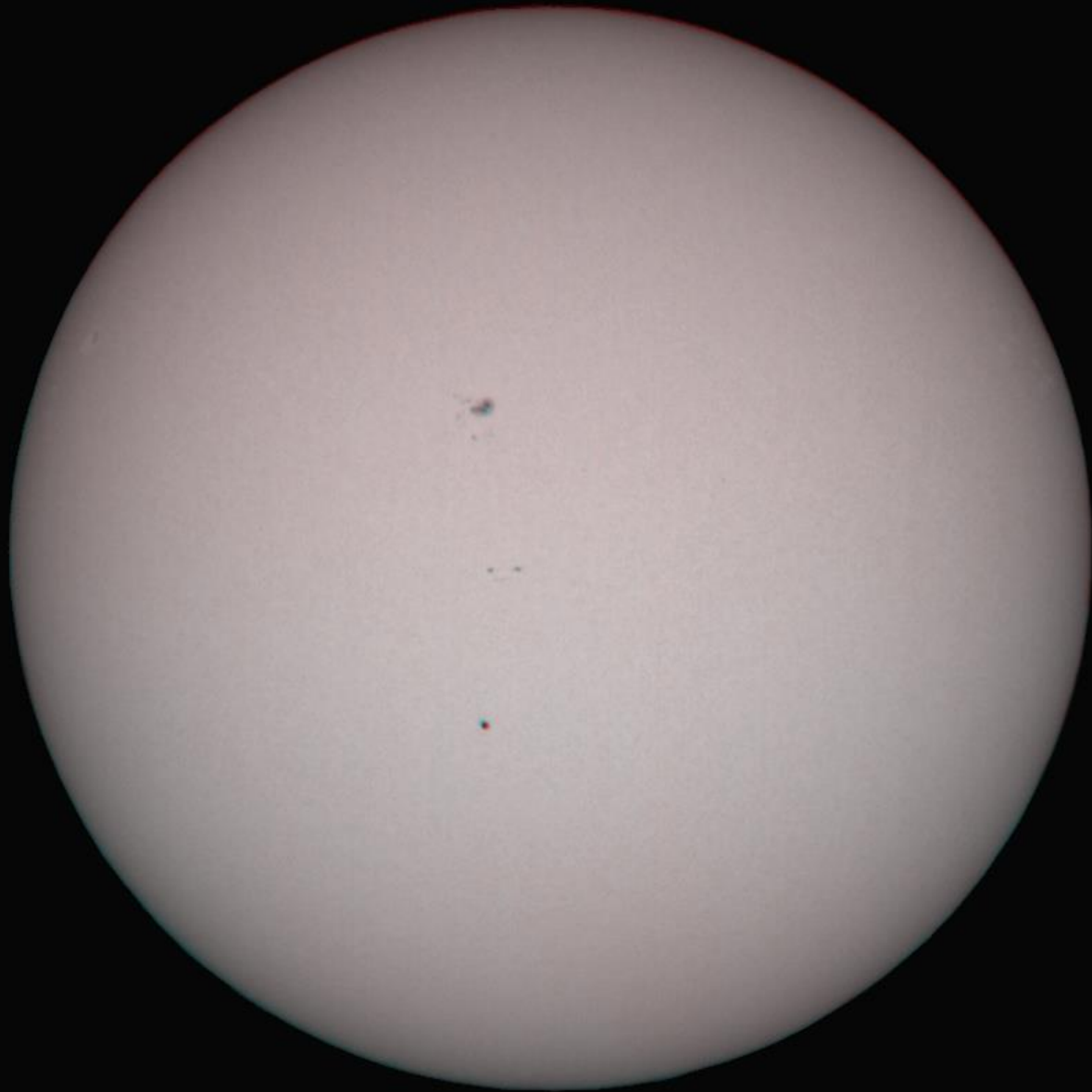
Mercury Transit as seen from Paranal Observatory on 2016-05-09 at 17:18 UTC



European Space Agency



Paranal-Tenerife Parallax of Mercury during the transit on 2016-05-09T14:34 UTC



**Blue disk: Seen from Paranal
Red disk: Seen from Tenerife**



CESAR – SCIENTIFIC EXPEDITIONS II

MERCURY TRANSIT 2016. CHILE - SPAIN

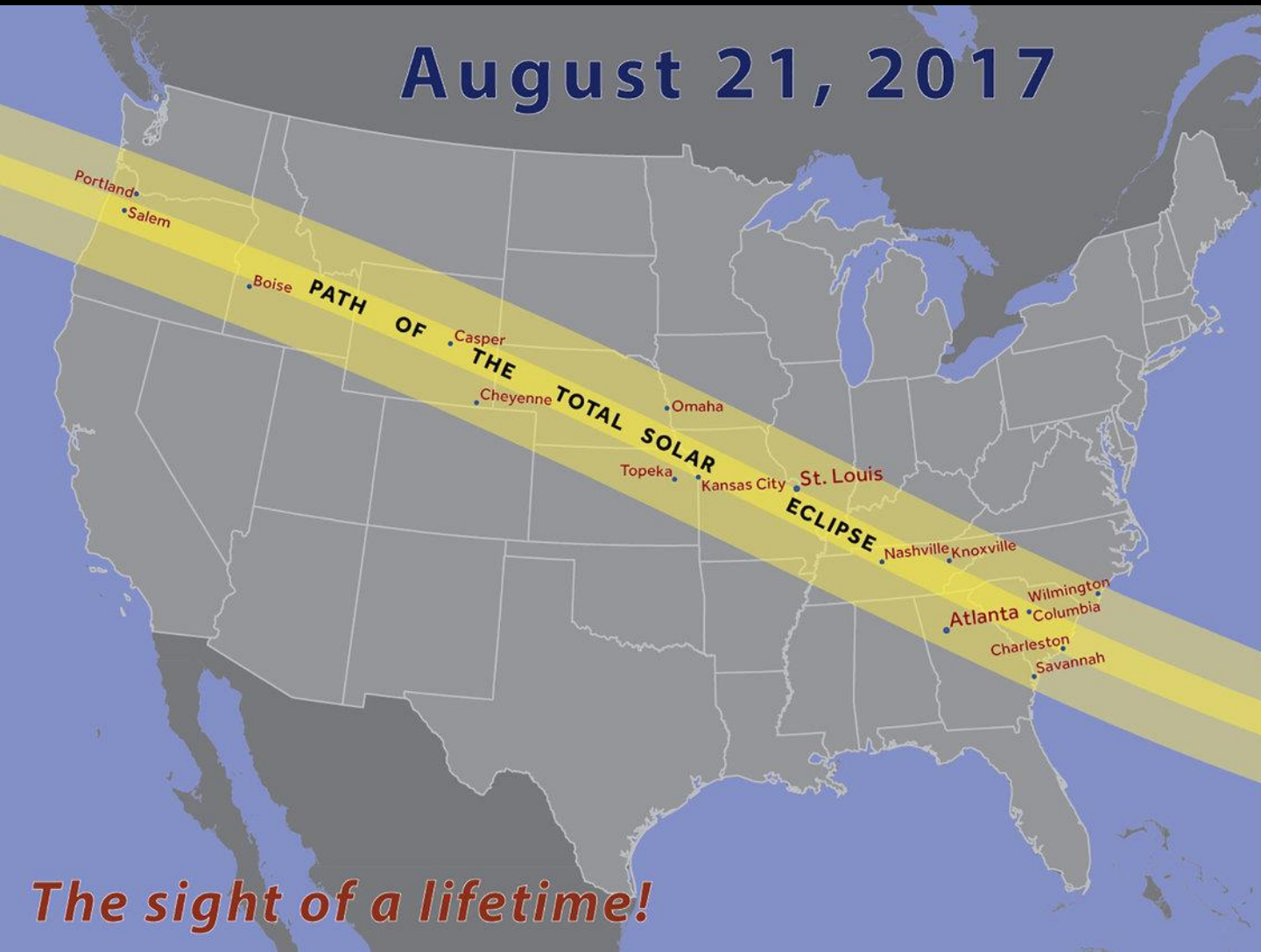


CESAR – SCIENTIFIC EXPEDITIONS III

SOLAR TOTAL ECLIPSE 21 AUG 2017



August 21, 2017



The sight of a lifetime!

47.0
MILLION
AMERICANS

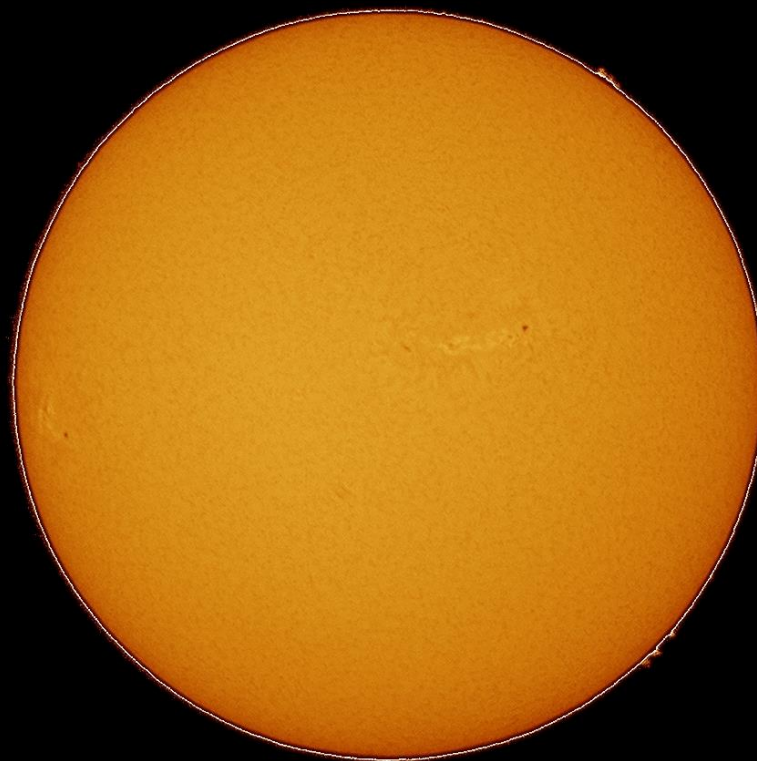
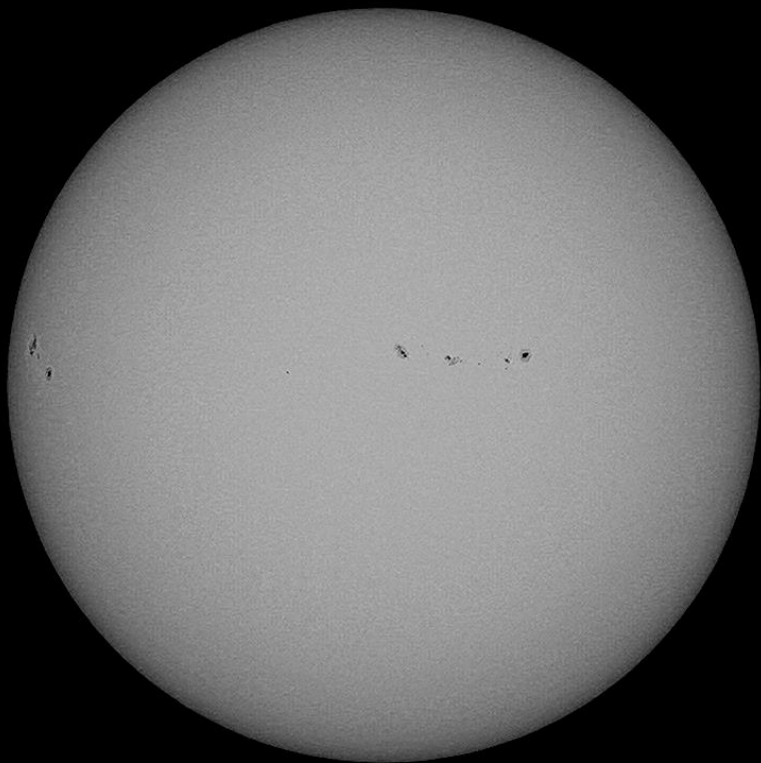
14.4% OF
THE NATION

LIVES WITHIN

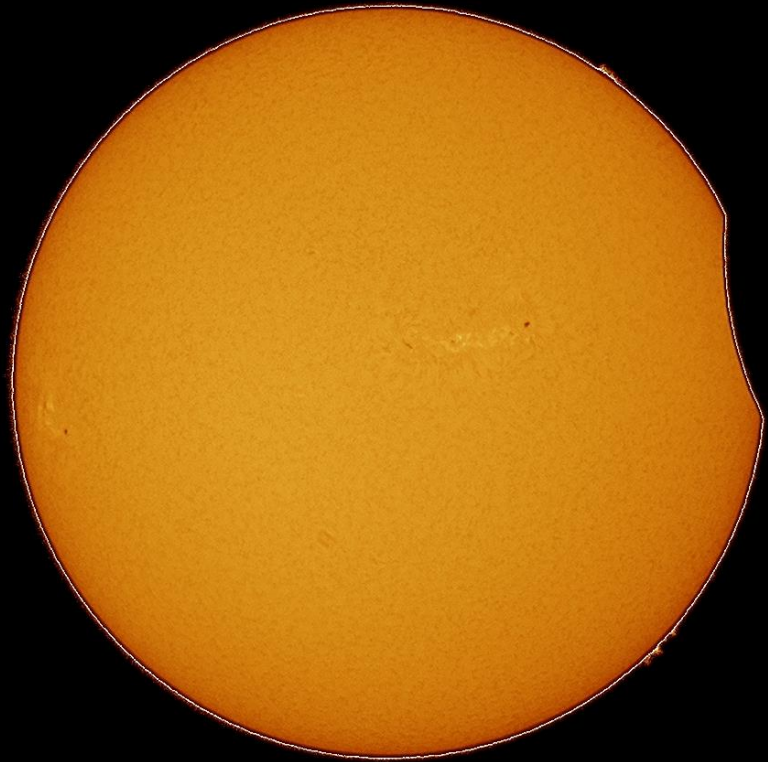
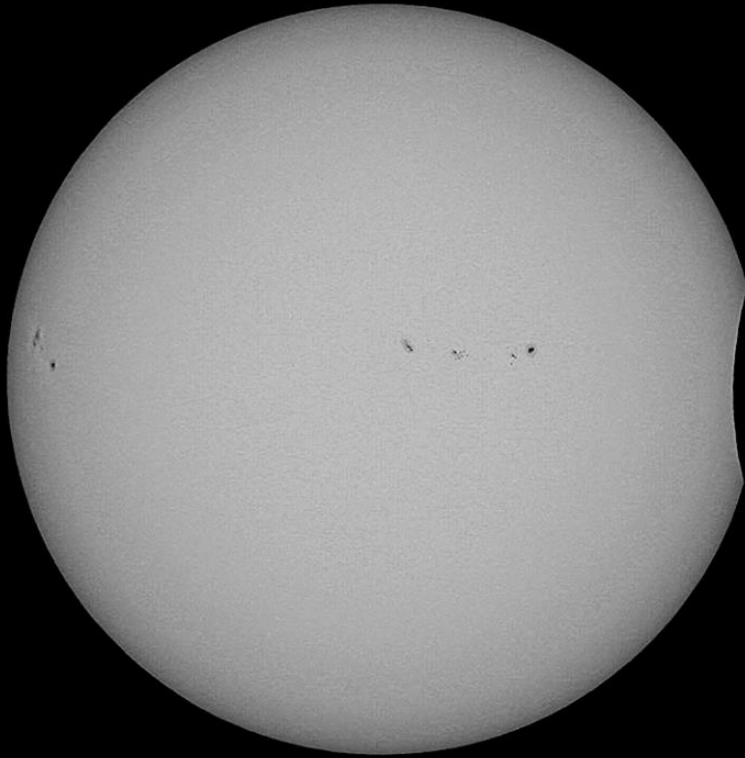
100
MILES OF
TOTAL ECLIPSE



LIVE IMAGES



LIVE IMAGES



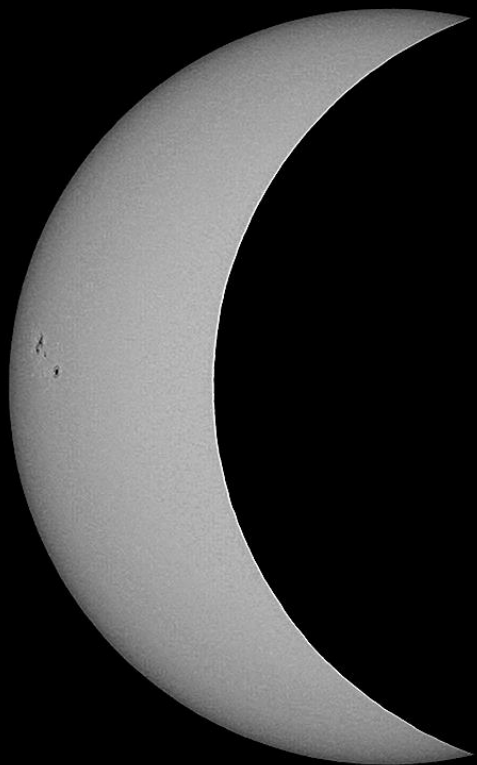
LIVE IMAGES



LIVE IMAGES



LIVE IMAGES



LIVE IMAGES



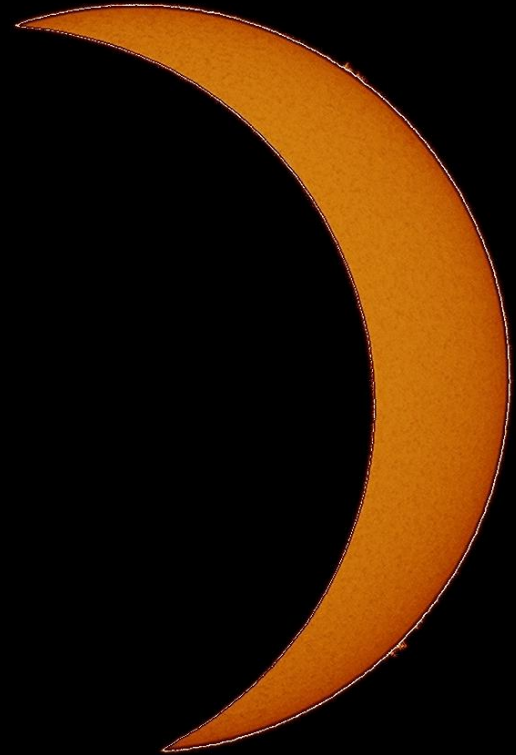
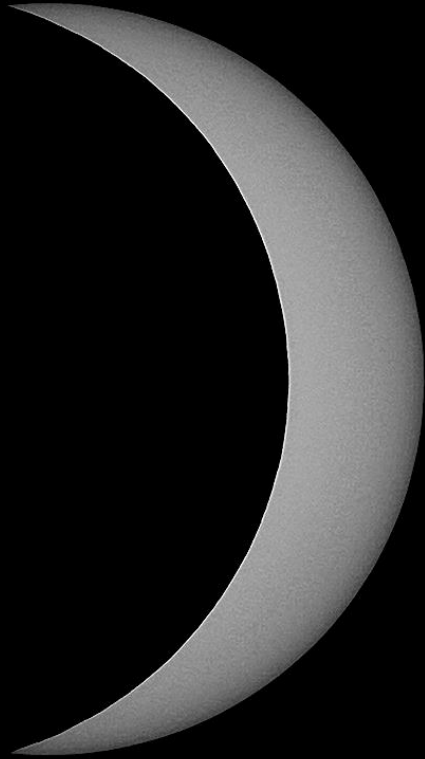
LIVE IMAGES



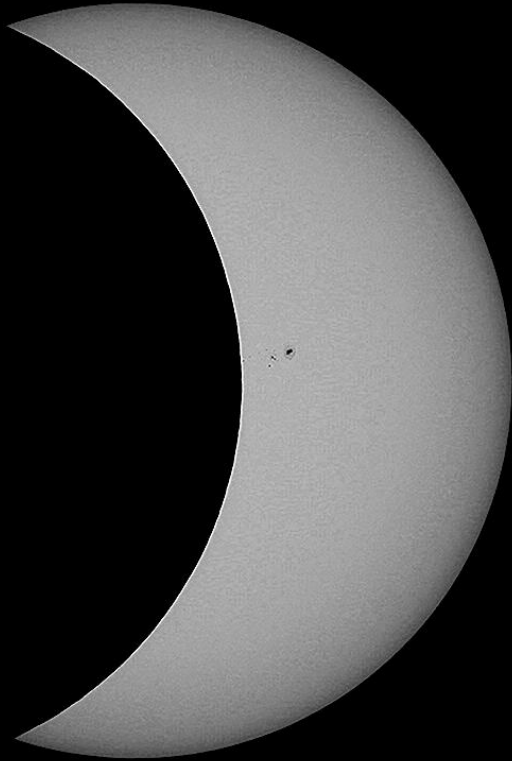
LIVE IMAGES



LIVE IMAGES



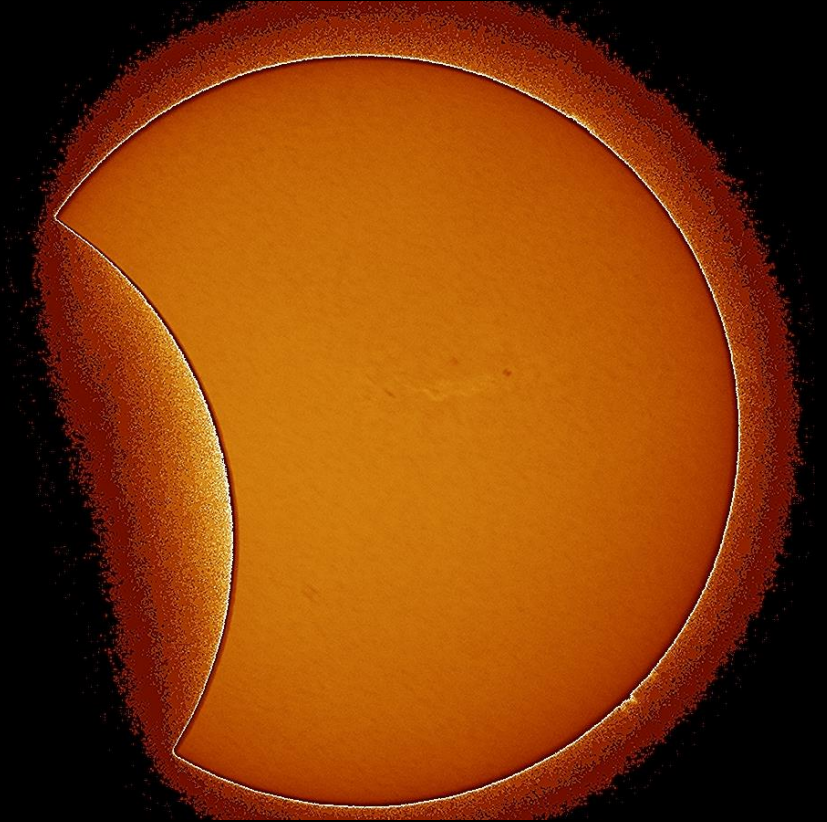
LIVE IMAGES



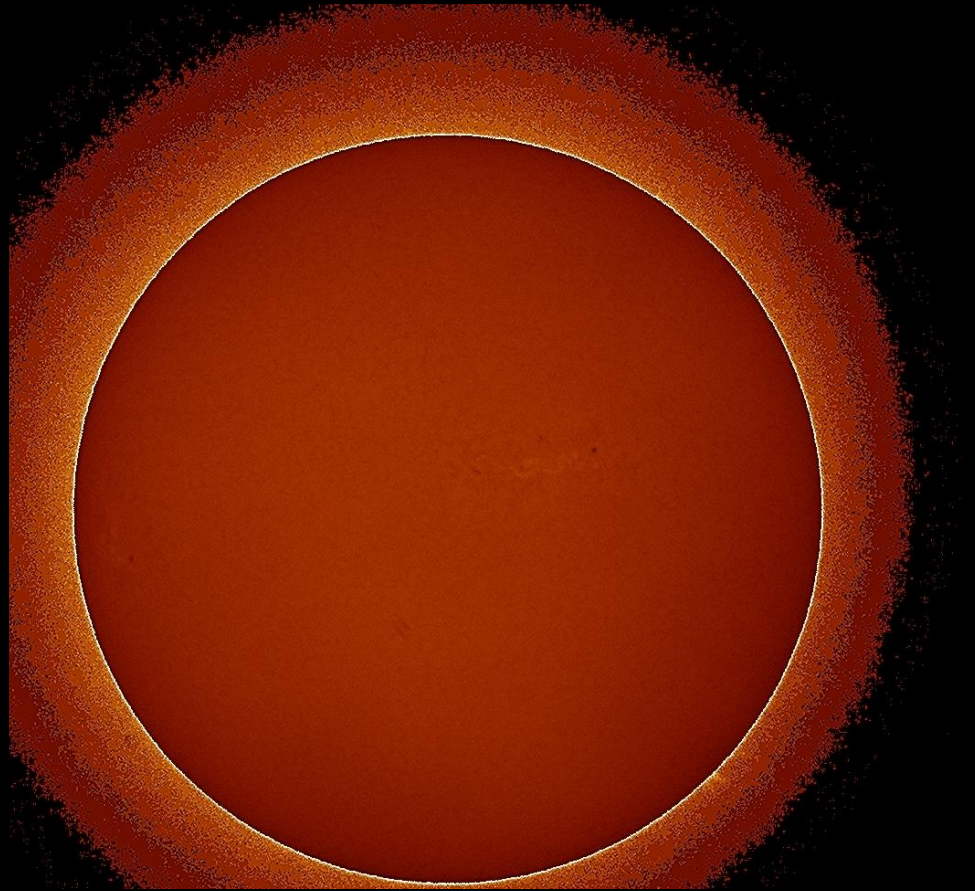
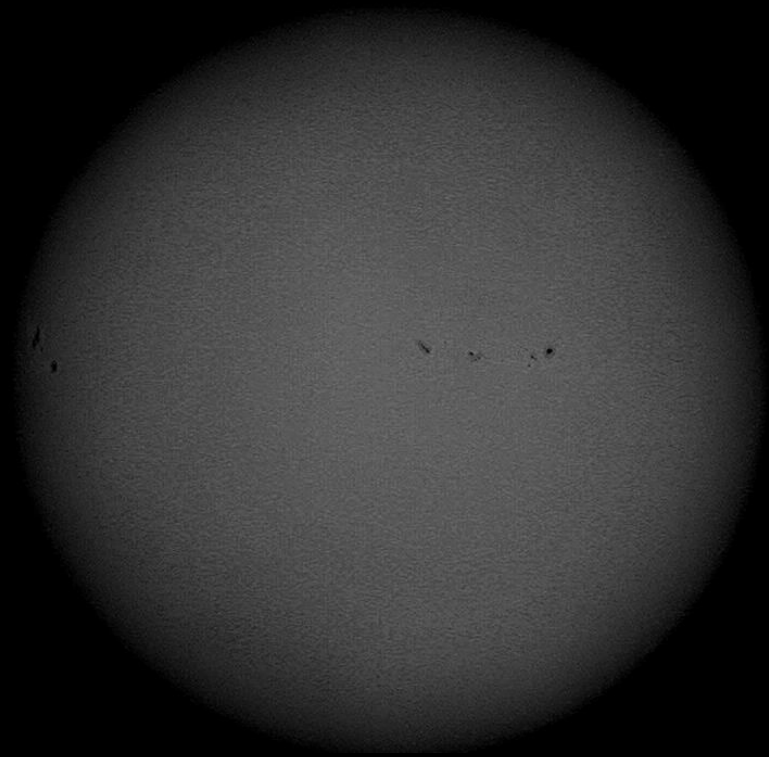
LIVE IMAGES



LIVE IMAGES



LIVE IMAGES







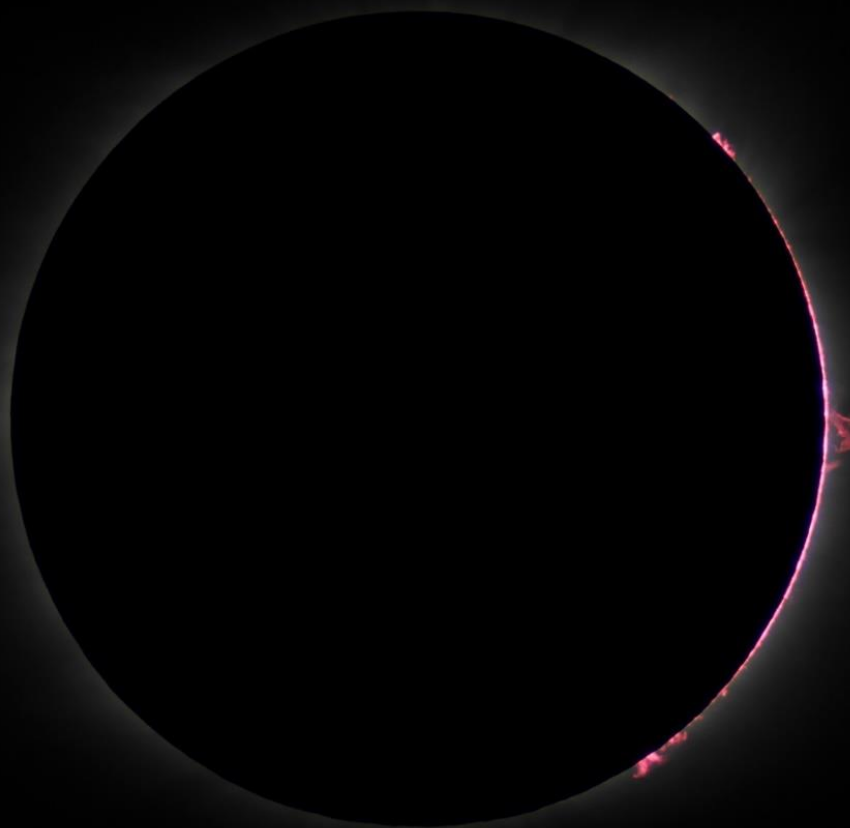
THE CHROMOSPHERE



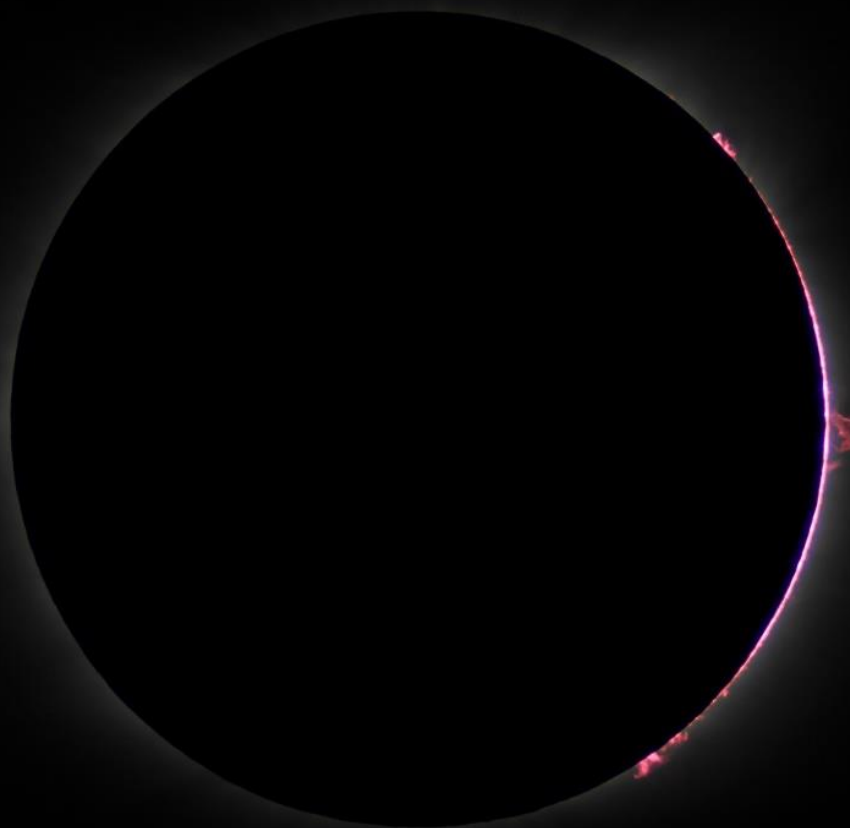
THE CHROMOSPHERE



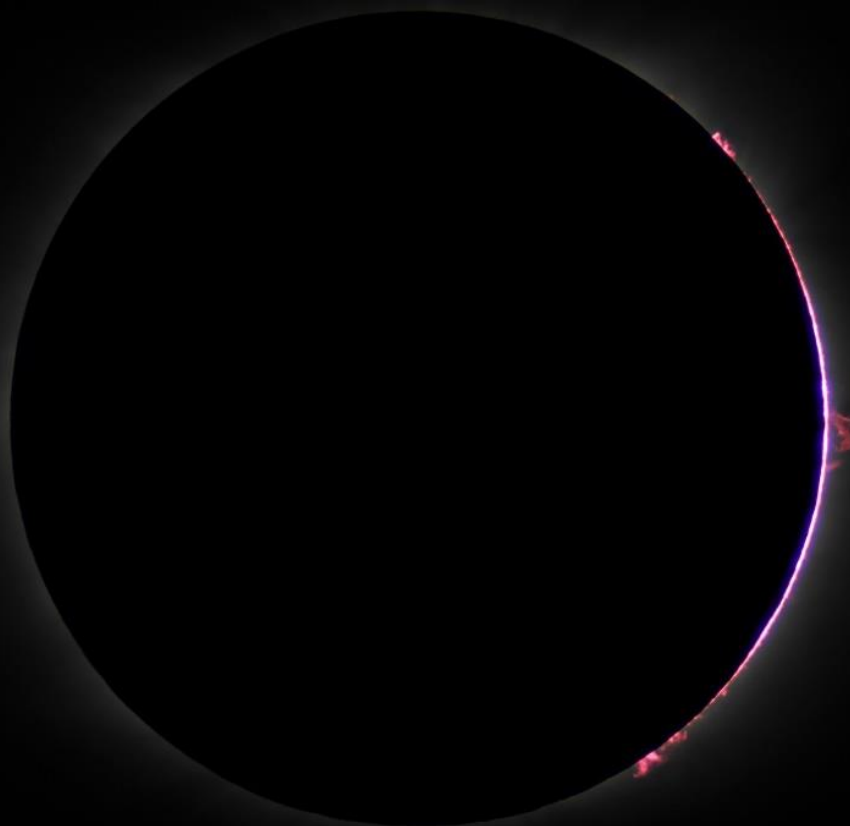
THE BAILY'S BEADS



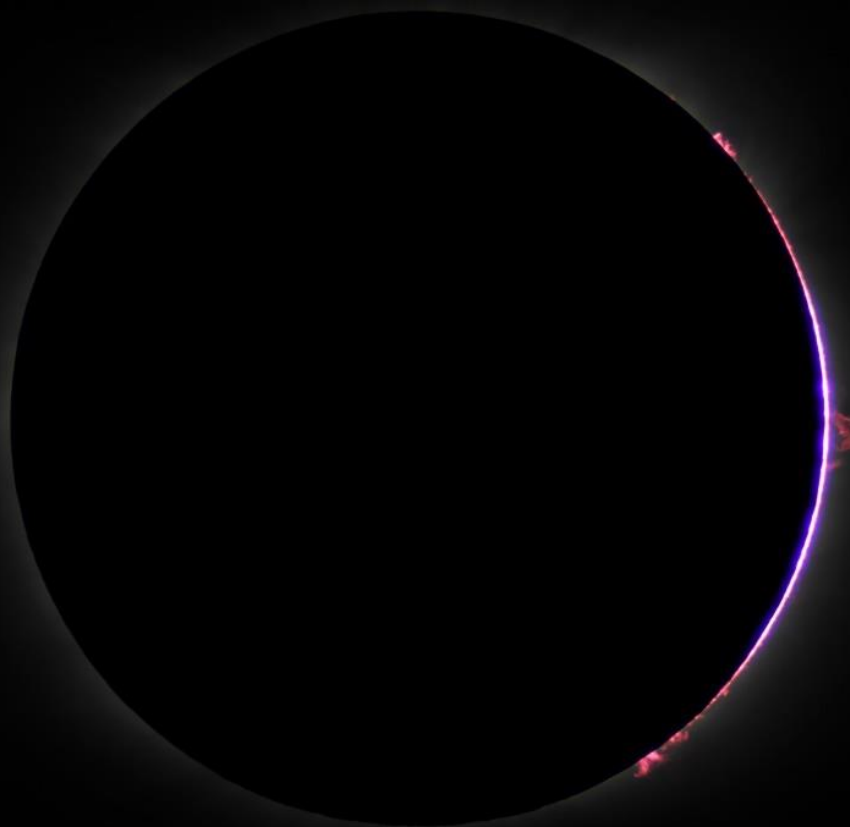
THE BAILY'S BEADS



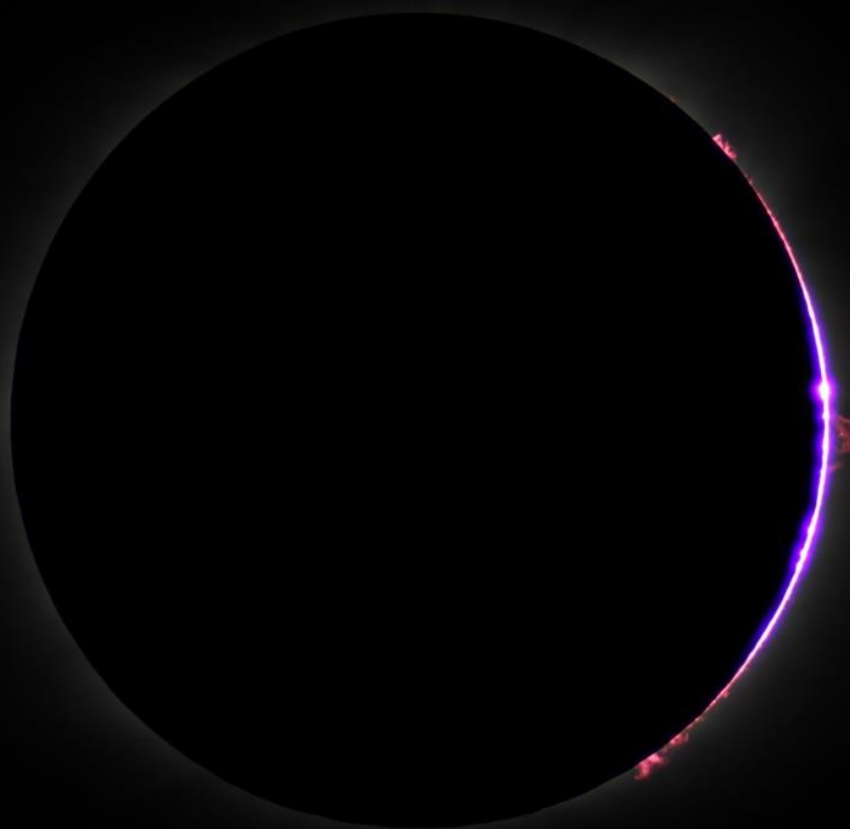
THE BAILY'S BEADS



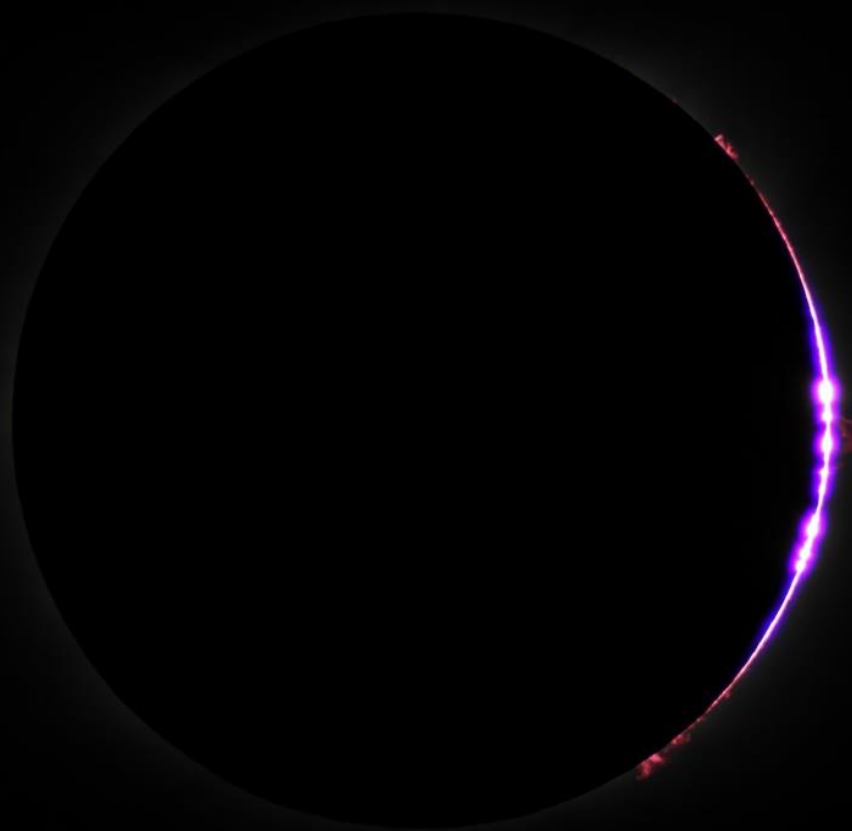
THE BAILY'S BEADS



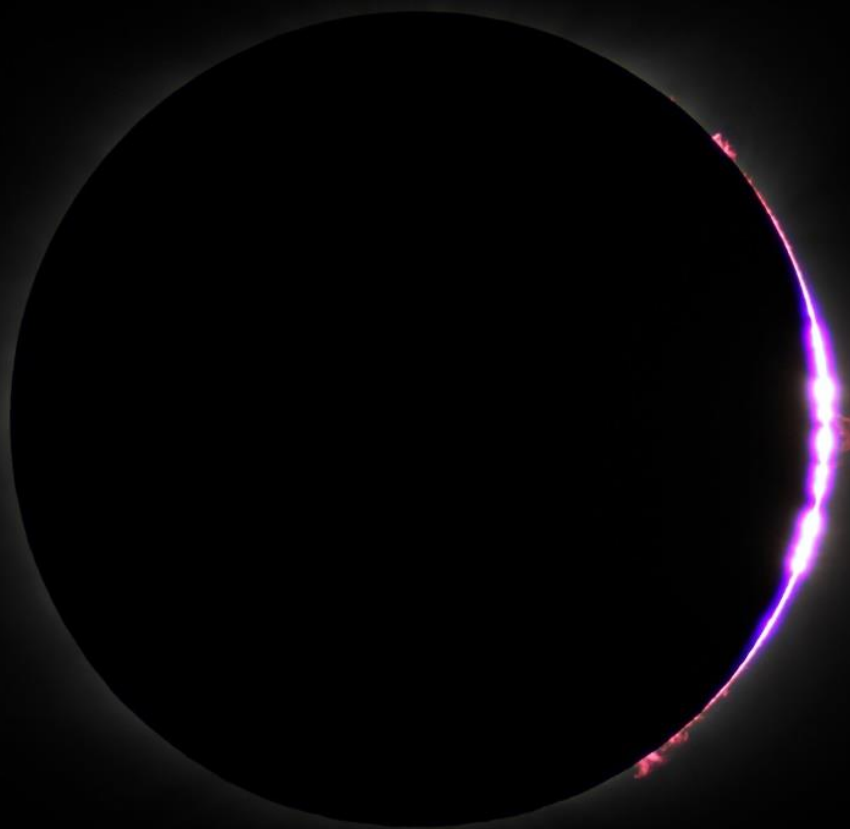
THE BAILY'S BEADS



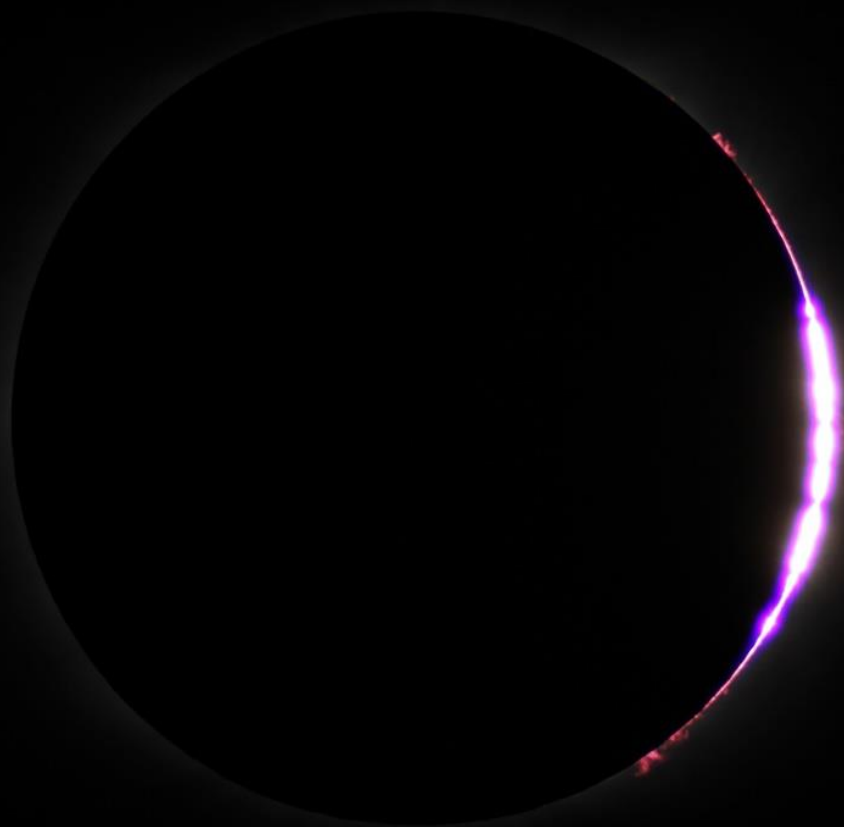
THE BAILY'S BEADS



THE BAILY'S BEADS



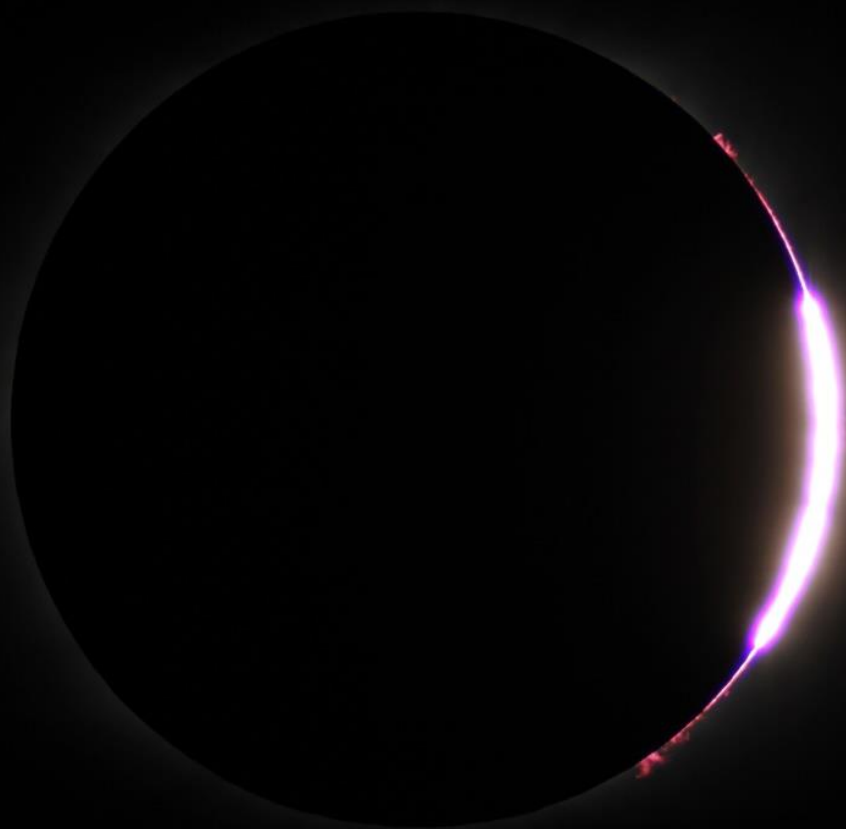
THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE BAILY'S BEADS



THE CORONA in HDR



THE CORONA in HDR



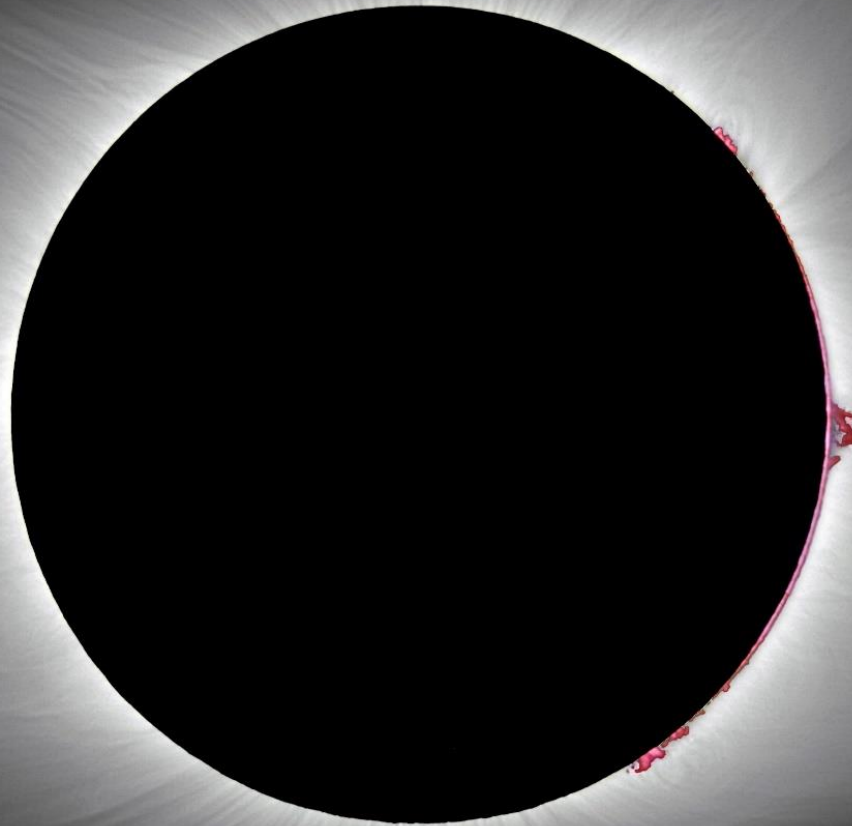
THE CORONA in HDR



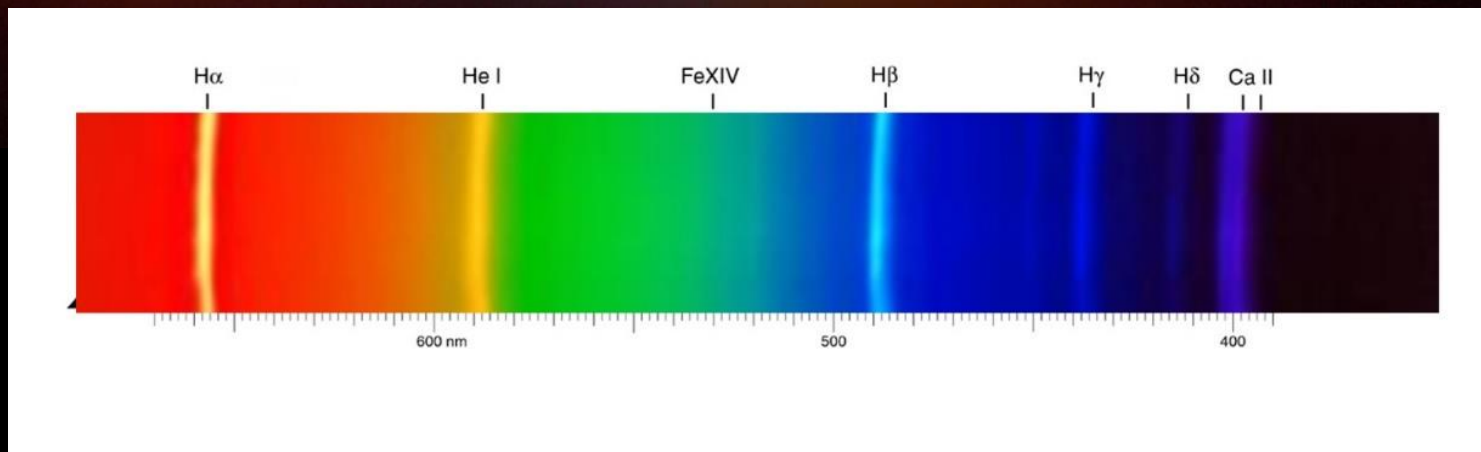
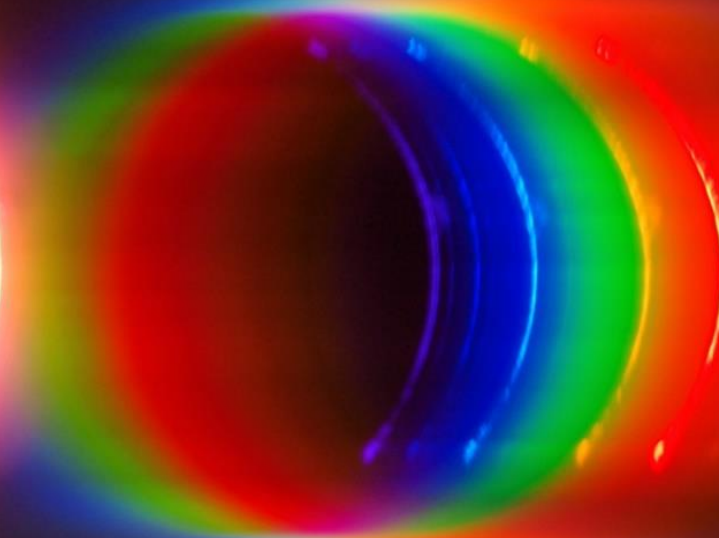
THE CORONA in HDR



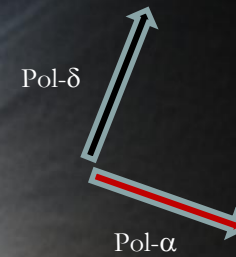
THE CORONA in HDR



SPECTRAL DATA: H, He, Fe, Ca ...

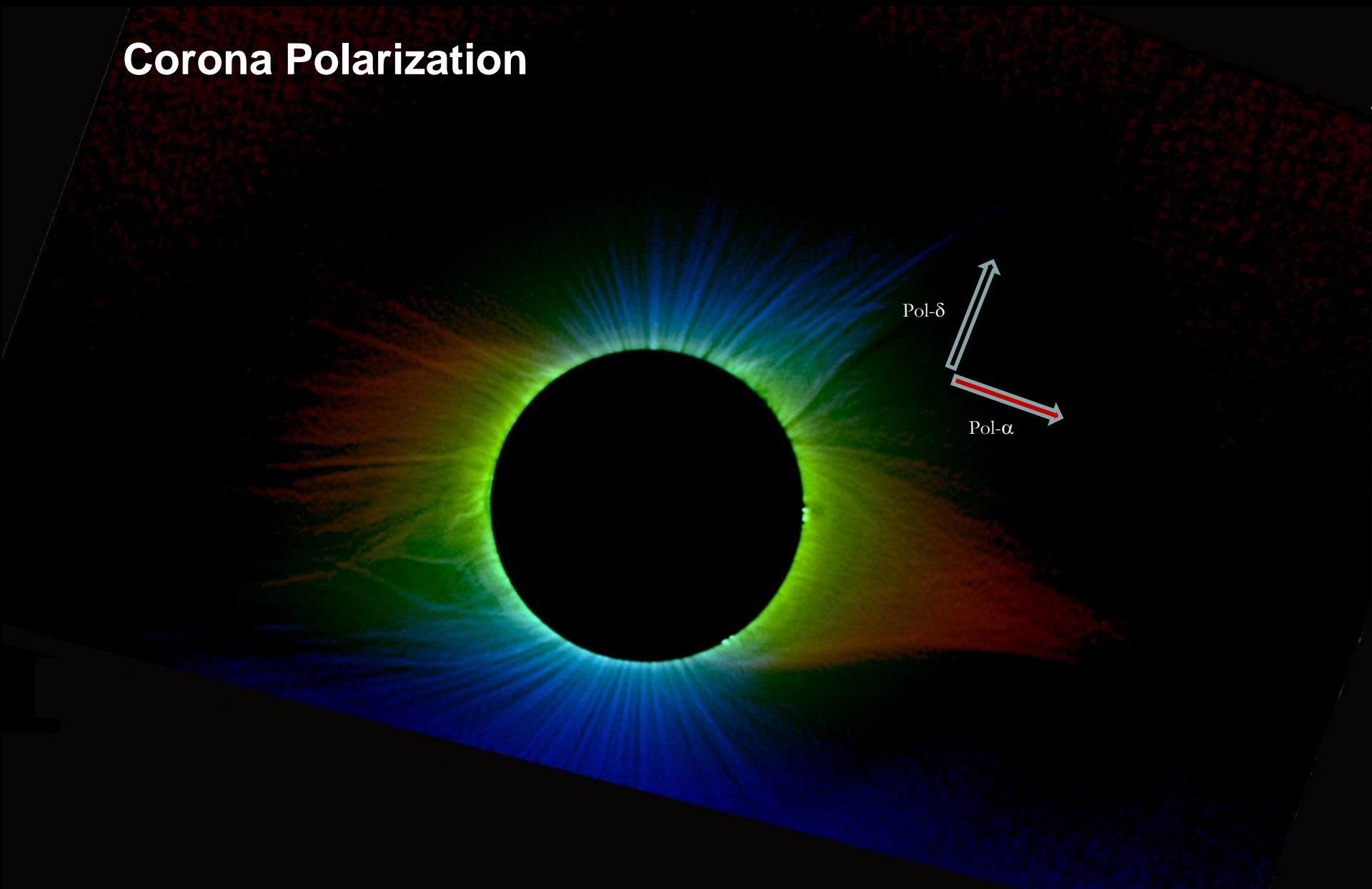


Corona Polarization



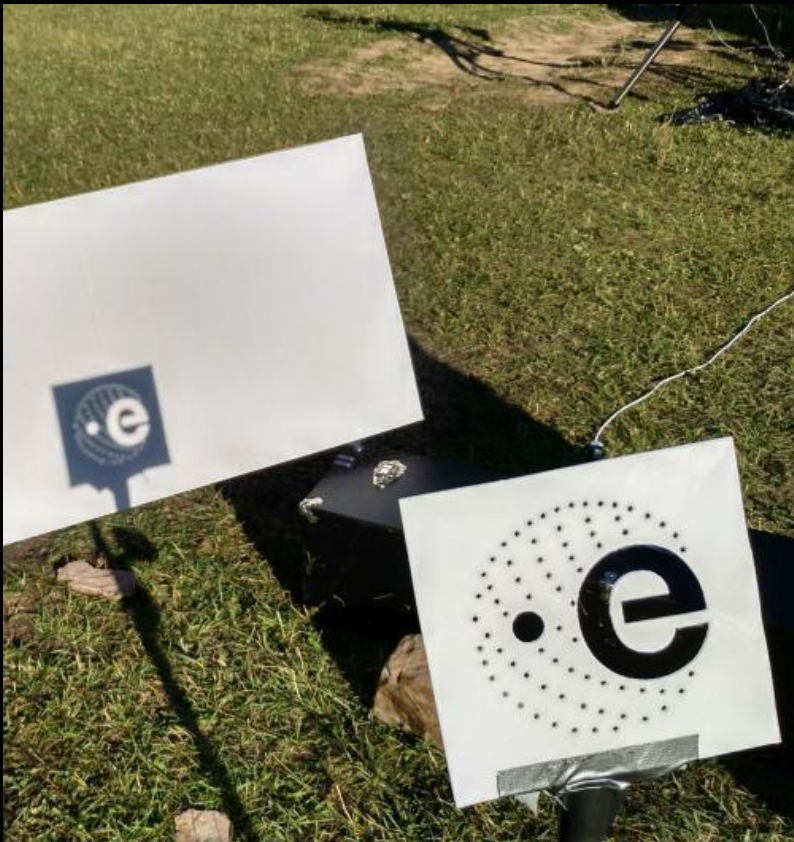
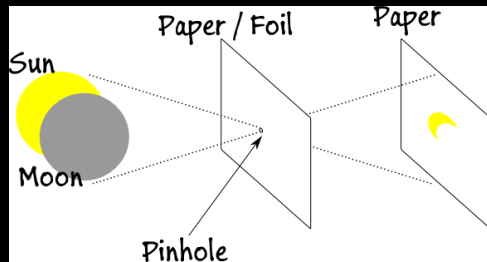
R: $\text{Pol-}\alpha$ G: $\text{Pol-}\alpha + \text{Pol-}\delta$ B: $\text{Pol-}\delta$ L: $\text{RotGrad}(\text{Pol-}\alpha + \text{Pol-}\delta)$

Corona Polarization



R: $\text{Pol-}\alpha / (\text{Pol-}\alpha + \text{Pol-}\delta)$ G: $\text{Pol-}\alpha + \text{Pol-}\delta$ B: $\text{Pol-}\delta / (\text{Pol-}\alpha + \text{Pol-}\delta)$ L: $\text{RotGrad} (\text{Pol-}\alpha + \text{Pol-}\delta)$

PINHOLE PROJECTION



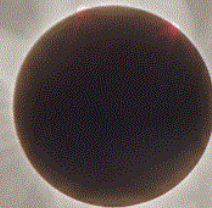
MOON - double reflected light



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**

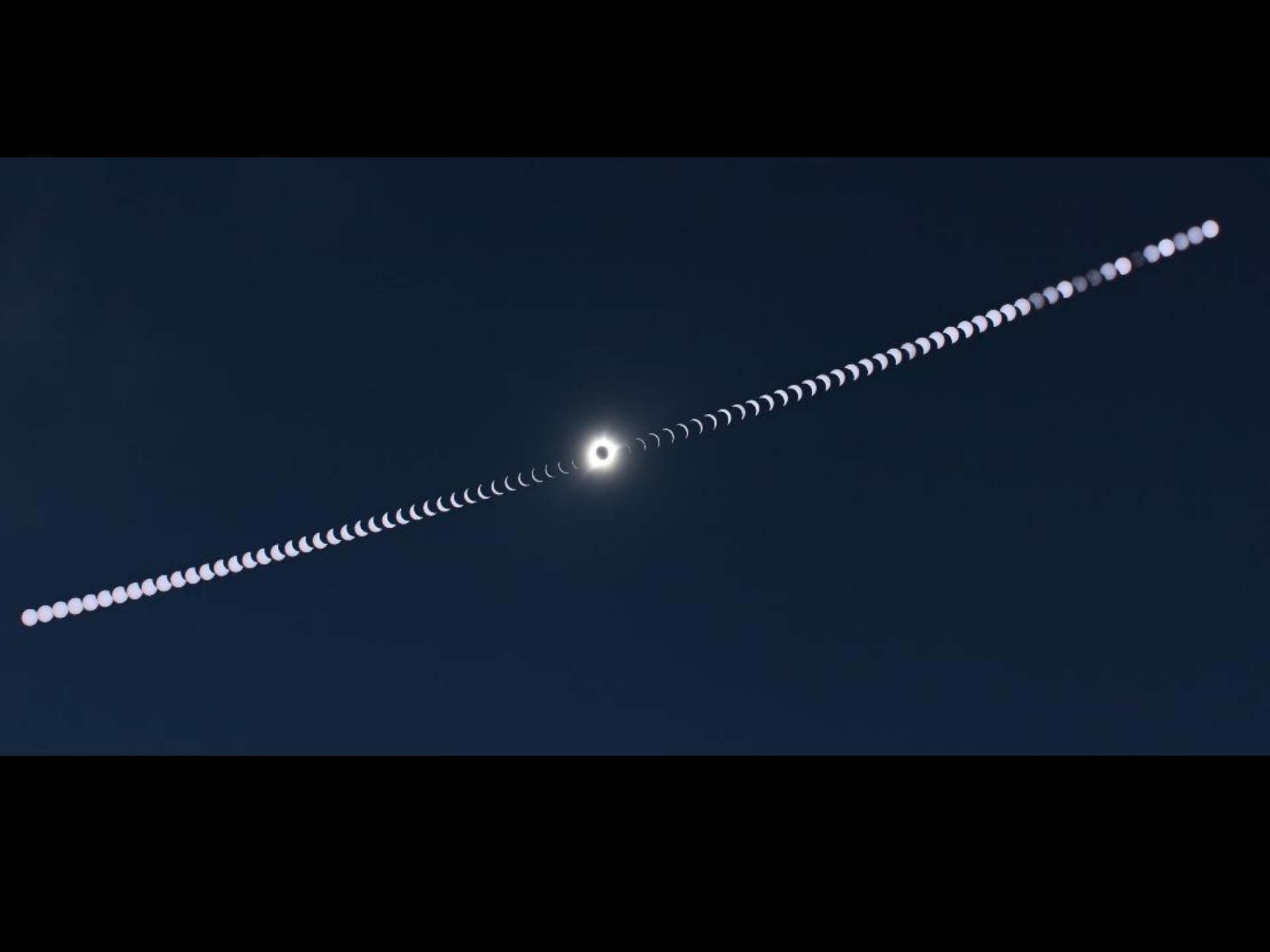


Regulus
α Leo - 32 Leo - HIP 49669 - SAO 98967

Type: **double star**
Magnitude: **1.35** (after extinction: **1.51**)
Absolute Magnitude: **-0.58**
Color Index (B-V): **-0.09**







IMPACT of these events



WEB	Number of visits	Pages	Hits	Bandwidth (GB)
Mercury Transit 2016 9 May	72,151	1,006,801	3,132,297	93
Venus Transit 2012 6 June	16,560	44,207	2,707,385	58



GOOGLE HANGOUT		
SIMULTANEOUS WATCHERS	2513	

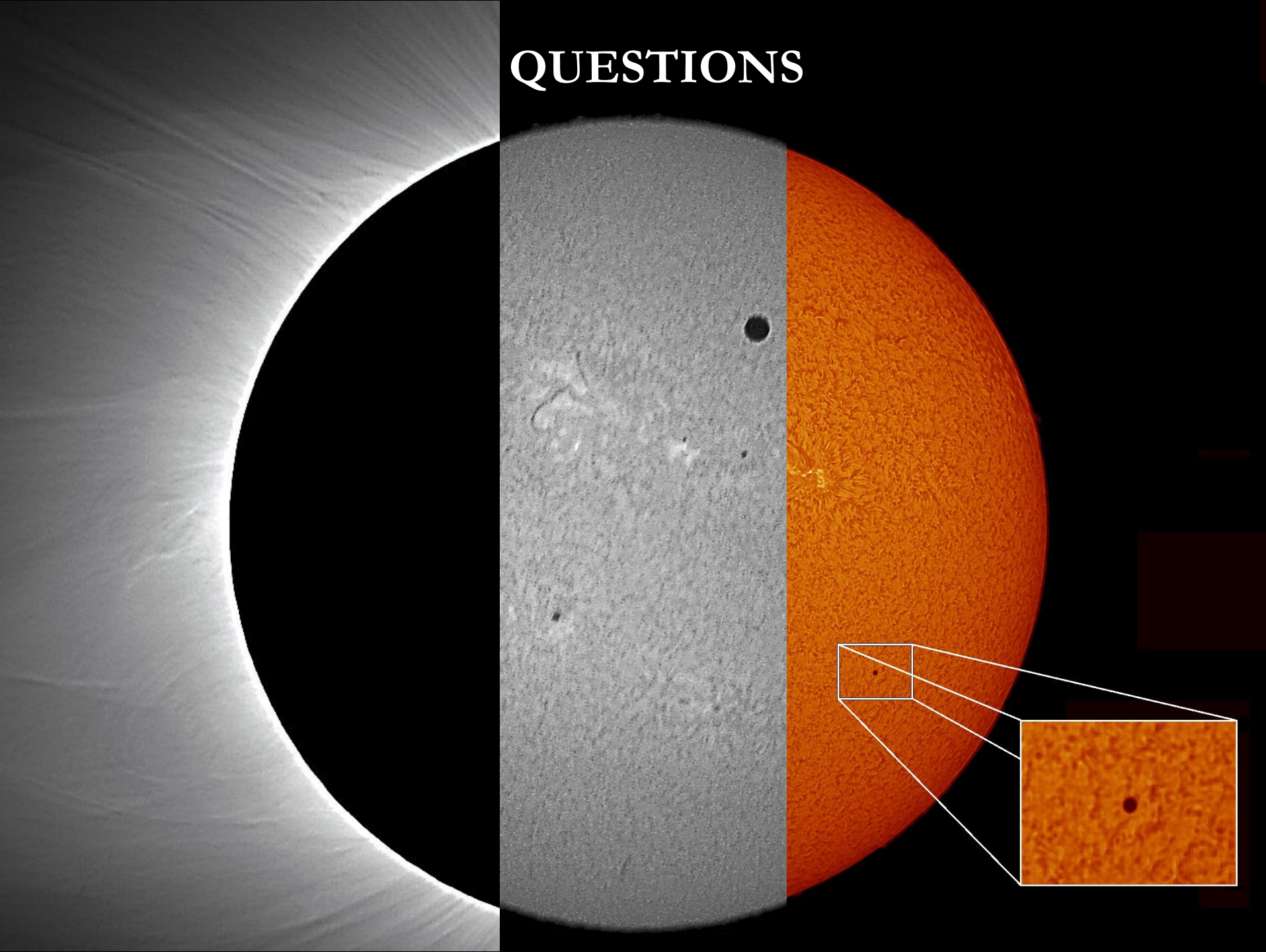


APP	IPHONE 	ANDROID 
DOWNLOADS	>1000	>1000

CONCLUSIONS

- CESAR-ESA Educational project offers **didactic material** based on ESA Science resources, from primary to University grades.
- **Scientific expeditions** are organized to engage students with **awesome rare exotic events**
 - Super rare: Venus transits (not anymore in our lifetime)
 - Mild Rare: Mercury transits
 - Normal Rare BUT AWE: solar eclipses
- These events cover naturally **outreach, education and science**
- The **public response is fabulous** so we will try to organize more in the future

QUESTIONS



OTHER TRANSITS

