Seminarios de Astronomía

Departamento de Física

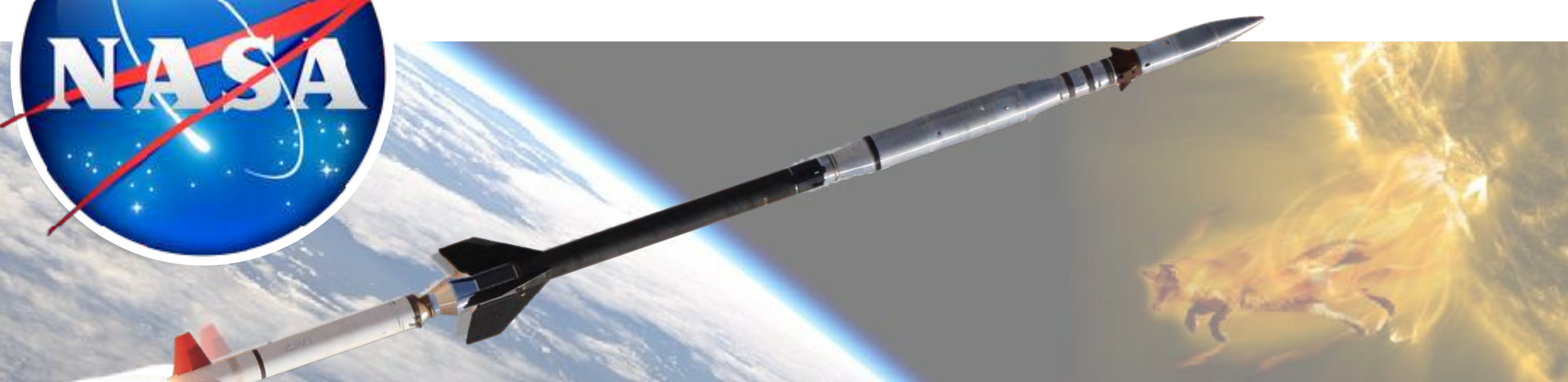
Universidad de los Andes
Colombia

Febrero 23 de 2021,
11:00am

Universidad de
los Andes
Colombia

Milo Buitrago-Casas

FOXSI *Una forma novedosa de observar rayos-X duros del Sol*



NASA

SPACE SCIENCES LABORATORY
UNIVERSITY OF CALIFORNIA
Berkeley

Ruta

¿Por qué estudiar el Sol?

Explosiones solares en rayos-X

Nuevas tecnologías y hallazgos en la observación del Sol

¿Por qué estudiar el Sol?

Una tormenta solar golpearía a la Tierra esta semana

Agencias de monitoreo reportan un evento entre el 23 y 24 de febrero. ¿Hay riesgo? Acá le contamos.

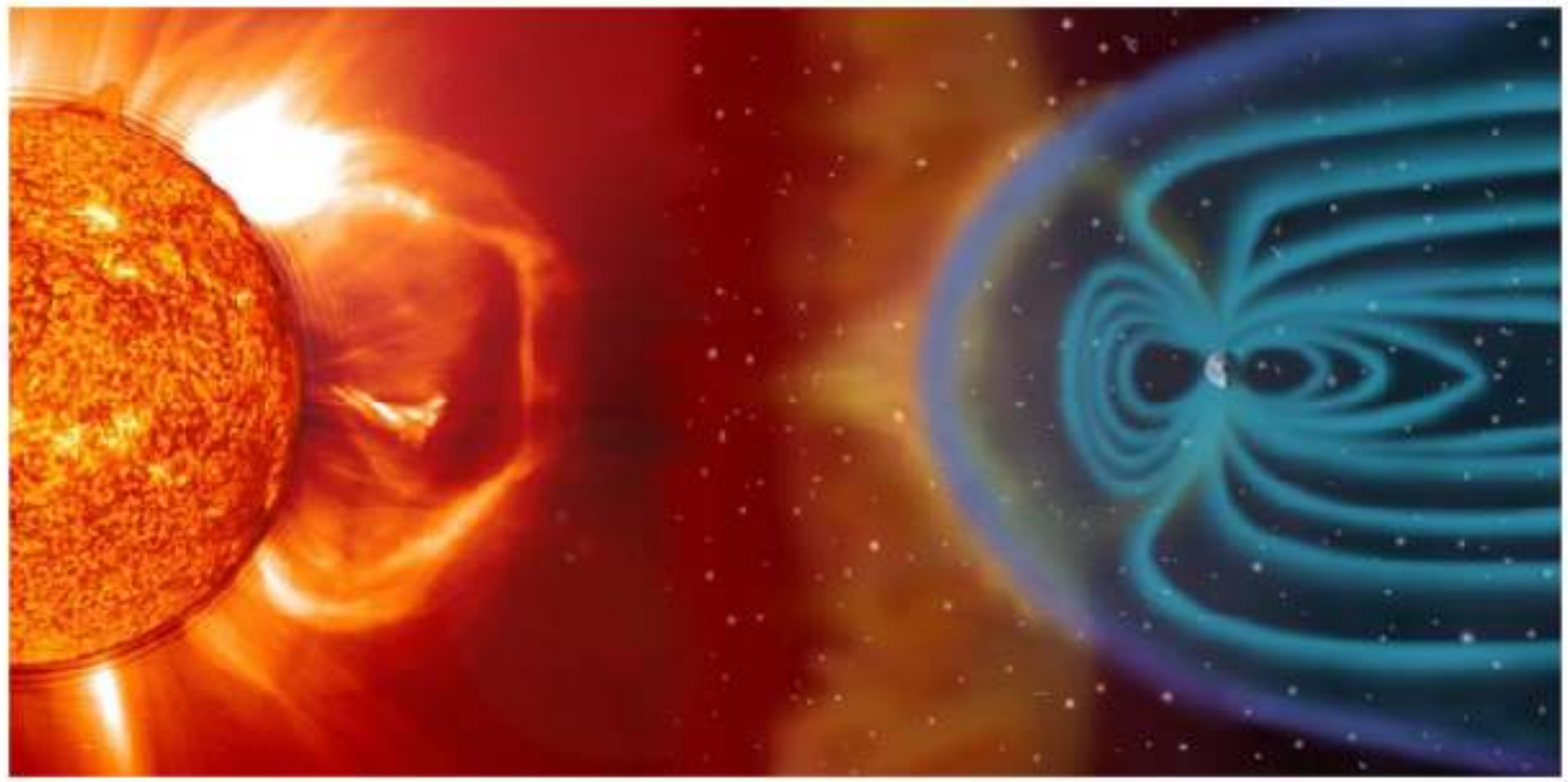


Ilustración que muestra la interacción entre las partículas eyectadas por el Sol y el campo magnético terrestre.
Foto: Nasa

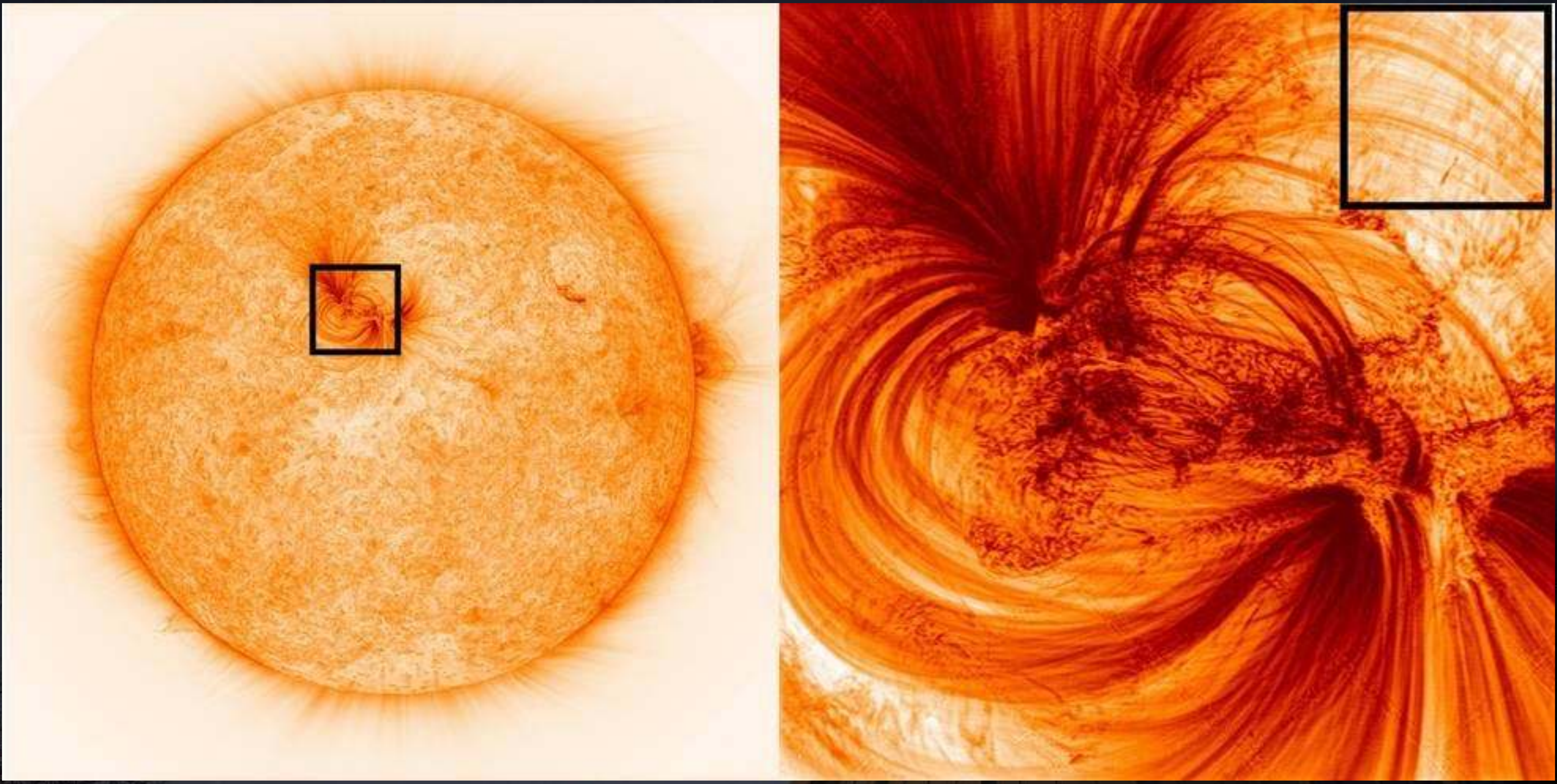
RELACIONADOS NASA TORMENTAS

Por: **REDACCIÓN CIENCIA** 23 de febrero 2021 , 11:15 a. m.

La Oficina Nacional de Administración Oceánica y Atmosférica (Noaa, por sus siglas en inglés) anunció que un posible **tormenta geomagnética** podría generarse en la Tierra entre el martes 23 y el miércoles 24 de febrero. En otras noticias de ciencia: Así suena Marte grabado por el róver Perseverance

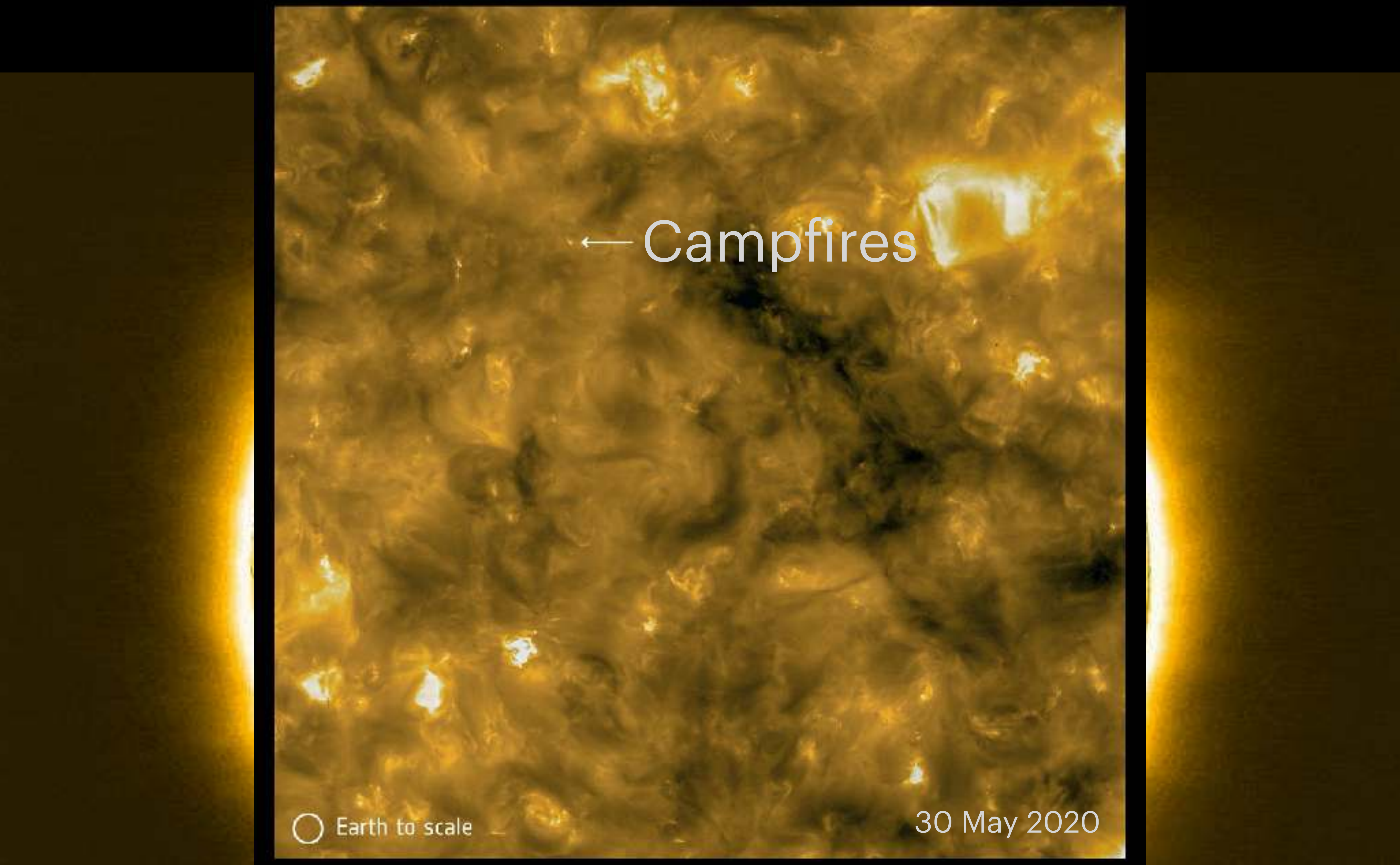
Temas relacionados

¿Por qué estudiar el Sol?

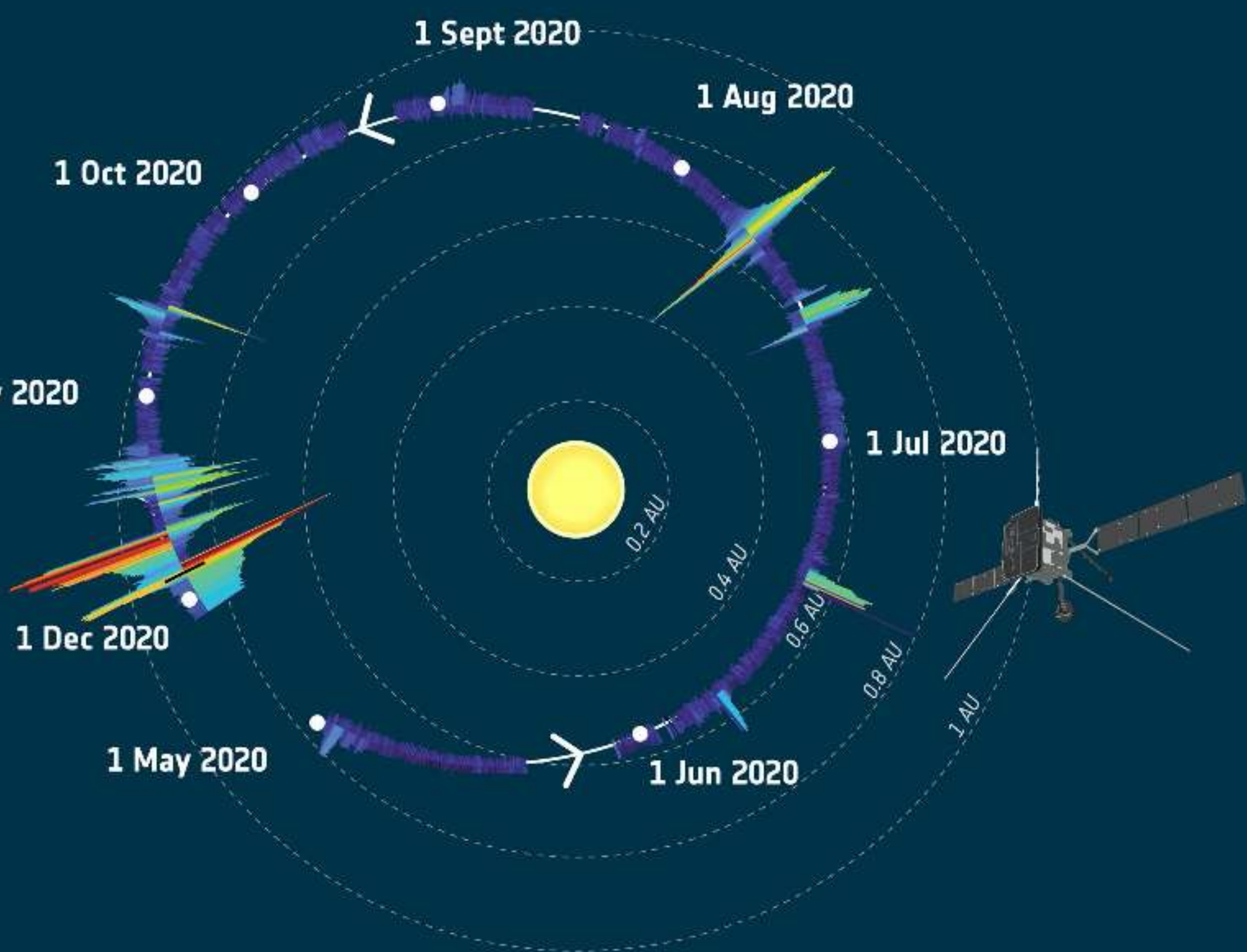


https://www.nasa.gov/feature/goddard/2020/rocket-borne-telescope-detects-super-fine-strands-on-the-sun

Solar Orbiter



Partículas energéticas solares

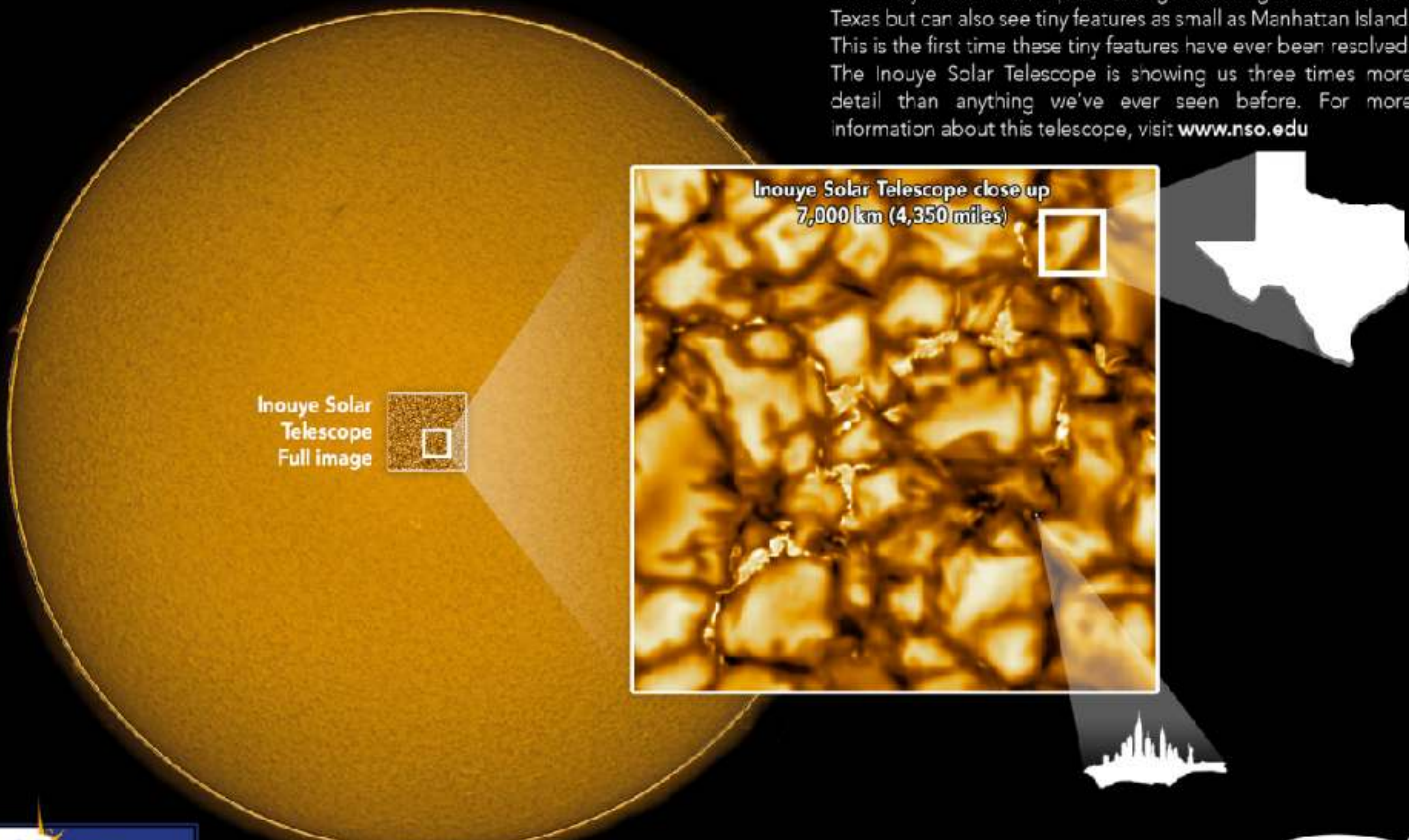


Credit: Solar Orbiter/EPD (ESA & NASA)

National Science Foundation

Daniel K. Inouye Solar Telescope

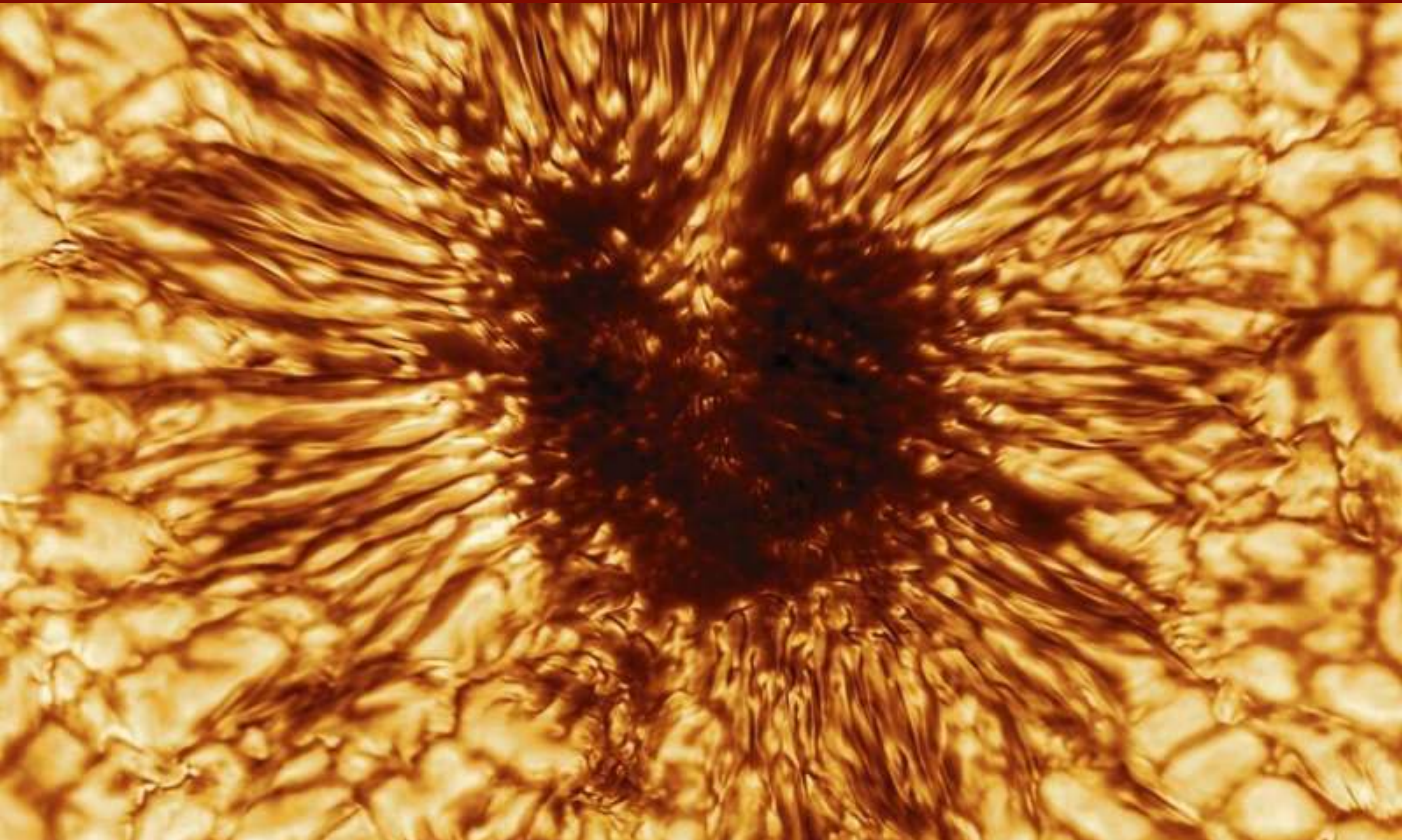
The Inouye Solar Telescope sees large bubbling cells the size of Texas but can also see tiny features as small as Manhattan Island. This is the first time these tiny features have ever been resolved. The Inouye Solar Telescope is showing us three times more detail than anything we've ever seen before. For more information about this telescope, visit **www.nso.edu**



NSO

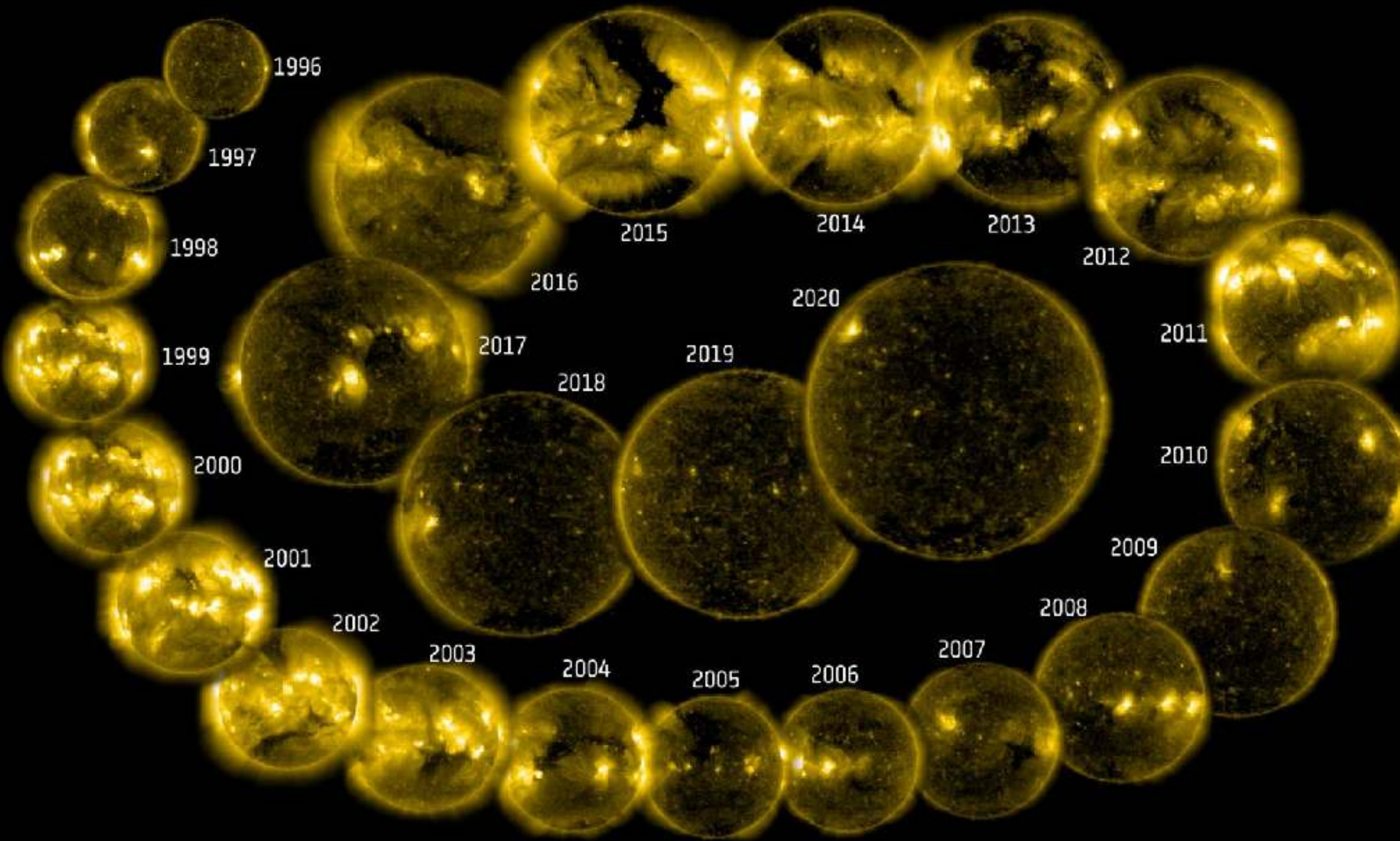
AURA

The first sunspot image taken on Jan. 28, 2020 by DKIST

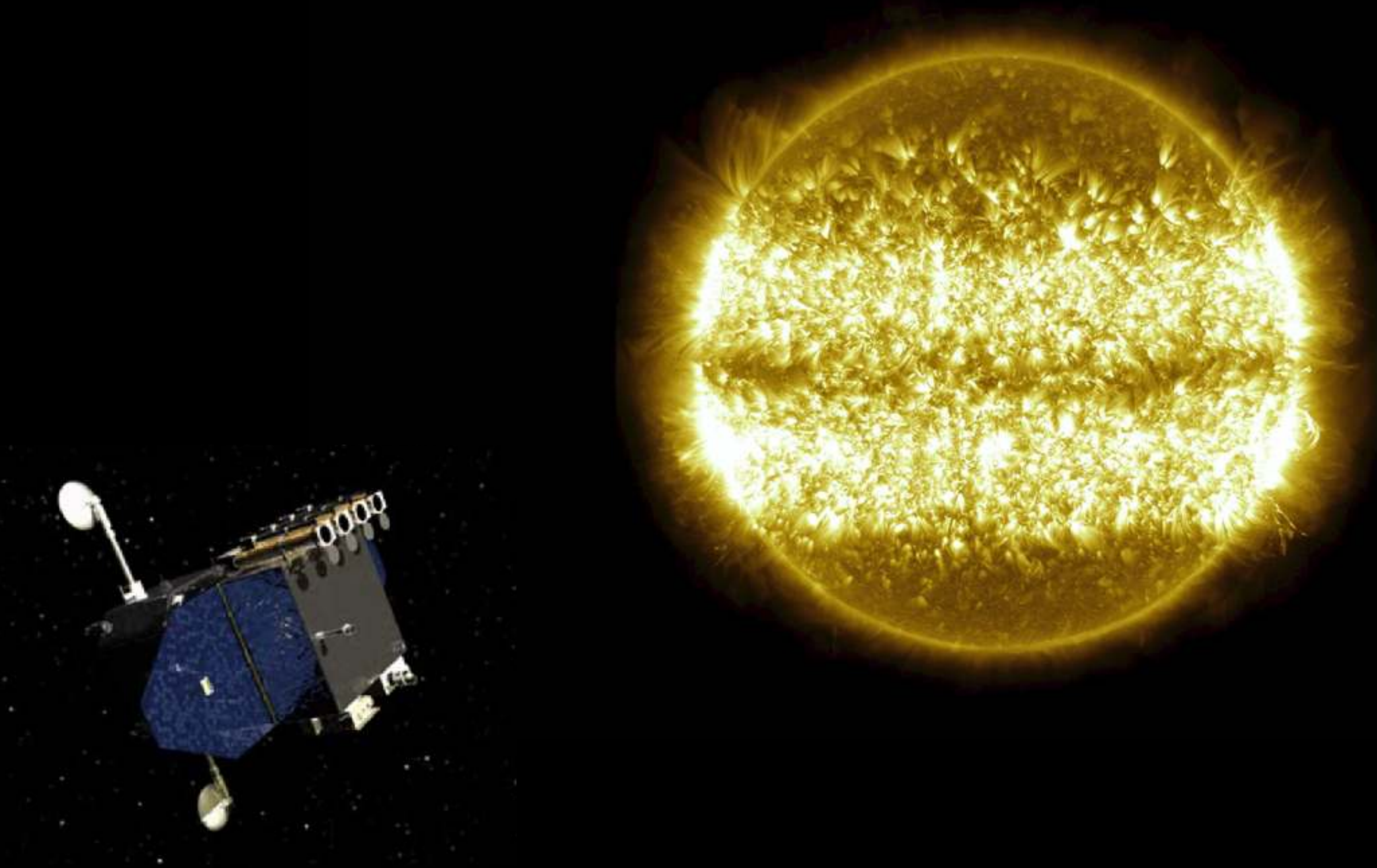


EL SOL COMO NUNCA ANTES SE HABIA OBSERVADO

SOHO: 25 años de observación solar



SDO: 10 años de observación solar



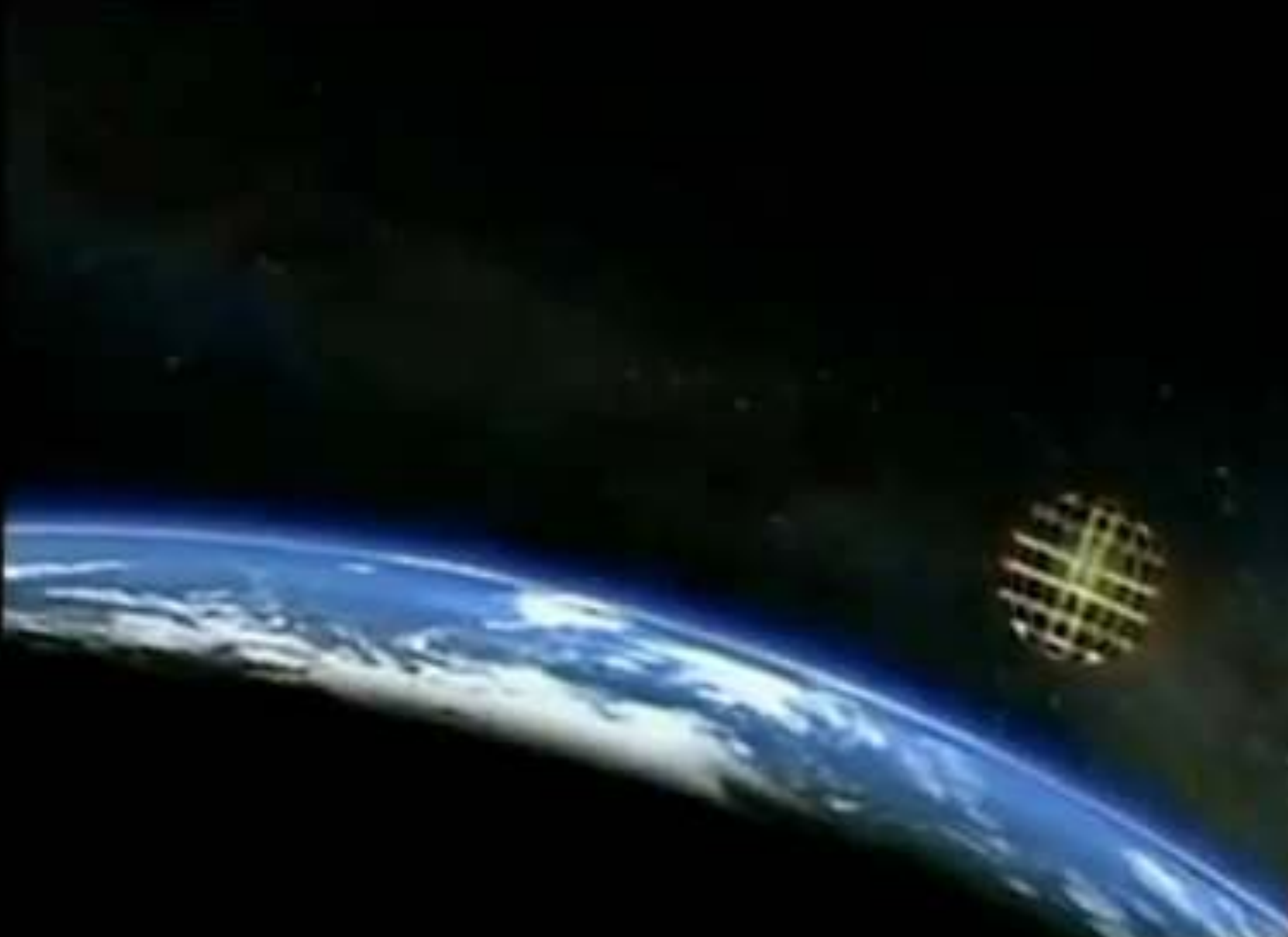
El Sol

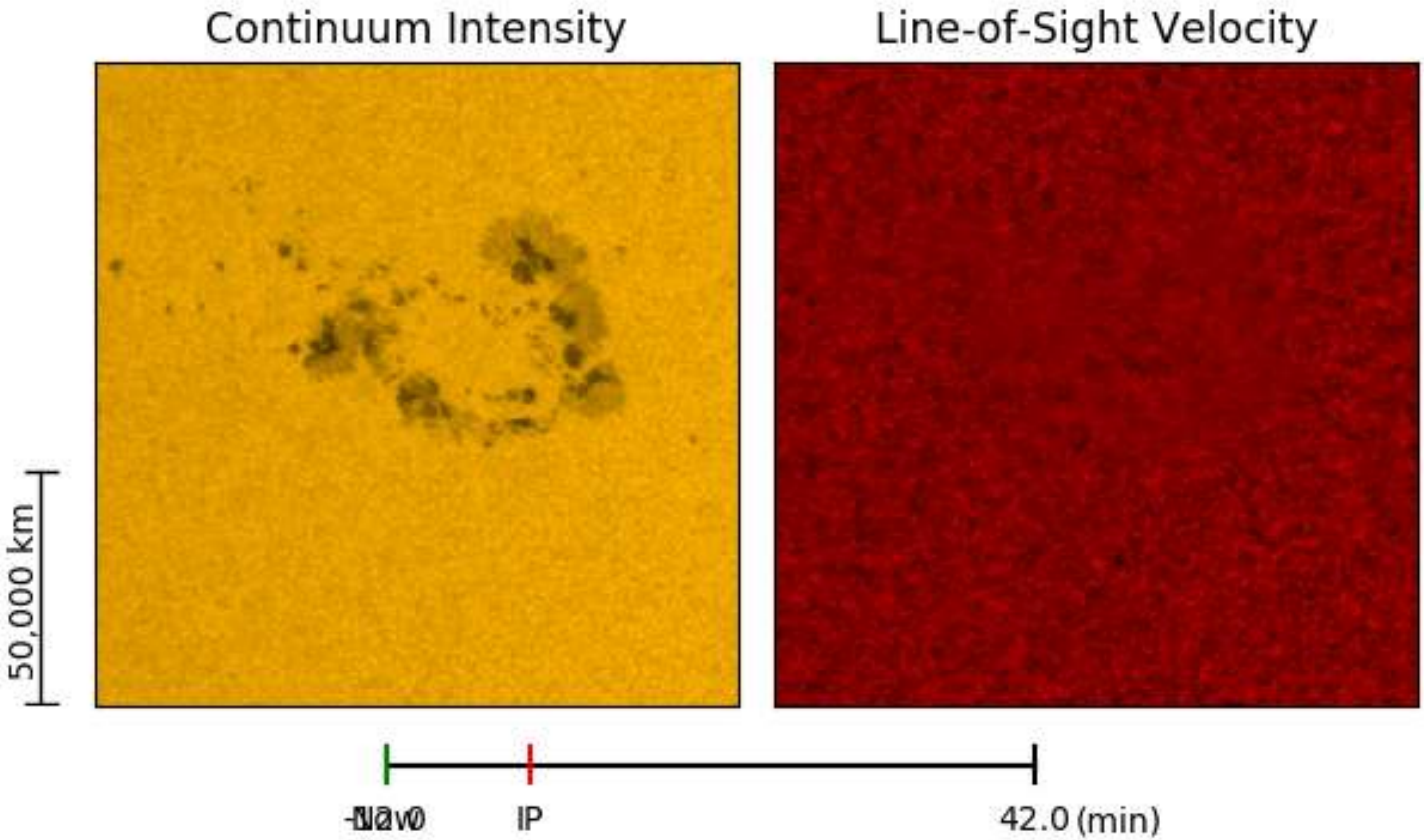
como sistema físico

El Sol como estrella

Estrella	G2V (enana amarilla)
Composición	74% H, 24% He, +...
Energía	Fisión nuclear
Trans. Energía	Radiación y convección
Temperatura	Núcleo: 15×10^6 K - Fotosfera: 6×10^3 - corona: 5×10^6 K
Edad	5×10^9 years
Radio	~700.000 km

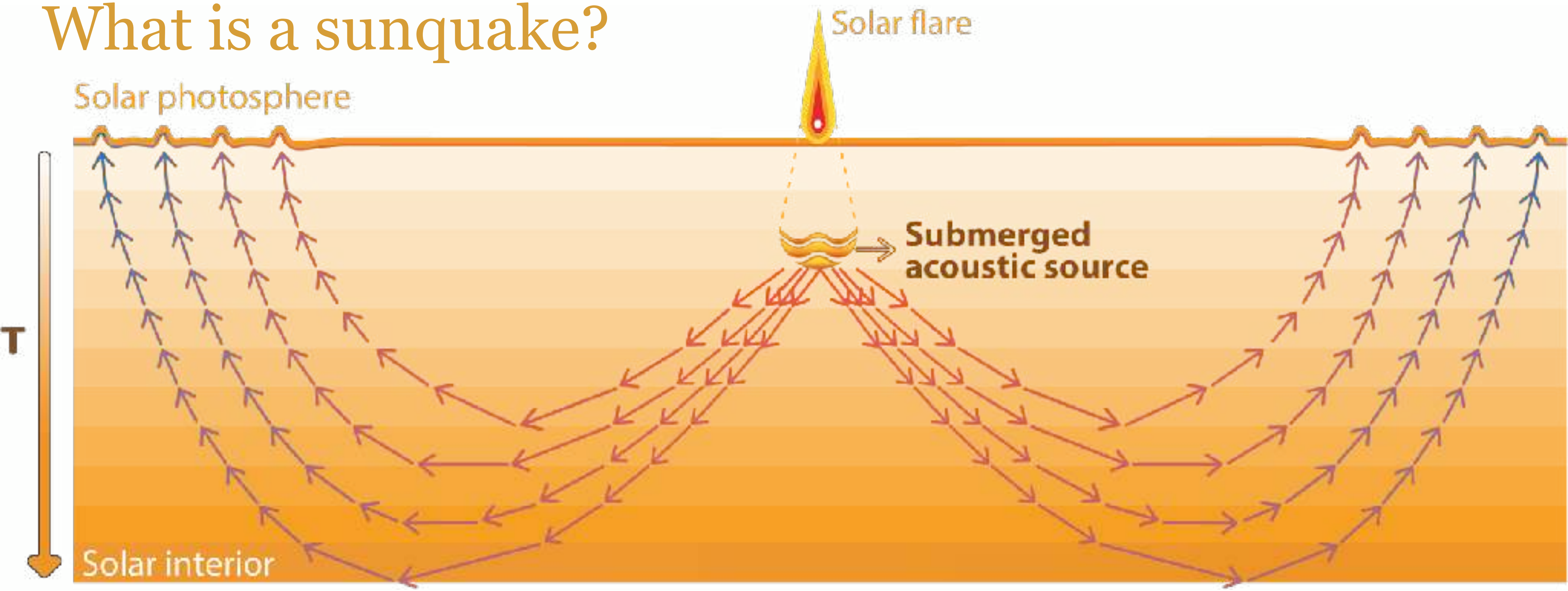
¿Cómo es el Sol por dentro?

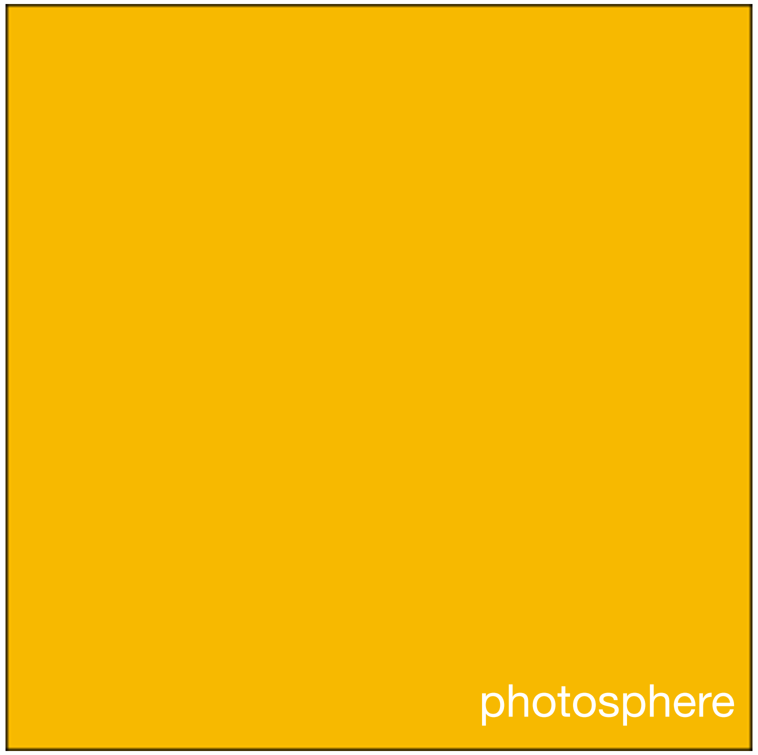



Continuum Intensity
Line-of-Sight Velocity
50,000 km
IP
42.0 (min)

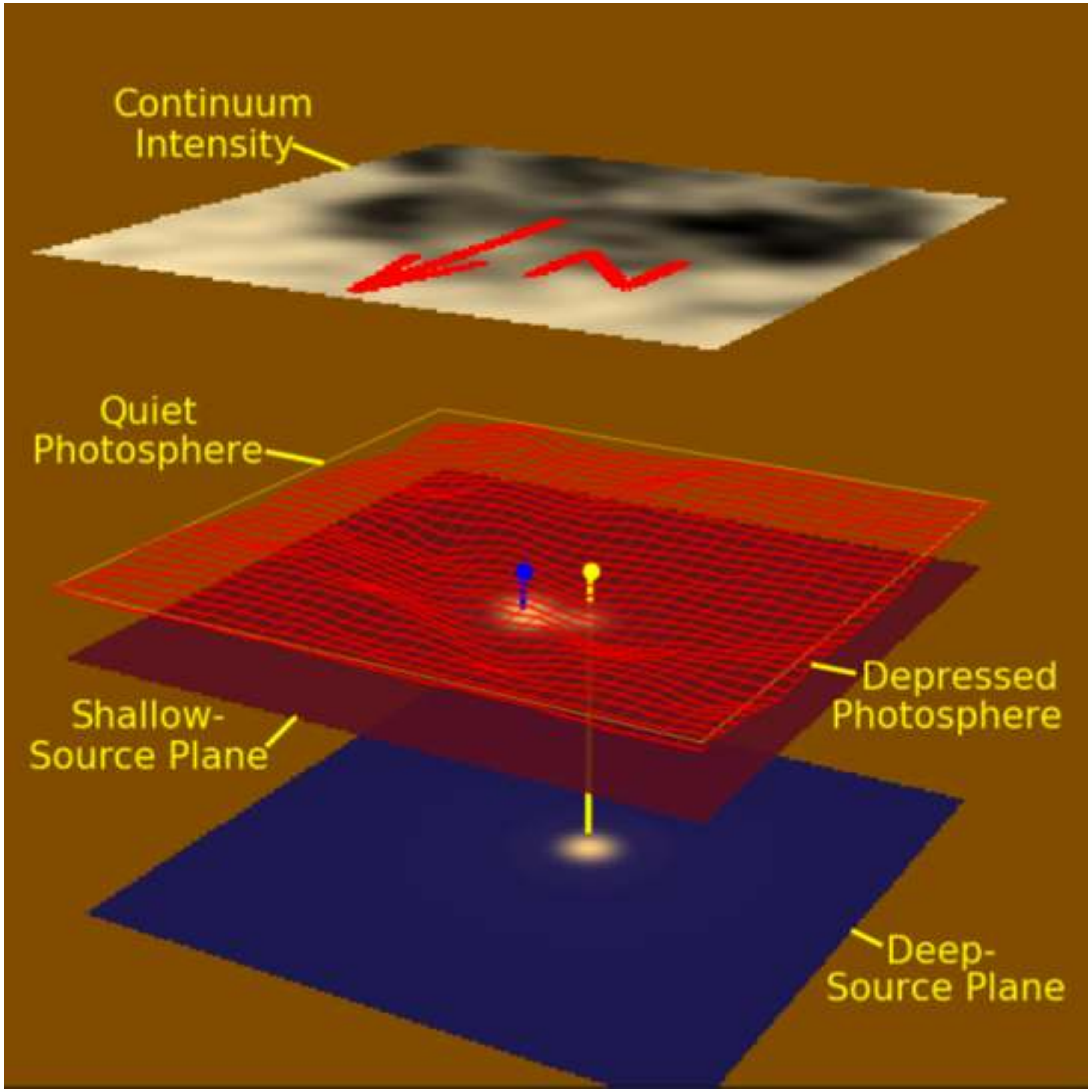
Flare-seismology

What is a sunquake?





Submerged Sources of Transient Acoustic Emission from **Solar Flares**



THE ASTROPHYSICAL JOURNAL LETTERS

OPEN ACCESS

Submerged Sources of Transient Acoustic Emission from Solar Flares

Charles Lindsey[1], J. C. Buitrago-Casas[2,3], Juan Carlos Martínez Oliveros[3], Douglas Braun[1], Angel D. Martínez[4], Valeria Quintero Ortega[4], Benjamín Calvo-Mozo[4], and Alina-Catalina Donea[5]

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The Astrophysical Journal Letters, Volume 901, Number 1

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THE ASTROPHYSICAL JOURNAL LETTERS

Ultra-impulsive Solar Flare Seismology

Angel D. Martínez[1], Valeria Quintero Ortega[1], J. C. Buitrago-Casas[2,3], Juan Carlos Martínez Oliveros[3], Benjamín Calvo-Mozo[1], and Charles Lindsey[4]

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The Astrophysical Journal Letters, Volume 895, Number 1

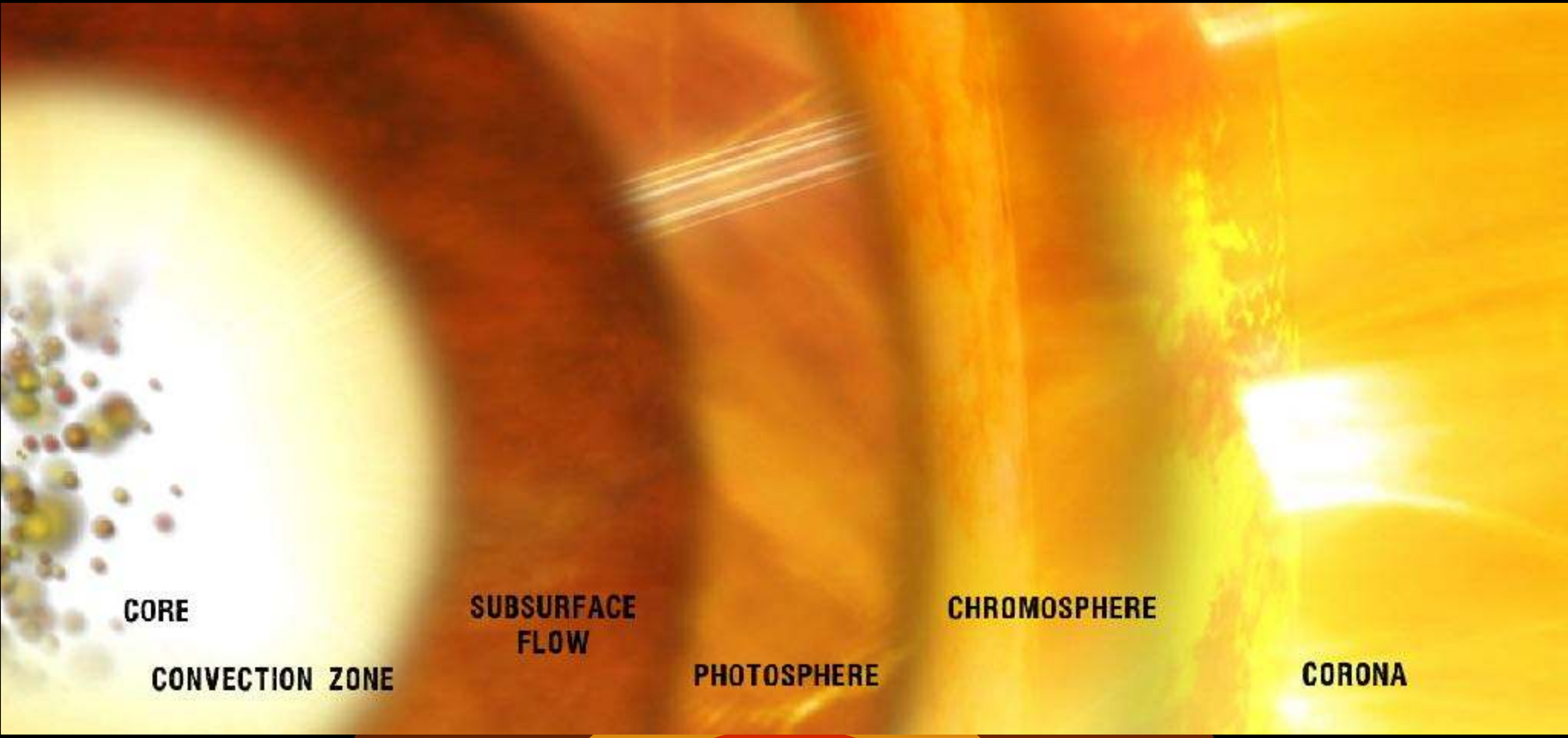
+ Article information

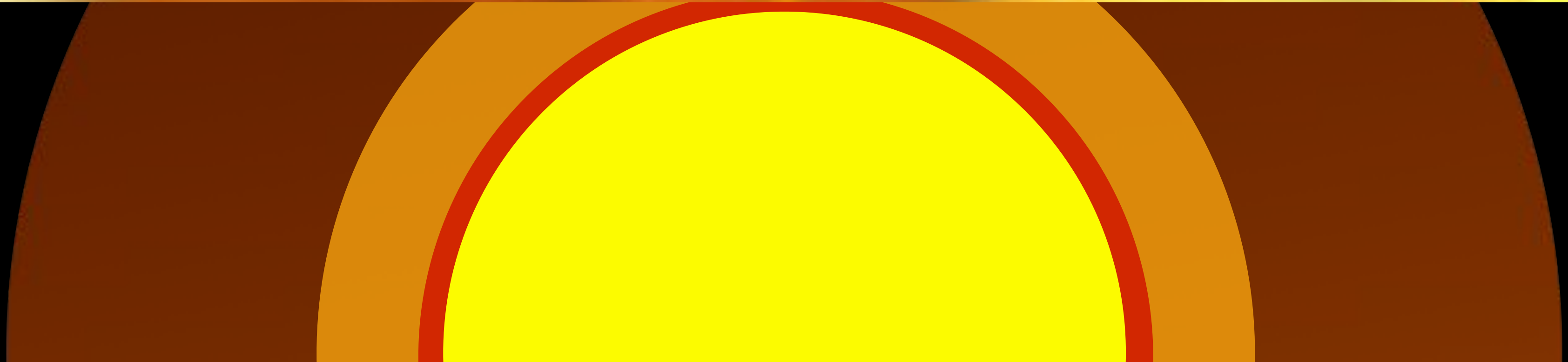
Abstract

Abstract

We examine a strong, coherent, highly impulsive acoustic transient radiated into the solar interior by the flare SOL20110730T02:04-M9.3. The acoustic spectrum of this transient extends out to 10 mHz. The fine diffraction limit of this high-frequency component of the flare acoustic transient allows us to discriminate different source components in operation during the flare. Acoustic-source power density maps of the 10

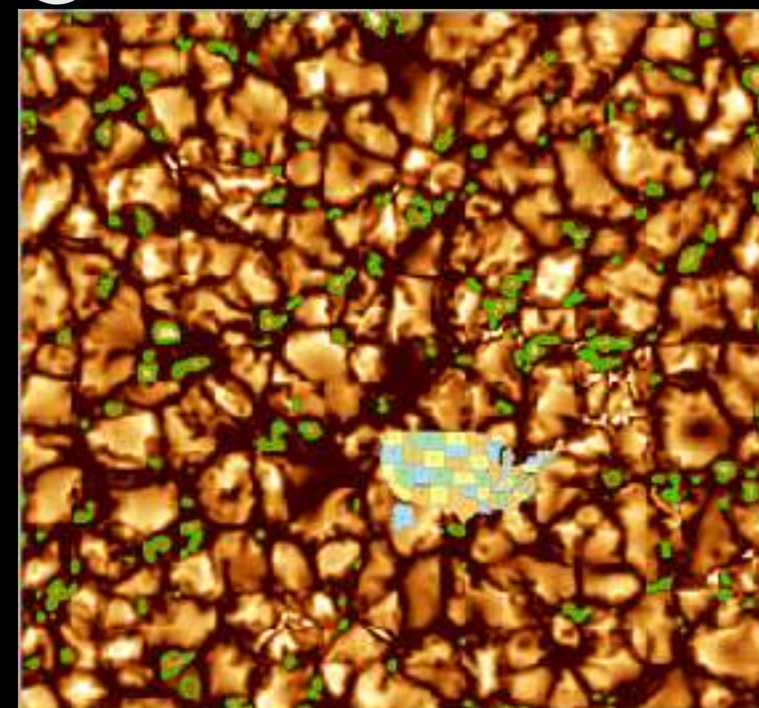
Atmósfera solar:

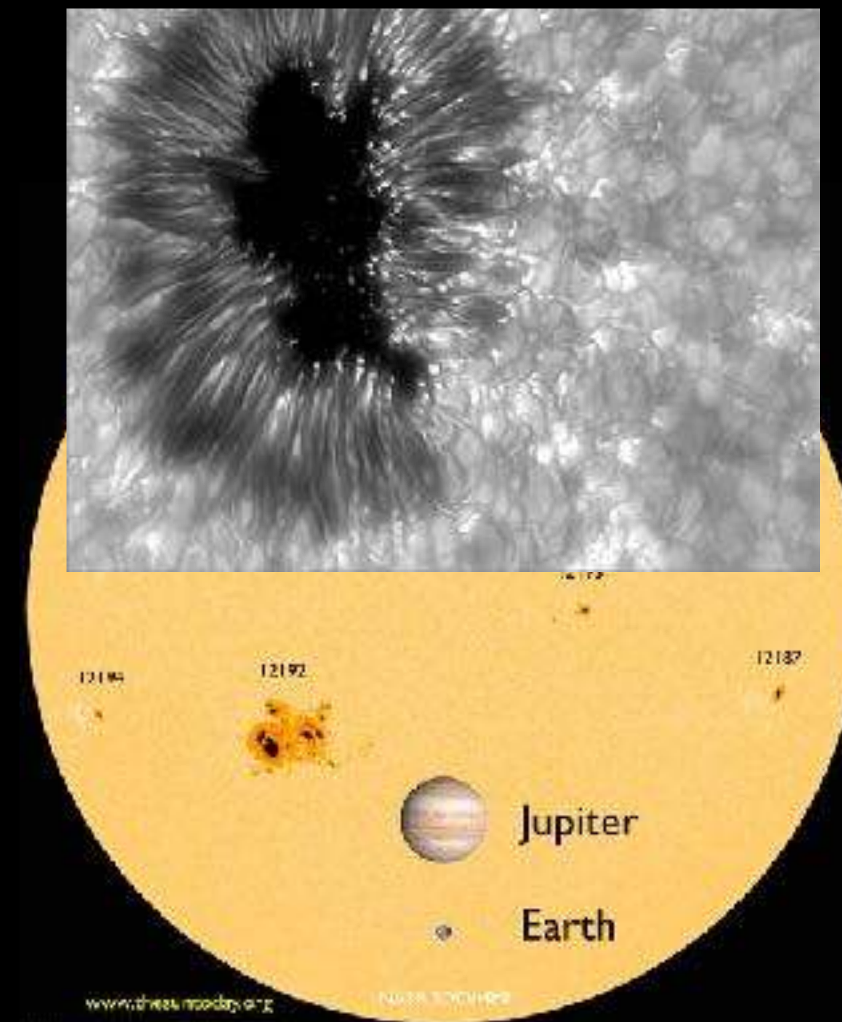




Fenómenos superficiales

granulación



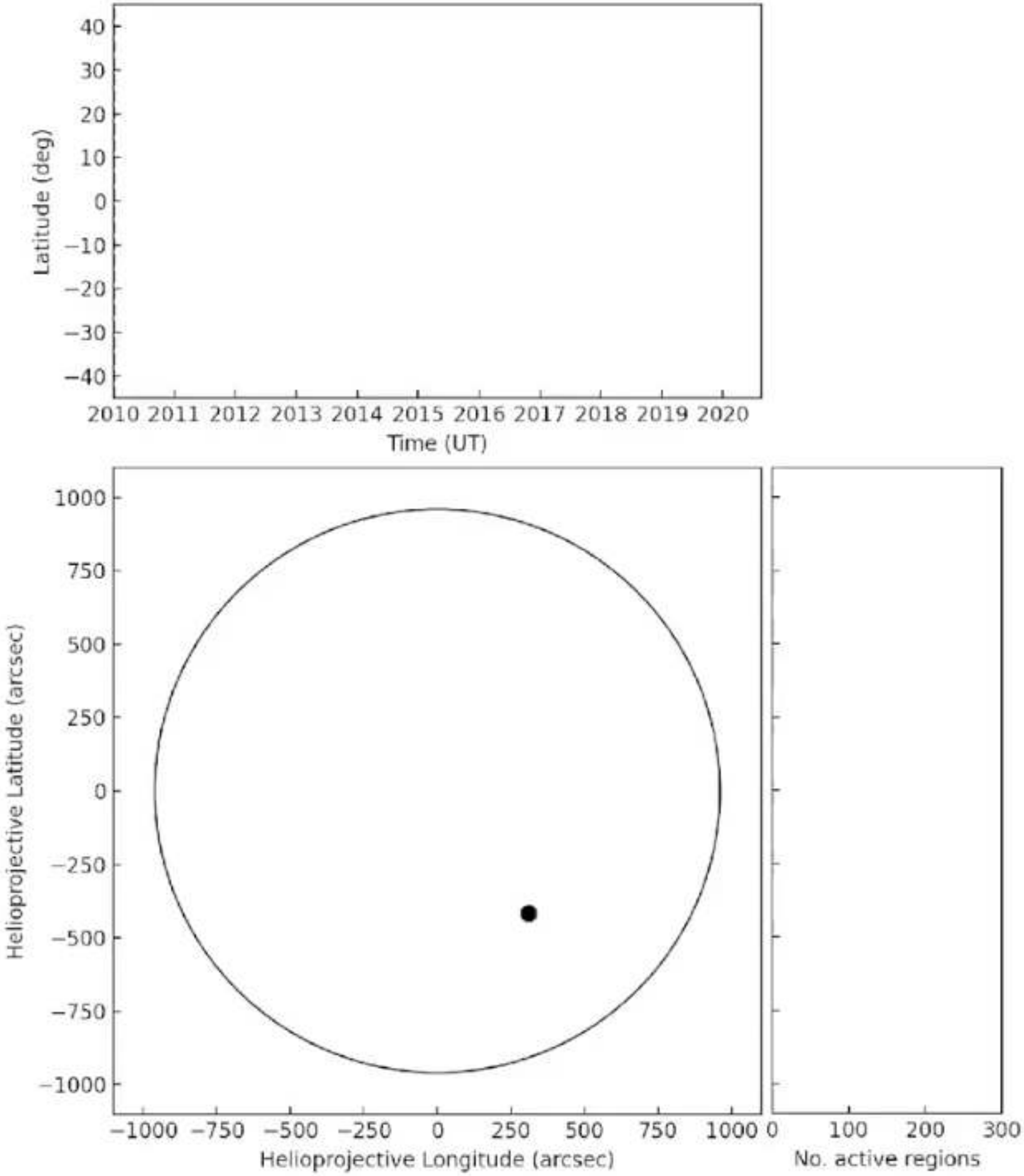


Prominencias

nano jets

Manchas

Ciclo Solar



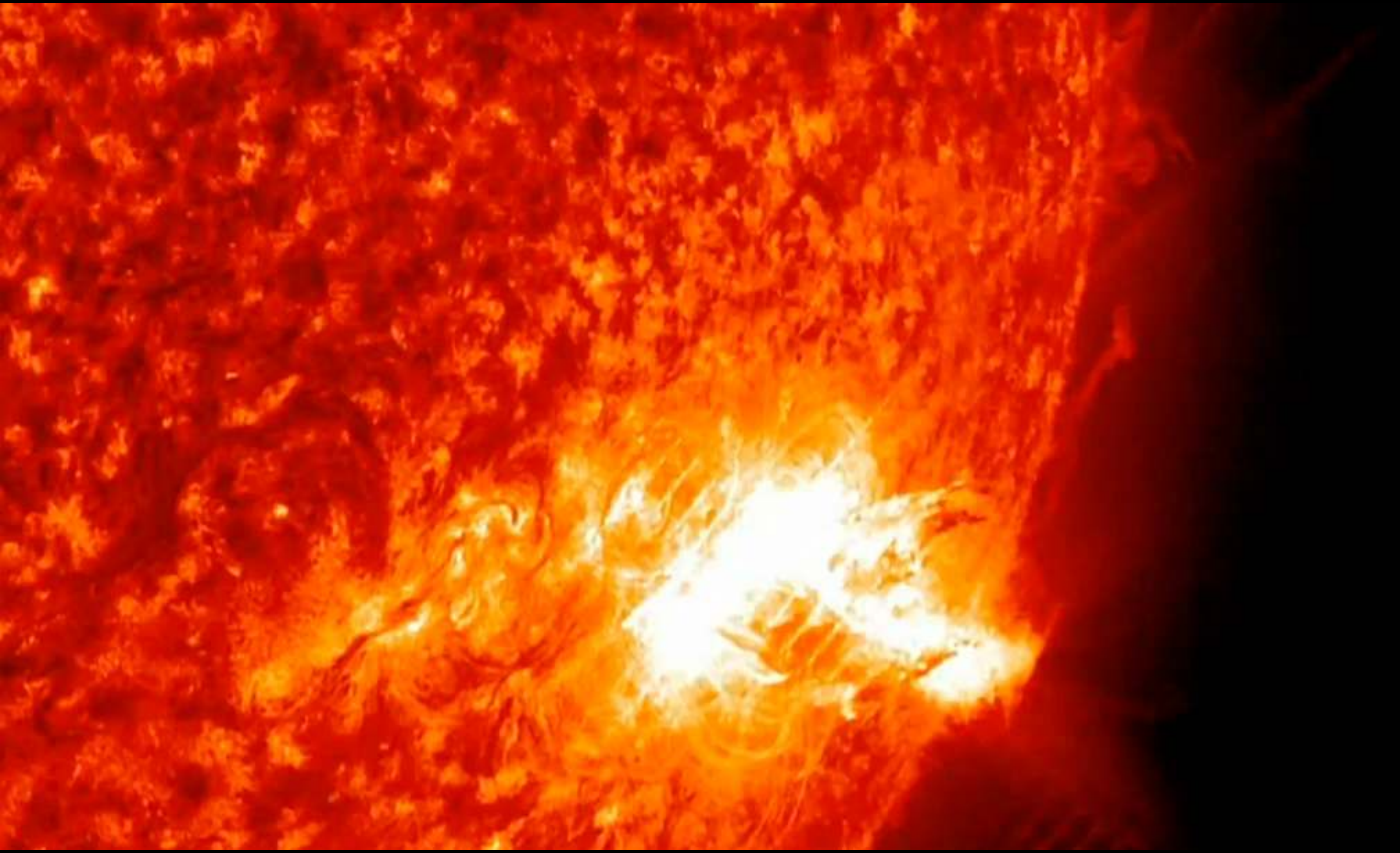
Créditos: Laura Hayes

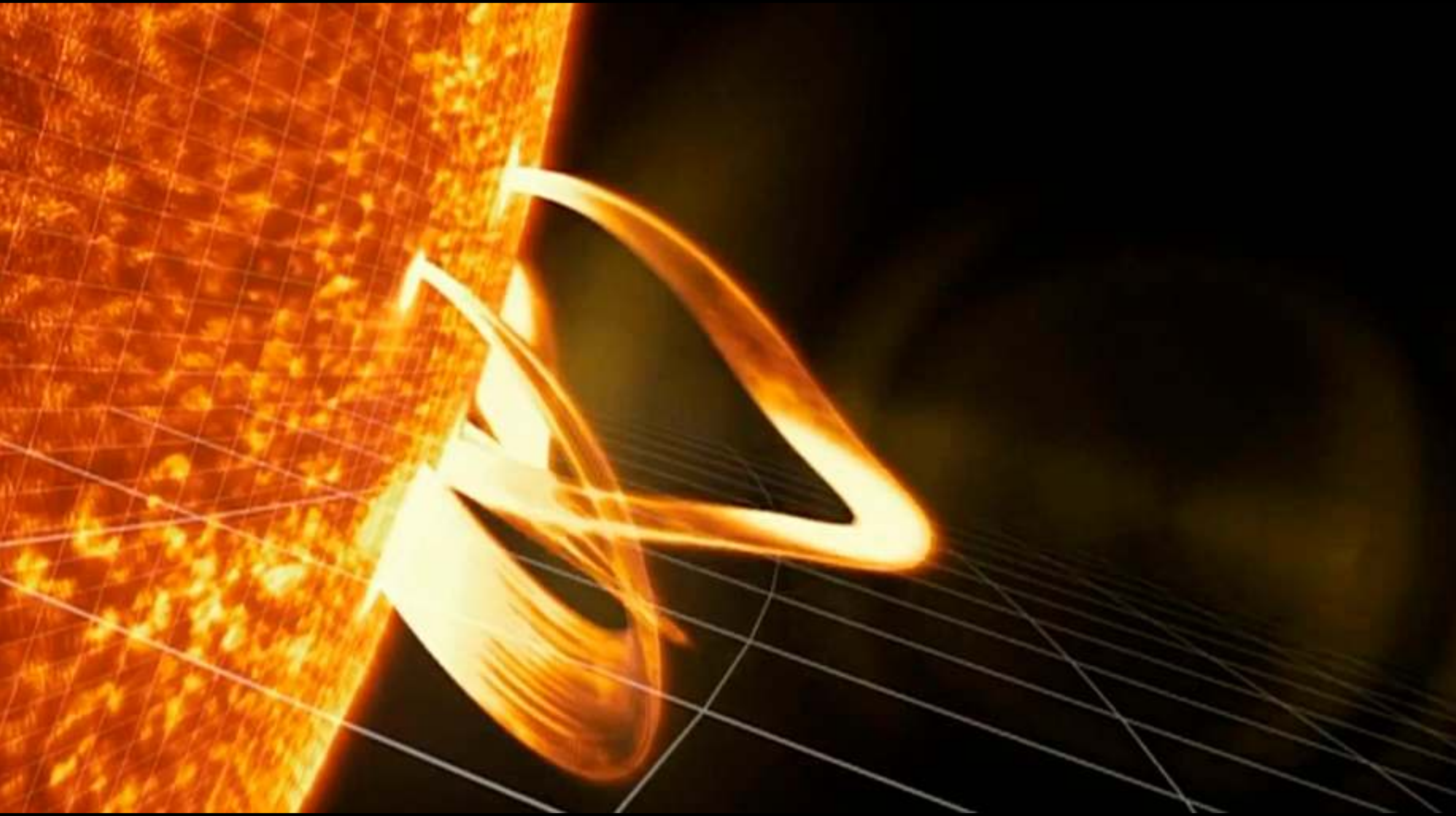
¿Qué es una fulguración solar?

Es una liberación explosiva de energía magnética en la corona

$$E_{magnetic} > E_{kinetic}$$

$$\beta \sim 0.01$$

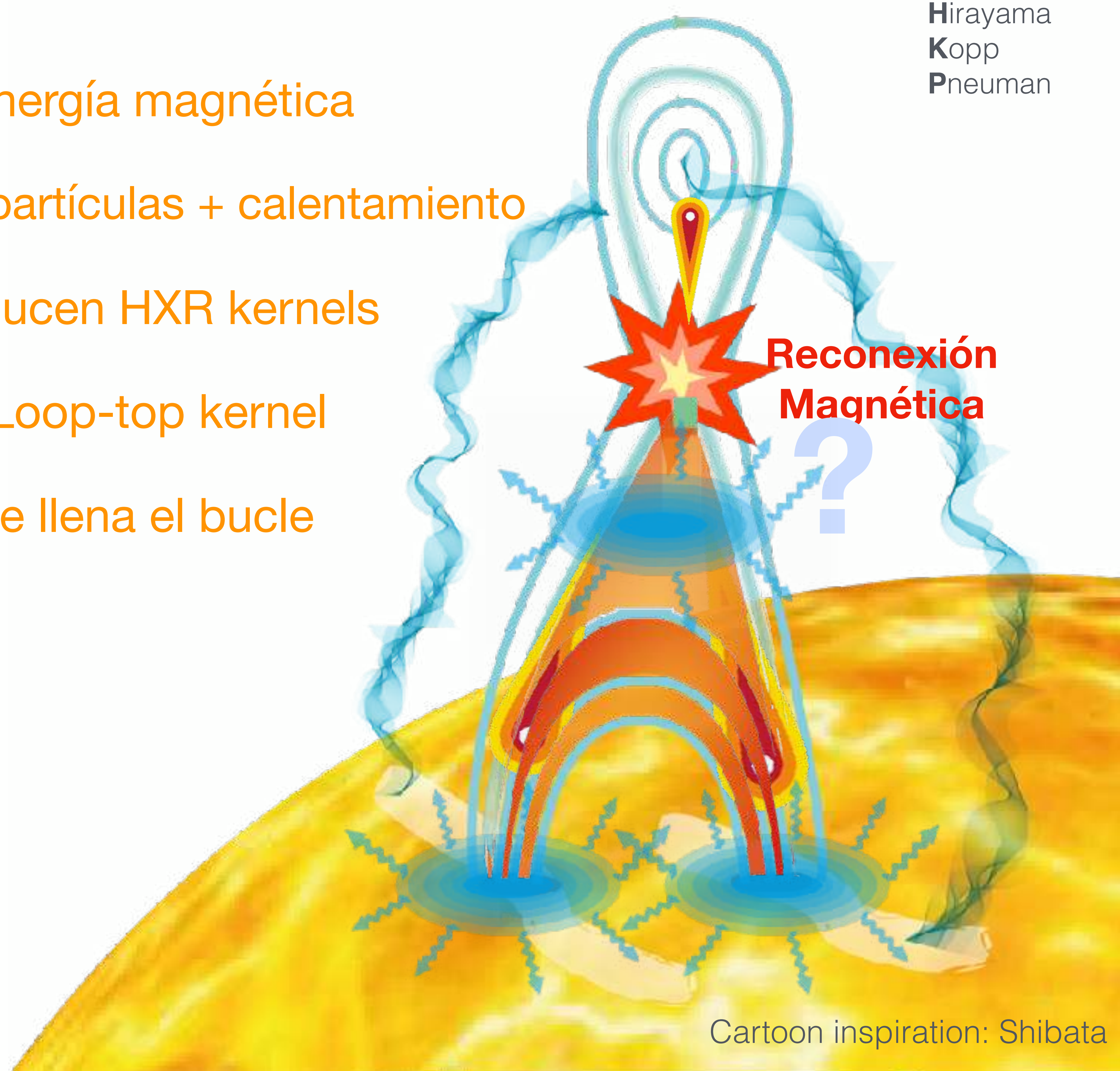




Modelo Estándar de una fulguración

Carmichael
Sturrock
Hirayama
Kopp
Pneuman

- Liberación de energía magnética
- Aceleración de partículas + calentamiento
- Electrones producen HXR kernels
- Algunas veces Loop-top kernel
- Evaporación que llena el bucle



Cartoon inspiration: Shibata

¿Por qué estudiar el Sol?

Porque contiene varios procesos físicos que aún no entendemos completamente

¿periodo de actividad de 11 años?

¿rotación diferencial?

¿velocidad del viento solar?

¿aceleración de particulas?

¿Calentamiento Coronal?

¿granulación fractal?

¿explosiones solares?

¿reconexión magnética?

¿Inicio del dínamo solar?

¿dinámica de la Tacoclina?

Muchas preguntas por resolver

WIKIPEDIA
The Free Encyclopedia

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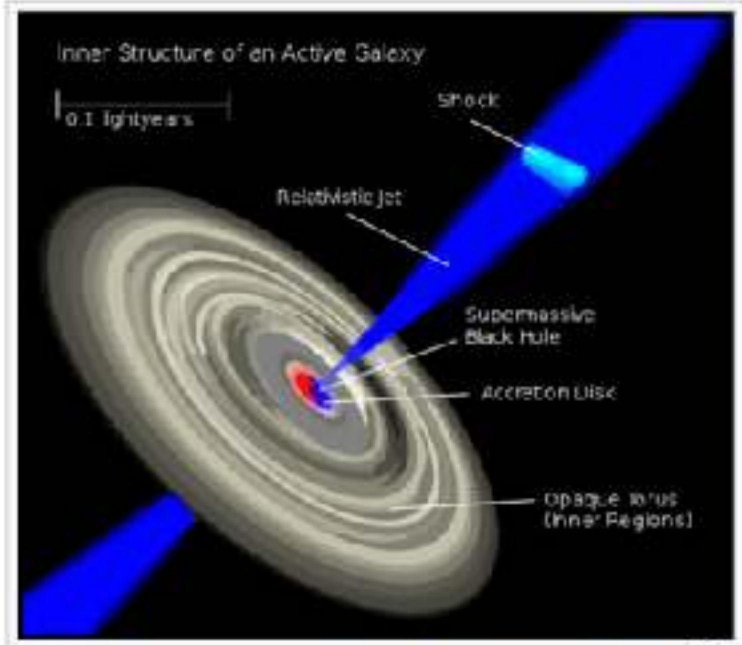
List of unsolved problems in physics

From Wikipedia, the free encyclopedia

Astronomy and astrophysics [edit]

Astrophysical jet

Why do the accretion discs surrounding certain astronomical objects, such as the nuclei of active galaxies, emit relativistic jets along their polar axes?[24] Why are there quasi-periodic oscillations in many accretion discs?[25] Why does the period of these oscillations scale as the inverse of the mass of the central object?[26] Why are there sometimes overtones, and why do these appear at different frequency ratios in different objects?[27]



Relativistic jet. The environment around the AGN where the relativistic plasma is collimated into jets which escape along the pole of the supermassive black hole

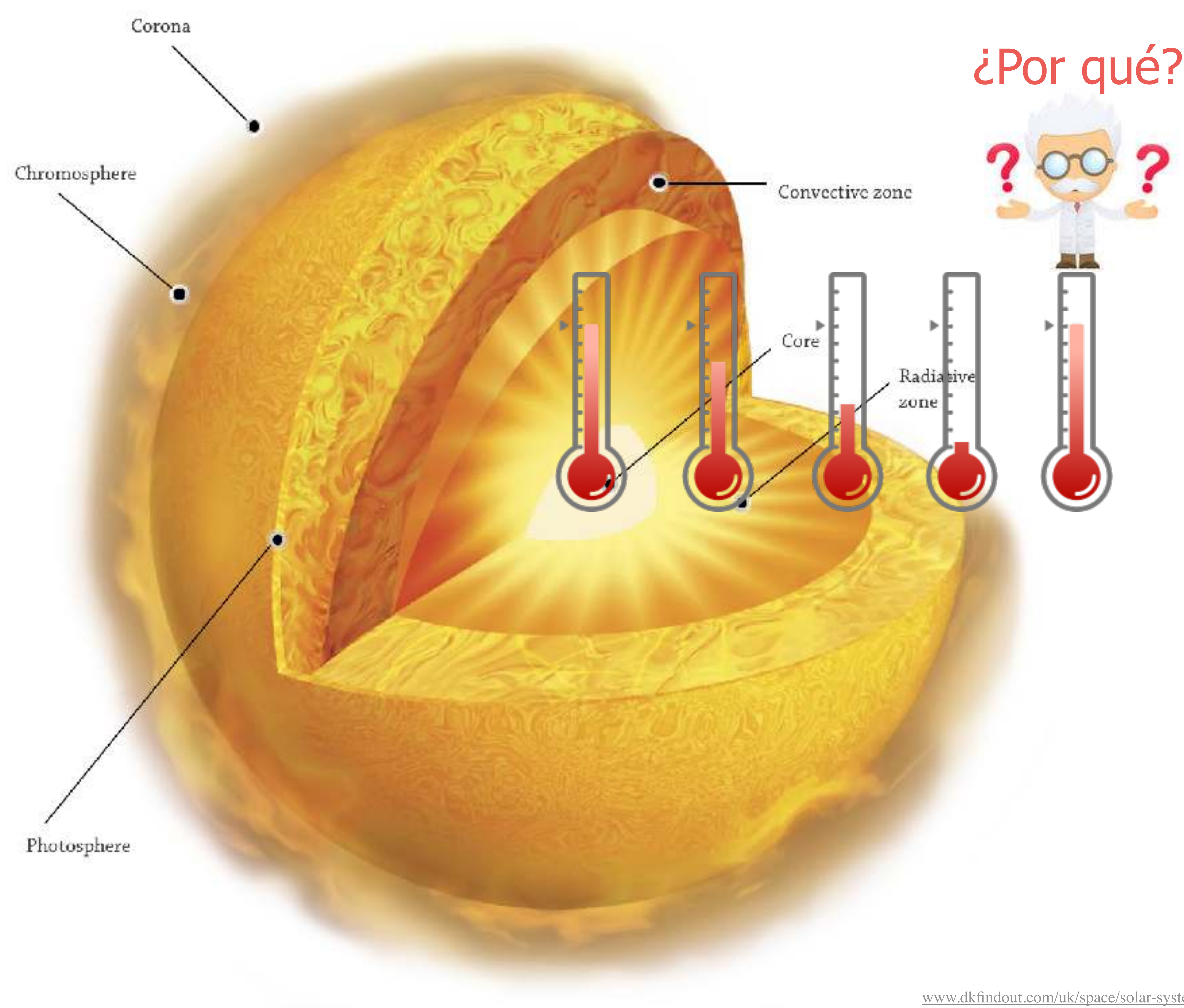
Solar cycle

How does the Sun generate its periodically reversing large-scale magnetic field? How do other solar-like stars generate their magnetic fields, and what are the similarities and differences between stellar activity cycles and that of the Sun?[28] What caused the Maunder Minimum and other grand minima, and how does the solar cycle recover from a minima state?

Coronal heating problem

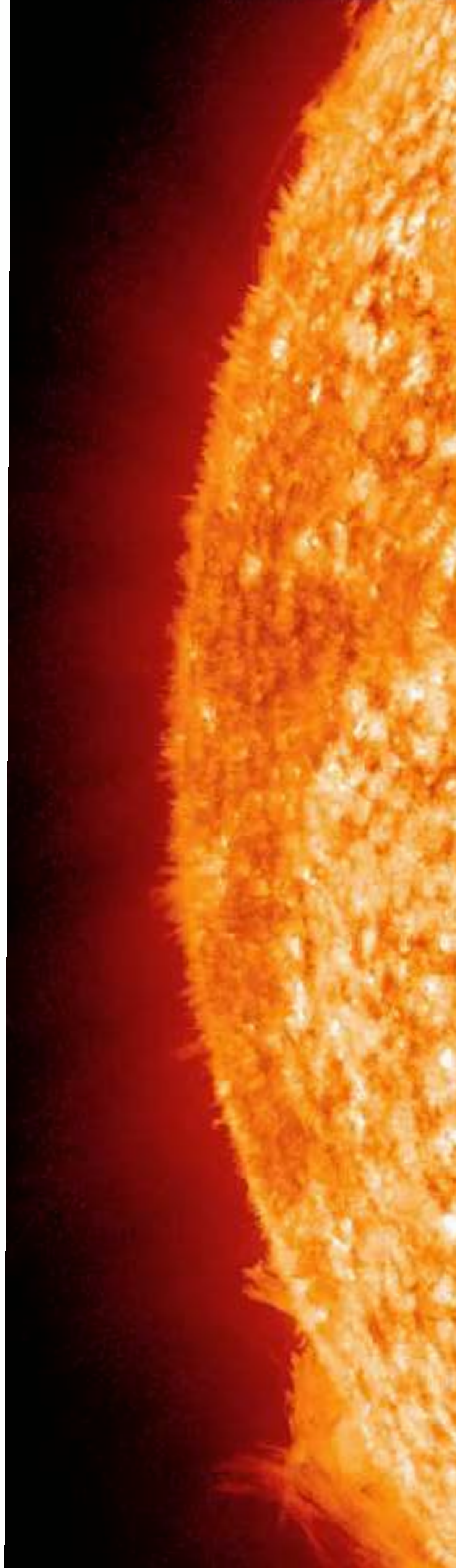
Why is the Sun's corona (atmosphere layer) so much hotter than the Sun's surface? Why is the magnetic reconnection effect many orders of magnitude faster than predicted by standard models?

Diffuse interstellar bands

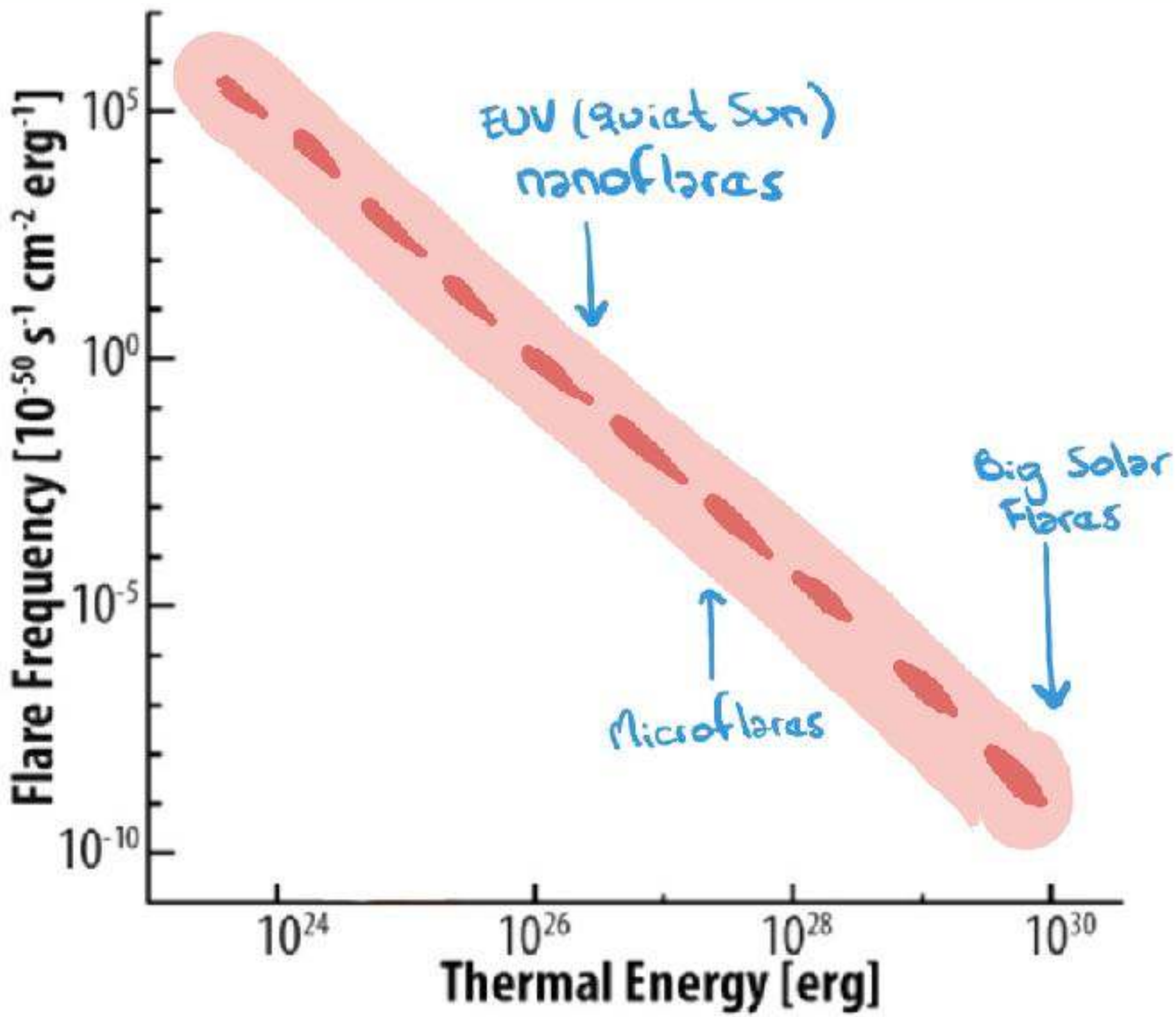


www.dkfindout.com/uk/space/solar-system/inside-sun/

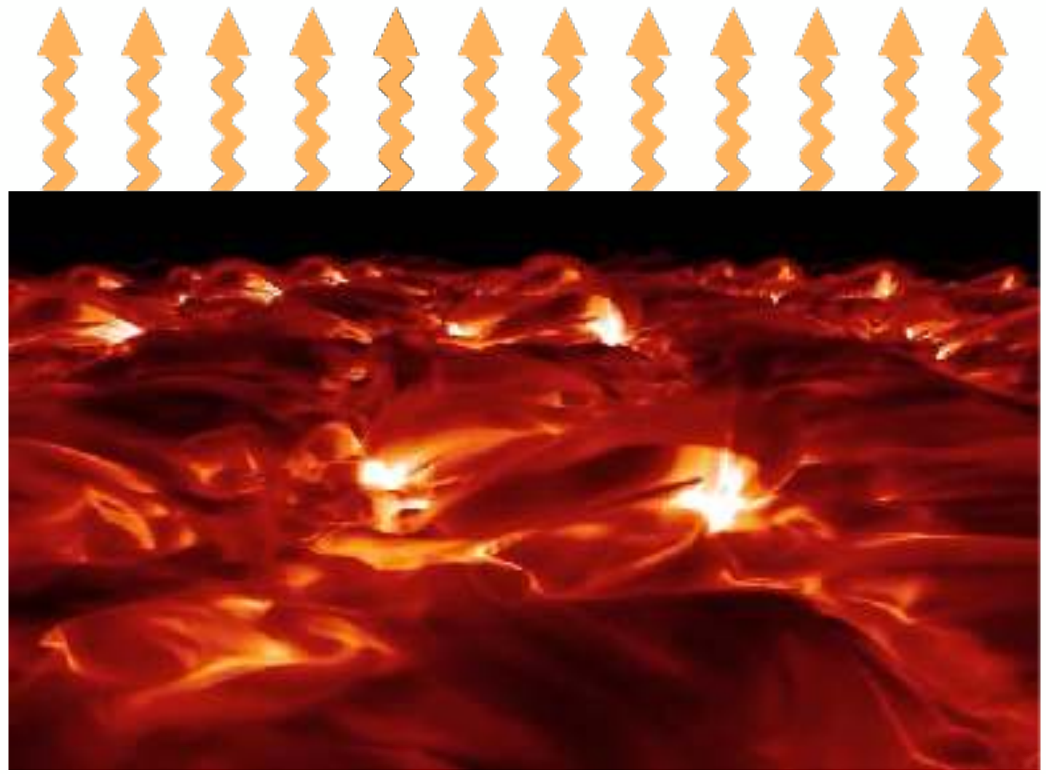
Una posible explicación asume la existencia de un sin número de pequeñas explosiones solares en rayos-X distribuidas sobre toda la superficie



Frecuencia de Fulguraciones
vs energía térmica



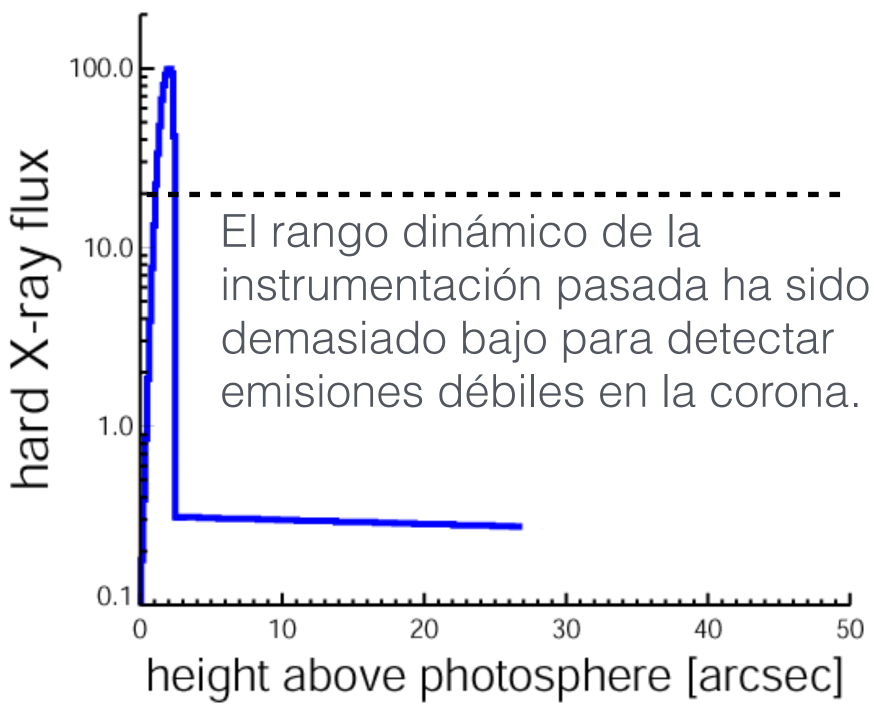
Calentamiento Coronal por nanoflares



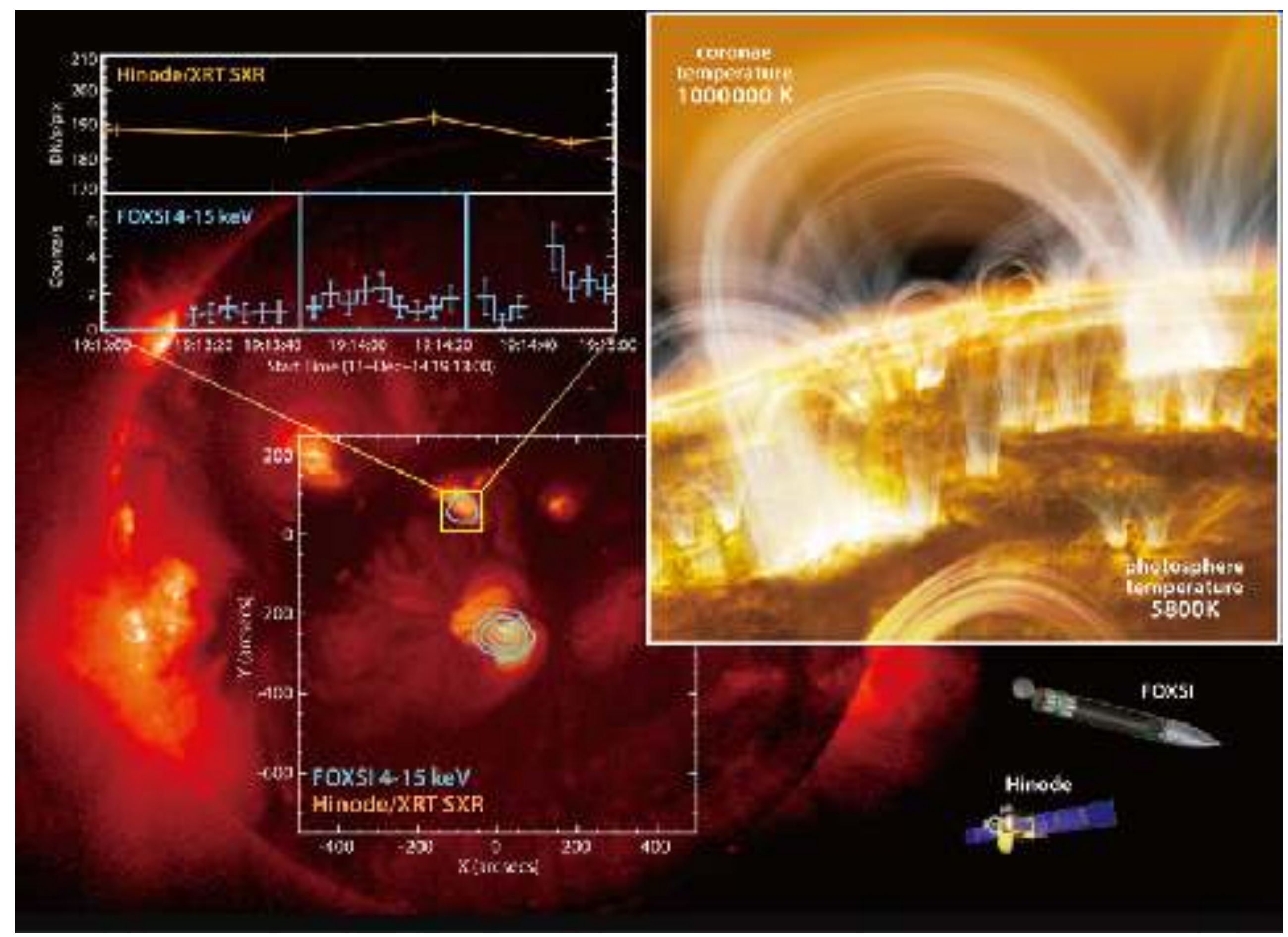
Credits: NASA

Calentamiento por una miríada de fulguraciones muy pequeñas que liberan energía magnética por reconexión en regiones de Sol calmo.

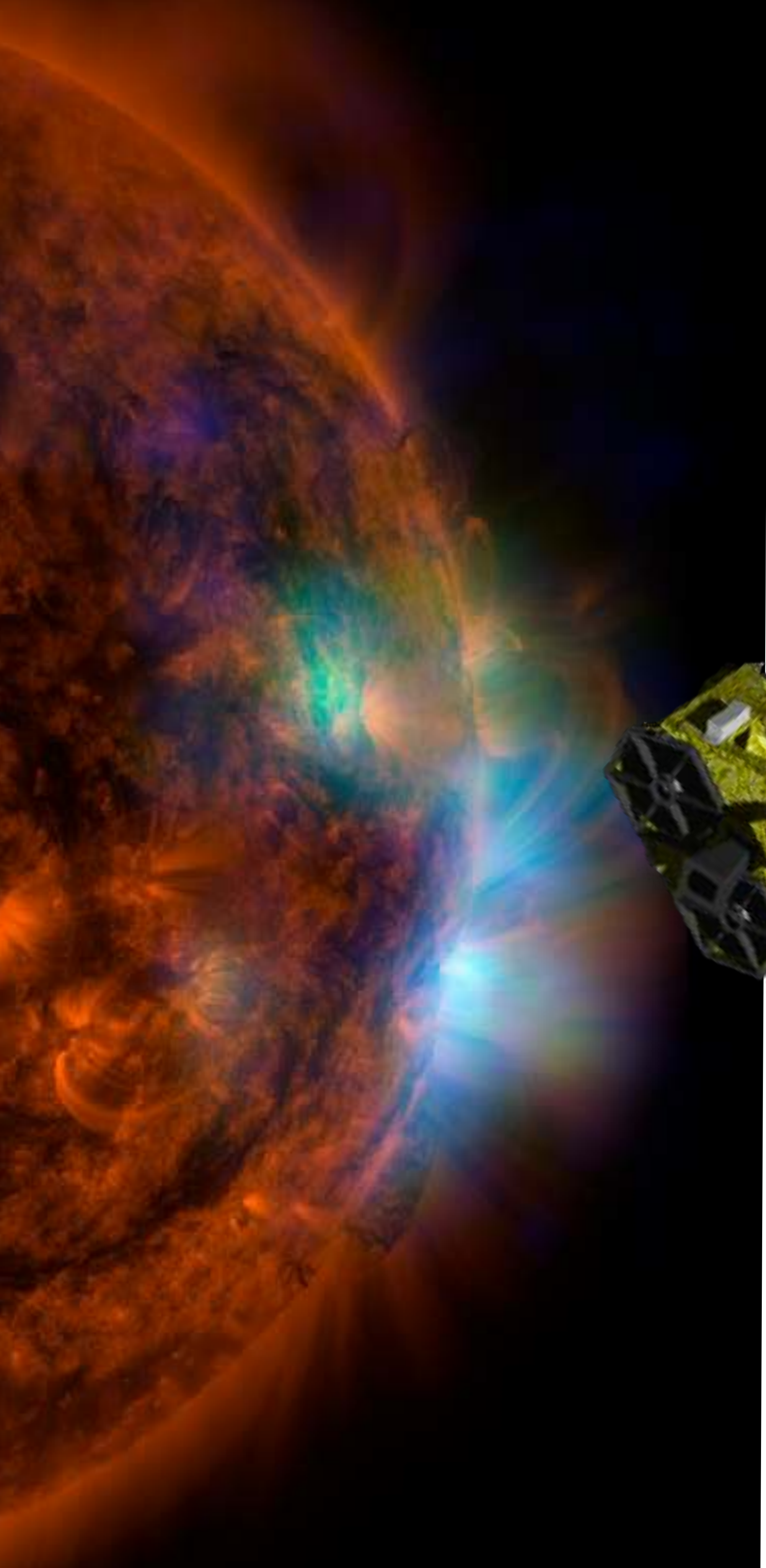
Gold [1964]; Priest [1982]; Parker [1988]

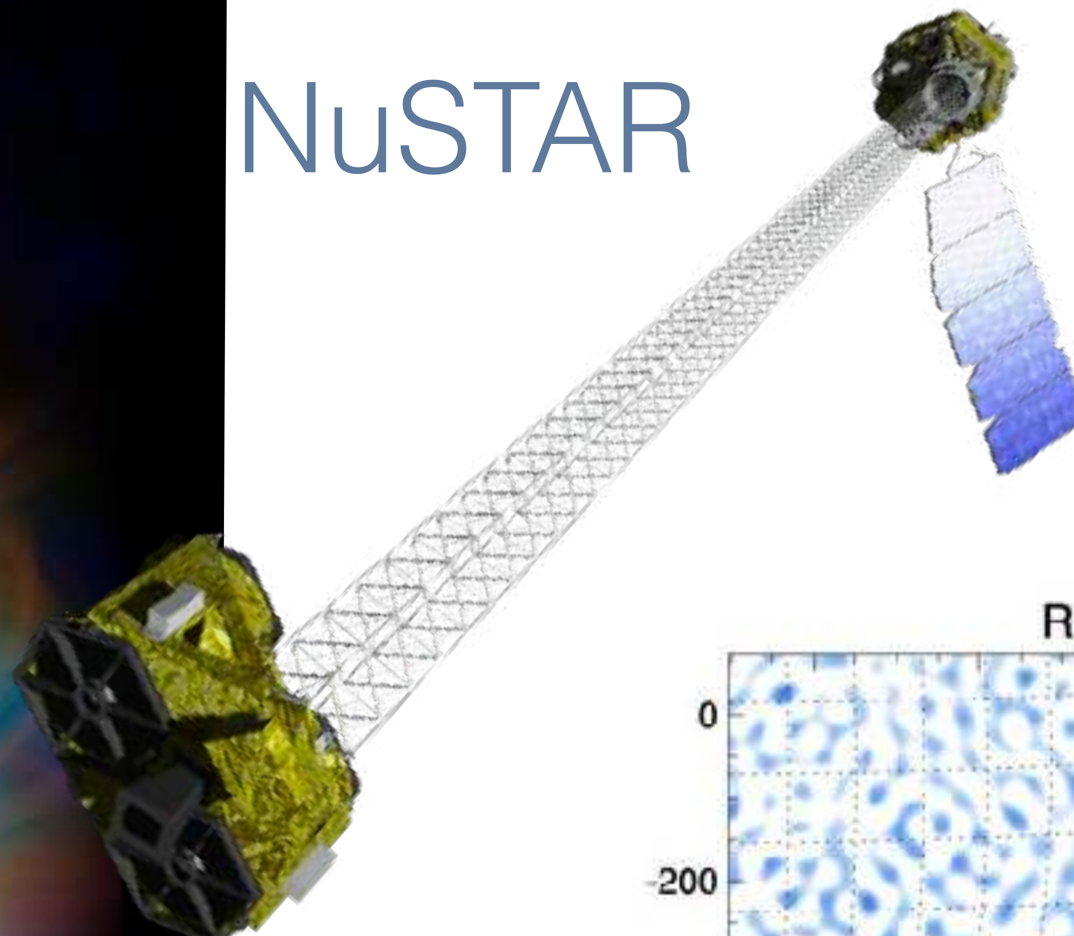


En un Sol "no-fulgurante", la mitad de los SXRs provienen del ~2% de la superficie (regiones activas).



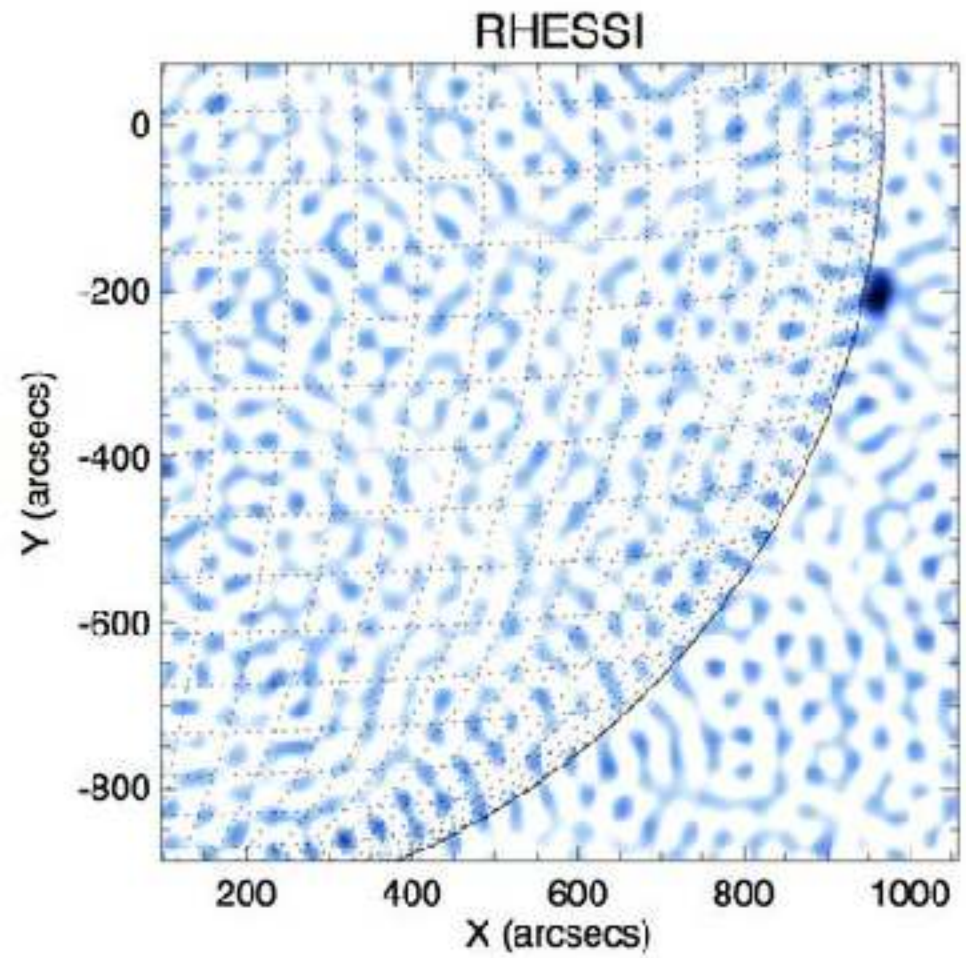
Ya hemos visto rayos-X muy energéticos en explosiones solares!





NuSTAR

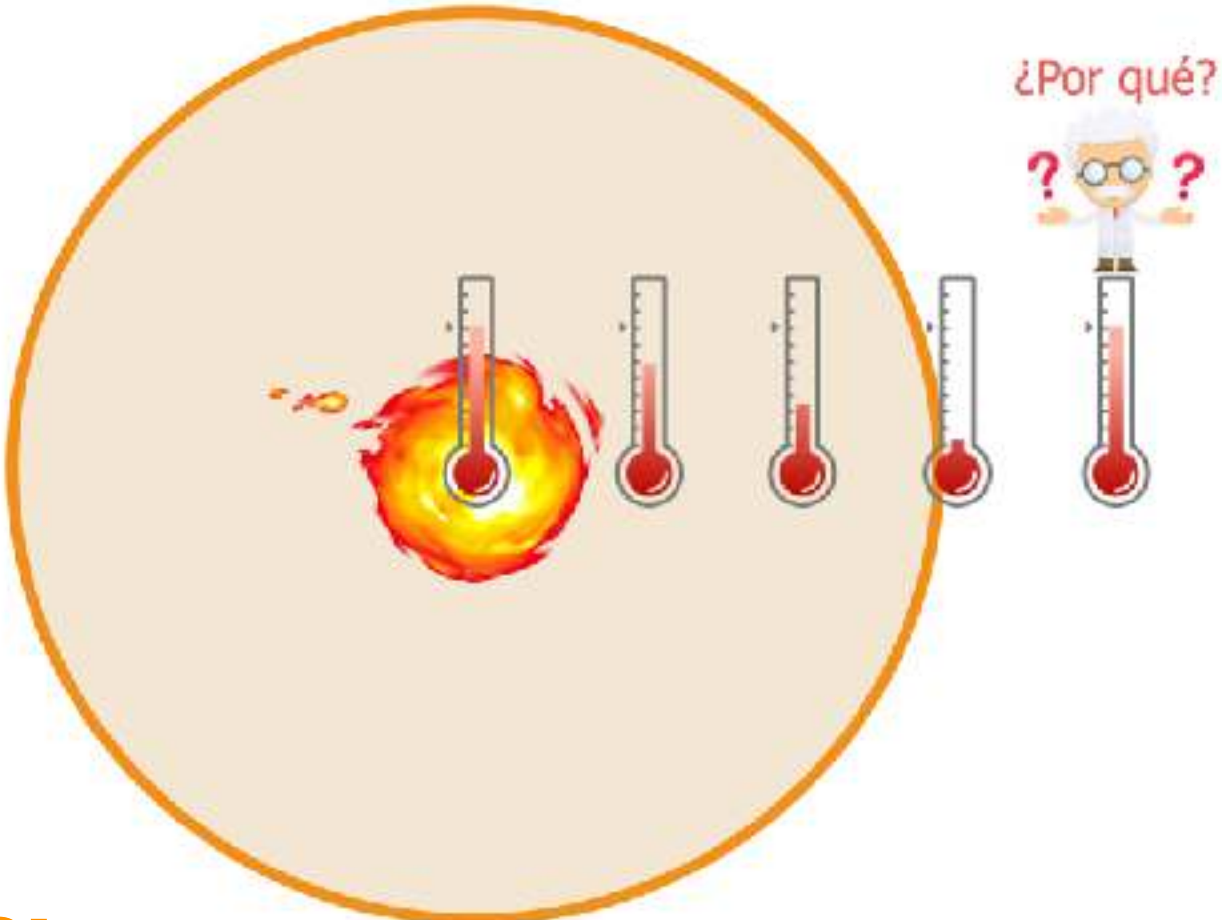
RHESSI



no suficiente rango dinámico y sensibilidad

La necesidad de un telescopio más sensible

Problema del calentamiento coronal



Hipotética causa:

Múltiples comparativamente pequeñas explosiones que ocurren todo el tiempo (nanofulguraciones).

¿Se pueden observar?

Sí, como una **tenue** emisión en rayos-X.

Los telescopios actuales NO tienen la sensibilidad necesaria

Queremos ver rayos-X en pequeñas explosiones solares
Necesitamos telescopios de alta sensibilidad

FOXSI

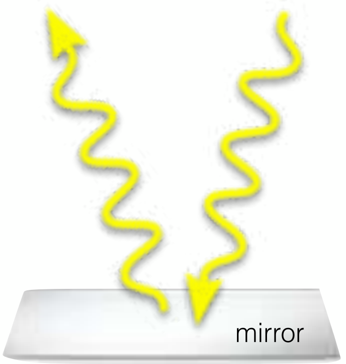
The Focusing Optics X-ray Solar Imager

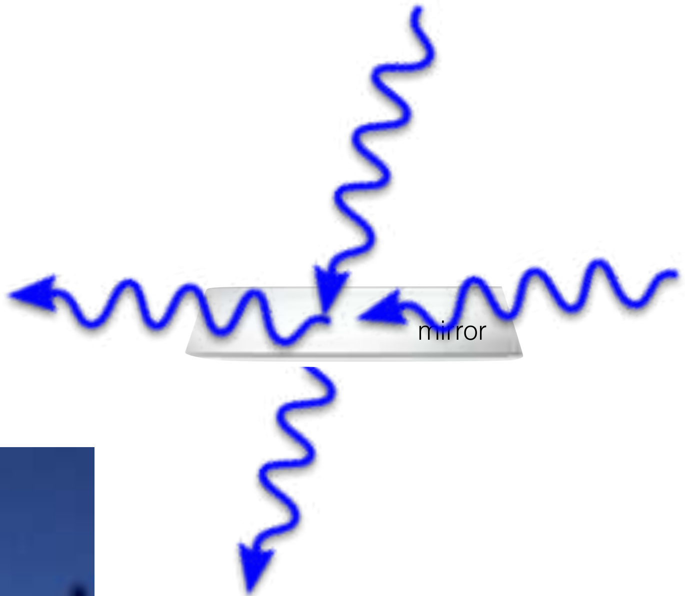
Telescopio que observa el Sol en rayos X-rays por **enfocamiento directo.**

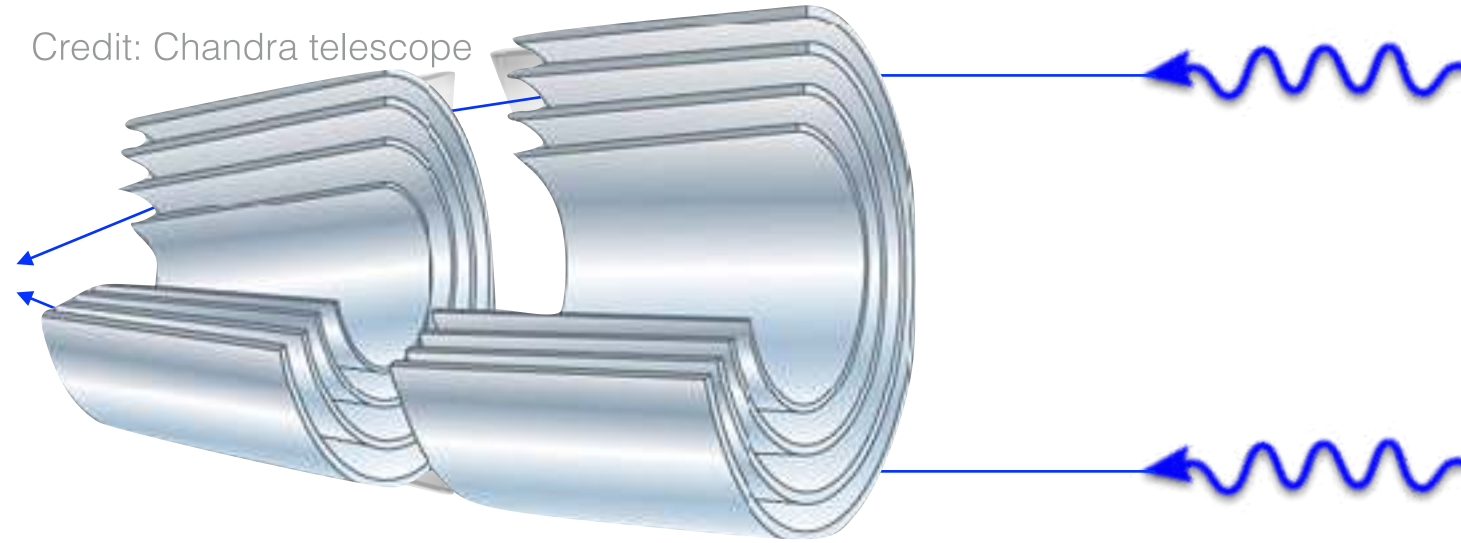
Carga útil de un cohete de sondeo

NASA program: Low Cost Access to Space

El reto de enfocar rayos-X con espejos

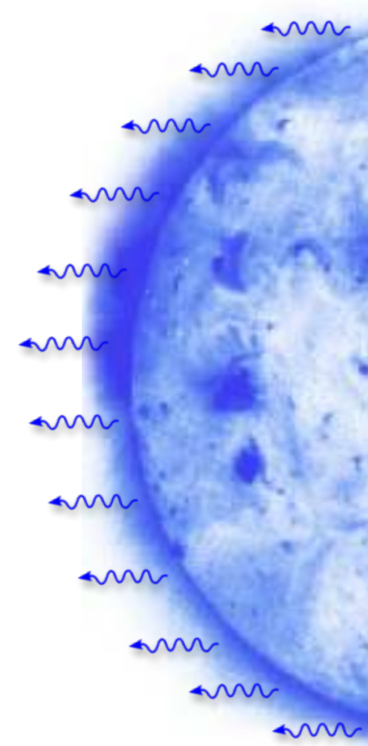






Wolter-I geometry

FOXSI payload



- FOXSI implementa **nueva tecnología** para reflejar rayos X solares y detectarlos en un plano focal.

Capacidades de **FOXSI**

Gran
Area Efectiva

Sensibilidad
Mejorada

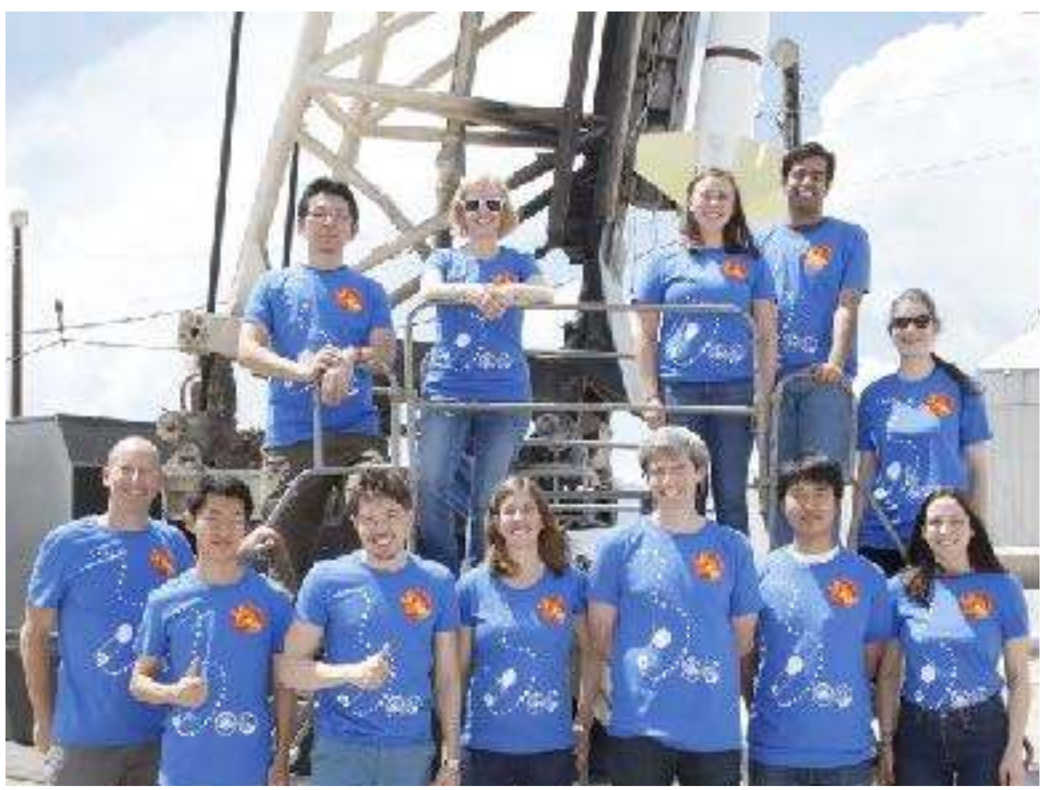
Mejor
Rango Dinámico

Mejor instrumento solar en rayos-X duros

Energy Range	4-15 keV
FOV	¼ Sun (16’ x 16’)
Angular Res.	~9” FWHM
Dynamic Range	~10 x RHESSI (~100) (for 30” separation)

FOXSI-3

Mejoras:



HXR Detectors

New fine-pitch CdTe detectors

Higher efficiency > 10 keV

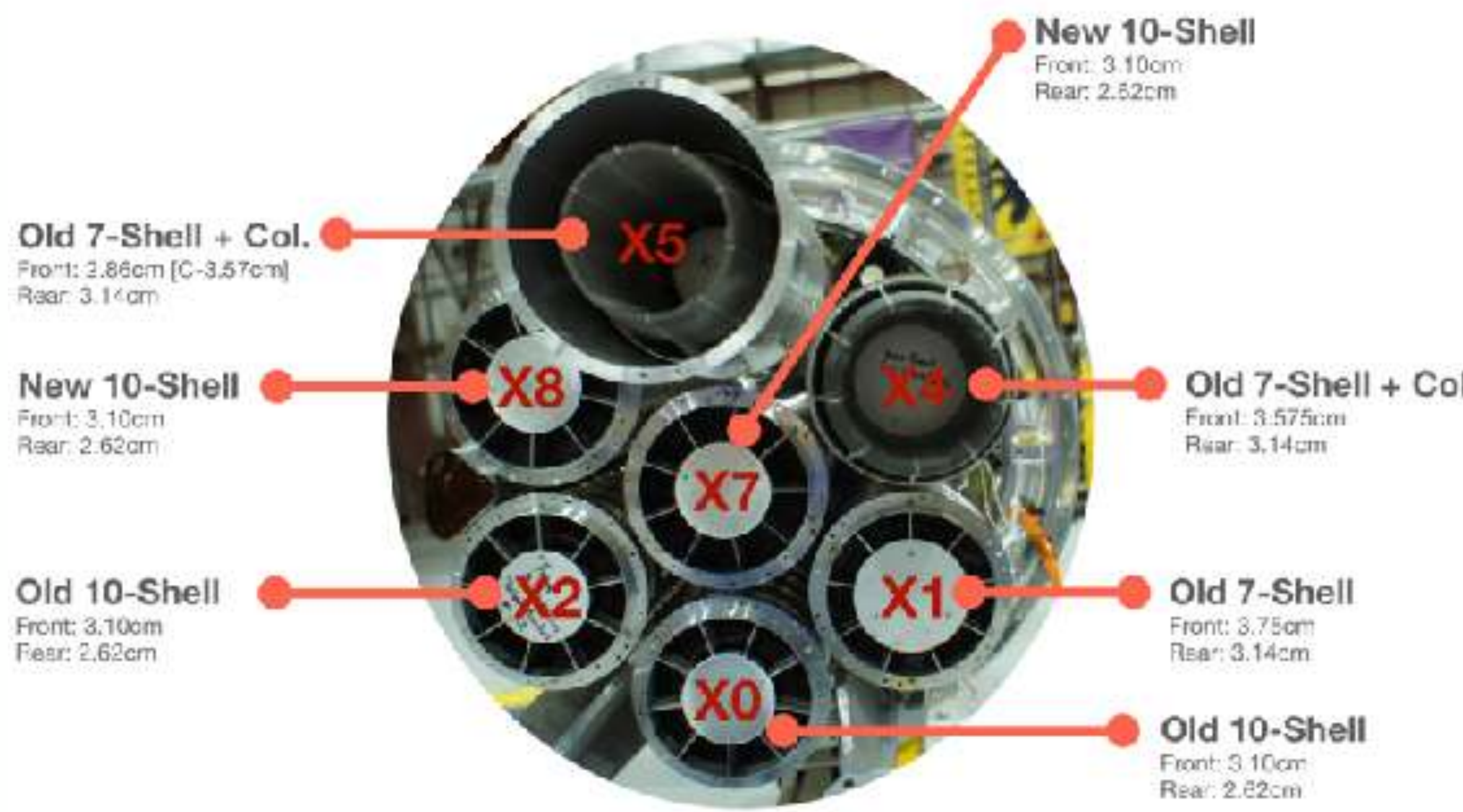
PhoEnIX Detector

CMOS imaging sensor

- Energy range: 0.5-5 keV
- High-speed data collection (250 frames/s)

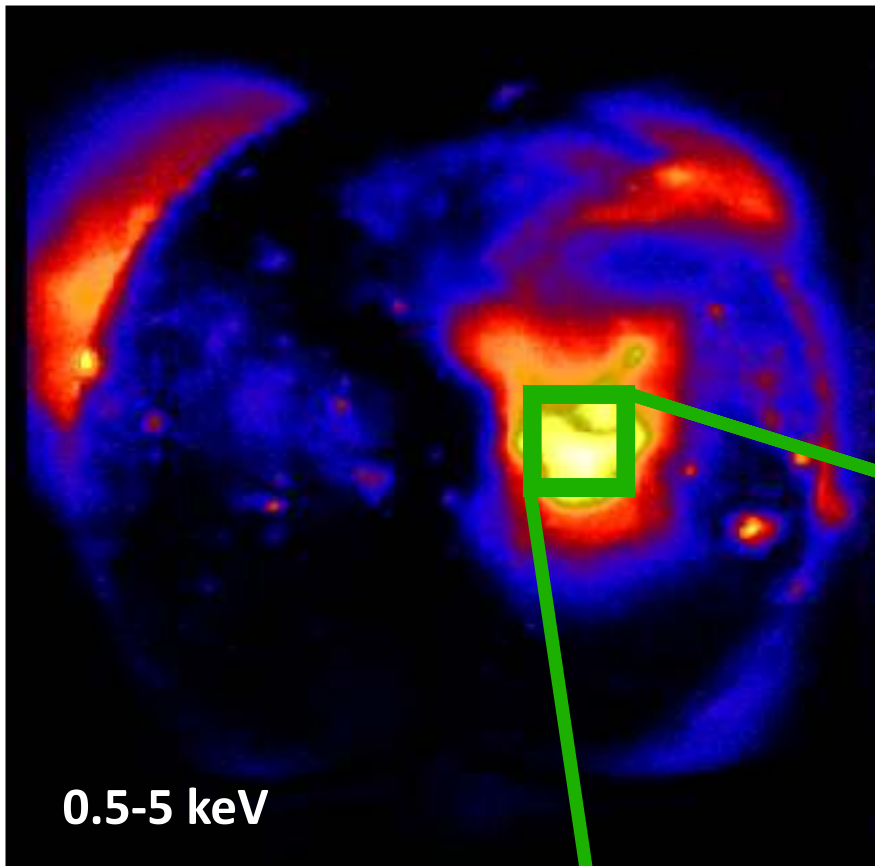
Ishikawa et al. 2017

First photon-counting soft X-ray imaging spectroscopy of the Sun!

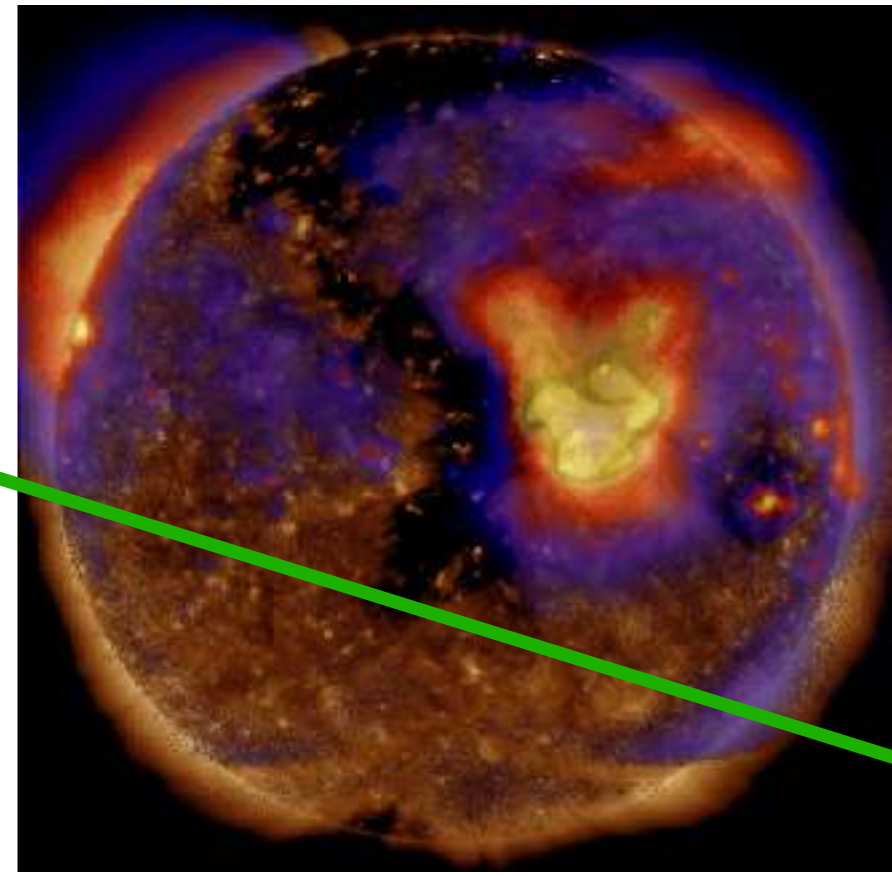


Observaciones de FOXSI-3 **PhoEnix**

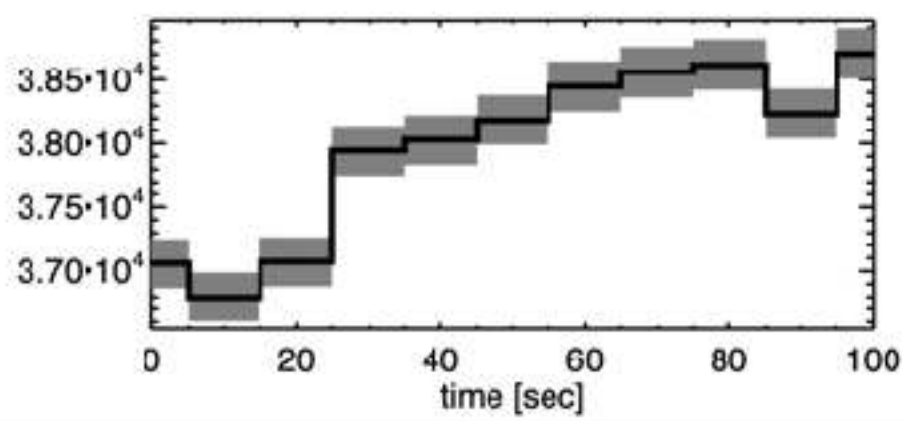
PhoEnIX Full Sun Mosaic



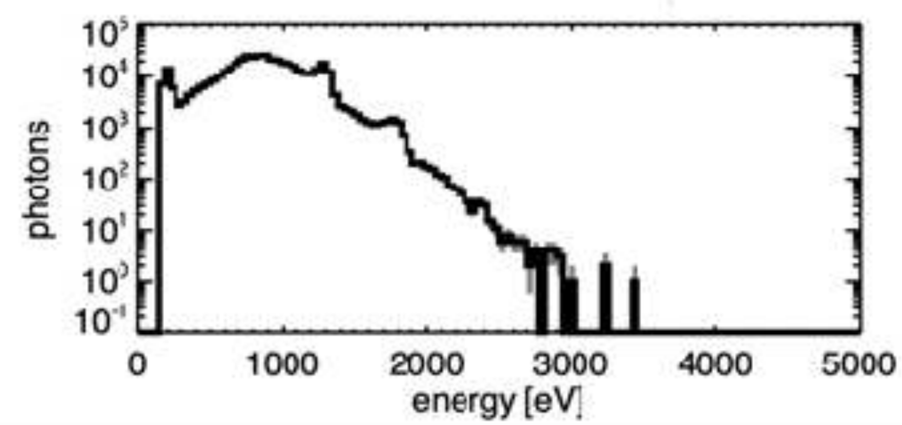
Composite PhoEnIX - AIA 193



Time variation of X-ray photon number in an active region



X-ray spectrum of an active region



Planes futuros

Solar **Flare** Sounding **rocket** campaign

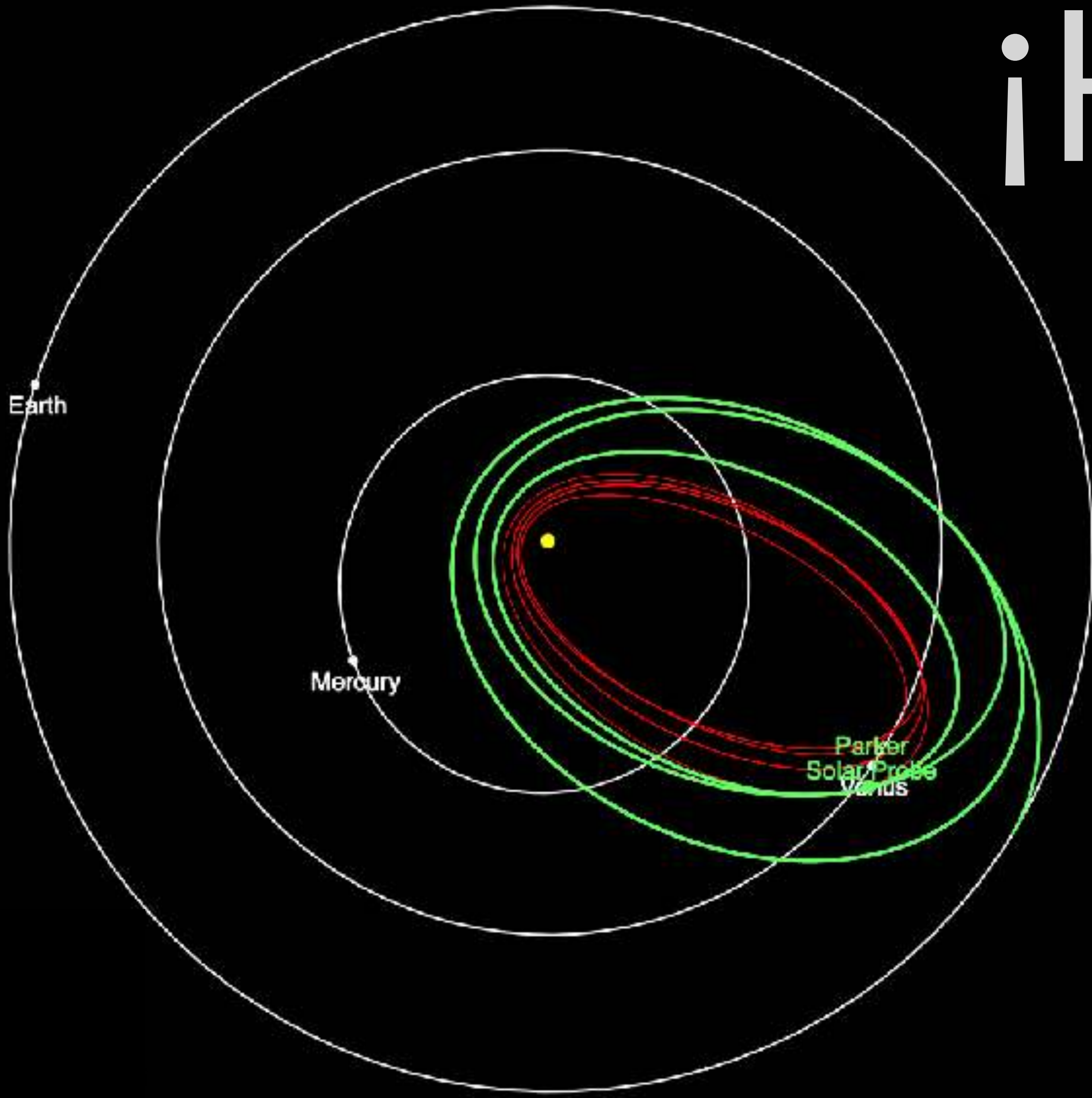
para Co-observación con la **Parker Solar Probe**

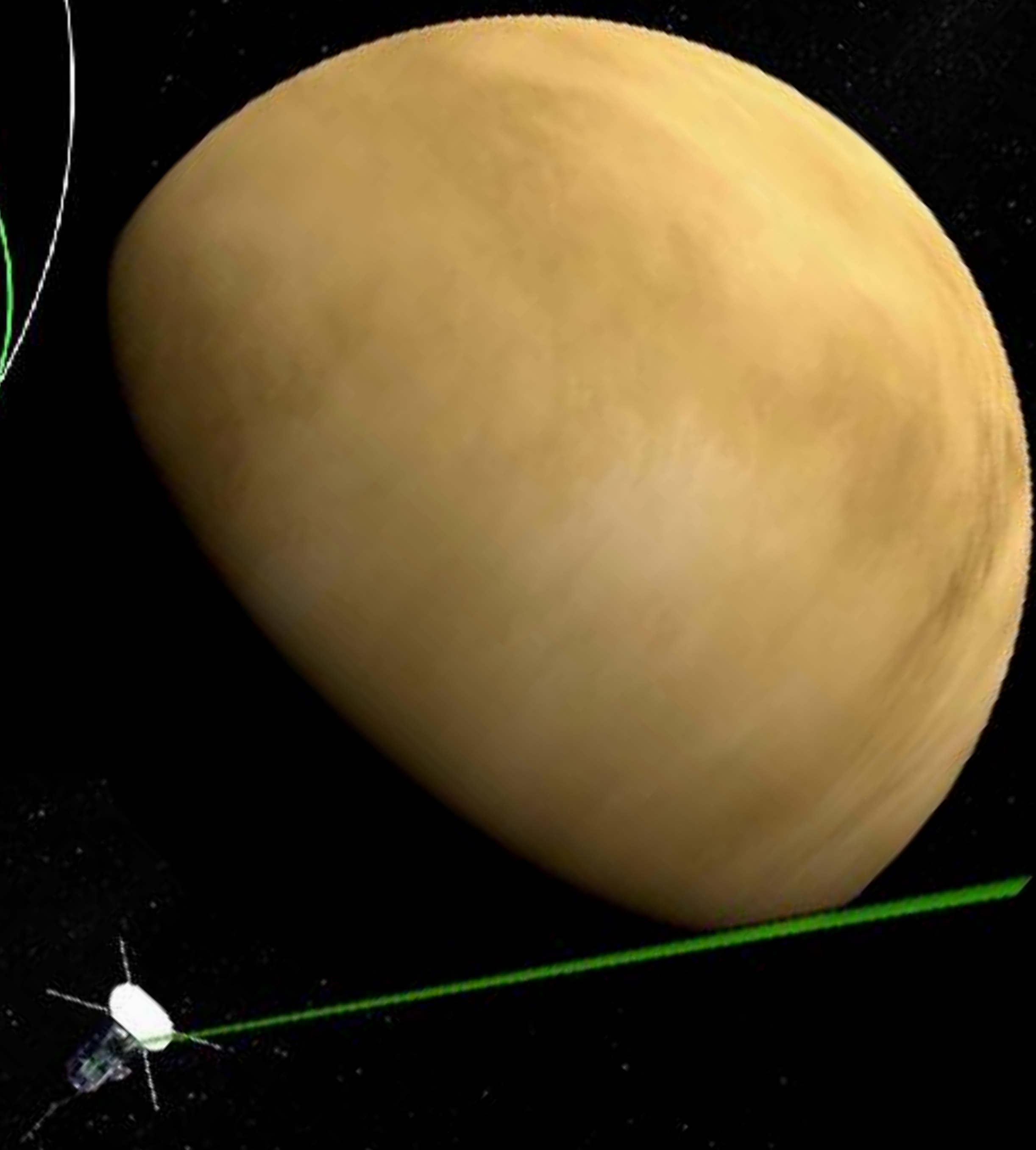

PARKER SOLAR PROBE

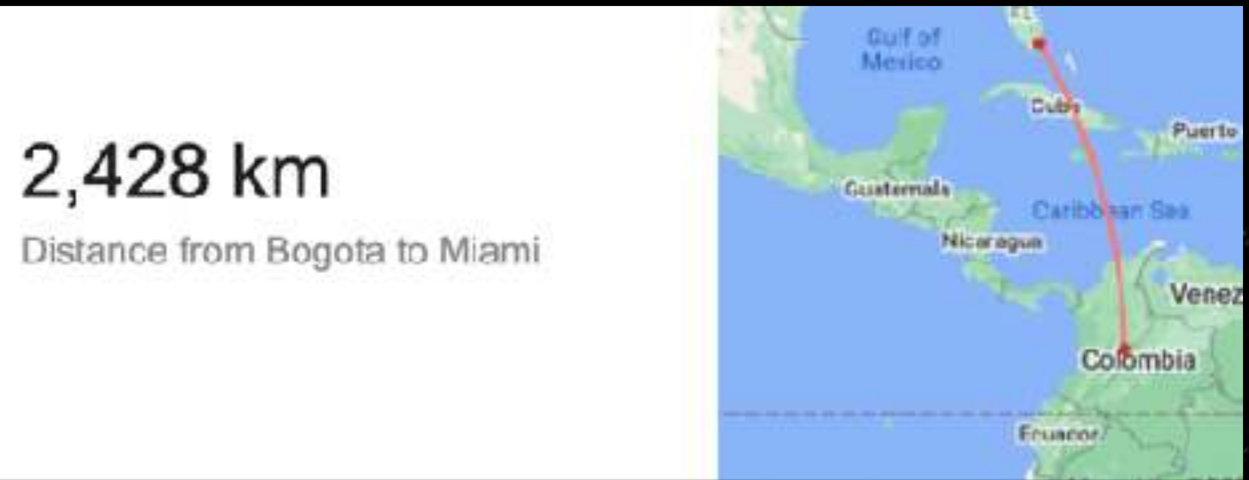

ASTROTECH
SPACE OPERATIONS
W


Parker Solar Probe launch
3:31am ET, August 1

¡Hoy!


Earth
Mercury
Parker
Solar Probe
Venus




2,428 km
Distance from Bogota to Miami
Gulf of
Mexico
Cuba
Guatemala
Nicaragua
Colombia

Carta abierta del 2019

Solar Flare Sounding Rocket Campaign

A White Paper on the Scientific Motivation and Feasibility of Introducing Routine Solar Flare Campaigns for Sounding Rockets

Authored by:
A. Winebarger (NASA Marshall Space Flight Center)
L. Glesener (University of Minnesota)
K. Reeves (Smithsonian Astrophysical Observatory)

1. Executive Summary

The sounding rocket platform allows instruments and technologies to mature for future satellite missions, provides an opportunity to capture unique scientific measurements not currently available by other means, and trains the next generation of instrumentalists. Historically, solar sounding rocket instruments have been launched from White Sands Missile Range (WSMR), which is a busy range with little flexibility in scheduling or changing a launch time. Additionally, to launch from the NASA launch site on the southern side of the range, a major road and the White Sands National Monument must close starting roughly an hour before the scheduled launch time. Because of this, scientists are provided, at most, a one-hour launch window and encouraged to launch as early in that window as possible. This limited window precludes the ability of an instrument to launch into an event like a solar flare. ***Instruments that are specifically designed for solar flare observations therefore cannot be matured through the sounding rocket program and instruments with significant solar flare capability cannot be fully tested via a standard launch at WSMR.***

We formally request that the Sounding Rocket Program office (SRPO) open an existing launch range for routine solar flare sounding rocket campaigns at least every other year during solar

Campaña de cohetes sonda

para estudiar

Fulguraciones solares

en conjunción con **PSP**

Mar o **Sep** de **2023** o **2024**

Objetivo:

Uno o más cohetes se lanzarán después del inicio de una fulguración en momento de máximo acercamiento de PSP

PSP perihelio:

Marzo 17, 2023: Perihelio #15
Septiembre 27, 2023: Perihelio #17
Marzo 30, 2024: Perihelio #19
Septiembre 30, 2024: Perihelio #21

La oficina de cohetes de la NASA Sounding ya ha analizado esta idea y está de acuerdo en que es factible con recursos modestos.

Campañas de cohetes propuestas para la convocatoria de la NASA / LCAS este año

(Propuestas en Noviembre de 2019)

FOXSI-4 | **Hi-C flare**

Propuesto para ser lanzado :

- Durante una fulguración (C5+)
- Lanzamiento casi-simultáneo.
- Desde el Poker Flat Research Range, Alaska

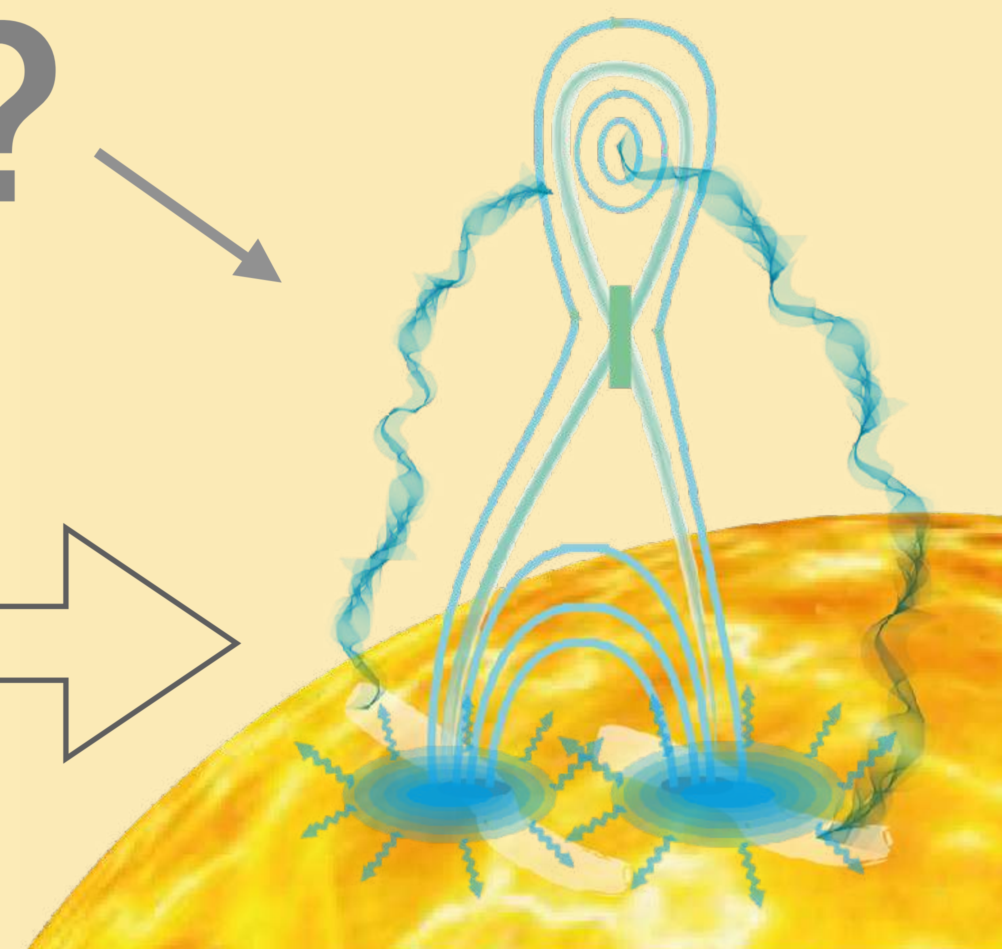
Objetivo científico :
Estudiar electrones acelerados en una fulguración

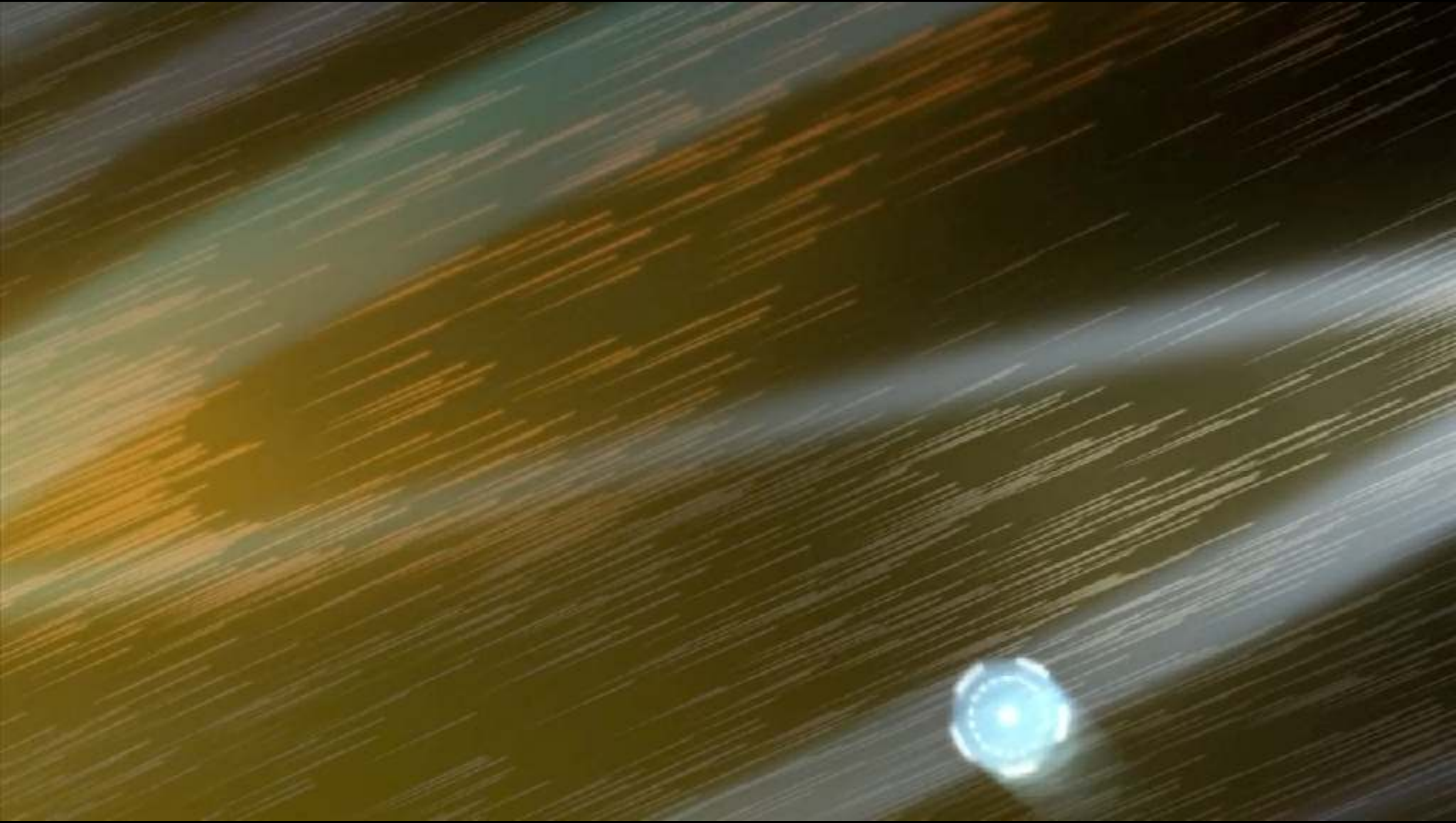
PSP
will observe **up** here

- Radio measurements of Type II and III bursts (FIELDS)
- In-situ measurements of particles (ISOIS, SWEAP)
- In-situ measurements of plasma waves generated by passing electron beams (FIELDS)

How are these two populations of accelerated particles connected? **?**

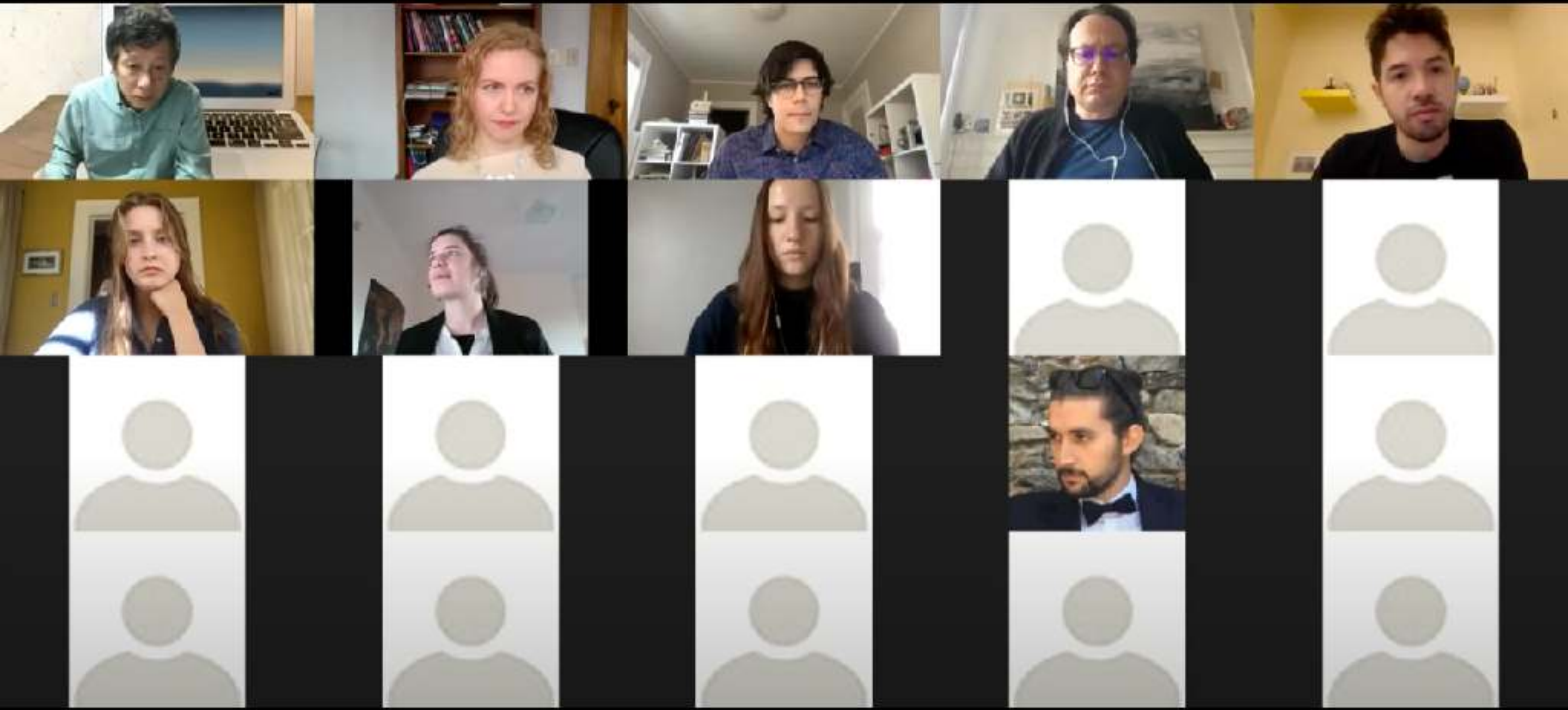
FOXSI-4 & Hi-C flare
will observe **down** here
in hard X-rays (from non-thermal e-)
and soft x-rays & EUV (from thermal plasma)





FOXSI-4 kickoff meeting

desde hace tres meses



… esta historia continua

¡Gracias!