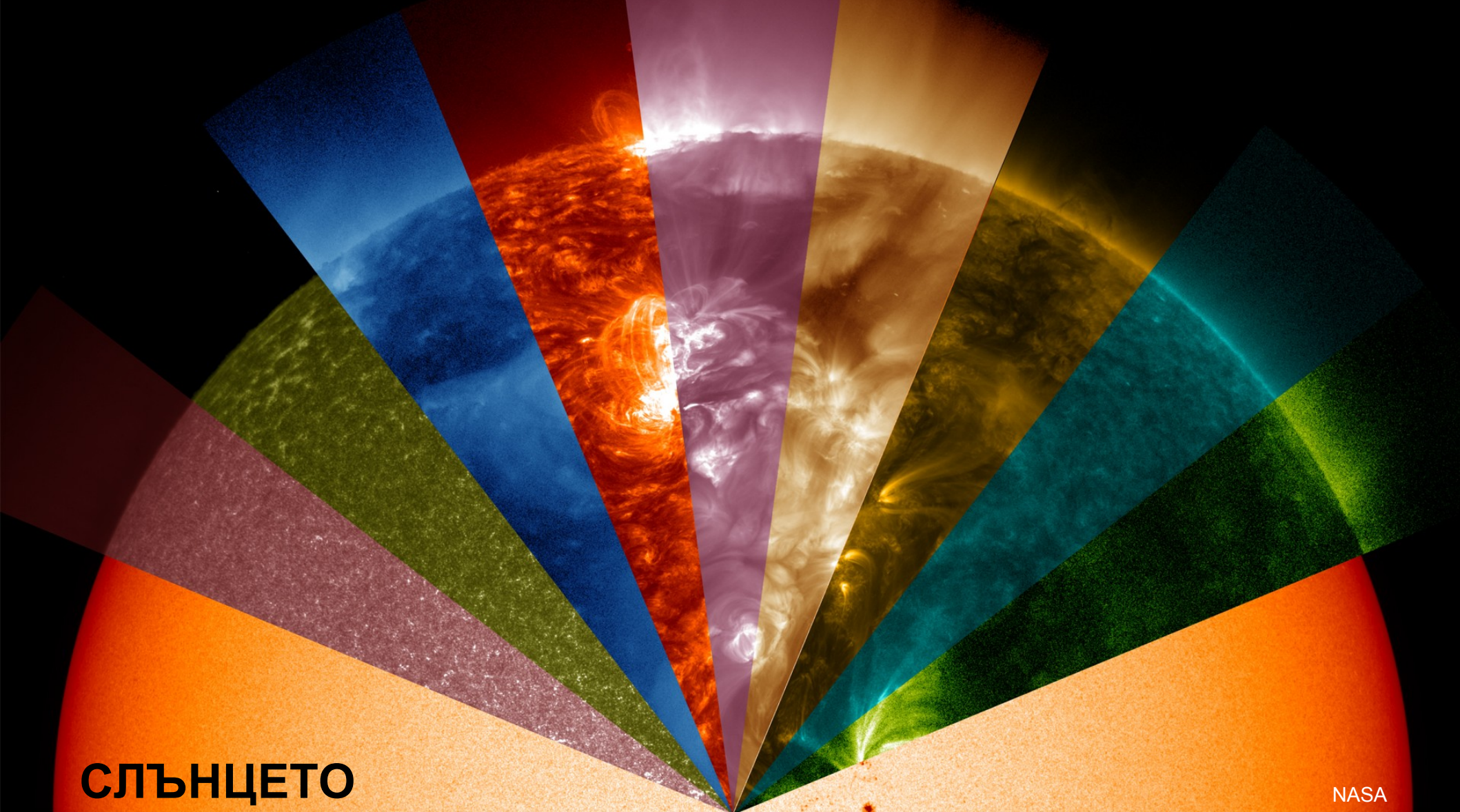




СЛЪНЦЕТО

различните лица и настроения на нашата звезда

д-р Росица Митева

**Институт за космически изследвания и технологии,
Българска академия на науките (ИКИТ-БАН)**

Астро-семинар, 8-март-2018, ФзФ-СУ

Наблюдения на астрономически обекти

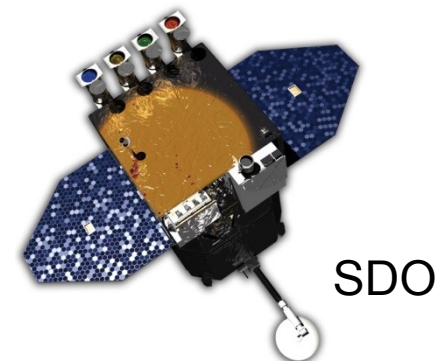
Източници



Вид лъчение и х-ки

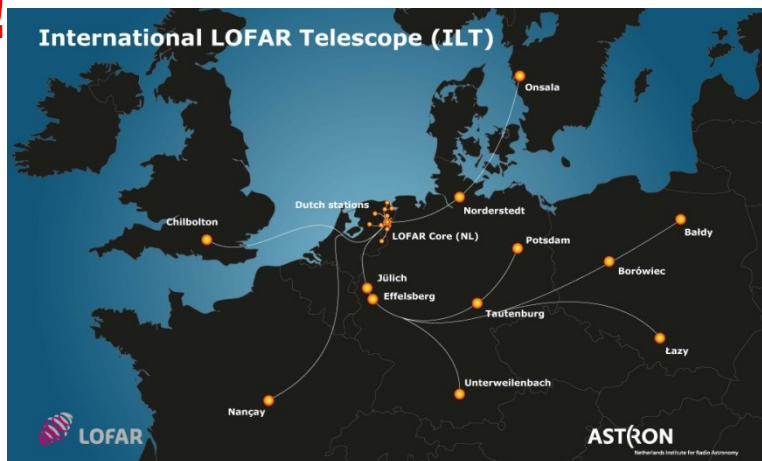
- **Какво:** фотони и частици (интензитет, дължина на вълната/енергия)
- **Къде:** къде се намира детектора и достъп на лъчението до него
- **Как:** технологична възможност за наблюдение

Детектори



SDO

**Не наблюдавайте
директно към
Слънцето!**



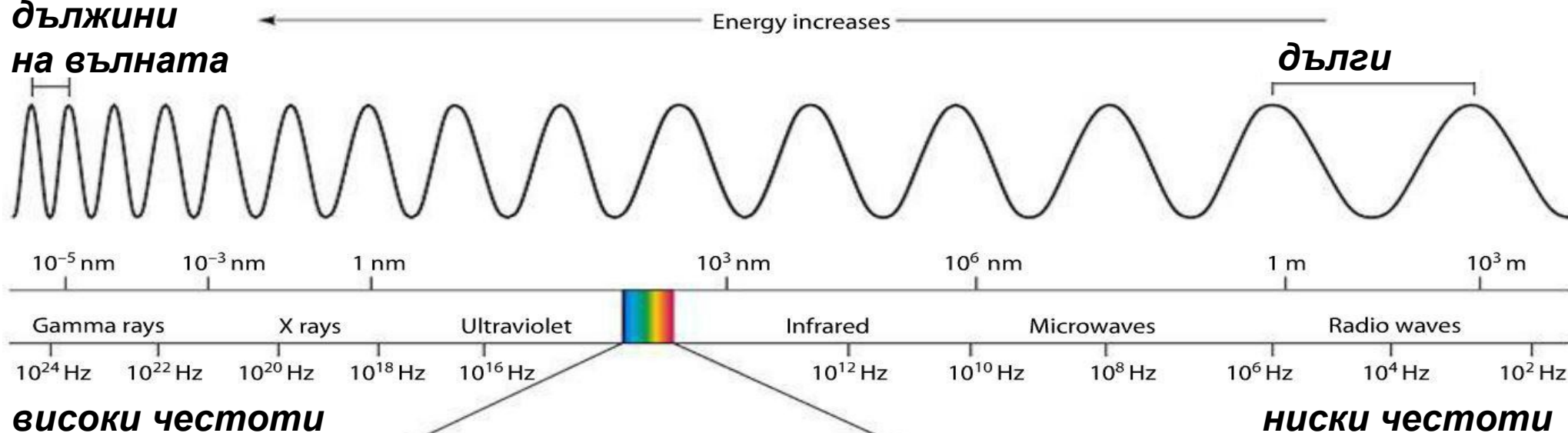
Nancay



HAO-Рожен

Електромагнитен спектър

**къси
дължини
на вълната**



видима светлина



<https://www.miniphysics.com/>

GeV – MeV – keV

Å

nm

THz – GHz – MHz – kHz

Radio



AM radio

Amateur
radioAircraft
communication

Infrared Microwave

Microwave
ovenTV Remote
ControlNight vision
goggles

Visible



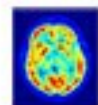
Ultraviolet

UV light
from the Sun

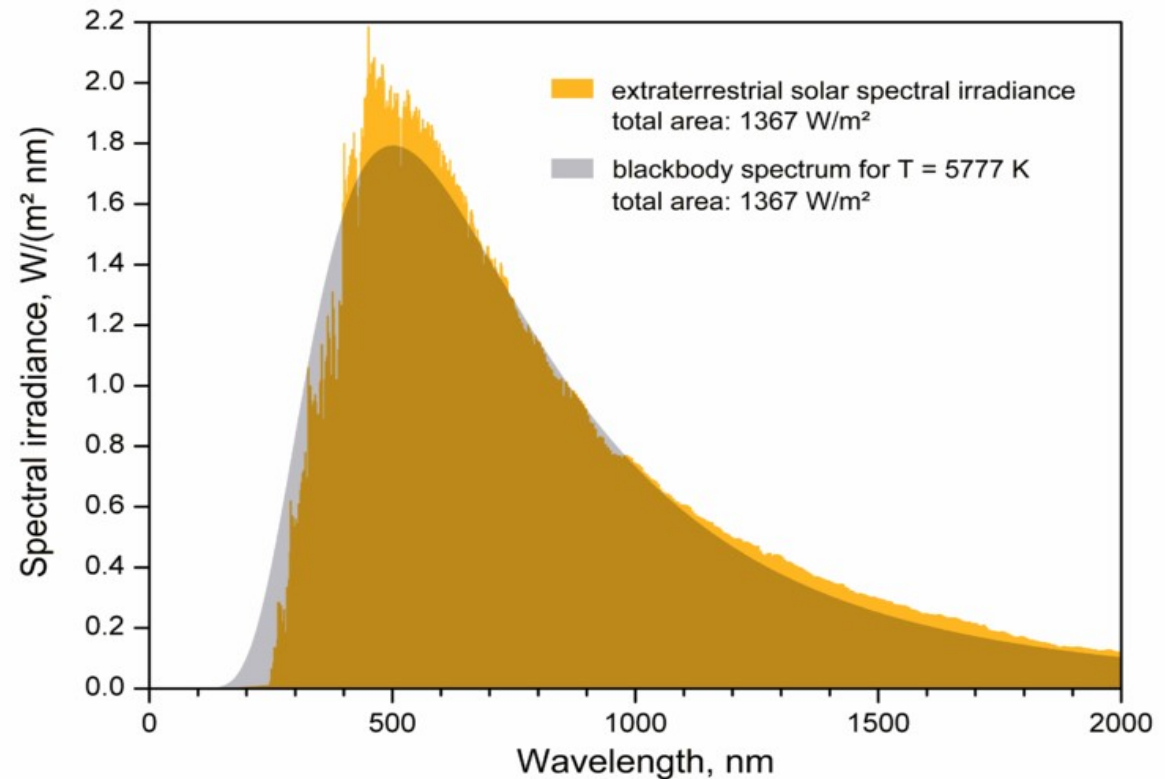
X-ray

Airport security
scanner

Gamma-ray

PET
scanTerrestrial
gamma-ray
flashes

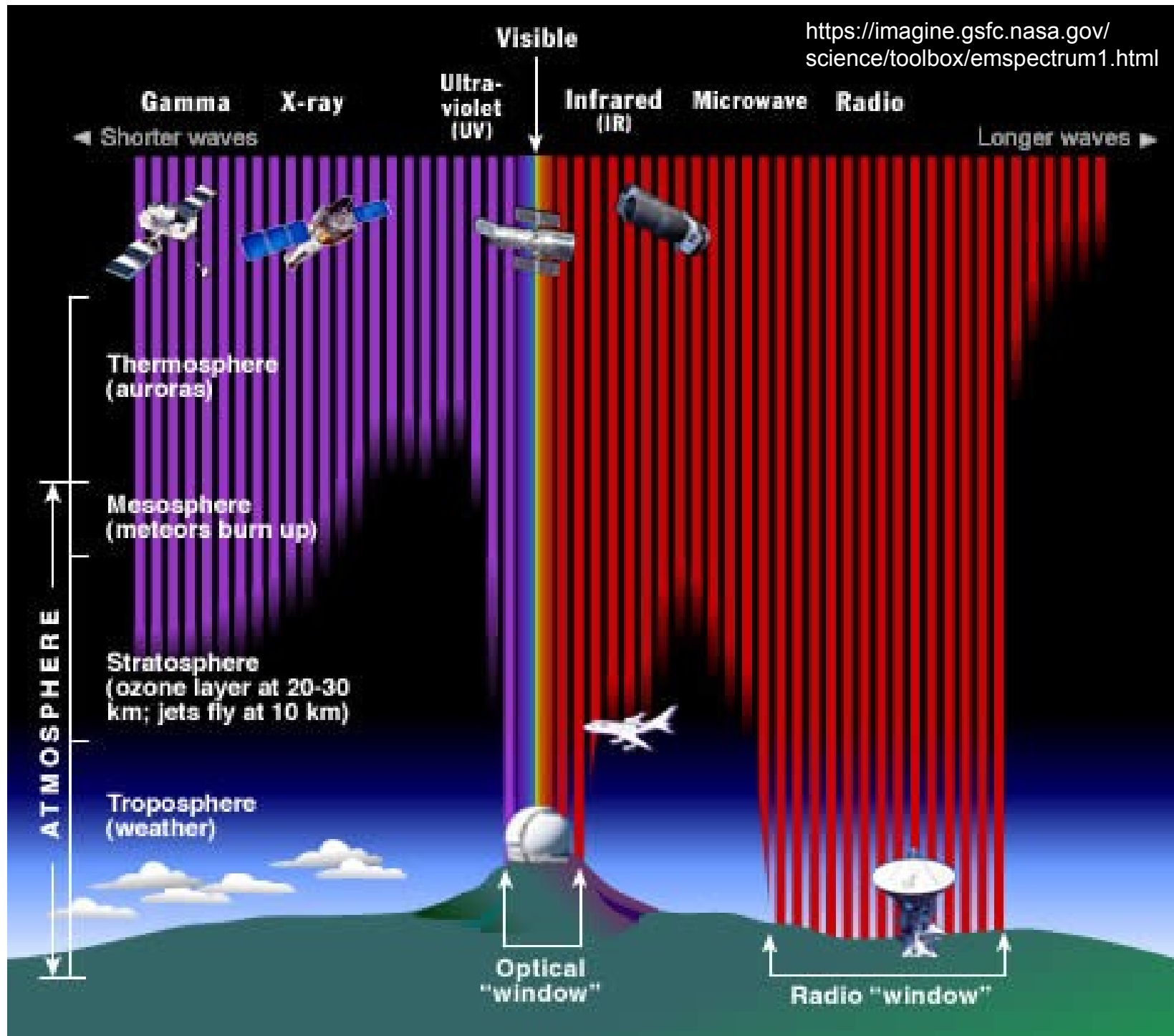
Спектър на Слънцето



https://en.wikipedia.org/wiki/Sun#/media/File:EffectiveTemperature_300dpi_e.png

<https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html>

Наземни и спътникови наблюдения



Наблюдения на Слънцето

Неутрален филтър

намаля общата светимост на Слънцето



ISO 12312-2
стандарт за безопасност
при наблюдения
на Слънцето

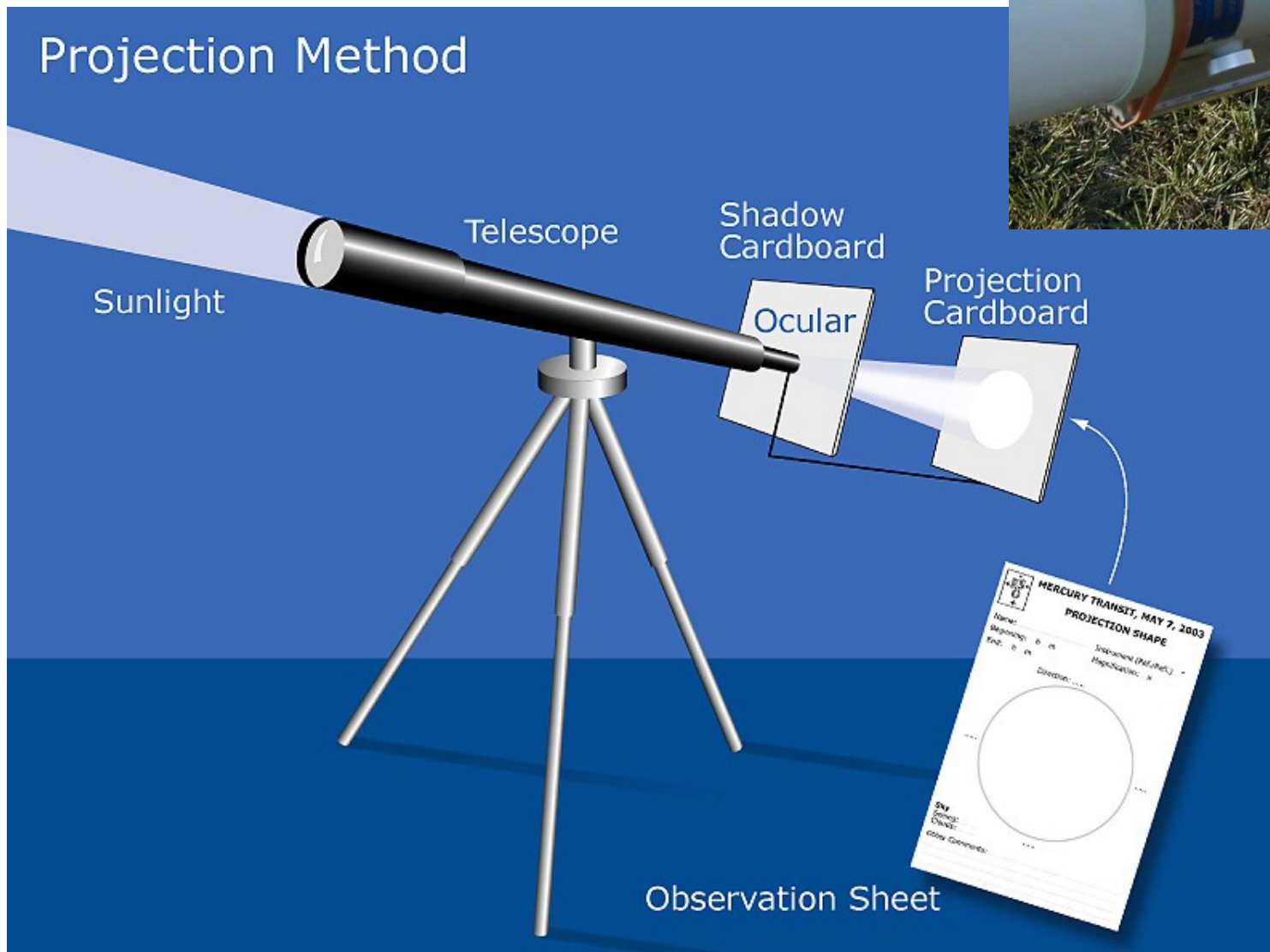
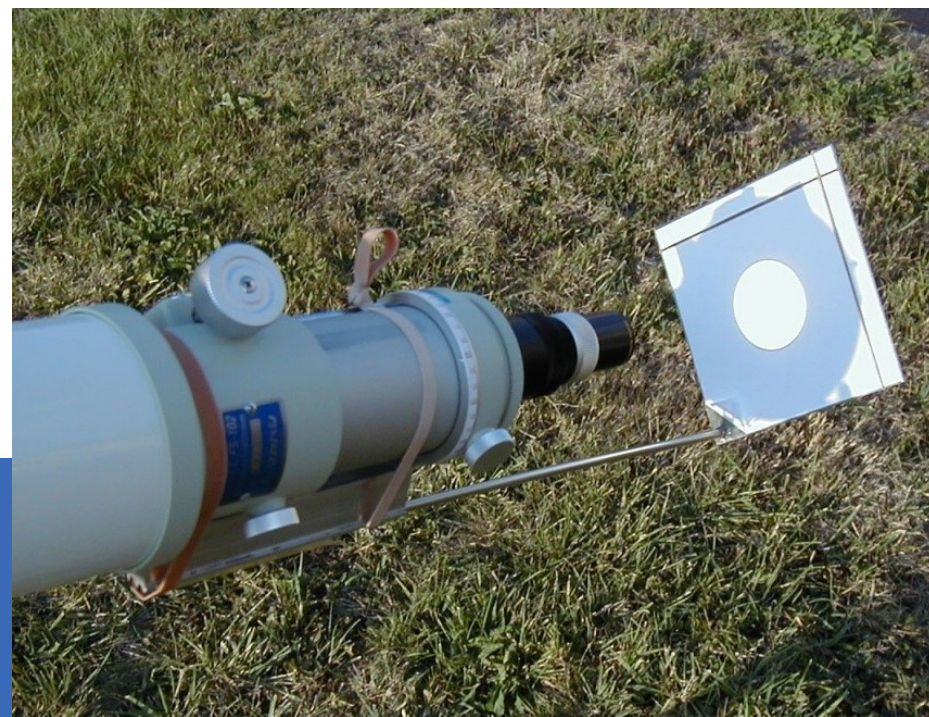
<http://www.eclipseshades.com/eclipse-glasses.html>

Внимание: Трябва да се филтрира и инфрачервената част от спектъра!

**Не наблюдавайте
директно към
Слънцето!**

Други филтри
H α , Ca II...

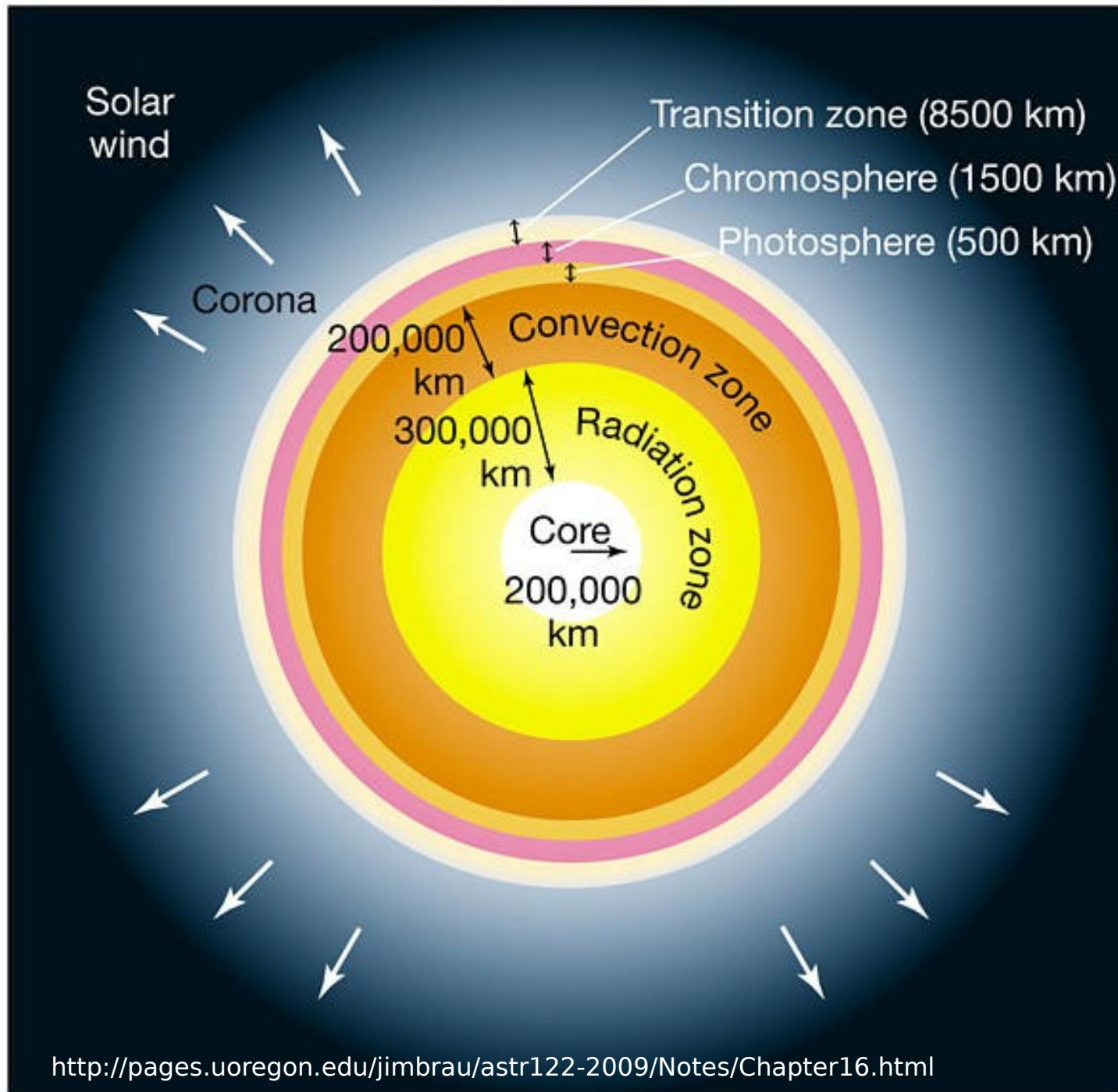
Наблюдения на Слънцето



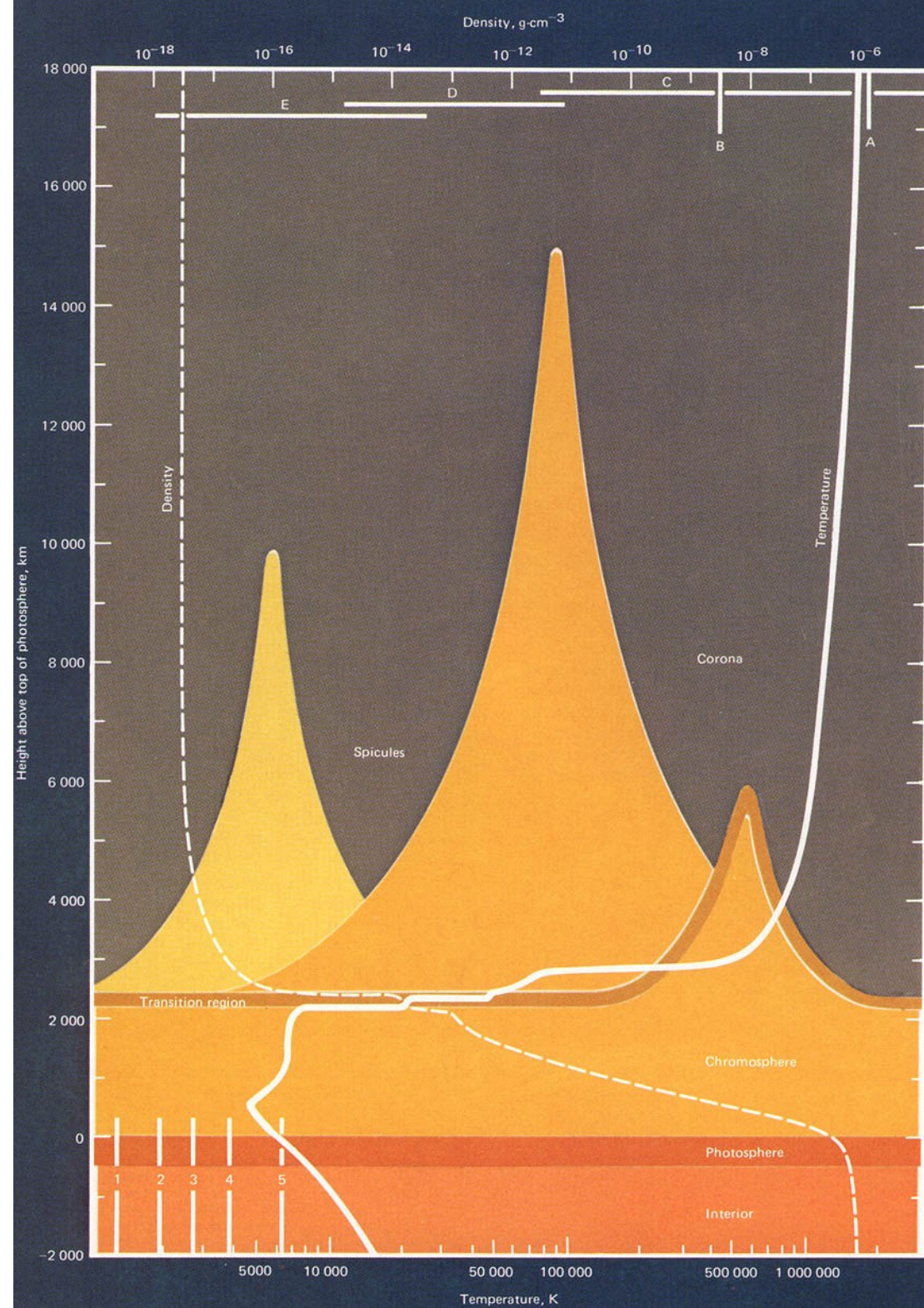
Не наблюдавайте директно към Слънцето!

www.eso.org;
www.deepskywatch.com

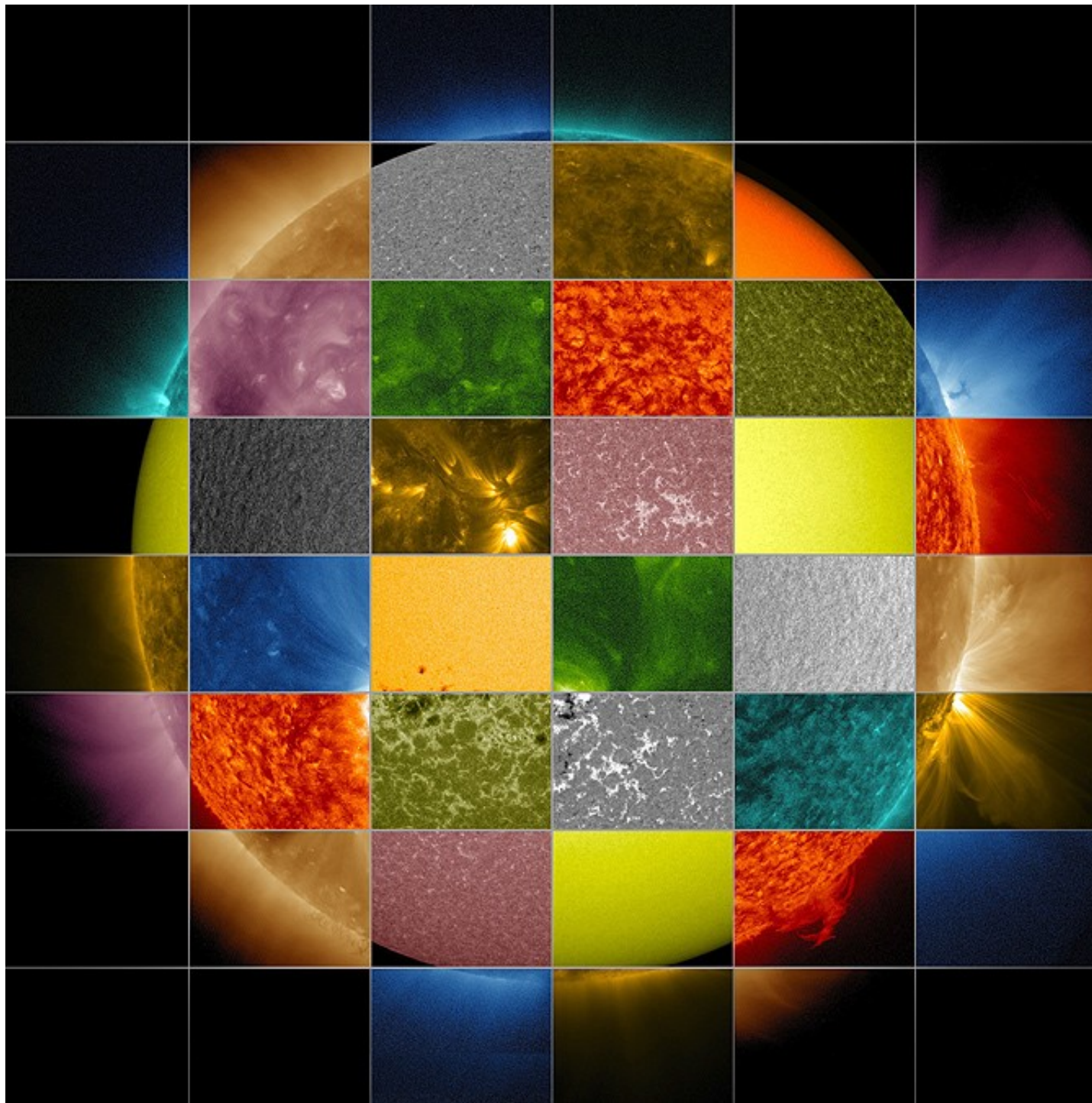
Слънцето - вътрешна структура и атмосфера



Слънцето: температура и плътност



Различните лица на Слънцето

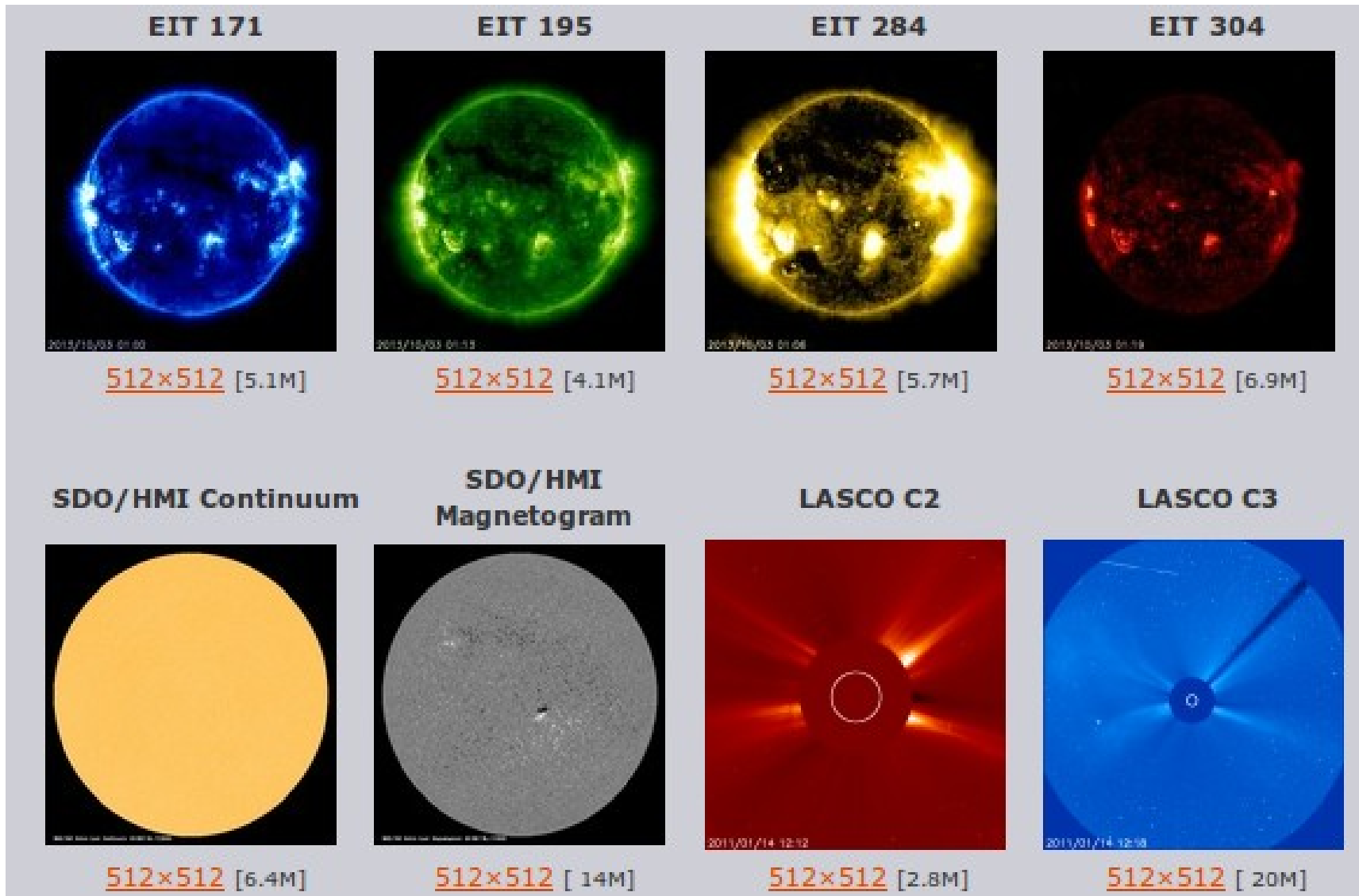


NASA/SDO/Goddard Space Flight Center https://www.nasa.gov/mission_pages/sunearth/news/light-

SOHO

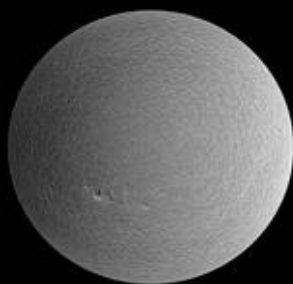
Solar and Heliospheric Observatory

(ESA&NASA: 1995)

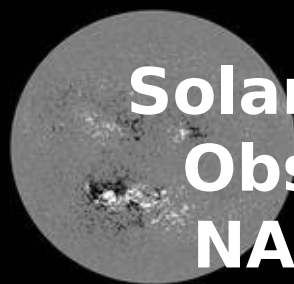


Реални изображенията на Слънцето!!!
с изключение на (повечето от) цветовете

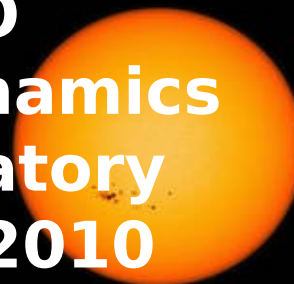
SDO Solar Dynamics Observatory NASA: 2010



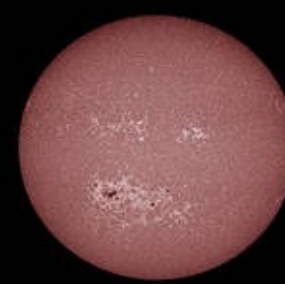
HMI Dopplergram
Surface movement
Photosphere



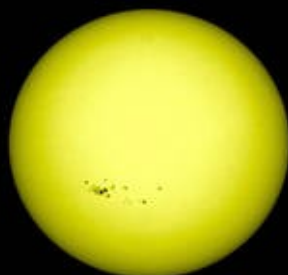
HMI Magnetogram
Magnetic field polarity
Photosphere



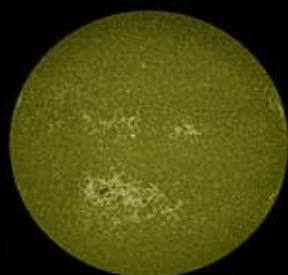
HMI Continuum
Matches visible light
Photosphere



AIA 1700 Å
4500 Kelvin
Photosphere



AIA 4500 Å
6000 Kelvin
Photosphere



AIA 1600 Å
10,000 Kelvin
Upper photosphere/
Transition region



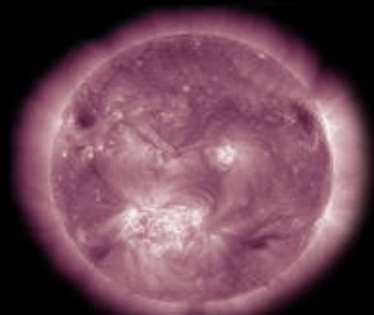
AIA 304 Å
50,000 Kelvin
Transition region/
Chromosphere



AIA 171 Å
600,000 Kelvin
Upper transition
Region/quiet corona



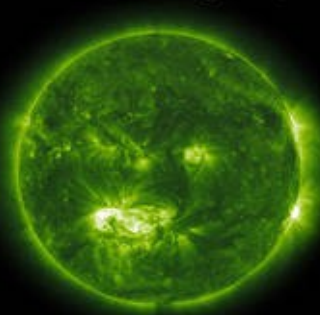
AIA 193 Å
1 million Kelvin
Corona/flare plasma



AIA 211 Å
2 million Kelvin
Active regions



AIA 335 Å
2.5 million Kelvin
Active regions



AIA 094 Å
6 million Kelvin
Flaring regions

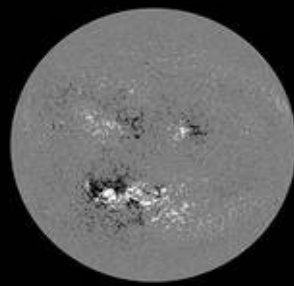


AIA 131 Å
10 million Kelvin
Flaring regions

1700: за наблюдение на слънчевата повърхност и част от хромосферата
4500: слънчева повърхност или фотосфера
1600: горна фотосфера и преходен слой



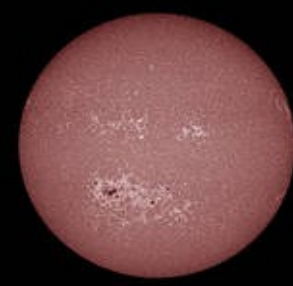
HMI Dopplergram
Surface movement
Photosphere



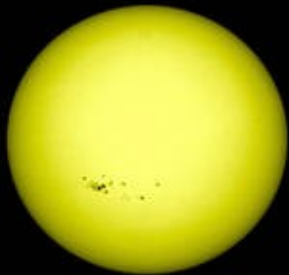
HMI Magnetogram
Magnetic field polarity
Photosphere



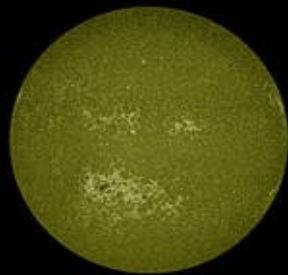
HMI Continuum
Matches visible light
Photosphere



AIA 1700 Å
4500 Kelvin
Photosphere



AIA 4500 Å
6000 Kelvin
Photosphere



AIA 1600 Å
10,000 Kelvin
Upper photosphere/
Transition region



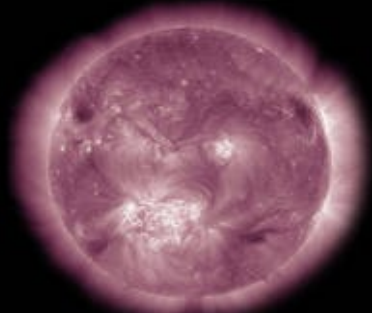
AIA 304 Å
50,000 Kelvin
Transition region/
Chromosphere



AIA 171 Å
600,000 Kelvin
Upper transition
Region/quiet corona



AIA 193 Å
1 million Kelvin
Corona/flare plasma



AIA 211 Å
2 million Kelvin
Active regions



AIA 335 Å
2.5 million Kelvin
Active regions

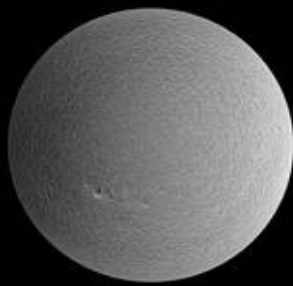


AIA 094 Å
6 million Kelvin
Flaring regions

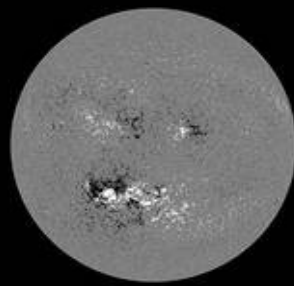


AIA 131 Å
10 million Kelvin
Flaring regions

304: излъчването е от хромосферата и преходния слой
171: при спокойна корона (магнитни арки и конални бримки)
193: по-горещи области от короната (избухвания)



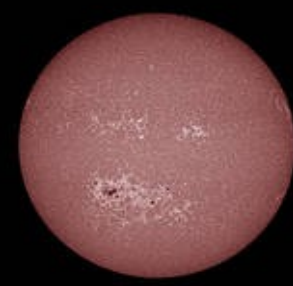
HMI Dopplergram
Surface movement
Photosphere



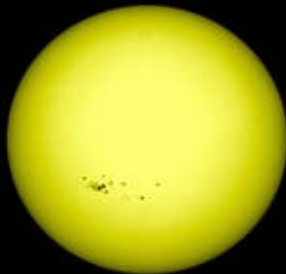
HMI Magnetogram
Magnetic field polarity
Photosphere



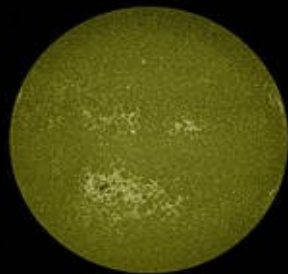
HMI Continuum
Matches visible light
Photosphere



AIA 1700 Å
4500 Kelvin
Photosphere



AIA 4500 Å
6000 Kelvin
Photosphere



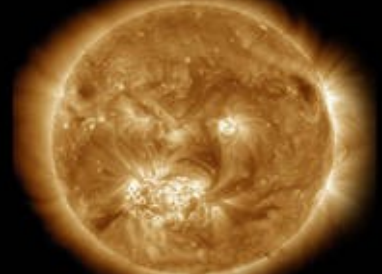
AIA 1600 Å
10,000 Kelvin
Upper photosphere/
Transition region



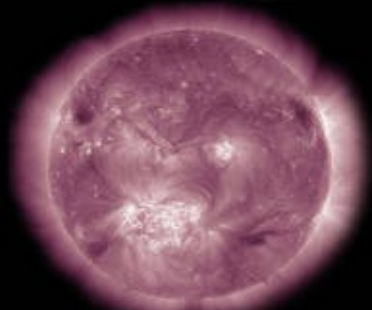
AIA 304 Å
50,000 Kelvin
Transition region/
Chromosphere



AIA 171 Å
600,000 Kelvin
Upper transition
Region/quiet corona



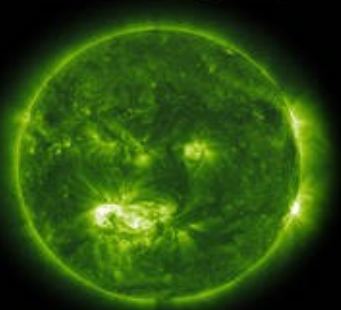
AIA 193 Å
1 million Kelvin
Corona/flare plasma



AIA 211 Å
2 million Kelvin
Active regions



AIA 335 Å
2.5 million Kelvin
Active regions



AIA 094 Å
6 million Kelvin
Flaring regions



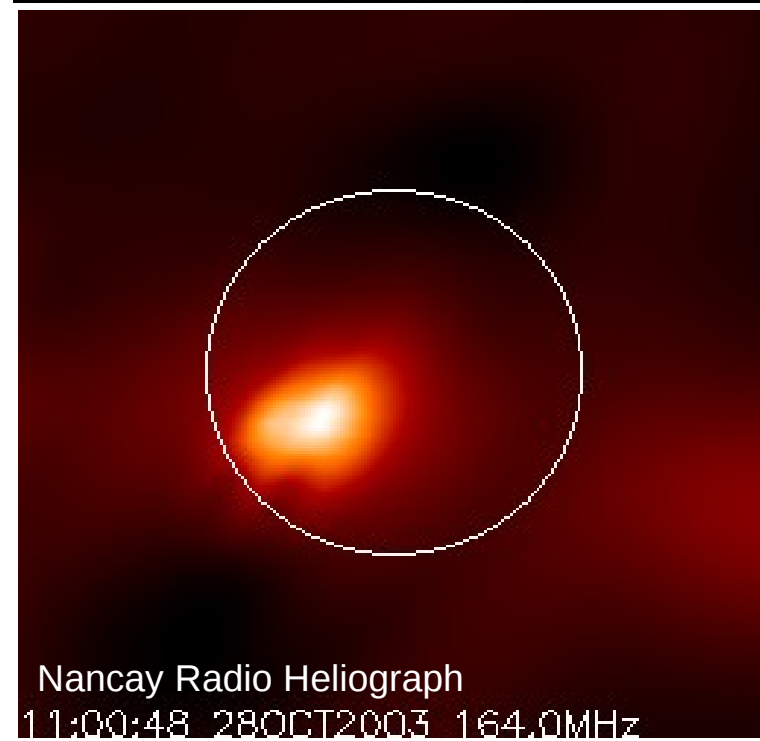
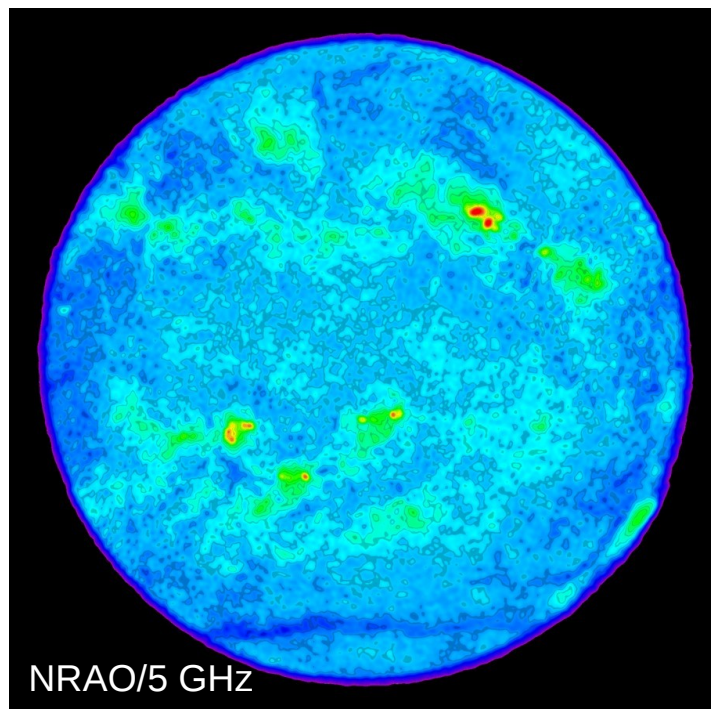
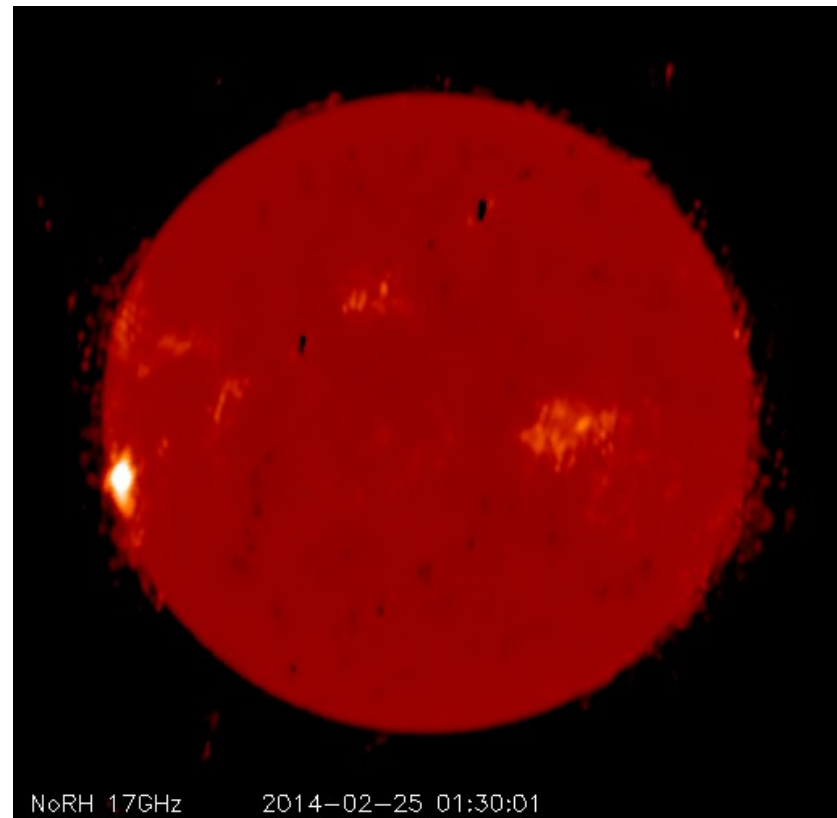
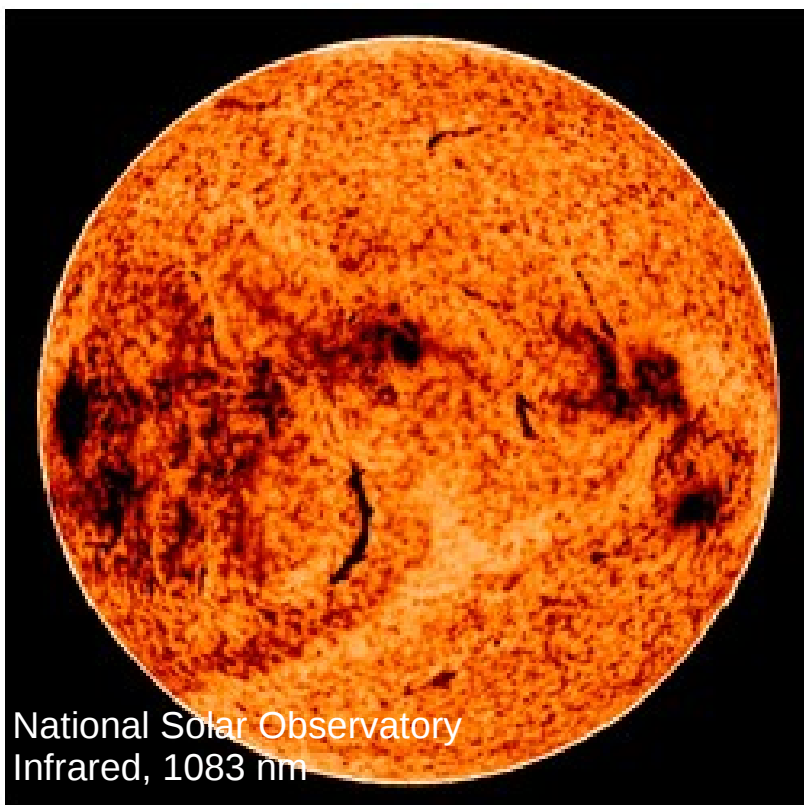
AIA 131 Å
10 million Kelvin
Flaring regions

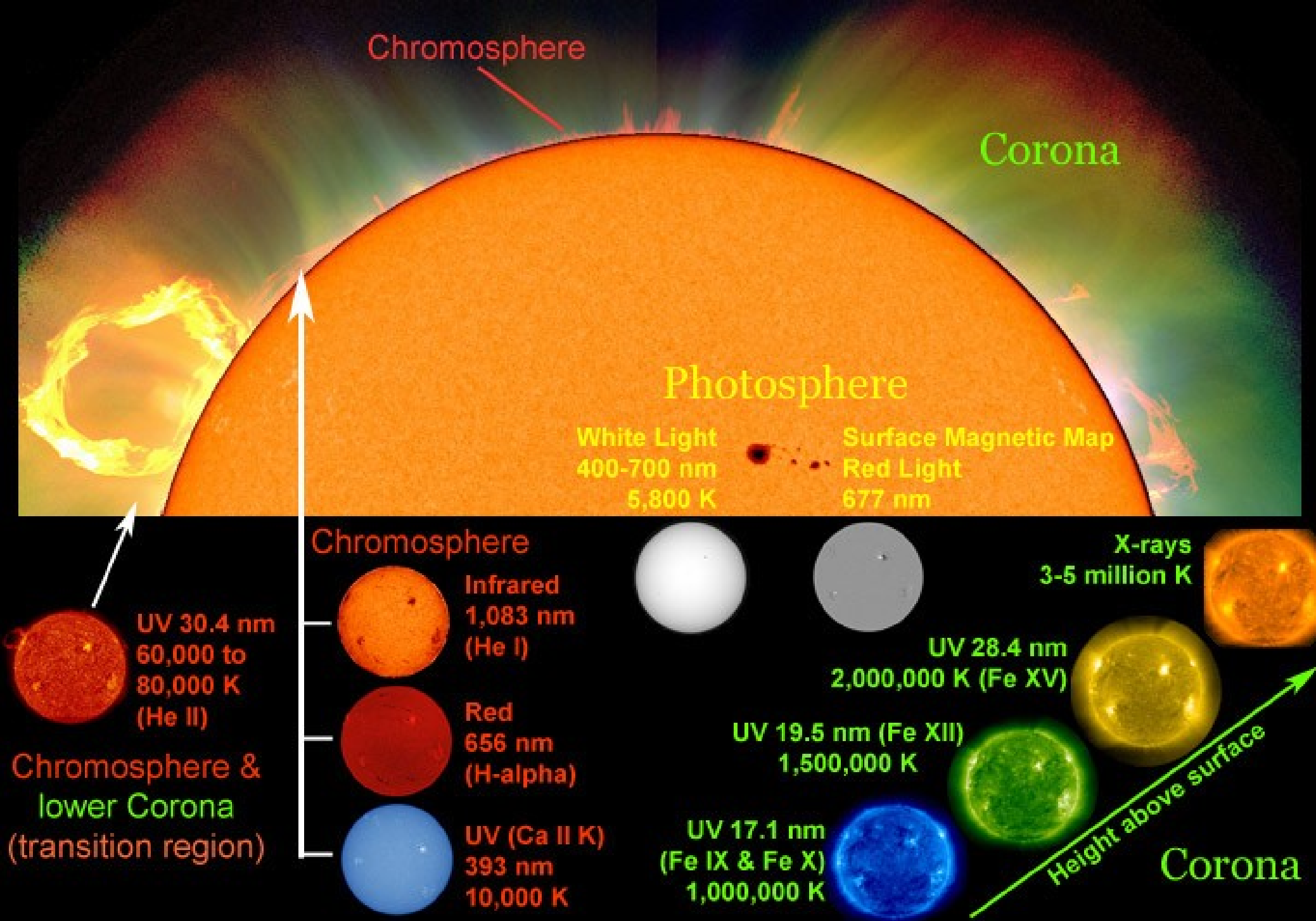
211: излъчване от по-горещи магнитно активни области

335: горещи активни области в короната

94: корона по време на слънчеви избухвания

131: най-горещия материал по време на избухването



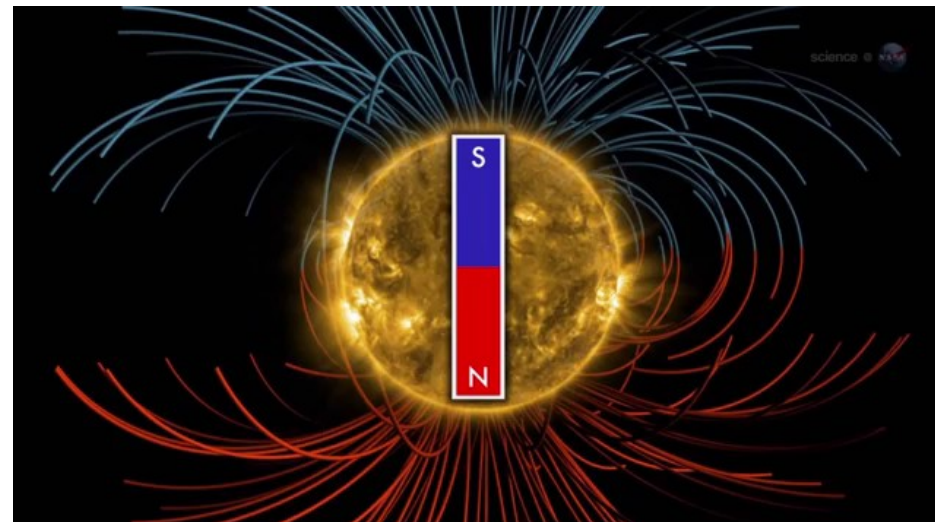
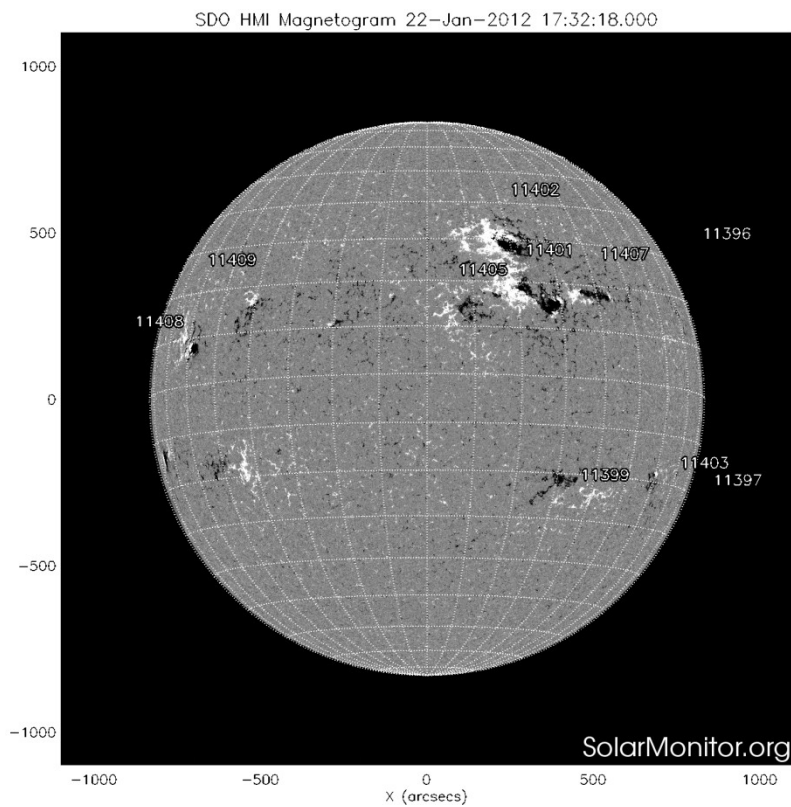
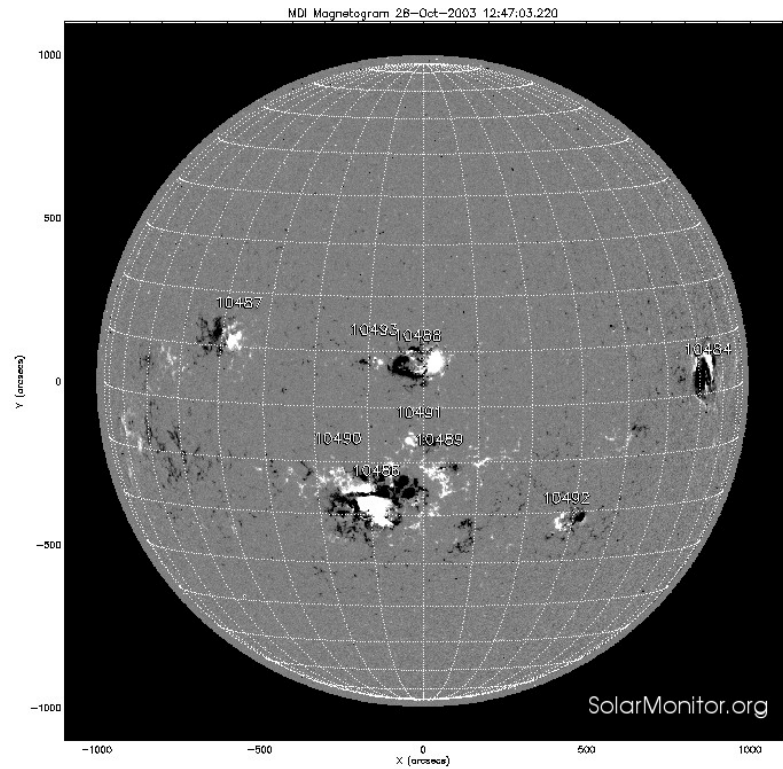
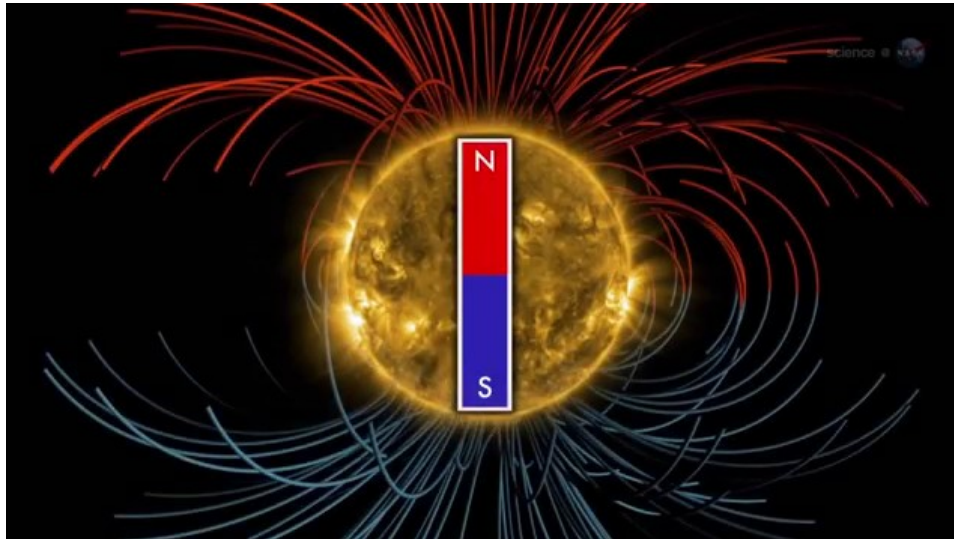


Различните настроения на Слънцето

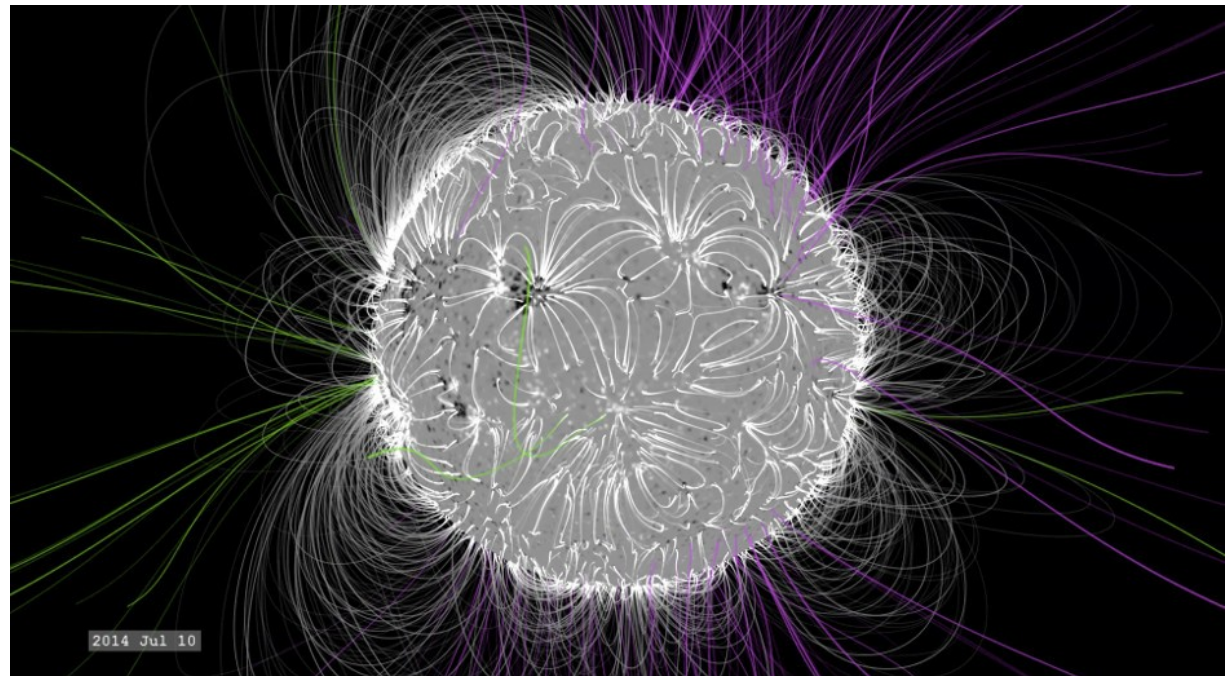
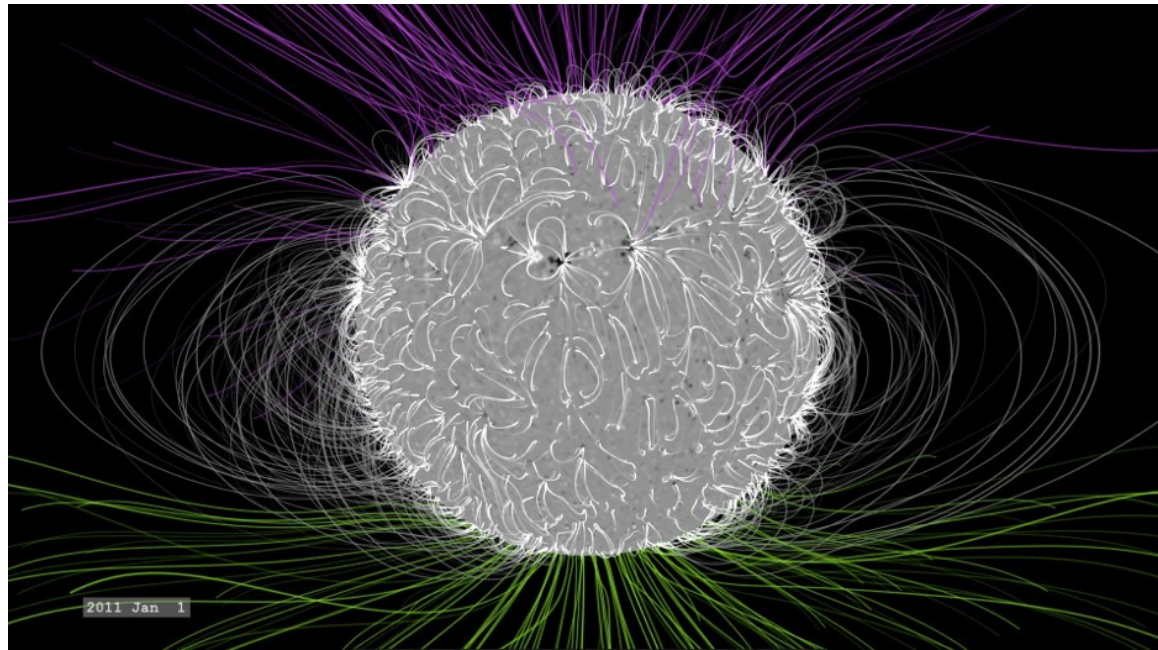


... фази на спокойствие и активност

Слънчев магнитен цикъл - наблюдения



Слънчев магнитен цикъл - модели



NASA/GSFC

Корона

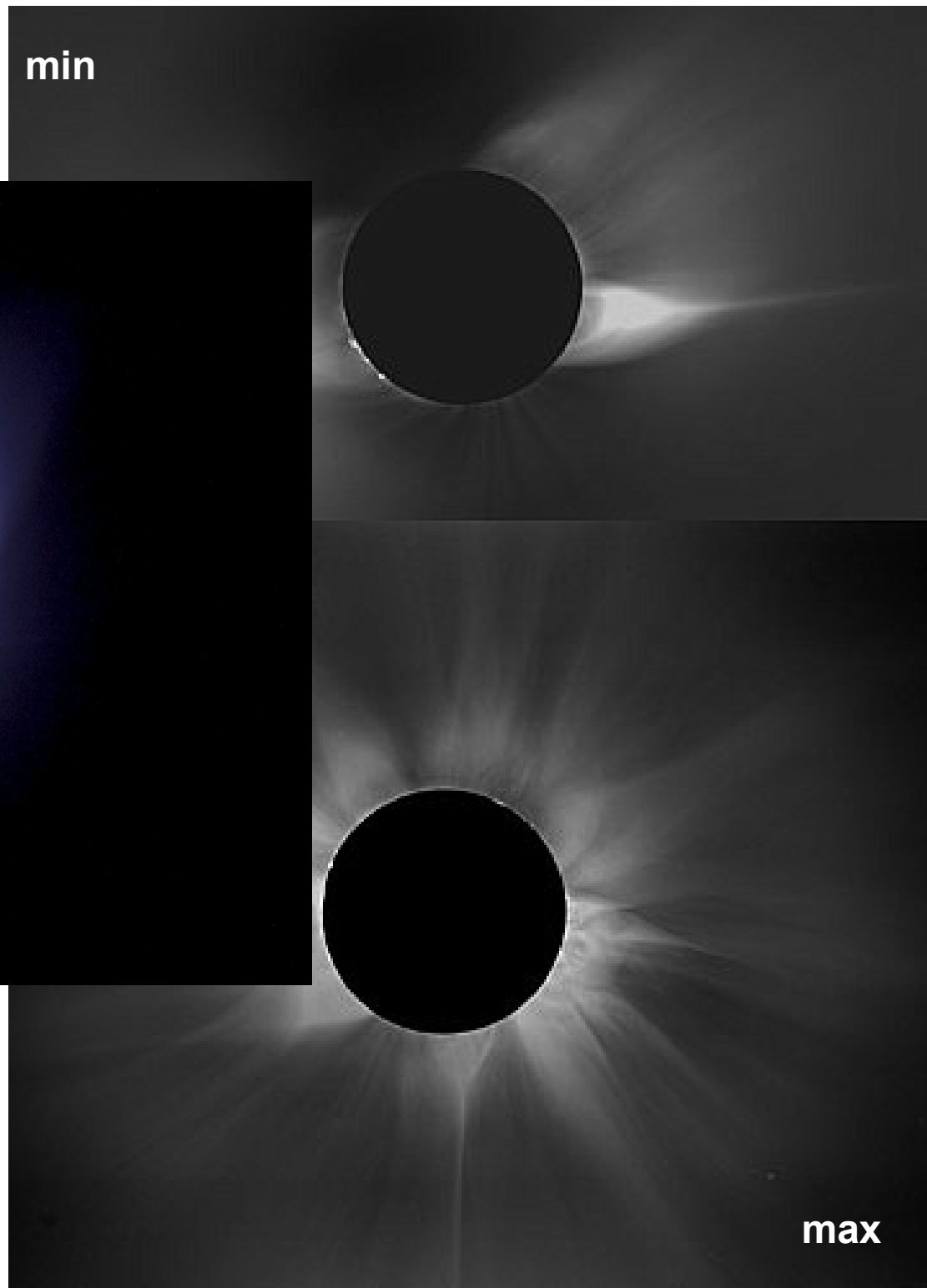
min



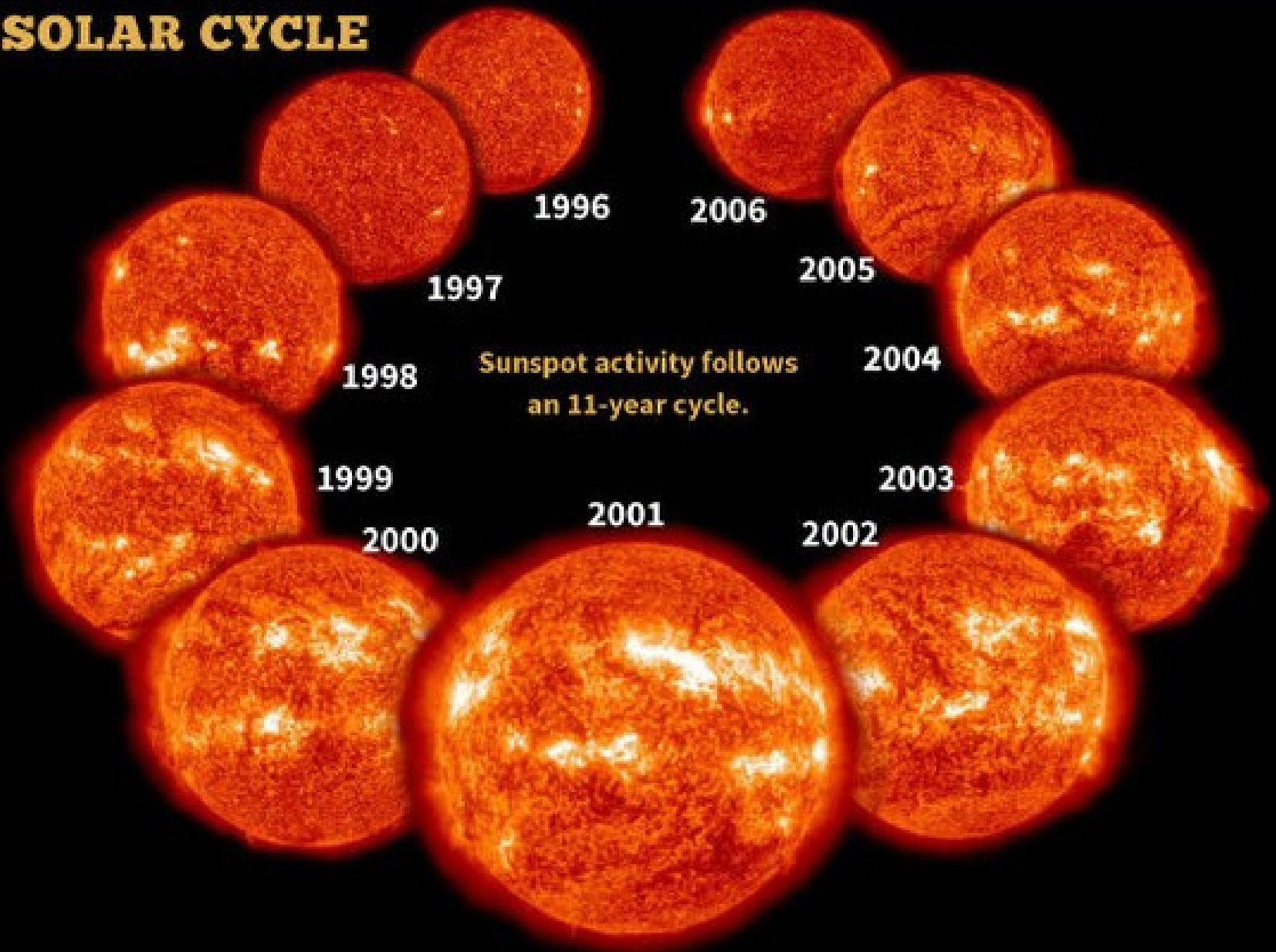
Н. Петров, 21-08-2017

<https://scied.ucar.edu/sun-corona-solar-min-max>

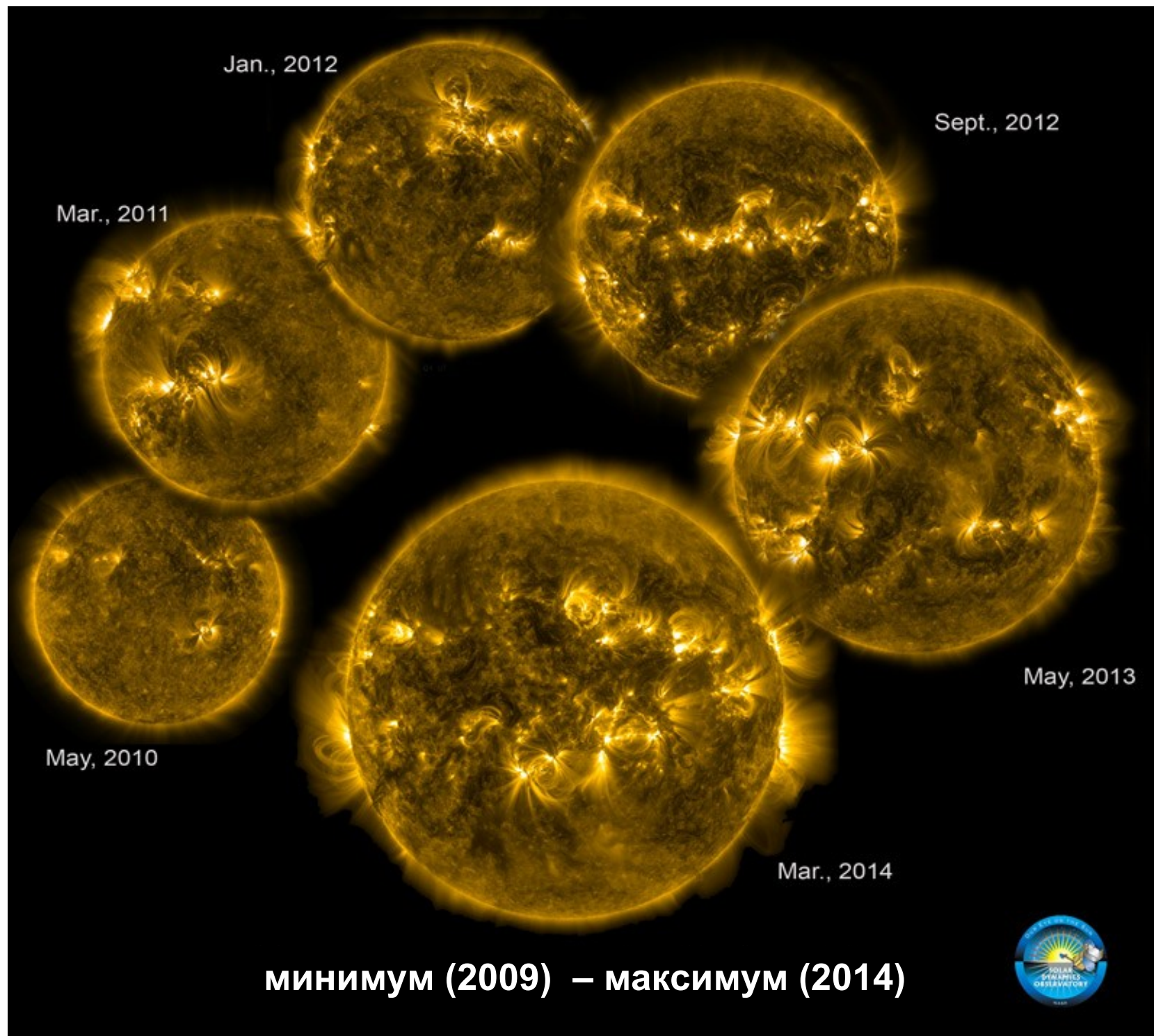
max



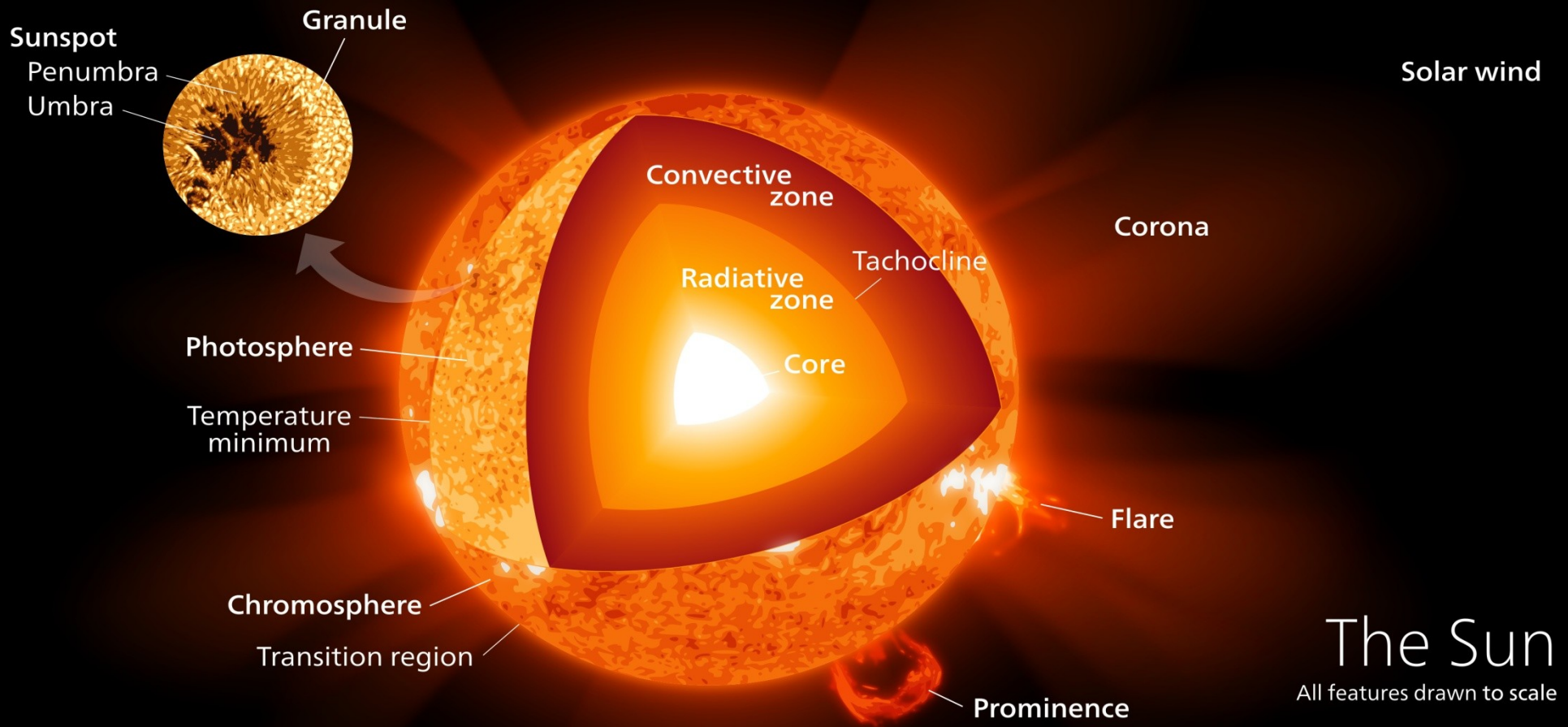
SOLAR CYCLE



минимум (1996) – максимум (2001) – минимум (2006)



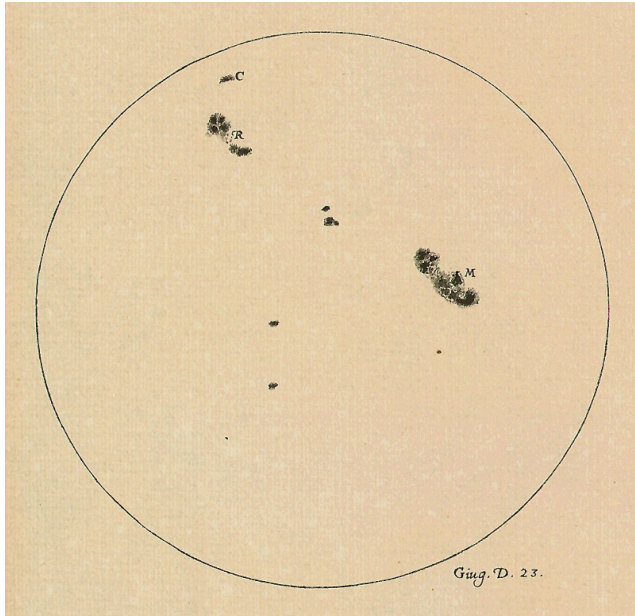
Слънчева активност



Kelvinsong, <https://commons.wikimedia.org/w/index.php?curid=23371669>

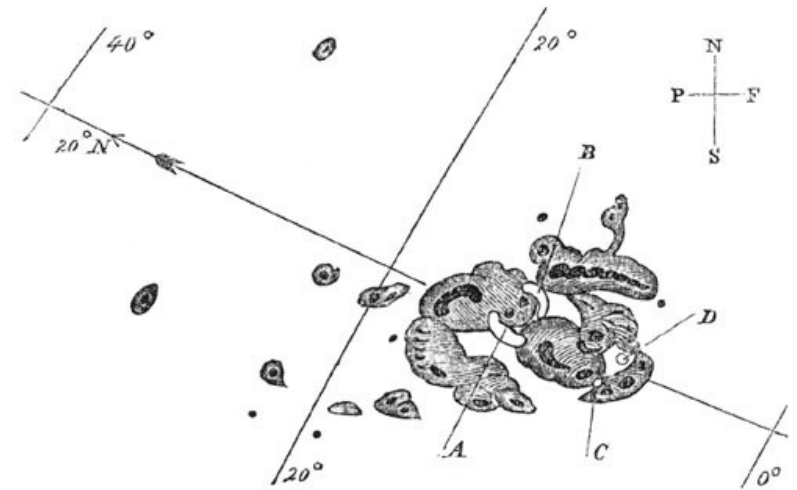
Слънчеви петна (активни области)
Избухвания
Коронални изхвърляния на маса
Протуберанси
Енергетични частици

Слънчеви петна

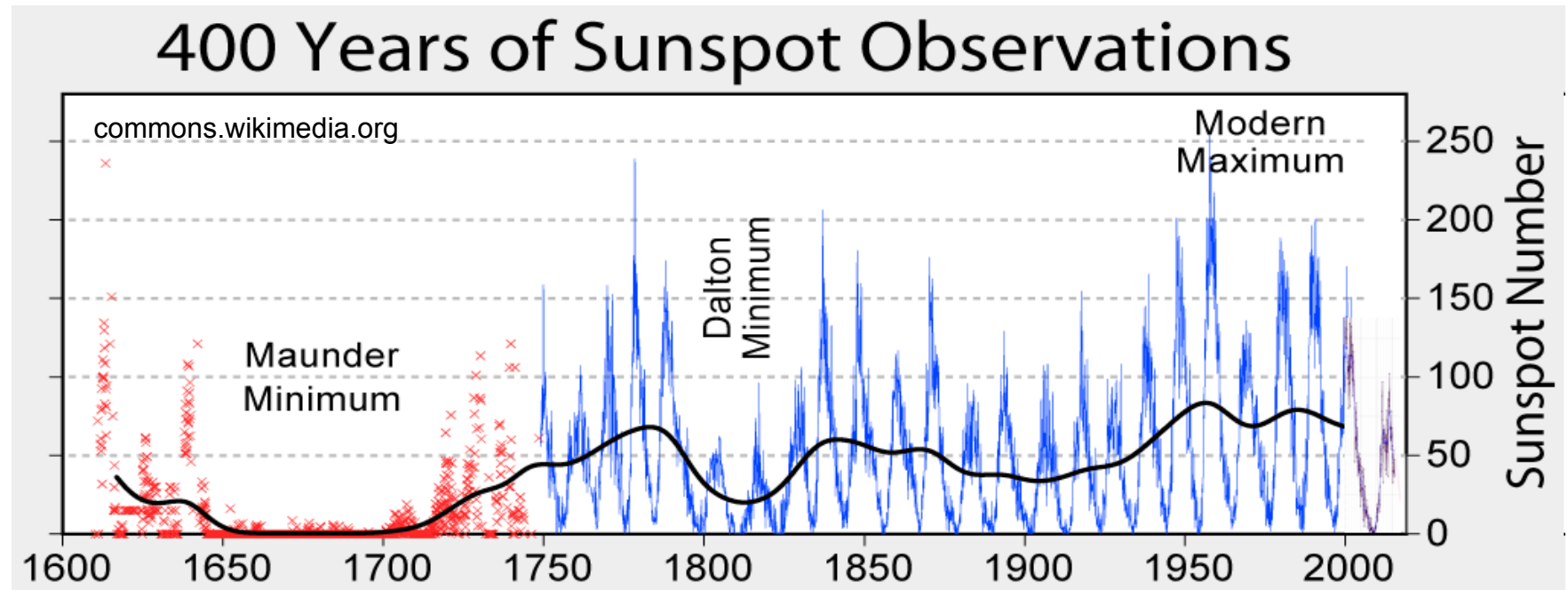


Галилей, 23-06-1613

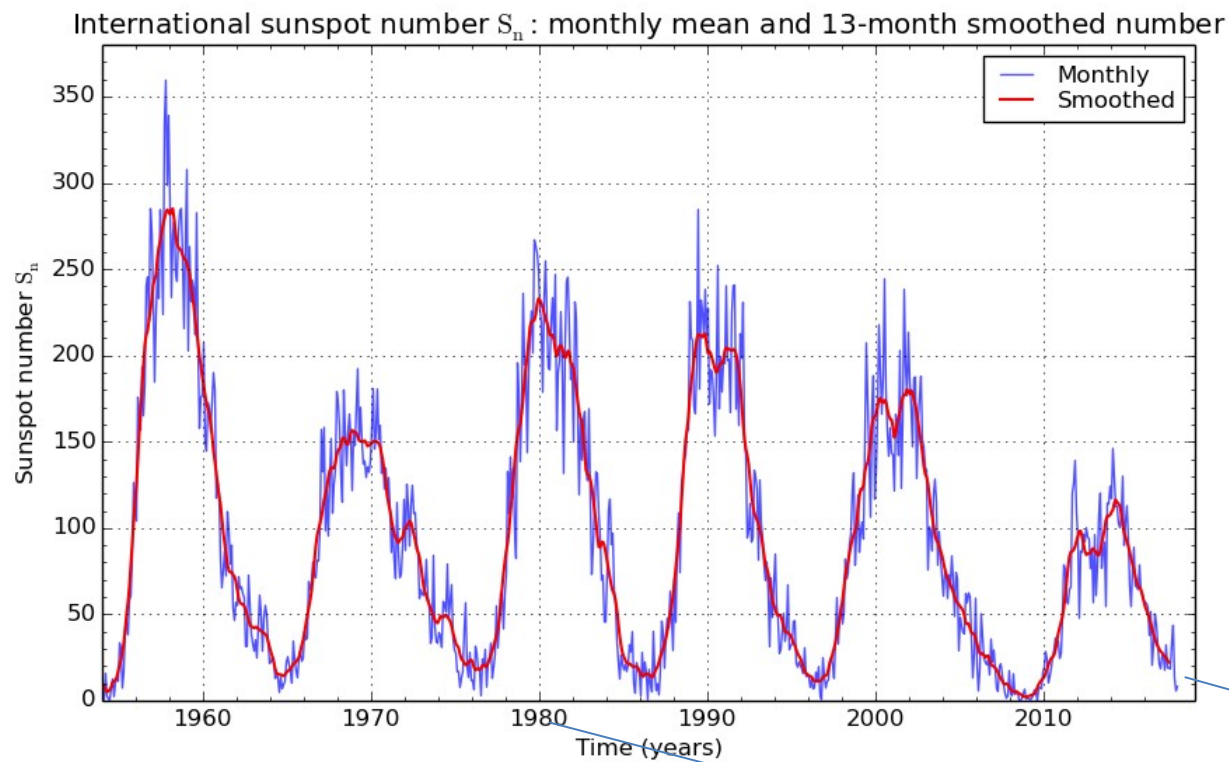
http://galileo.rice.edu/sci/observations/sunspot_drawings.html



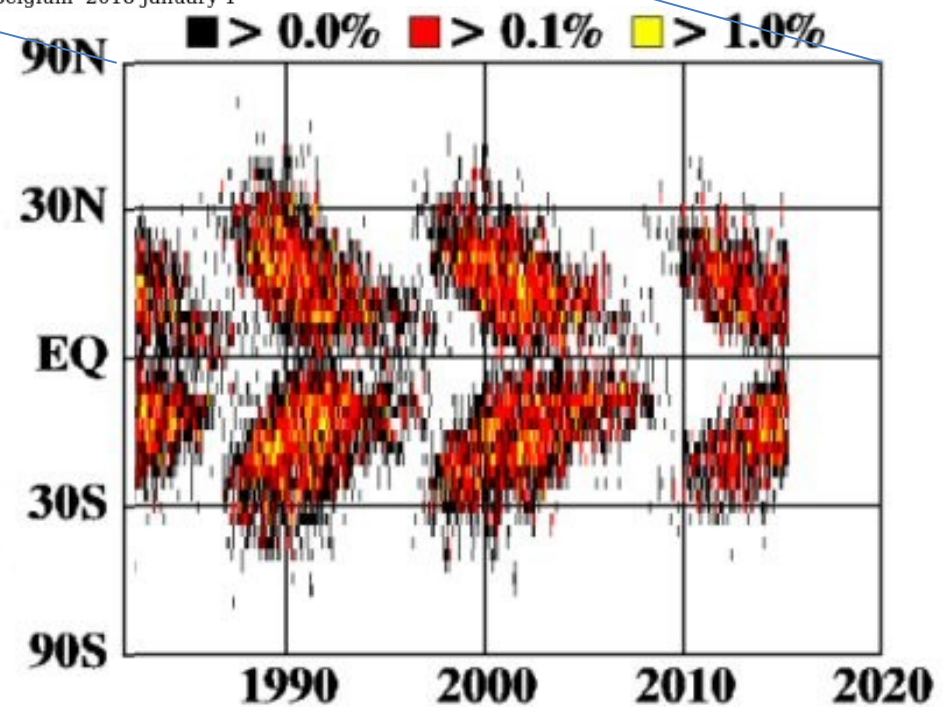
Карингтън, 01-09-1859
MNRAS, 1859



Слънчеви цикли

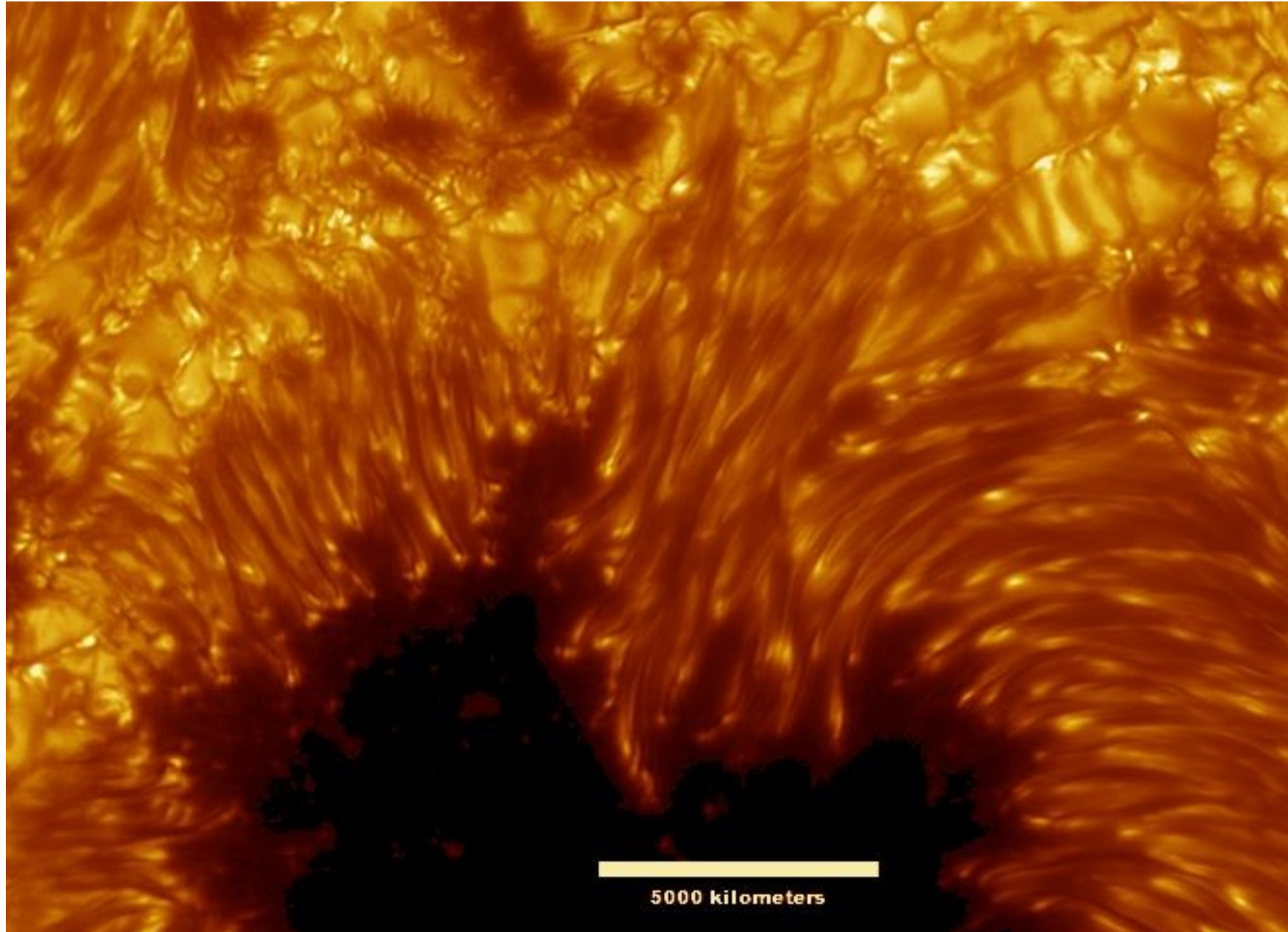


SILSO graphics (<http://sidc.be/silso>) Royal Observatory of Belgium 2018 January 1



Слънчеви петна

[sunspots]



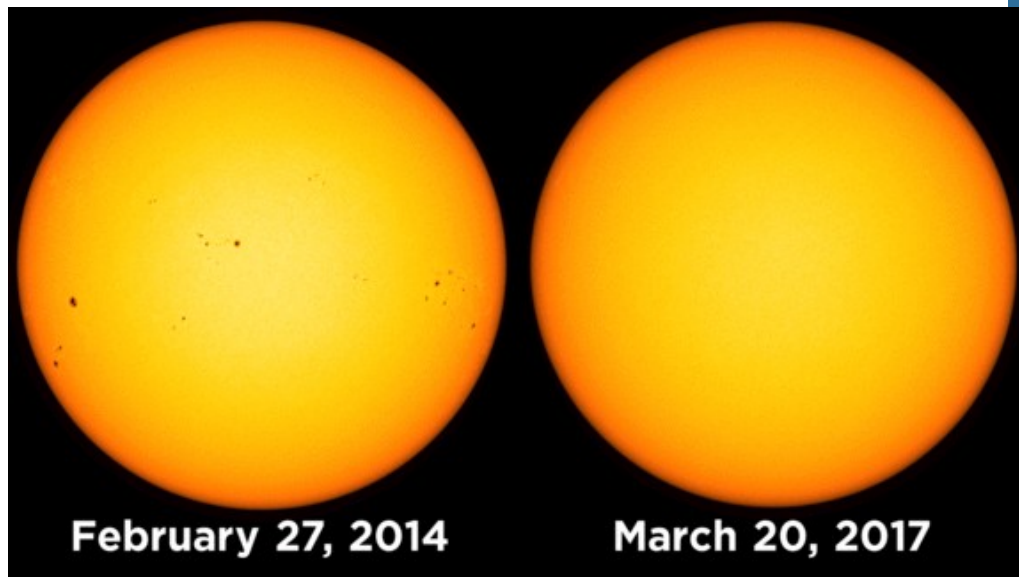
1-m
Swedish
Telescope

15 Jul 2002

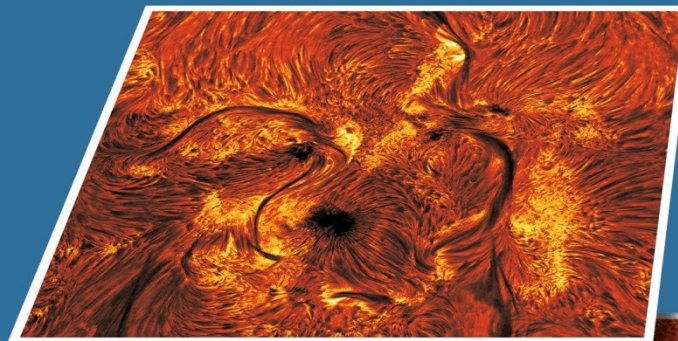
Royal Swedish Academy of Sciences

<http://www.isf.astro.su.se/>

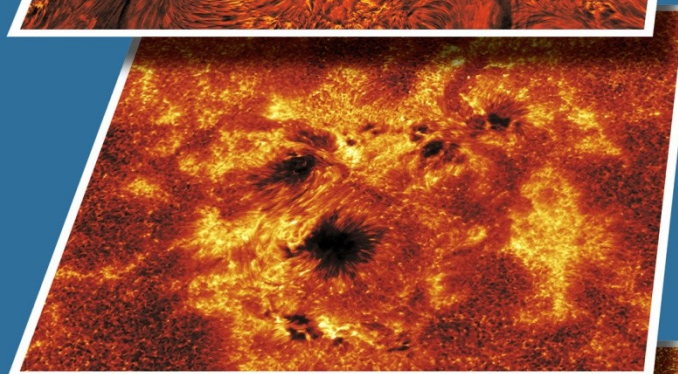
Слънчеви петна [sunspots]



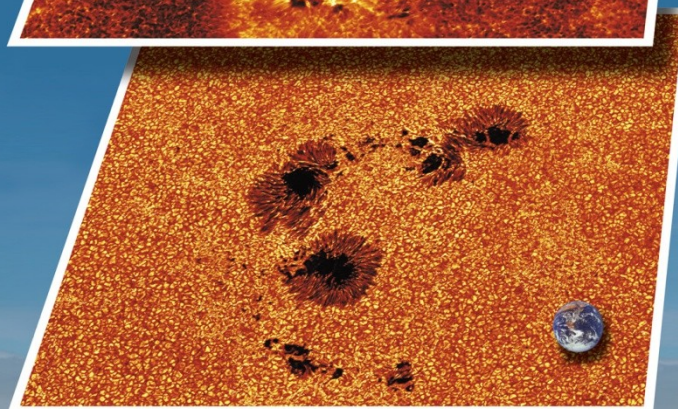
NASA's Solar Dynamics Observatory
Joy Ng/NASA's GSFC/SDO
<https://www.space.com/36188-spotless-sun-has-no-sunspots.html>



H α , 656.3 nm
хромосфера
+2000 км



Ca II, 397 nm
ниска хромосфера
+500 км



G-band, 430.5 nm
фотосфера 0 км

Dutch Open Telescope
Ла Палма (Канарски острови)
08-06-2005

<http://staff.science.uu.nl>



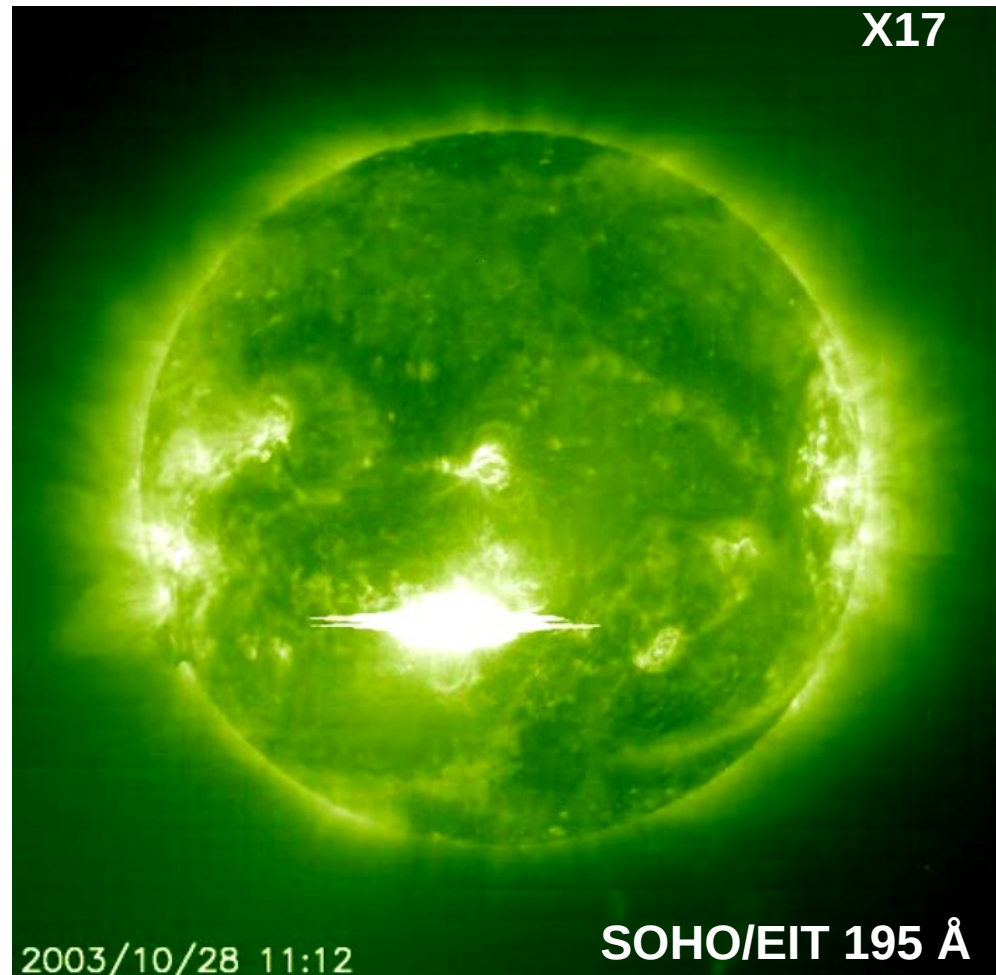
Слънчево избухване [solar flare]

Внезапна, бърза и интензивна промяна в яркостта: огромна експлозия в слънчевата атмосфера, която създава:

- излъчване: от γ до радио вълни (10^{32} erg or 10^{25} J)
- движение на плазма
- заредени частици

Често се наблюдава в активни области, където има различна полярност на магнитните силови линии

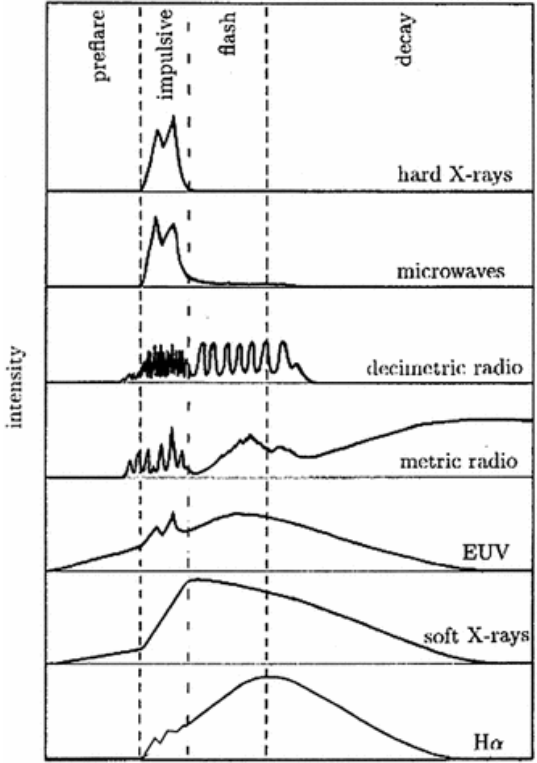
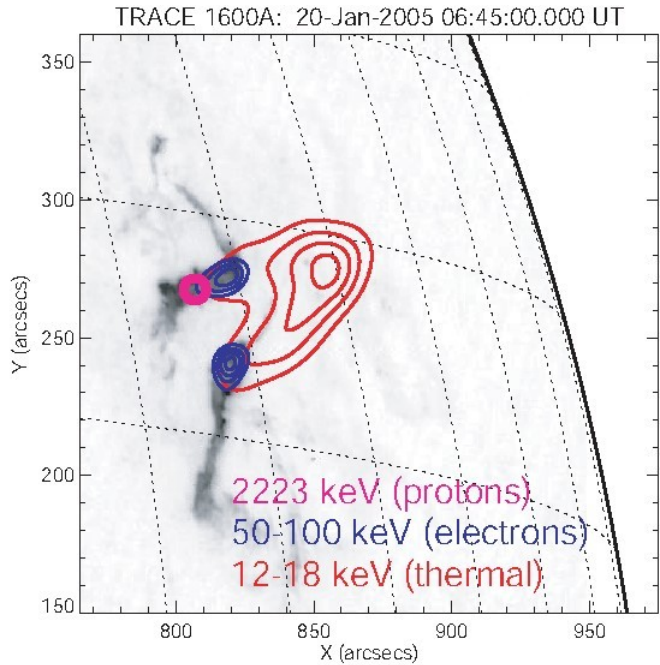
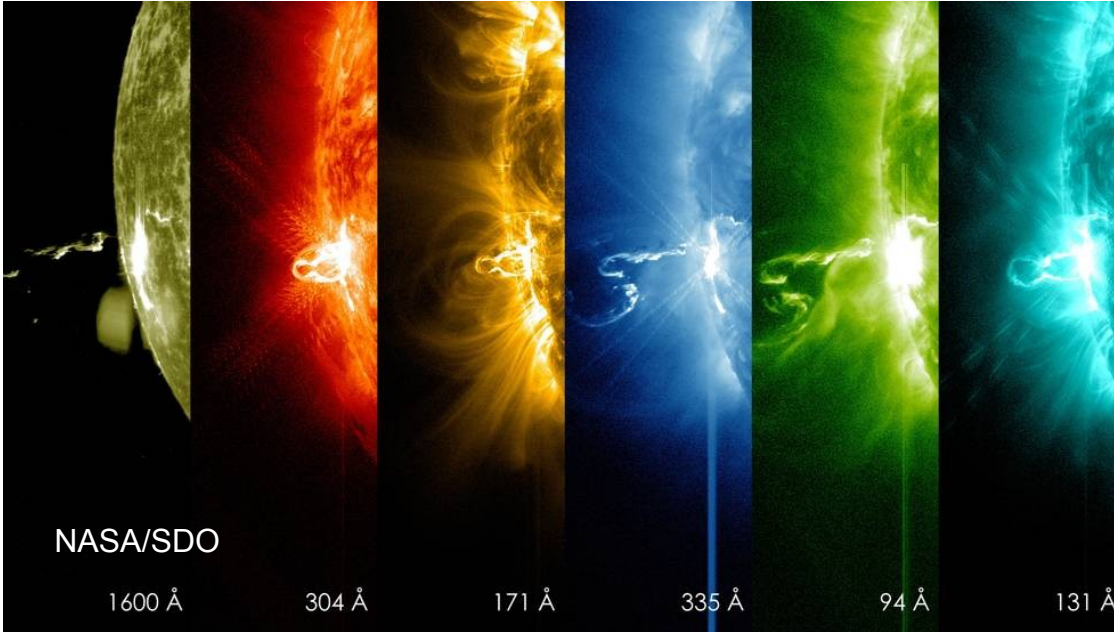
Спътникови и наземни наблюдения – в зависимост от дължината на вълната



Слънчево избухване

[solar flare]

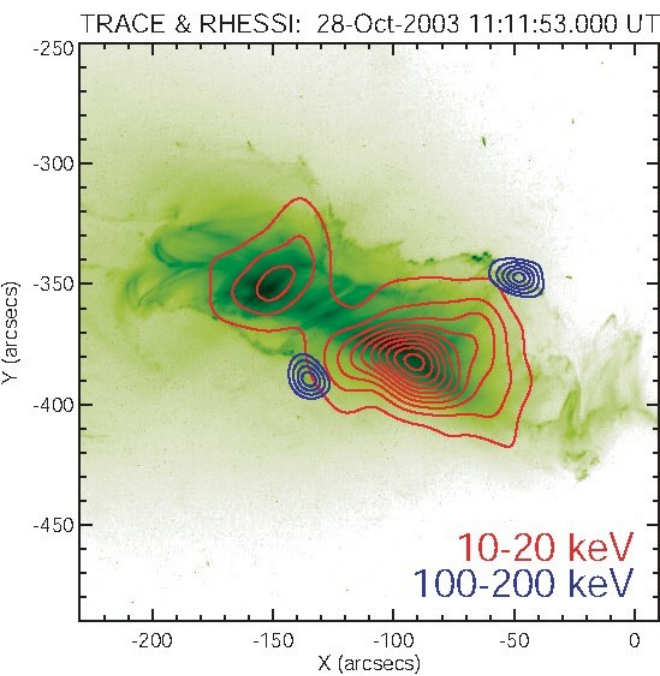
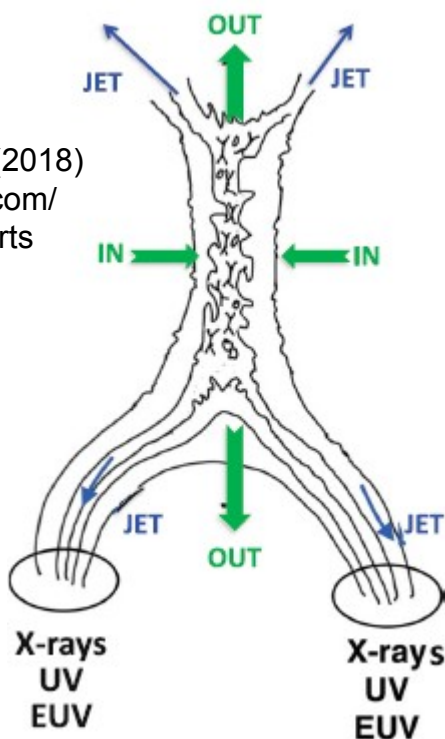
X4.9
($X=10^{-4}$ W/m²)
25-02-2014
(00:39 UT)



Benz (2002)

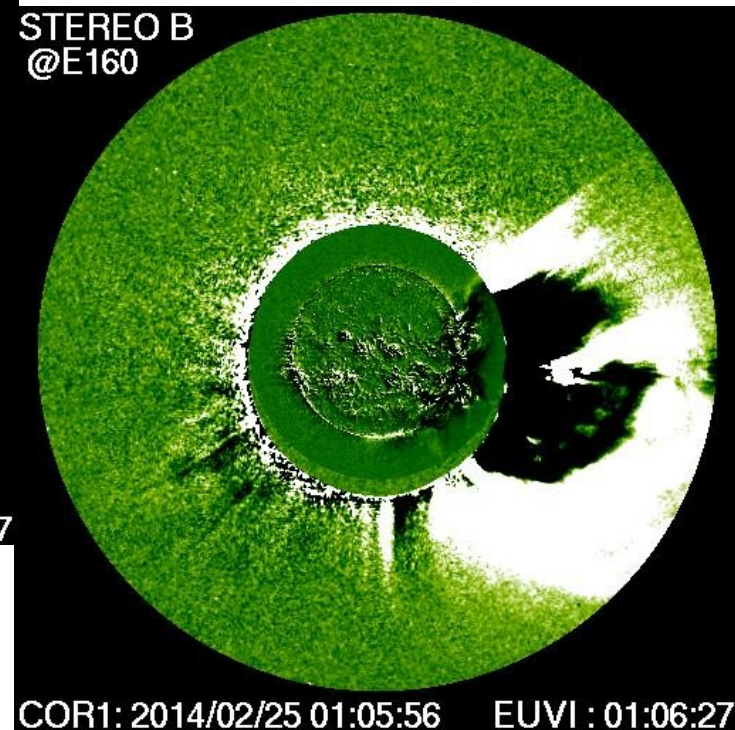
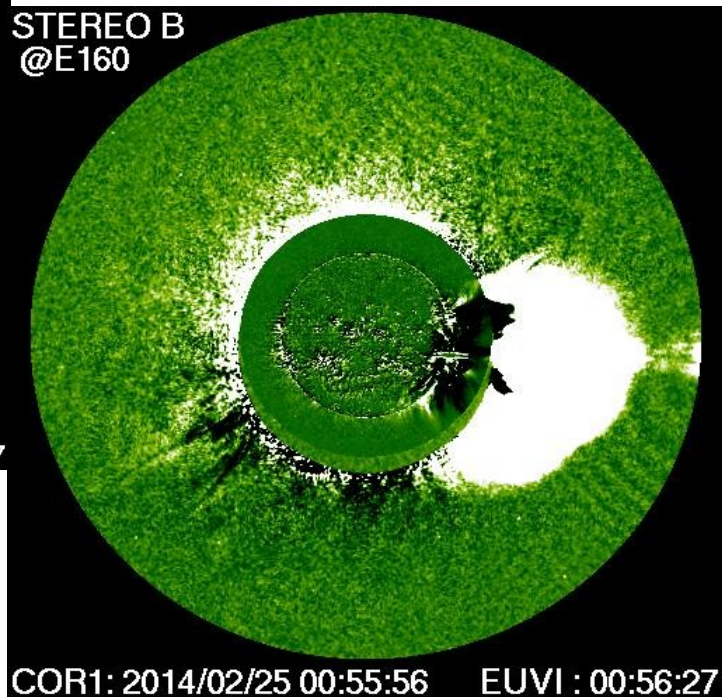
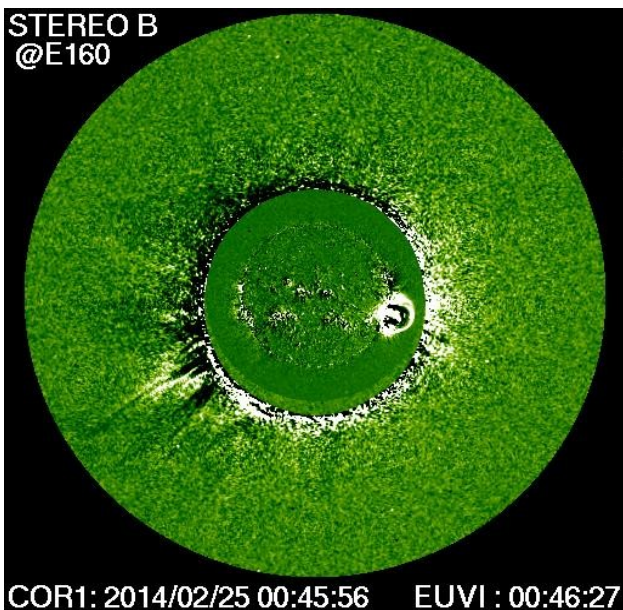
time

Cairns et al. (2018)
www.nature.com/scientificreports



Hard X-ray and γ -line
S. Krucker
ILWS workshop 2006

Коронално изхвърляне на маса [coronal mass ejection: CME]



Открити през 1970-те

наблюдения: чрез закриване
на ярката фотосфера (от земята и спътници)

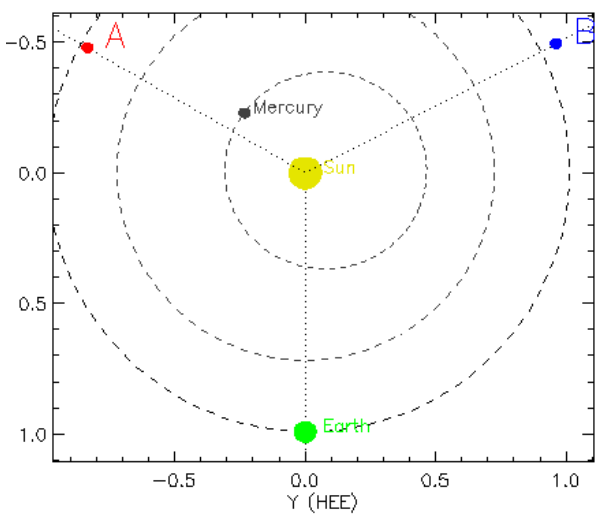
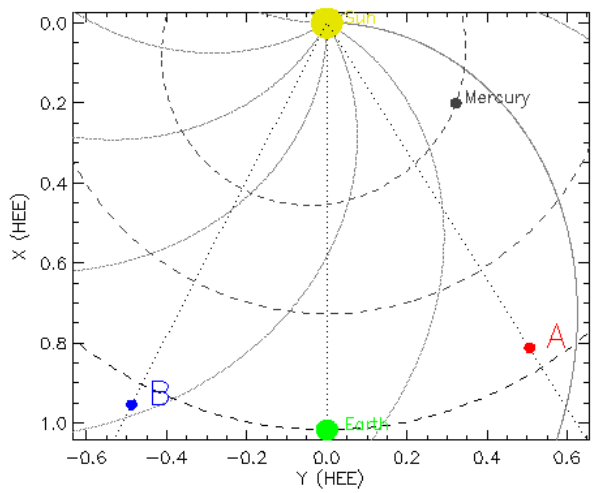
Представяват огромни облаци от плазма и
магнитно поле

Скорости – в проекция: 100 km/s – 3000 km/s

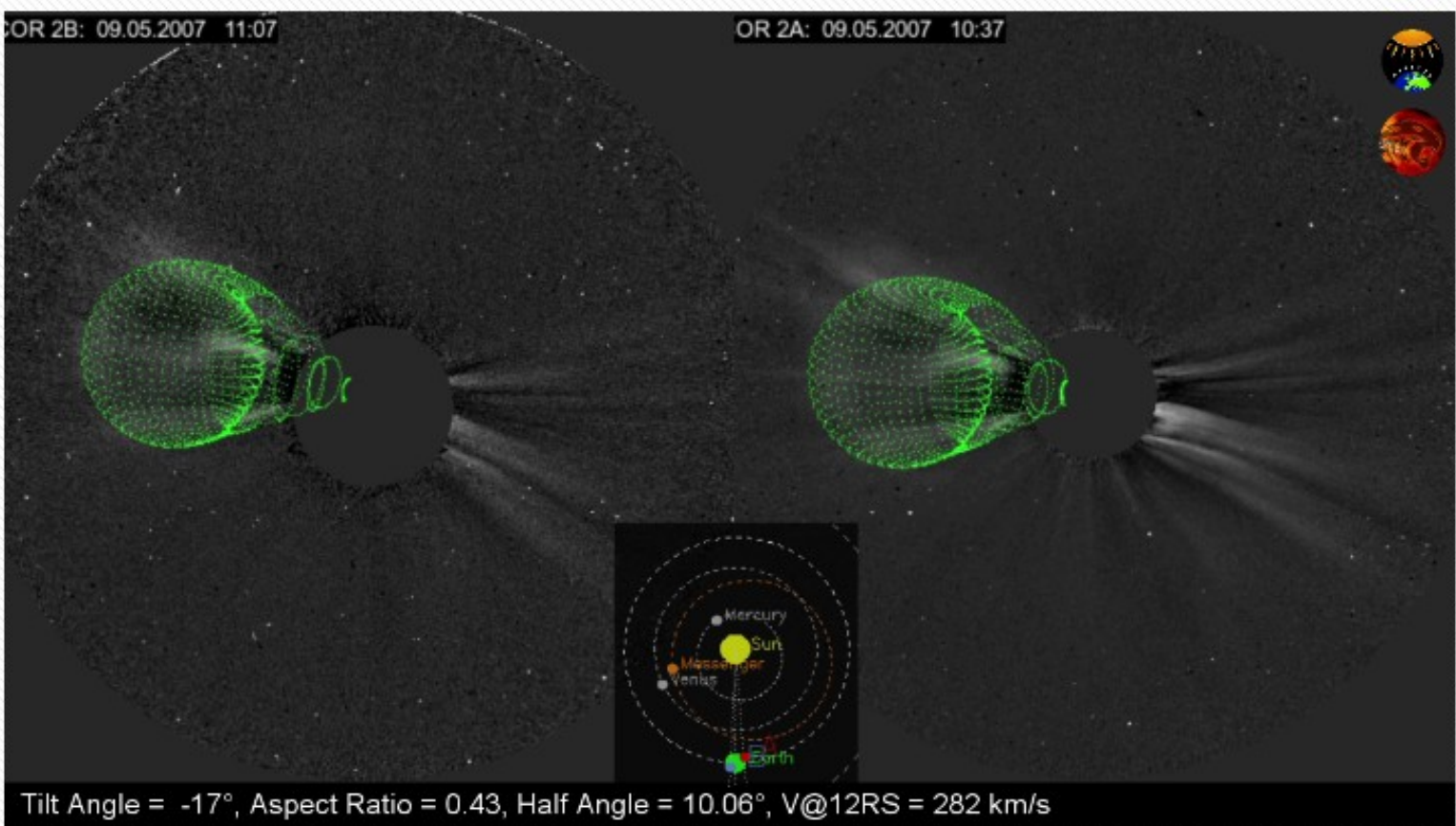
Маса: $\sim 10^{15}$ g (1–10 % от слънчевия вятър)

Коронално изхвърляне на маса [CME]

STEREO: 2008 ↔ 2018 <https://stereo-ssc.nascom.nasa.gov>



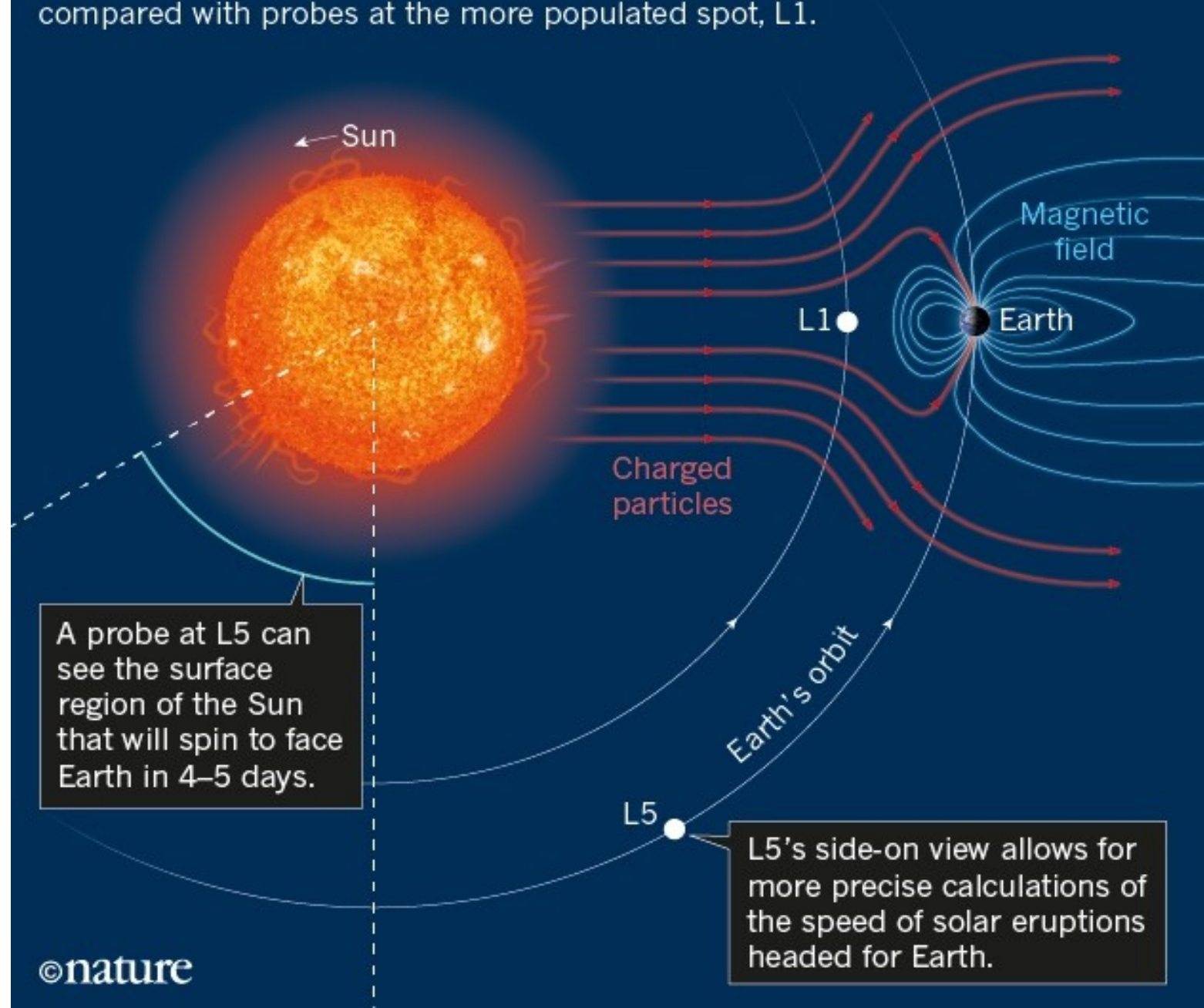
<http://www.affects-fp7.eu/>
<https://www.helcats-fp7.eu/>



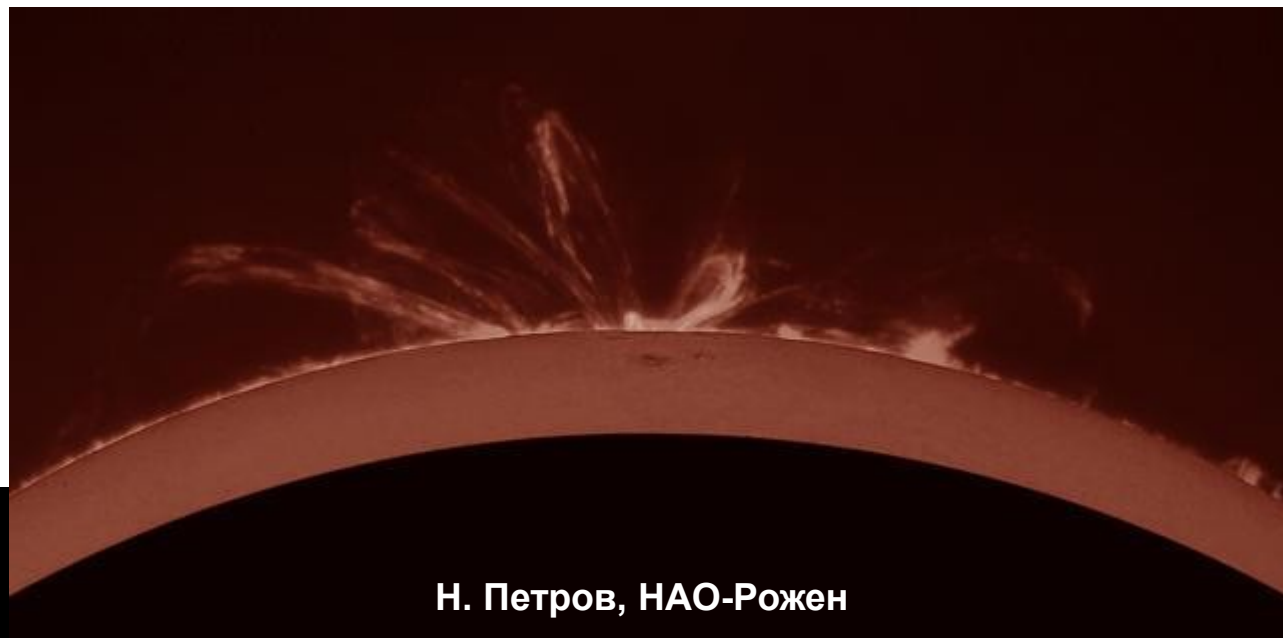
Наблюдения на Слънцето

PARKING SPACE-WEATHER PROBES

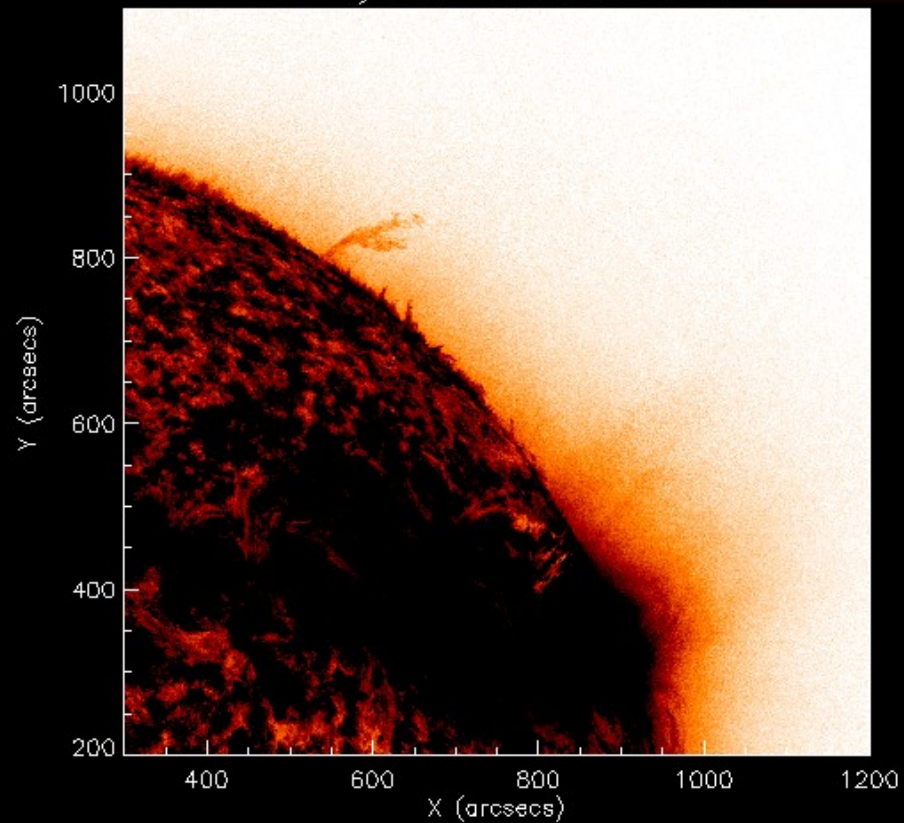
The European Space Agency hopes to place its new probe at the gravitationally stable Lagrange point 5 (L5), where it will have a different view of the Sun compared with probes at the more populated spot, L1.



Протуберанси/ филаменти [prominence/ filaments]

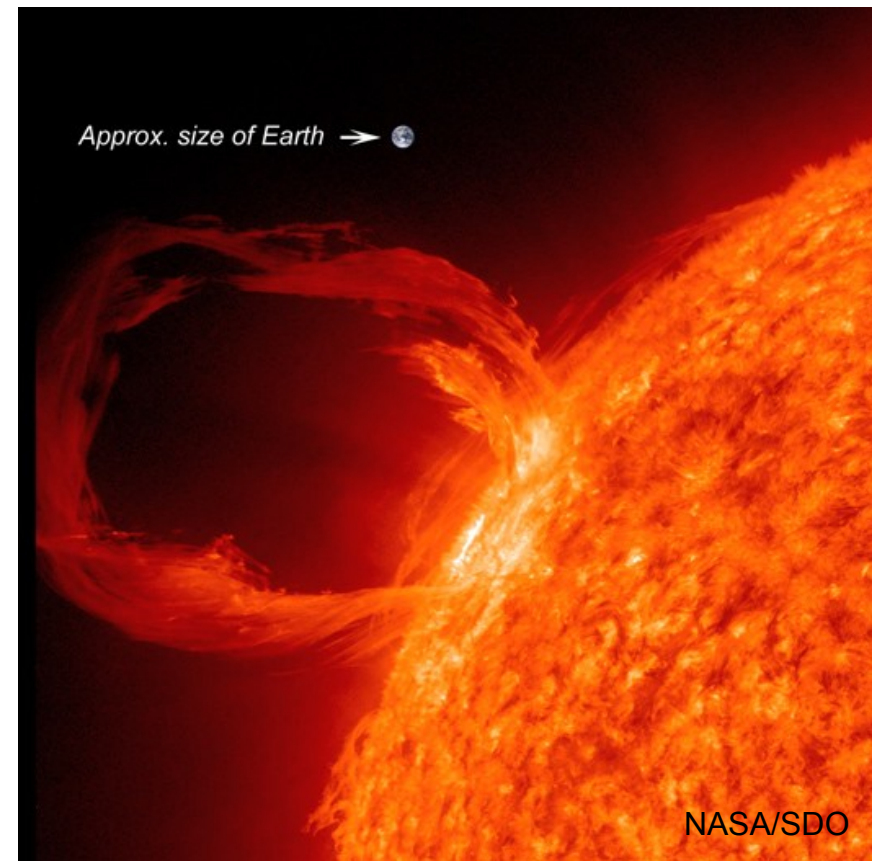


11-May-2011 02:25:08.120 UT

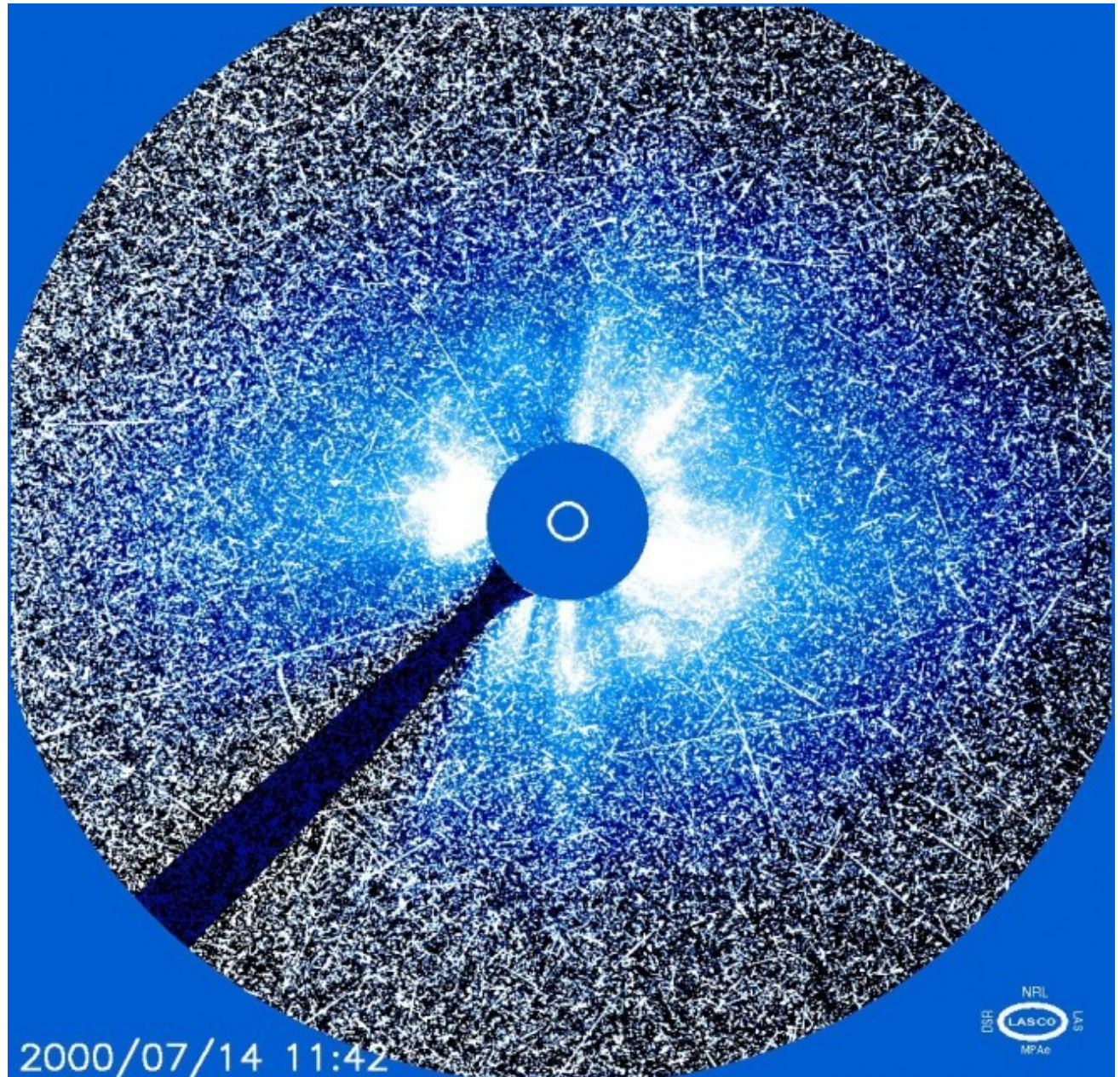


Ц. Цветков

SDO/NASA 304 Å



Слънчеви енергетични частици [solar energetic particles]

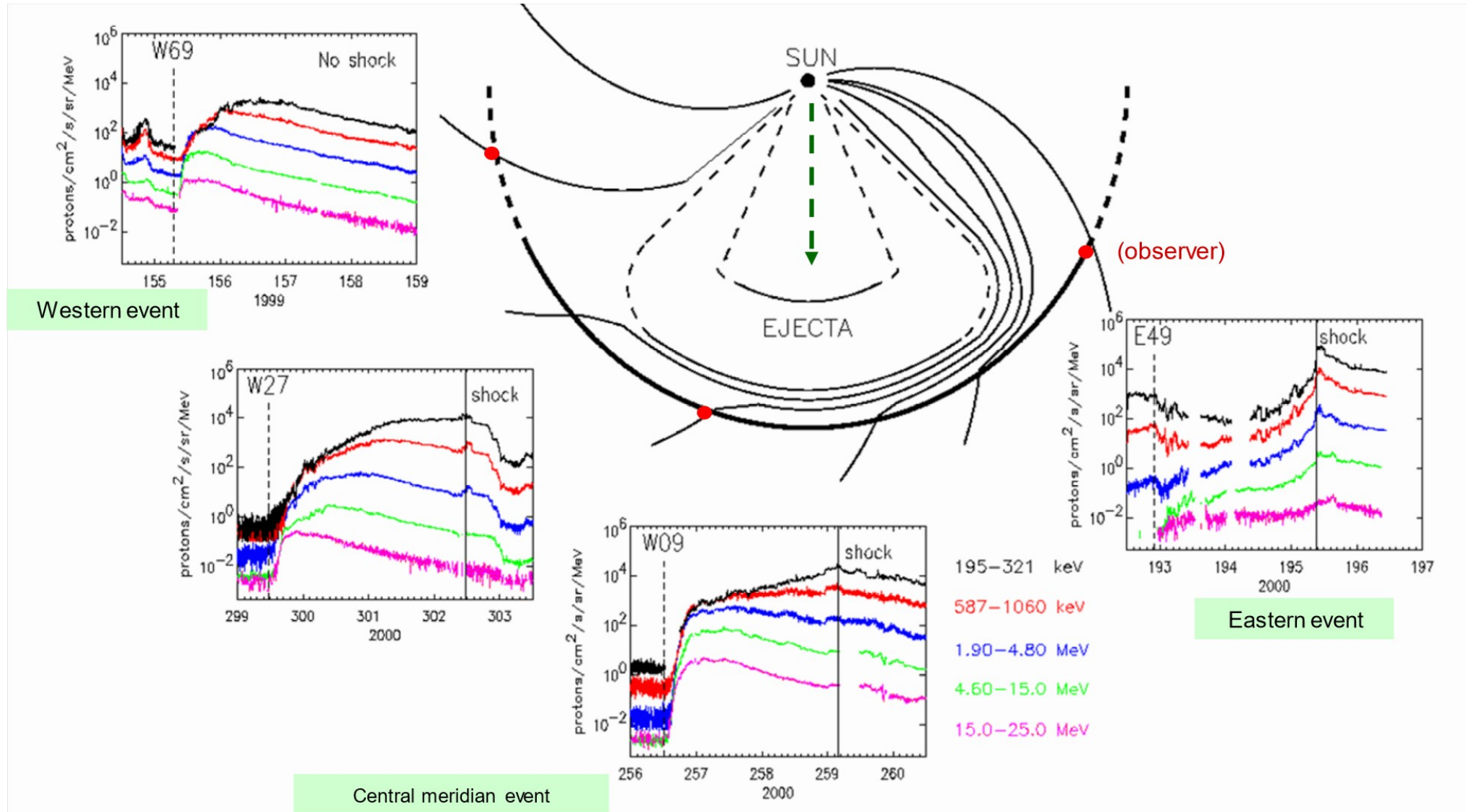


SOHO/LASCO
ESA & NASA

2000/07/14 11:42

Слънчеви енергетични частици

[solar energetic particles]



Космическо време

Национален план по космическо време на САЩ:

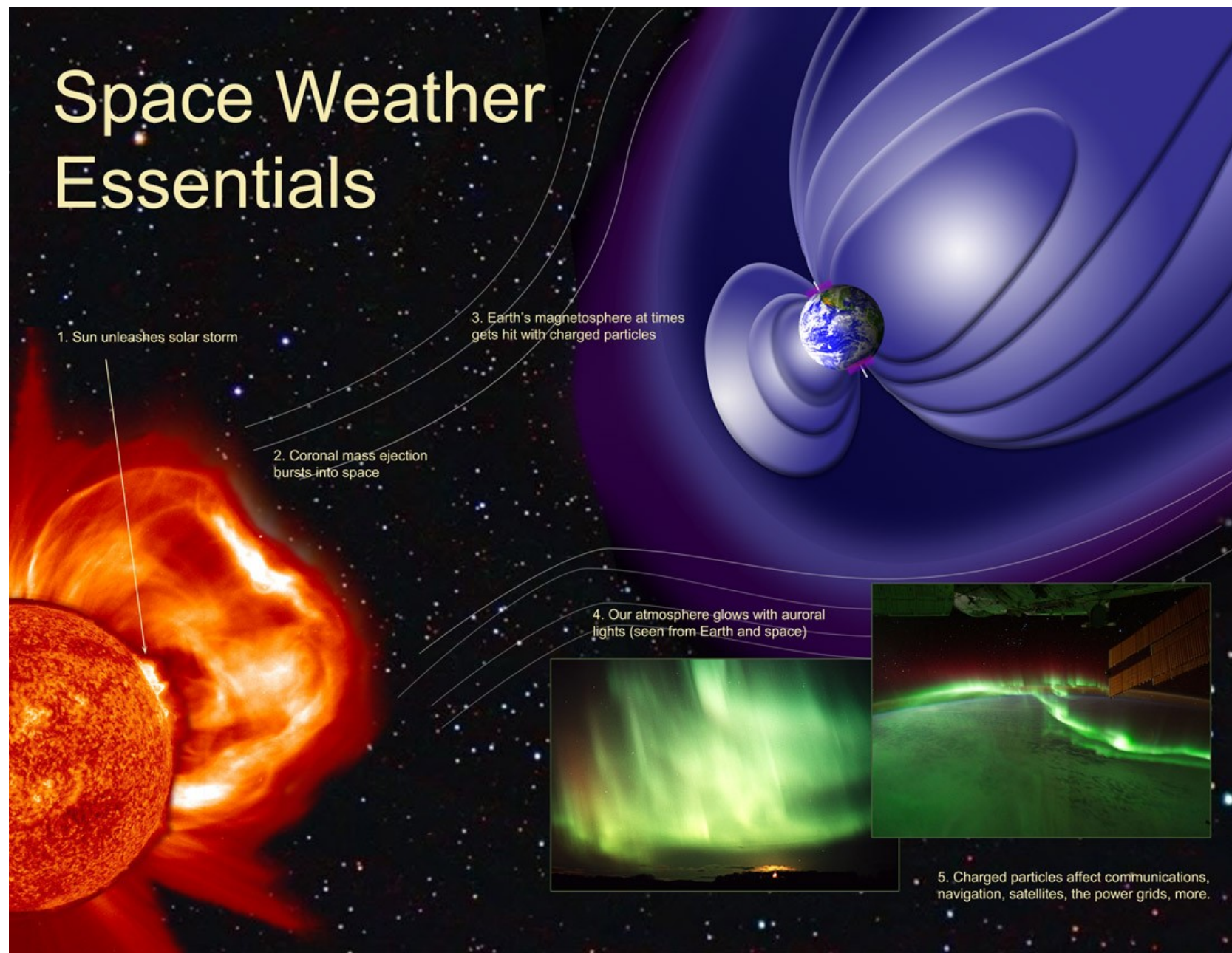
„... космическо време се отнася до условията [и промените, наблюдавани в краткосрочен план] на Слънцето и в слънчевия вятър, магнитосферата, йоносферата и термосферата, които могат да повлияят върху работата и надеждността на космически и наземни технологични системи и да въздействат върху човешкия живот и здраве...“

Избрани обзорни статии със свободен достъп (на англ. ез.):

R. Schwenn, 'Space Weather: The Solar Perspective', Living Rev. Solar Phys. (2006, 2010)

T. Pulkkinen, 'Space Weather: Terrestrial Perspective', Living Rev. Solar Phys. (2007)

Гео- магнитни бури



Причини за геомагнитните бури

- южна компонента на междупланетното магнитно поле
- бързоскоростни потоци от плазма

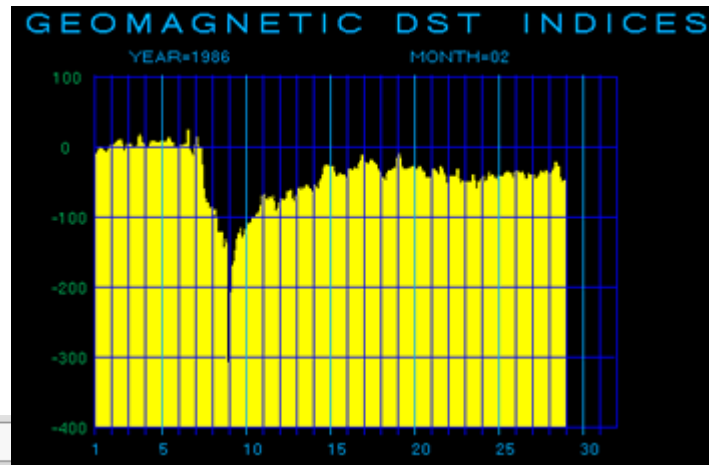
Измервания

компоненти на приземното магнитно поле

$\sim 60 \mu\text{T} = 0.6 \text{ Gauss}$ в полярните области
 $\sim 30 \mu\text{T} = 0.3 \text{ Gauss}$ на екватора
 $1 \text{ Tesla} = 10^4 \text{ Gauss}$
 11° наклон към оста на въртене

Геомагнитни бури

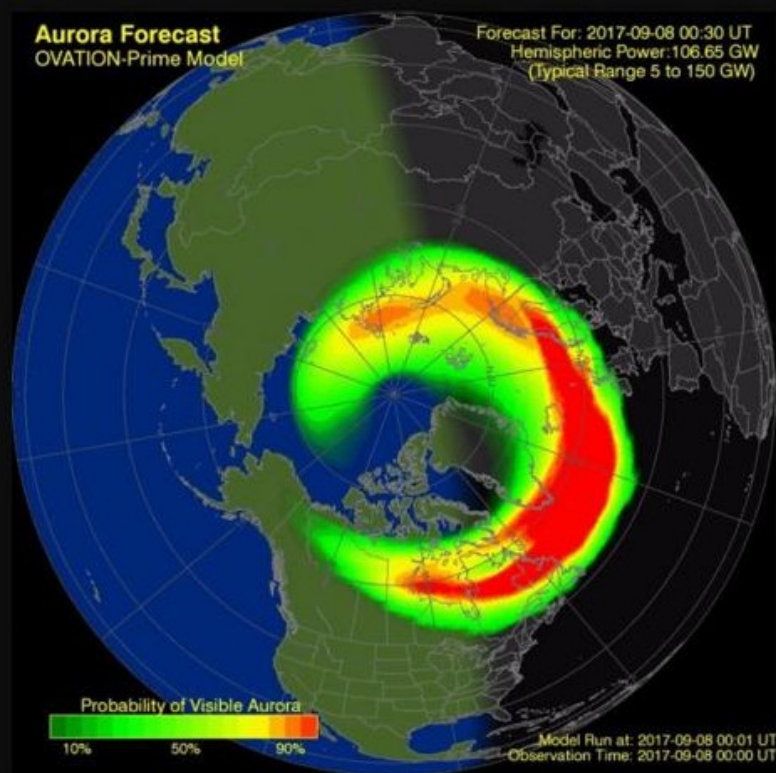
www.ngdc.noaa.gov/stp/GEOMAG/dst.html



www.swpc.noaa.gov/news/update-continued-g4-severe-geomagnetic-storming-observed

Severe storm conditions met at: 07/2350 UTC

G4



G4

UPDATE: CONTINUED G4 (SEVERE) GEOMAGNETIC STORMING OBSERVED

published: Saturday, September 09, 2017 01:54 UTC

G4 (Severe) geomagnetic storm levels were observed at 2350 UTC (19:50 Eastern) on 07 September, again at 0151 UTC (21:51 Eastern) on 08 September and 1304 UTC (09:04 Eastern) due to effects from a coronal mass ejection. A G3 (Strong) or greater warning continues to be in effect until 1500 UTC (11:00 Eastern) on 08 September.

Геомагнитни бури



NOAA Space Weather Scales

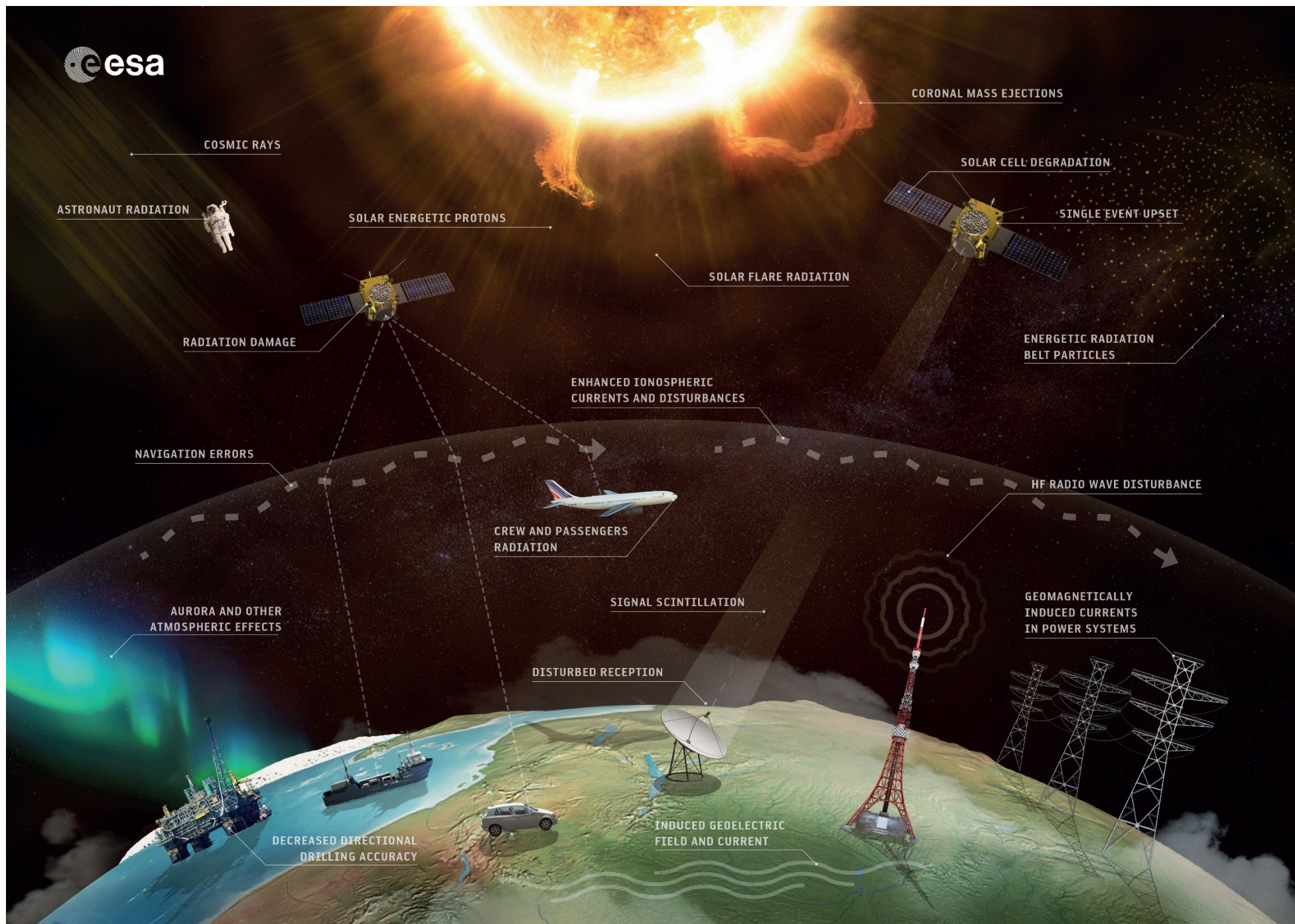


Category		Effect	Physical measure	Average Frequency (1 cycle = 11 years)
Scale	Descriptor	Duration of event will influence severity of effects		
Geomagnetic Storms			Kp values* determined every 3 hours	Number of storm events when Kp level was met; (number of storm days)
G 5	Extreme	<u>Power systems</u>: widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage. <u>Spacecraft operations</u>: may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites. <u>Other systems</u>: pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.).**	Kp=9	4 per cycle (4 days per cycle)
G 4	Severe	<u>Power systems</u>: possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid. <u>Spacecraft operations</u>: may experience surface charging and tracking problems, corrections may be needed for orientation problems. <u>Other systems</u>: induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.).**	Kp=8	100 per cycle (60 days per cycle)
G 3	Strong	<u>Power systems</u>: voltage corrections may be required, false alarms triggered on some protection devices. <u>Spacecraft operations</u>: surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems. <u>Other systems</u>: intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.).**	Kp=7	200 per cycle (130 days per cycle)
G 2	Moderate	<u>Power systems</u>: high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage. <u>Spacecraft operations</u>: corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions. <u>Other systems</u>: HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.).**	Kp=6	600 per cycle (360 days per cycle)
G 1	Minor	<u>Power systems</u>: weak power grid fluctuations can occur. <u>Spacecraft operations</u>: minor impact on satellite operations possible. <u>Other systems</u>: migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).**	Kp=5	1700 per cycle (900 days per cycle)

* Based on this measure, but other physical measures are also considered.

** For specific locations around the globe, use geomagnetic latitude to determine likely sightings (see www.swpc.noaa.gov/Aurora)

Космическо време



Космическо време

Sunspots

Sunspots are comparatively cool areas at up to 7,700° F and show the location of strong magnetic fields protruding through what we would see as the Sun's surface. Large, complex sunspot groups are generally the source of significant space weather.

Coronal Mass Ejections (CMEs)

Large portions of the corona, or outer atmosphere of the Sun, can be explosively blown into space, sending billions of tons of plasma, or superheated gas, Earth's direction. These CMEs have their own magnetic field and can slam into and interact with Earth's magnetic field, resulting in geomagnetic storms. The fastest of these CMEs can reach Earth in under a day, with the slowest taking 4 or 5 days to reach Earth.

Solar Wind

The solar wind is a constant outflow of electrons and protons from the Sun, always present and buffeting Earth's magnetic field. The background solar wind flows at approximately one million miles per hour!

Solar Flares

Reconnection of the magnetic fields on the surface of the Sun drive the biggest explosions in our solar system. These solar flares release immense amounts of energy and result in electromagnetic emissions spanning the spectrum from gamma rays to radio waves. Traveling at the speed of light, these emissions make the 93 million mile trip to Earth in just 8 minutes.

Earth's Magnetic Field

Earth's magnetic field, largely like that of a bar magnet, gives the Earth some protection from the effects of the Sun. Earth's magnetic field is constantly compressed on the day side and stretched on the night side by the ever-present solar wind. During geomagnetic storms, the disturbances to Earth's magnetic field can become extreme. In addition to some buffering by the atmosphere, this field also offers some shielding from the charged particles of a radiation storm.

Space Weather

Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space-based and ground-based technological systems, as well as endanger life or health. Just like weather on Earth, space weather has its seasons, with solar activity rising and falling over an approximate 11 year cycle.

Sun's Magnetic Field

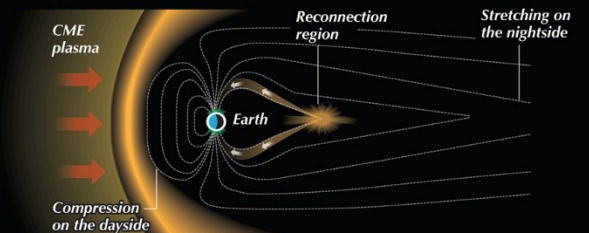
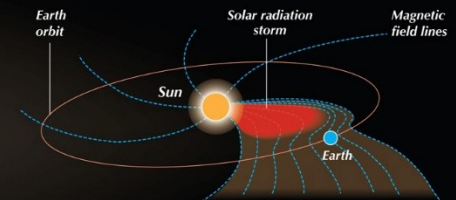
Strong and ever-changing magnetic fields drive the life of the Sun and underlie sunspots. These strong magnetic fields are the energy source for space weather and their twisting, shearing, and reconnection lead to solar flares.

Solar Radiation Storms

Charged particles, including electrons and protons, can be accelerated by coronal mass ejections and solar flares. These particles bounce and gyrate their way through space, roughly following the magnetic field lines and ultimately bombarding Earth from every direction. The fastest of these particles can affect Earth tens of minutes after a solar flare.

Geomagnetic Storms

A geomagnetic storm is a temporary disturbance of Earth's magnetic field typically associated with enhancements in the solar wind. These storms are created when the solar wind and its magnetic field interacts with Earth's magnetic field. The primary source of geomagnetic storms is CMEs which stretch the magnetosphere on the nightside causing it to release energy through magnetic reconnection. Disturbances in the ionosphere (a region of Earth's upper atmosphere) are usually associated with geomagnetic storms.



Космическо време

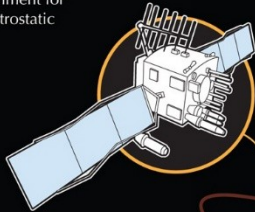
Global Positioning System (GPS)

Geomagnetic storms can impact the accuracy and availability of GPS by changing the ionosphere, the electrically charged layer of the atmosphere. A GPS signal must pass through from satellite to ground receiver. The ionosphere is the largest source of error in GPS positioning and navigation. These ionospheric disturbances are ever-present but can become severe during geomagnetic storms, resulting in range errors in excess of 100 feet, or even resulting in loss of lock on the GPS signal entirely. These errors can have significant impacts on precision uses of GPS such as navigation, agriculture, oil drilling, surveying, and timing.



Satellite Operations

There are thousands of satellites in orbit around Earth with applications in television and radio, communications, meteorology, national defense, and much more. Space weather can affect these satellites in many ways. Solar radiation storms can cause spacecraft orientation problems by interfering with star trackers and by causing errors or damage in electronic devices. Geomagnetic storms can create a hazardous charging environment for satellites resulting in damaging electrostatic discharge, much like touching a door knob and getting that spark on a dry winter day. Geomagnetic storms also cause heating of the atmosphere, essentially causing it to expand, which results in more drag or slowing down of an orbiting satellite. In a worst case, space weather can cause the satellite to fail.



Space Operations

Astronauts and their equipment in space are bombarded with charged particle radiation. This radiation causes tissue or cell damage in humans. Space weather and solar radiation storms are of particular concern for activities outside the protection of Earth's atmosphere and magnetic field.

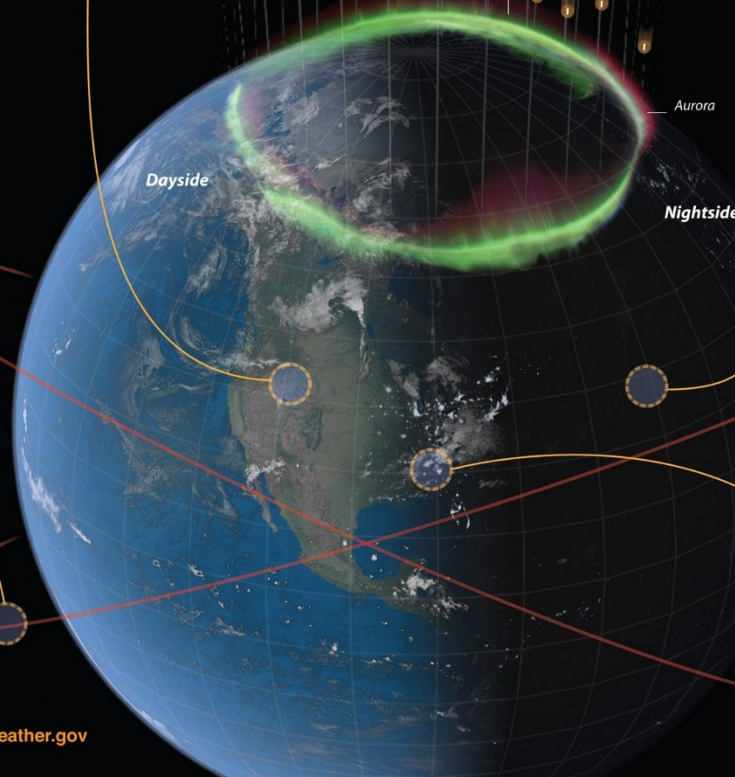


Space Weather Impacts on Earth

Electrons accelerated in the tail of the magnetosphere travel down the magnetic field lines.

Electrons collide with the upper atmosphere 50 to 300 miles above Earth.

Electrons exchange energy with the atmosphere exciting the atmospheric atoms and molecules to higher energy levels. When the atoms and molecules relax back to lower energy levels, they release their energy in the form of light.



Aurora

The Aurora Borealis (Northern Lights) and Aurora Australis (Southern Lights) are the result of electrons colliding with Earth's upper atmosphere. The electrons are energized through acceleration processes in the downwind tail (nightside) of the magnetosphere. The accelerated electrons follow the magnetic field of Earth down to the polar regions where they collide with oxygen and nitrogen atoms and molecules in Earth's upper atmosphere. In these collisions, the electrons transfer their energy to the atmosphere, thus exciting the atoms and molecules to higher energy states. When they relax back to lower energy states, they release their energy in the form of light. The aurora typically forms 50 to 300 miles above the ground. Earth's magnetic field guides the electrons such that the aurora forms two ovals approximately centered at each magnetic pole.



THE COLORS OF THE AURORA

- Deep red from high altitude atomic nitrogen
- Magenta from high altitude molecular nitrogen in sunlight
- Greenish yellow from lower altitude atomic oxygen
- Magenta from low altitude molecular nitrogen (not shown in the picture)

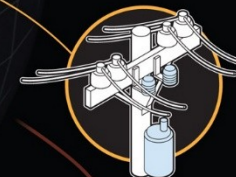
Aviation

Aircraft use High Frequency (HF) radio communication to stay in touch with ground controllers in remote areas such as over the oceans or over the poles. Solar flares can "black out" the use of HF on the dayside of Earth and solar radiation storms can "black out" use of HF near the poles, impacting the aircraft's ability to stay in touch with the ground. Impacts to GPS systems can also significantly affect airline operations.



Power Grids

Geomagnetic storms result in electric currents in the magnetosphere and ionosphere as the area shaped by Earth's magnetic field is compressed and disturbed. The disturbed conditions create additional currents in long conductors on the ground such as overhead transmission lines or long pipelines. In the most extreme cases, these currents can cause voltage instability or damage to power system components, potentially resulting in temporary service disruptions, or even a widespread power outage.

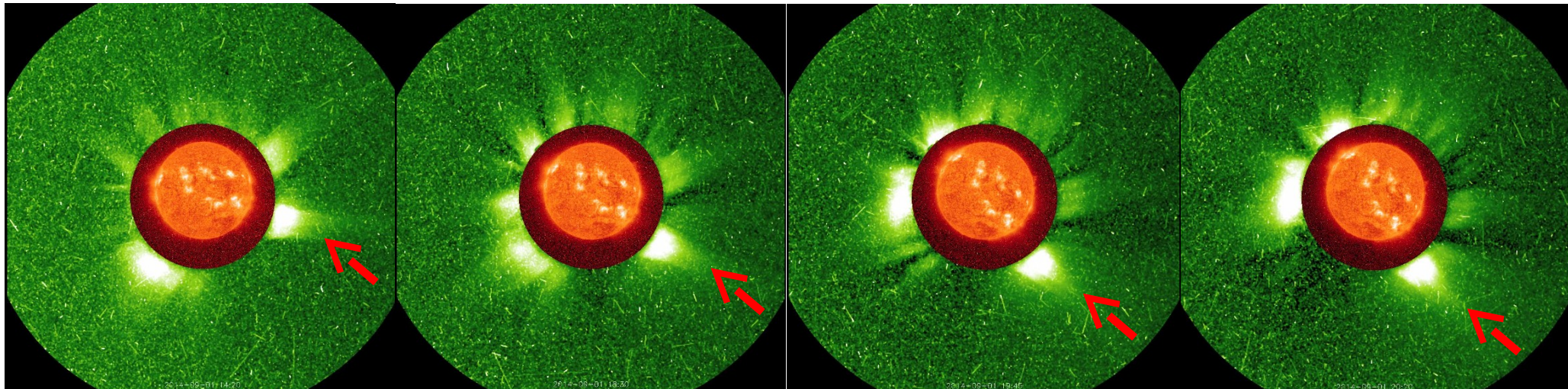
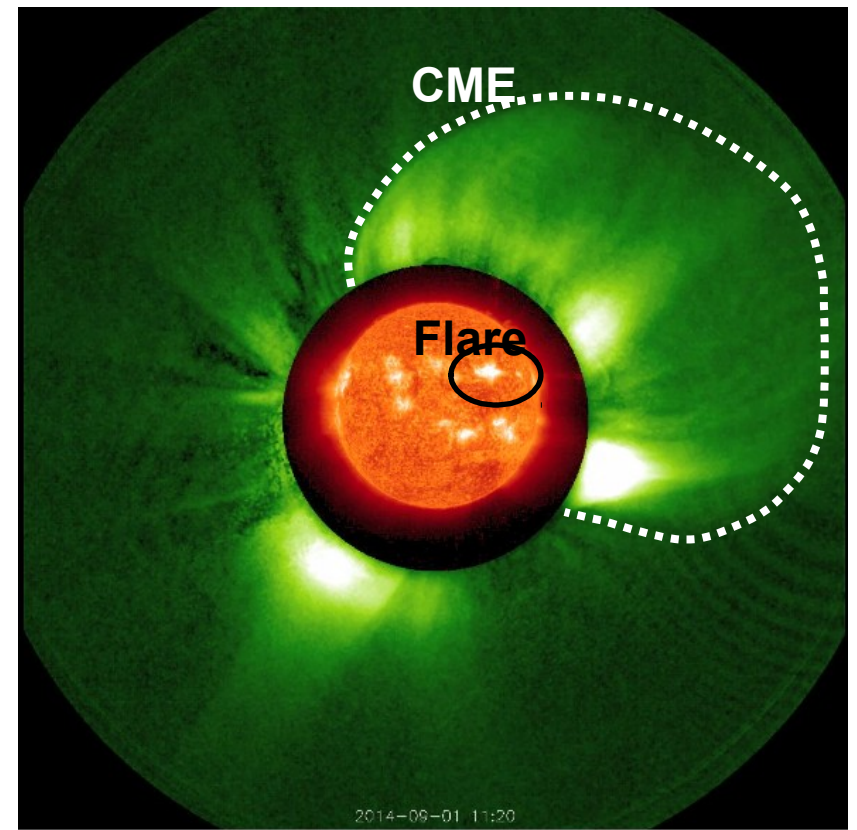


NOAA Education www.education.noaa.gov

NOAA Space Weather Prediction Center www.spaceweather.gov

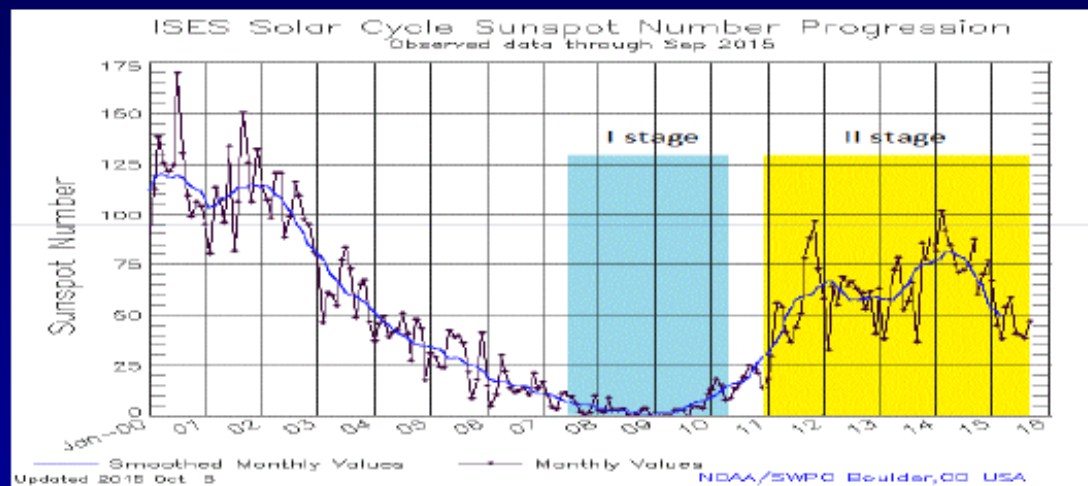
*Image source: Aurora Borealis taken from the International Space Station in April of 2012.

Космическо време - стабилност на спътници

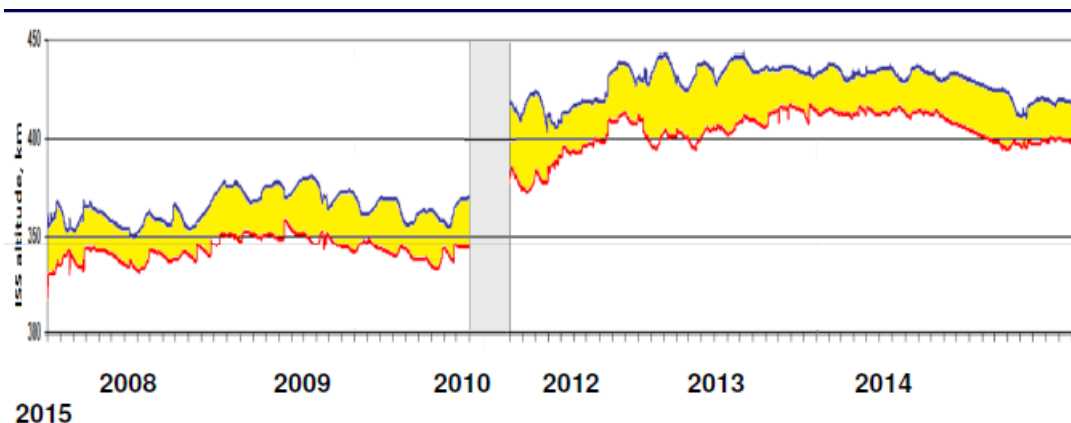
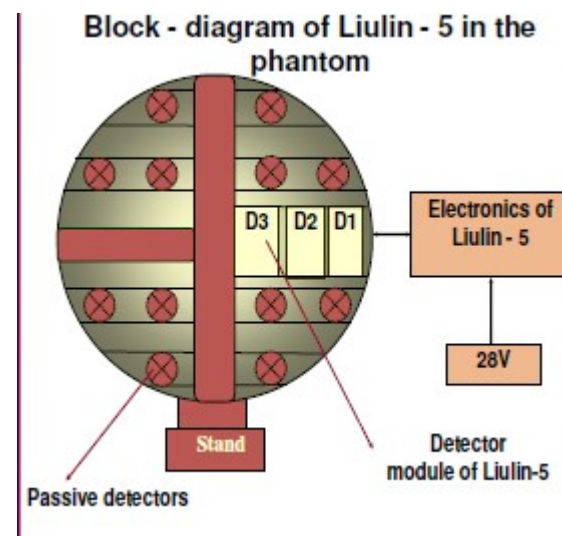


Подготовка за пилотирани мисии до Марс – българското участие на МКС: Люлин-5

Experiment Liulin-5 was observing the radiation characteristics in the spherical tissue-equivalent phantom of MATROSHKA-R project on ISS since June 2007 till September 2015.



Koleva et al. (2017)
<http://ws-sozopol.stil.bas.bg/>

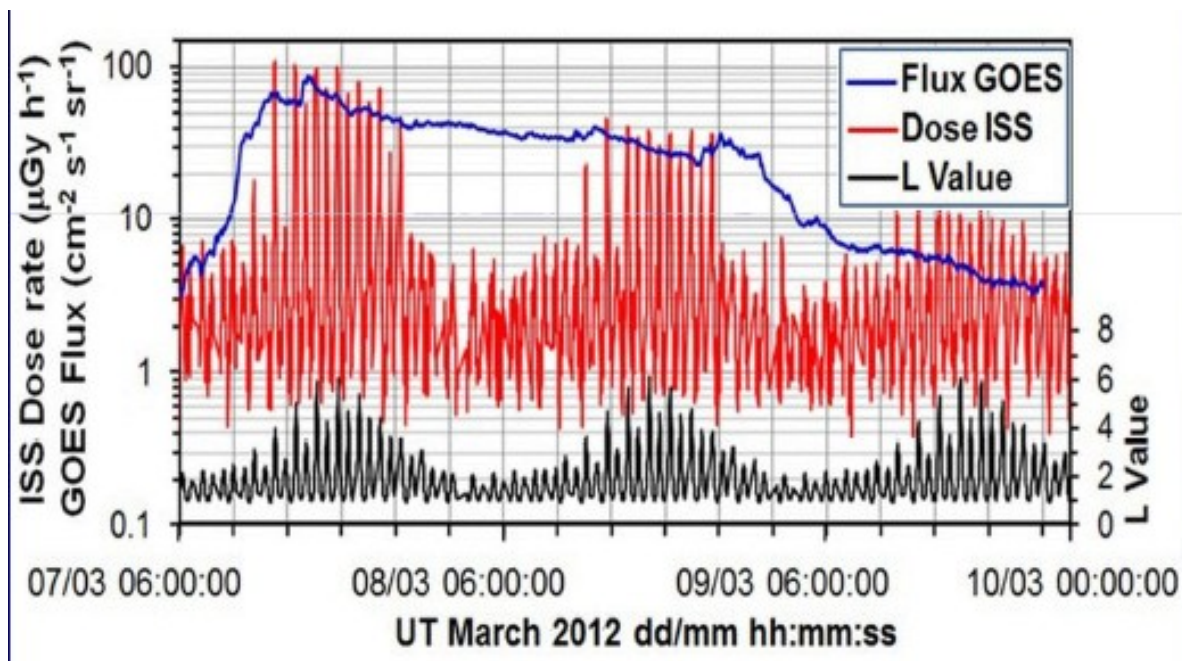


I stage - 330 – 380 km

II stage – 380 – 445 km



Подготовка за пилотирани мисии до Марс – българското участие на МКС: Люлин-5



Liulin-5 registered the effect from the SPE from 07.03.2012, at 13:01 UT till 08.03.2012, at 21:31 UT

Koleva et al. (2017)
<http://ws-sozopol.stil.bas.bg/>

27 Solar Proton Events (SPE) in 2012 – September 2015

To be observed inside ISS :

- Energy > 100 MeV
- intensity above the threshold of $10 \text{ p/cm}^2 \text{s}^{-1} \text{sr}^{-1}$
- long duration

	2007-2009 in the phantom	2012-2015 in the phantom	2012-2015 outside the phantom	SPE 7-10.03.2012 (at $L > 3$ for 3 days)
D1	186 – 230 $\mu\text{Gy/day}$	130-220 $\mu\text{Gy/day}$	150-280 $\mu\text{Gy/day}$	+ 180 μGy
D3	83 - 150 $\mu\text{Gy/day}$	120 - 160 $\mu\text{Gy/day}$		
Dose Equivalent	590-880 $\mu\text{Sv/day}$	220-600 $\mu\text{Sv/day}$	300-700 $\mu\text{Sv/day}$	+ 450 μSv

NASA/ESA/Roskosmos
max 1 Sv радиационна доза през
цялата кариера на един астронавт

Естествена радиация на Земята: $\sim 2.4 \text{ mSv/year}$
На морско ниво от галактични лъчи: $\sim 0.3 \text{ mSv}$
При медицински изследвания: $\sim 0.1-10 \text{ mSv}$
www.nmdb.eu

Some comparative whole-body radiation doses and their effects

2.4 mSv/yr	Typical background radiation experienced by everyone (average 1.5 mSv in Australia, 3 mSv in North America).
1.5 to 2.5 mSv/yr	Average dose to Australian uranium miners and US nuclear industry workers, above background and medical.
Up to 5 mSv/yr	Typical incremental dose for aircrew in middle latitudes.
9 mSv/yr	Exposure by airline crew flying the New York – Tokyo polar route.
10 mSv/yr	Maximum actual dose to Australian uranium miners.
10 mSv	Effective dose from abdomen & pelvis CT scan.
20 mSv/yr	Current limit (averaged) for nuclear industry employees and uranium miners in most countries. (In Japan: 5 mSv per three months for women)
50 mSv/yr	Former routine limit for nuclear industry employees, now maximum allowable for a single year in most countries (average to be 20 mSv/yr max). It is also the dose rate which arises from natural background levels in several places in Iran, India and Europe.
50 mSv	Allowable short-term dose for emergency workers (IAEA).
100 mSv	Lowest annual level at which increase in cancer risk is evident (UNSCEAR). Above this, the probability of cancer occurring from radiation harm has been demonstrated.

250 mSv/yr Natural background level at Ramsar in Iran, with no identified health effects (Some exposures reach 700 mSv/yr). Maximum allowable annual dose in emergency situations in Japan (NRA).

350 mSv/lifetime Criterion for relocating people after Chernobyl accident.

500 mSv Allowable short-term dose for emergency workers taking life-saving actions (IAEA).

680 mSv/yr Tolerance dose level allowable to 1955 (assuming gamma, X-ray and beta radiation).

700 mSv/yr Suggested threshold for maintaining evacuation after nuclear accident. (IAEA has 880 mSv/yr over one month as provisionally safe.

800 mSv/yr Highest level of natural background radiation recorded, on a Brazilian beach.

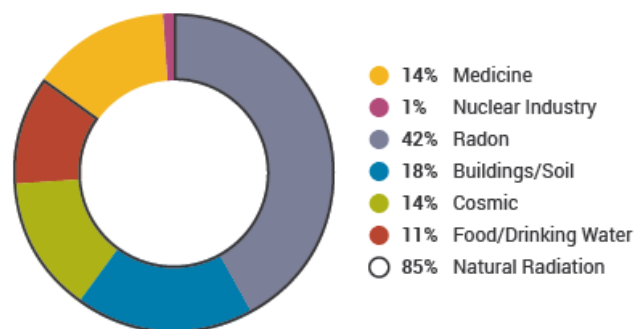
1,000 mSv short-term Assumed to be likely to cause a fatal cancer many years later in about 5 of every 100 persons exposed to it (i.e. if the normal incidence of fatal cancer were 25%, this dose would increase it to 30%). Highest reference level recommended by ICRP for rescue workers in emergency situation.

1,000 mSv short-term Threshold for causing (temporary) radiation sickness (Acute Radiation Syndrome) such as nausea and decreased white blood cell count, but not death. Above this, severity of illness increases with dose.

5,000 mSv short-term Would kill about half those receiving it as whole body dose within a month. (However, this is only twice a typical daily therapeutic dose applied to a very small area of the body over 4 to 6 weeks or so to kill malignant cells in cancer treatment.)

10,000 mSv short-term Fatal within a few weeks.

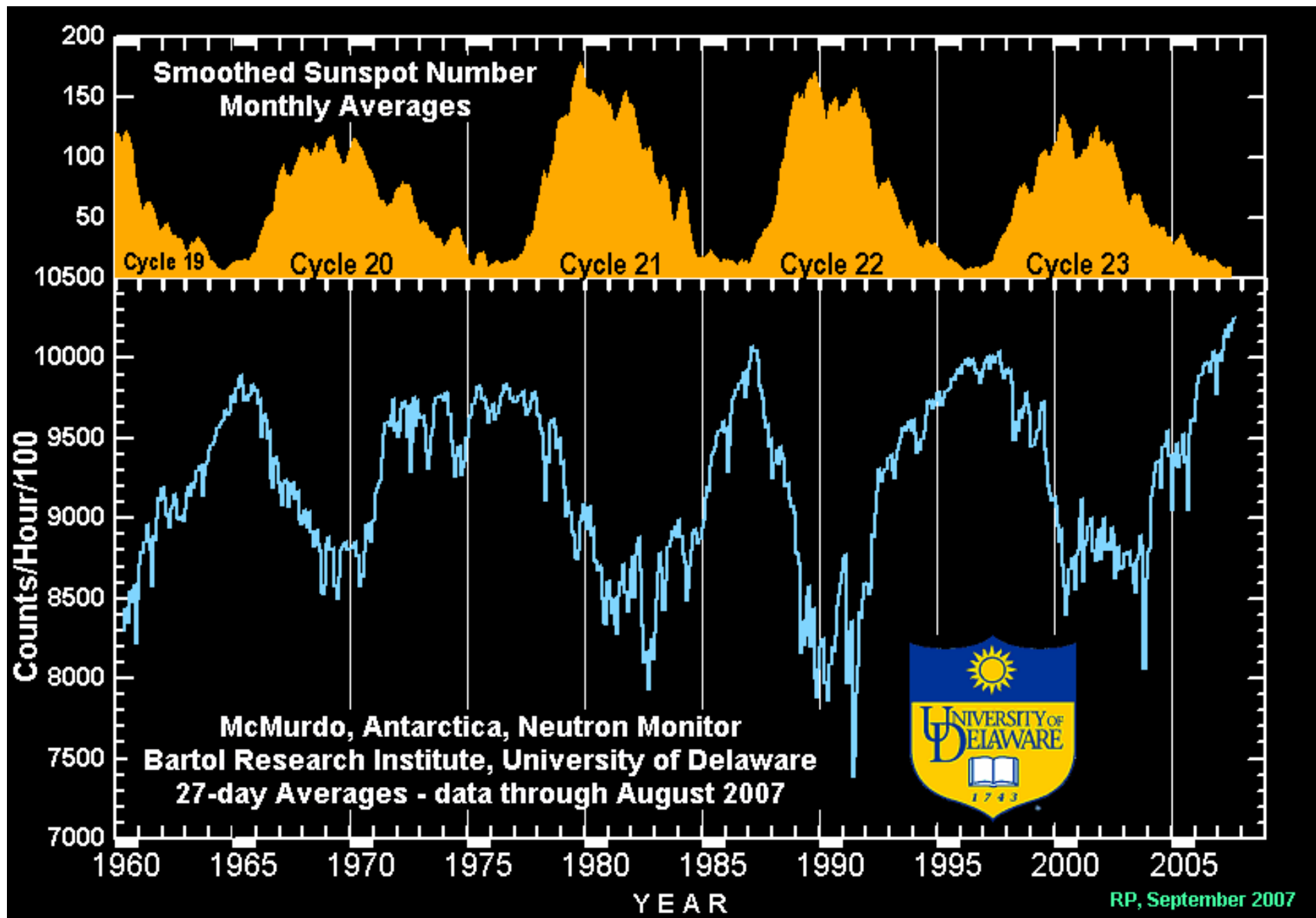
Sources of Radiation



Галактически космически лъчи

[galactic cosmic rays]

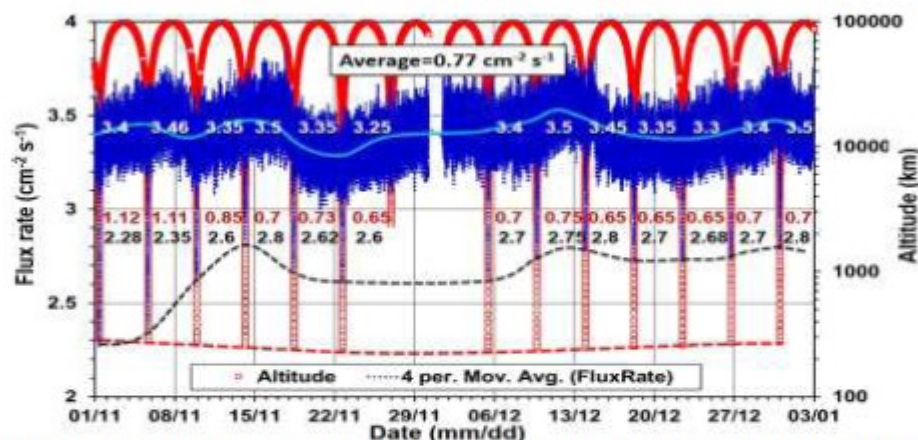
<http://neutronm.bartol.udel.edu/catch/cr3.html>



Космическо време и полети до Марс

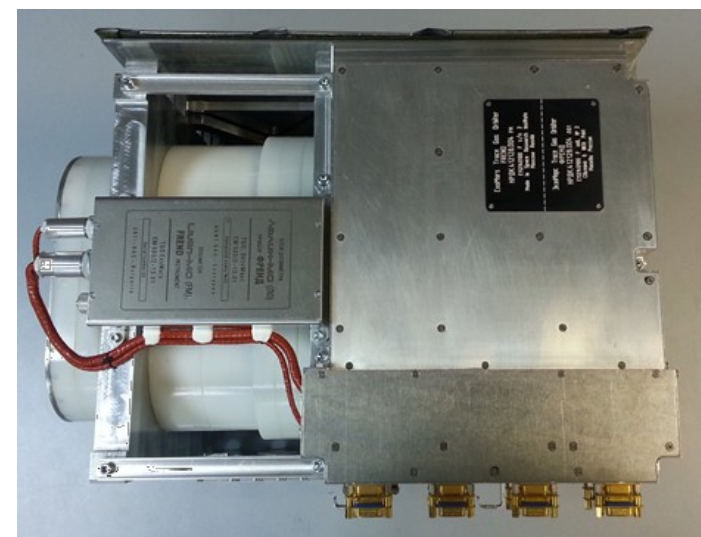
Мощности на радиационните дози и потоците галактически космически лъчи (ГКЛ) в междупланетното пространство и елиптичните орбити на спътника Trace Gas Orbiter (TGO) около Марс по проекта “ЕкзоМарс” на Европейската и Руска космически агенции

Анализирани са данните за вариациите на радиацията от ГКЛ, получени от дозиметъра Люлин-МО по време на полета до Марс и в елиптичните орбити на спътника Trace Gas Orbiter (TGO) около Марс по проекта “ЕкзоМарс” на Европейската и Руска космически агенции. Изследванията са проведени в рамките на 3-странния проект между



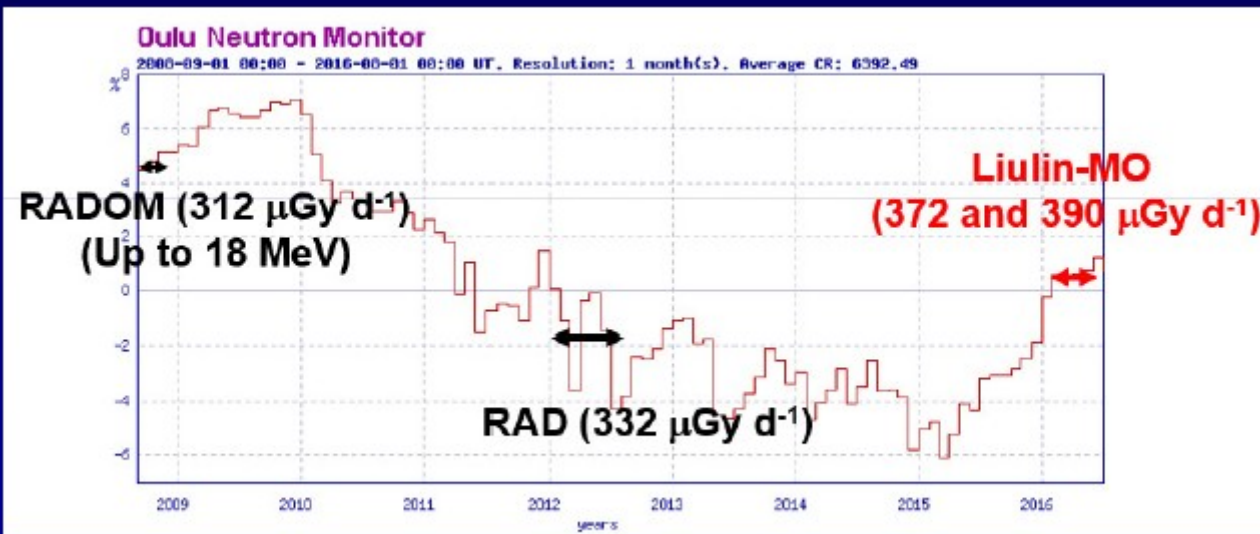
Фиг. 1. Вариации на потока частици от ГКЛ (сини точки) от 01 ноември 2016 г. до 04 януари 2017 г. Светлосинята линия показва пълзящата средна стойност на потока от ГКЛ. Пунктираната черна линия показва значенията на потока ГКЛ в пери-центровете. Височината на спътника над повърхността на Марс е представена с червени квадрати, а червената пунктирана линия свързва височините в областите на пери-центровете. Вижда се, намалението на потока частици от ГКЛ в областите на пери-центровете.

ИКИТ-БАН, ИКИ-РАН и ИМБП-РАН за радиационни изследвания по проект “ЕкзоМарс”. Анализирани са данните за вариациите на мощността на дозата и потока частици от ГКЛ от 22.04.2016 до 07.03.2017г. Резултатите показват, че при пилотиран полет до Марс и обратно (6 месеца във всяка посока), осъществен по време на ниска слънчева активност, членовете на екипажите ще получат минимум 60% от максималната допустима доза за цялата кариера на космонавтите и астронавтите само от ГКЛ и техните вторични частици, без наличие на допълнителни облъчвания от слънчеви ерупции.



FRIEND/Liulin-MO
ESA/Roscosmos/

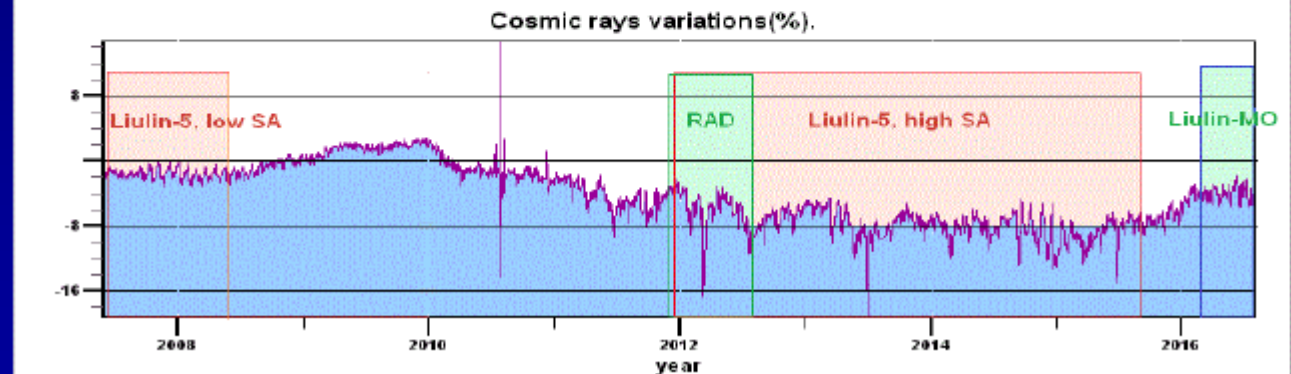
NASA/ESA/Roskosmos
max 1 Sv радиационна доза през
цялата кариера на един астронавт



Semkova et al. (2017)
Koleva et al. (2017)
<http://ws-sozopol.stil.bas.bg/>

- ✓ Doses for an round trip to Mars - 1 year, 6 month in each direction
- ✓ One year stay in ISS

	To and from MARS	On ISS – Liulin-5
high SA <i>without SPE</i>	RAD: ~ 630 mSv	~ 180 mSv
<i>addition by SEP</i>	RAD: ~24.7 mSv (5 SPE)	~ 0.45 mSv
low SA	Liulin-MO: ~ 729 mSv	~ 234 mSv ~ 316 mSv <i>extreme case</i>



Catalogs of Solar Energetic Particles and Related Phenomena

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**Научни проекти:
изграждане на
каталози**

Wind/EPACT proton event catalog

Solar cycle 24: 2009-present

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[Back to list of Catalogs](#)
[Back to Wind/EPACT](#)
[Solar cycle 23: 1996-2008](#)

Event date	19-28 MeV			28-72 MeV	Flare	CME	Comment
yyyy-mm-dd	onset time (UT)	peak time (UT)	J_p (cm ² s sr MeV) ⁻¹ / F_p (cm ² sr MeV) ⁻¹	J_p (cm ² s sr MeV) ⁻¹ / F_p (cm ² sr MeV) ⁻¹	SXR class/ onset time (UT)/ location	time (UT)/ speed (km s ⁻¹)/ width (deg)	
2009	-	-	-	-	-	-	no SEP events
2010-05-07/08	-	-	-	-	-	-	data gap
2010-05-12/18	-	-	-	-	-	-	data gaps
2010-06-12	04:04	08:39	0.0123 /216	0.0020 /20	M2.0/00:30/N23W43	01:32/489/119	
2010-08-03	15:13	18:25	0.0478 /336	0.0014 /19	uncertain	11:12/221/21	
2010-08-03	N/A	01:45 nd	0.0027 /u	0.0002 /u	uncertain	21:17/265/14	u
2010-08-07	22:45	01:43 nd	0.0111 /152	0.0014 /6	M1.0/17:55/N11E34	18:36/871/360	
2010-08-08	N/A	11:22	0.0074 /u	0.0008 /u	uncertain	uncertain	
2010-08-08	N/A	19:25	0.0031 /u	0.0007 /u	uncertain	uncertain	
2010-08-14	11:15	13:05	0.1581 /762	0.0185 /28	C4.4/09:38/N17W52	10:12/1205/360	
2010-08-18	08:01	12:18	0.0486 /613	0.0034 /14	C4.5/04:45/N18W88	05:48/1471/184	
2010-09-09	03:02	04:25	0.0071 43 ^u	0.0007 /u	C3.3/23:05 ^{pd} /N21W87	23:27 ^{pd} /818/147	
2010-12-07	-	-	-	-	-	-	data gap

Научни сътрудничества

<http://newserver.stil.bas.bg/SEPorigin>

Заглавие на проекта:

Произход на слънчевите енергетични частици:
слънчеви избухвания или коронални изнасяния на маса

**Конкурс за проекти по програми за двустранно сътрудничество 2016 г. –
България–Русия**

Продължителност: 2 години
Начало: 23 Юни 2017

Ръководител (България): Росица Митева
Ръководител (Русия): Лариса Кашапова

Цели

Основната цел на проекта е определяне на приноса на слънчевите избухвания и короналните изнасяния на маса към потока слънчеви енергетични частици.

Ще проверим три работни хипотези: ускорението на всички частици се дължи на един основен процес (избухване или изнасяне на маса); и двата типа ускорителни процеса оказват влияние, което се променя при различните явления; инжектирането и преносните ефекти са доминиращите фактори, които определят профила на енергетичните частици, в сравнение с процесите на ускорение.

Обширни статистически проучвания ще бъдат допълнени от подробни изследвания на явленията (използвайки данни от руските спътници "Vernov" и CORONAS-F SONG, както и наземни наблюдения от Националната астрономическа обсерватория Рожен, България).

Работна програма



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Last modified 27-11-2017

Проектът е подкрепен от:

Фонд "Научни изследвания"



договор № ДНТС/Русия 01/6 (23 юни 2017 г.)

Руската фондация за фундаментални изследвания



проект № 17-52-18050

Solar Missions

