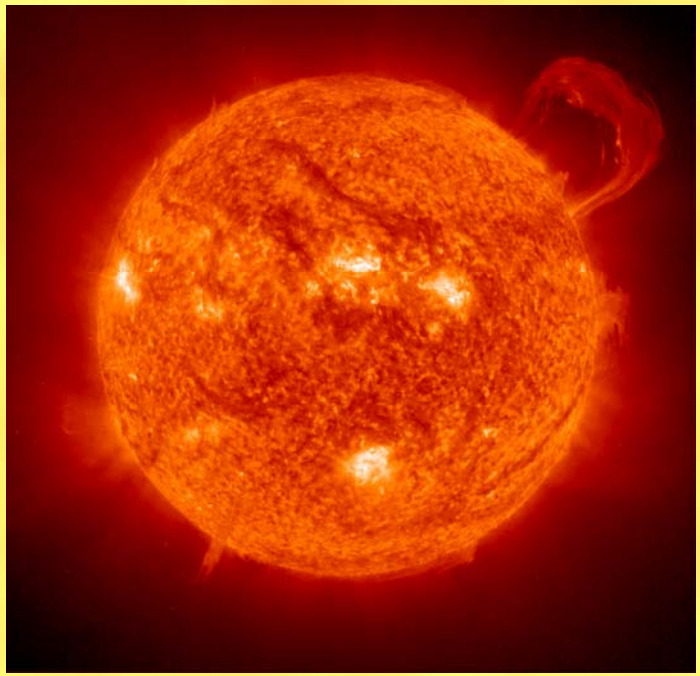
Opazovanje Sonca v različnih valovnih dolžinah



Sonja Jejčič

Sprehod skozi vesolje, Ljubljana, 10. november 2011

Povzetek

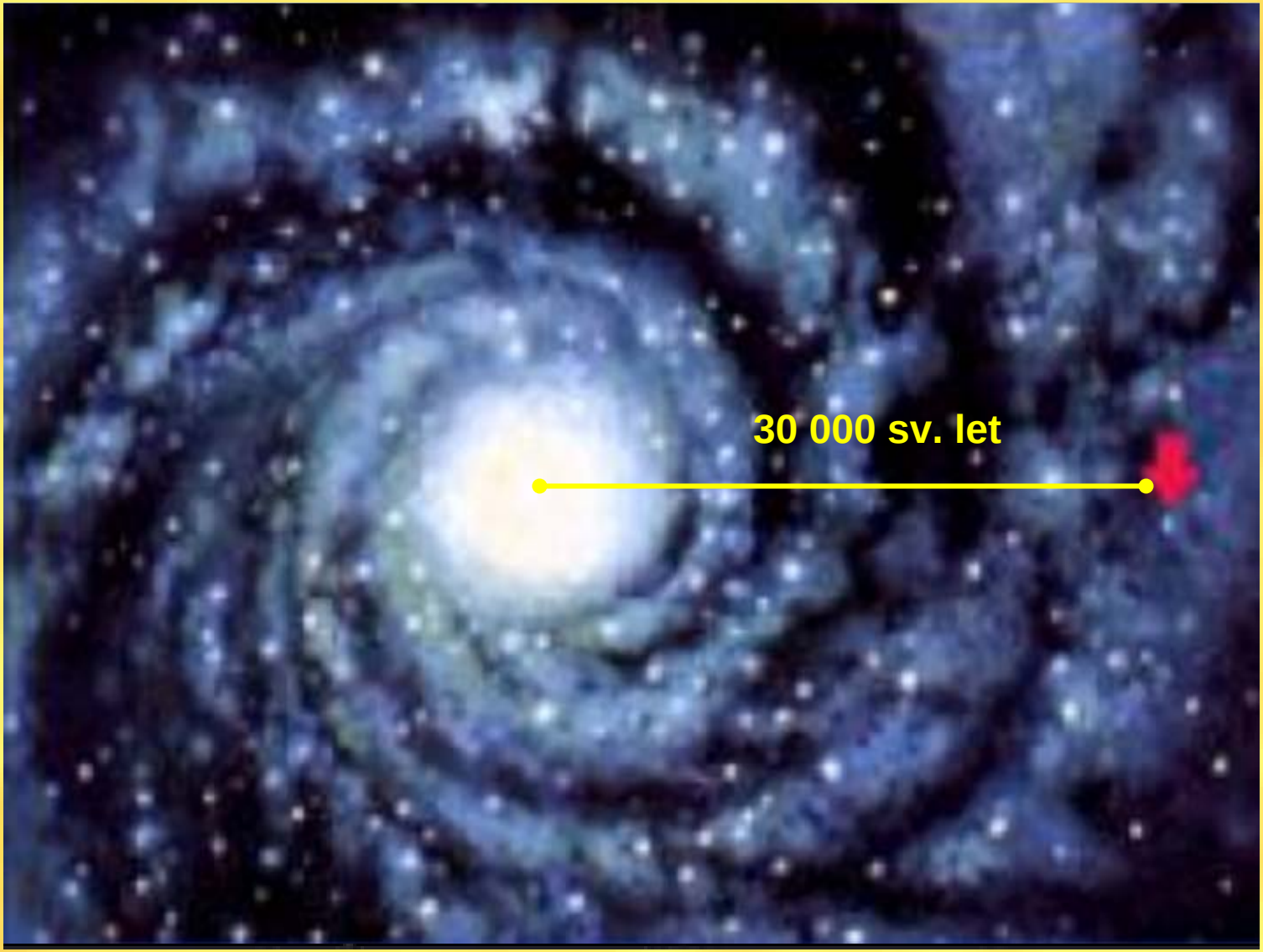
splošne lastnosti Sonca

dogajanje v notranjosti Sonca

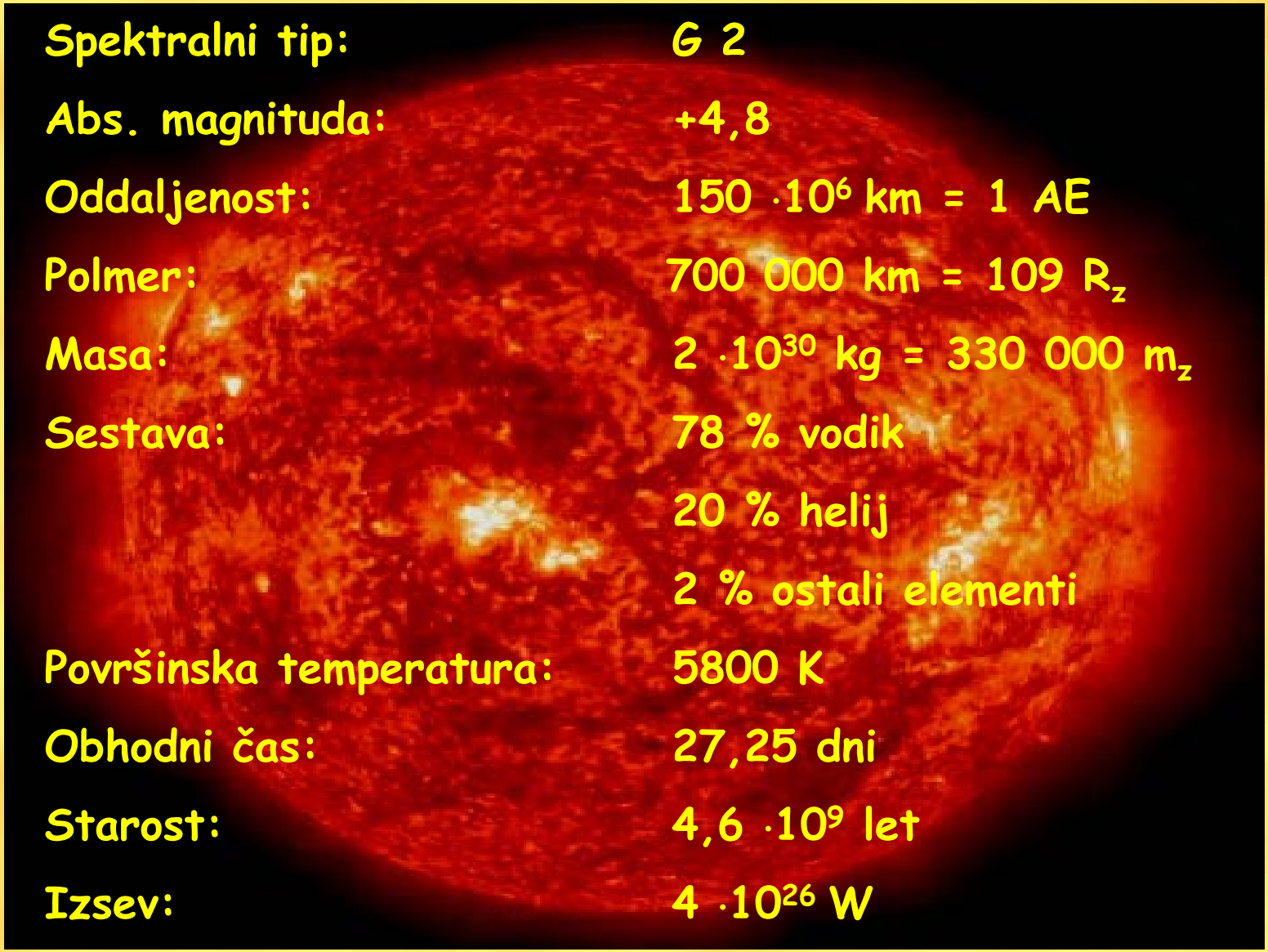
pojavi na površju in v atmosferi

Sonce v različnih valovnih dolžinah s teleskopi na Zemlji in s satelitov

Položaj v Galaksiji

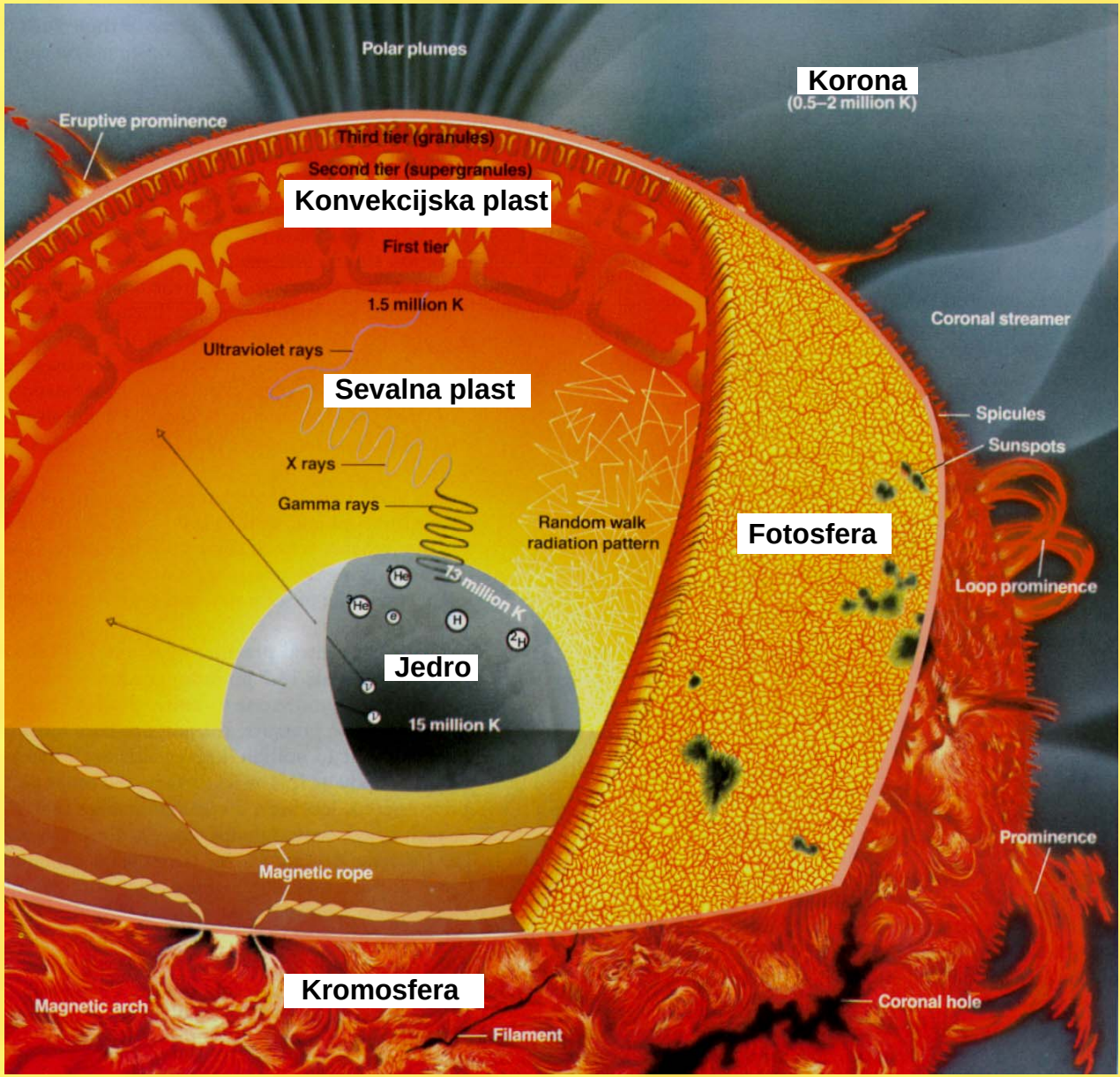


Fizikalne lastnosti



Spektralni tip:	G 2
Abs. magnituda:	+4,8
Oddaljenost:	$150 \cdot 10^6$ km = 1 AE
Polmer:	700 000 km = 109 R_z
Masa:	$2 \cdot 10^{30}$ kg = 330 000 m_z
Sestava:	78 % vodik
	20 % helij
	2 % ostali elementi
Površinska temperatura:	5800 K
Obhodni čas:	27,25 dni
Starost:	$4,6 \cdot 10^9$ let
Izsev:	$4 \cdot 10^{26}$ W

Struktura Sonca



Jedro

$T_c = 15 \cdot 10^6$ K, $p_c = 15 \cdot 10^9$ bar

$T_c < 16 \cdot 10^6$ K → reakcija proton- proton

$H^1 + H^1 \rightarrow H^2 + e^+ + \nu$

$H^1 + H^2 \rightarrow He^3 + \gamma$

$6 \cdot 10^{11}$ kg H → He

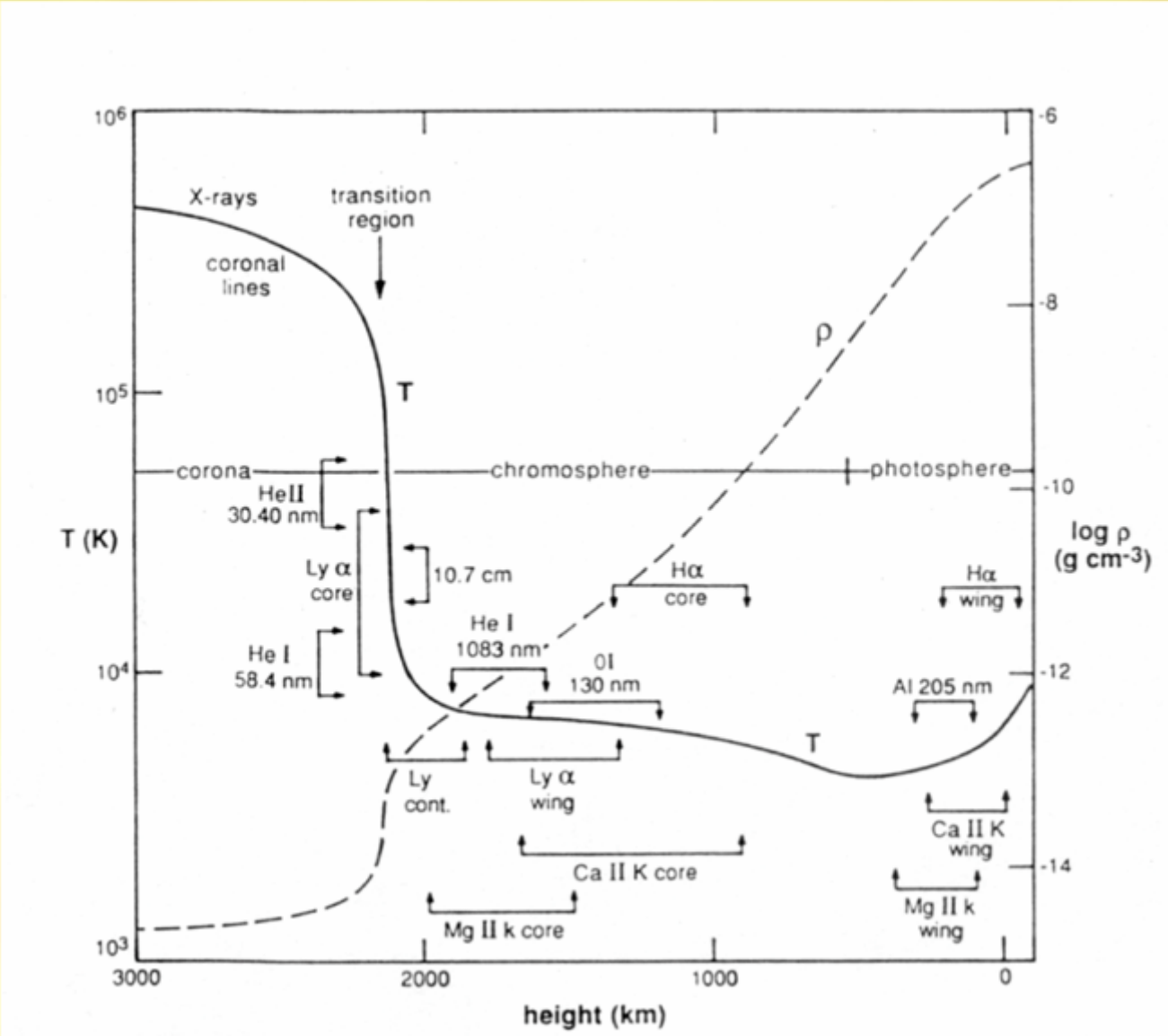
dm/m = -0,7 % →

dm= - $4 \cdot 10^9$ kg

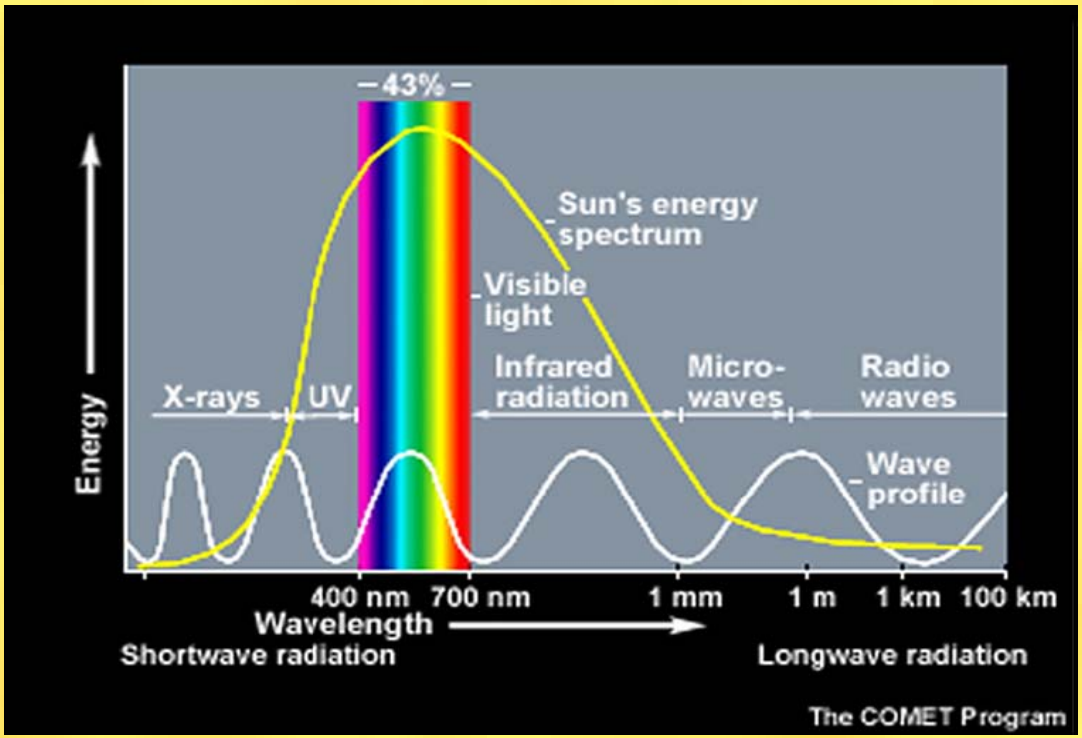
$E=mc^2$ → L= $4 \cdot 10^{26}$ W

$He^3 + He^3 \rightarrow He^4 + H^1 + H^1$

Temperatura in gostota v zunanjih plasteh Sonca



Sončev spekter



vidna svetloba (40%)

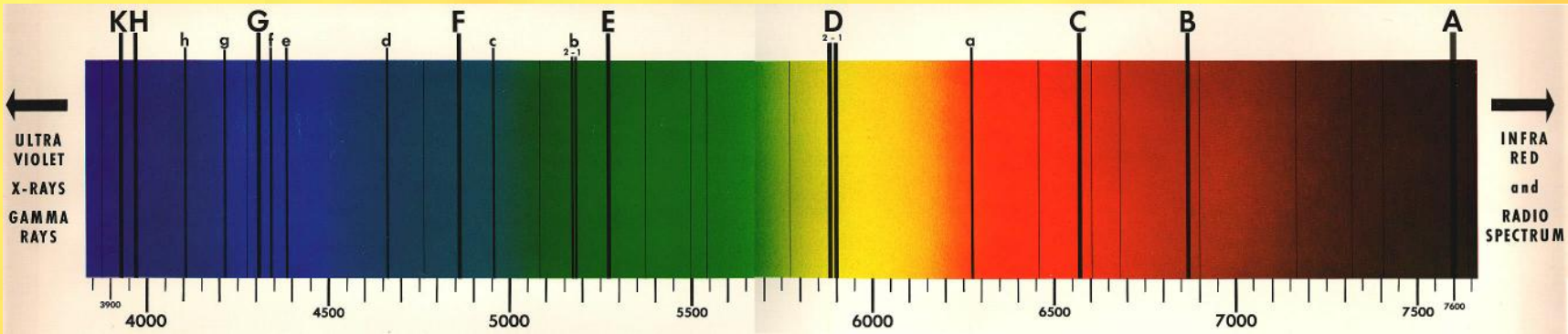
infrardeča (50%)

ultravijolična (10 %)

Sevanje črnega telesa T= 5800 K

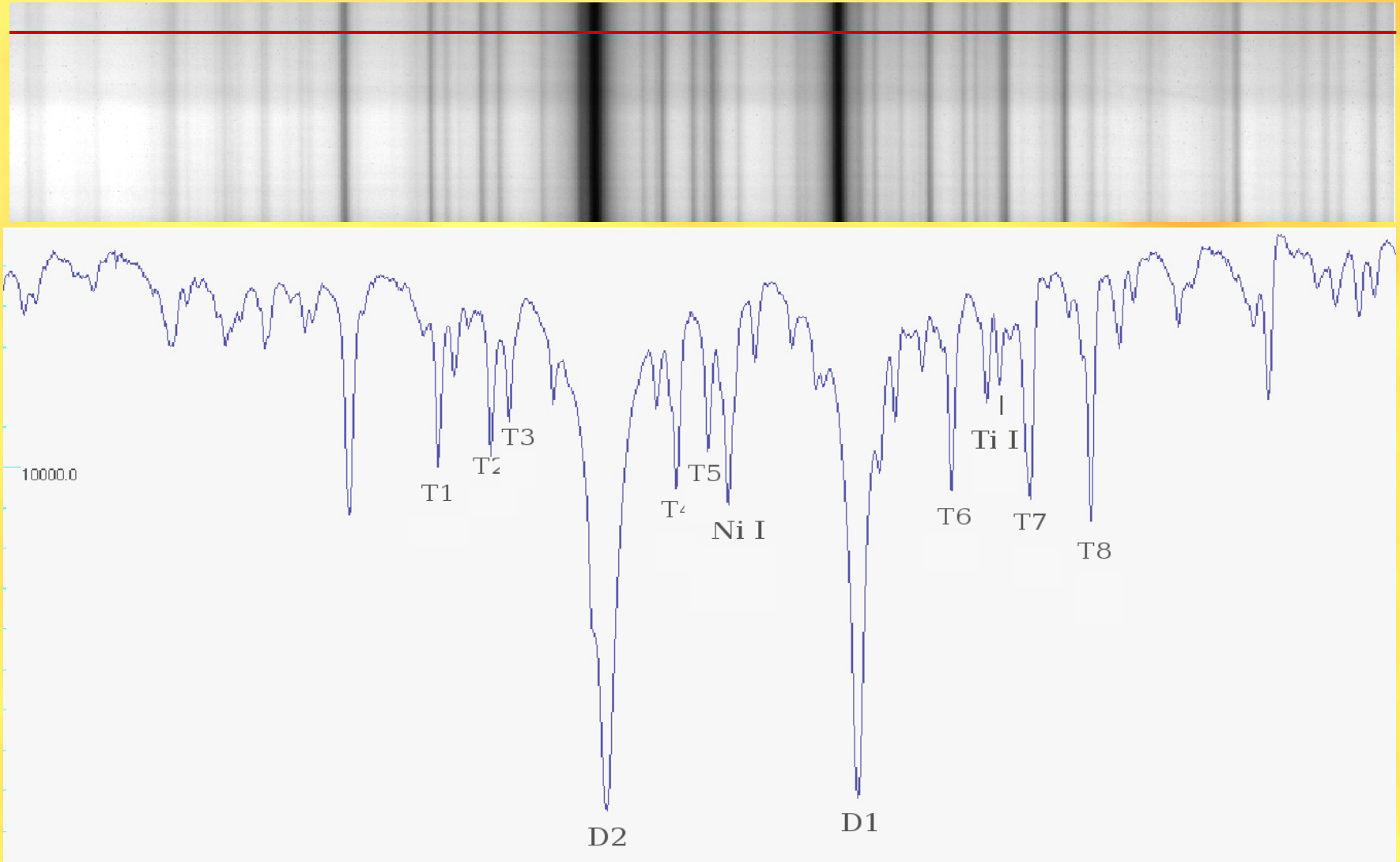
$$\frac{dj}{d\lambda} = \frac{2\pi hc^5}{\lambda^5} \cdot \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$

Sončev spekter v vidni svetlobi



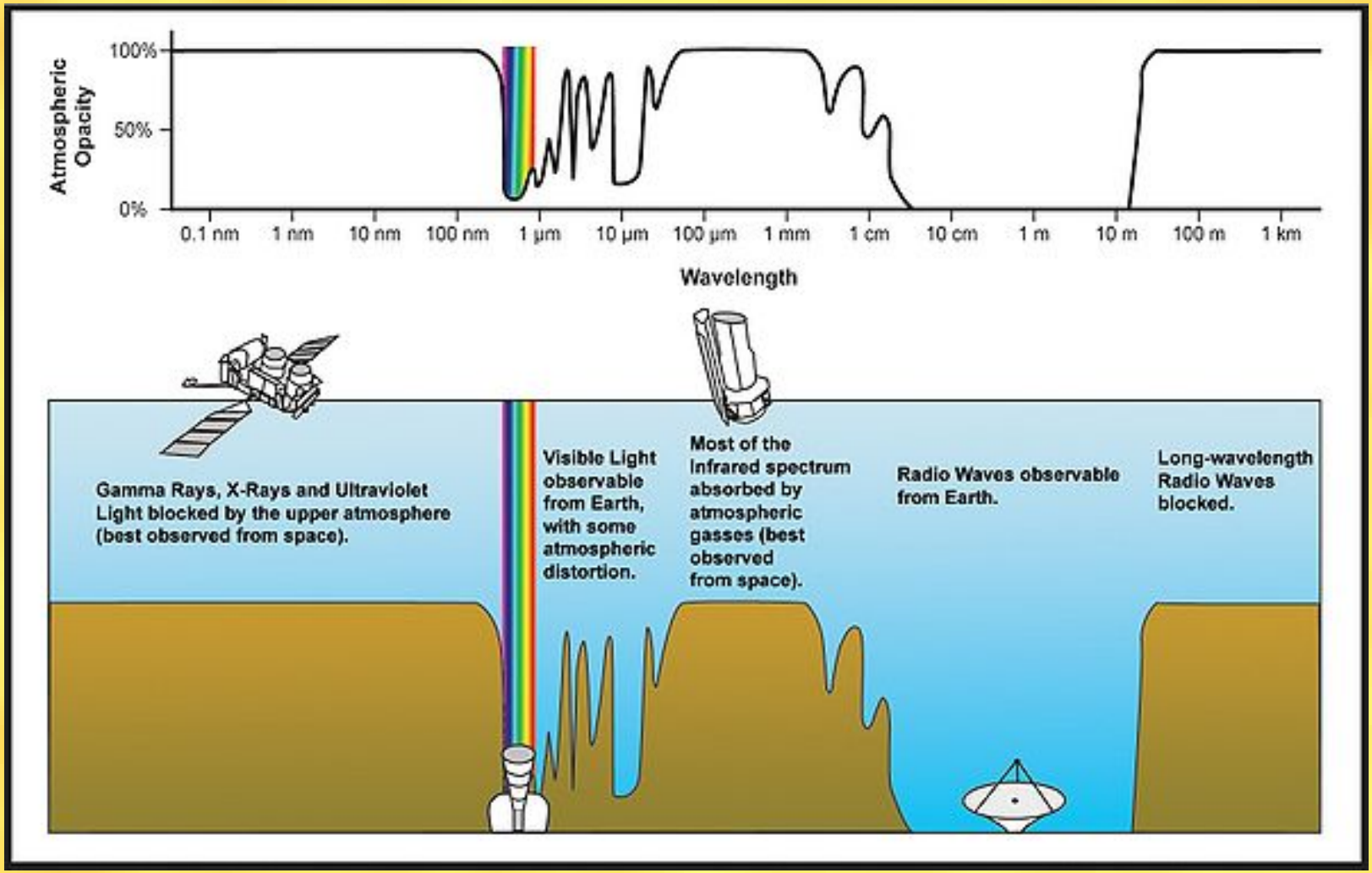
Absorpcijske (Fraunhoferjeve) črte		
Oznaka	**Val. dolžina (Å)**	**izvor**
A	7594	atmosferski kisik
B	6867	atmosferski kisik
C	6563	vodik (Hα)
D_1	5896	nevtralni natrij(Na I)
D_2	5890	nevtralni natrij (Na I)
E	5270	nevtralno železo (Fe I)
F	4861	vodik (Hβ)
H	3968	ioniziran kalcij (Ca II)
K	3934	ioniziran kalcij (Ca II)

Sončev spekter v okolici Na

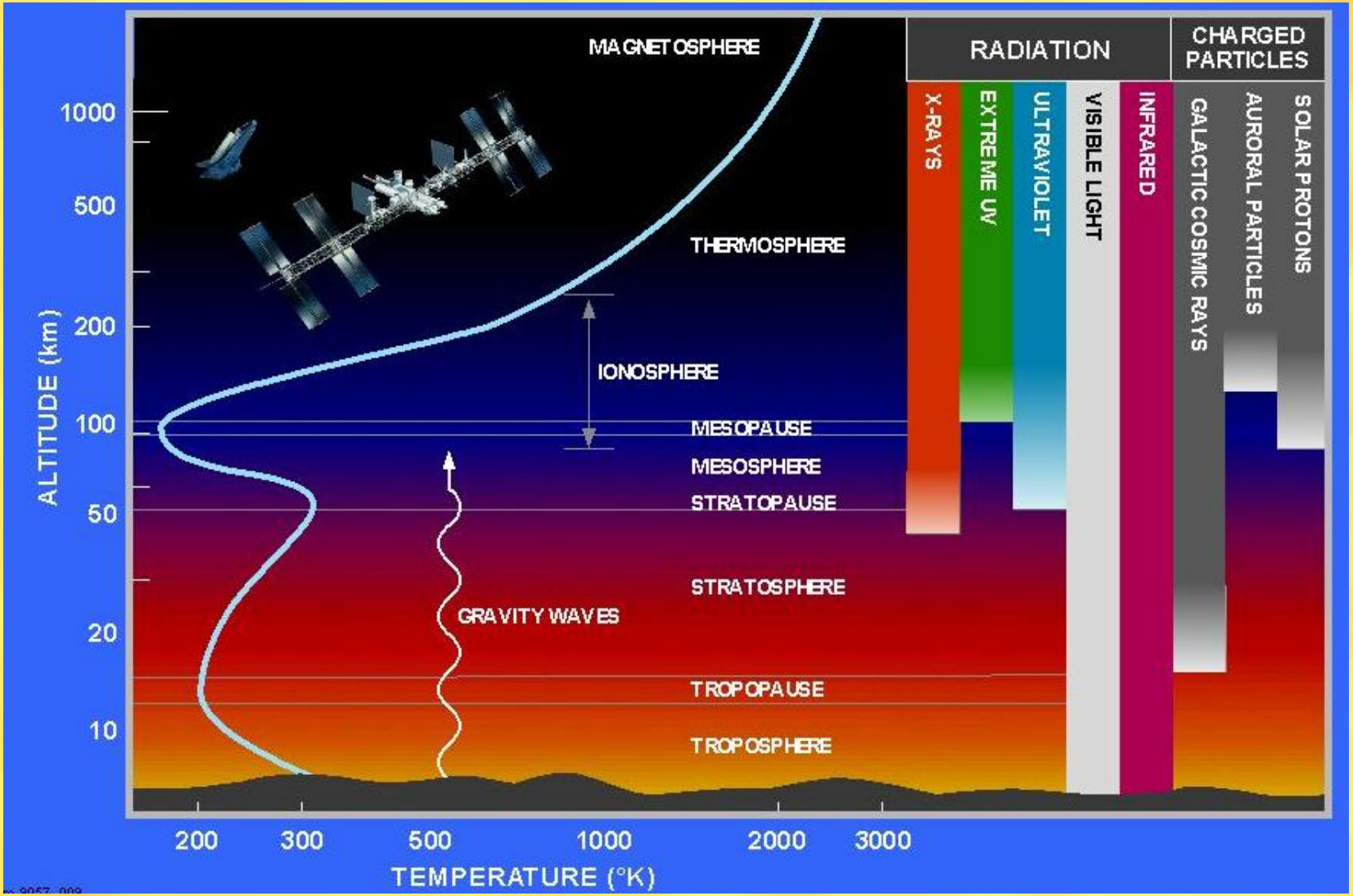


AGO Ljubljana

Prepustnost sevanja v Z. atmosferi



Prepustnost sevanja in delcev



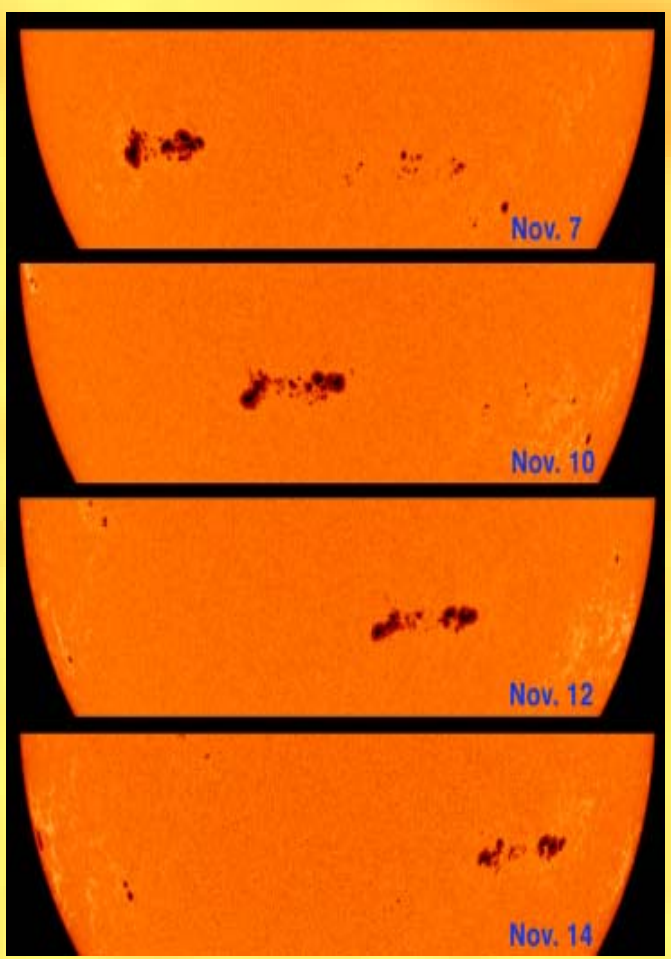
Diferencialna rotacija Sonca

L= 0° → to= 25 dni

L= 60° → to= 30 dni

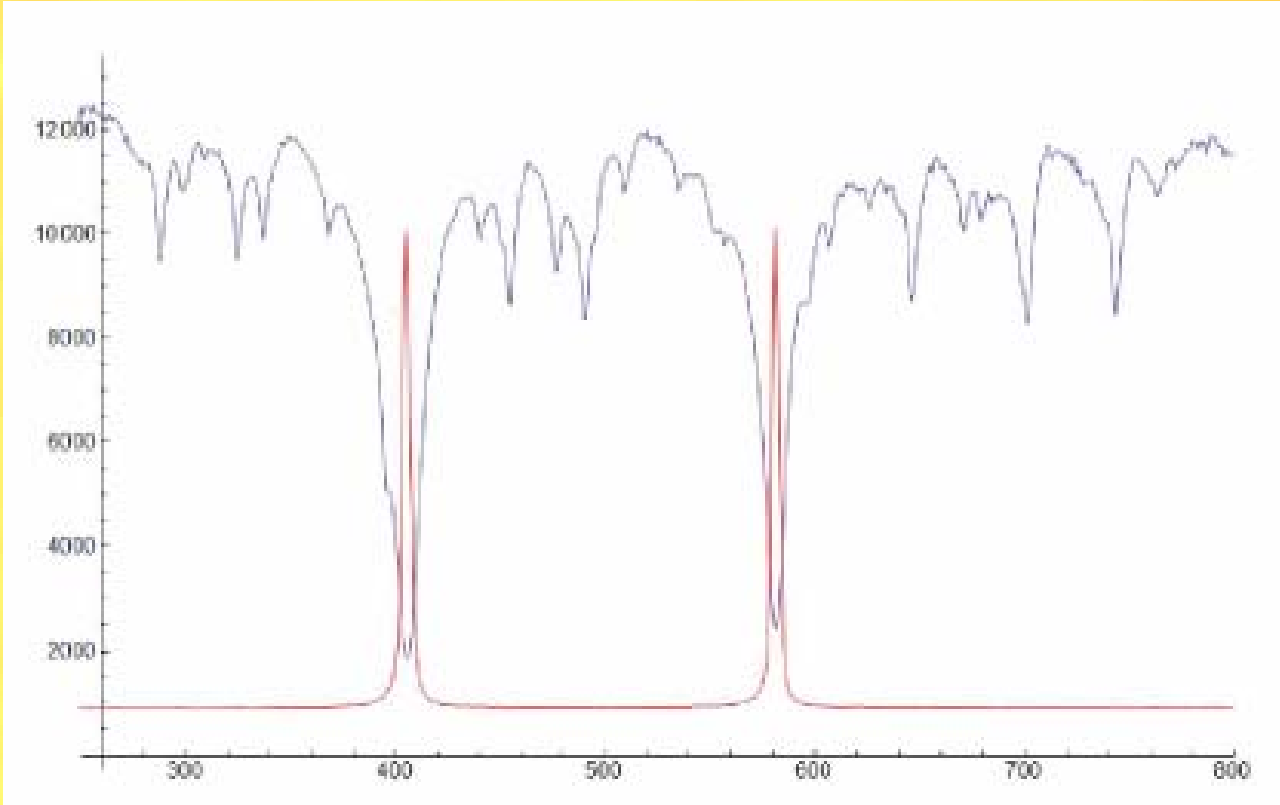
metoda sledenja

Sončevih peg



Diferencialna rotacija Sonca

spektroskopska metoda



Dopplerjev pojav

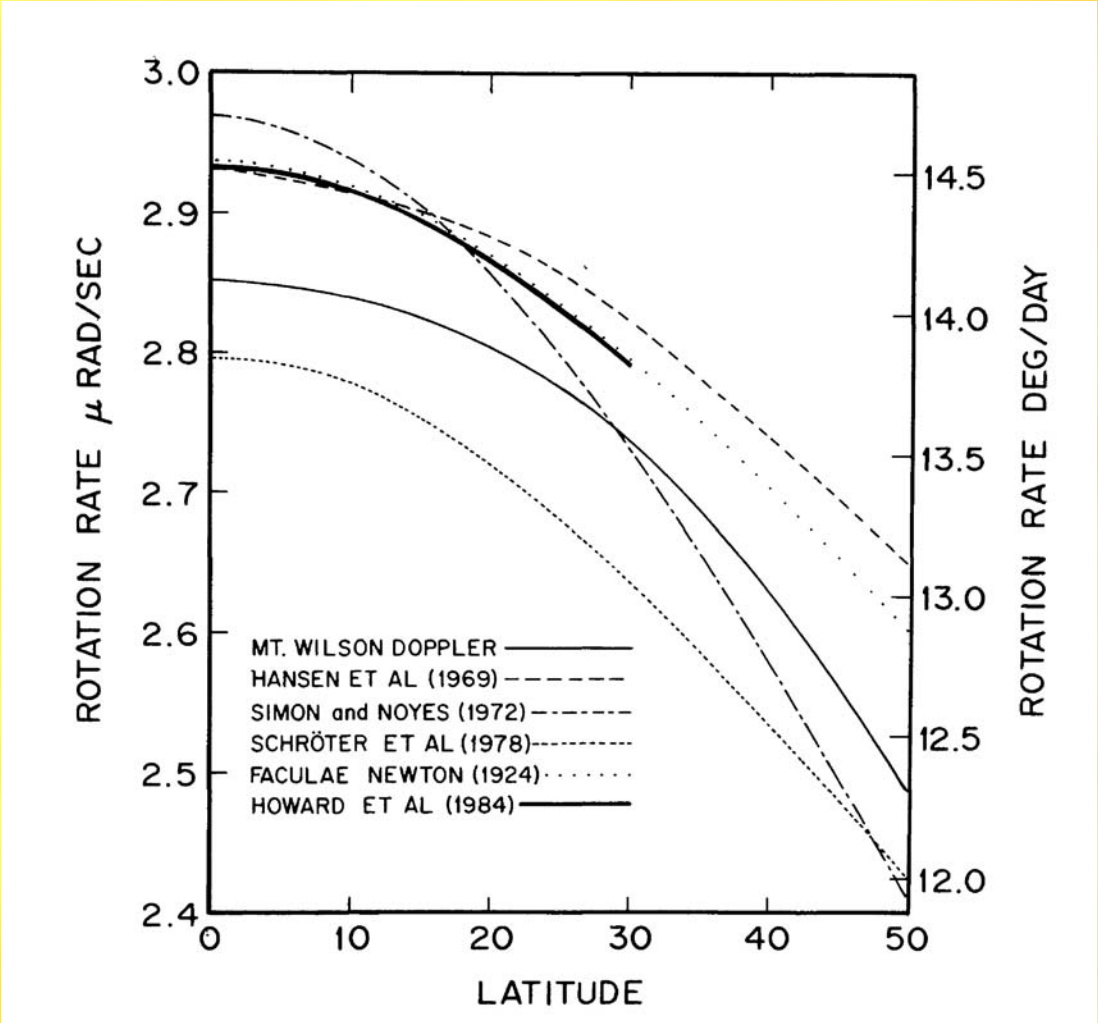
$$\frac{d\lambda}{\lambda} = \frac{V_R}{c}$$

$$V_R \propto (\vec{r} \times \vec{\omega}) \cdot \vec{n}$$

$$\omega = a + b \sin^2 L + c \sin^4 L$$

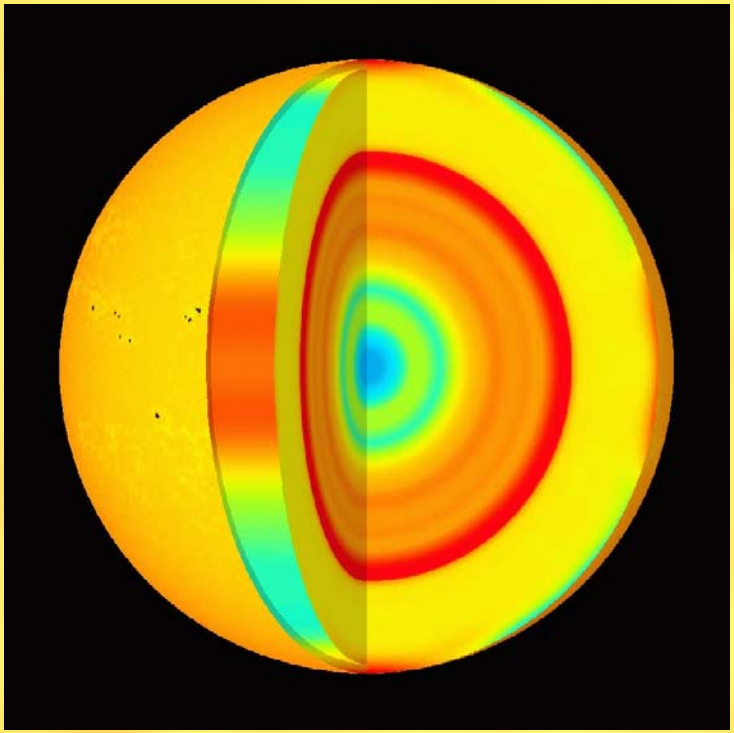
Diferencialna rotacija Sonca

ujemanje 5 %



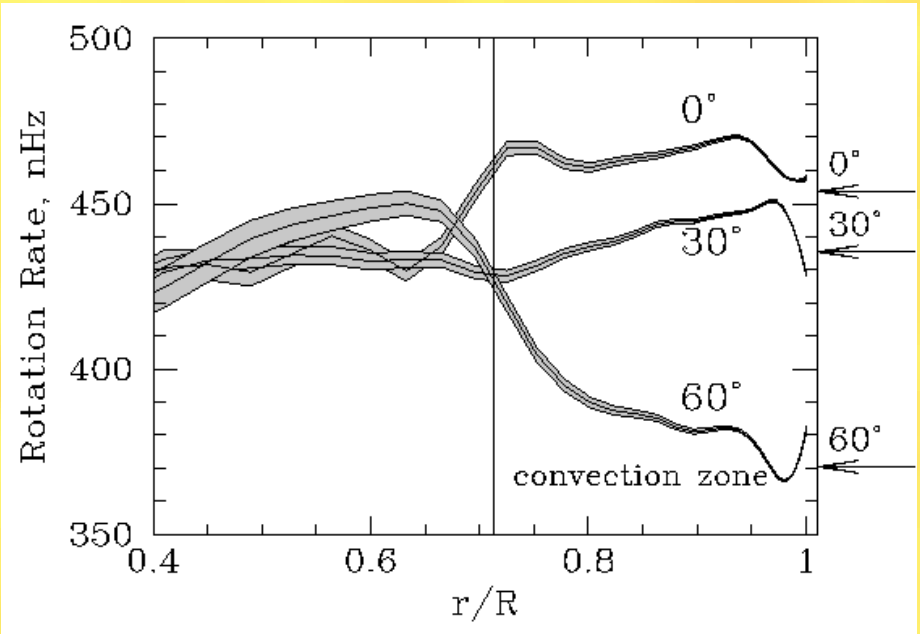
Helioseizmologija

MDI (Michelson Doppler Imager)

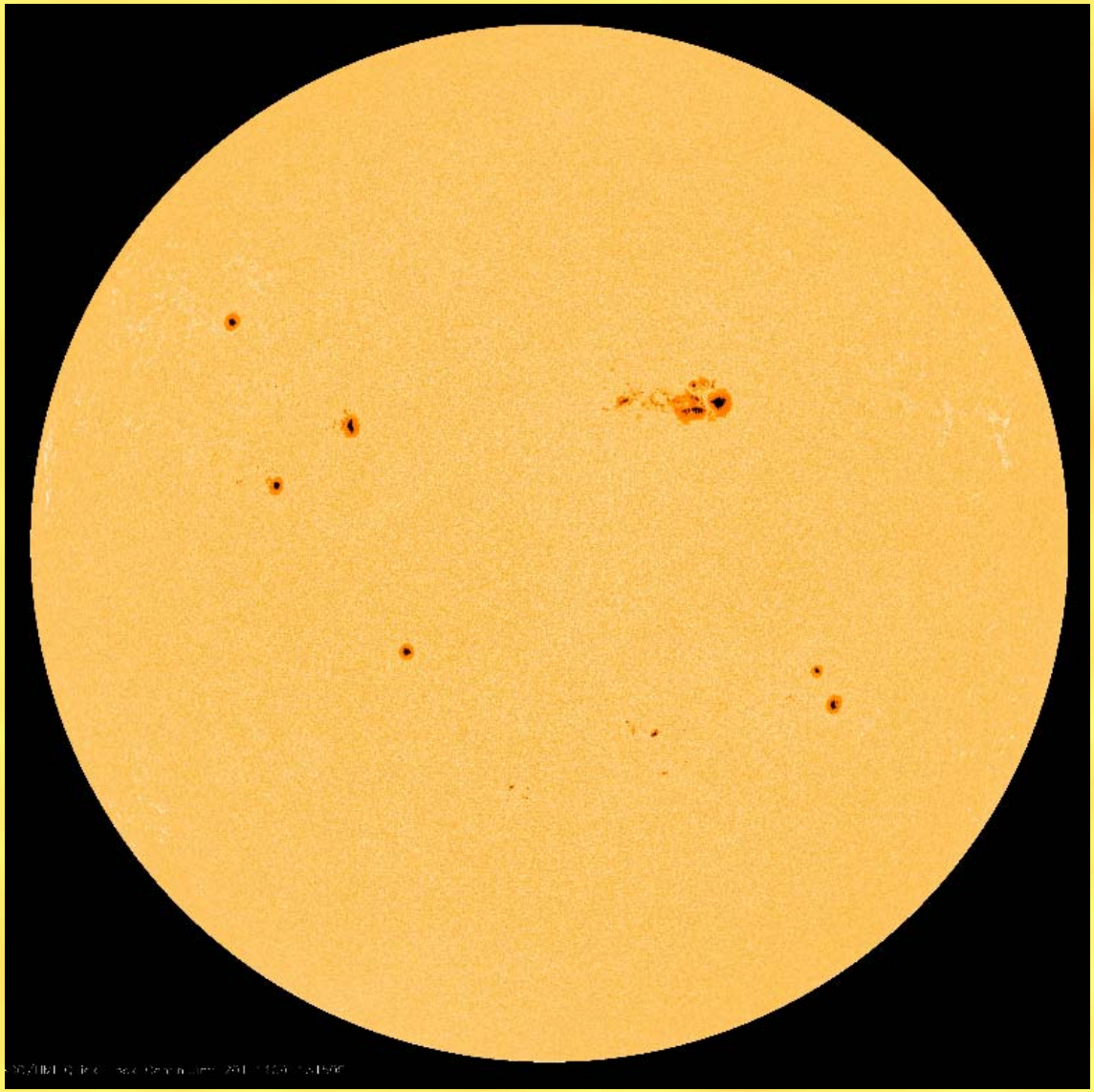


Konvekcijska plast –

dif. rotacija, magnetno polje



Sonce – 9. 11. 2011



Granule

Granule

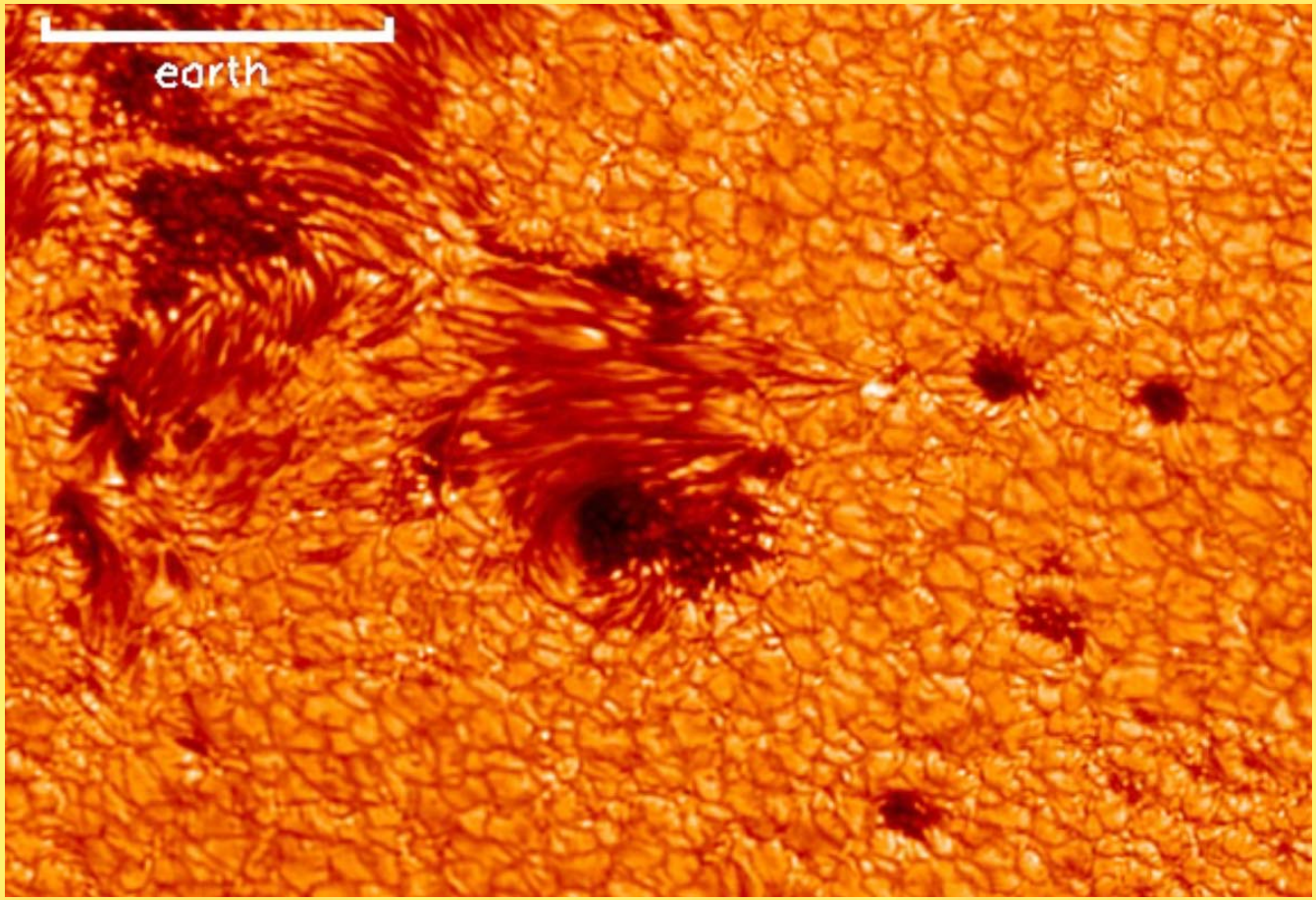
premer:
1000 km

življenska doba:
nekaj min

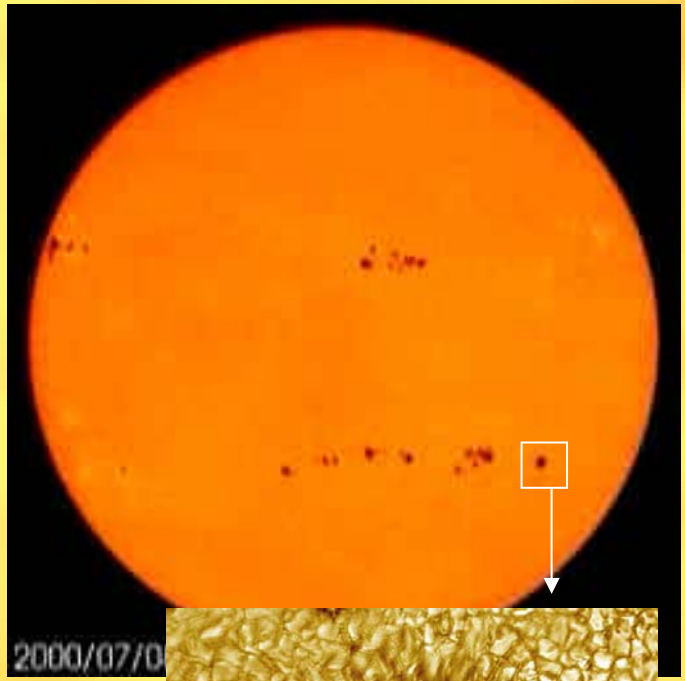
Supergranule

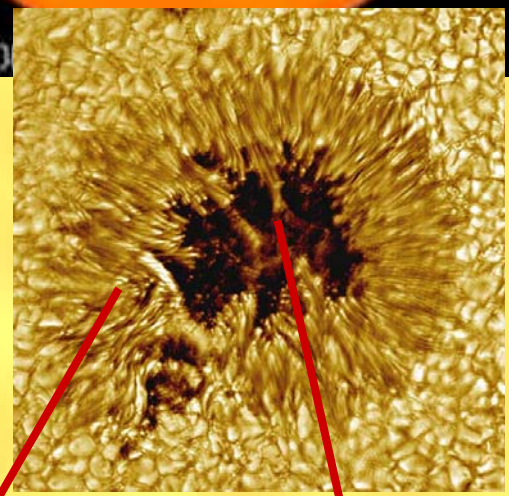
premer:
30 000 km

življenska doba:
nekaj ur



Sončeve pege





temna področja, T= 4000 K

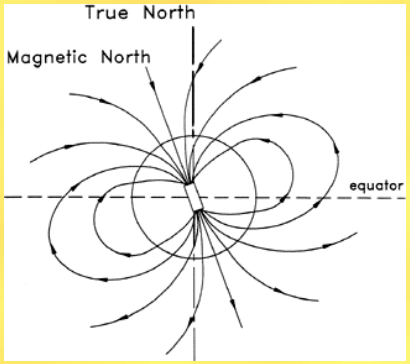
življenska doba:

nekaj ur do nekaj mesecev

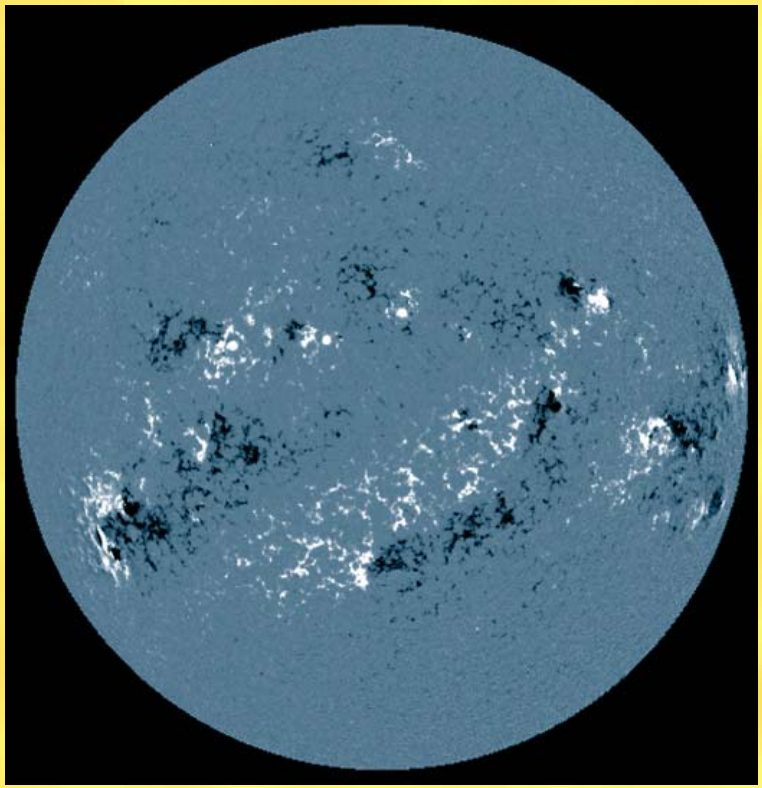
B ≅ 0.1 T

Sončev cikel ≅ 11 let

Nastanek Sončevih peg



MDI (Michelson Doppler Imager)

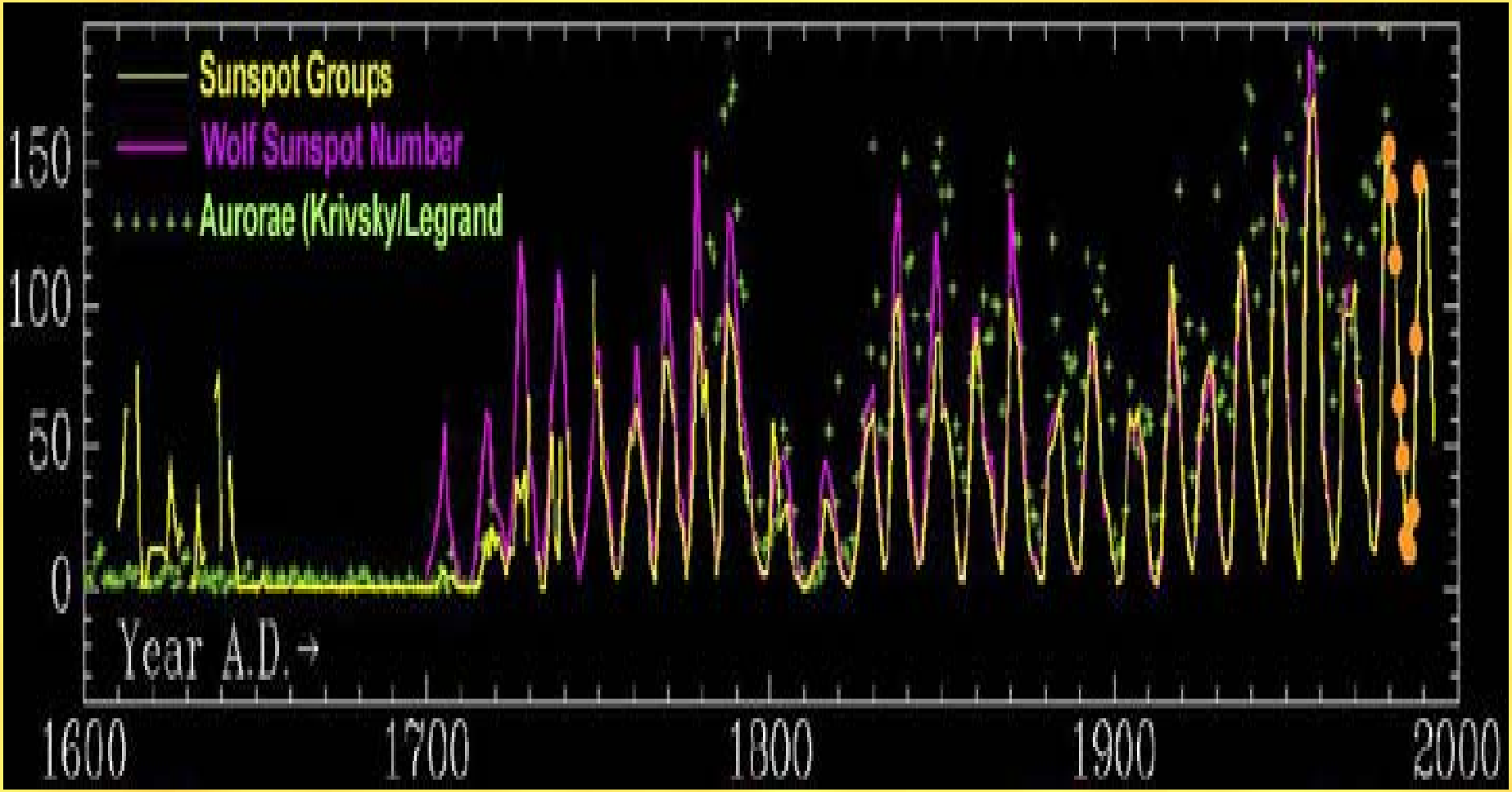


Magnetno površje Sonca

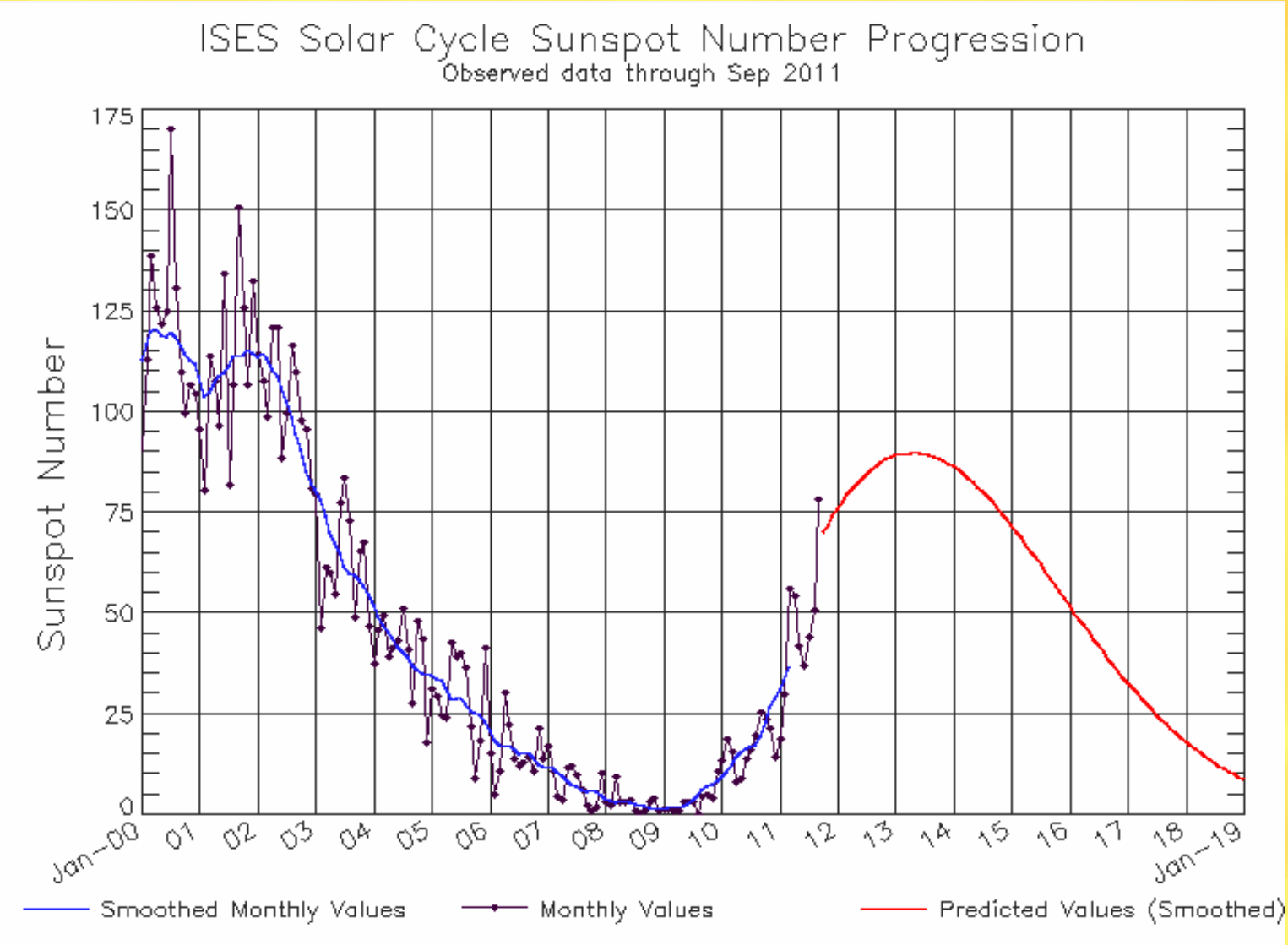
Slika v vidni svetlobi – isti dan

Aktivnost Sonca

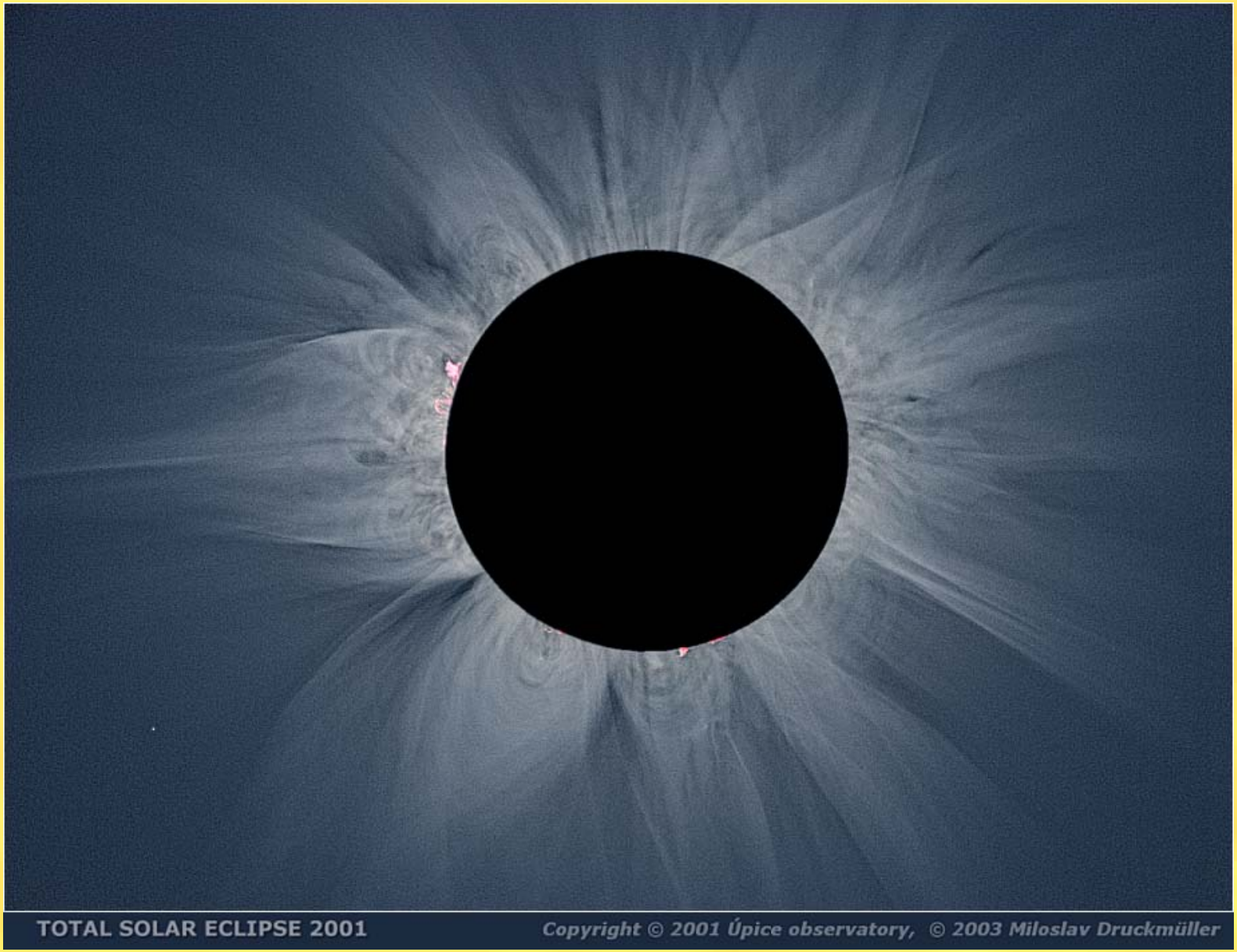
W=k(10·s+p) **Wolfovo število**



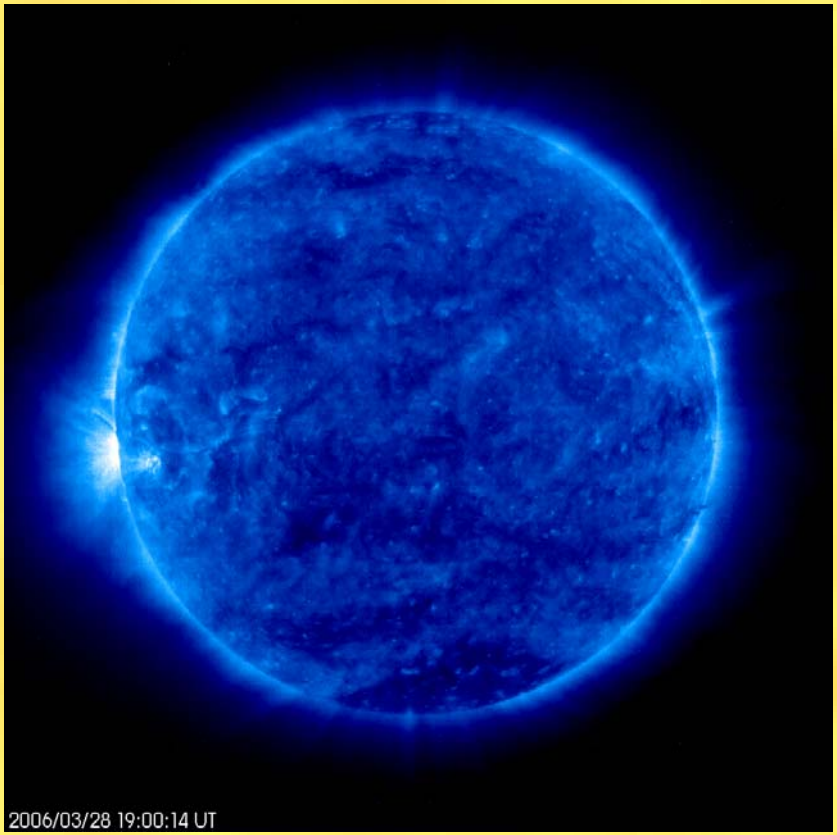
Napoved za naprej



Popolni Sončev mrk

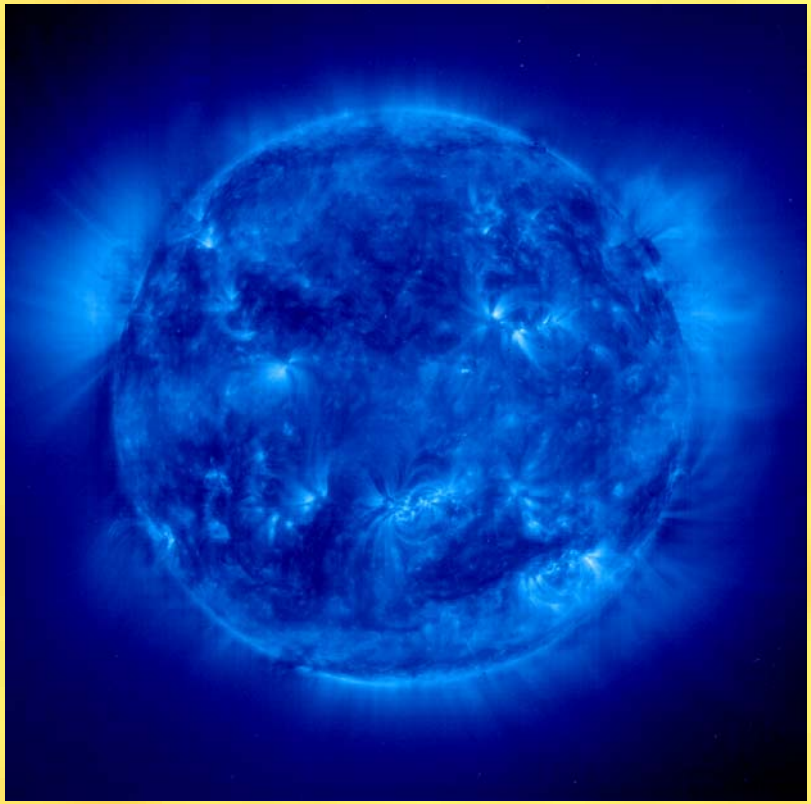


29. marec 2006, Turčija



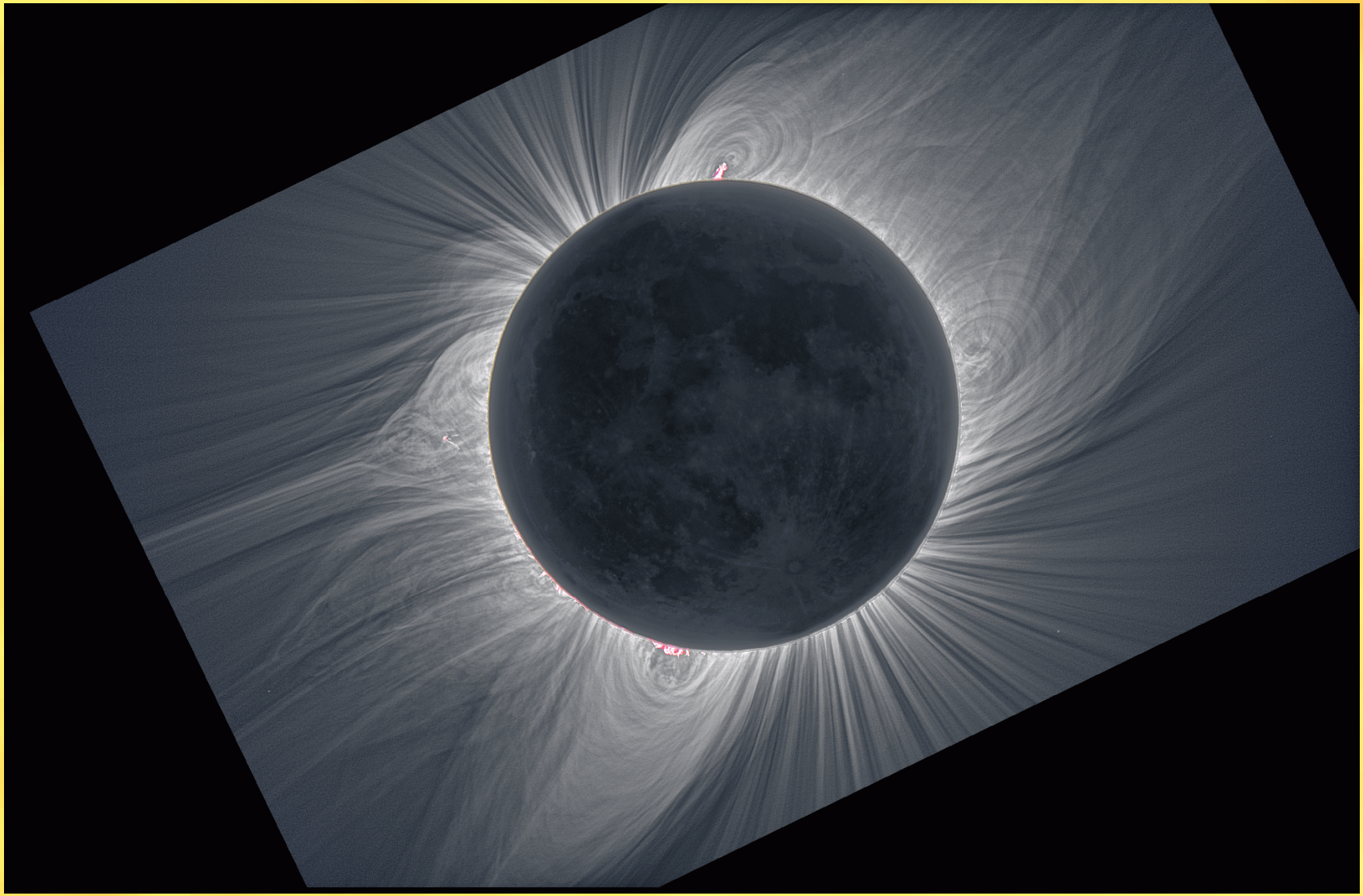
SOHO-EIT, 171 Å

11. avgust 1999, Madžarska



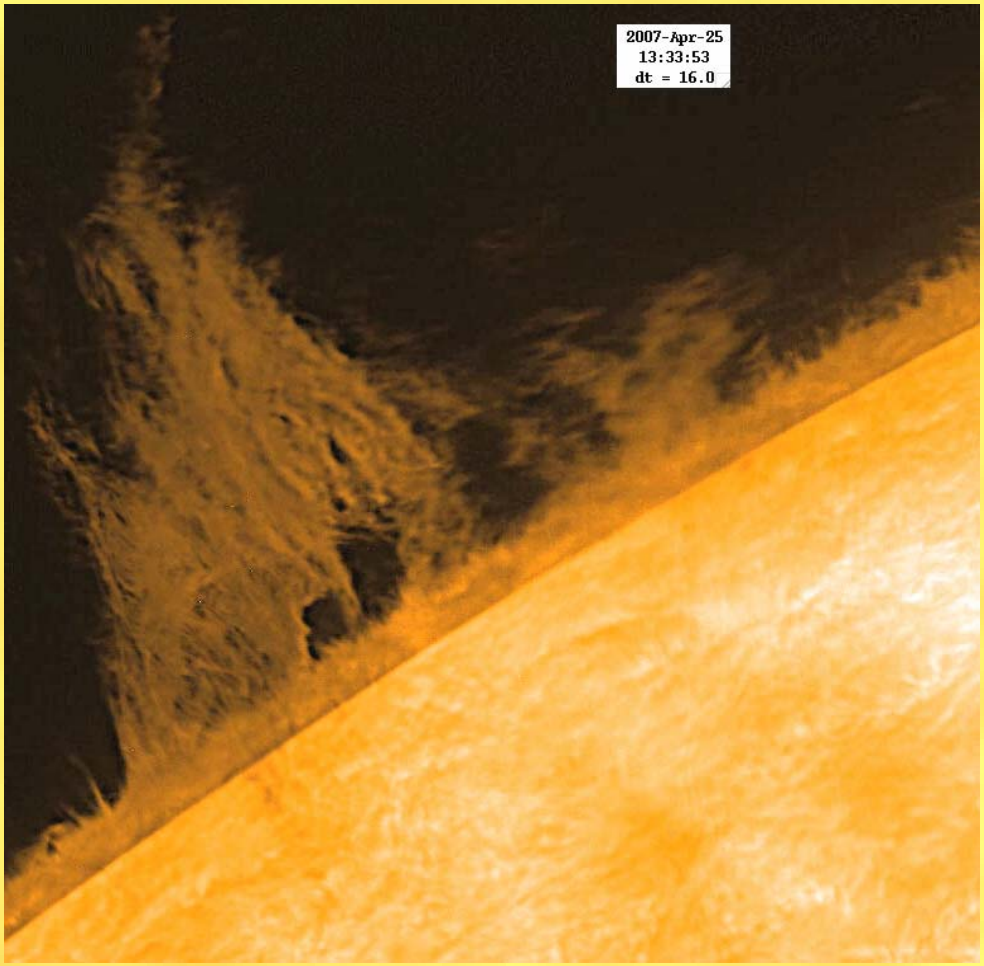
SOHO-EIT, 171 Å

Novosibirsk /Mongolija 1.8.2008



M. Druckmüller

Protuberance



Hα filter SOT Hinode

izbruhi ogromnih curkov relativno hladnega plina

T= 6000 – 10 000 K

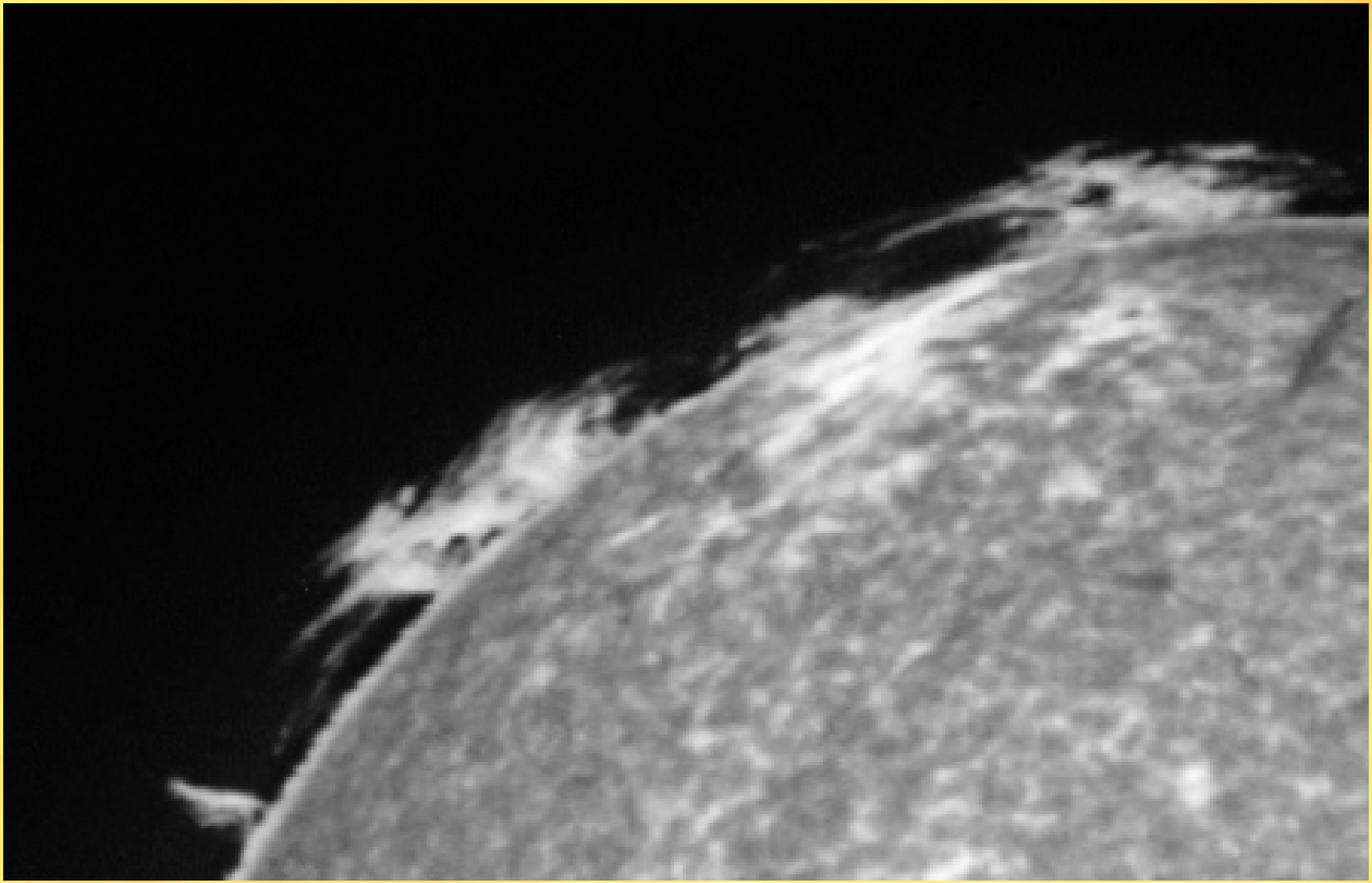
h= 10 000 – 100 000 km

$\rho = 10^{-14} - 10^{-13}$ kg/m^3

B= 1 – 10 G

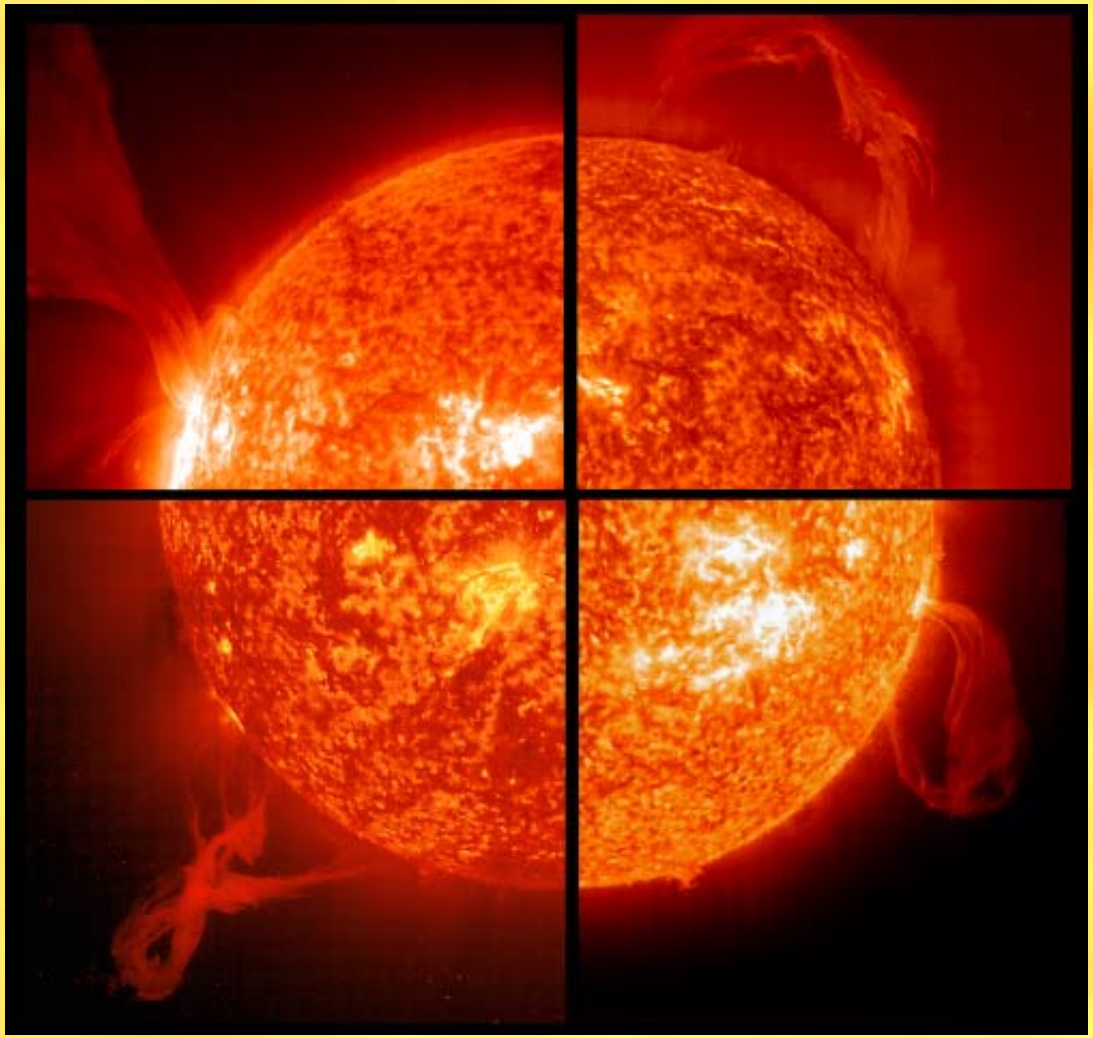
$\lambda_{H\alpha}$ = 6563 Å

Protuberance



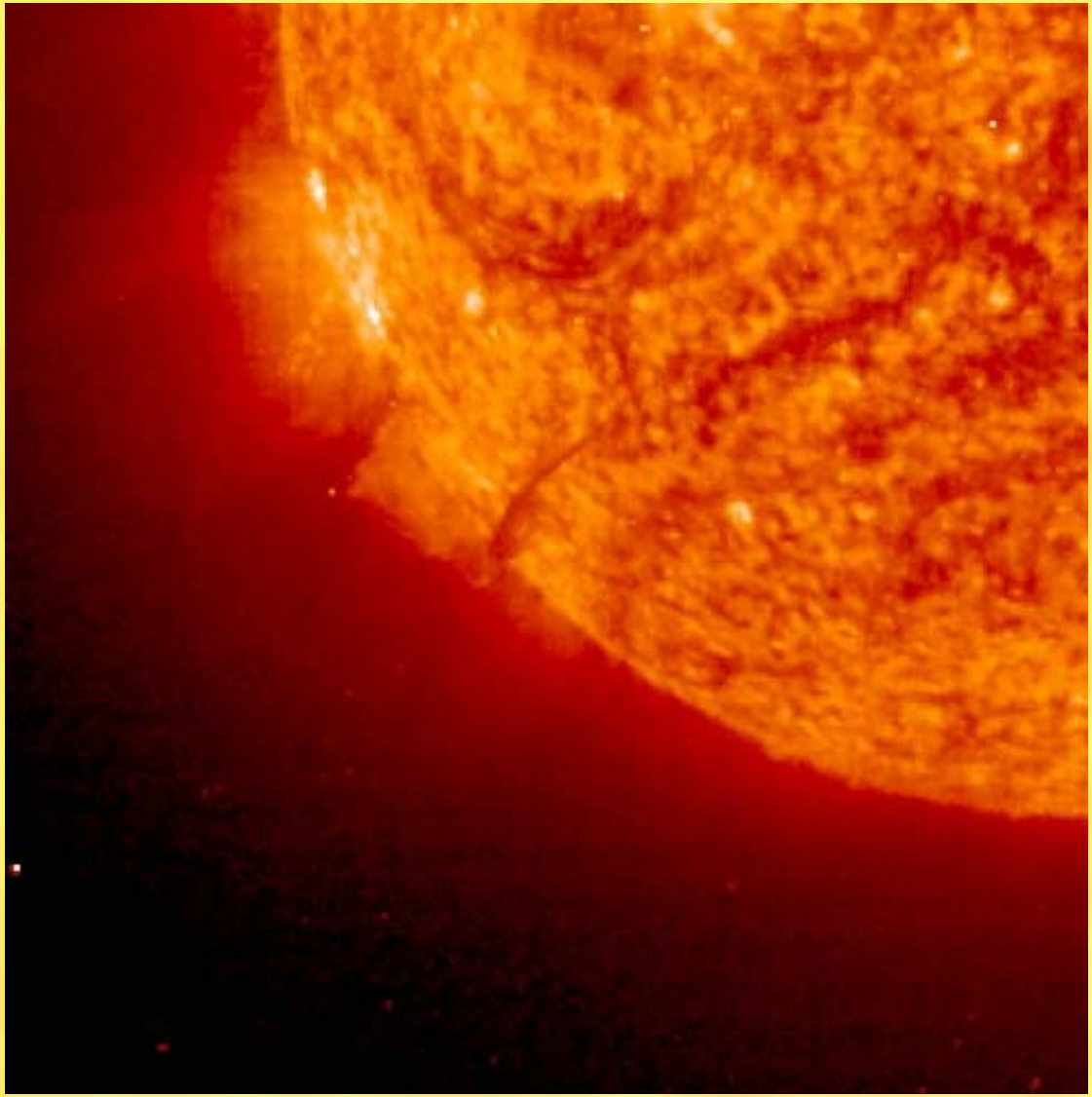
CaII K 3934 Å Meudon

Sestavljena slika najlepših protuberanc

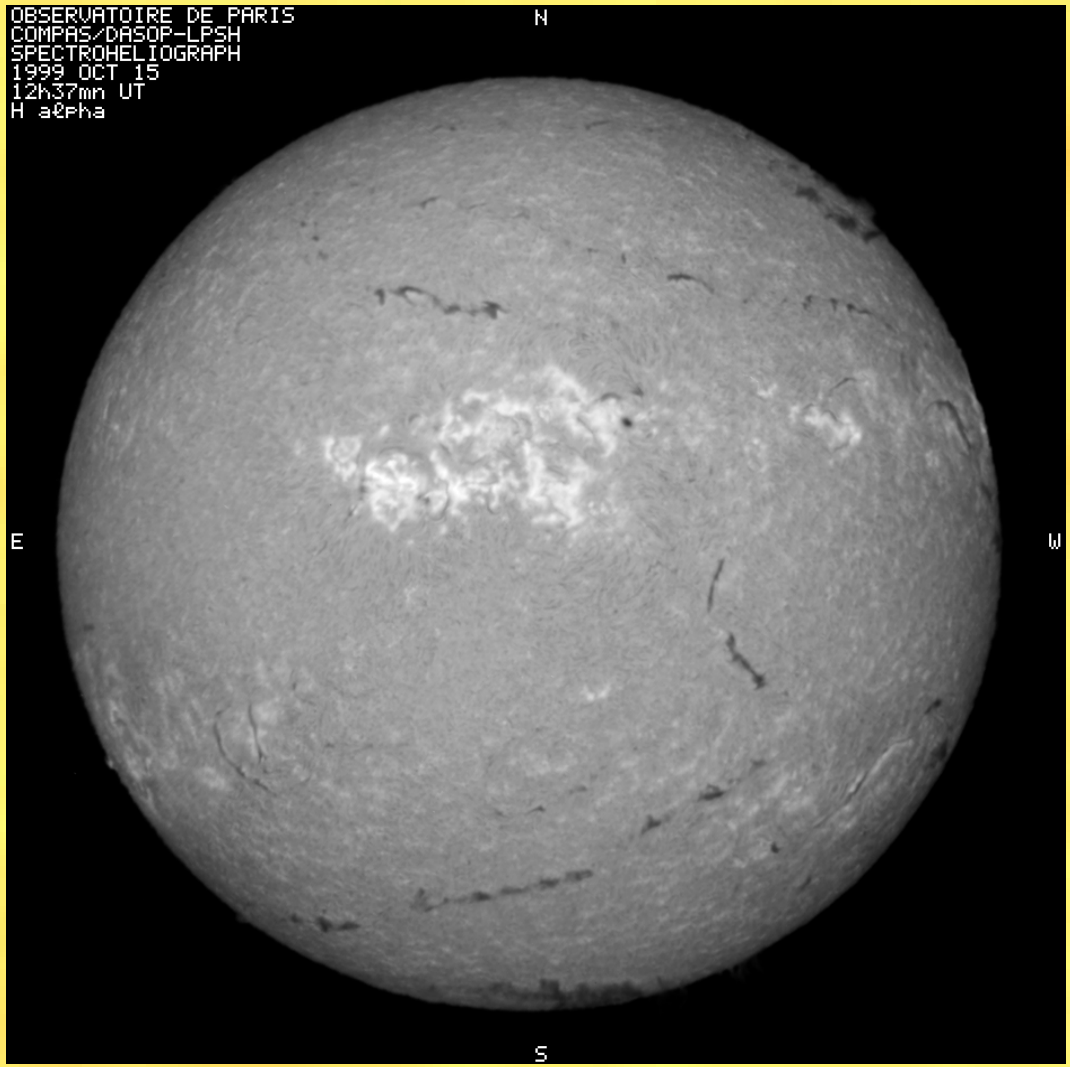


HeII 304 Å SOHO -EIT

Izbruh protuberance

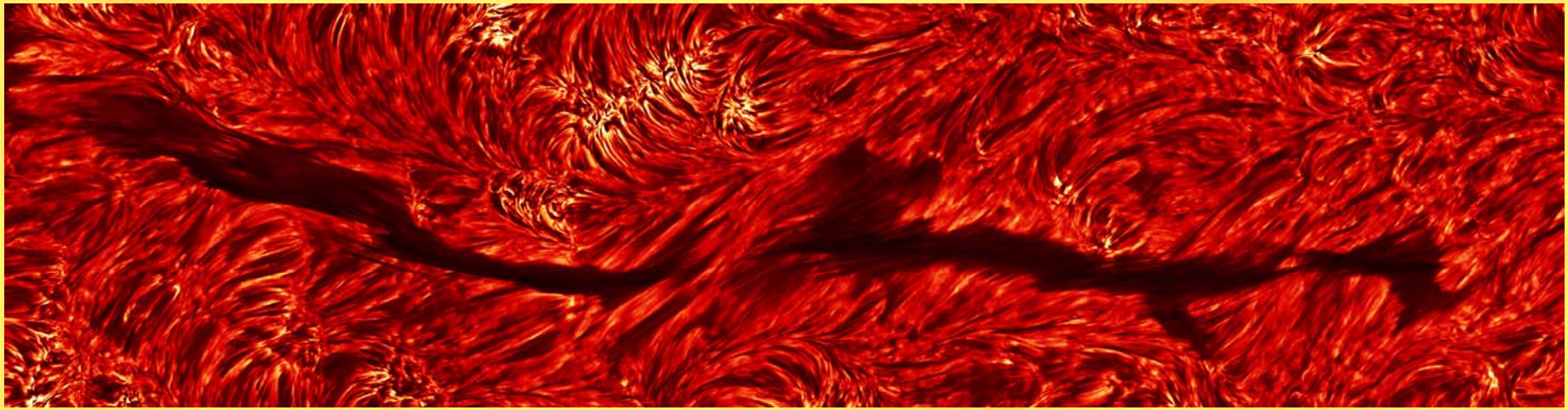


Filamenti



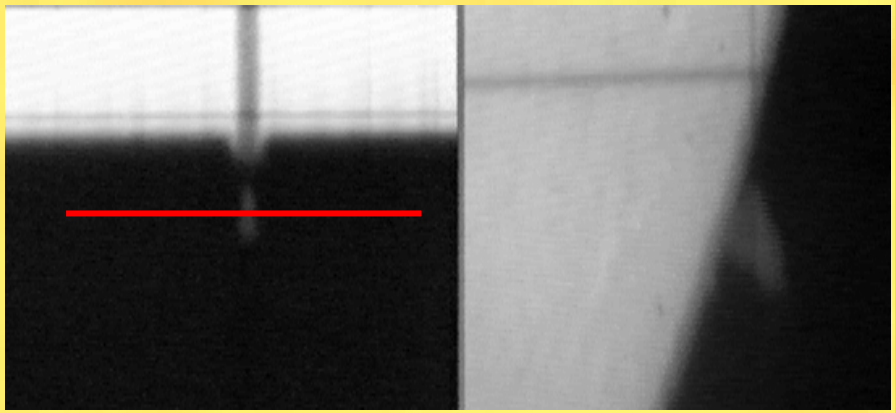
Hα filter Meudon

Detail filamenta

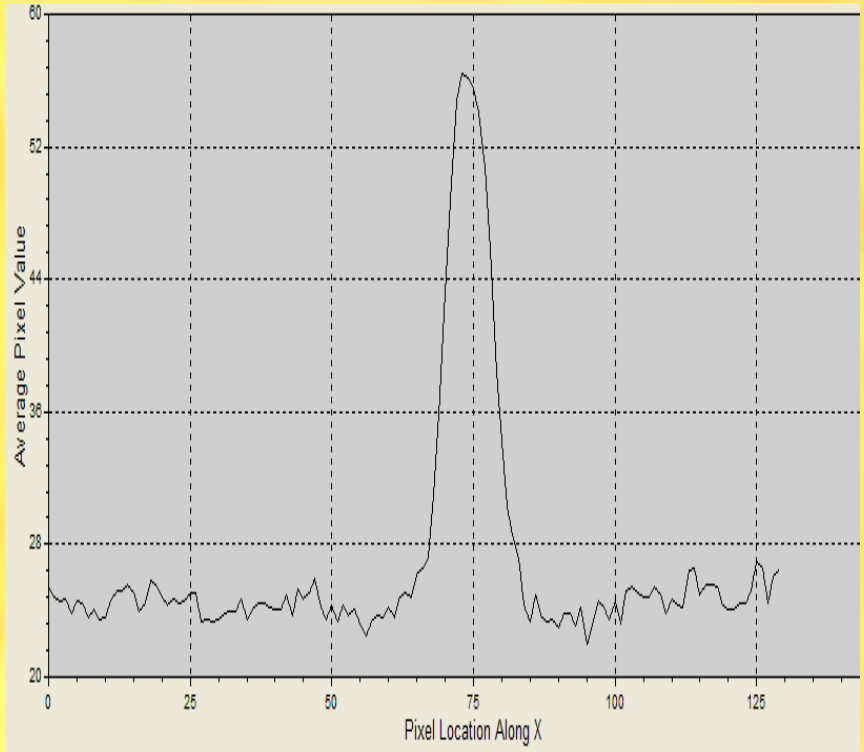


Hα filter DOT

Spekter protuberanc

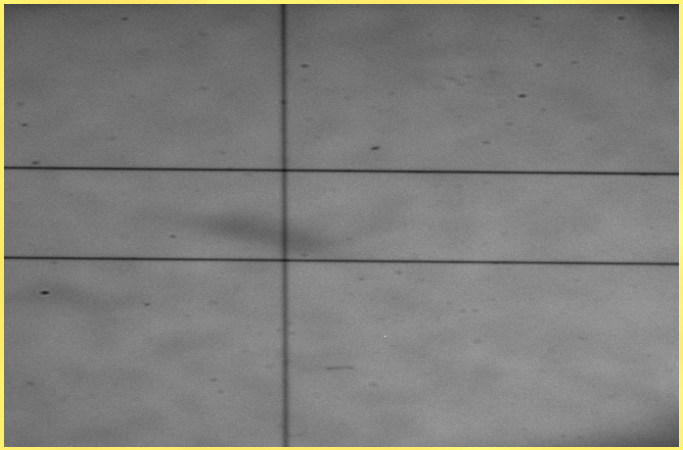


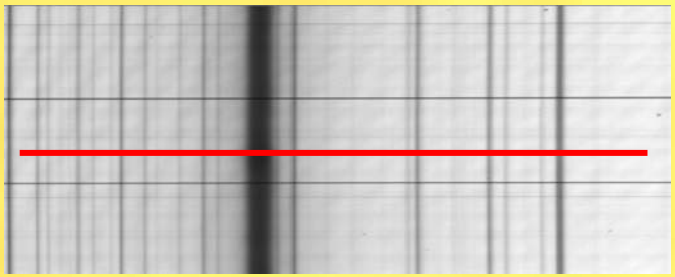
Hα filter Ondrejov

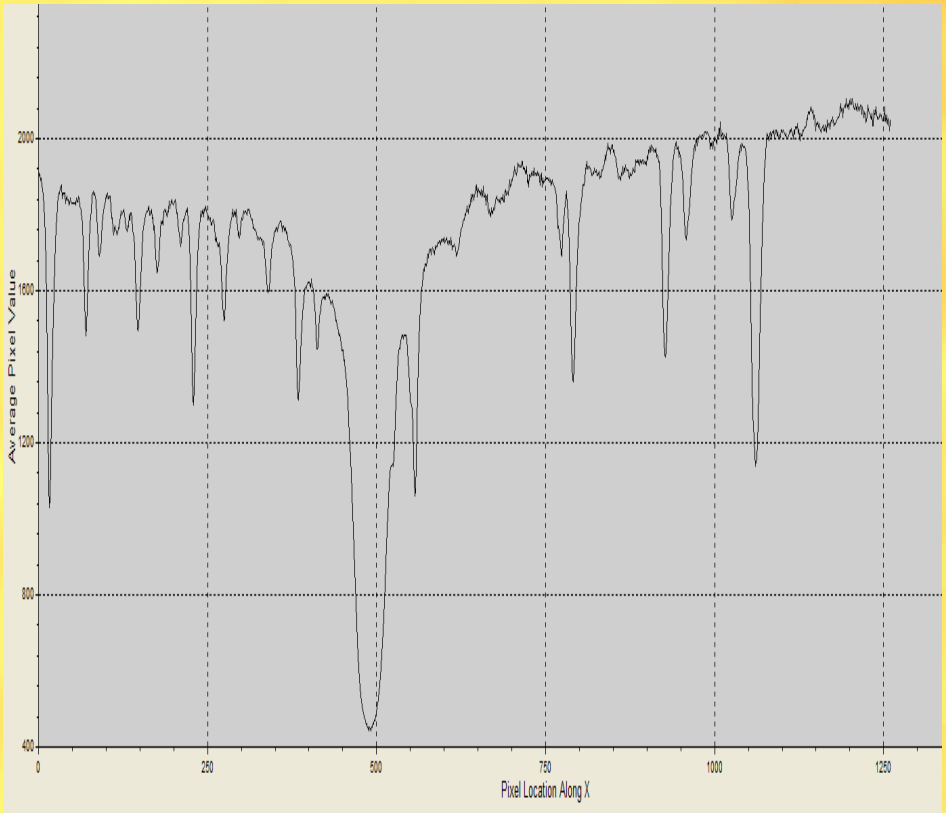


Emisijski spekter protuberanc Hα

Spekter filamentov





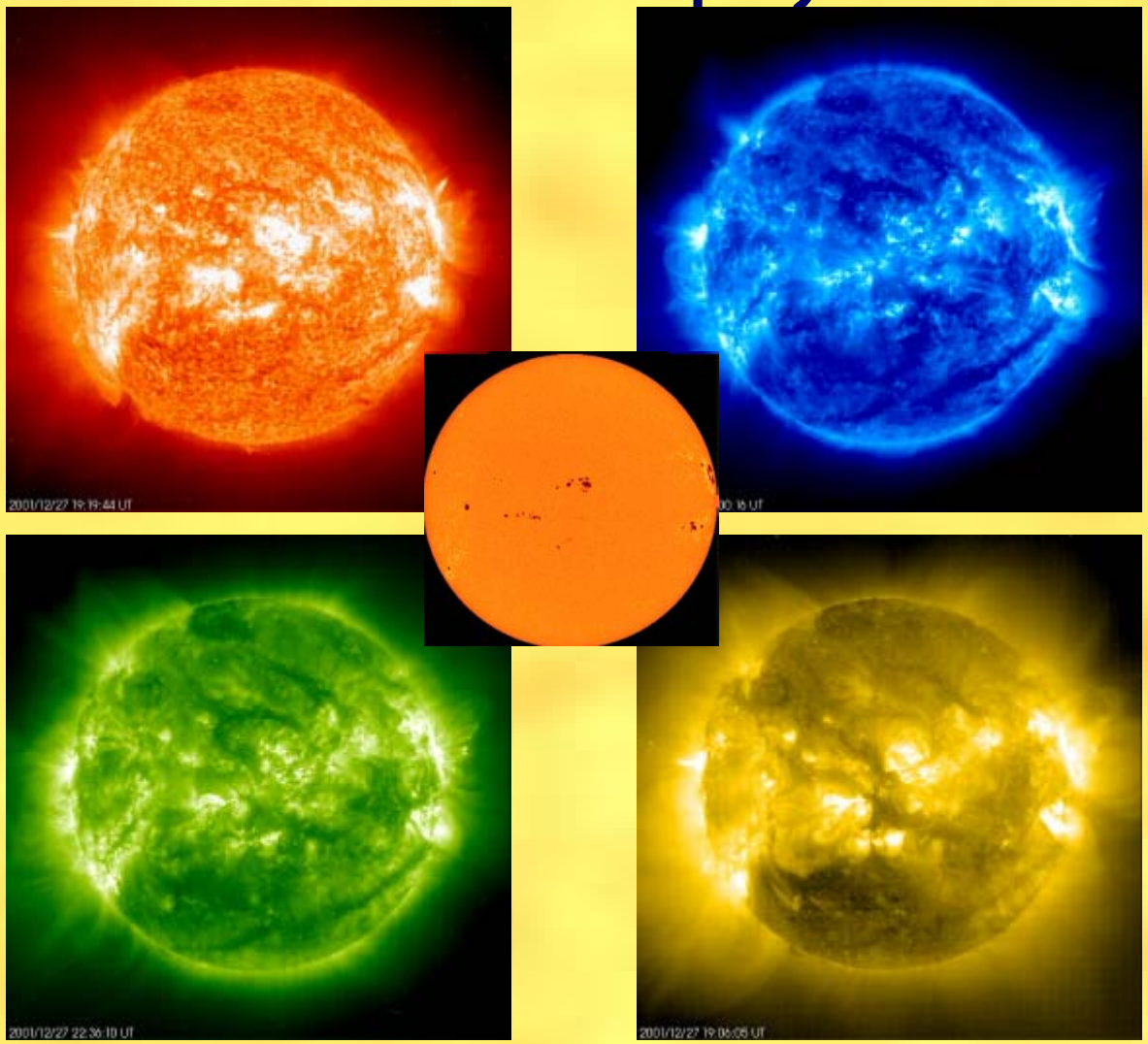


Hα filter Ondrejov

Absorpcijski spekter filamentov Hα

EIT (Extreme ultraviolet Imaging Telescope)

304 Å
zgornja kromosfera
$6 \cdot 10^4$ K
He II



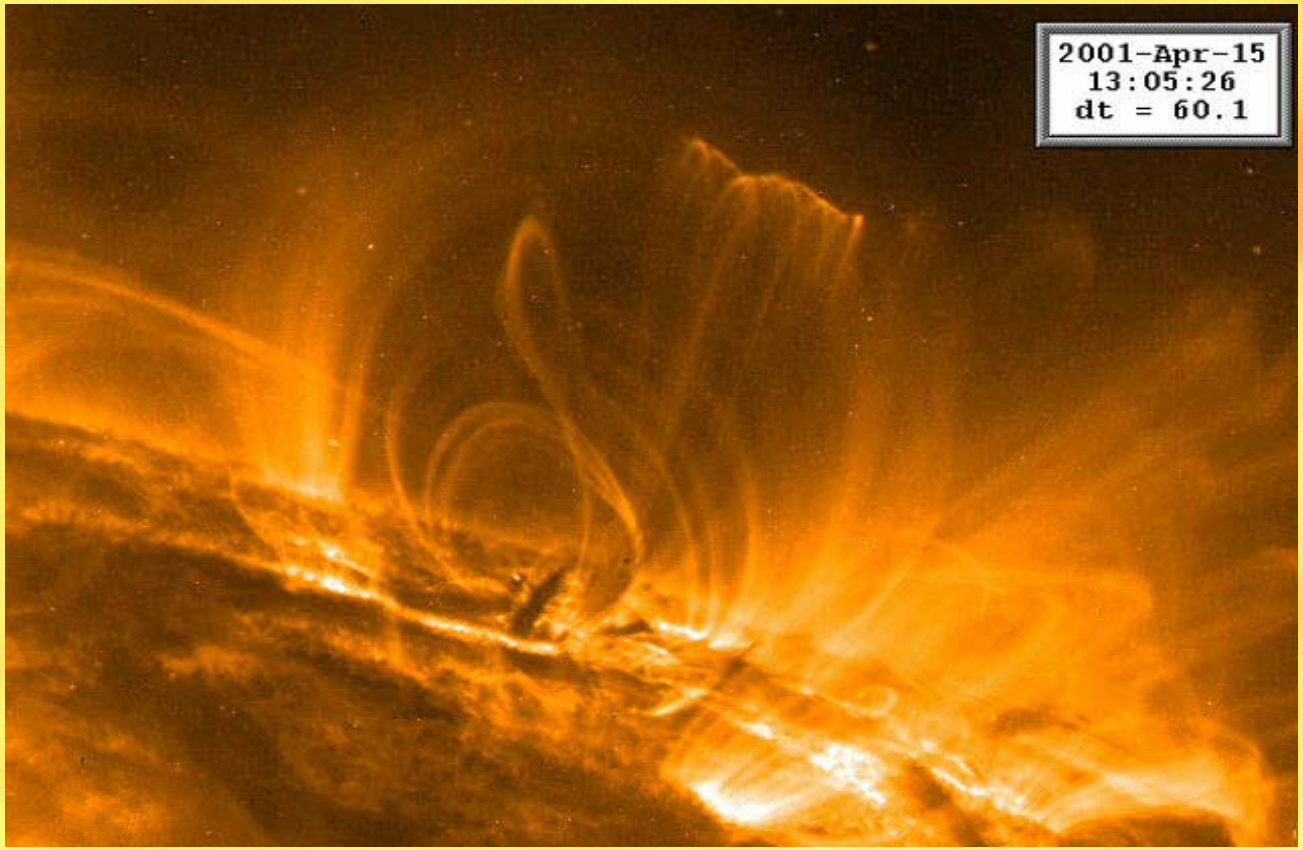
171 Å
sp. korona
10^6 K
Fe IX

195 Å
sr. korona
$1{,}5 \cdot 10^6$ K
Fe XII

284 Å
zg. korona
$2 \cdot 10^6$ K
Fe XV

Barve niso prave!

TRACE (Transition Region and Coronal Explorer)



Loki razbeljenega ioniziranega plina in aktivna območja v UV

Blišči

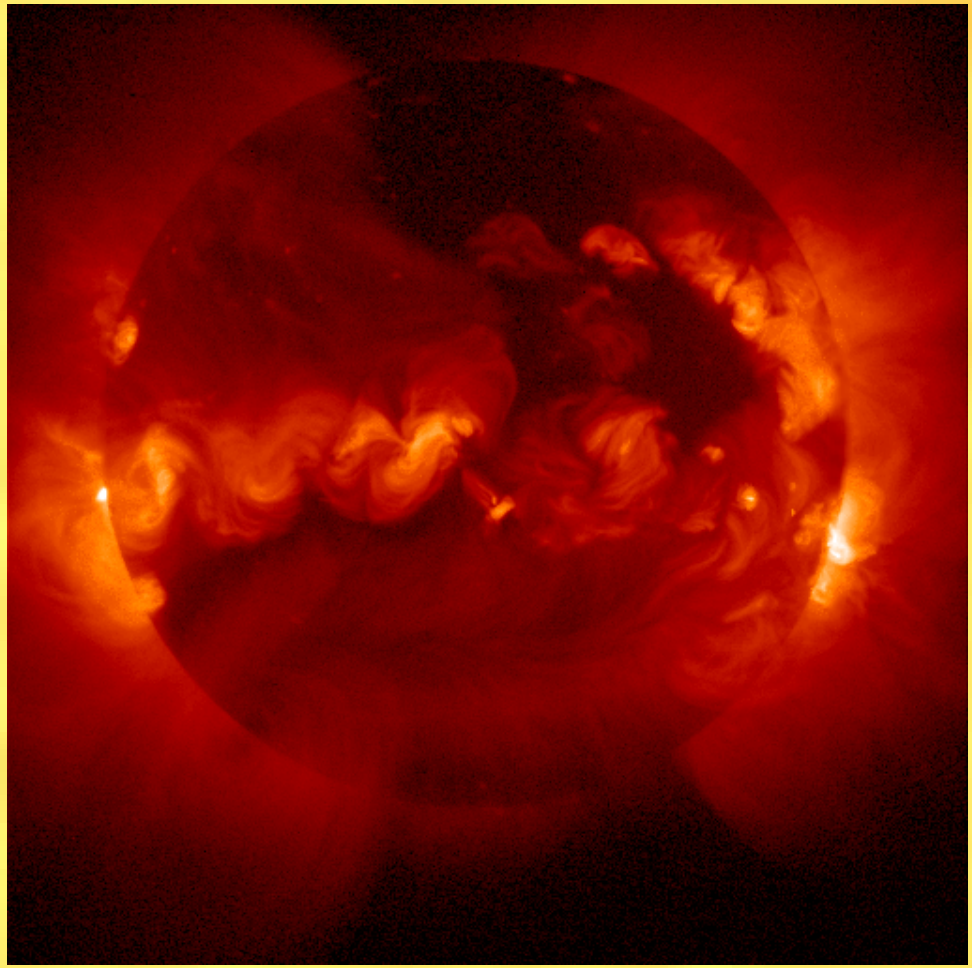
svetli izbruhi v zunanjem delu Sončeve atmosfere

povezani z AP → W_m

življenska doba: 20 min

temperatura do $40 \cdot 10^6$ K

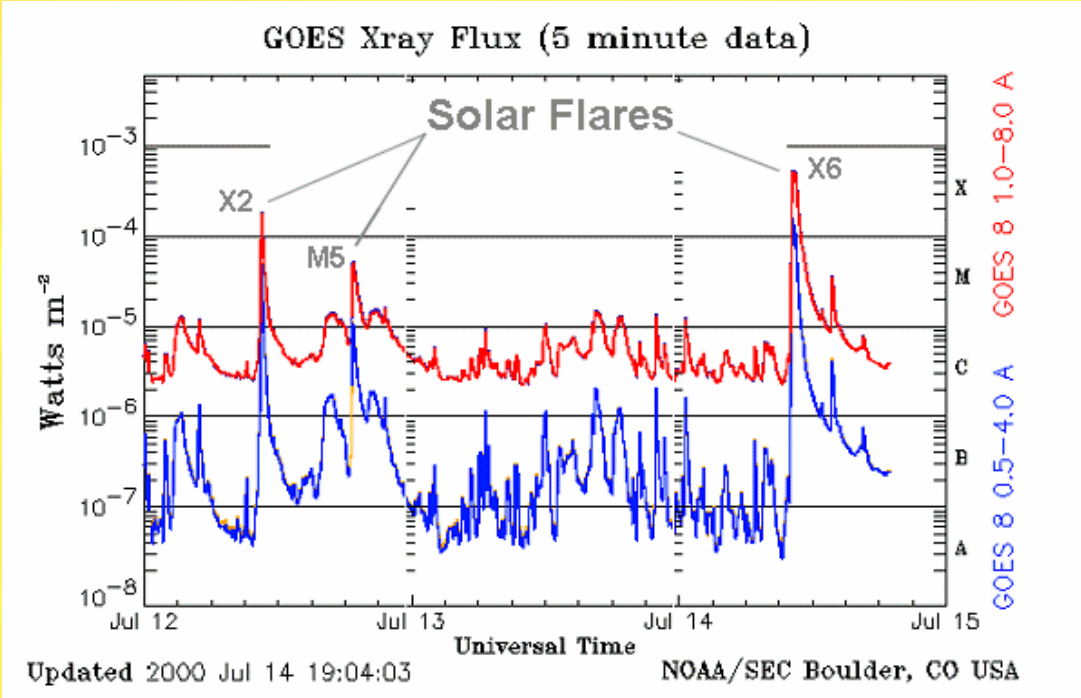
energija: 10^{22} – 10^{25} J

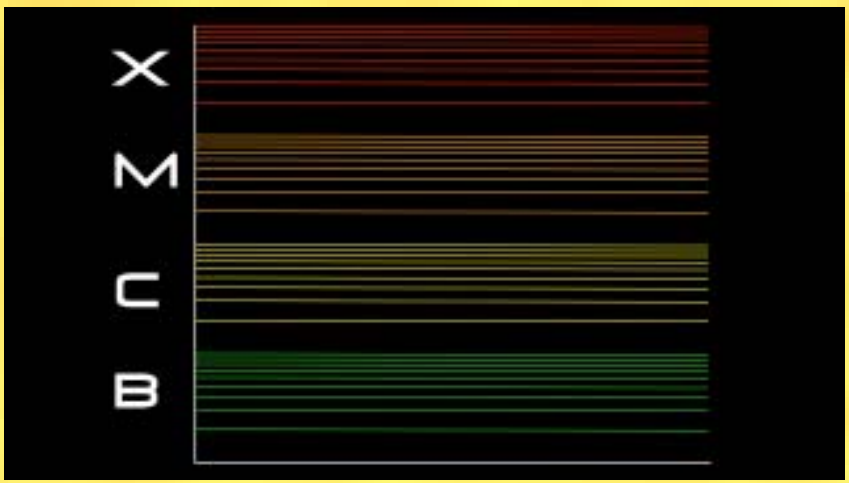


SXT- Yohkoh

Nastanek bližča

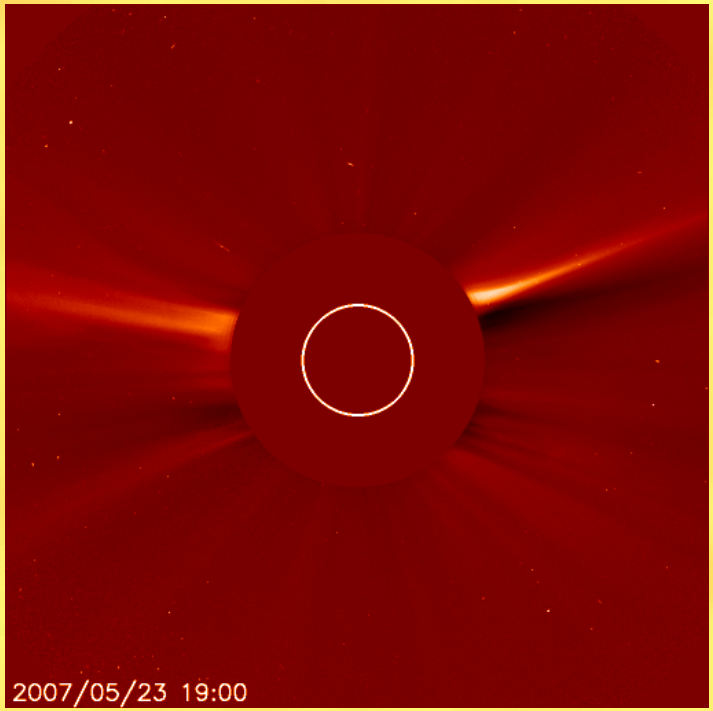
Klasifikacija bliščev



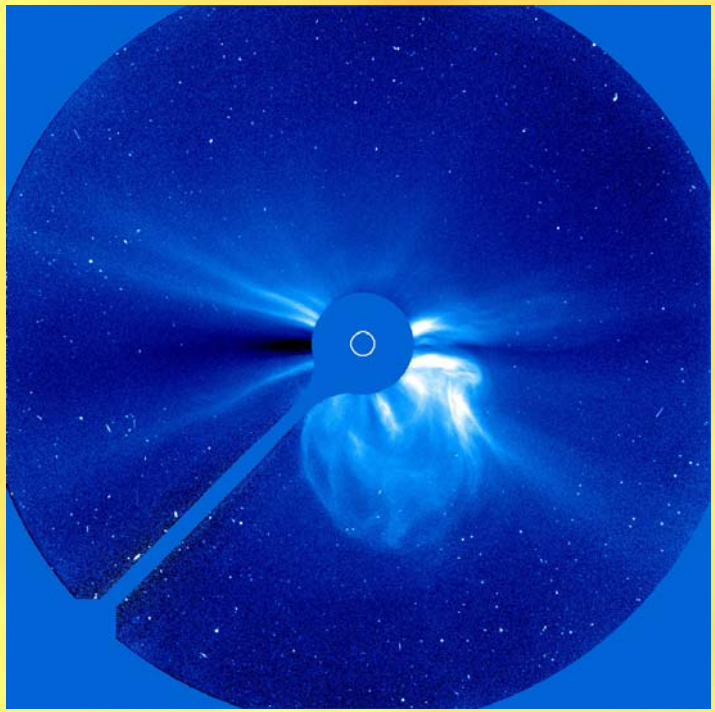


Class	*Peak (W/m^2) between 1 and 8 Angstroms*
B	$I < 10^{-6}$
C	$10^{-6} <= I < 10^{-5}$
M	$10^{-5} <= I < 10^{-4}$
X	$I >= 10^{-4}$

SOHO LASCO (Large Angle and Spectrometric COronagraph)



C2– vidno polje 3°



C3 -vidno polje 16°

Izbruh koronalne mase (CMEs)

velike eksplozije

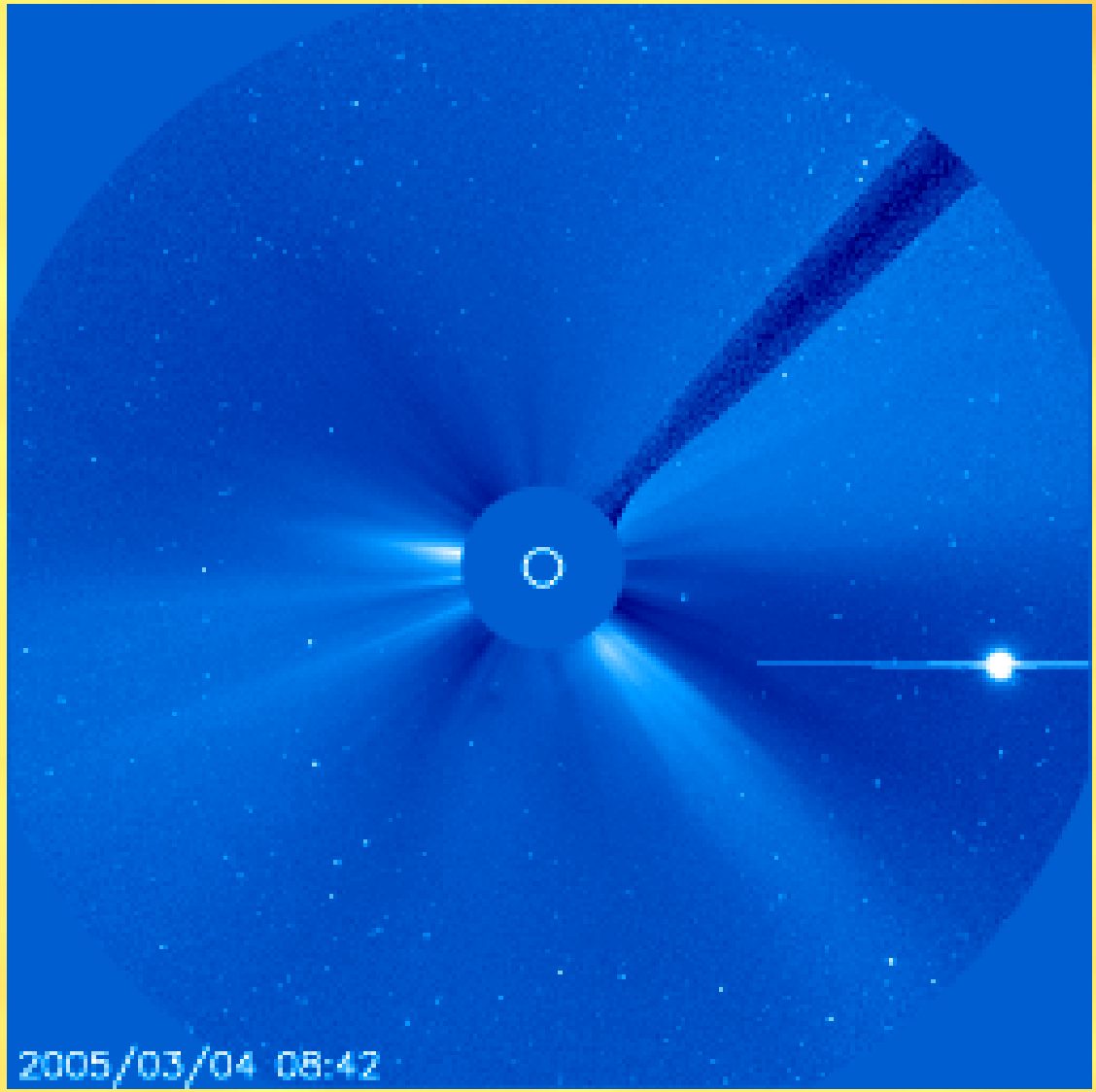
masa: 10^{15} g

hitrost: 20 - 2000 km/s

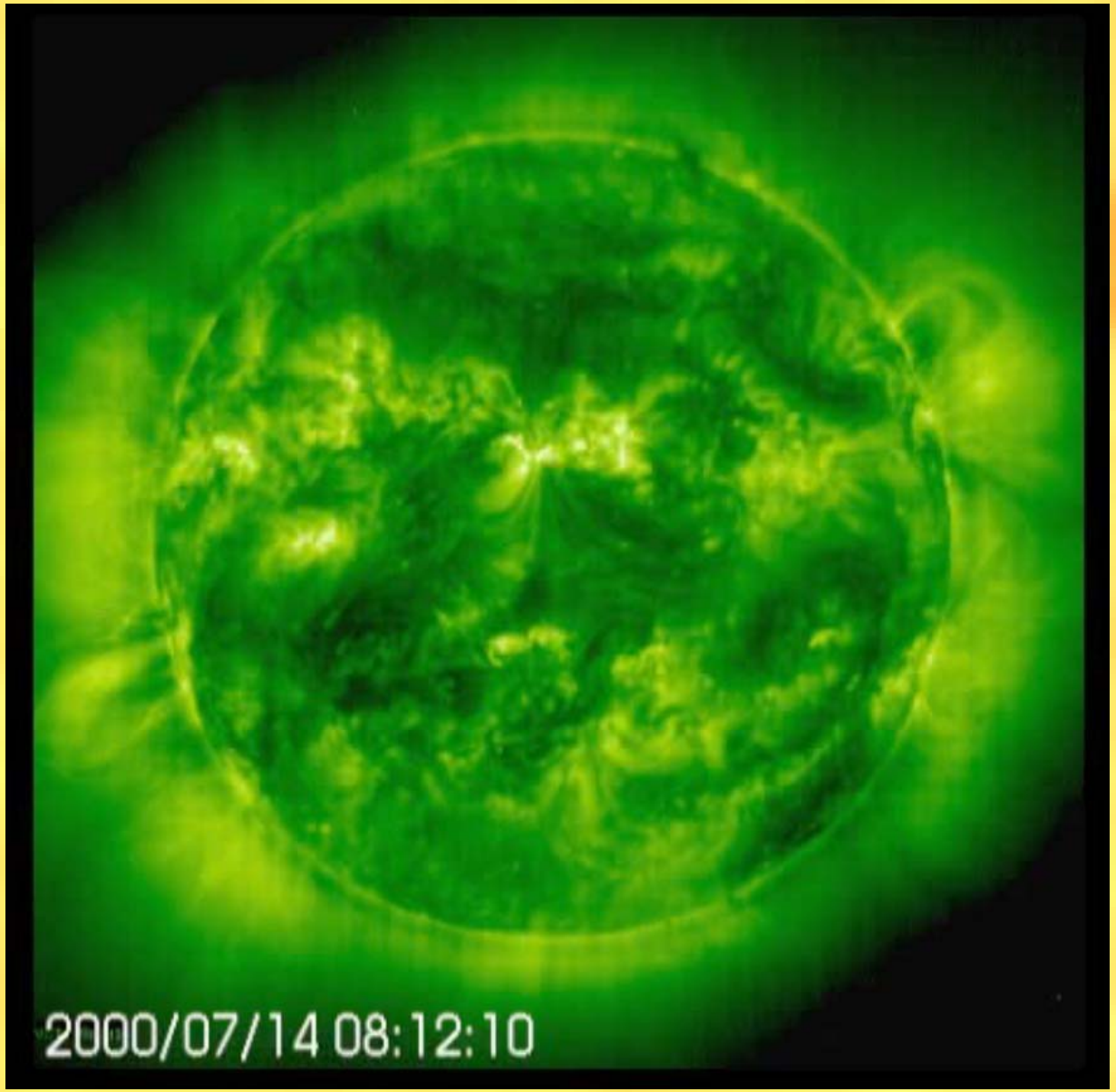
T=8000 K - $2 \cdot 10^6$ K

ν_{min} =0,5 /dan

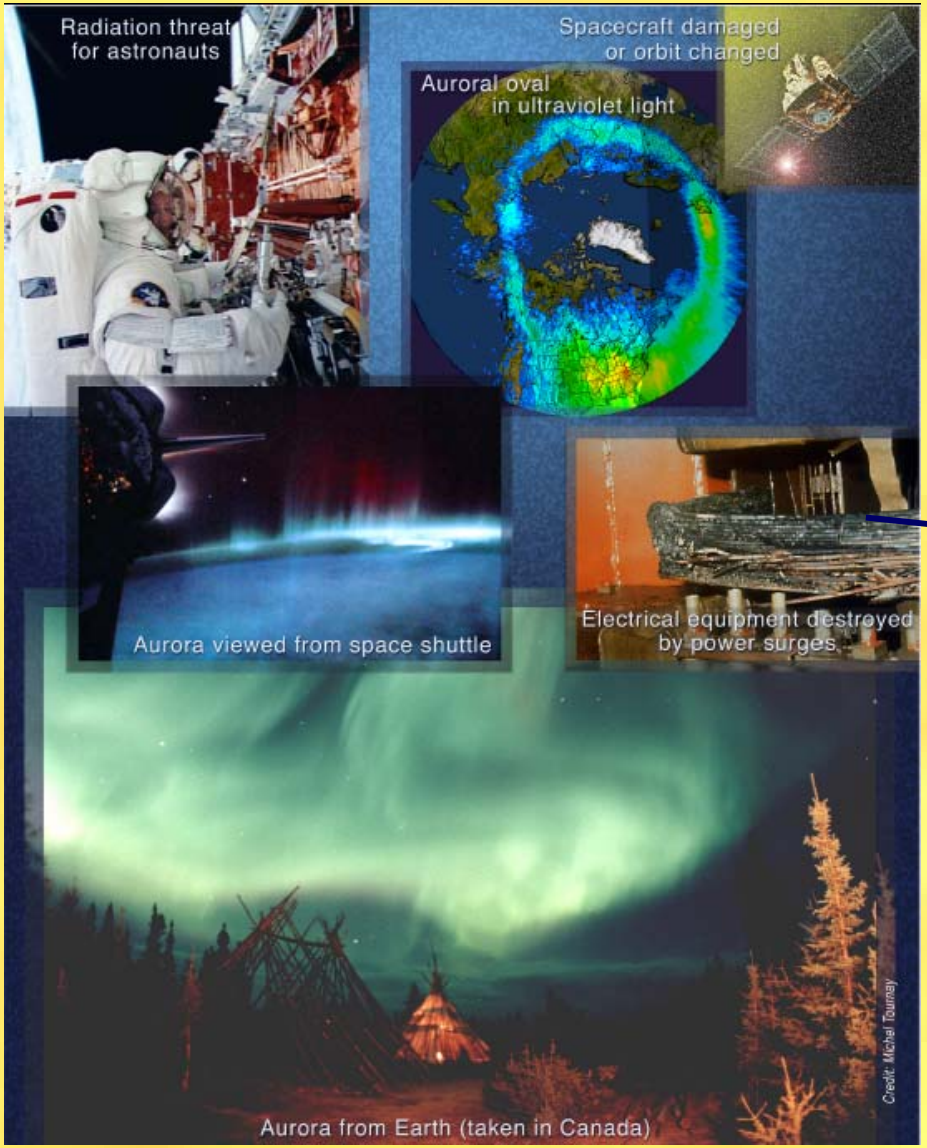
ν_{max} =4,5 /dan



Izbruh bližča in koronalne mase



Geomagnetni vihar



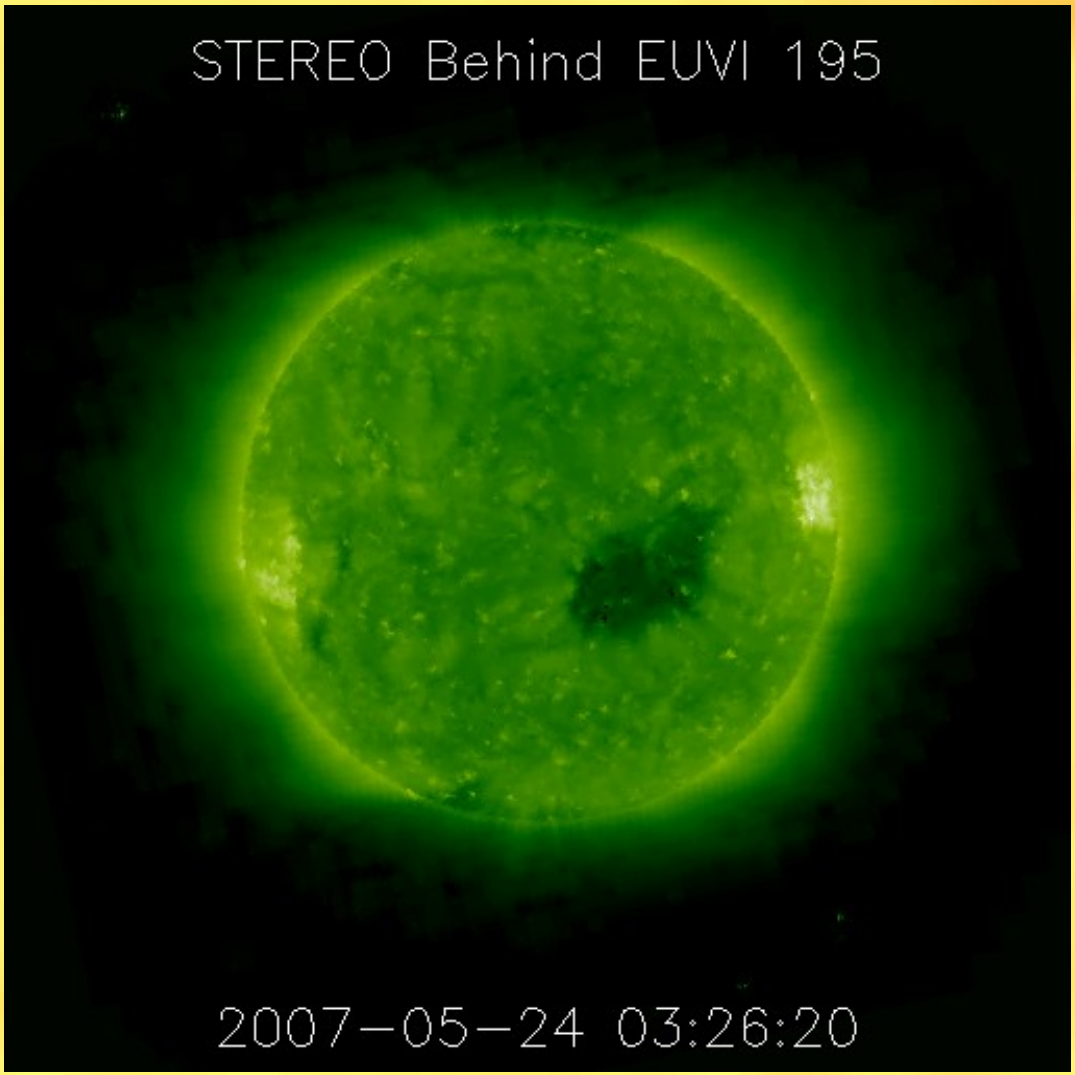
Norveška, 1989

Koronalne luknje

s teleskopi nad Zemljino atmosfero v rtg, UV

povezane z „odprtimi“ magnetnimi silnicami

izvor hitrega sončevega vetra



Sončev veter

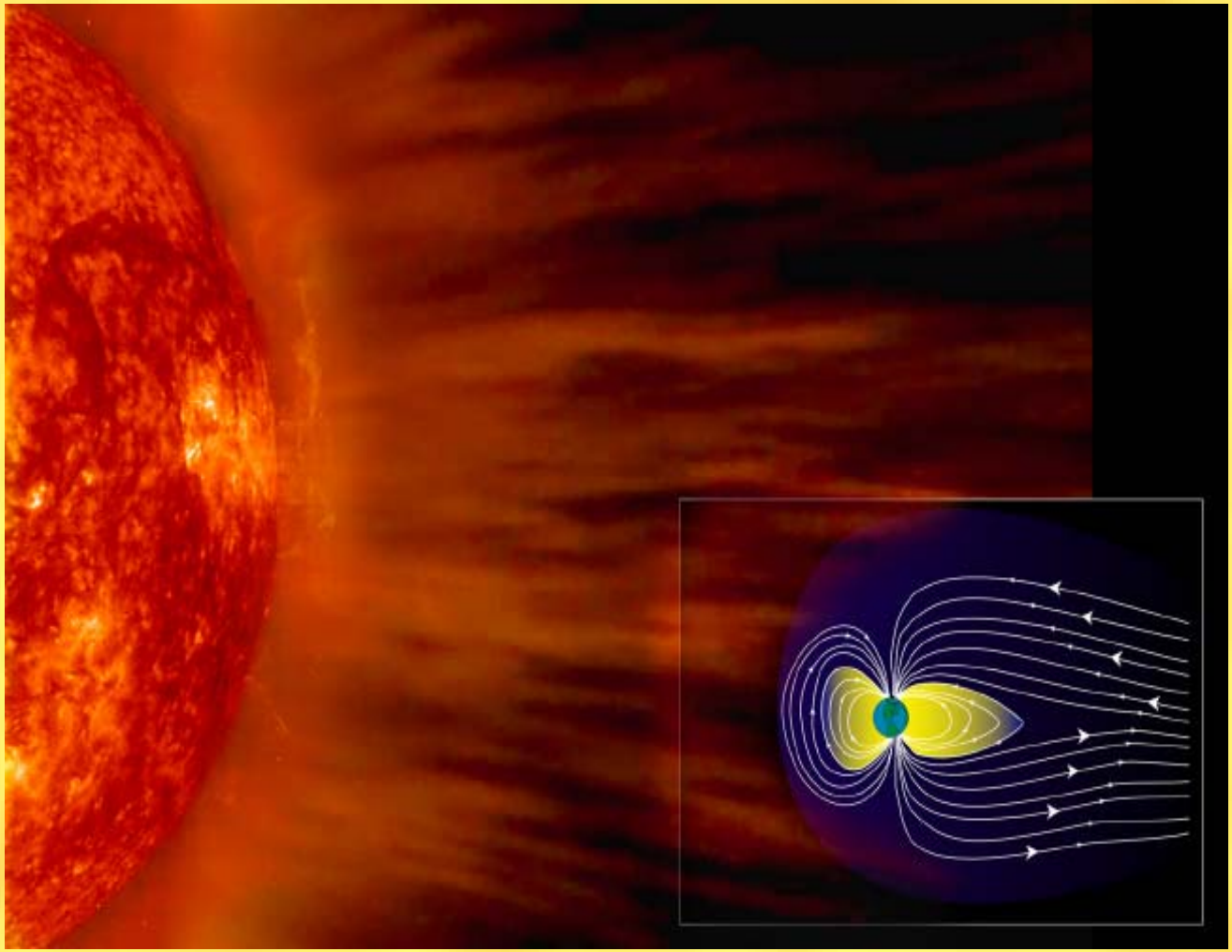
stalni tok ioniziranega plina (protoni, elektroni)

hitrost:

350 – 450 km/s

heliosfera do

100 AE



Zaključek

Sonce nam najbližja in najlepša zvezda

vir energije, toplote in omogoča življenje

edinstven laboratorij za razumevanje fizike plazme, fizike delcev, MHD

edina zvezda, na kateri lahko razločimo podrobnosti tako na površju kot v atmosferi

osnovne fizikalne zakonitosti, ki uravnavajo življenje Soncu podobnih zvezd in določajo njihove lastnosti