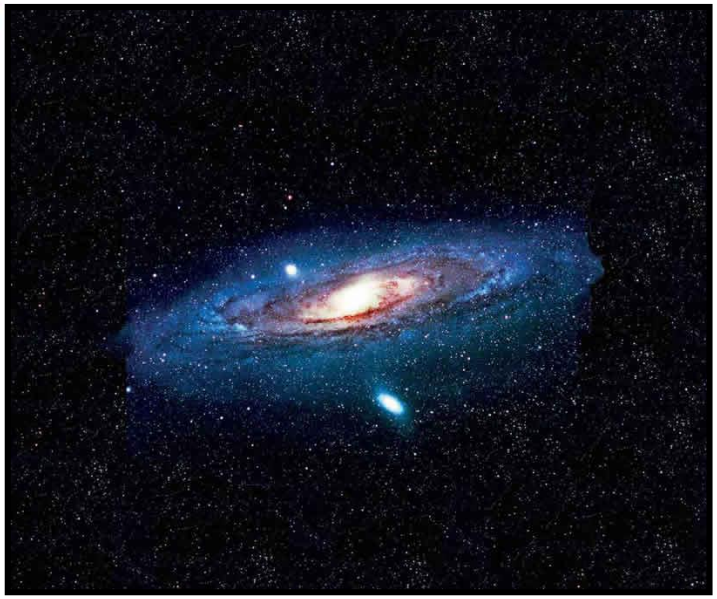
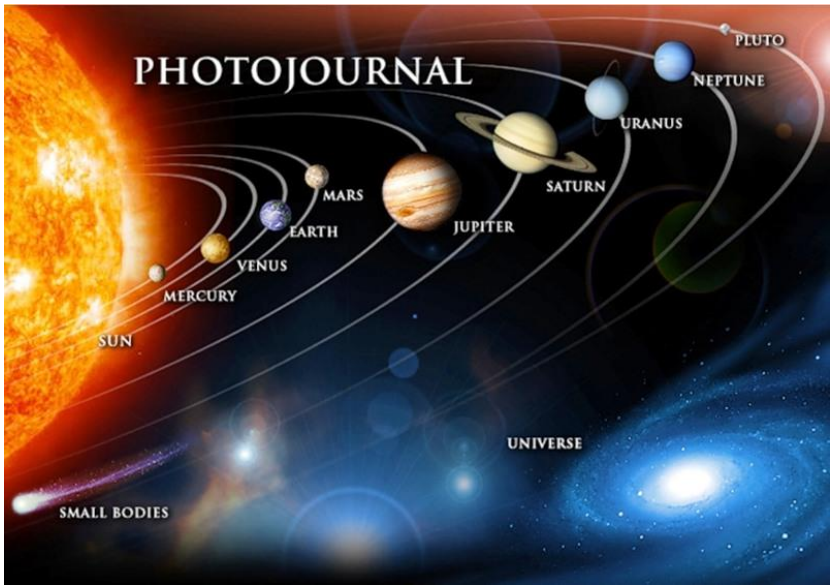
緒論

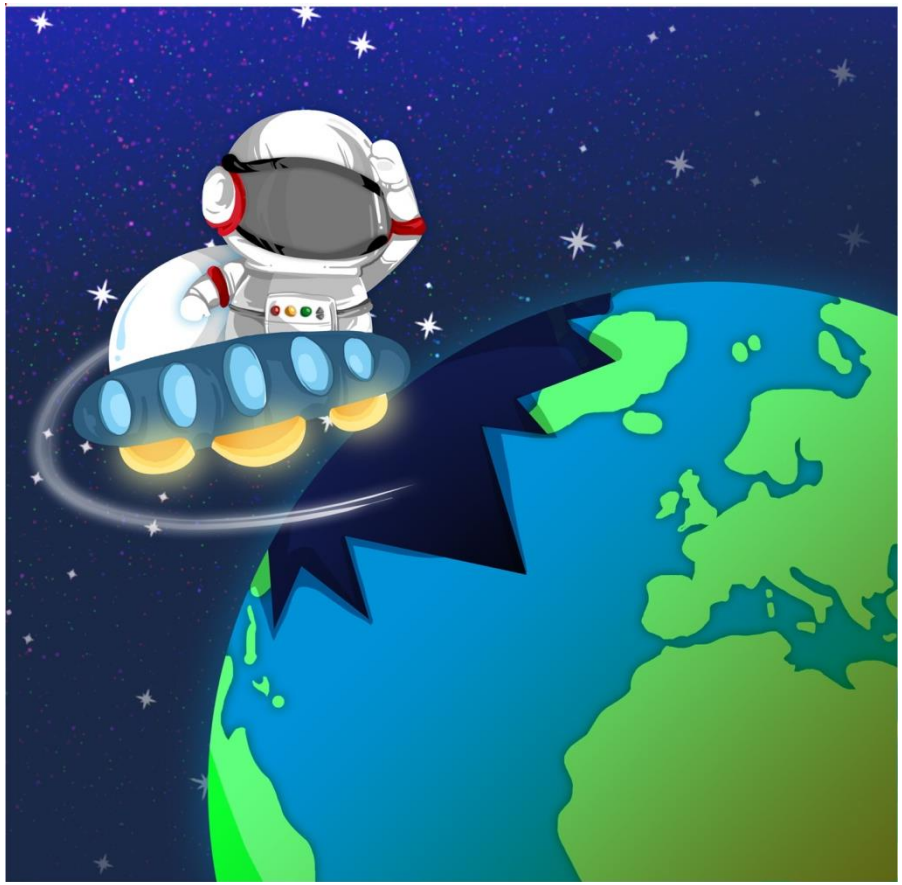
太空簡介

太空是哪一個?




PHOTOJOURNAL
PLUTO
NEPTUNE
URANUS
SATURN
JUPITER
MARS
EARTH
VENUS
MERCURY
SUN
UNIVERSE
SMALL BODIES

什麼是太空？　太空船所能到的範圍



太空-太空船能到處
太陽系

Heliopause
日磁層頂

1977年
137.0AU
航海家一號

太陽

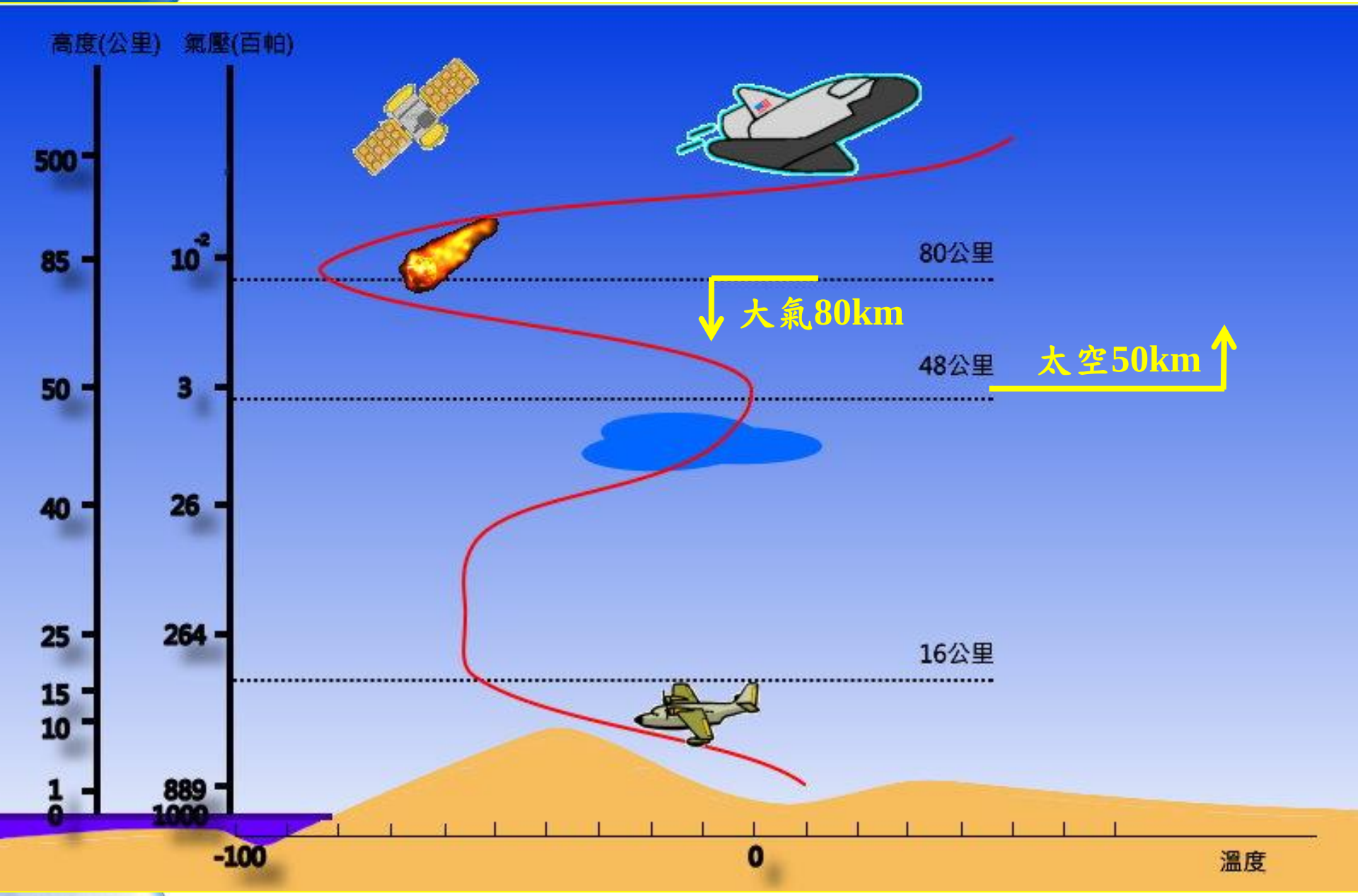
太陽風終極震波
Termination shock

八大行星軌道

Heliosphere
日磁層

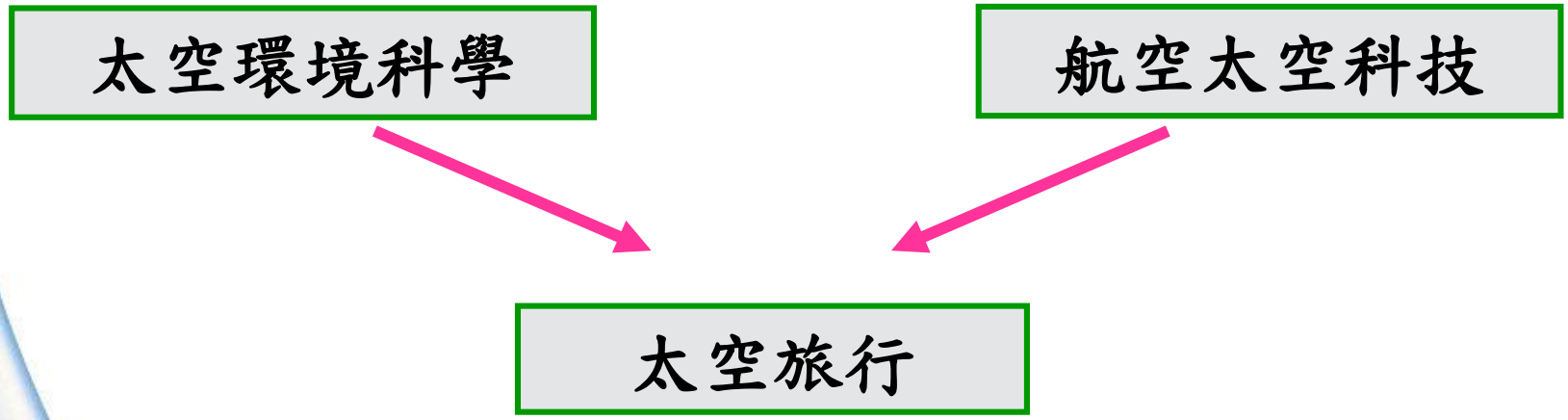
航海家二號
1977年
112.6AU

http://voyager.jpl.nasa.gov/index.html

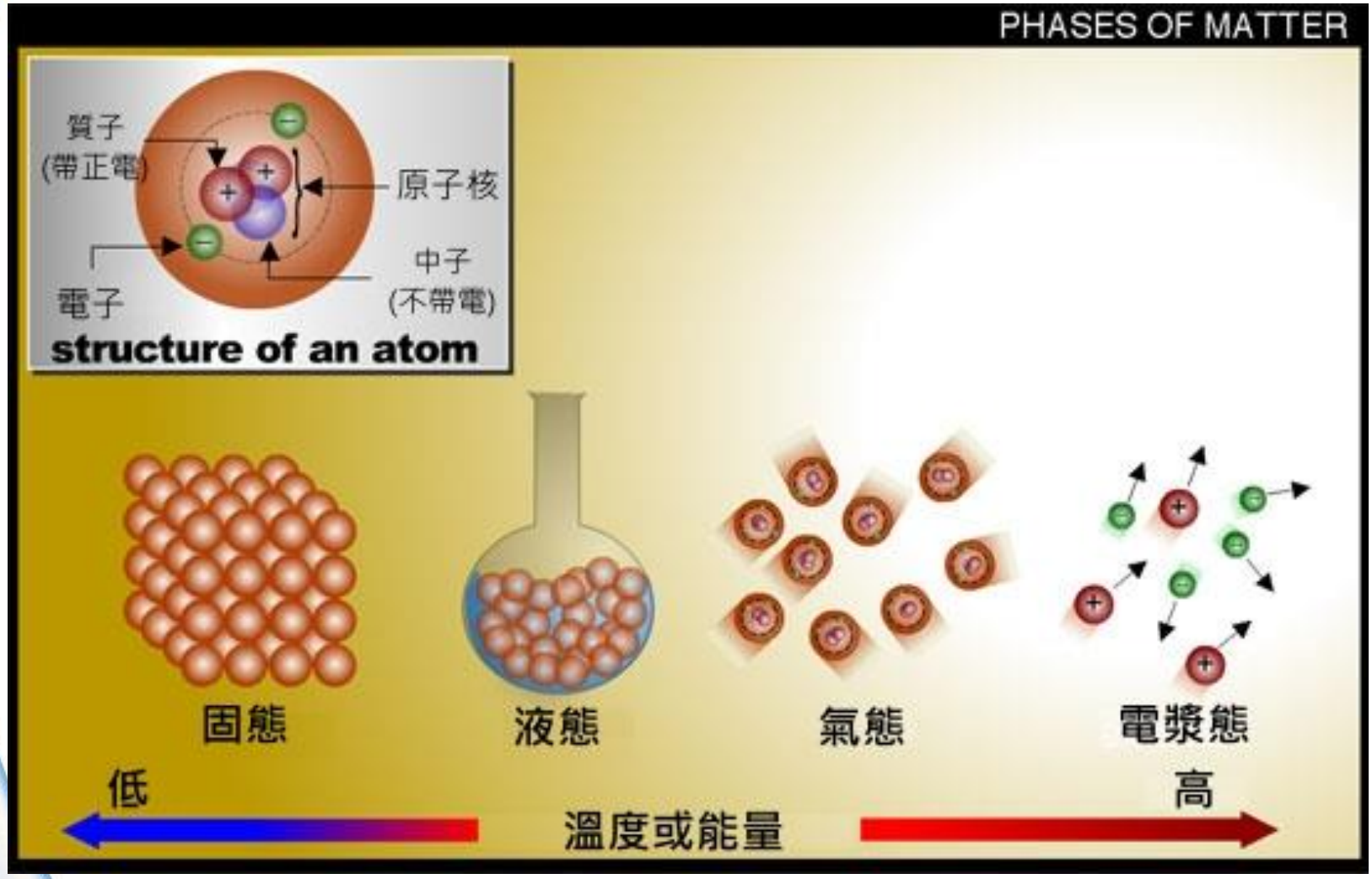

高度(公里)
氣壓(百帕)
500
85
50
40
25
15
10
1
0
10^{-2}
3
26
264
889
1000
80公里
48公里
16公里
大氣80km
太空50km
-100
0
溫度

- 大氣—地球表面至地表80公里
- 太空—地球表面50公里到太陽系　電漿態!
- 天文—太陽、恆星、星系以至銀河

- 科學—數學、生物、物理、化學與自然科學
- 科技—電機、機械、土木…等工業技術



物質四態


PHASES OF MATTER
質子
(帶正電)
原子核
中子
(不帶電)
電子
structure of an atom
固態
液態
氣態
電漿態
低
高
溫度或能量

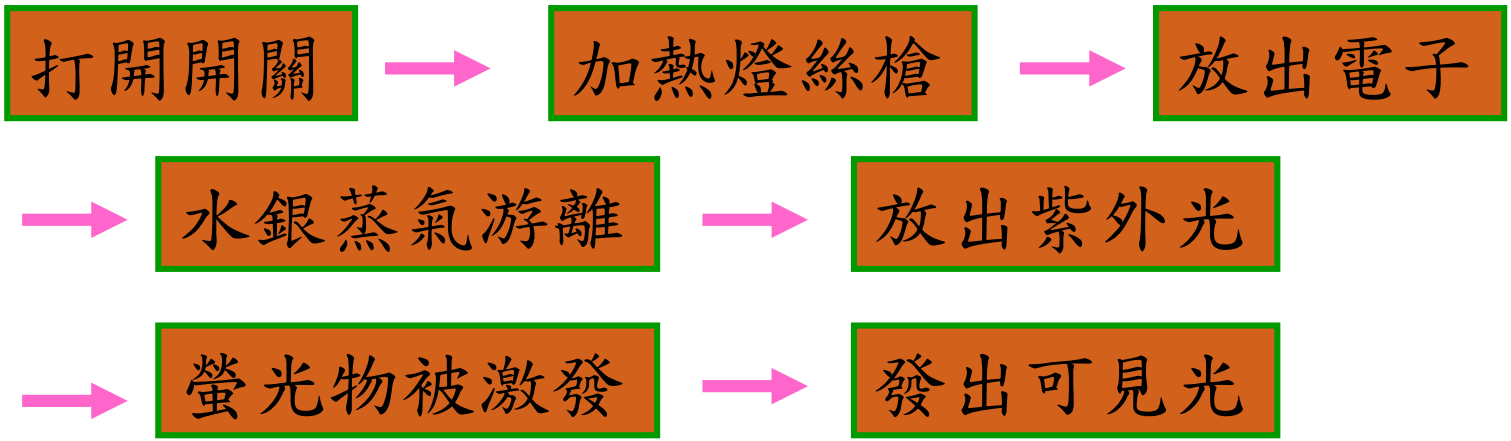
+2凝態 +黑物質

電漿就在我們的生活中

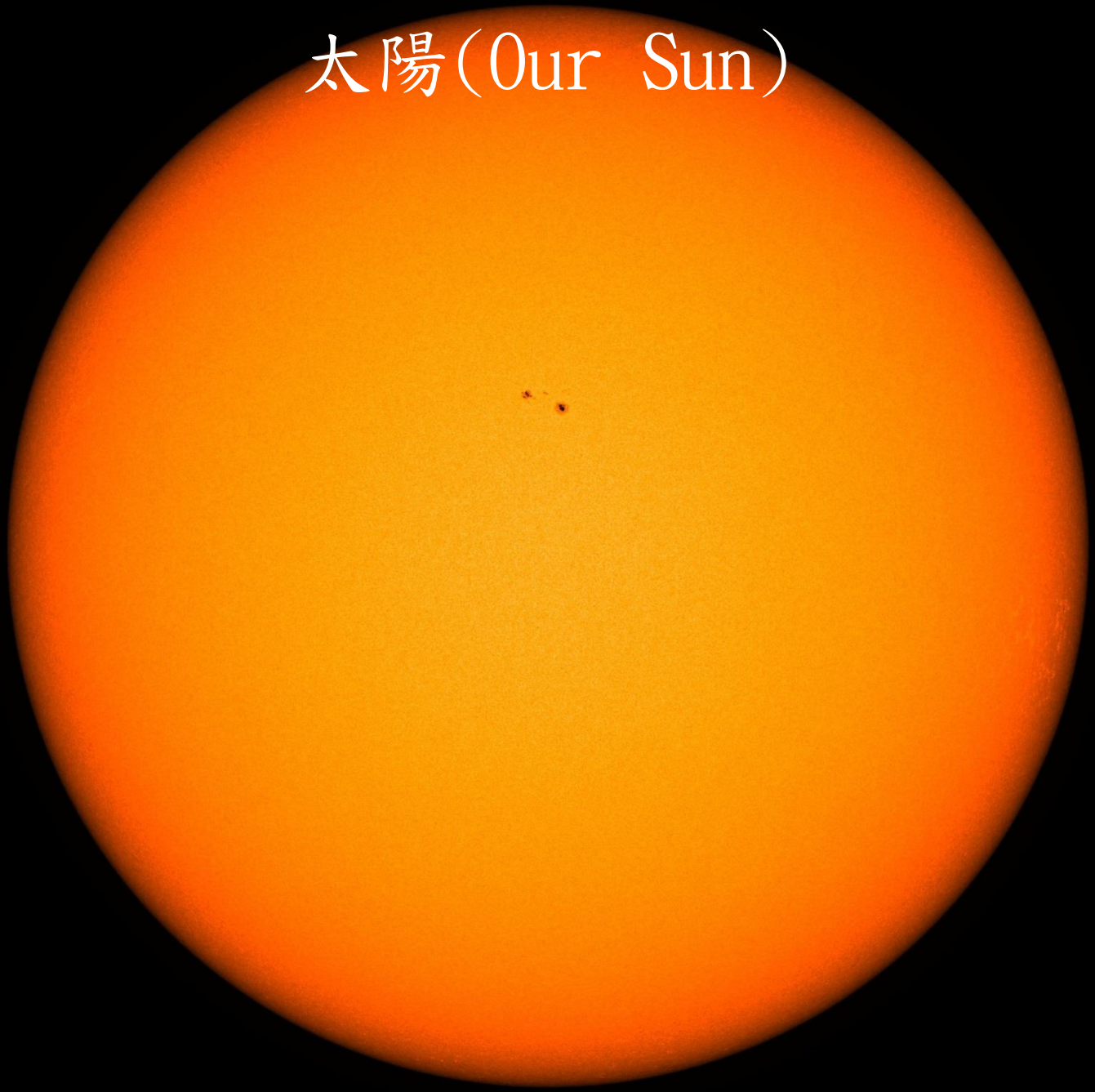
http://blog.goo.ne.jp/nabanatei/e/3e076305218bddac72d063b092aca2c7
http://canitbesaturdaynow.com/dived/single/purple_lighting/
http://blog.yhb.com/jimyang/Archives/2013/02/07/21236

日光燈的原理

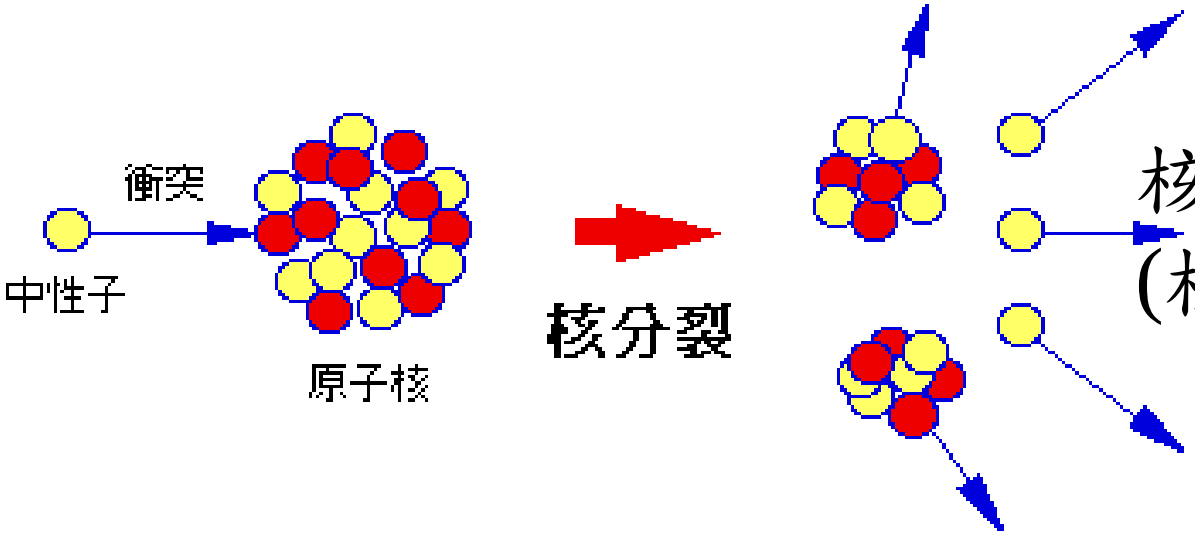
- 構造：
  - 兩端各具有一組燈絲槍，並塗有電子放射物
  - 密閉的低壓管，約為大氣的0.3%
  - 充滿惰性氣體以及微量的水銀蒸氣
  - 管壁塗有螢光物
- 原理：



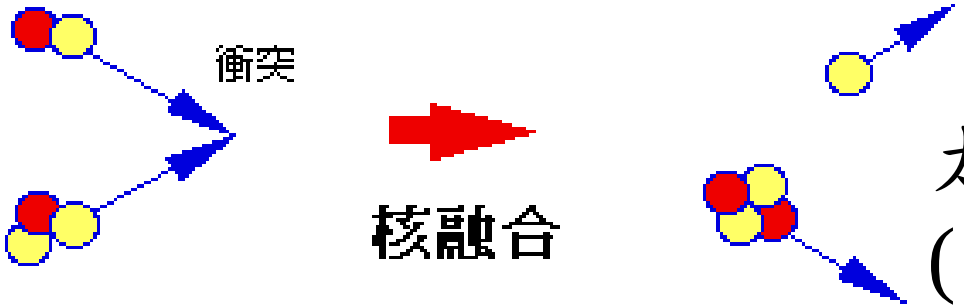
太陽（Our Sun）



核融合反應
(與核分裂)



核能發電
(核汙染)



太陽核心
(零污染)

太陽參數Sun Facts

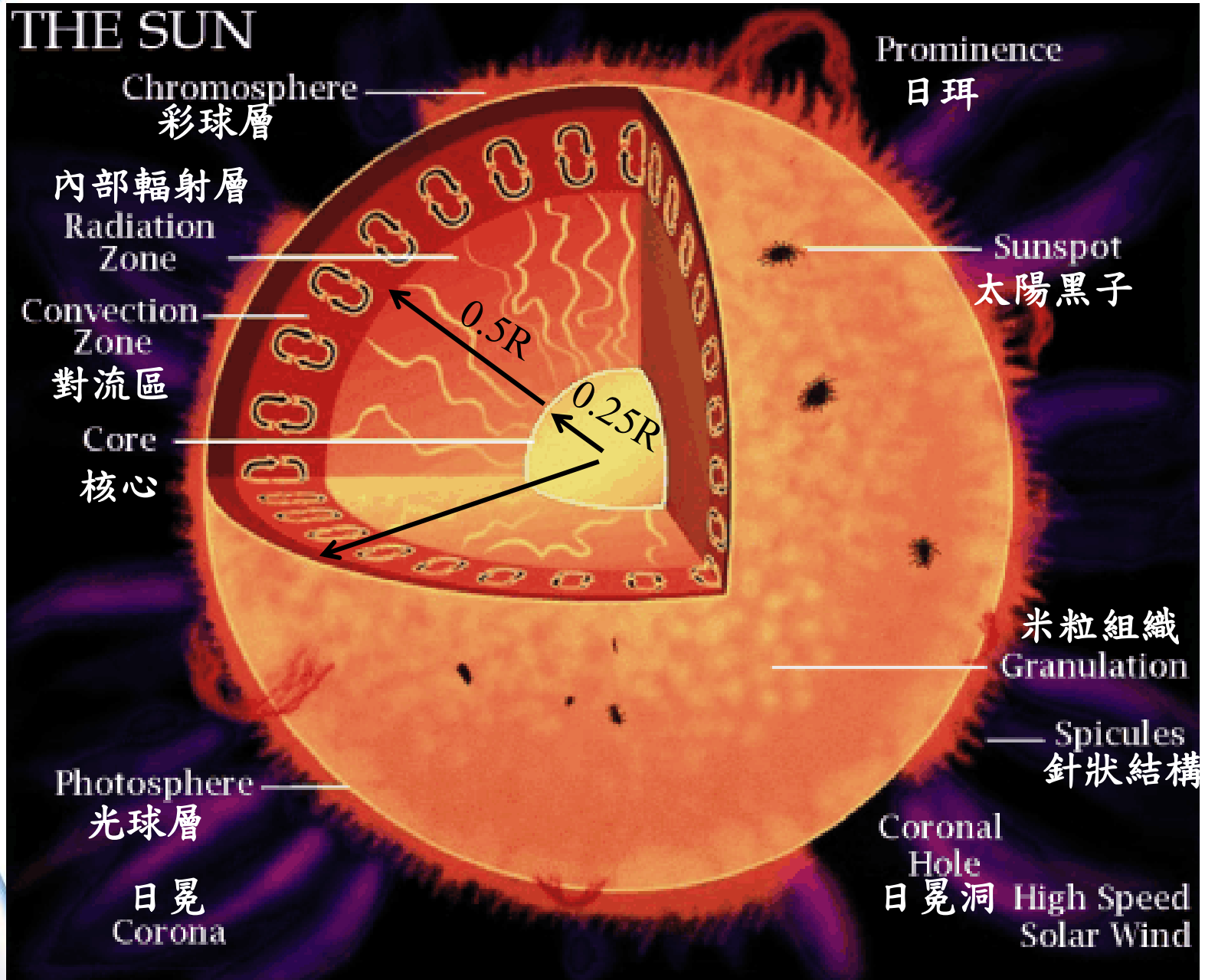
Solar age = 4.57×10^9 yr

Solar radius = 695,990 km = 432,470 mi
= 109 Earth radii
Solar mass = 1.989×10^{30} kg = 4.376×10^{30} lb
= 333,000 Earth masses

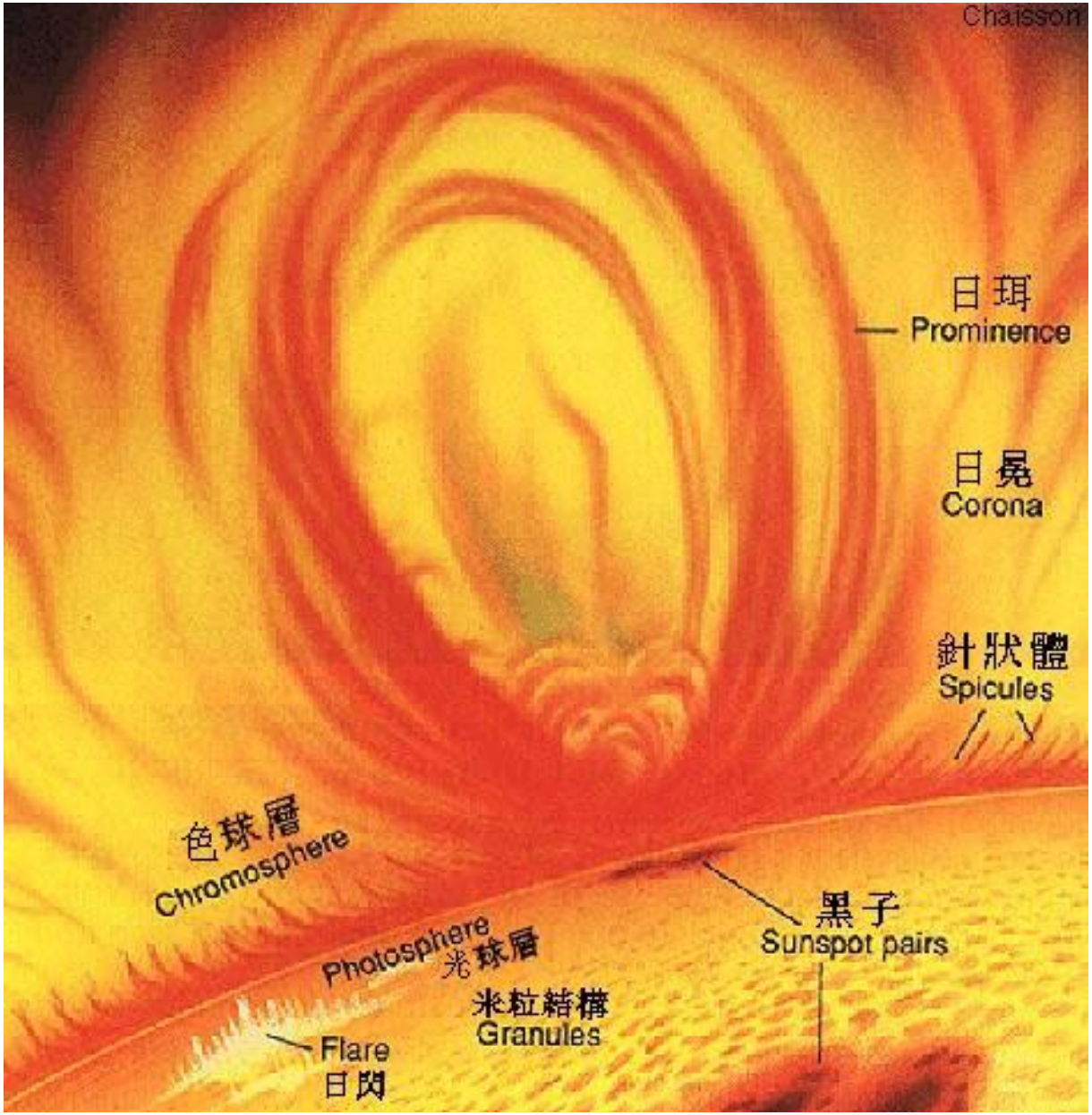
Surface temperature = 5770 K = 9,930° F
Surface composition = 70% H, 28% He, 2% (C, N, O, ...) by mass

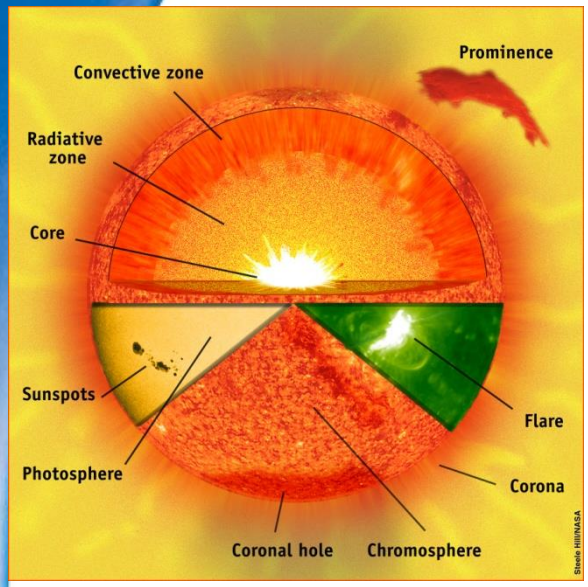
Central temperature = 15,600,000 K = 28,000,000° F
Central density = 150 g/cm^3 = 8 × Gold density
Central composition = 35% H, 63% He, 2% (C, N, O, ...) by mass

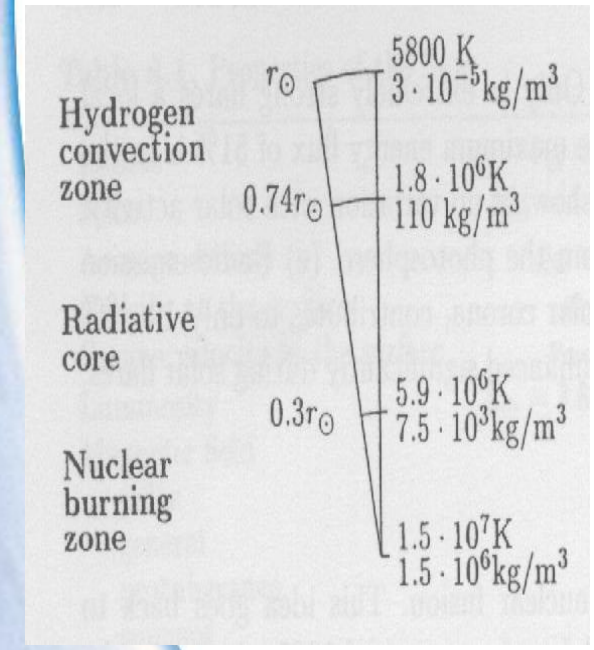
太陽結構


THE SUN
Chromosphere
彩球層
Prominence
日珥
內部輻射層
Radiation
Zone
Sunspot
太陽黑子
Convection
Zone
對流區
0.5R
0.25R
Core
核心
米粒組織
Granulation
Spicules
針狀結構
Photosphere
光球層
Coronal
Hole
日冕洞
High Speed
Solar Wind
日冕
Corona

太陽的表面結構

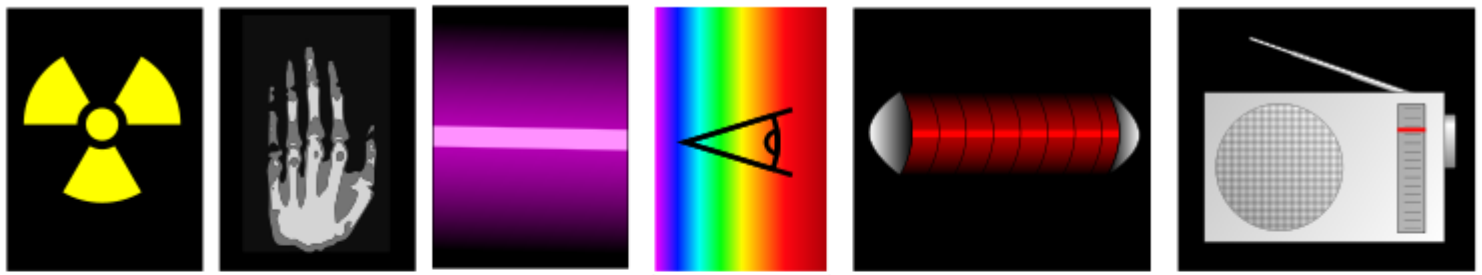

Chaisson
日珥
Prominence
日冕
Corona
針狀體
Spicules
色球層
Chromosphere
Photosphere
光球層
黑子
Sunspot pairs
米粒結構
Granules
Flare
日閃





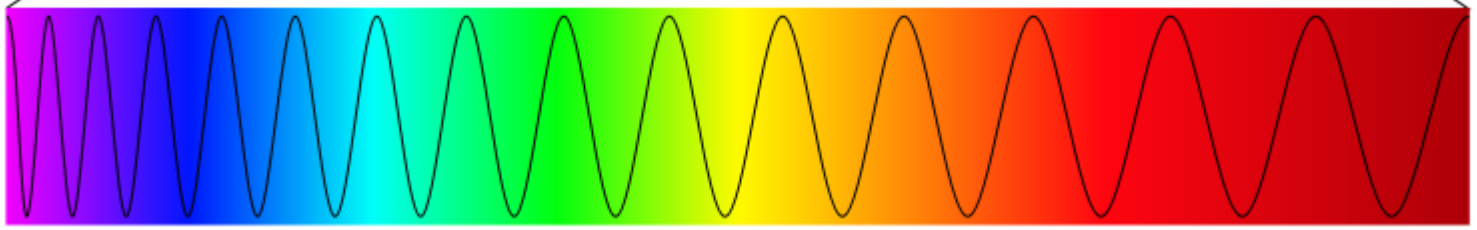
- 核　心: 能量的來源(核融合)
  - $0.3R_\odot$, 1.5×10^7K
- 輻射層: 先吸收再以輻射傳遞
  - $0.5R_\odot$, 5.0×10^5K
- 對流層: 利用對流方式傳遞
  - $0.2R_\odot$, 6.6×10^5K
- 光球層: 肉眼所看到的部份
  - $0.001R_\odot$, 5750K
- 彩球層: 最薄的一層
  - 10000KM , 4500-500000K
- 日　冕: 相當於太陽的大氣層
  - $>R_\odot$,1.5×10^6K

γay Xray 紫外線 紅外線 無線電波



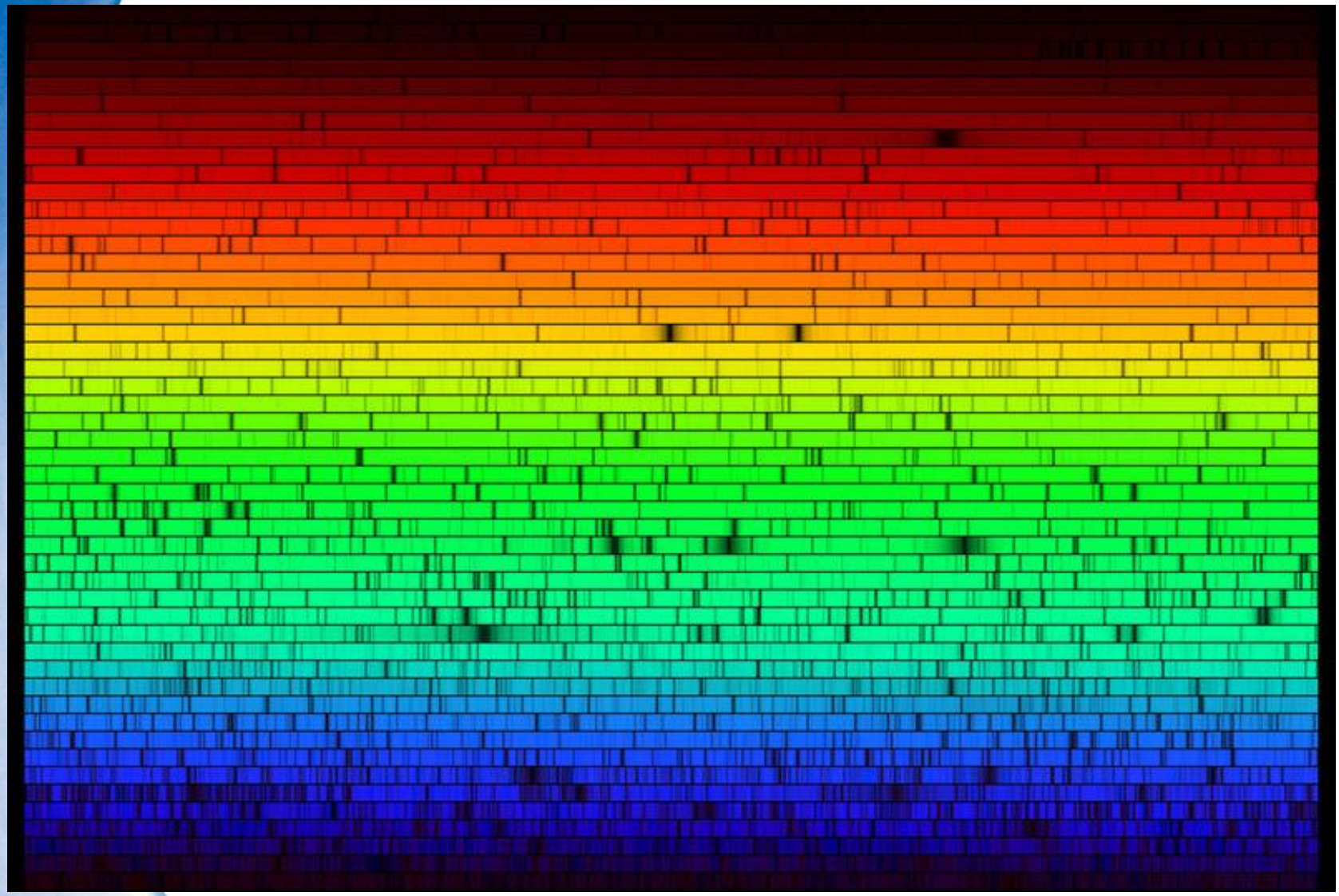
0.01nm 1nm 100nm 1mm 1cm 1m 1km

400nm 700nm



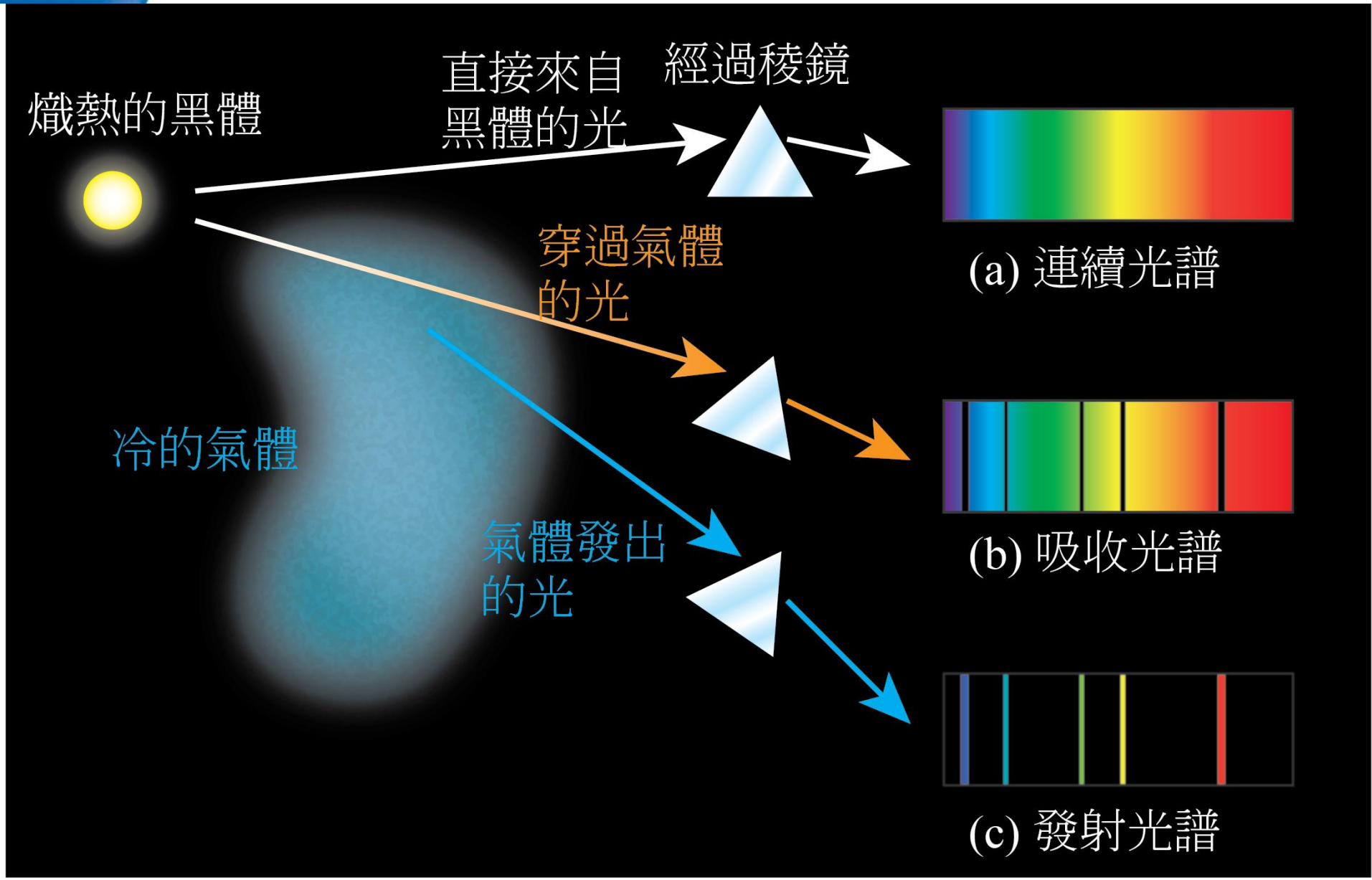
可見光

太陽 可見光譜(吸收)

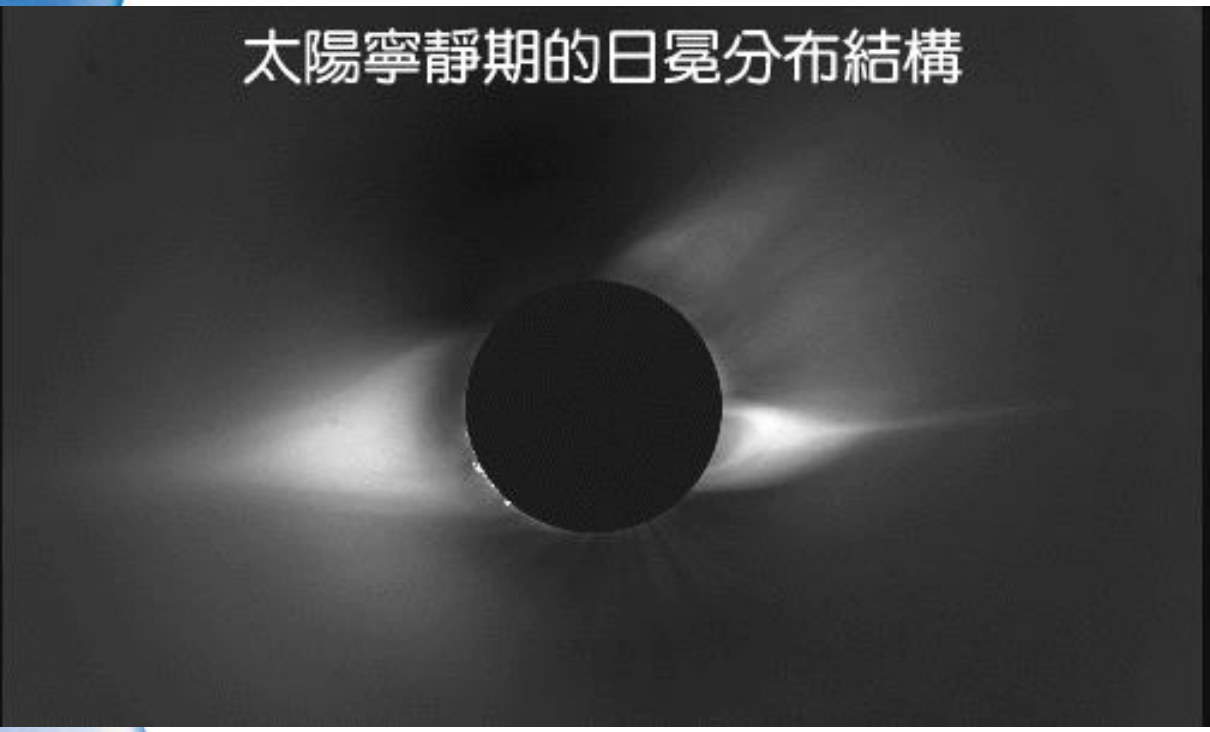


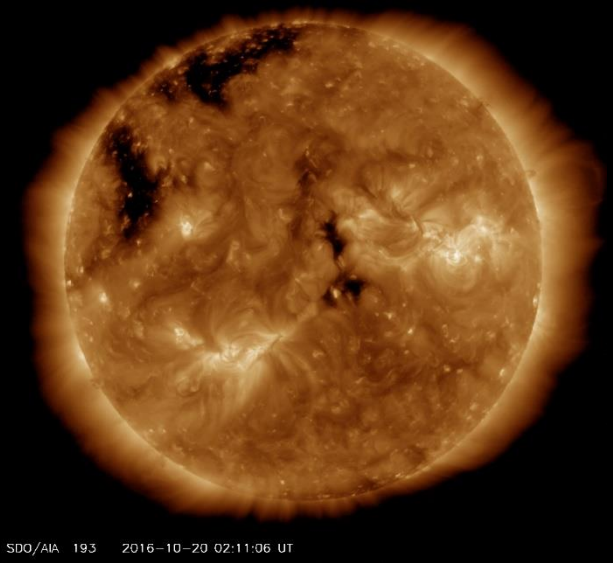
700nm

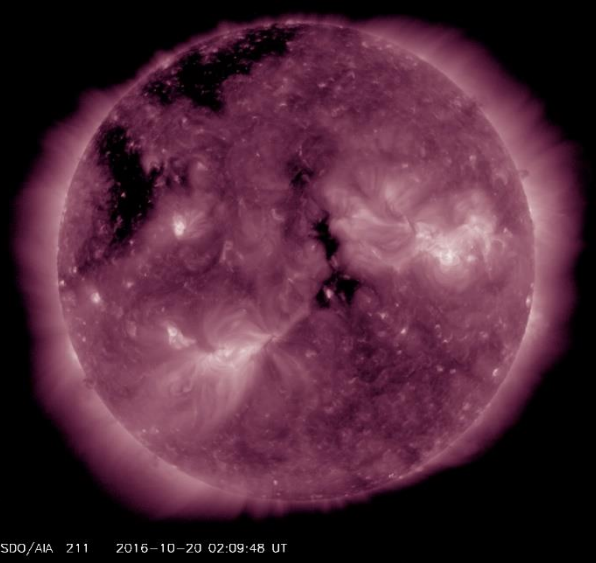
400nm

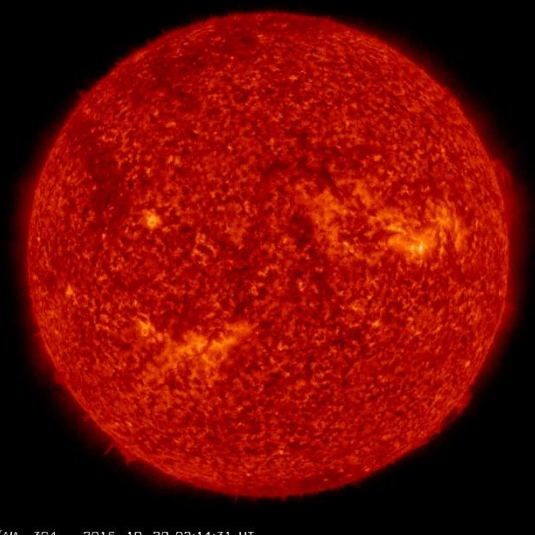

熾熱的黑體
直接來自
黑體的光
經過稜鏡
穿過氣體
的光
冷的氣體
氣體發出
的光
(a) 連續光譜
(b) 吸收光譜
(c) 發射光譜

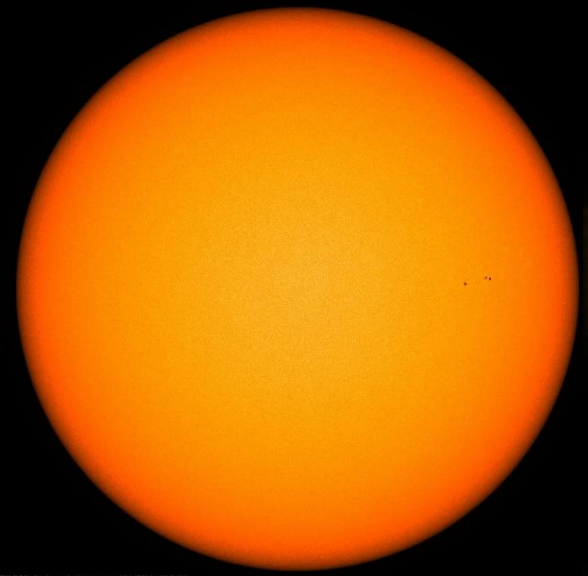
太陽的最外層:日冕(150萬度)

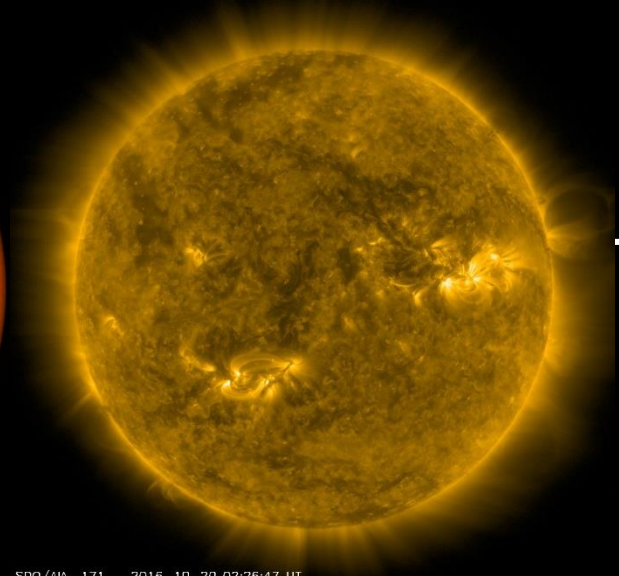










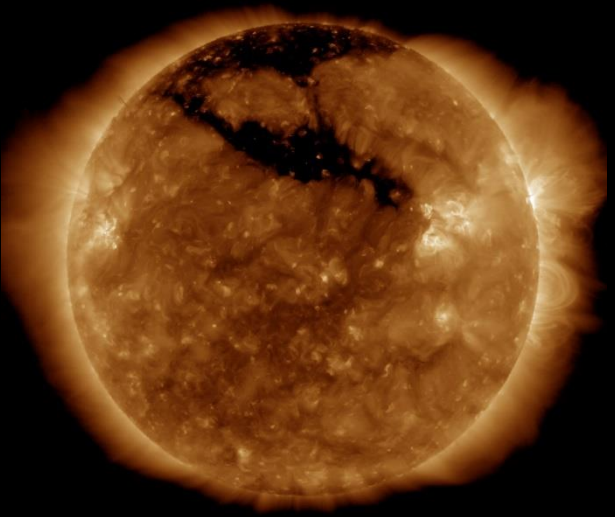


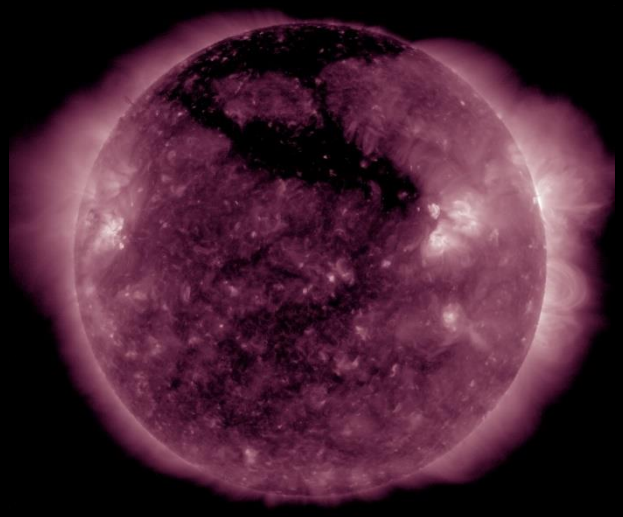
193Å	211Å	304Å
1.25 million	2 million	50,000

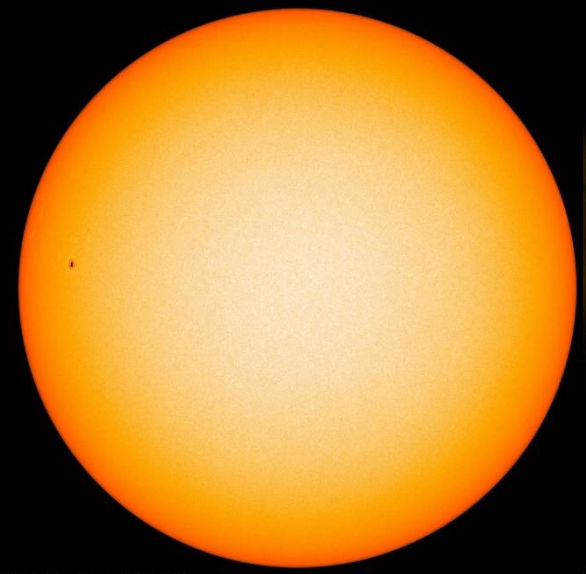
MDI	171Å
6000	1million

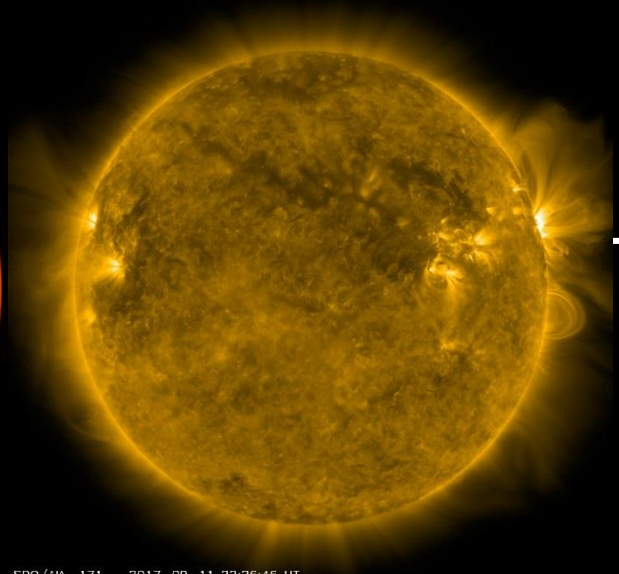
2016.10.20.02:26

http://sdo.gsfc.nasa.gov/data/









193Å	211Å	304Å
1.25 million	2 million	50,000

MDI	171Å
6000	1million

2017.09.12

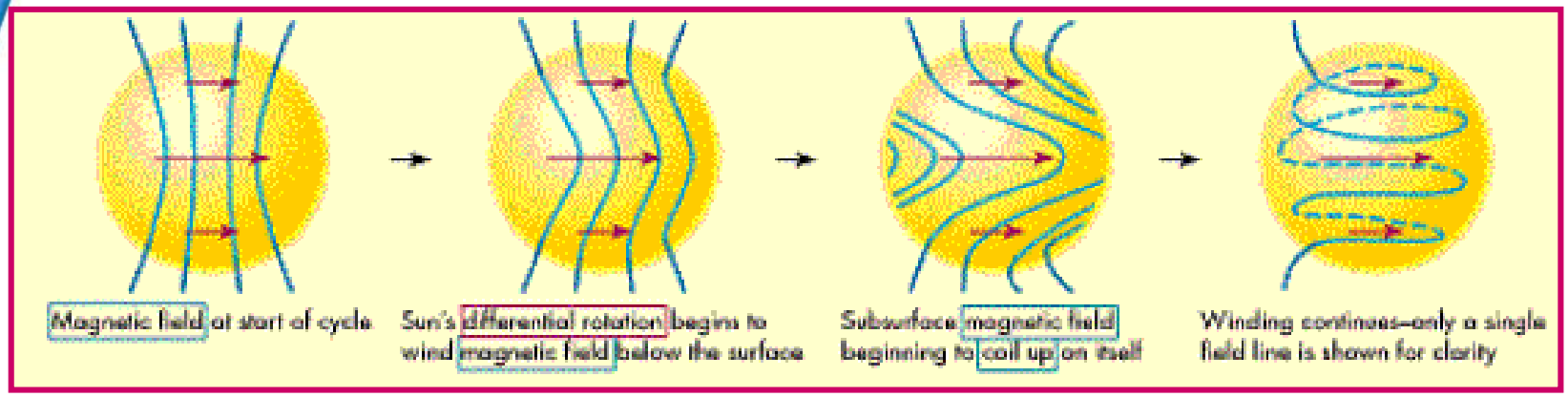
http://sdo.gsfc.nasa.gov/data/

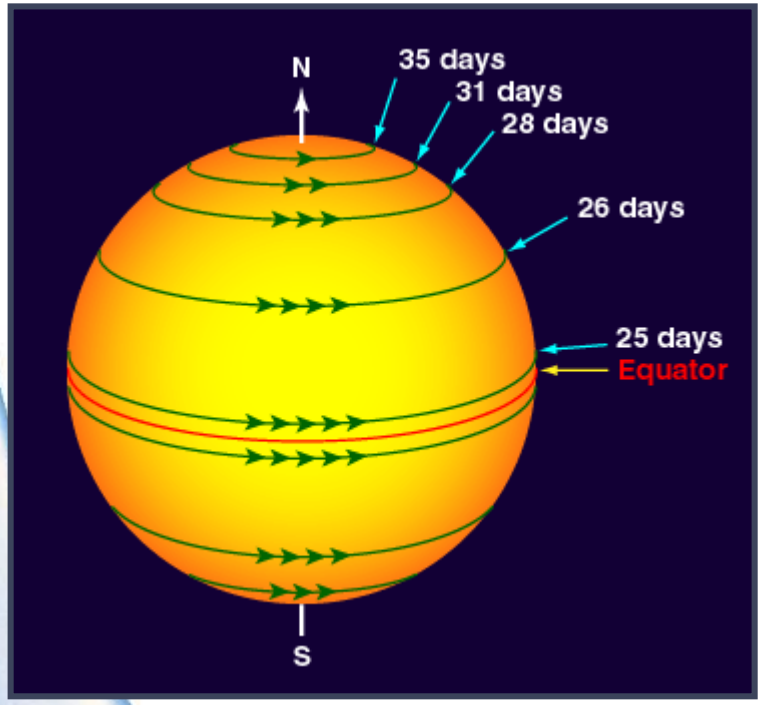
太陽活動的指標:黑子

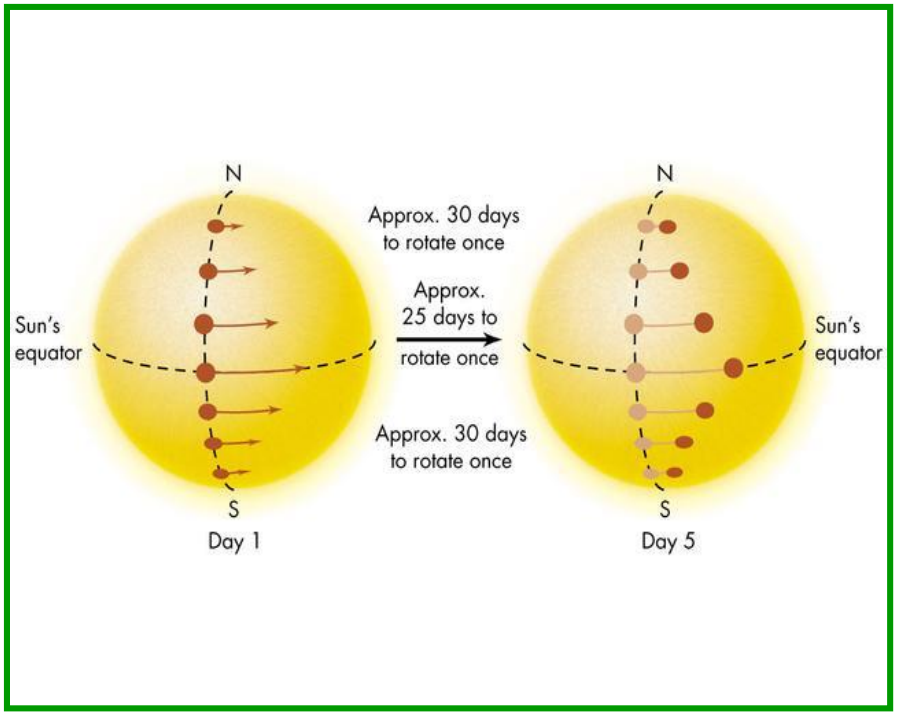
太空天氣預測參數

太陽黑子特性:低溫、強磁、週期

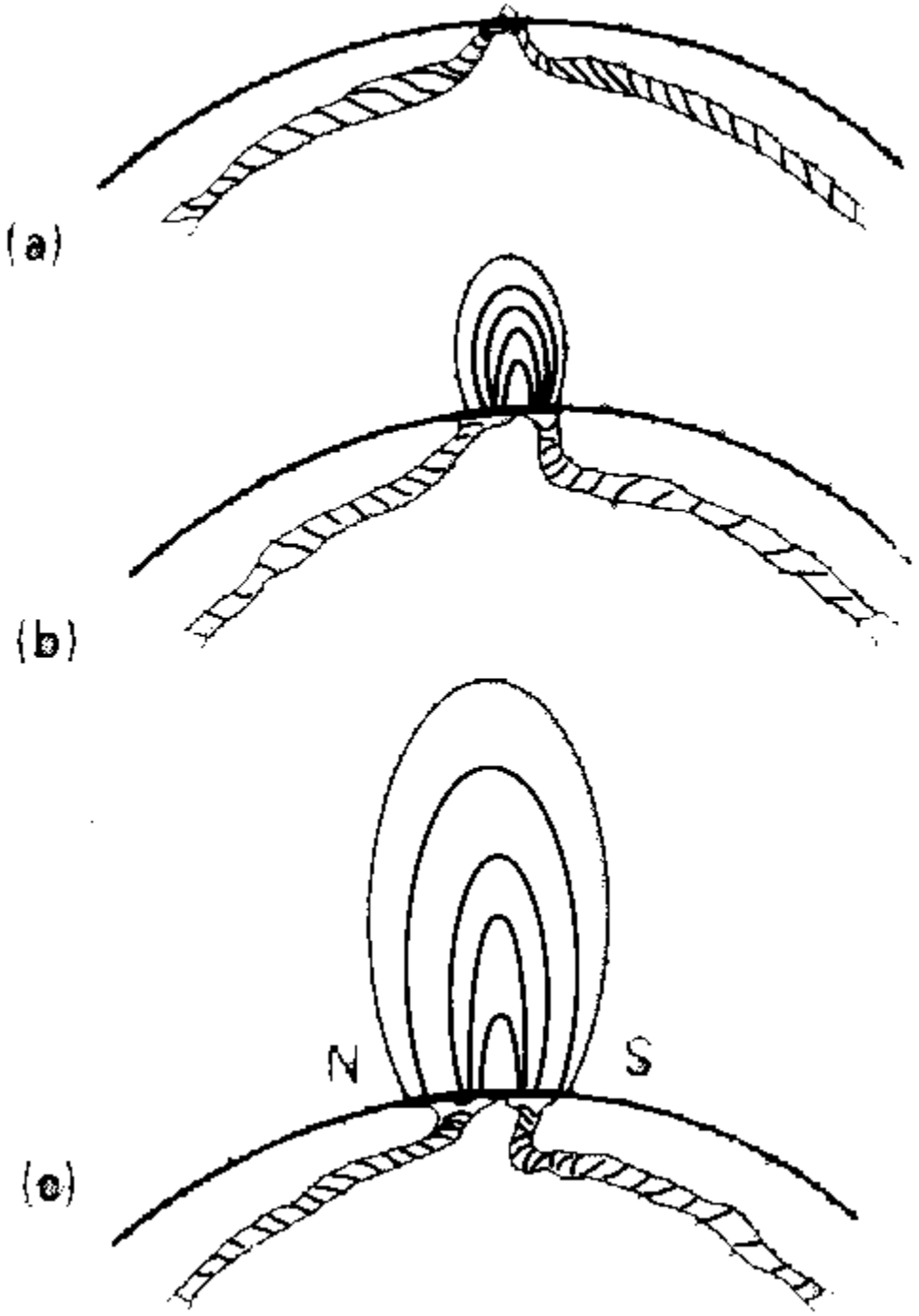
太陽的自轉—差動式自轉


Magnetic field at start of cycle
Sun's differential rotation begins to wind magnetic field below the surface
Subsurface magnetic field beginning to coil up on itself
Winding continues—only a single field line is shown for clarity

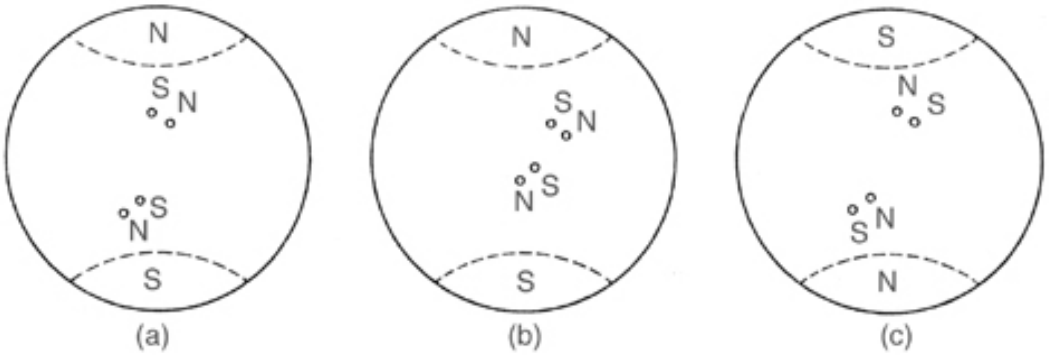

N
35 days
31 days
28 days
26 days
25 days
Equator
S


N
Sun's equator
Approx. 30 days to rotate once
Approx. 25 days to rotate once
Approx. 30 days to rotate once
S
Day 1
N
Sun's equator
S
Day 5

黑子的生成



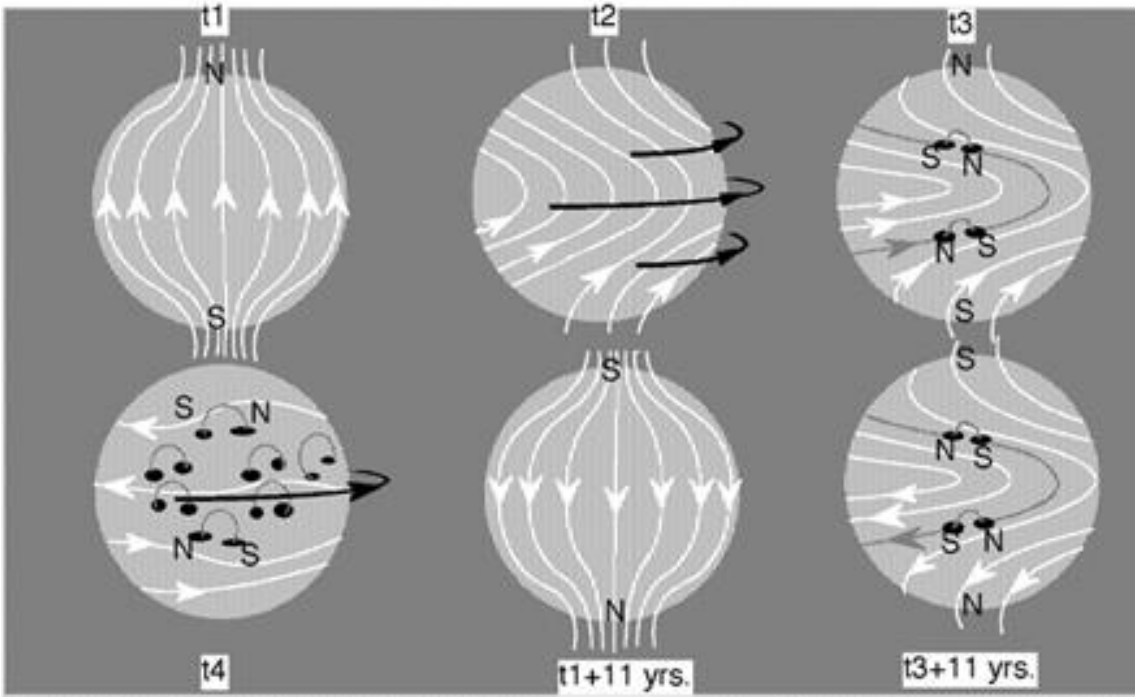
太陽黑子週期



黑子極性22年週期變化的示意圖

隨著太陽磁場反轉，成對出現之太陽黑子磁場極性分布，也隨之改變的示意圖。

A sketch of the formation of sunspots and the 22-years sunspot cycle due to the differential rotion of plasma in the photosphere



最早太陽黑子觀測紀錄

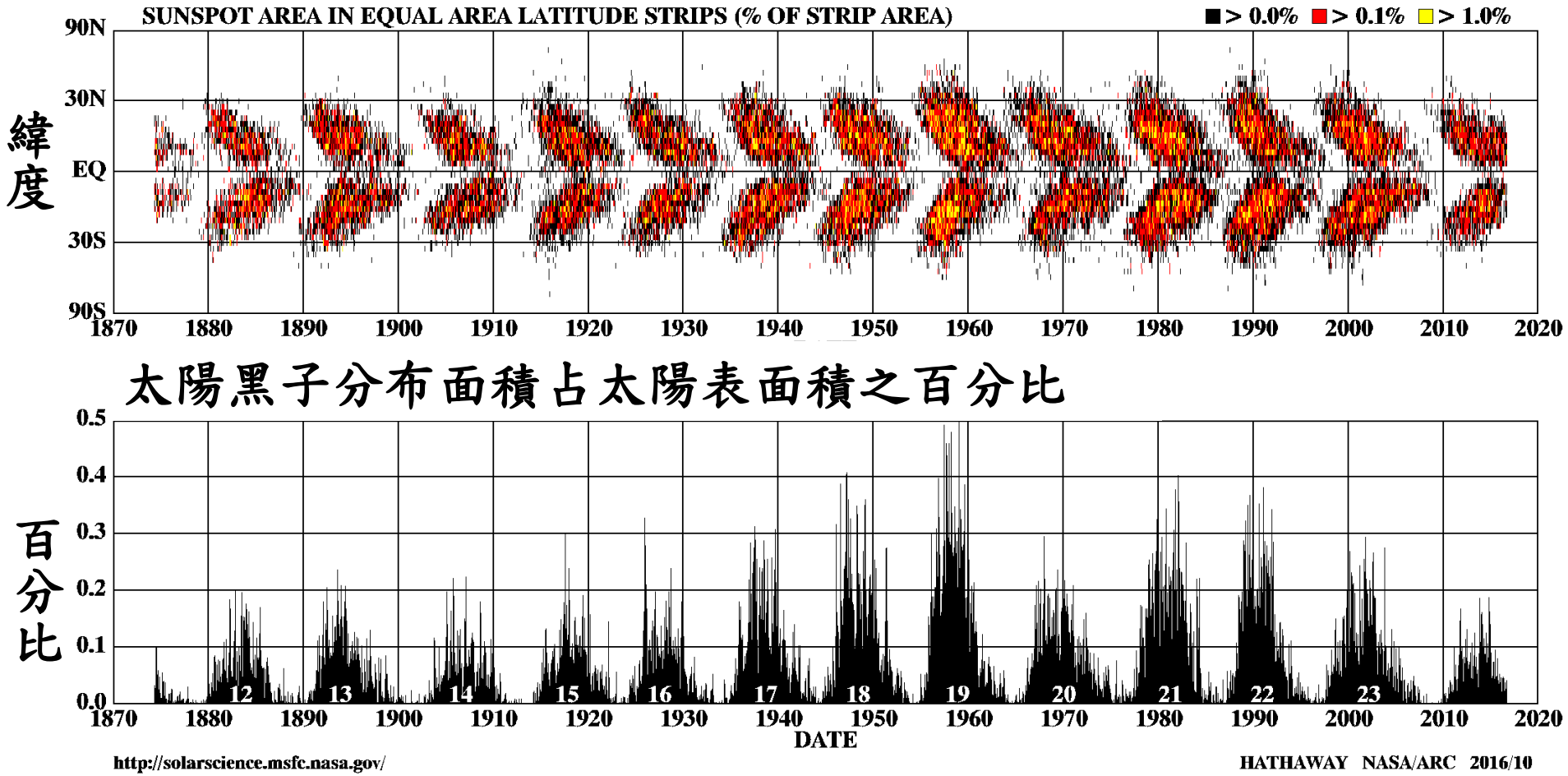
漢代王充《論衡・說日》：“日中有三足烏，月中有兔、蟾蜍。”

- **東方**
  - 公元前140年左右的《淮南子》記載：「日中有踆烏」；
  - 《漢書・五行志》記：「漢元帝永光元年（公元前43年）四月，……日黑居仄，大如彈丸」，
  - 《漢書・五行志》記：「漢成帝河平元年（公元前28年）乙未，日出黃，有黑氣大如錢，居日中央。」對太陽黑子出現日期、時間、黑子的形狀、大小和位置都有詳述，是世界公認最早的黑子詳實紀錄。

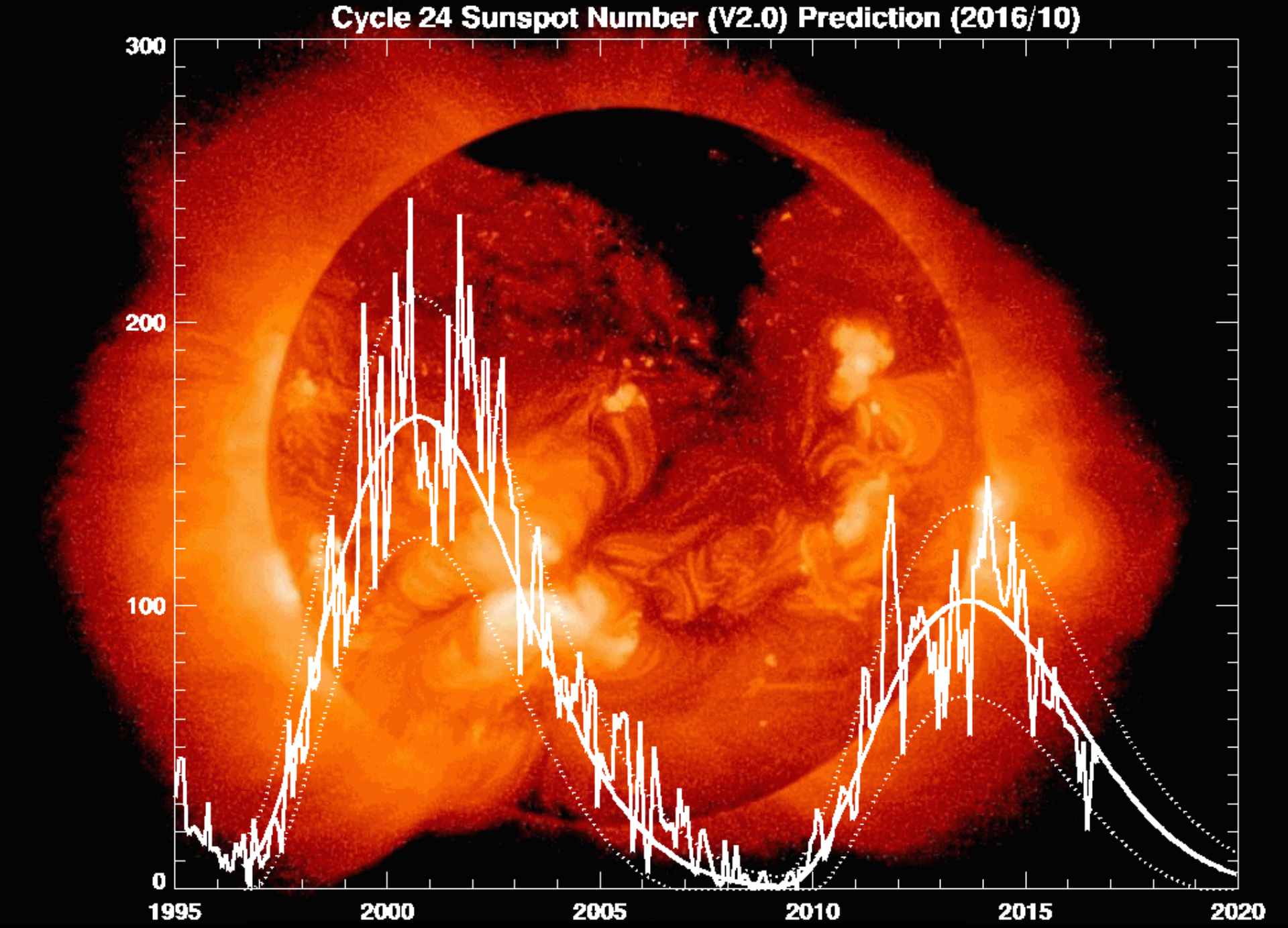
- **西方**
  - 西元一六〇九年，伽利略利用望遠鏡觀測到太陽表面還有一些深色的斑點

太陽黑子變化

太陽黑子逐年隨緯度分布圖(蝴蝶圖案)

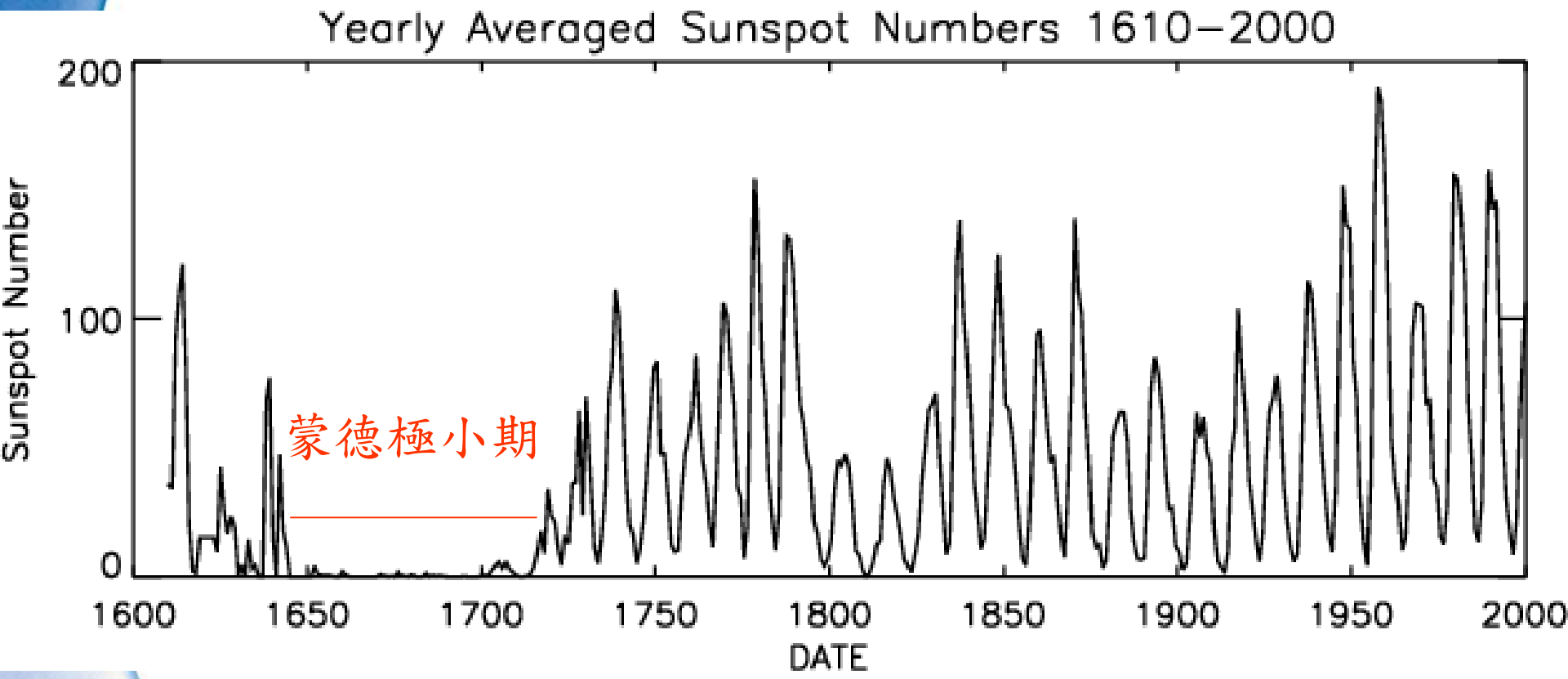


http://solarscience.msfc.nasa.gov/images/bfly.gif



http://solarscience.msfc.nasa.gov/images/ssn_predict_l.gif

太陽黑子(活動)與地球氣候

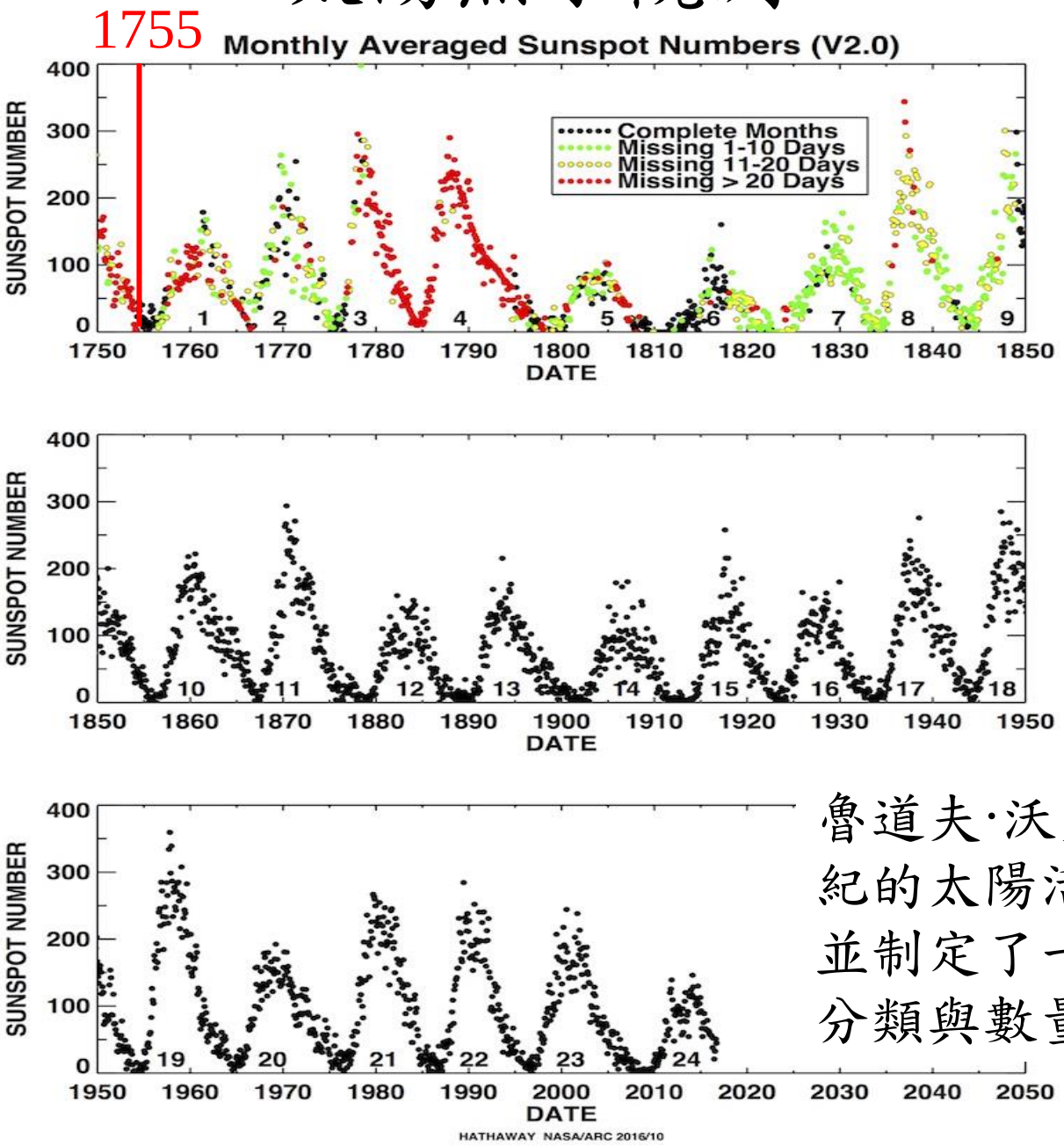


義大利的科學家伽利略於1609年製作了一部口徑42mm的望遠鏡

小冰期

是指一段在中世紀溫暖時期之後開始，全球氣溫出現下降的現象，時間約在自1550年至1770年這220年間（明嘉靖二十九年至清乾隆三十五年），結束於18世紀初期，相當於中國明清時期。

太陽黑子觀測

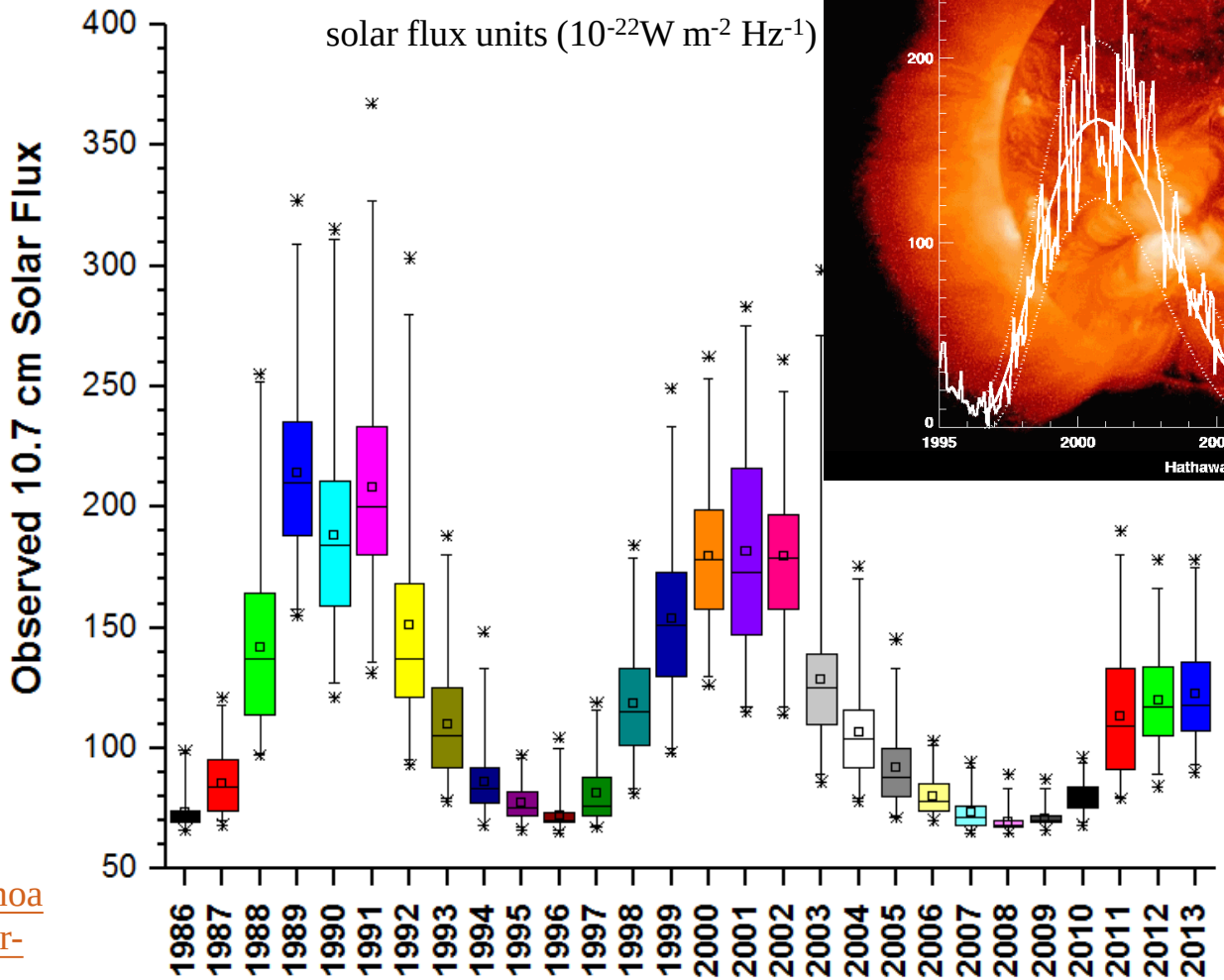


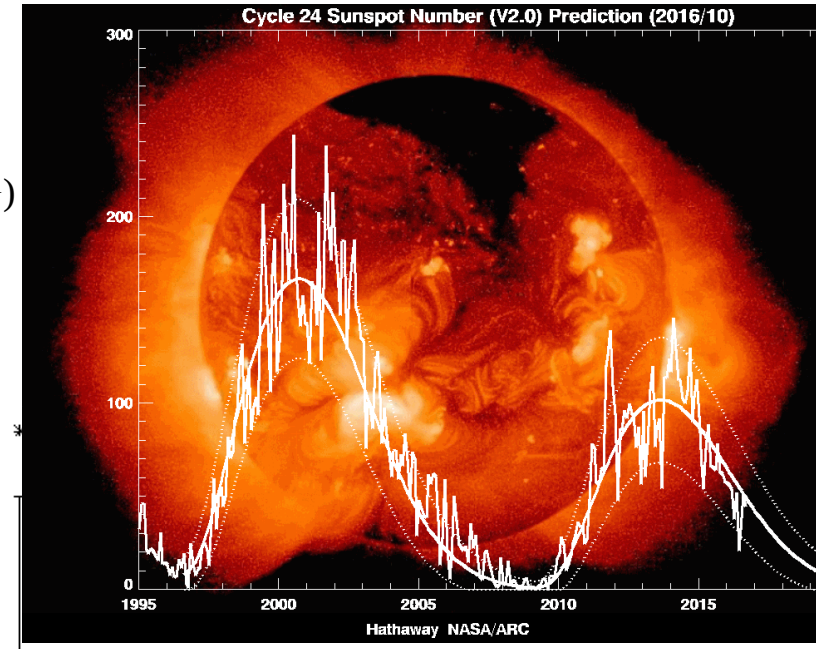
魯道夫·沃夫追溯17世紀的太陽活動的歷史並制定了一套有效的分類與數量標準

R=10g+f

http://solarscience.msfc.nasa.gov/images/Zurich_Color_Small.jpg

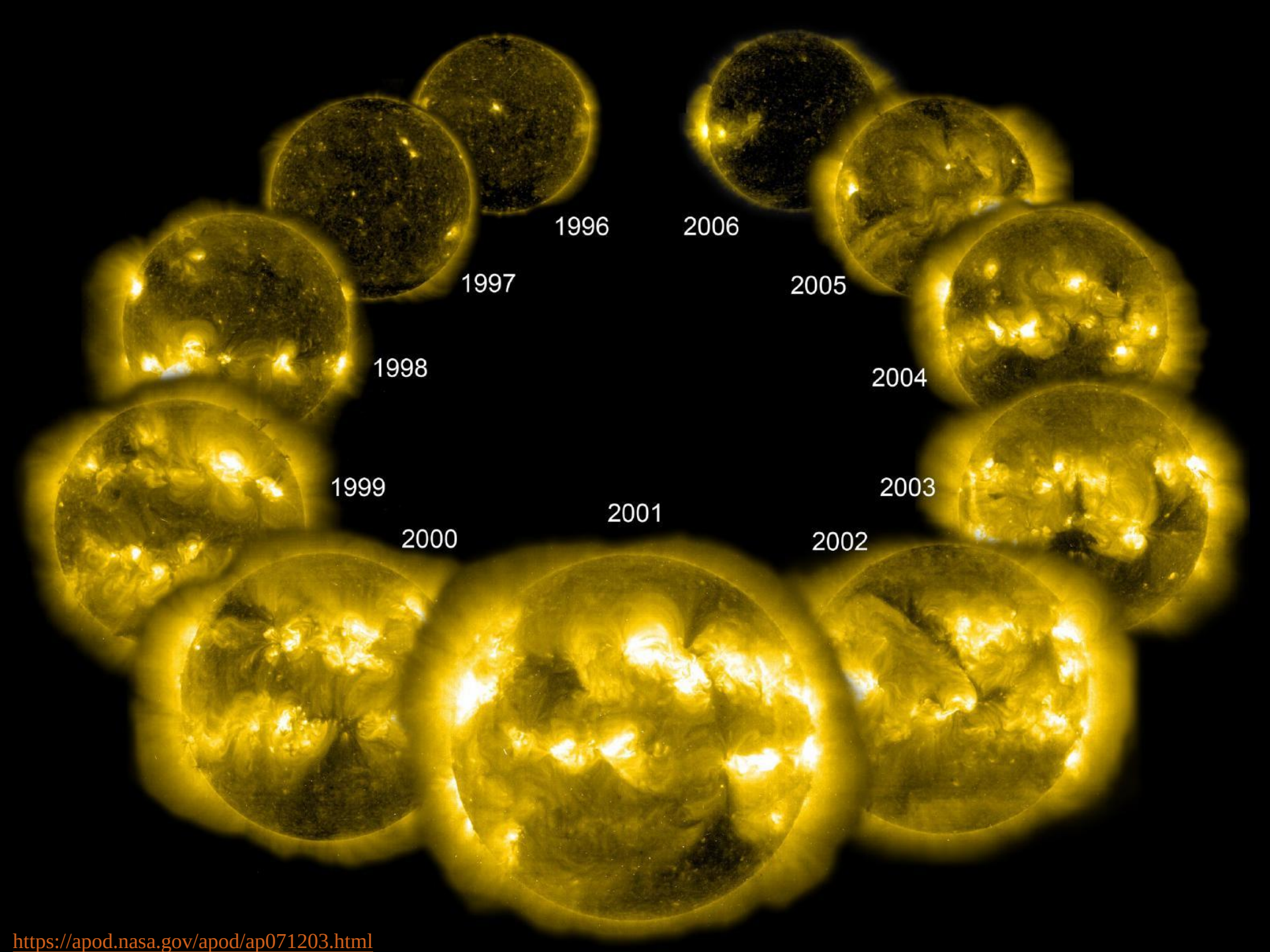
F10.7 指數(index)
太陽背景噪音強度



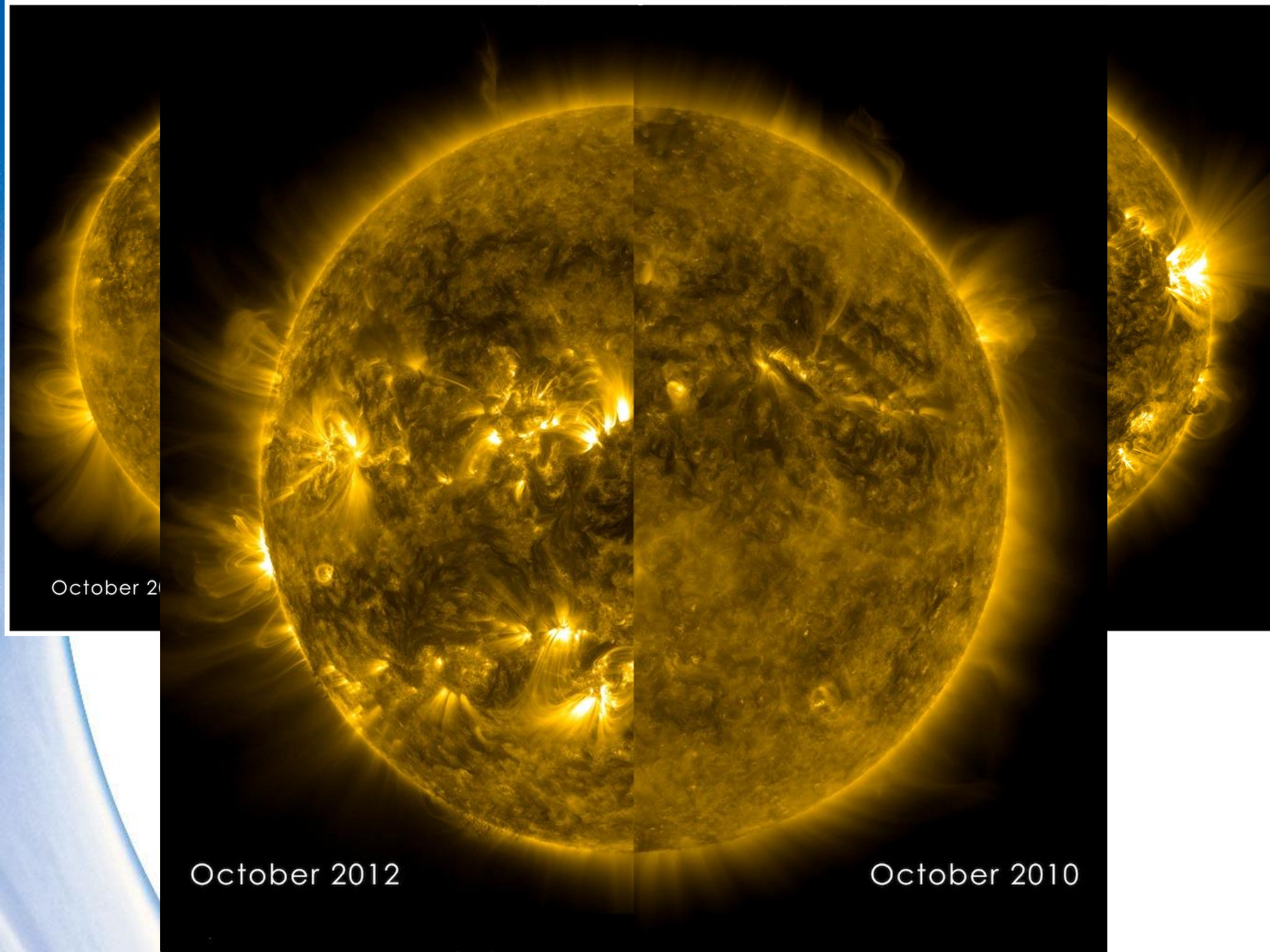


http://www.swpc.noaa.gov/content/solar-activity-forecast-verification

From 1948



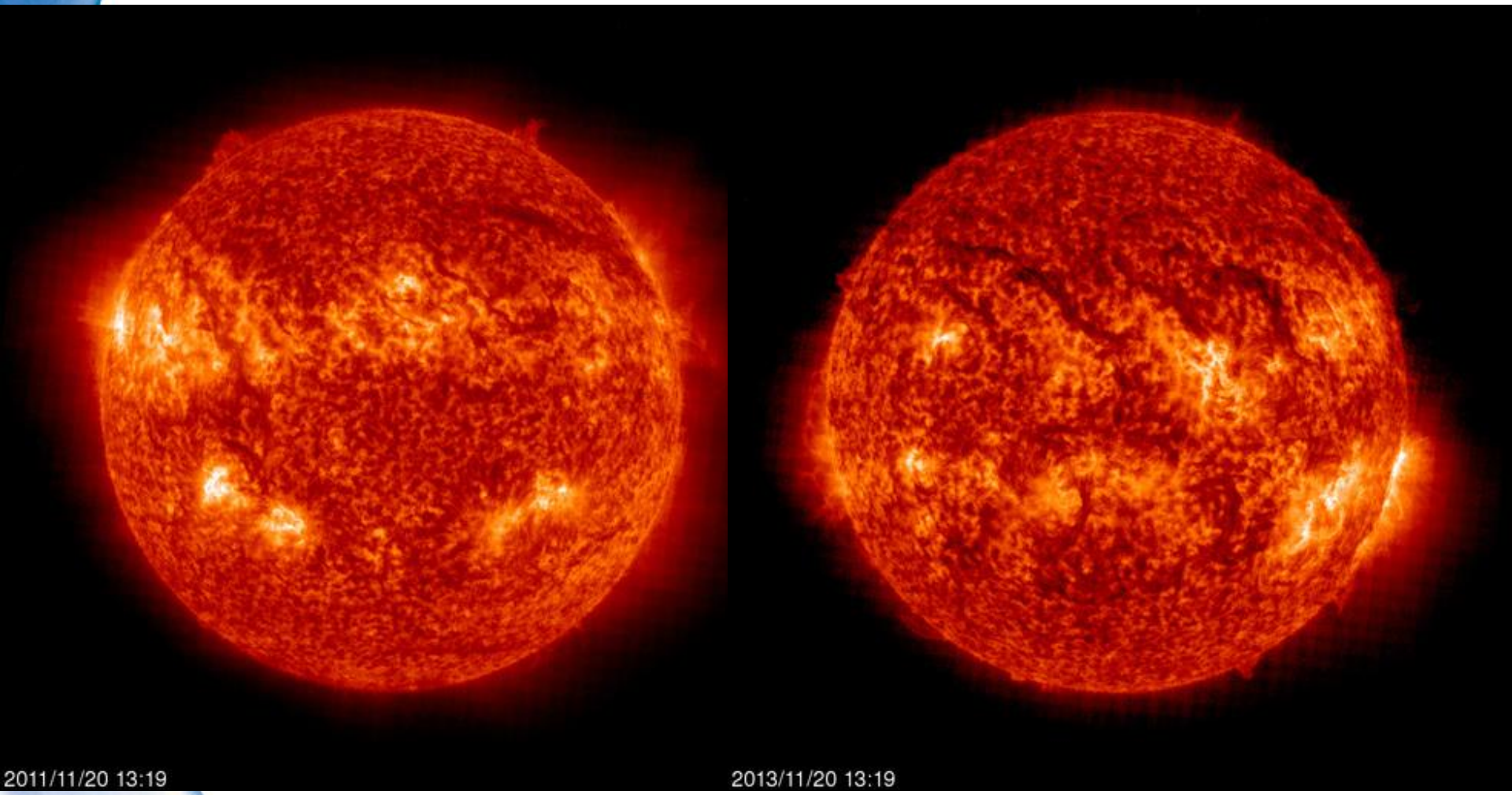
https://apod.nasa.gov/apod/ap071203.html


October 2
October 2012
October 2010

太陽光與風輻射

太陽光(電磁波)輻射

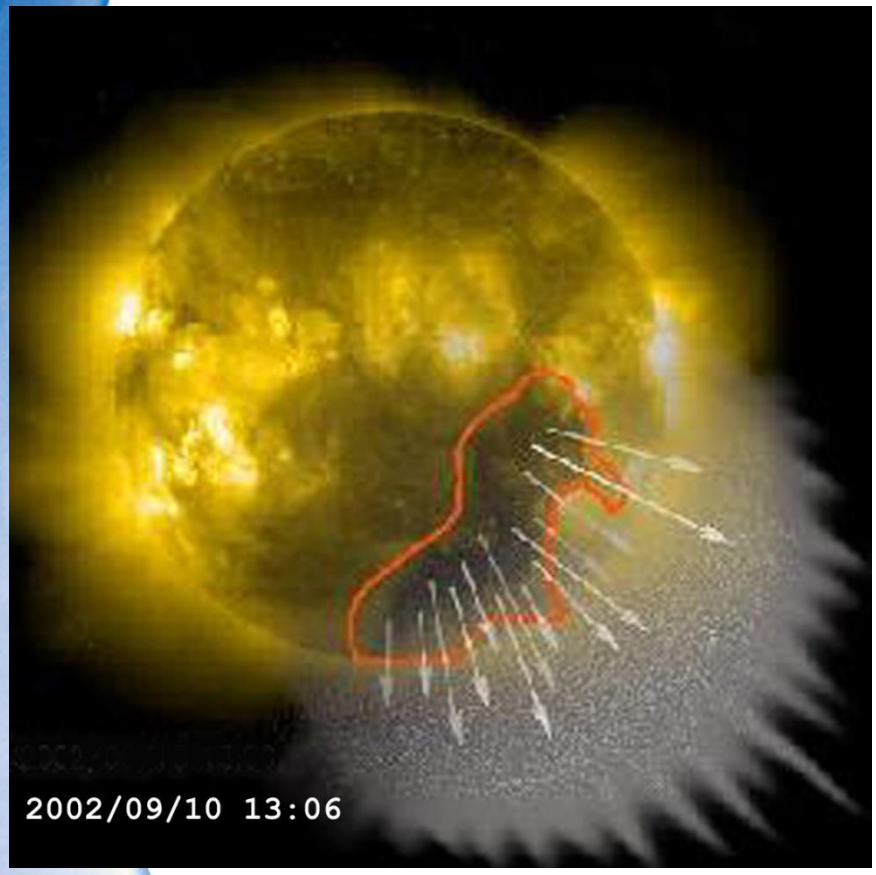
每秒30萬公里



太陽風(帶電粒子)輻射

太陽風(質子與電子)

每秒300-800公里



太陽風的證據:彗星尾

中國史上的彗星紀錄

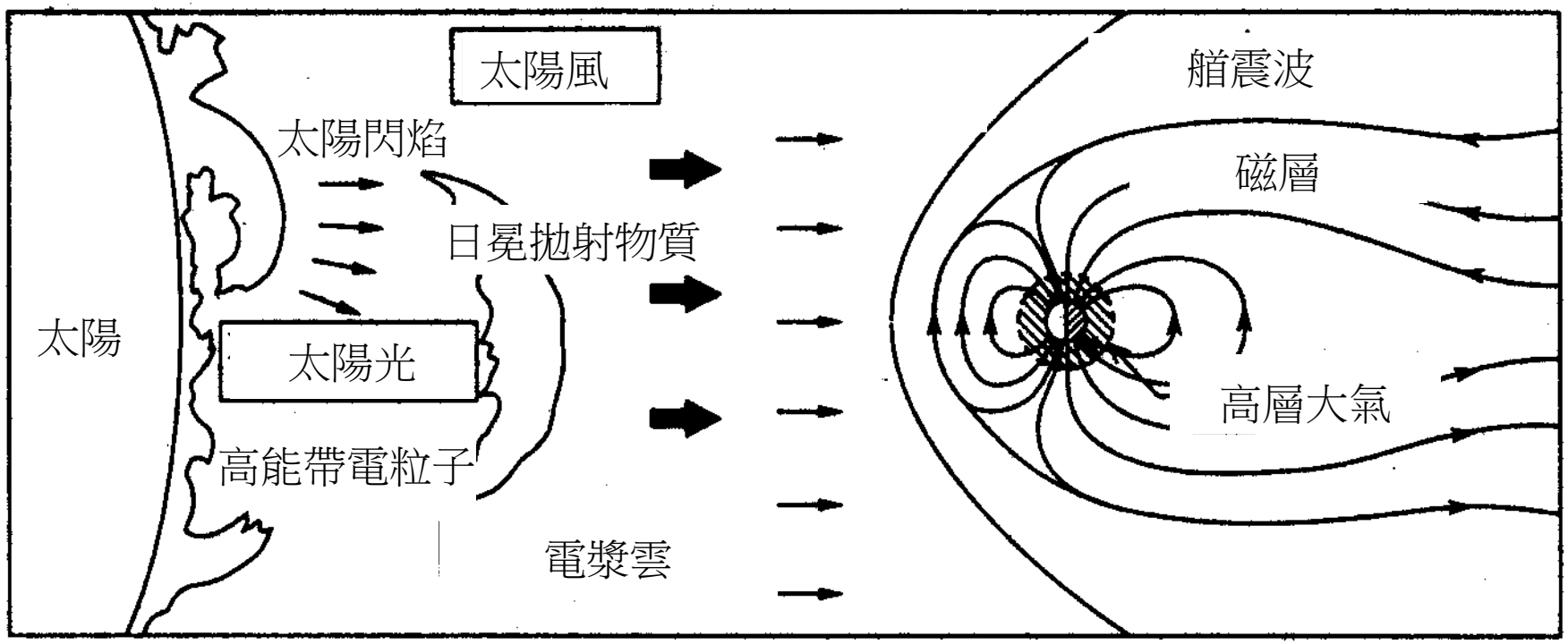
- **《春秋》**

「秋七月，有星孛入於北斗」。西元前613年

- **《晉書·天文志》**

「彗星所謂掃星，本類星，末類彗，小者數寸，長或經天。彗星本無光，傅日而為光，故夕見則東指，晨見則西指。在日南北皆隨日光而指，頓挫其芒，或長或短。」

太陽輻射



太陽輻射
(太空天氣)

- 平時(穩態)
  - 太陽光
  - 太陽風
- 擾亂(暫態)
  - 太陽閃焰 → 電離層擾亂
  - 太陽黑子爆炸
    - 高能帶電粒子
    - 日冕拋射物質 → 磁暴 → 電離層暴
    - 電漿雲

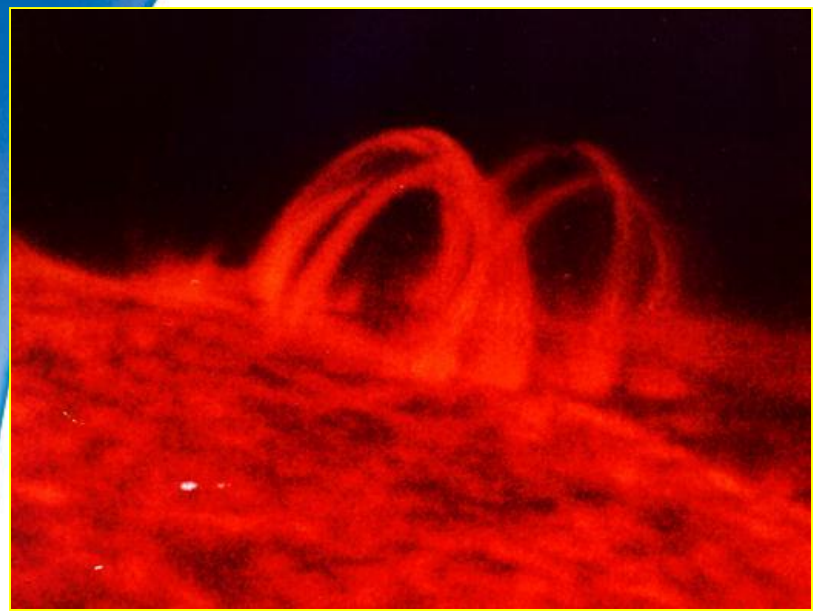
太陽輻射能量與質量

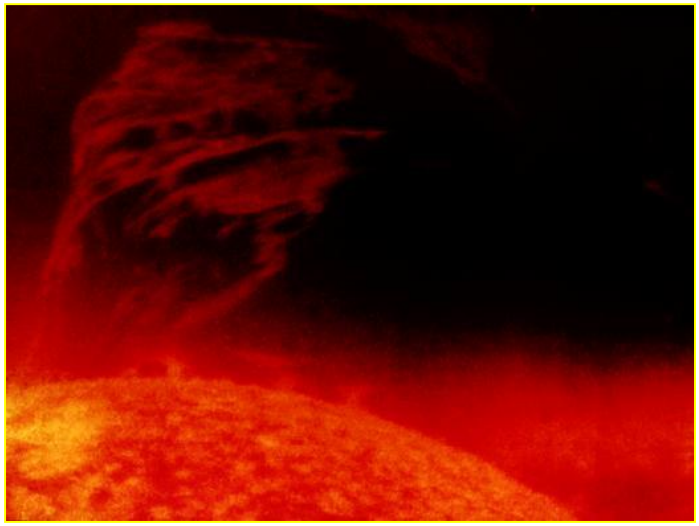
	種類	速率
太陽輻射能量	太陽光(電磁波)	3.8×10^{26} W/sec
	太陽風(質子+電子)	4.1×10^{20} W/sec
	太陽風暴事件	7×10^{18} W/sec
太陽質量消耗率	太陽光(電磁波)	4.2×10^{9} kg/sec
	太陽風(質子+電子)	1.4×10^{9} kg/sec

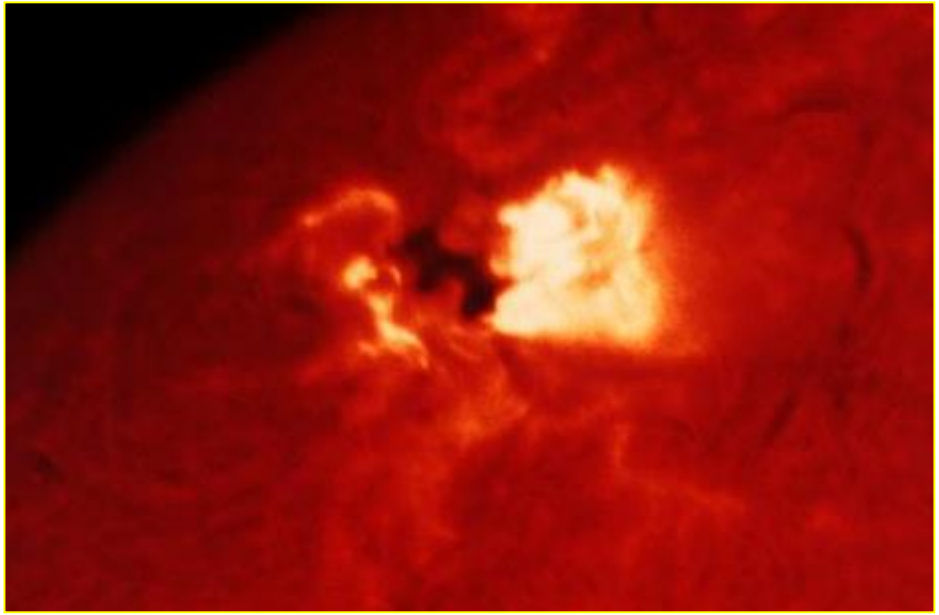
420萬公噸

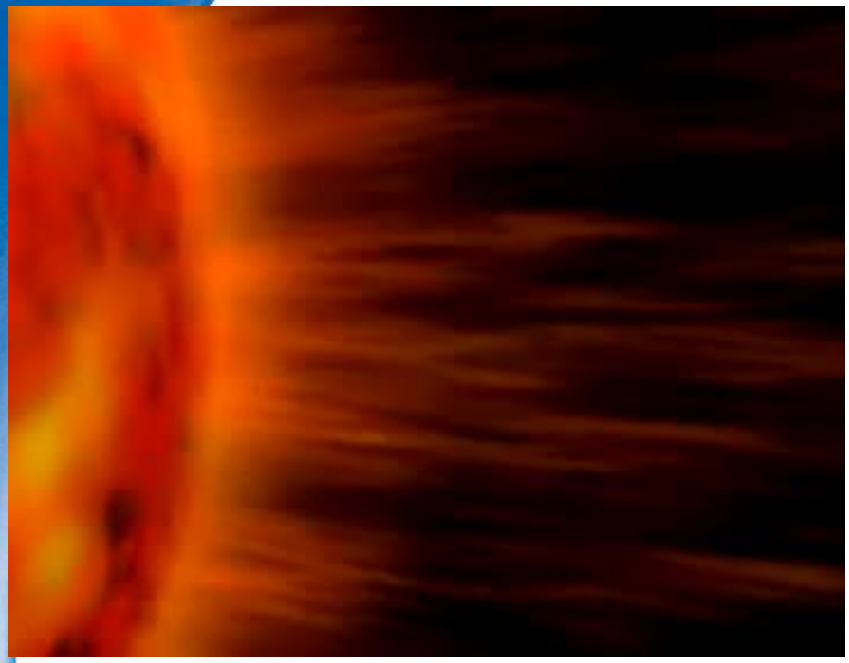
$$E=MC^2$$

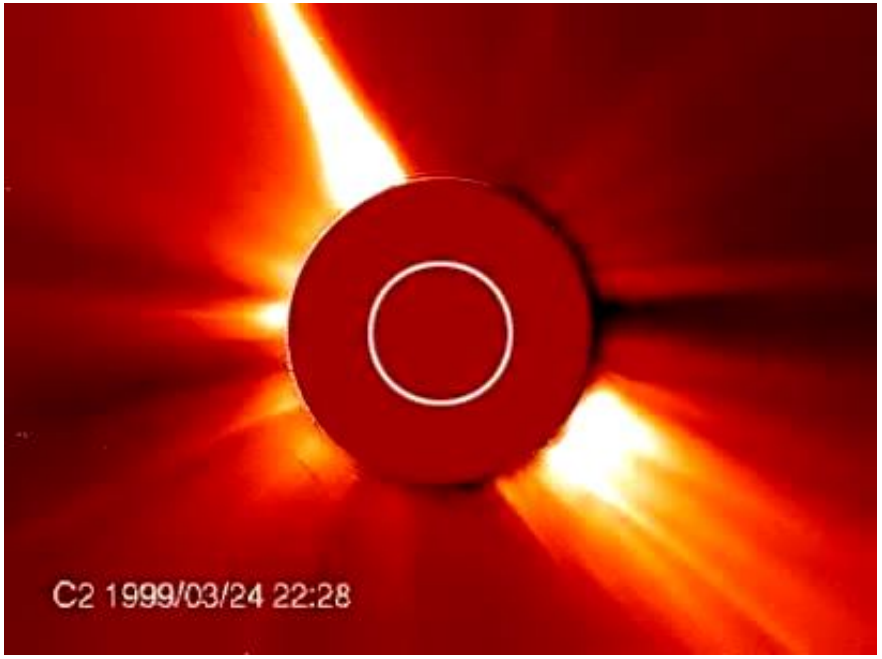
太空能量的源頭：太陽







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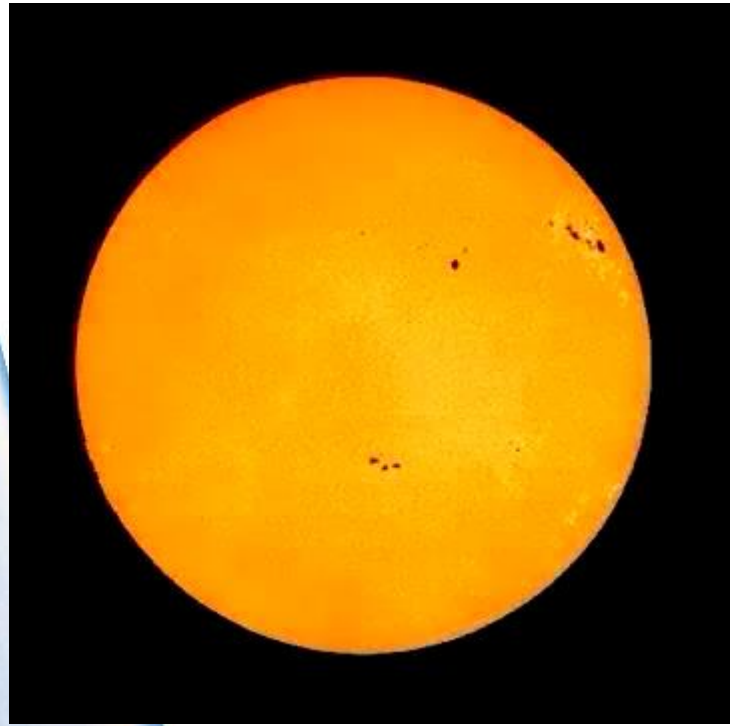

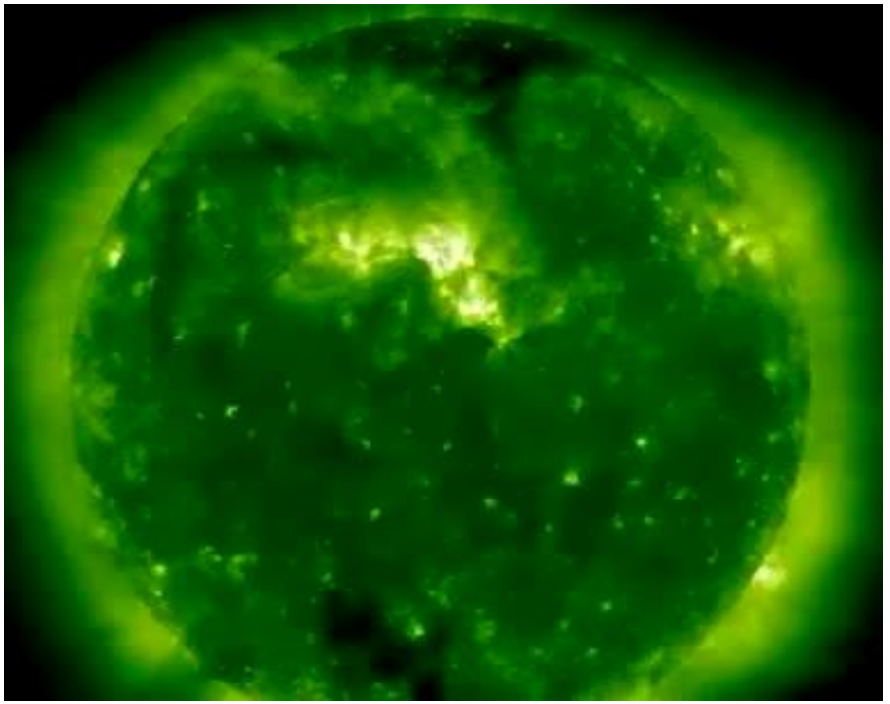

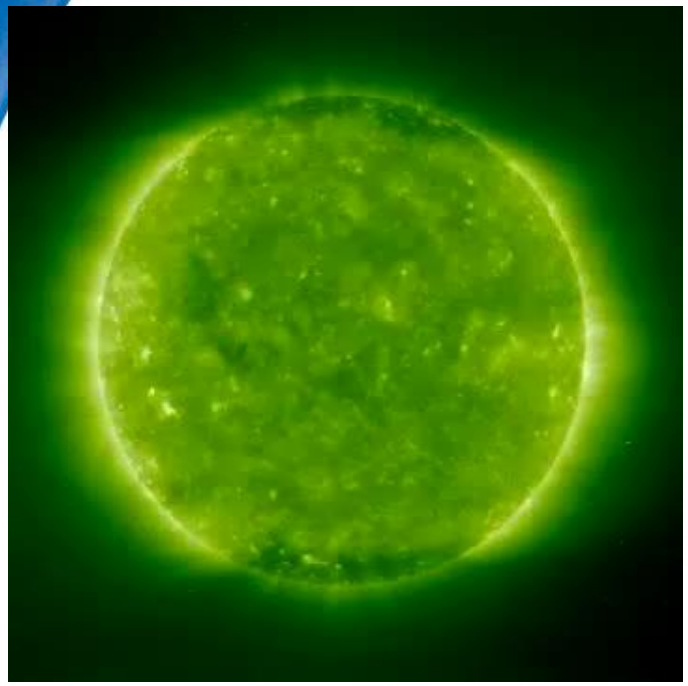

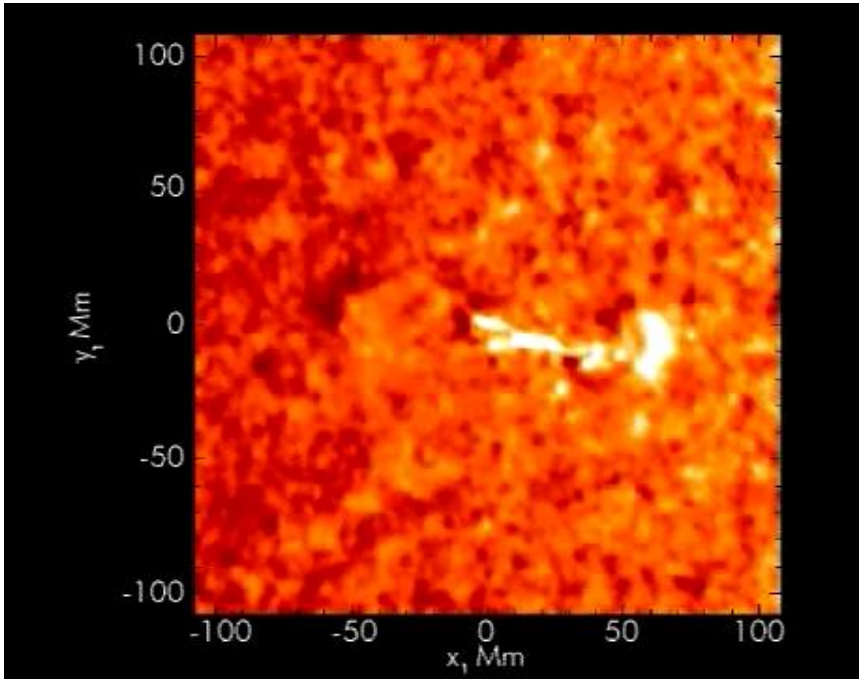
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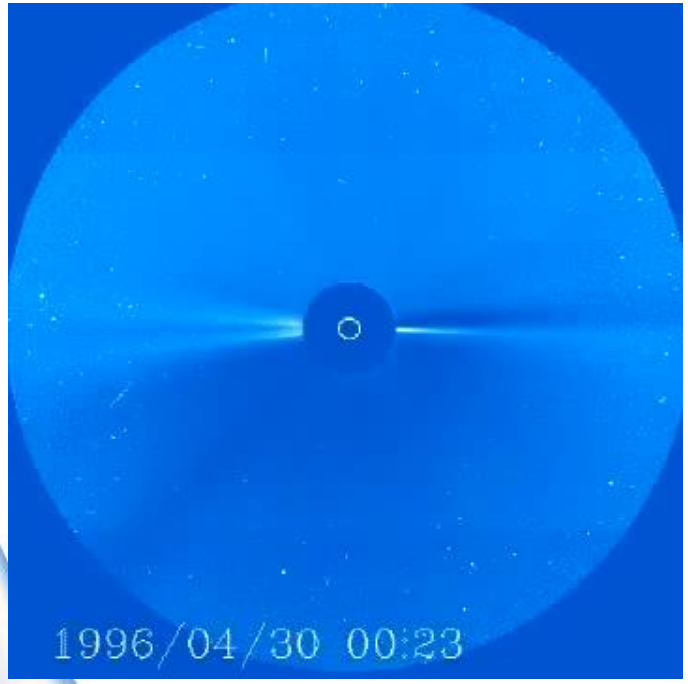
-50
-100
y, Mm
-100
-50
0
50
100
x, Mm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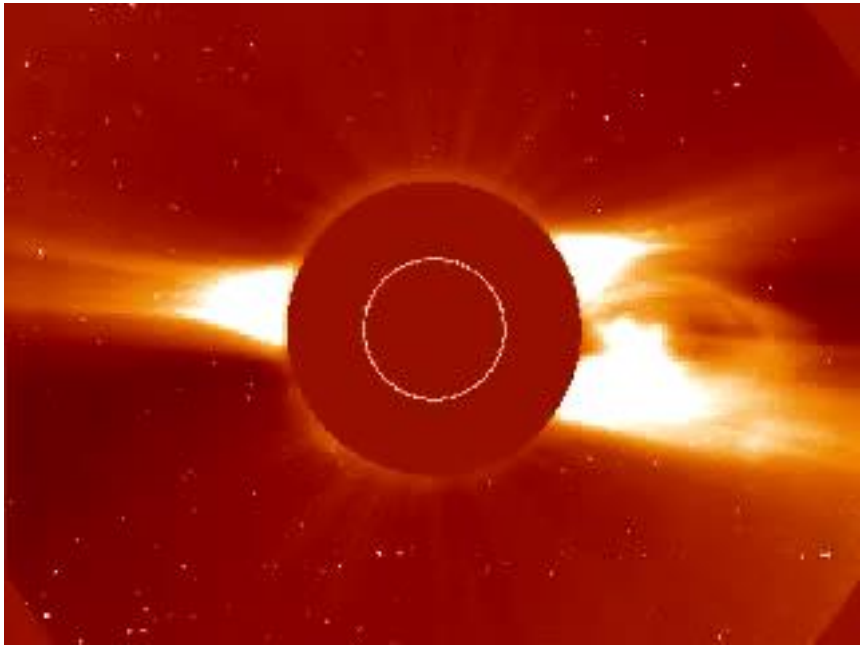


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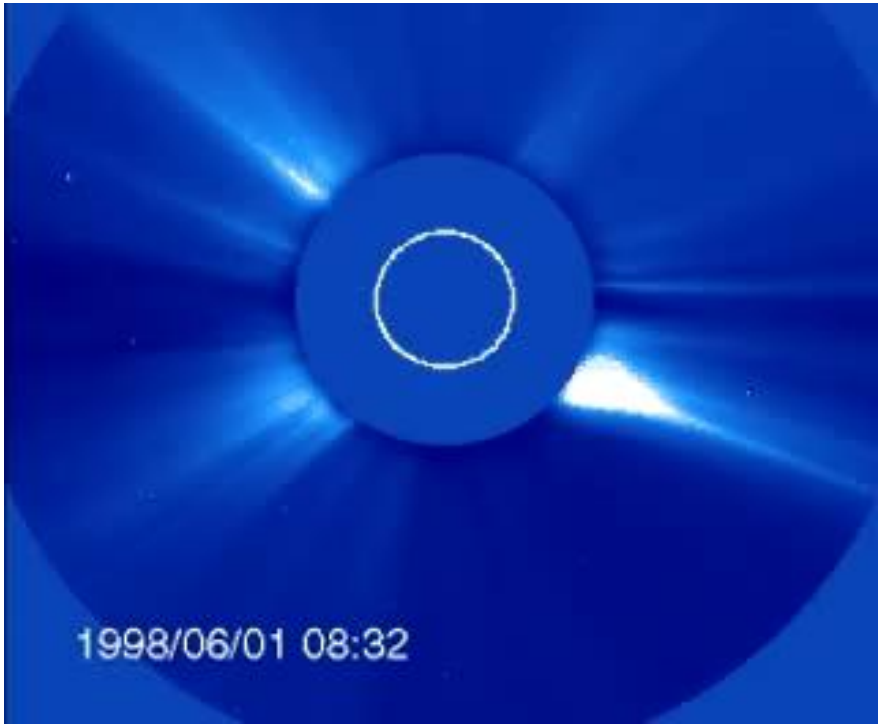
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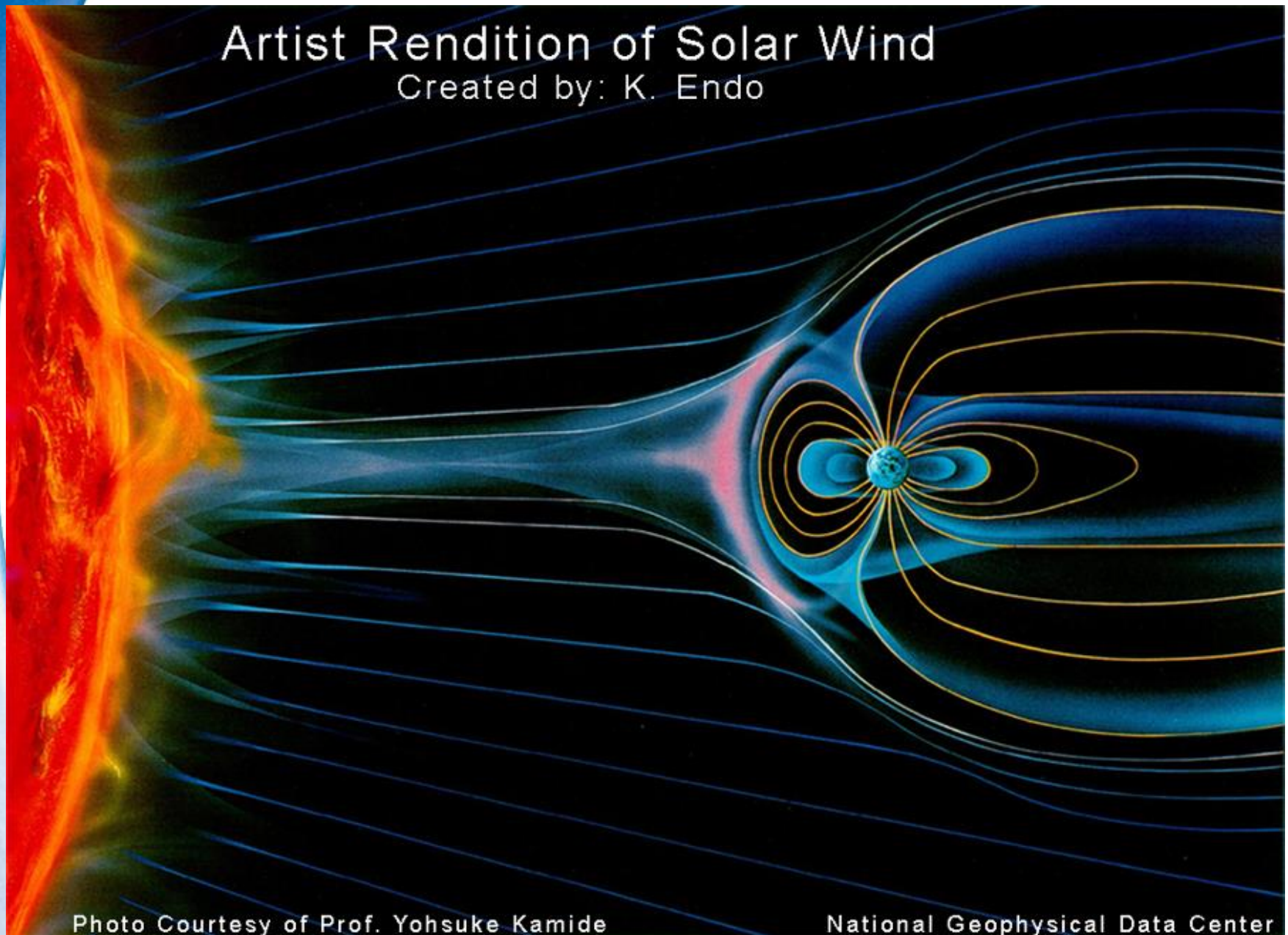
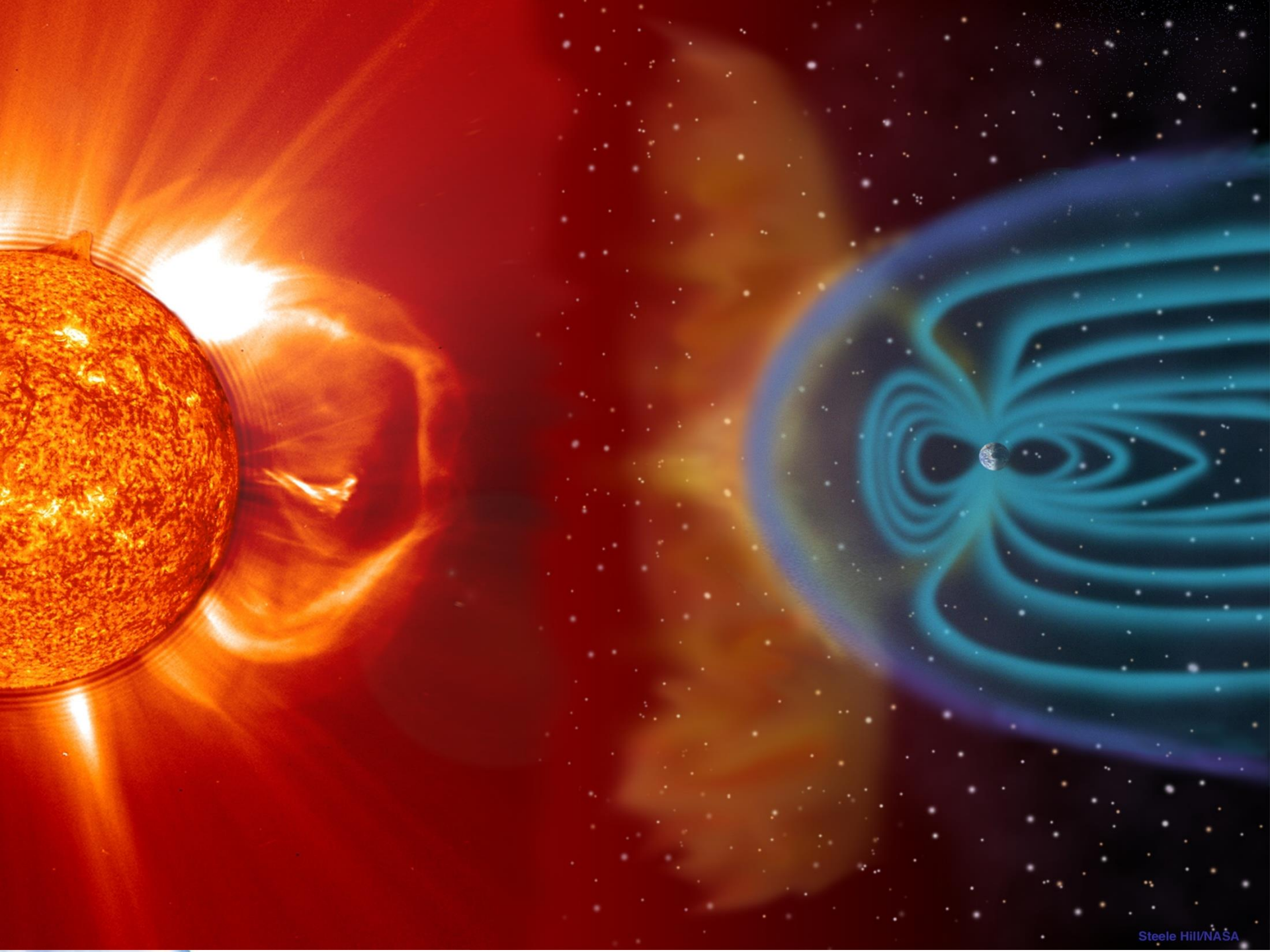
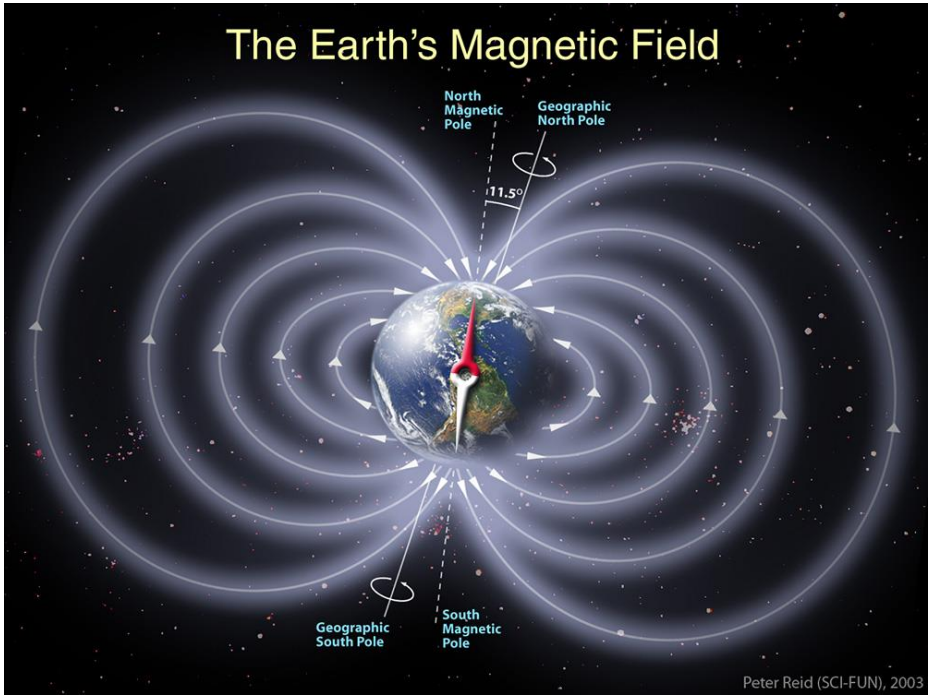
日地環境


Artist Rendition of Solar Wind
Created by: K. Endo
Photo Courtesy of Prof. Yohsuke Kamide
National Geophysical Data Center

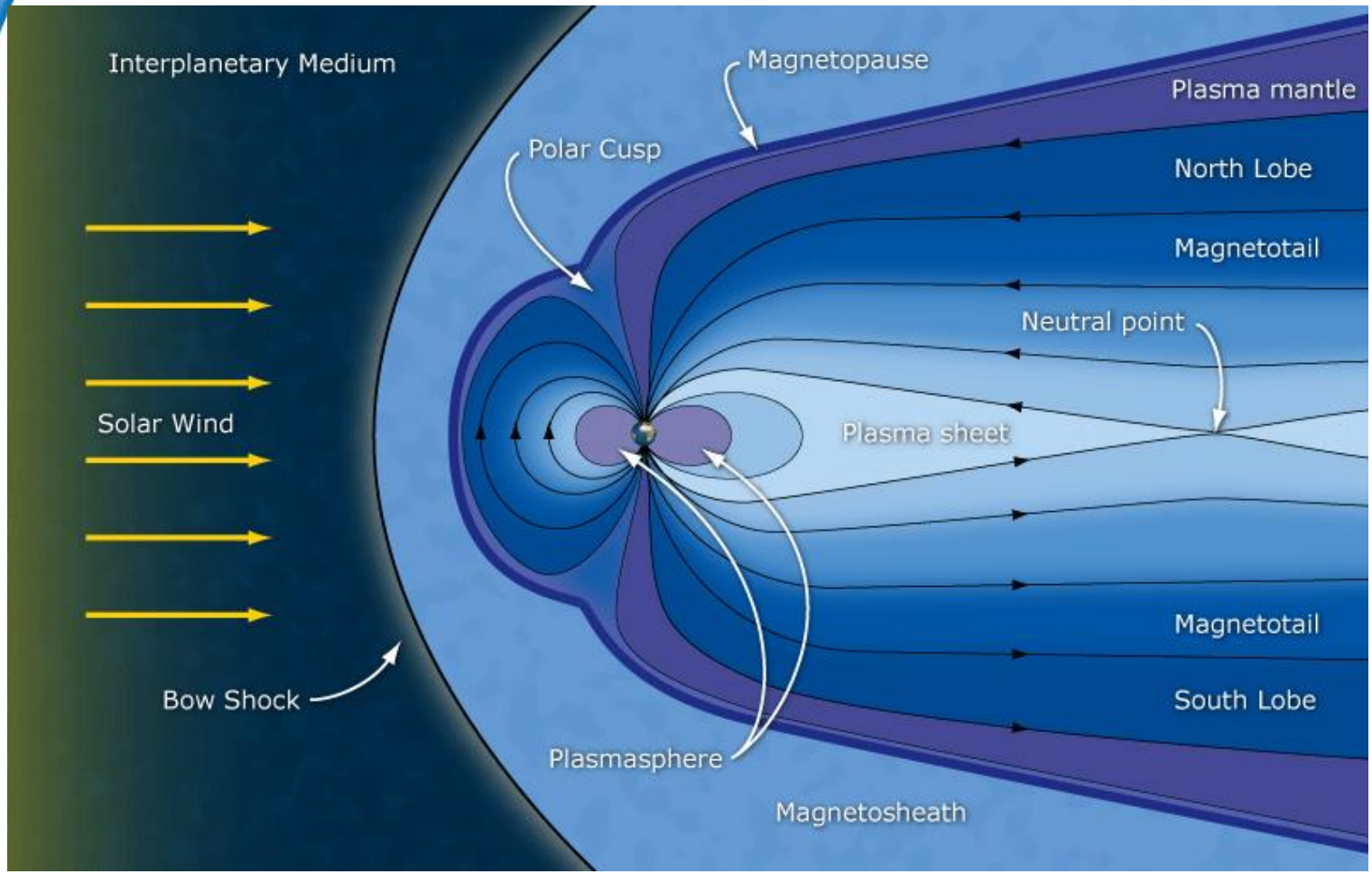

Steele Hill/NASA

地球四大守護神

- 磁層 (Magnetosphere)
- 電離層 (Ionosphere)
- 大氣層
- 臭氧層

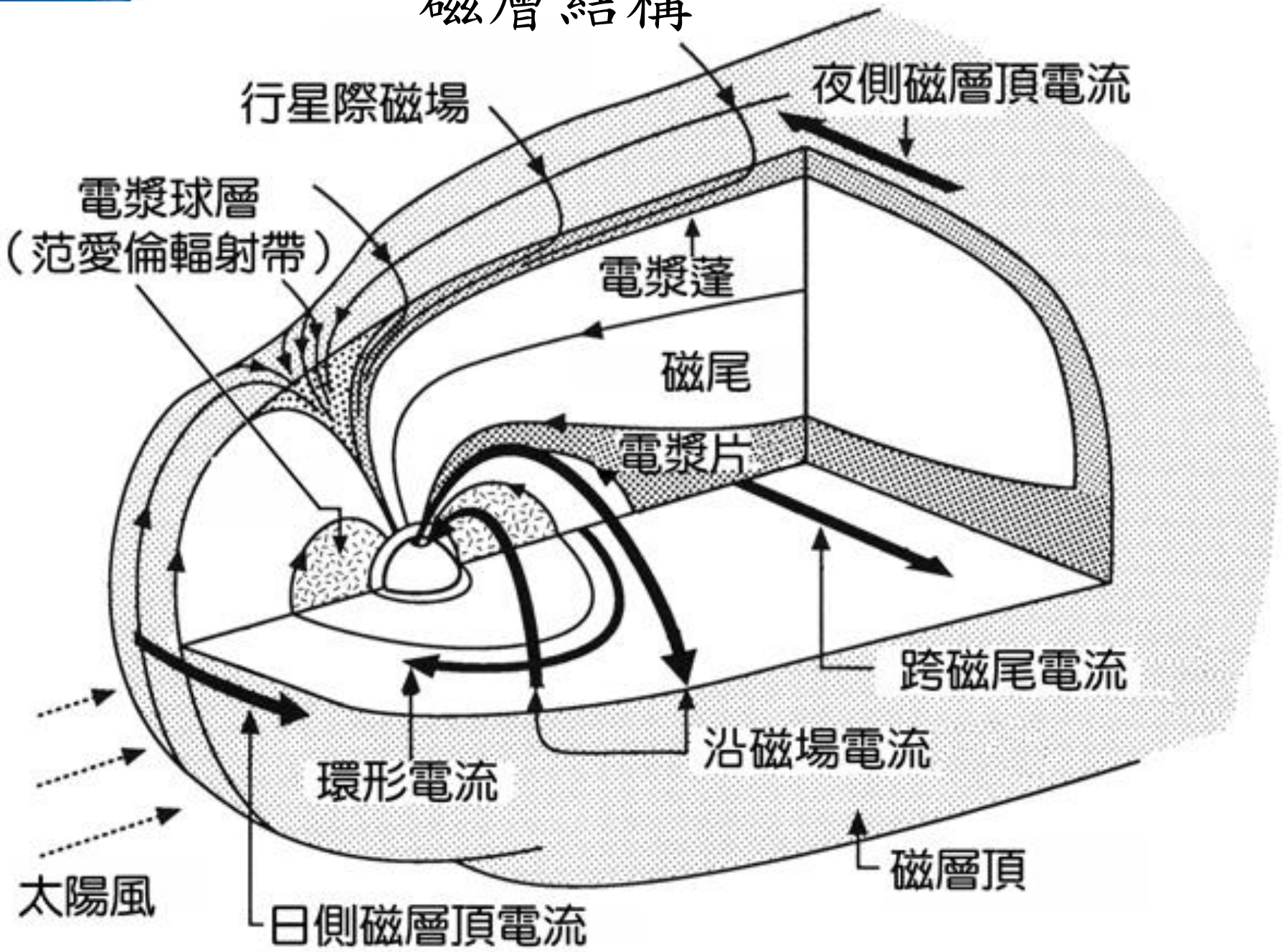


地磁盾:磁層

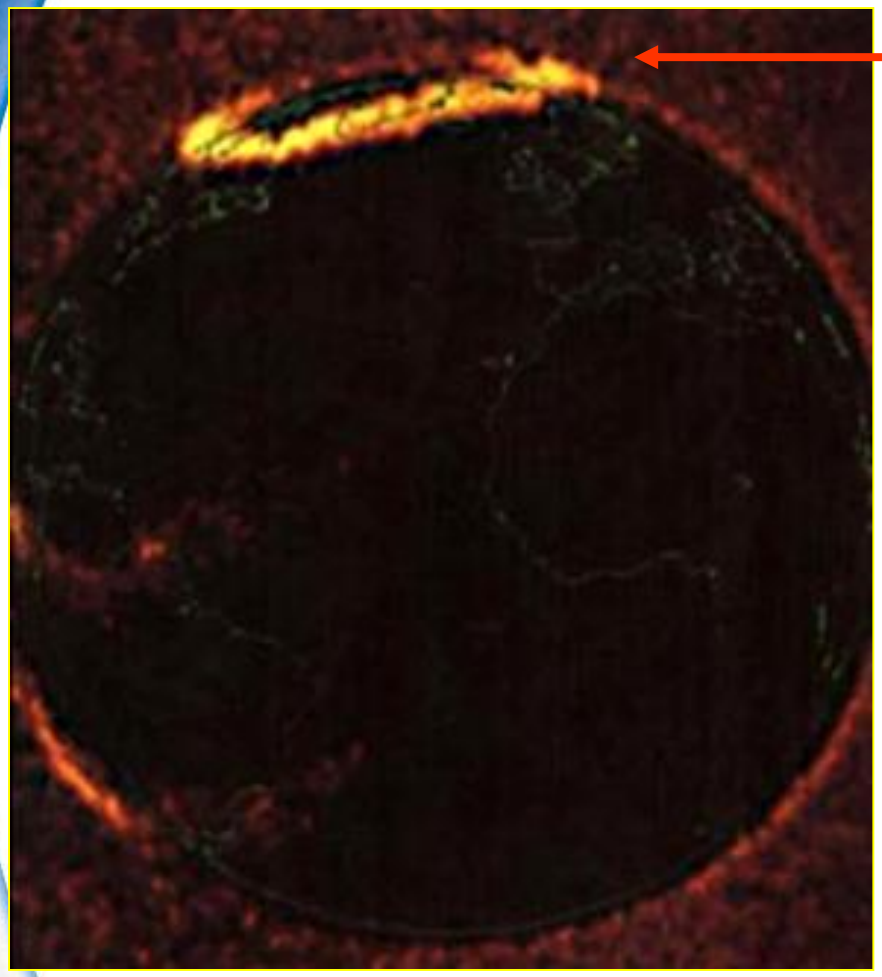


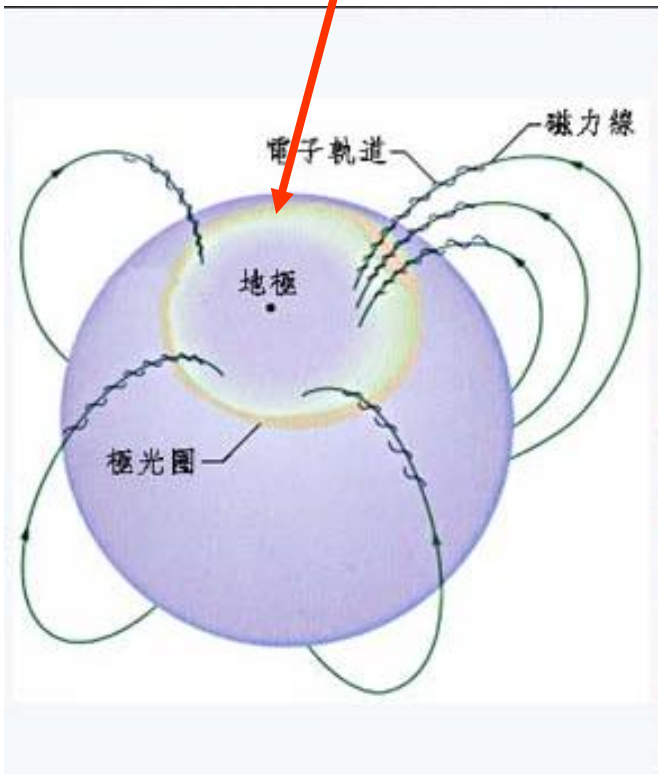
由於電磁力的作用，地球的磁場在太陽風中的帶電高能粒子的吹襲之下，產生了著名的磁層結構(magnetosphere) 。

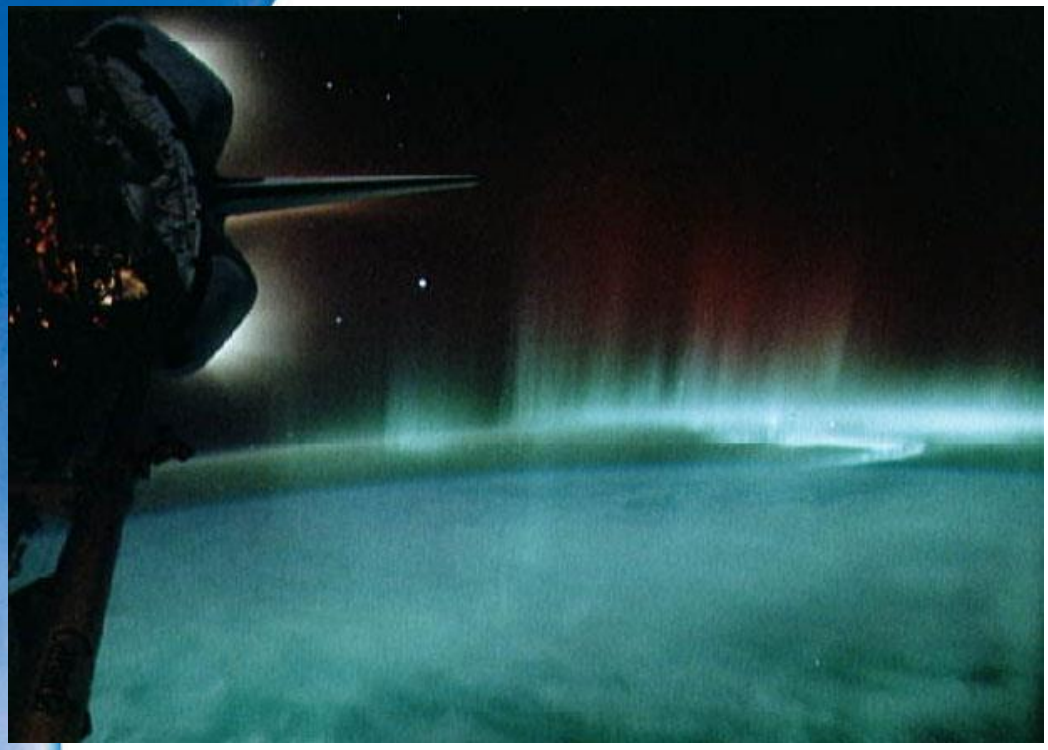
磁層結構

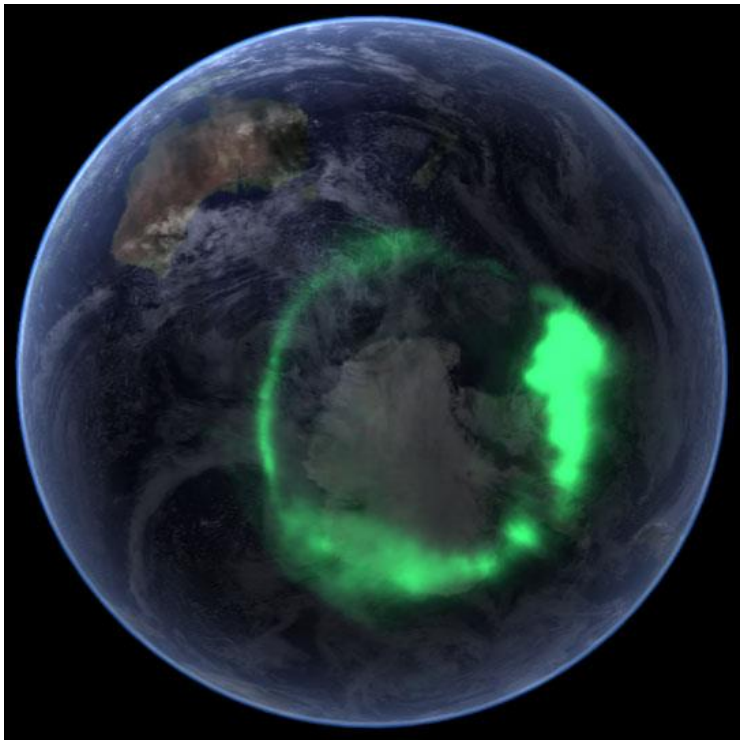

行星際磁場
夜側磁層頂電流
電漿球層
（范愛倫輻射帶）
電漿薄
磁尾
電漿片
跨磁尾電流
沿磁場電流
環形電流
磁層頂
太陽風
日側磁層頂電流

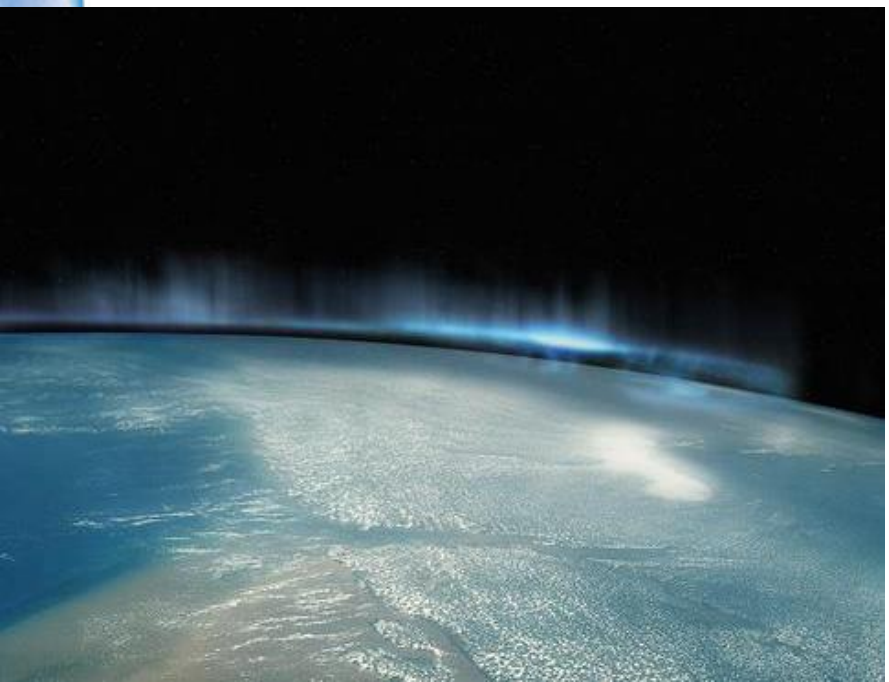
極　光

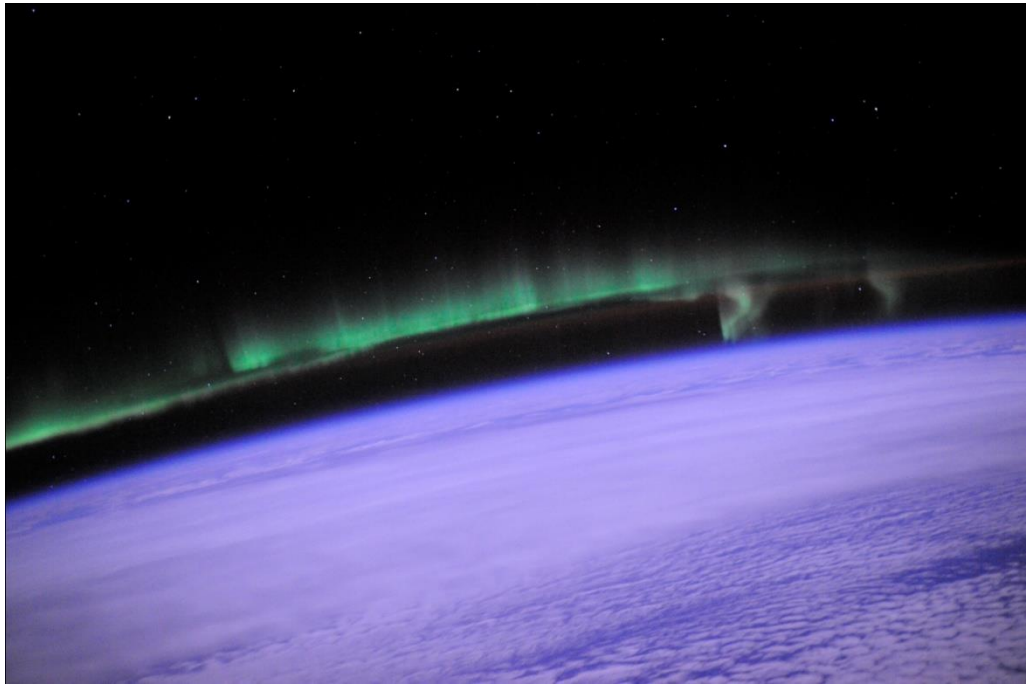




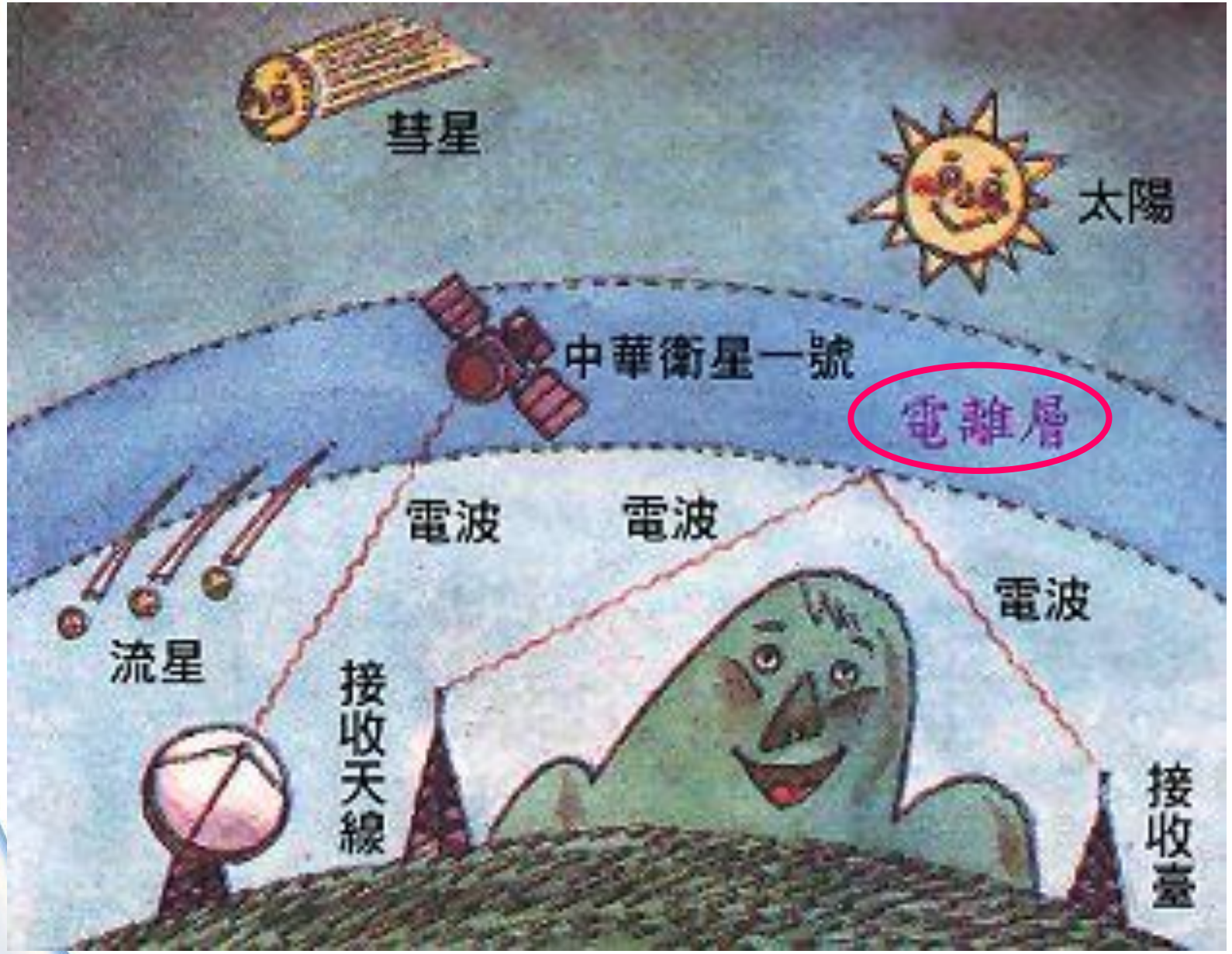




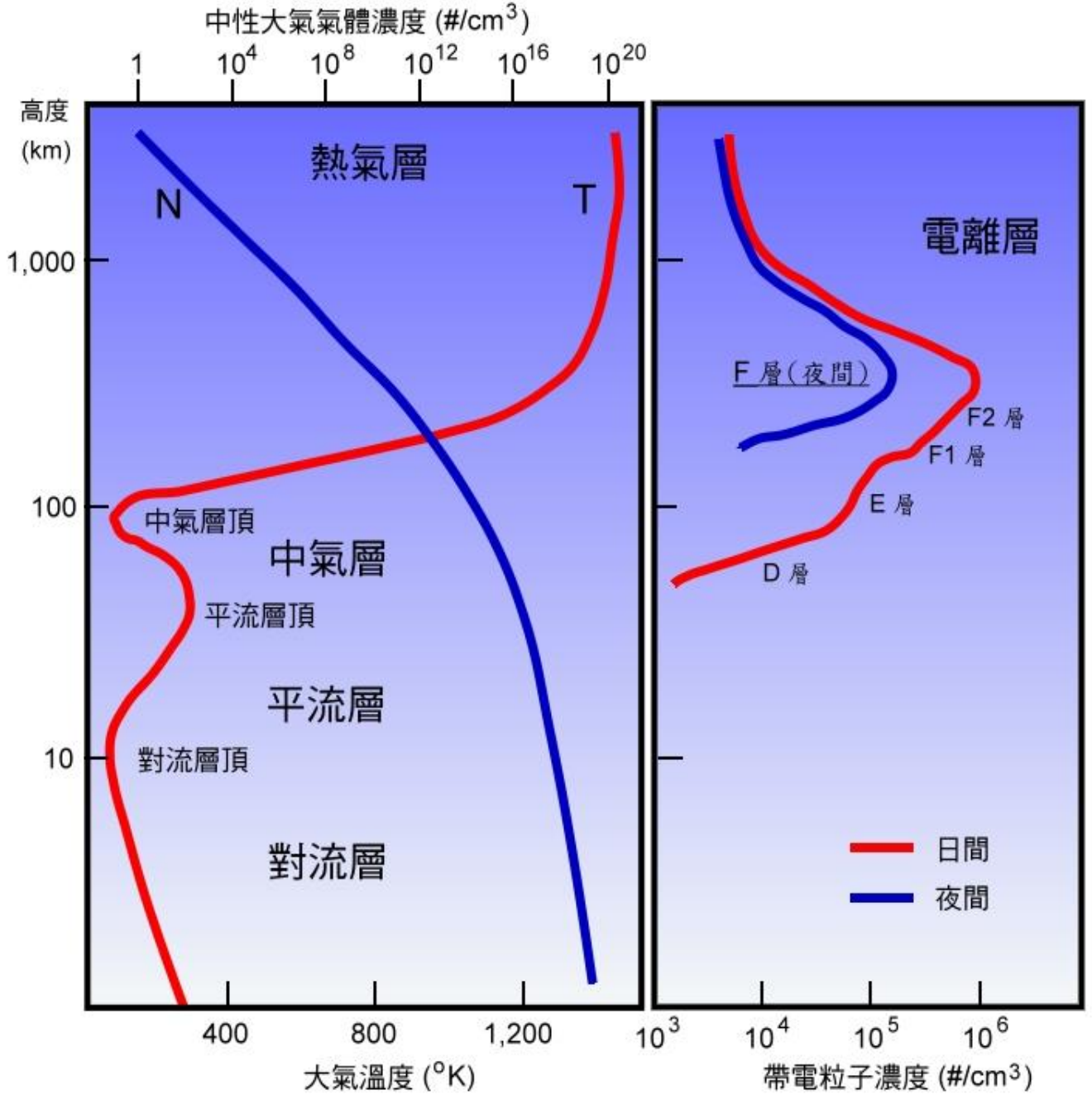


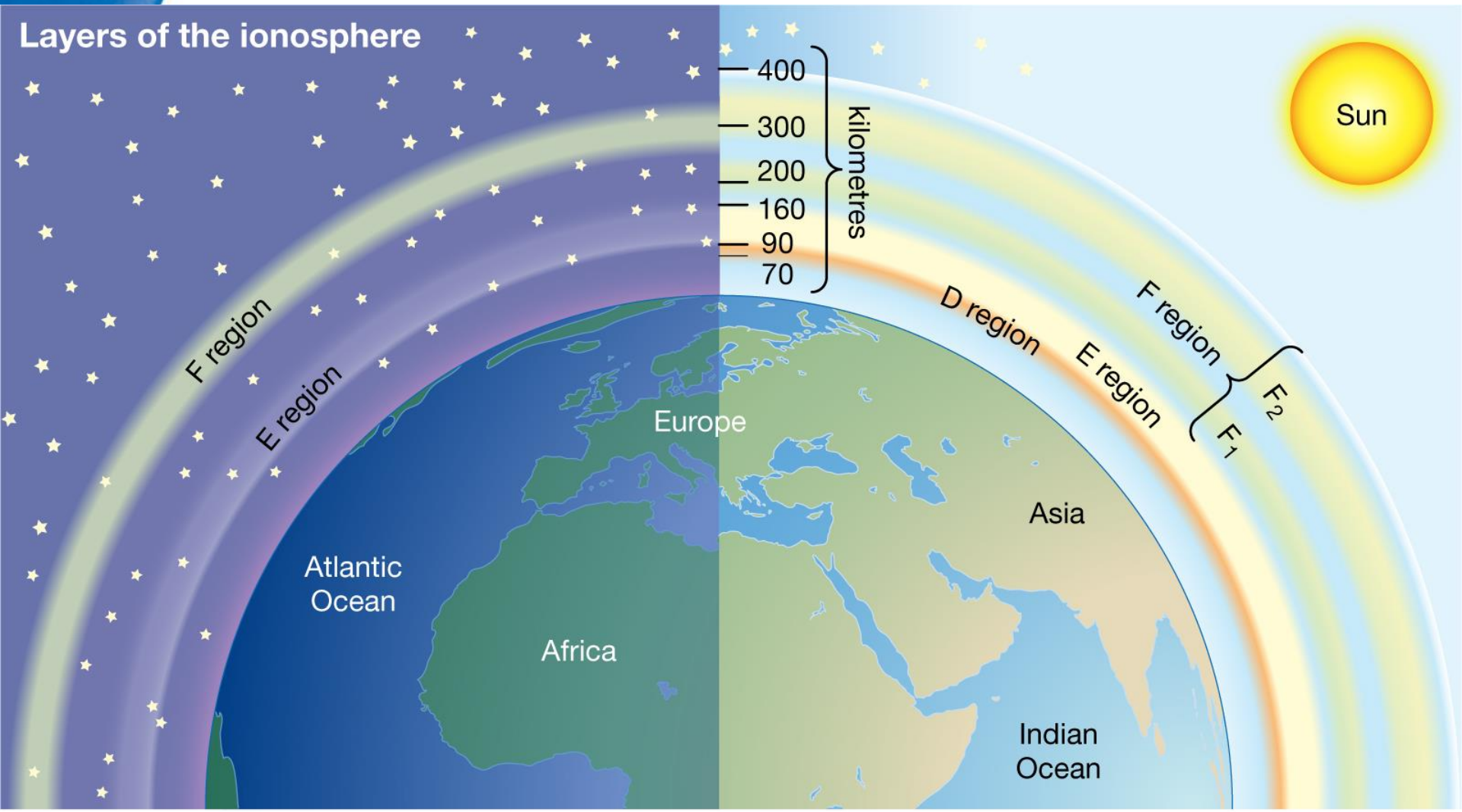


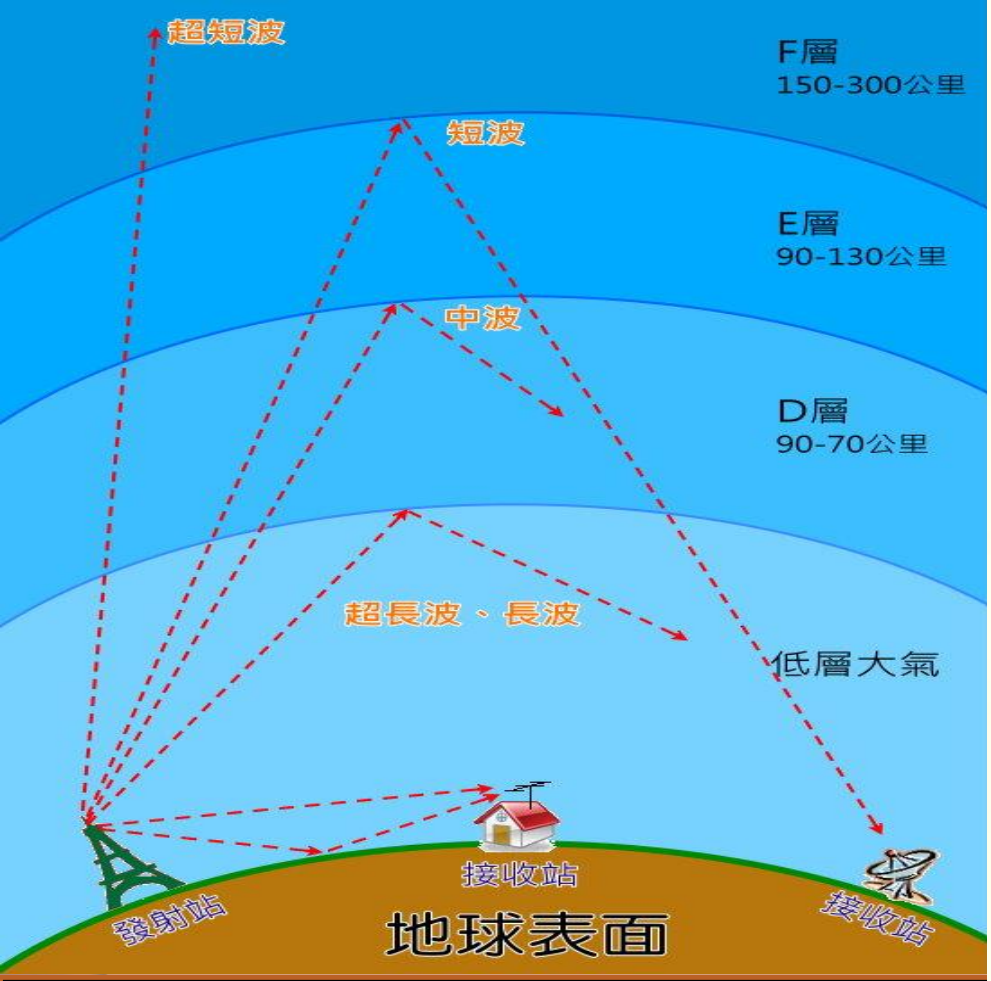
電離層

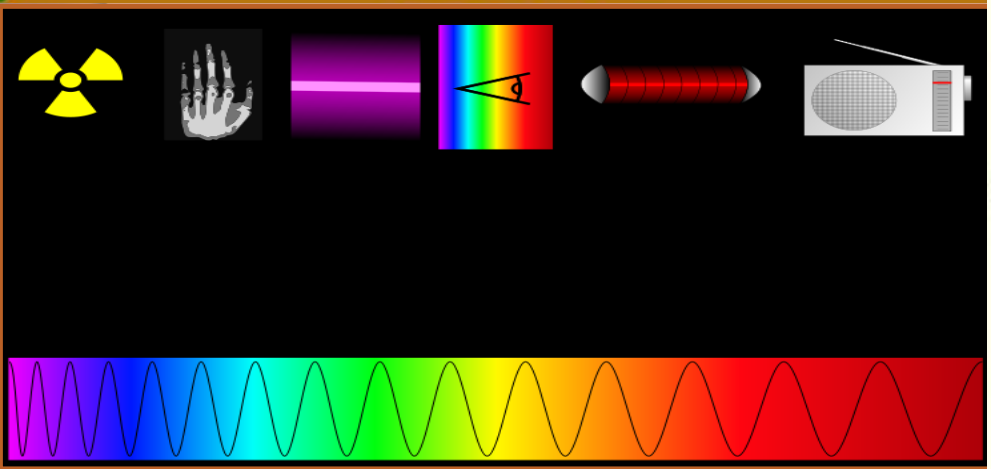


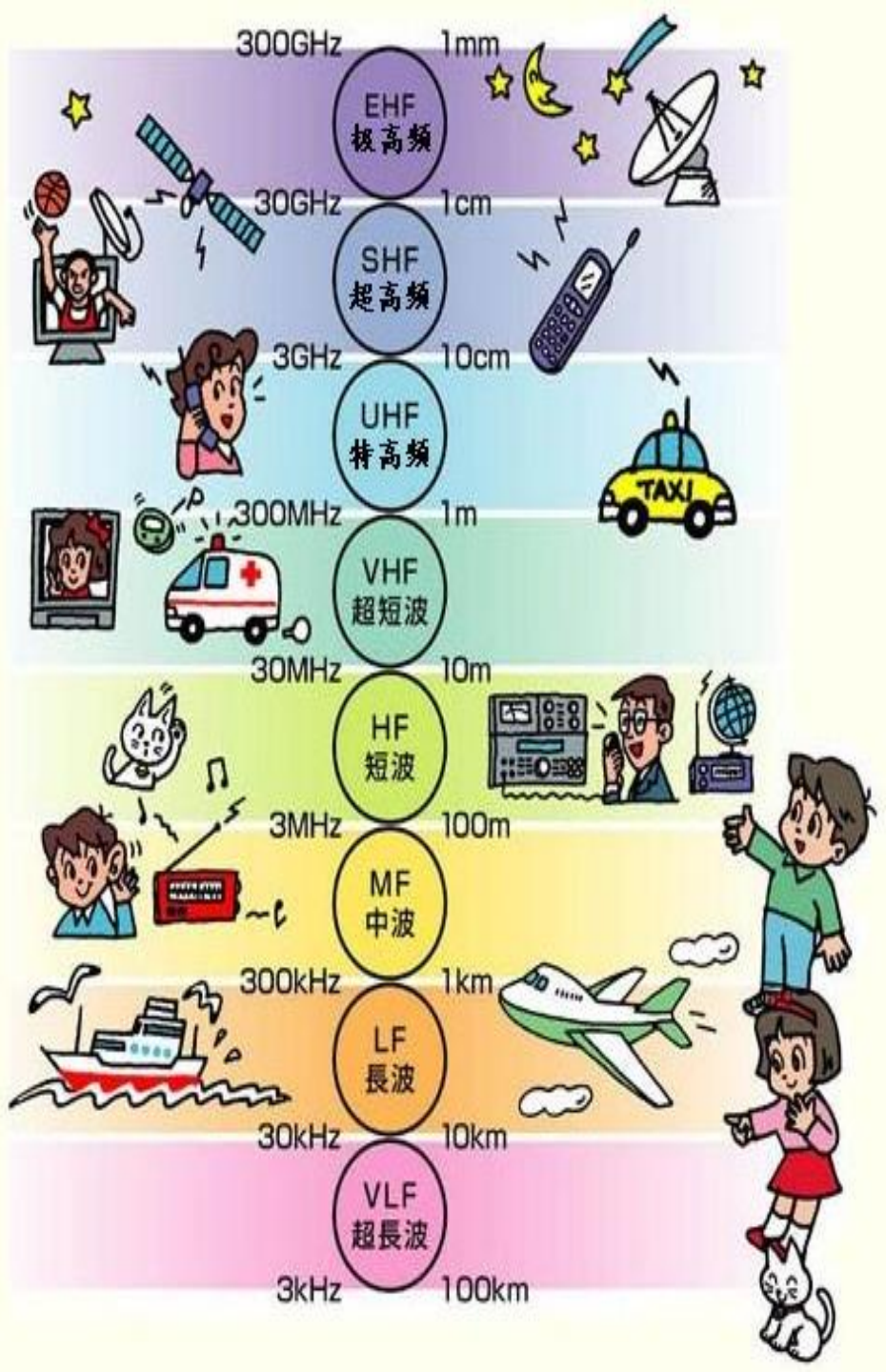
中性大氣層結構　　電離層結構





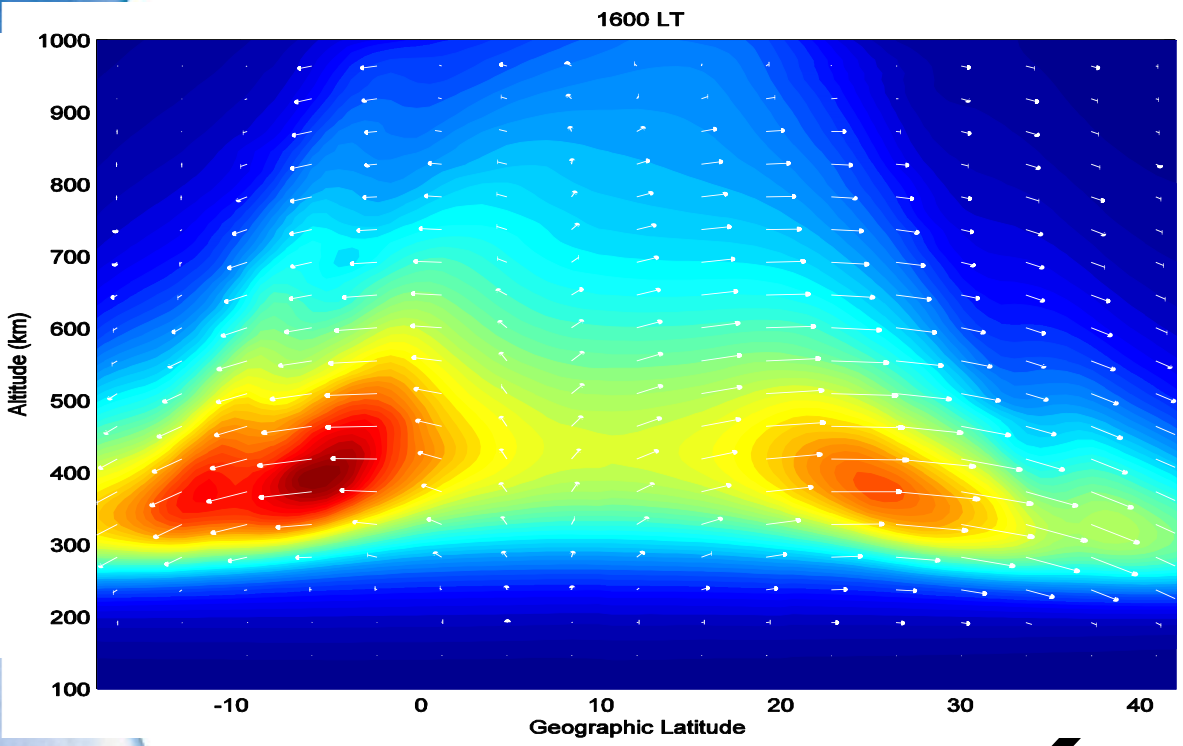

超短波
F層
150-300公里
短波
E層
90-130公里
中波
D層
90-70公里
超長波、長波
低層大氣
接收站
發射站
接收站
地球表面

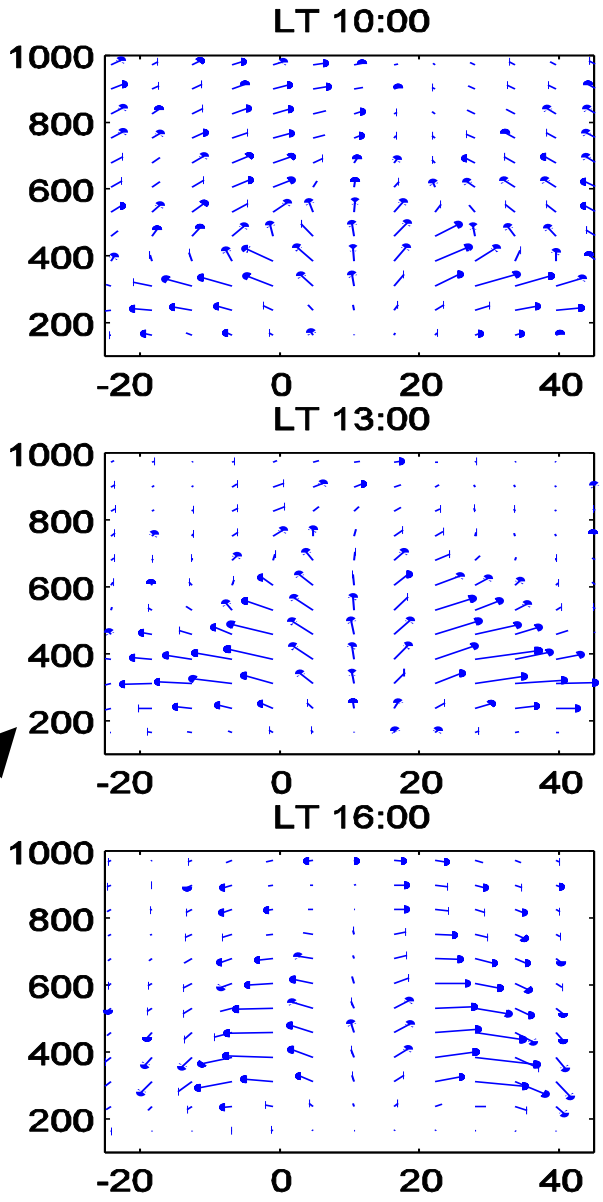



300GHz
1mm
EHF
極高頻
30GHz
1cm
SHF
超高頻
3GHz
10cm
UHF
特高頻
300MHz
1m
VHF
超短波
30MHz
10m
HF
短波
3MHz
100m
MF
中波
300kHz
1km
LF
長波
30kHz
10km
VLF
超長波
3kHz
100km
TAXI

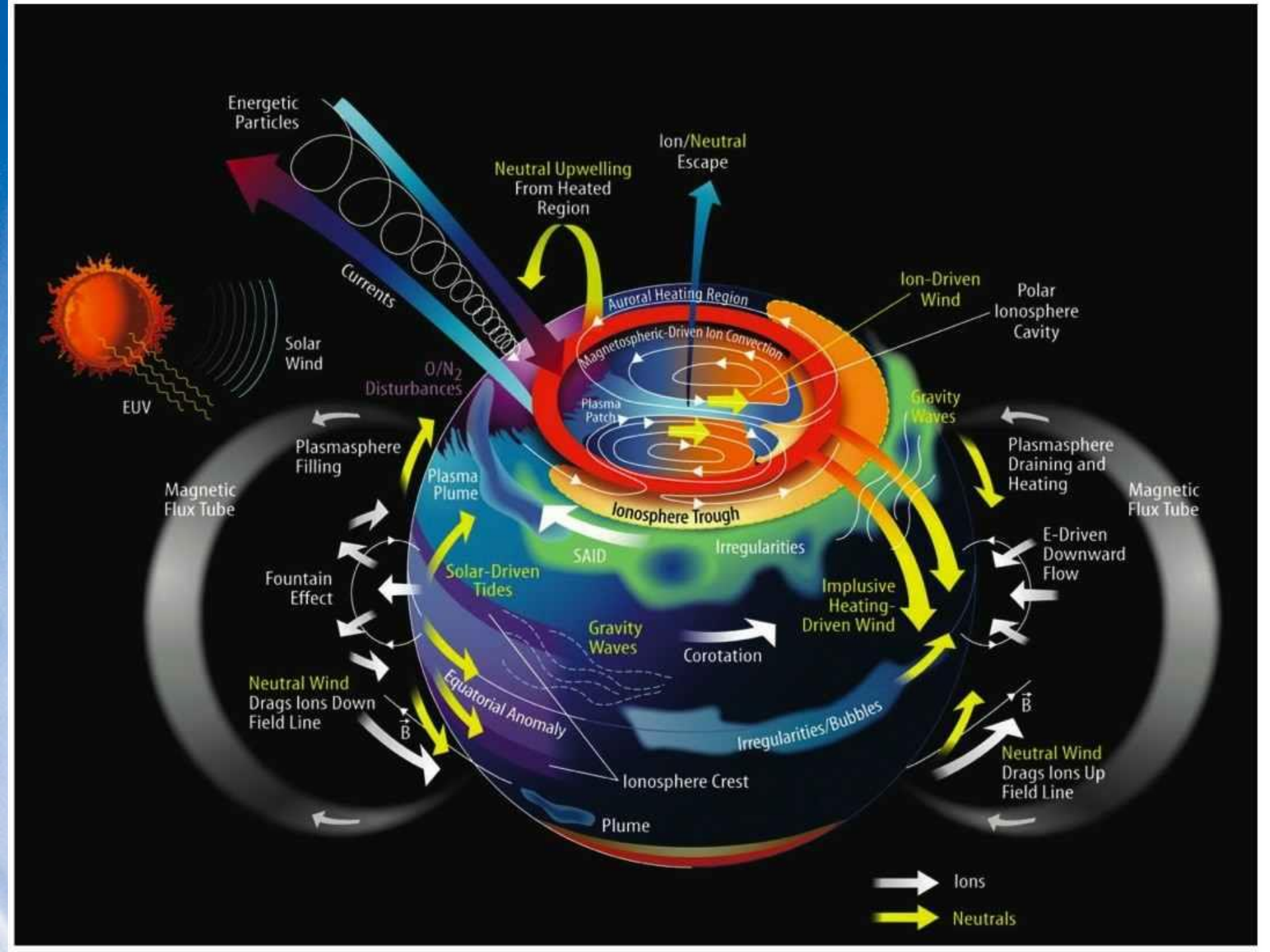
Equatorial plasma fountain

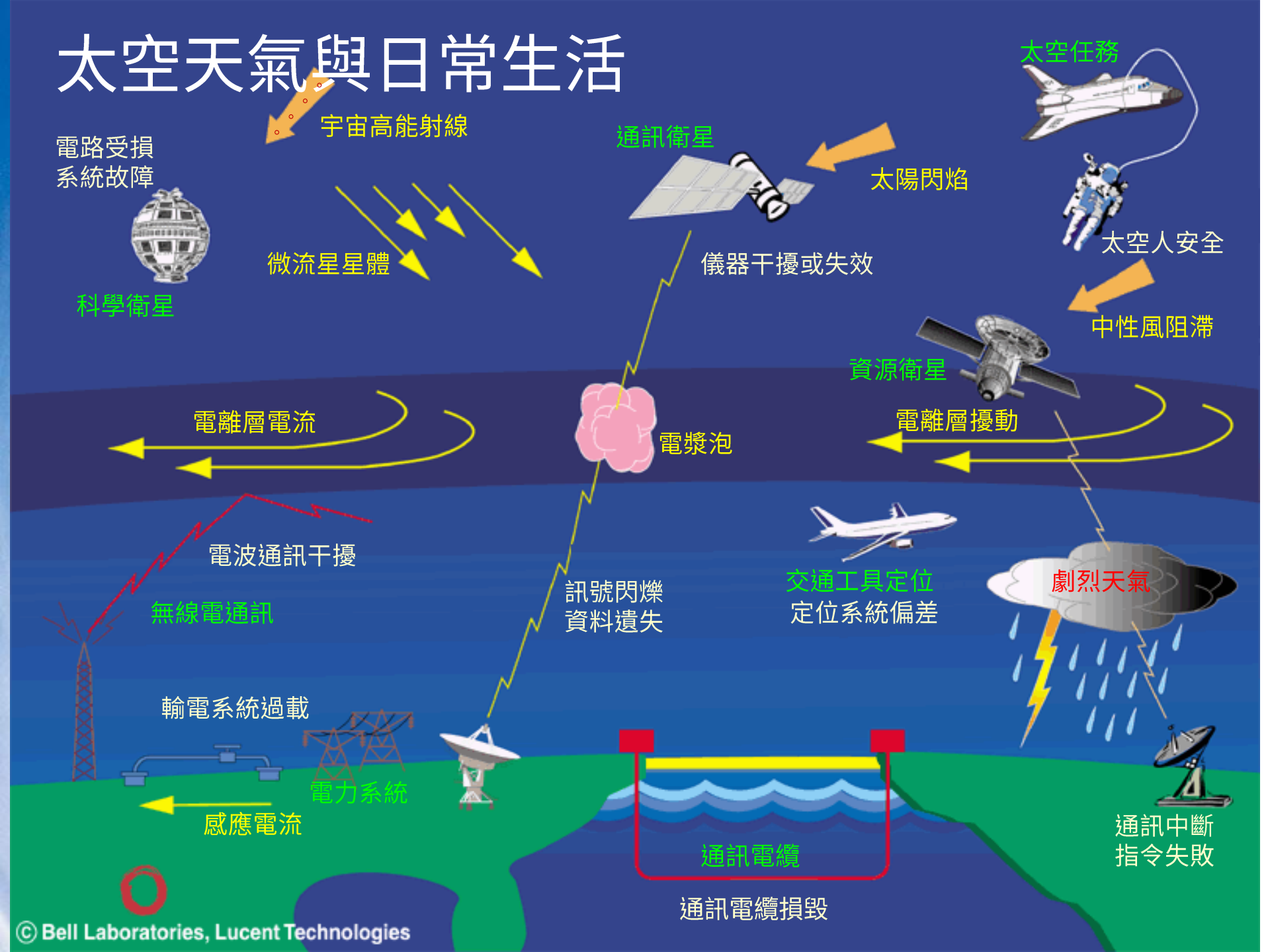
Low-Latitude Ionosphere is dominated by the electrodynamics





A model simulated plasma fountain effect starting in the morning and enhance to its maximum around noon


Energetic Particles
Ion/Neutral Escape
Neutral Upwelling From Heated Region
Currents
Auroral Heating Region
Magnetospheric-Driven Ion Convection
Ion-Driven Wind
Polar Ionosphere Cavity
Solar Wind
EUV
O/N2 Disturbances
Plasma Patch
Gravity Waves
Plasmasphere Filling
Plasmasphere Draining and Heating
Magnetic Flux Tube
Plasma Plume
Ionosphere Trough
Magnetic Flux Tube
SAID
Irregularities
E-Driven Downward Flow
Fountain Effect
Solar-Driven Tides
Implusive Heating-Driven Wind
Gravity Waves
Corotation
Neutral Wind Drags Ions Down Field Line
Equatorial Anomaly
Irregularities/Bubbles
Neutral Wind Drags Ions Up Field Line
Ionosphere Crest
Plume
Ions
Neutrals


太空天氣與日常生活
太空任務
宇宙高能射線
電路受損
系統故障
通訊衛星
太陽閃焰
太空人安全
微流星星體
儀器干擾或失效
科學衛星
中性風阻滯
資源衛星
電離層電流
電漿泡
電離層擾動
電波通訊干擾
交通工具定位
定位系統偏差
劇烈天氣
無線電通訊
訊號閃爍
資料遺失
輸電系統過載
電力系統
感應電流
通訊電纜
通訊中斷
指令失敗
通訊電纜損毀
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