Διαστημικό Περιβάλλον

Space Environment

Space Environment
Lecture 2

N
W
E
S

Planetary Magnetism

- All planets and generally all solar system bodies have some kind of magnetism.
- The giant outer planets all have strong magnetic fields.
- The innermost small planet Mercury has a substantial magnetic field.
- Jupiter's moon Ganymede has an intrinsic magnetic field.

Planetary Magnetism

- Europa and Callisto have induced magnetospheres possibly related to a subsurface ocean.
- The Moon has a remnant magnetic field.
- Mars has localized field concentrations.
- Asteroids *may* have a strong magnetic field.

Planetary magnetism

Planet	Radius (km)	Rotation period (days)	Equatorial magnetic field (nT)
Mercury	2439	58.6	340
Venus	6052	243	0.4
Earth	6371	1	30,000
Mars	3397	1	< 0.5
Jupiter	71,398	0.4	424,000
9969 Braille	0.8	3.6	92,500
Saturn	60,000	0.41	21,500
Uranus	26,200	0.72	22,800
Neptune	24,300	0.70	14,400

Planetary magnetism

Planet	Radius (km)	Rotation period (days)	Equatorial magnetic field (nT)
Mercury	2439	58.6	340
Venus	6052	243	0.4
Earth	**6371**	**1**	**30,000 (0.3 G)**
Mars	3397	1	< 0.5
Jupiter	71,398	0.4	424,000
9969 Braille	0.8	3.6	92,500
Saturn	60,000	0.41	21,500
Uranus	26,200	0.72	22,800
Neptune	24,300	0.70	14,400

Planetary magnetism

Planet	Radius (km)	Rotation period (days)	Equatorial magnetic field (nT)
Mercury	2439	58.6	340
Venus	6052	243	0.4
Earth	6371	1	30,000
Mars	3397	1	< 0.5
Jupiter	**71,398**	**0.4**	**424,000 (4.24 G)**
9969 Braille	0.8	3.6	92,500
Saturn	60,000	0.41	21,500
Uranus	26,200	0.72	22,800
Neptune	24,300	0.70	14,400

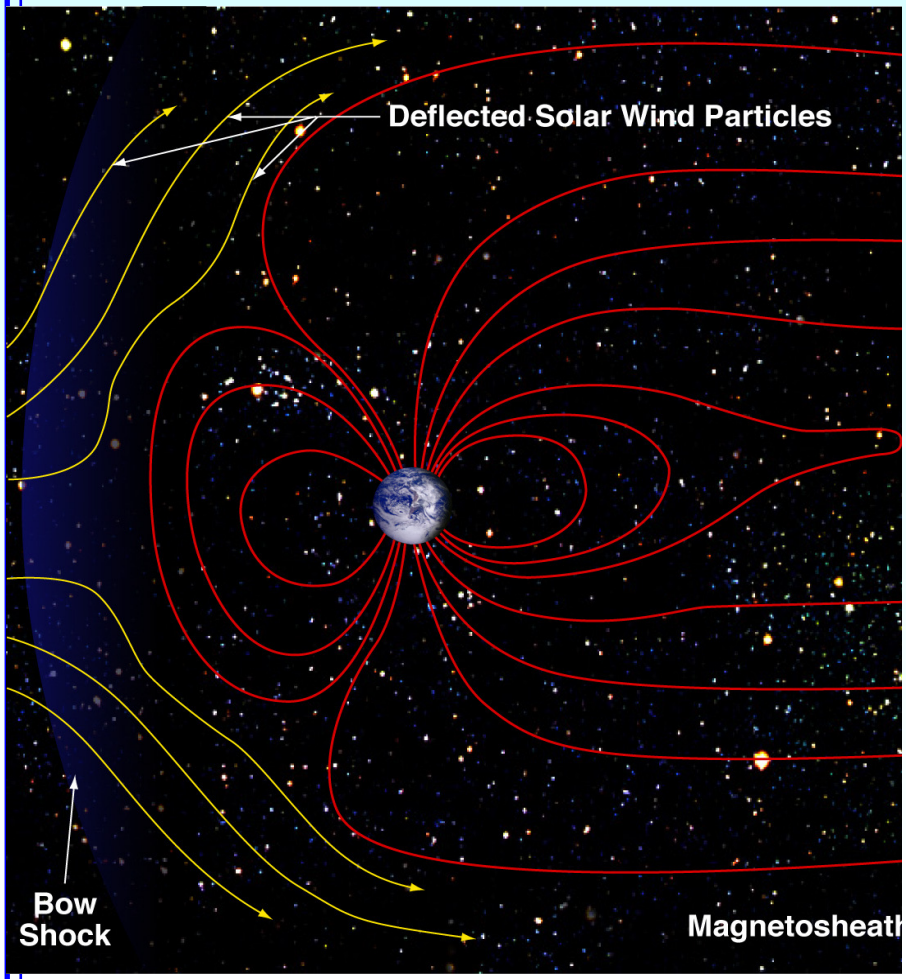
Planetary magnetism

Planet	Radius (km)	Rotation period (days)	Equatorial magnetic field (nT)
Mercury	2439	58.6	340
Venus	**6052**	**243**	**0.4**
Earth	6371	1	30,000
Mars	3397	1	< 0.5
Jupiter	**71,398**	**0.4**	**424,000**
9969 Braille	0.8	3.6	92,500
Saturn	60,000	0.41	21,500
Uranus	26,200	0.72	22,800
Neptune	24,300	0.70	14,400

Planetary magnetism

Planet	Radius (km)	Rotation period (days)	Equatorial magnetic field (nT)
Mercury	2439	58.6	340
Venus	6052	243	0.4
Earth	6371	1	30,000
Mars	3397	1	< 0.5
Jupiter	71,398	0.4	424,000
Braille/Gaspra	***0.8***	***3.6***	***92,500 / 78,000***
Saturn	60,000	0.41	21,500
Uranus	26,200	0.72	22,800
Neptune	24,300	0.70	14,400

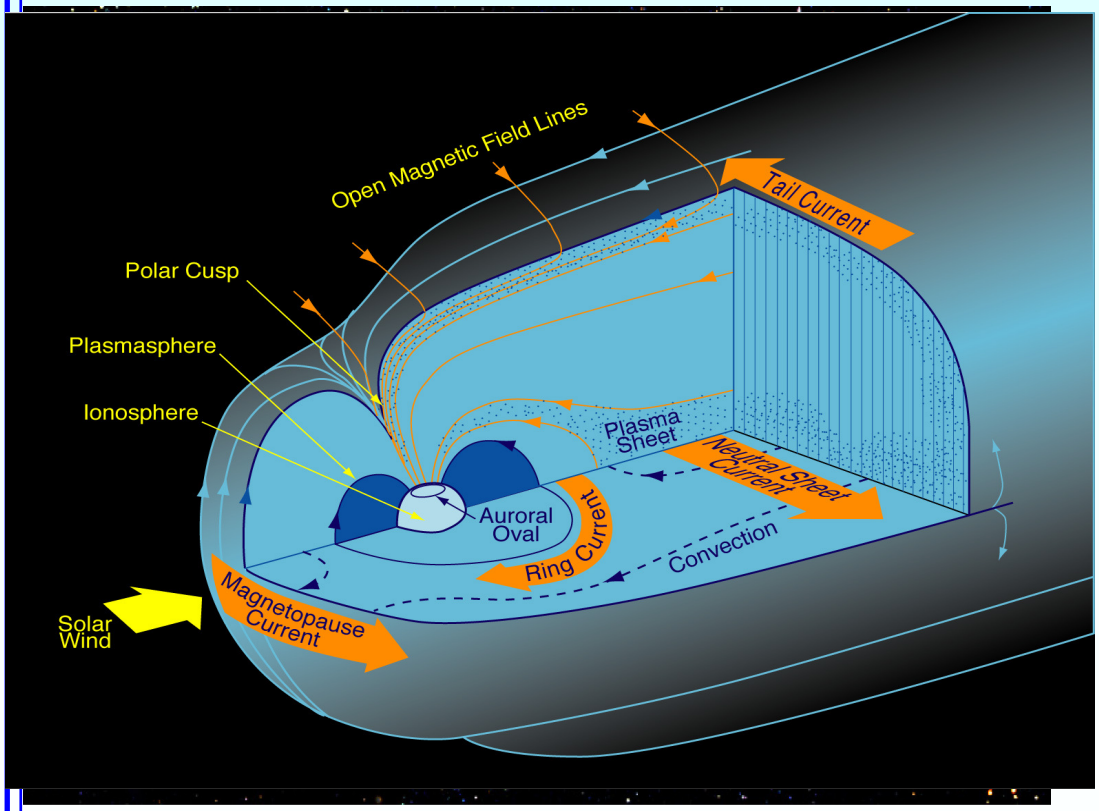
Planetary Magnetospheres I



- Produced by rotation of conducting fluid
  - Earth: liquid Fe core
  - Jupiter & Saturn: metallic H_2
  - Uranus & Neptune: salty oceans
- So what?
  - Atmospheric retention
  - Habitability

Planetary-scale magnetic fields:
Earth, Jupiter, Saturn, Uranus, & Neptune (Mercury)

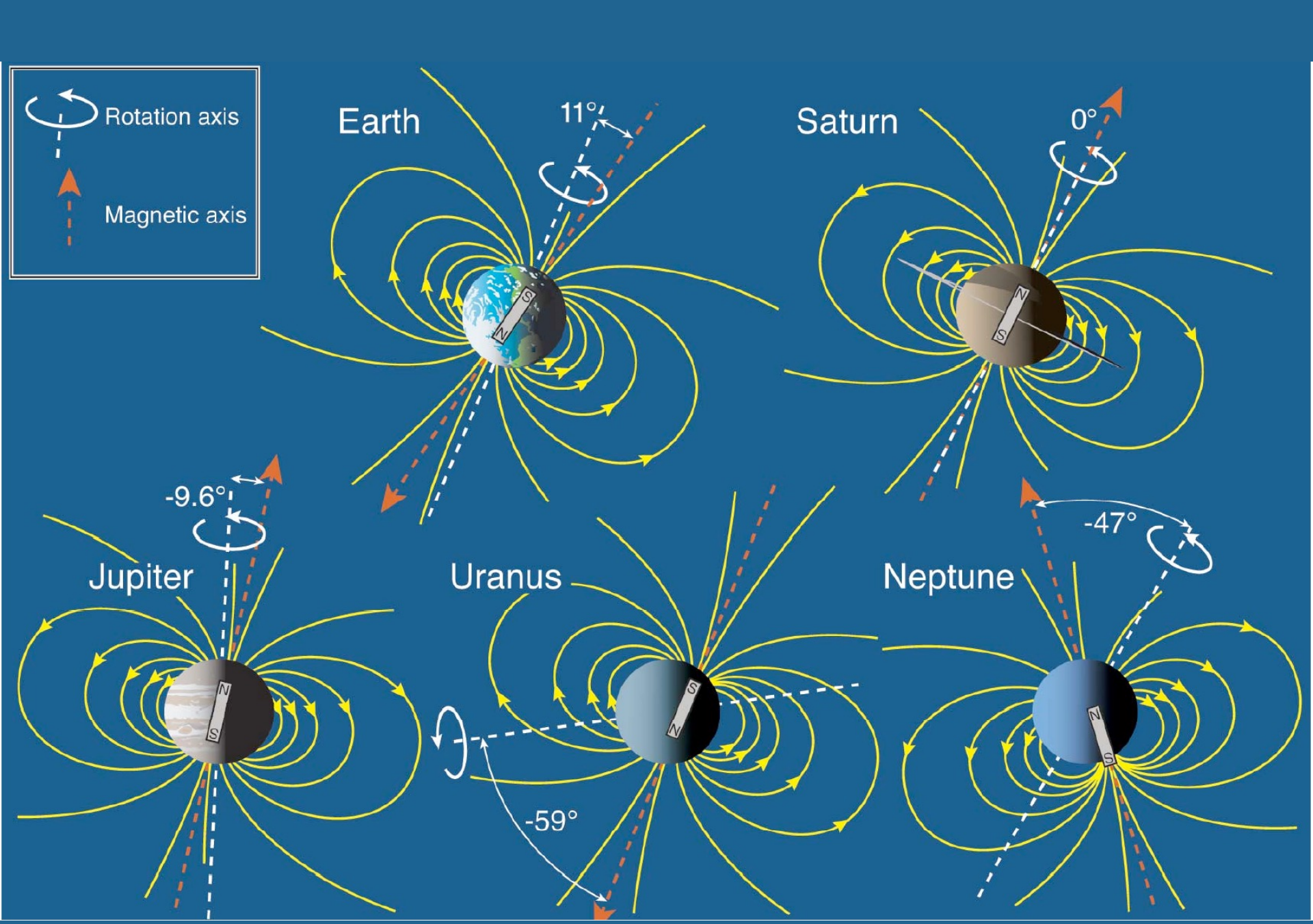
Planetary Magnetospheres II

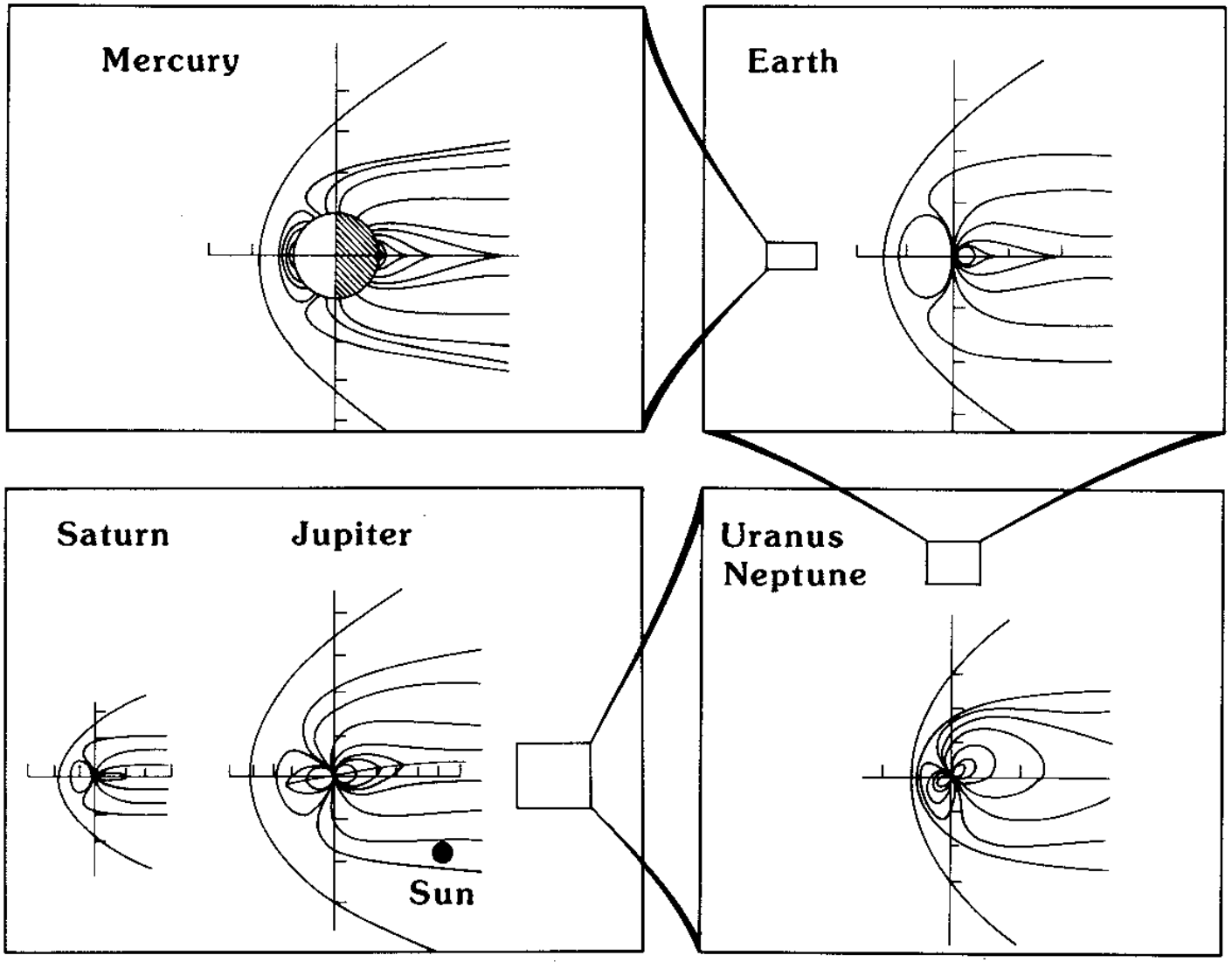


- Planetary magnetic field immersed in solar wind
- Solar wind is high-speed plasma with embedded magnetic field
- Pressure from solar wind impacts and deforms planetary magnetic field

➢ Magnetosphere

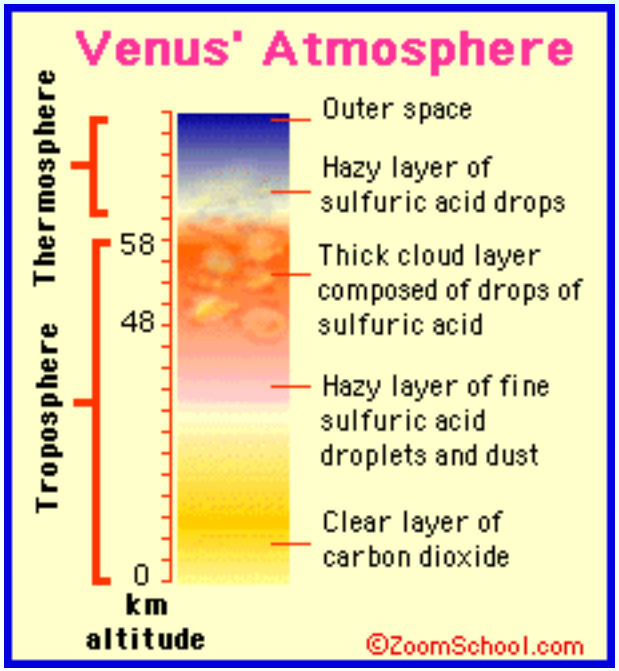
Large objects, e.g., Jovian magnetosphere is 5x diameter of full Moon


Rotation axis
Magnetic axis
Earth
11°
Saturn
0°
-9.6°
Jupiter
Uranus
-59°
Neptune
-47°
N
S


Mercury
Earth
Saturn
Jupiter
Uranus
Neptune
Sun

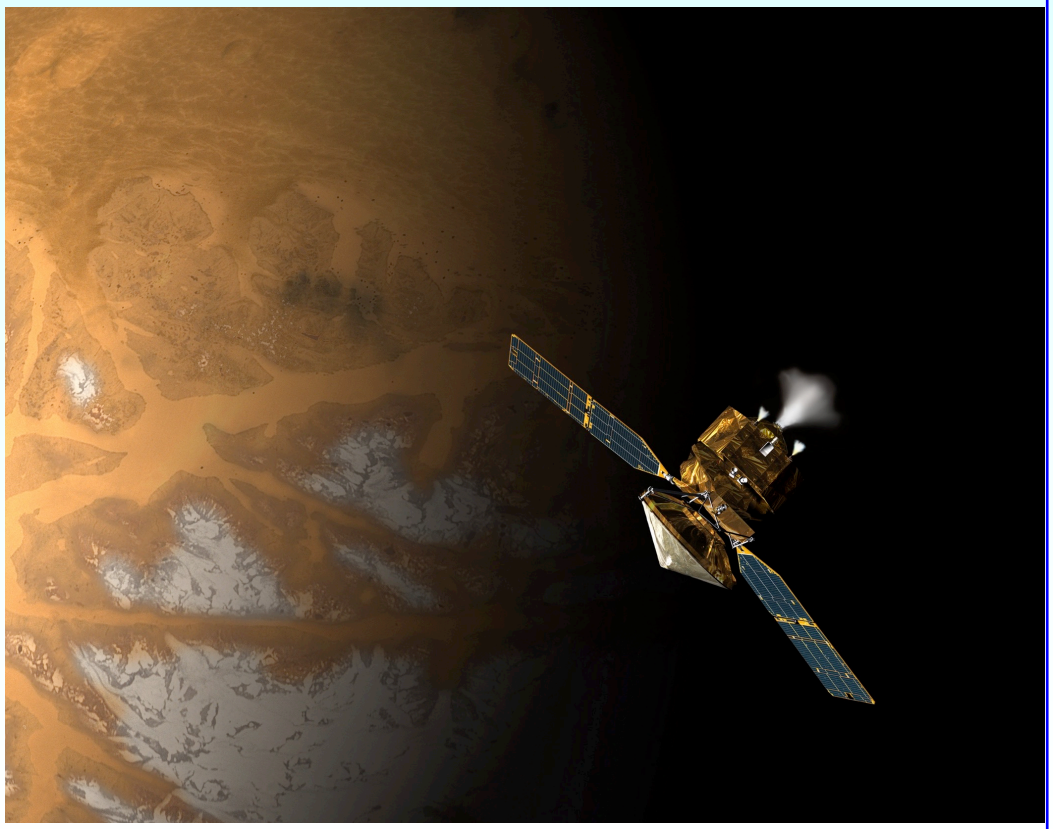
Venus

- Venus rotates too slowly to generate an internal magnetic field, so the solar wind interacts directly with the ionosphere.
- Hydrogen is stripped away, and over time, there is very little left to form water.



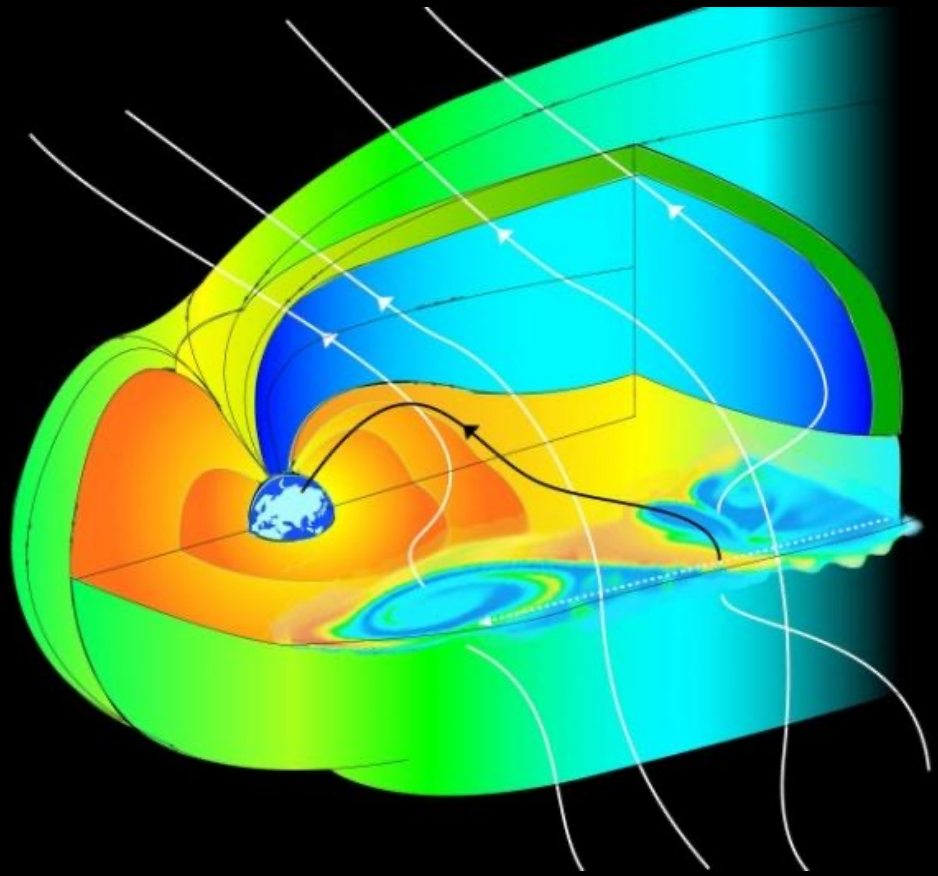
Mars

- Mars also lacks a global magnetic field, although in this case due to the absence of a liquid core layer.
- Most of the Martian atmosphere has been lost to the solar wind, leaving it a dead world.



Μαγνητόσφαιρα

Μαγνητόσφαιρα είναι εκείνη η περιοχή του διαστήματος γύρω από τον πλανήτη, στην οποία κυριαρχεί το μαγνητικό πεδίο του πλανήτη. Η μαγνητόσφαιρα θωρακίζει τη Γη από ηλιακά επεισόδια



Sun - Planet Coupling

- Mercury, Jupiter, Saturn, Uranus and Neptune have an interaction similar to that at Earth - a supersonic solar wind interacts with a magnetic field to form a magnetospheric cavity but the nature of the obstacle differs greatly as do the solar wind parameters.
- Jupiter's moon Ganymede interacts with a plasma wind within Jupiter's vast magnetosphere rather than the solar wind.

Sun - Planet Coupling

- Asteroids may have a strong interaction with the solar wind.
- The ionospheres of Venus and Titan (when outside Saturn's magnetosphere) interact with the solar wind flow to form an induced magnetospheric cavity.
- The small size of comets and the large amount of gas that evaporates from them, make their interaction with the solar wind unique. Rosetta!

Magnetospheric Control Parameters

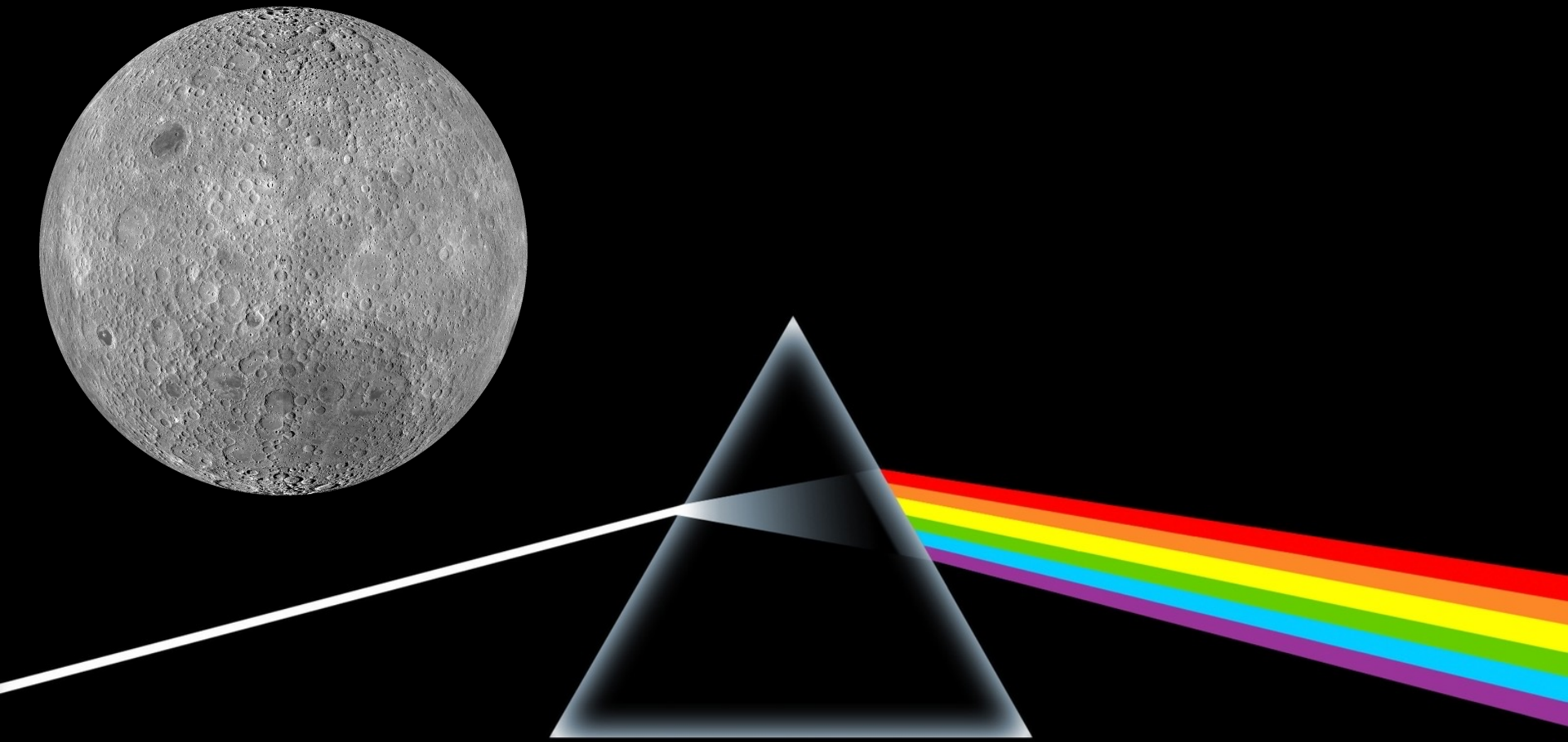
- Solar wind dynamic pressure
- B_Z component of the interplanetary magnetic field
- Planetary magnetic field
- Planetary rotation
- Plasma sources and mass density
- Ionospheric conductivity
- Magnetospheric scale

The Moon ?

Radius (km)	Rotation period (days)	Equatorial magnetic field (nT)
1737	?	-

The Moon

Radius (km)	Rotation period (days)	Equatorial magnetic field (nT)
1737	27.3	-

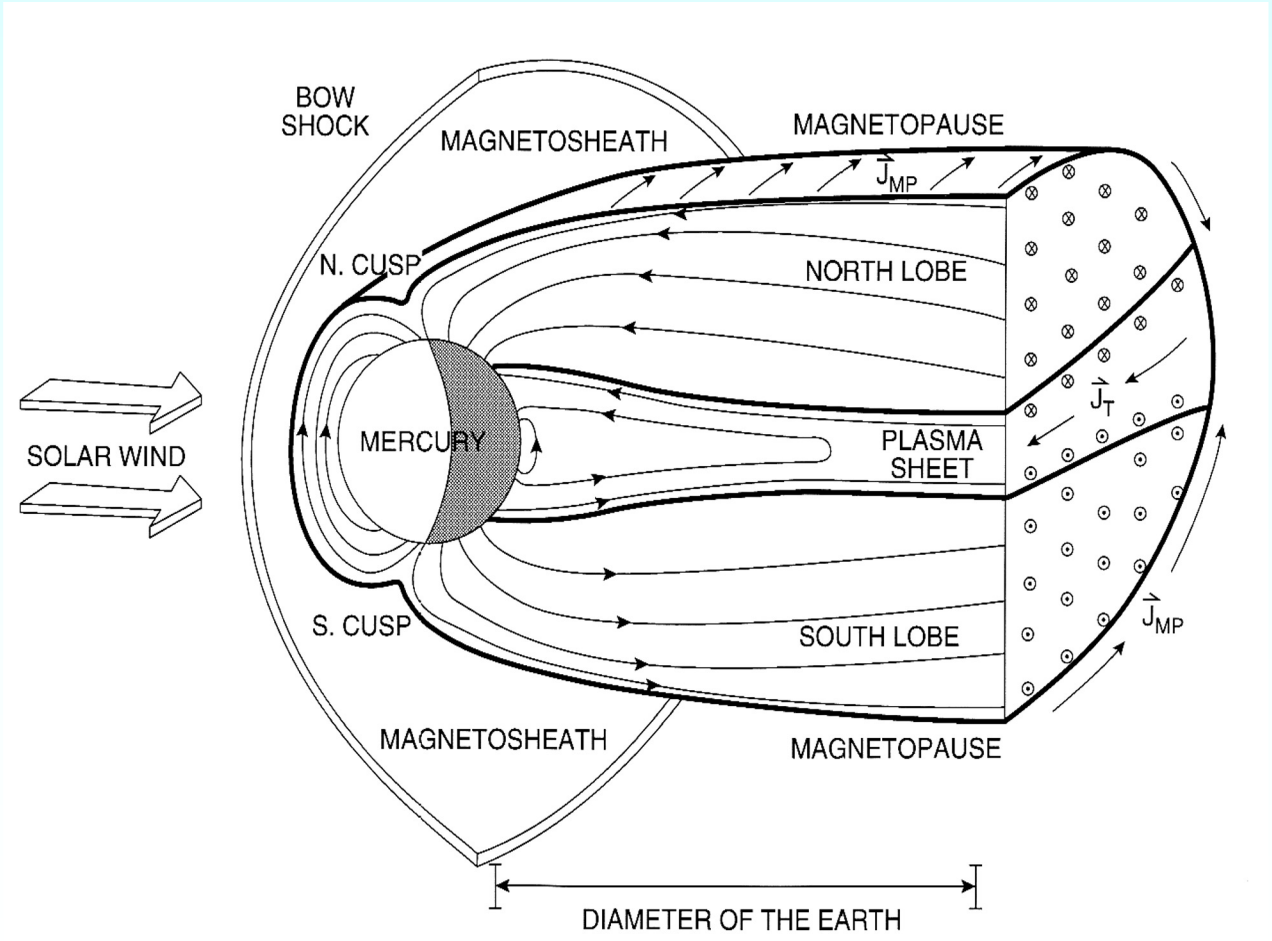


PINK FLOYD - DARK SIDE OF THE MOON

https://www.youtube.com/watch?v=iux6rrK4fic

Τα δύο άκρα
στο ηλιακό μας σύστημα

The Magnetosphere of Mercury: Facts



No atmosphere

No ionosphere

Exosphere

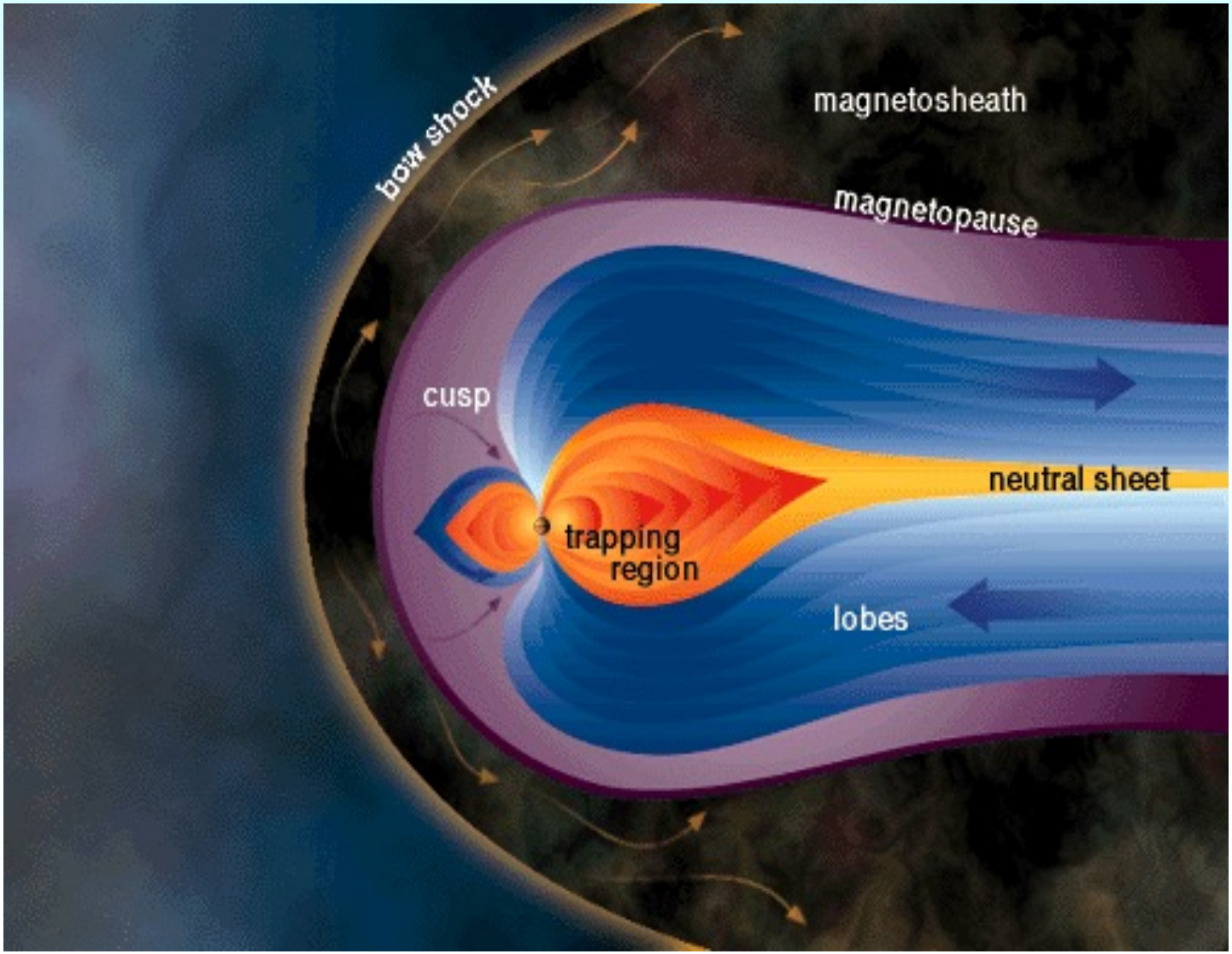
No plasmasphere

Weak magnetic field

Multi-ion plasma

Small magnetosphere

The Magnetosphere of Jupiter



Reference:

Dessler, A. J. (Ed.), Physics of the Jovian Magnetosphere, Cambridge, 1983.

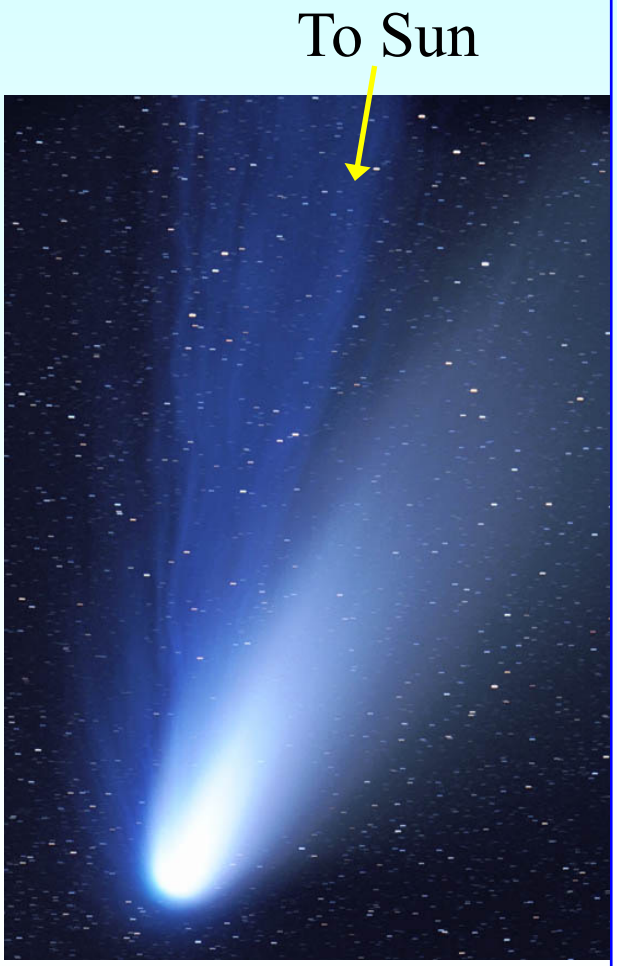
Jupiter's magnetosphere is "sharper" than the others because of the rotating plasma.

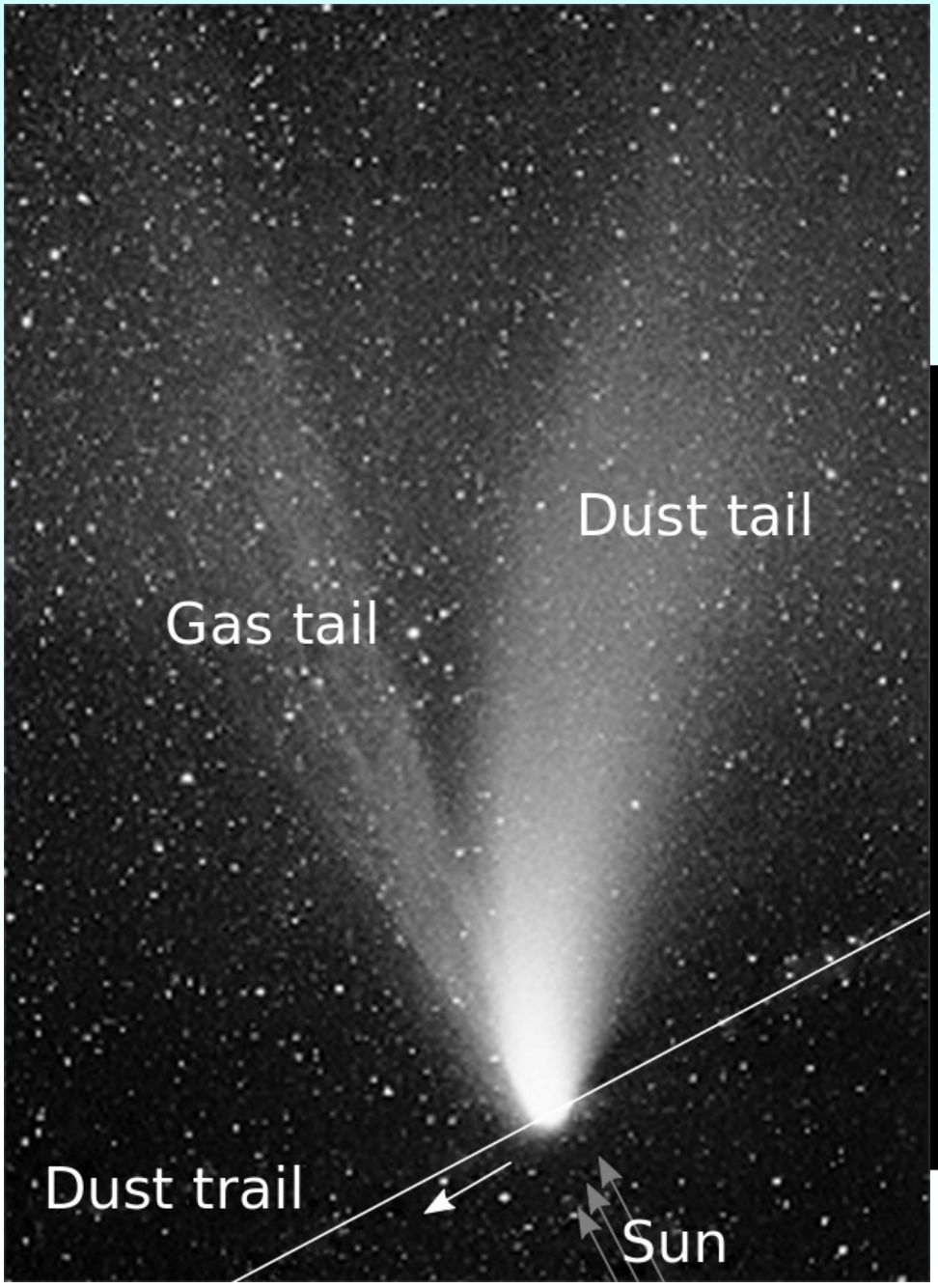
Magnetospheric Plasma Sources

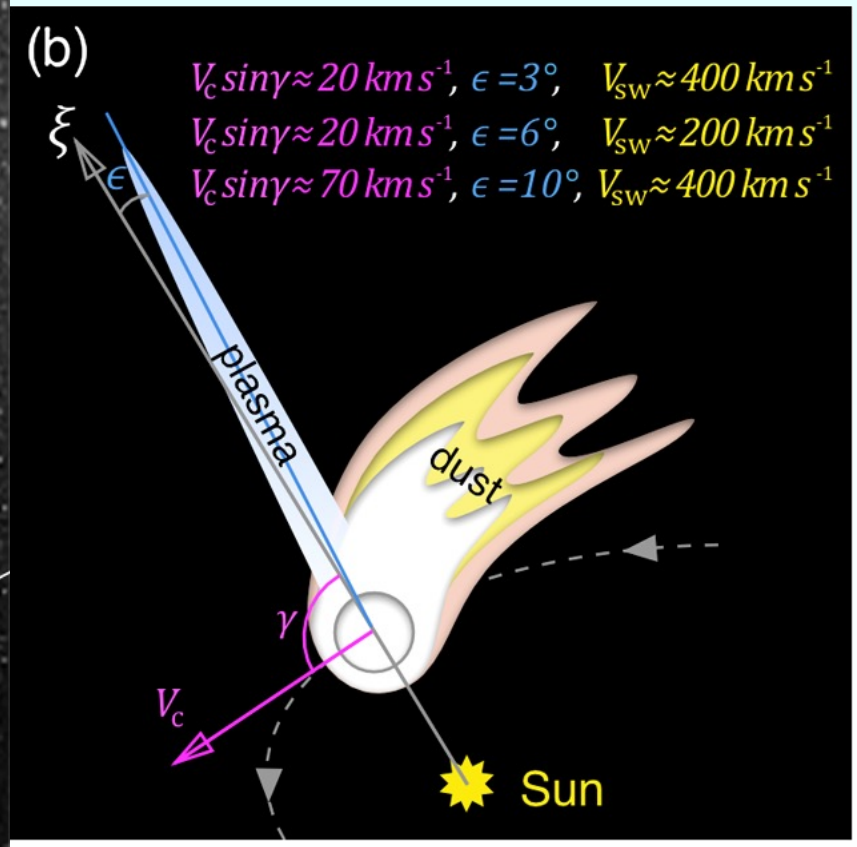
Mercury:	**solar wind and sputtering of surface material, e.g. sodium**
Earth:	**solar wind and ionosphere**
Jupiter:	**solar wind and volcanic activity of the moon Io**
Saturn:	**solar wind, atmosphere of moon Titan, sputtering at surfaces of icy moons and rings**
Uranus:	**polar ionosphere, minor solar wind contribution**
Neptune:	**ionosphere, moon Triton**

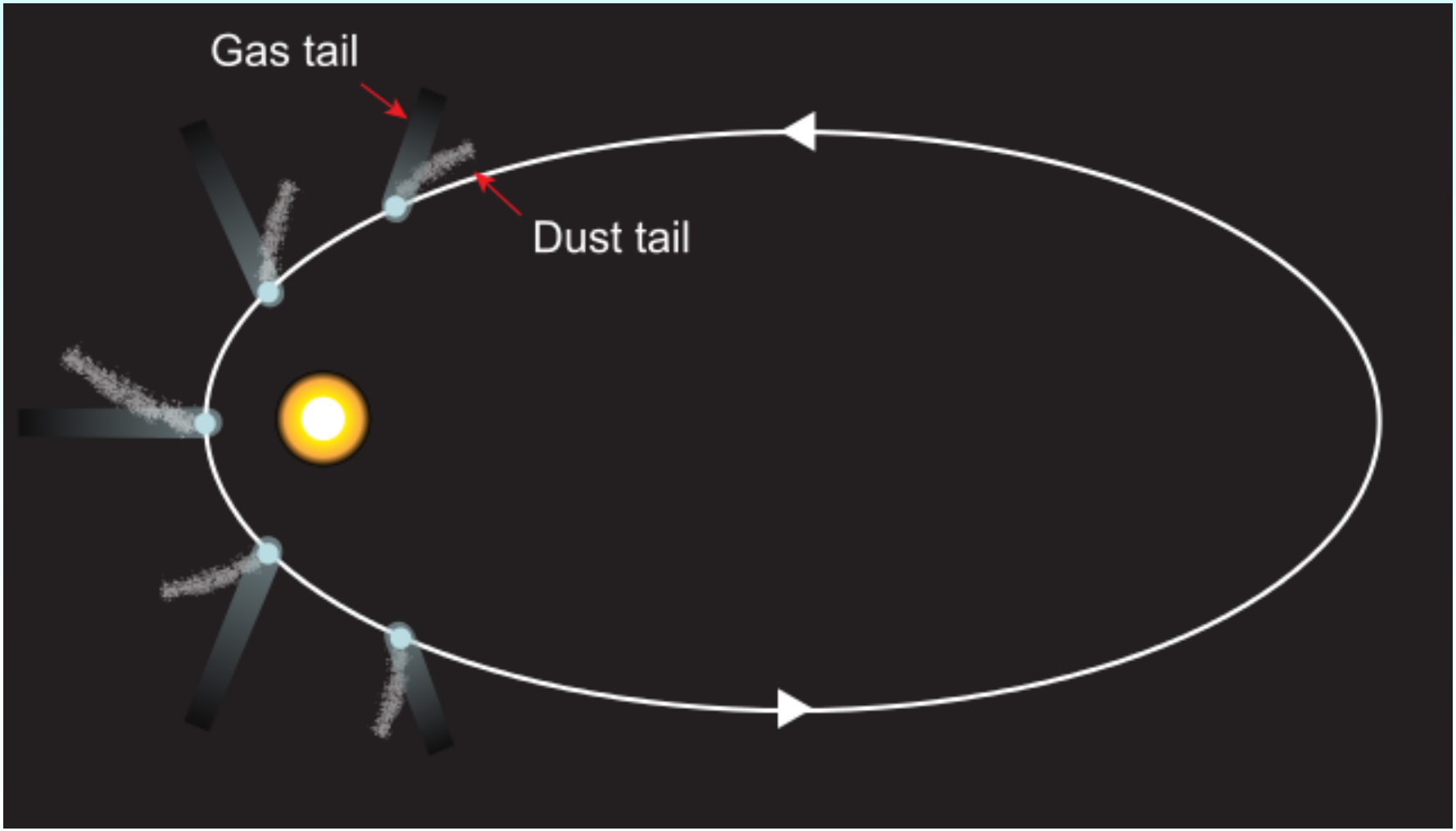
Solar Wind

- Observations of comets suggested solar ionized outflow (Biermann, 1951)
- Confirmed in 1960s by spacecraft measurements
- At 1 AU (Earth orbit)
  - speed: 200–1400 km/s (~400 km/s)
  - density: 1–100 cm^{-3}
  - magnetic field: 2-20 nT
- Great variability during solar storms




Dust tail
Gas tail
Dust trail
Sun


(b)
$V_c \sin\gamma \approx 20\,km\,s^{-1}$, $\epsilon = 3°$, $V_{sw} \approx 400\,km\,s^{-1}$
$V_c \sin\gamma \approx 20\,km\,s^{-1}$, $\epsilon = 6°$, $V_{sw} \approx 200\,km\,s^{-1}$
$V_c \sin\gamma \approx 70\,km\,s^{-1}$, $\epsilon = 10°$, $V_{sw} \approx 400\,km\,s^{-1}$
ξ
ϵ
plasma
dust
γ
V_c
Sun


Gas tail
Dust tail

Icons and Moments

https://iconsandmoments.blogspot.com/2020/07/blog-post_21.html

The successor of *1000 and One Joys and Sorrows*

Tuesday, July 21, 2020

Κομήτης NEOWISE

Ο κομήτης Neowise απόψε πάνω από την Πεντέλη

Ασύστολη διαφήμιση

Άρτεμις Φευγάτη

Waves, particles and storms

My YouTube Channel

Η έλξη του αγνώστου

Στο διάστημα μπορεί να κρύβεται η θεραπεία αλλά και ο όλεθρός μας

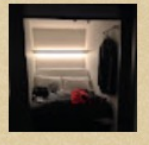
My other blog

Diamonds and Rust

Total Pageviews

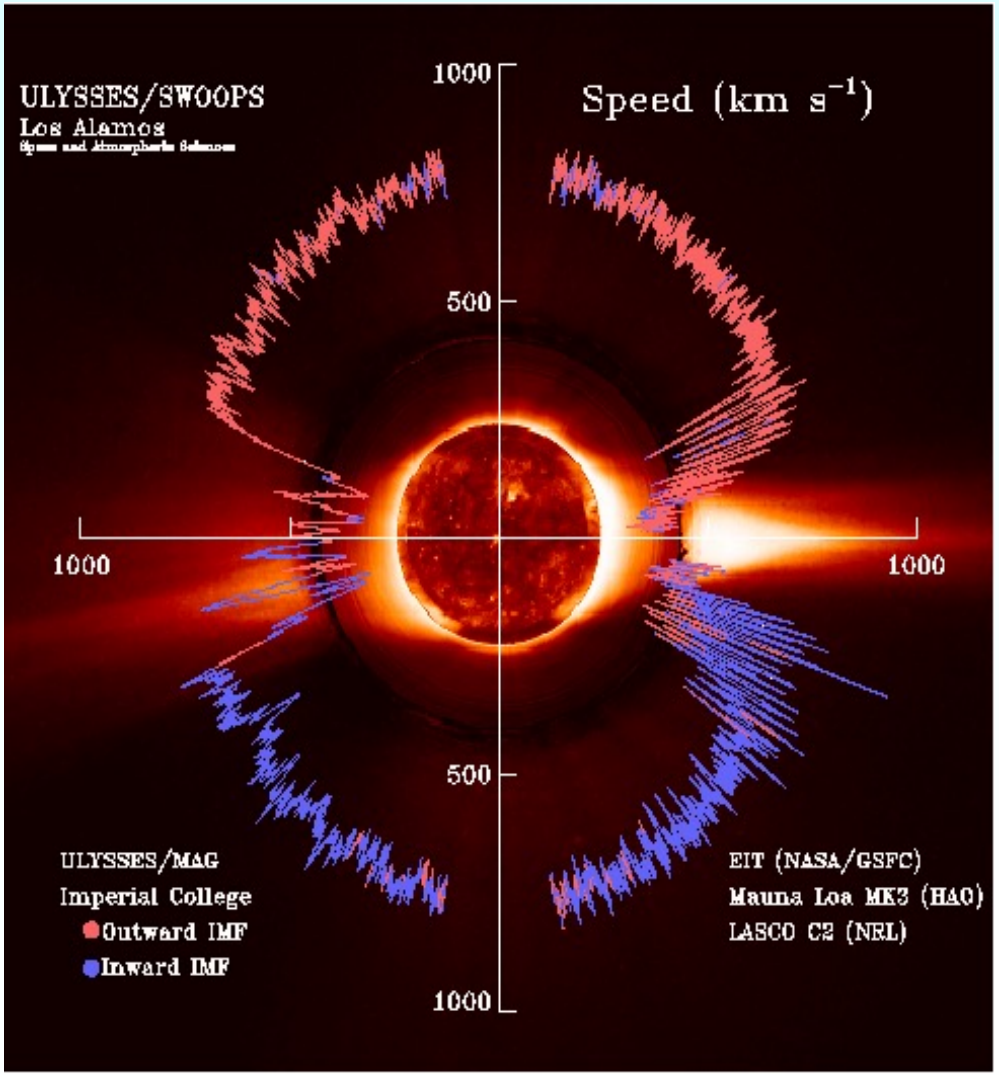
186,931

This Month's Top-10



Capsule Hotel
Πρώτη φορά σε γιαπωνέζικο capsule hotel - The Millennials στο Κυότο.
Σημαντικό αξεσουάρ ... Video 1

Solar Wind



Magnetic field and plasma density

Mercury:	39 nT	33 cm^{-3}
Earth:	8 nT	5 cm^{-3}
Jupiter:	1 nT	0.2 cm^{-3}
Saturn:	0.6 nT	0.06 cm^{-3}
Uranus:	0.3 nT	0.01 cm^{-3}
Neptun:	0.005 nT	0.005 cm^{-3}

Solar-terrestrial coupling

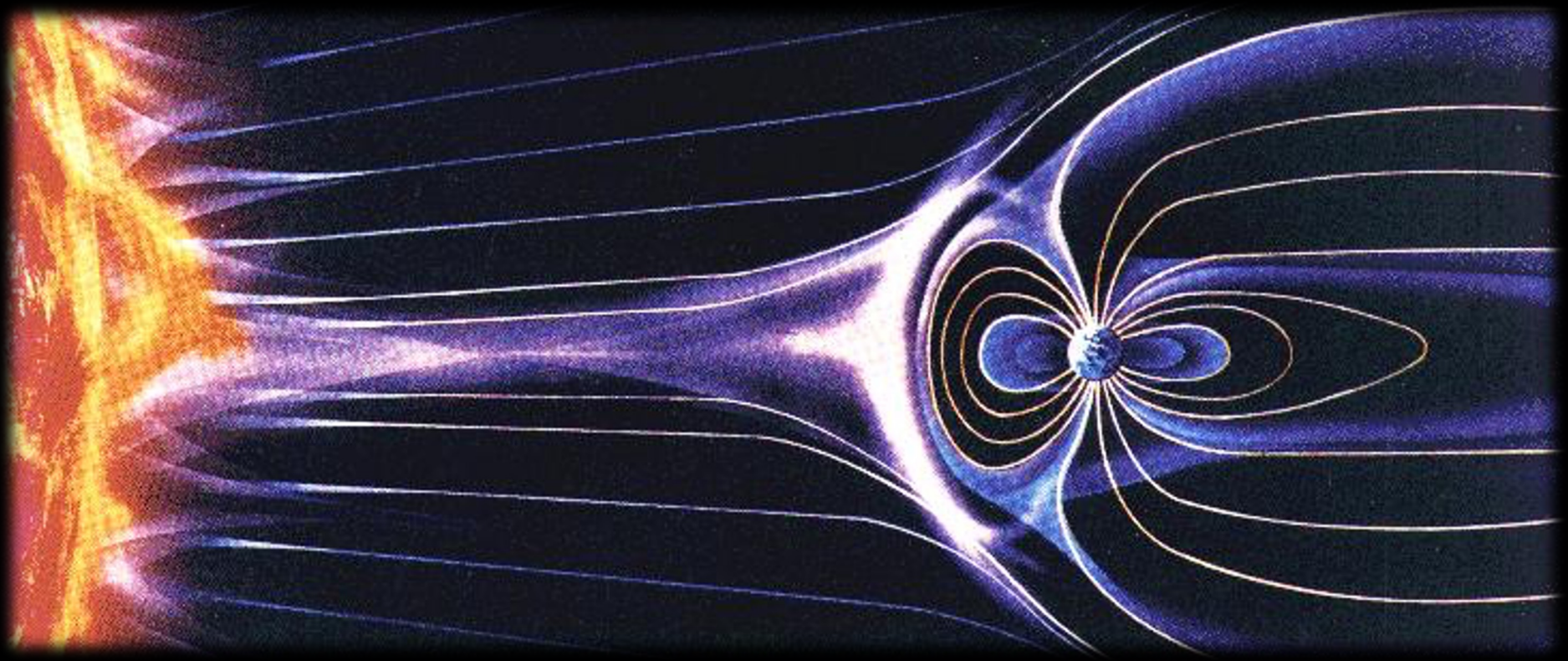


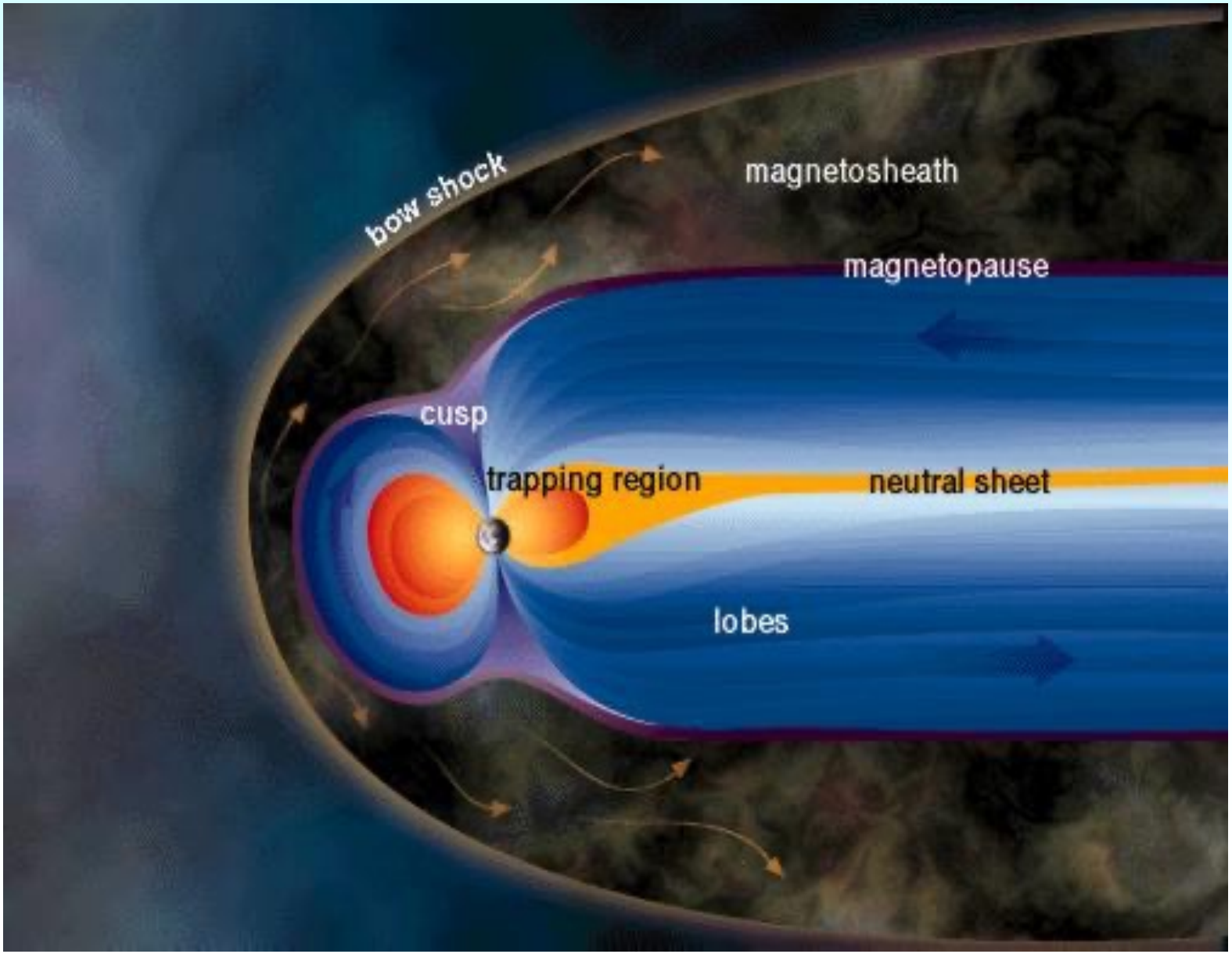
Illustration by K. Endo / Y. Kamide

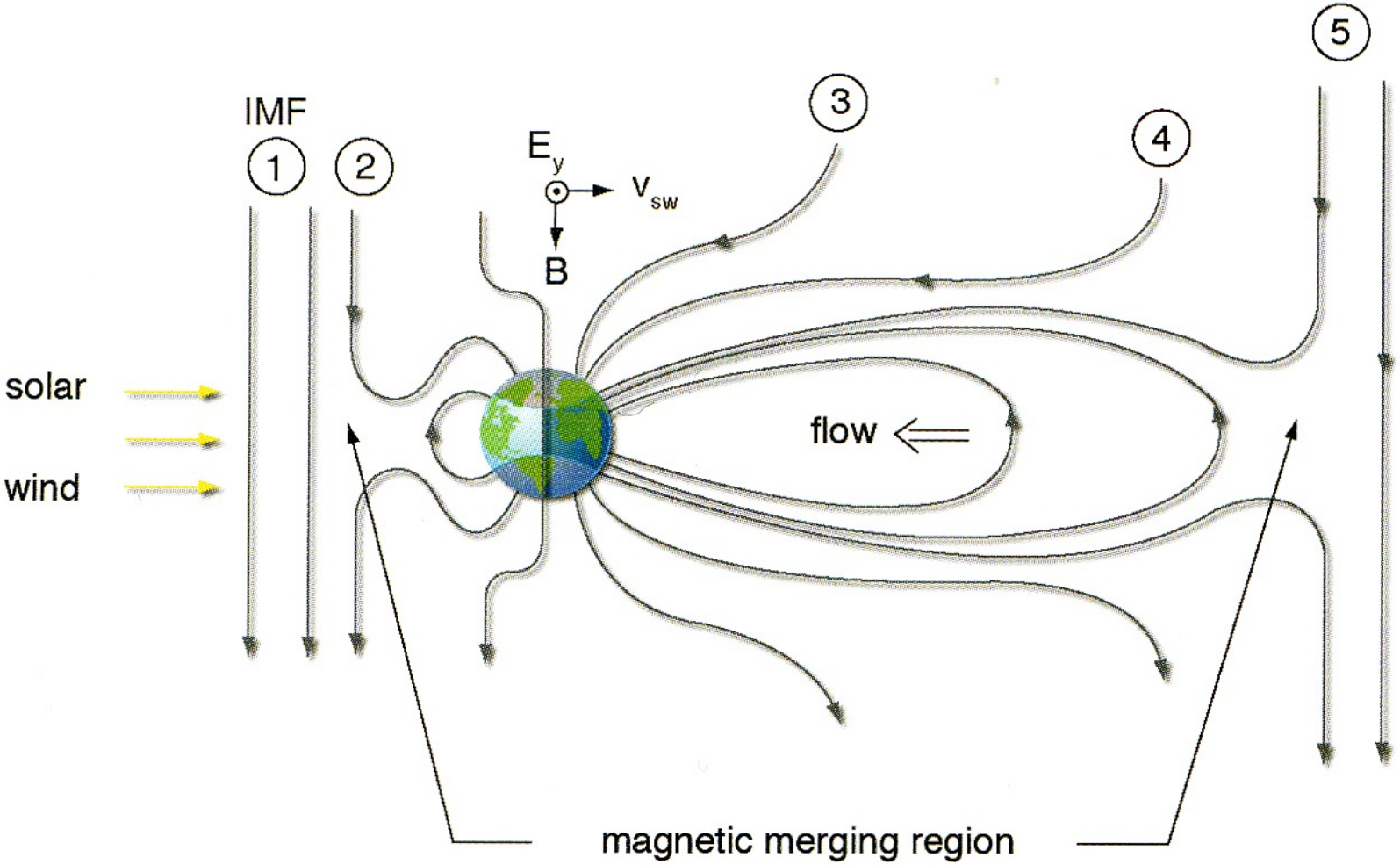
Sun-Earth Coupling

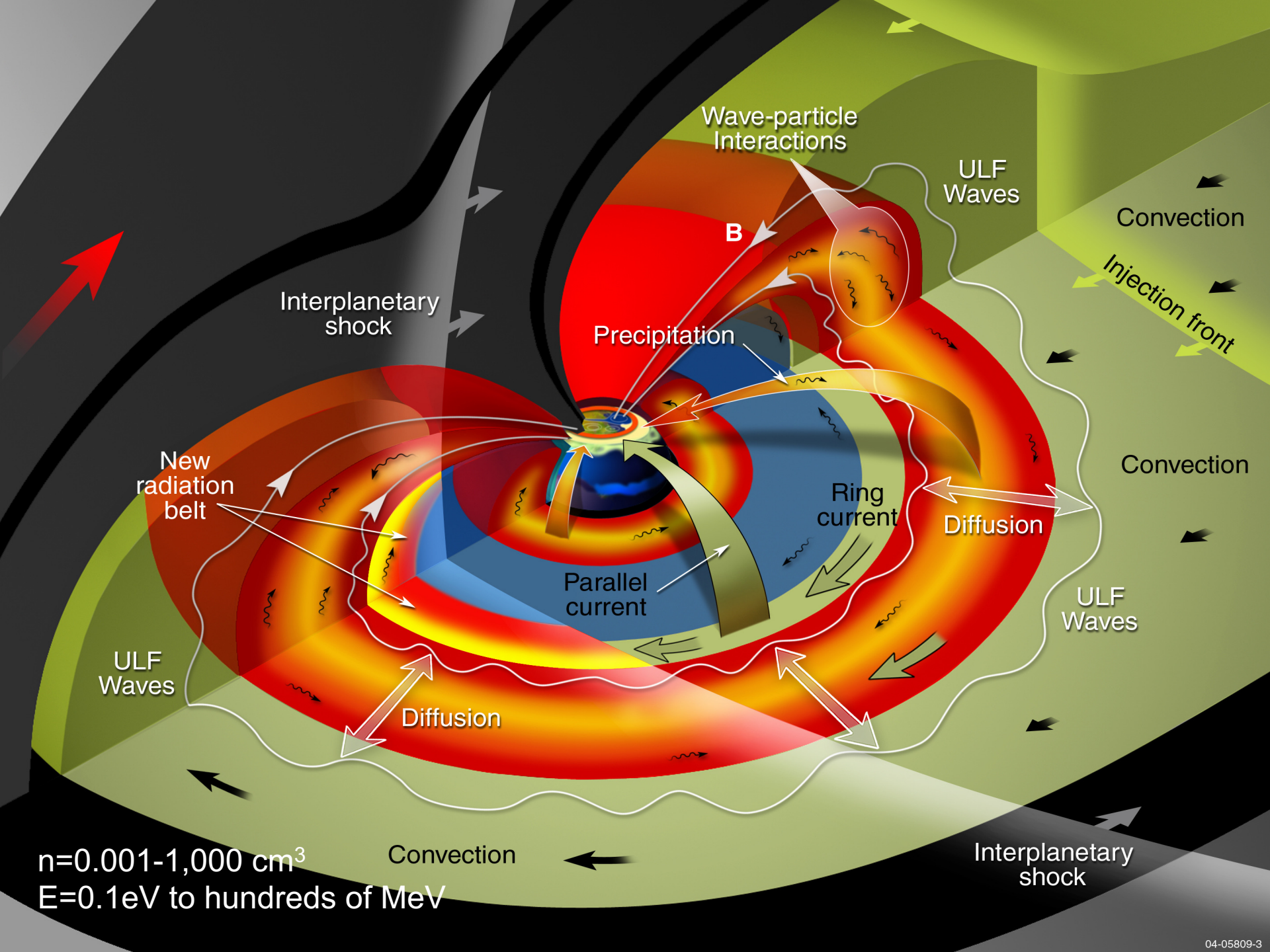
Discovery Channel

https://www.youtube.com/watch?v=Iz9ETgxVBS8

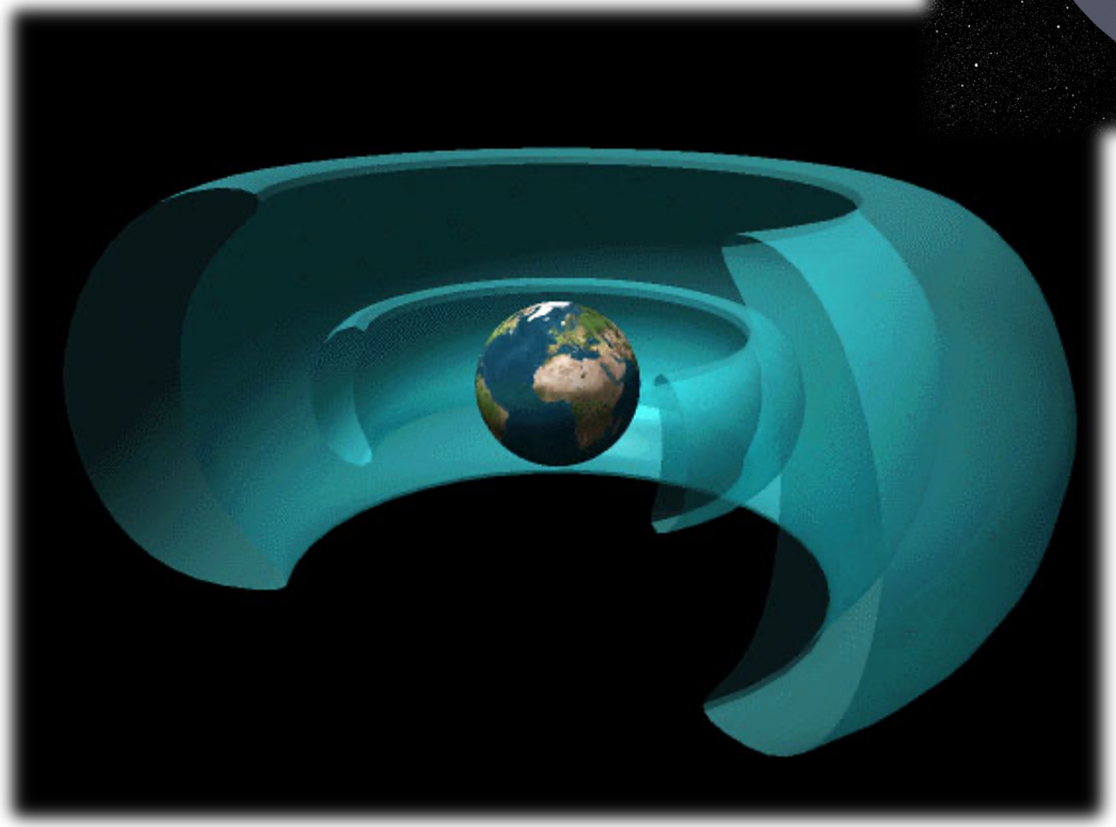
Terrestrial Magnetosphere

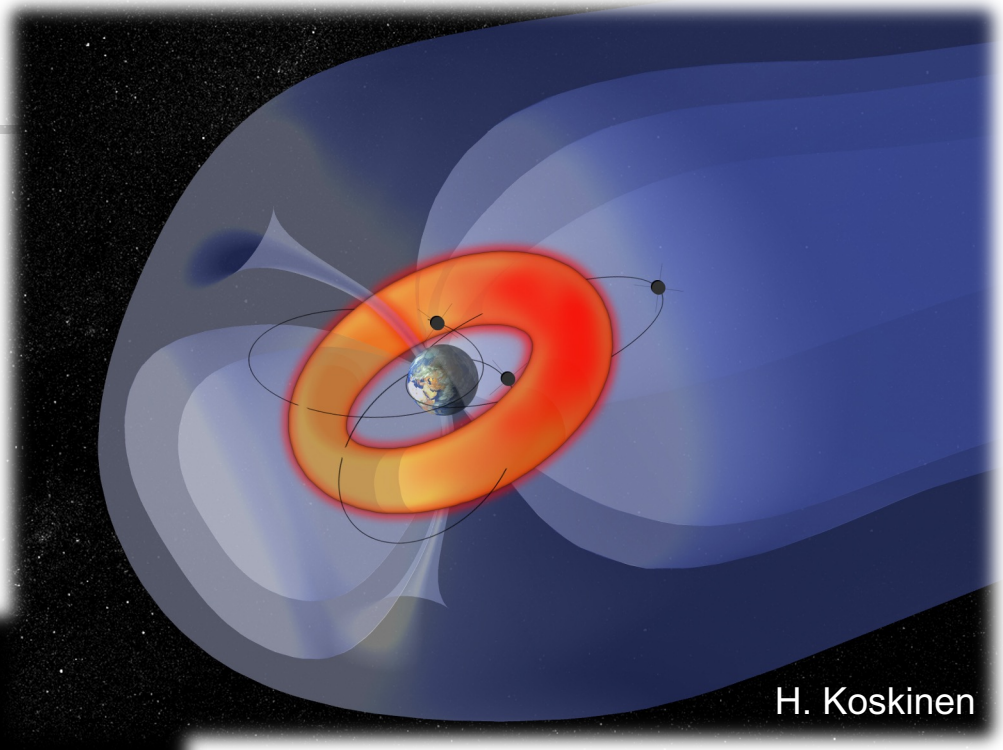



IMF
1
2
3
4
5
E_y
V_{sw}
B
solar
wind
flow
magnetic merging region

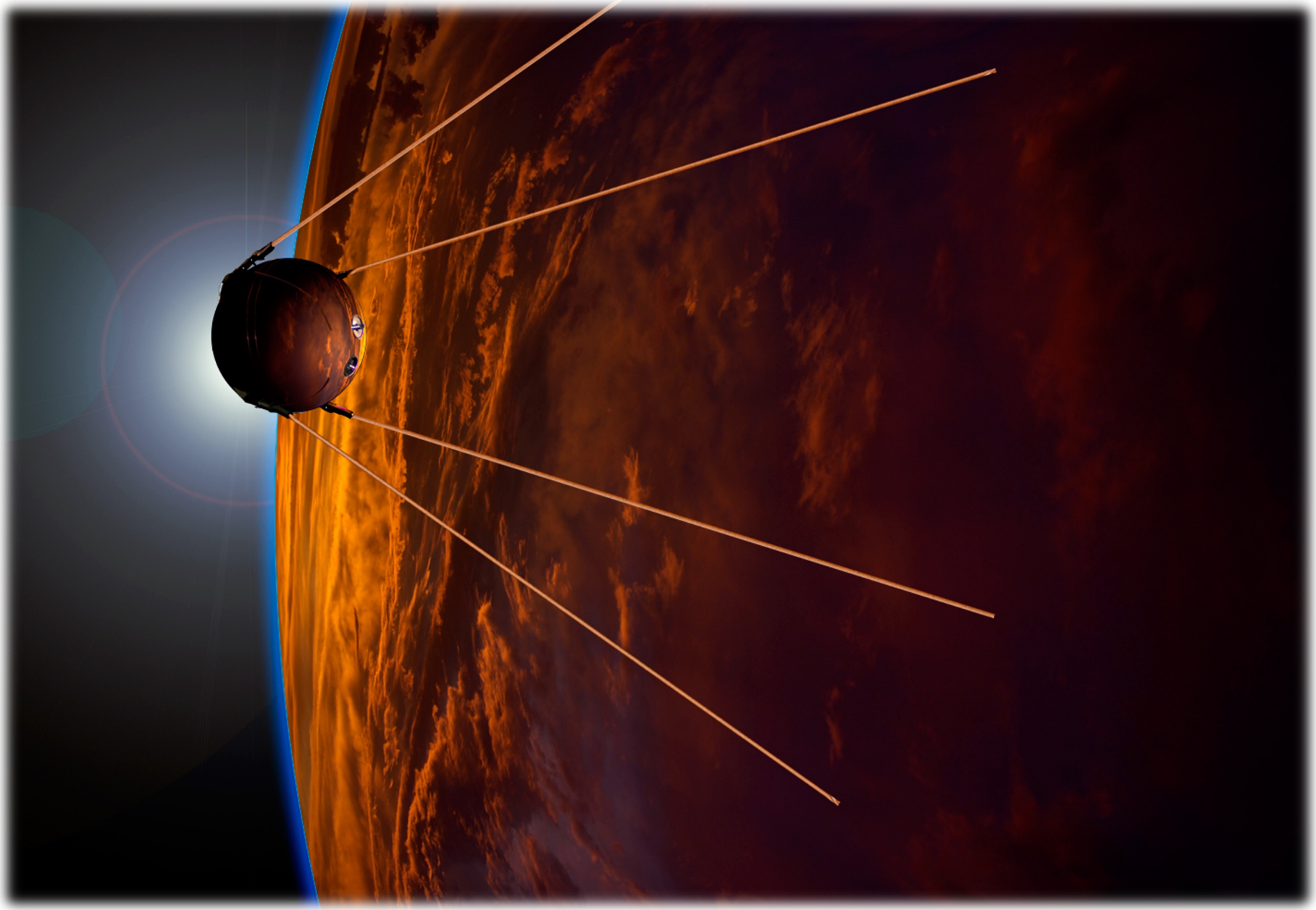

Wave-particle Interactions
ULF Waves
Convection
B
Injection front
Interplanetary shock
Precipitation
New radiation belt
Ring current
Diffusion
Convection
Parallel current
ULF Waves
ULF Waves
Diffusion
n=0.001-1,000 cm3
E=0.1eV to hundreds of MeV
Convection
Interplanetary shock
04-05809-3

RC/RB

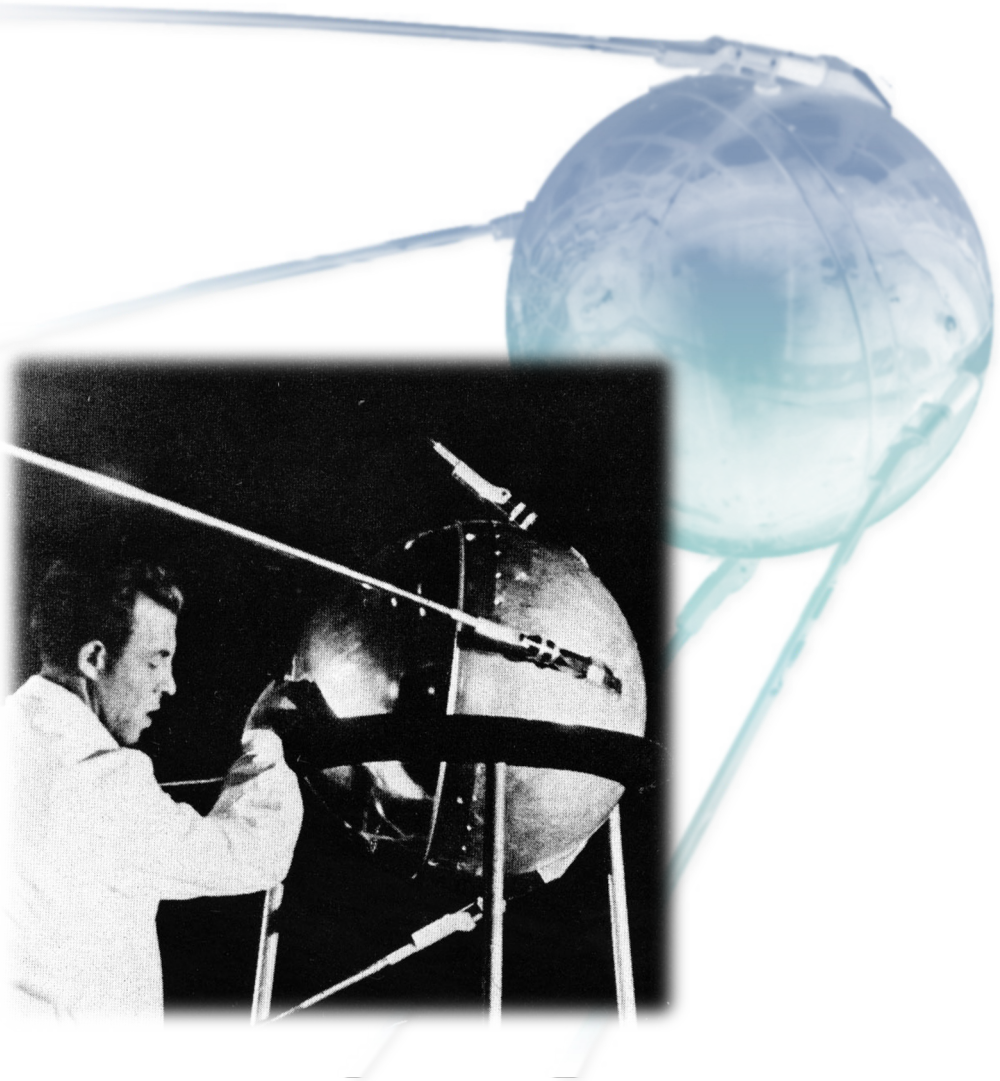




1957: Dawn of a new era

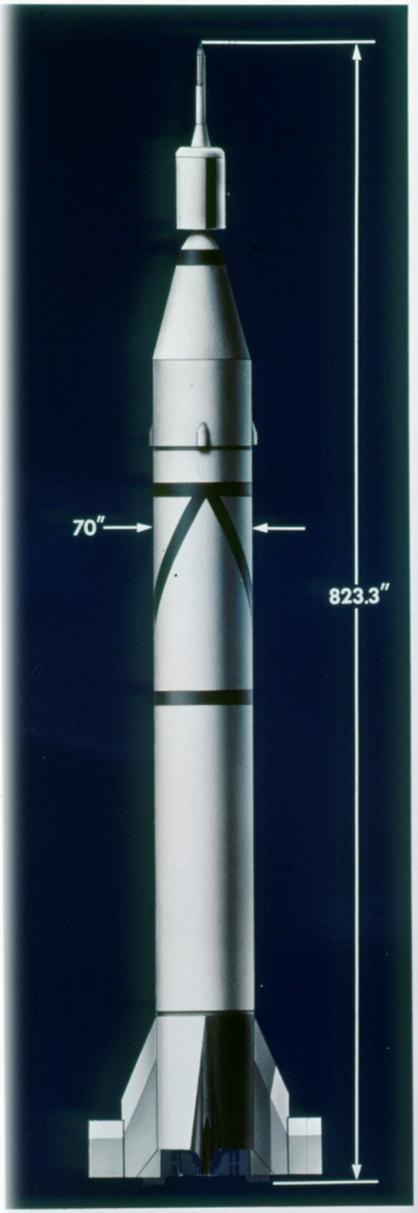


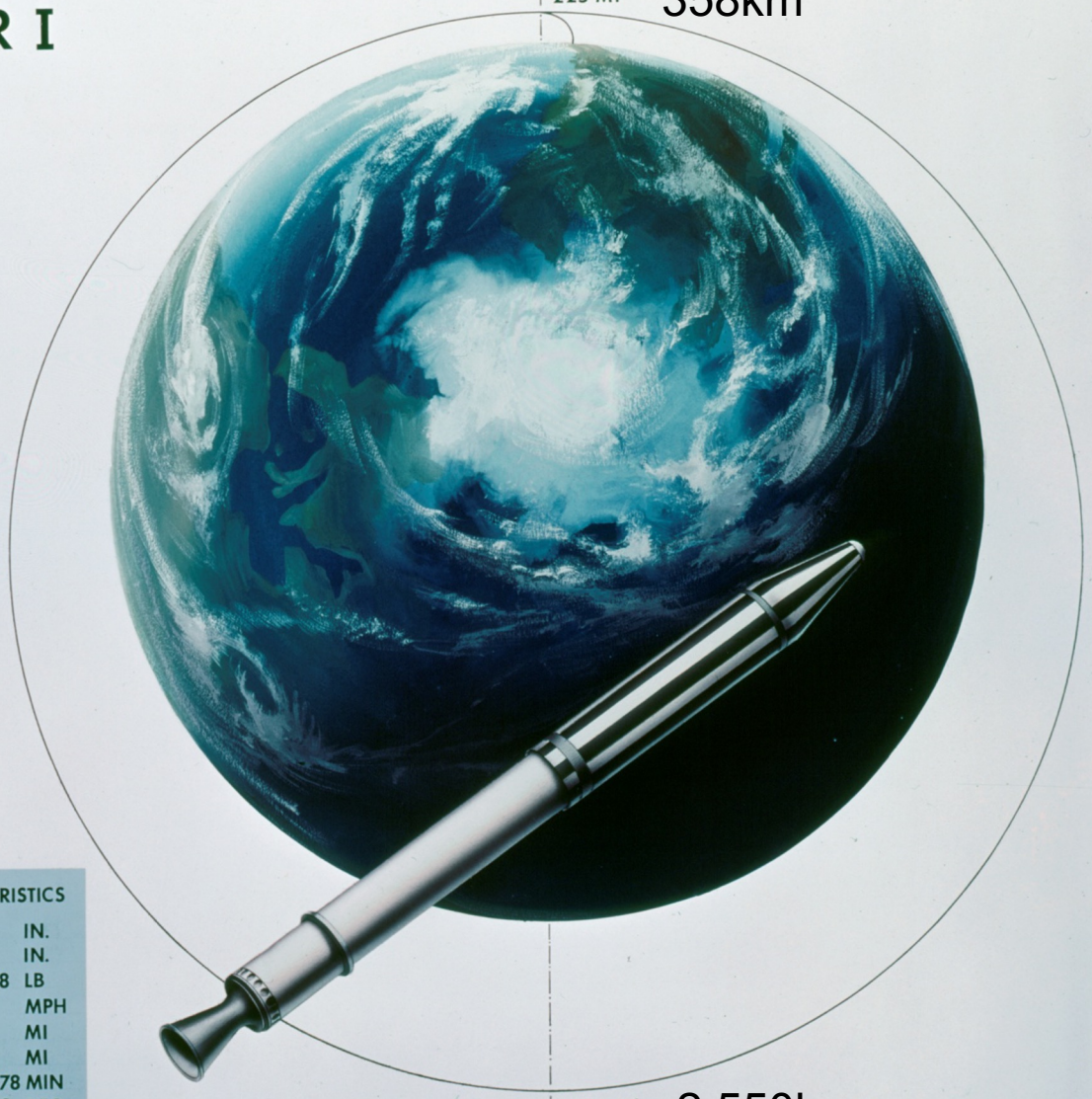
Η αυγή μιας νέας εποχής



4 Οκτωβρίου 1957: СРУТНИК - Ο Δορυφόρος

JUPITER-C EXPLORER I



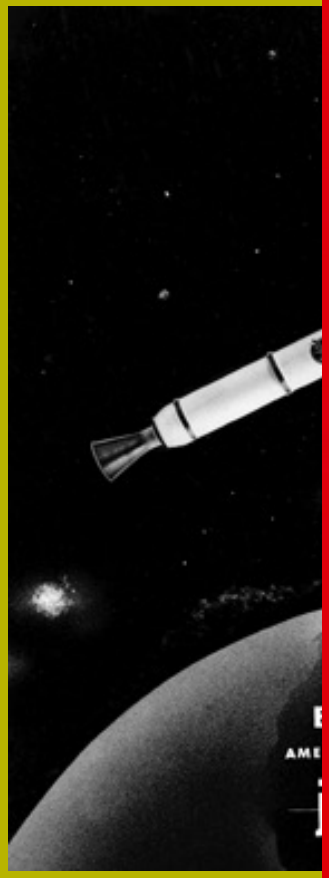


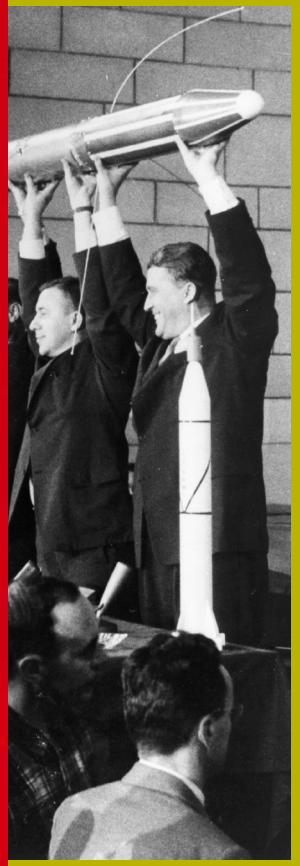
EXPLORER MAIN CHARACTERISTICS		
LENGTH	80	IN.
DIAMETER	6	IN.
WEIGHT	30.8	LB
VELOCITY (APPROX.)	18,000	MPH
APOGEE ALTITUDE	1,594	MI
PERIGEE ALTITUDE	225	MI
PERIOD	114.78	MIN
MAXIMUM LATITUDE	33.3	DEG.

MSFC-58-PA-3292

History tion

Trapped p discovery in space – orer



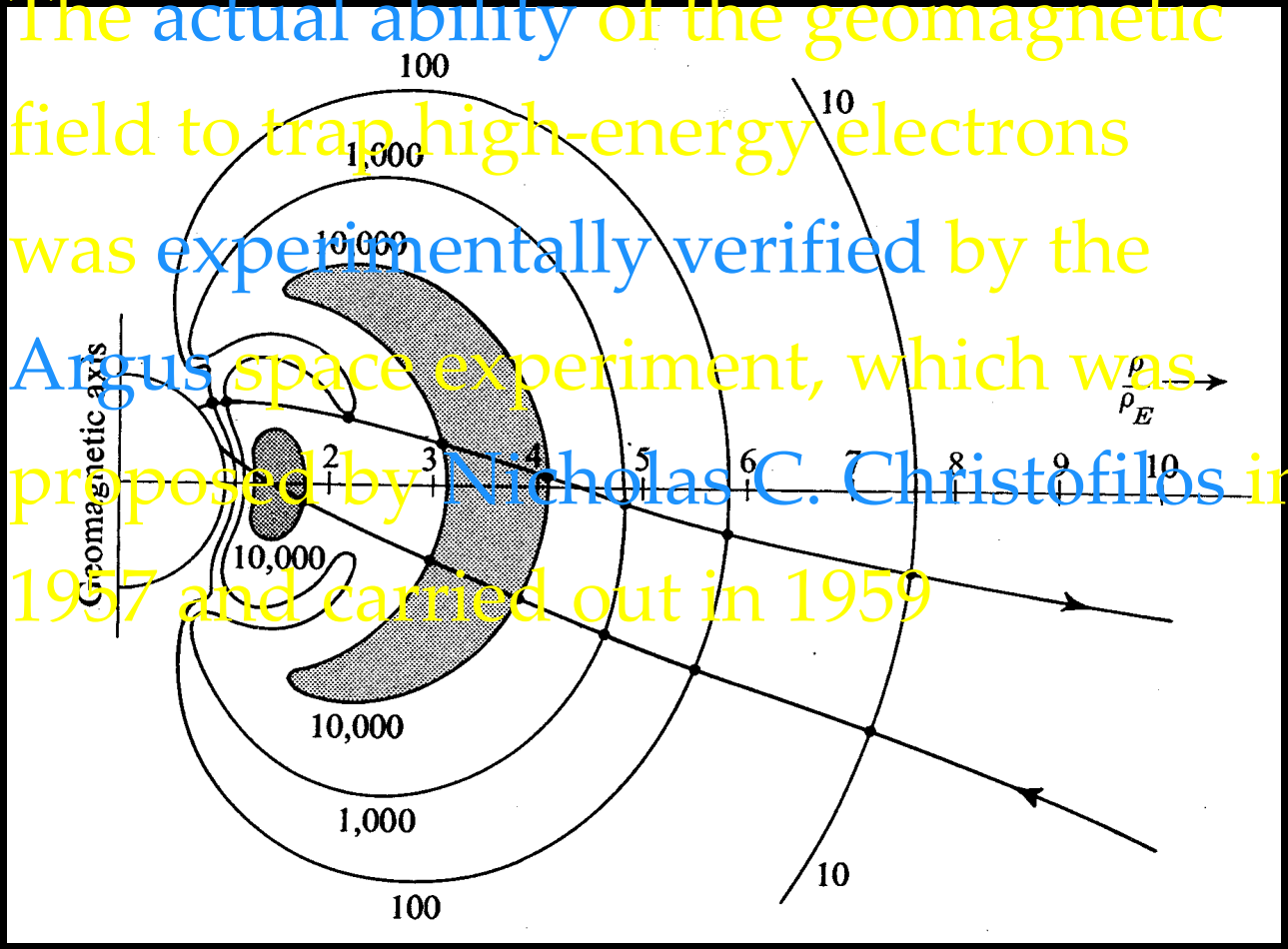


Importance of data routing …

Sputnik 2 detected the Earth's outer radiation belt in the far northern latitudes, but the significance of the elevated radiation was not realized. In Australia, Professor Harry Messel intercepted the signals but the Soviets **would not provide the code** and the Australians **would not send the data**.

The first RB map

The actual ability of the geomagnetic field to trap high-energy electrons was experimentally verified by the Argus space experiment, which was proposed by Nicholas C. Christofilos in 1957 and carried out in 1959



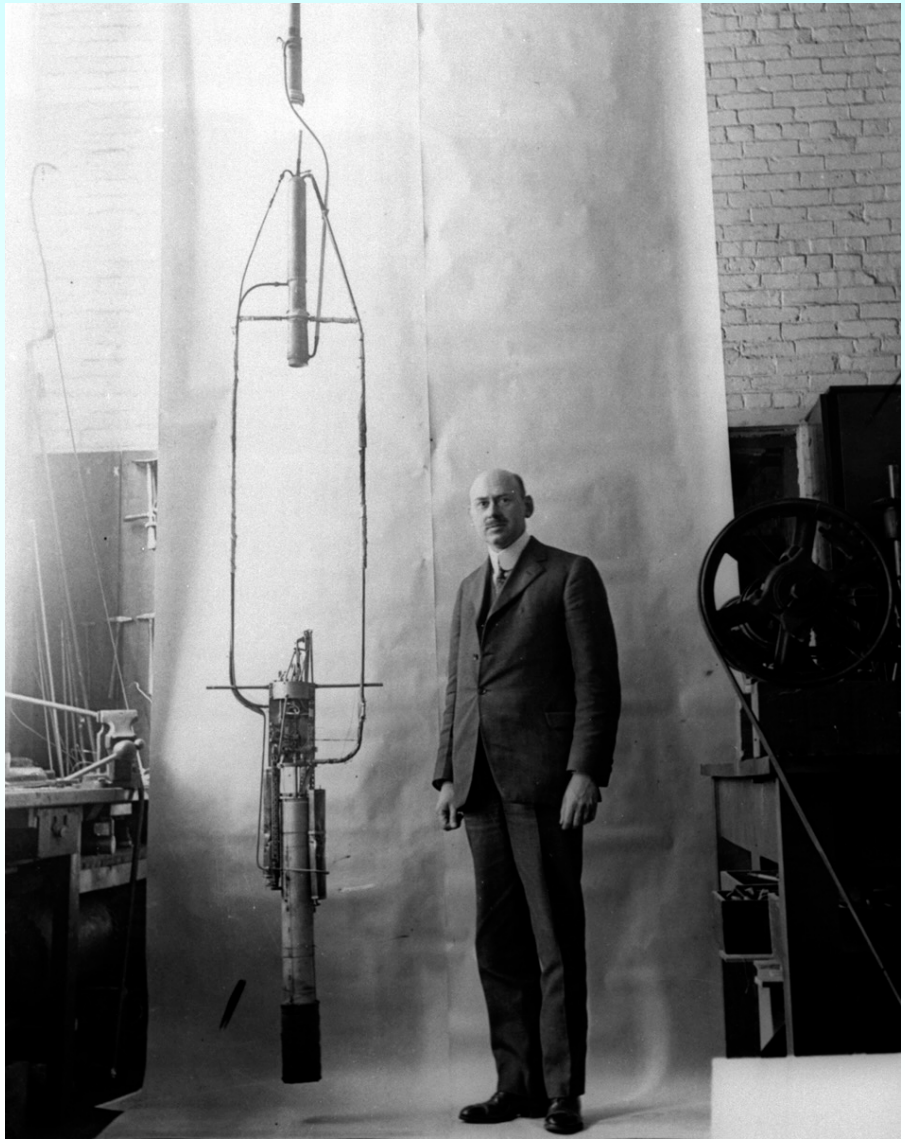
Van Allen [1959]

Ορόσημα της διαστημικής εξερεύνησης

1902: “*La Voyage dans la Lune*” (1865)

1903: Τσιολκόφσκι

1926: Goddard



Moon
limit of balloon; 20 miles
limit of atmosphere;
200 miles

Ορόσημα της διαστημικής εξερεύνησης

1902: “*La Voyage dans la Lune*” (1865)
1903: Τσιολκόφσκι
1926: Goddard
1957: Σπούτνικ
1958: Ζώνες Van Allen
1961: Γκαγκάριν – ο άνθρωπος στο διάστημα
1963: Μετρήσεις ηλιακού ανέμου
1966: “*Star Trek*”
1969: Ο άνθρωπος στη Σελήνη
1971: Salyut-1
1972: Ανακάλυψη οξυγόνου στο γεωδιάστημα
1973-1979 Δίας, Αφροδίτη, Ερμής, Κρόνος

Ορόσημα της διαστημικής εξερεύνησης

1981: STS-1
1982: “*Blade runner*” (androids, 1968)
1984: McCandless
1986-1989: Ουρανός, Ποσειδώνας
1990: Φωτογραφία ηλιακού συστήματος
1995: Galileo στον Δία
1997: Mars Pathfinder
2001: NEAR στον 433 Eros
2005: Huygens στον Τιτάνα
2011: MESSENGER στον Ερμή
2012: Voyager-1 στον γαλαξία
2014: “*Interstellar*”

Α και Ω

Α και Ω:

Φως (ενέργεια)

Α και Ω:

Φως (ενέργεια) – Fiat Lux!

FIAT LUX

SATHER GATE
ERECTED BY
JANE K SATHER
MDCCCVIII
IN MEMORY OF
PEDER SATHER

Ο Ήλιος

The Sun: some basics

Mass	**1 $M_\odot$ = 1.989 × 10^{30} kg**
Radius (photosphere)	**1 $R_\odot$ = 696,000 km**
Mean density	**1,410 kg m^{-3} (Earth: 5,510 kg m^{-3})**
Irradiance (at Earth)	**1.368 kW m^{-2}**
Luminosity	**3.85 × 10^{23} kW**
Effective temperature	**5778 K**
Mean distance from Earth	**1 AU = 149,600,000 km = 1/206265 parsec**
Rotation period	**~25 days (equator), ~35 days (poles)**
Rotation speed (equator)	**2 km s^{-1}**
Magnetic field strength (typical values)	**General solar ~ 10^{-4} T (100 μT) Sunspot ~0.5 T / Geospace ~1 μT Chromospheric plage ~ 0.02 T Prominence ~ 0.001-0.01 T**
Solar wind velocity	**300 -700 km s^{-1}**
Solar wind mass loss	**5 × 10^{16} kg/year = 2.5 × 10^{-14} $M_\odot$/year**

Lightbulb Sun

The solar radiation energy absorbed in some form by the Earth's atmosphere, oceans, continents and living organisms in or on them has an average value of **250 watts per square meter**. 250 watts correspond to the power of four humble standard lightbulbs.

Despite its rather modest magnitude this energy, combined with the equally modest greenhouse effect of the terrestrial atmosphere, keeps the average temperature of our planet at 15 degrees centigrade, making life - as we know it - possible on Earth.

https://www.youtube.com/watch?v=3RoA-CMCy00

The Sun is a lightbulb

Είναι λοιπόν αλήθεια ότι η ισχύς της ηλιακής ακτινοβολίας που φτάνει στην επιφάνεια της Γης έχει μάλλον ταπεινό μέγεθος.

Αλλά είναι επίσης αλήθεια ότι χωρίς αυτήν δεν θα υπήρχε ίχνος ζωής.

Photosynthesis
is the foundation of life on Earth
providing
the food, oxygen and energy
that sustains the biosphere and
human civilisation