The Shrinking of the Heliosphere Due to Reduced Solar Wind

SHAHINAZ YOUSEF[1], SAYEDA M. AMIN[2] and WALID ABDEL-SATTAR[1]

1- Astronomy & Meteorology Dept., Faculty of Science, Cairo University

2- National Research Institute of Astronomy and Geophysics, NRIAG, Helwan, Egypt

Abstract

As early as 1995, the first author, warned from the reduction of solar activity for several decades and as a sequence the drop of the solar wind.

The heliosphere is the space within which the solar wind dominates and the solar interplanetary magnetic field prevails.

Its boundary is determined by the balance between stellar and solar winds.

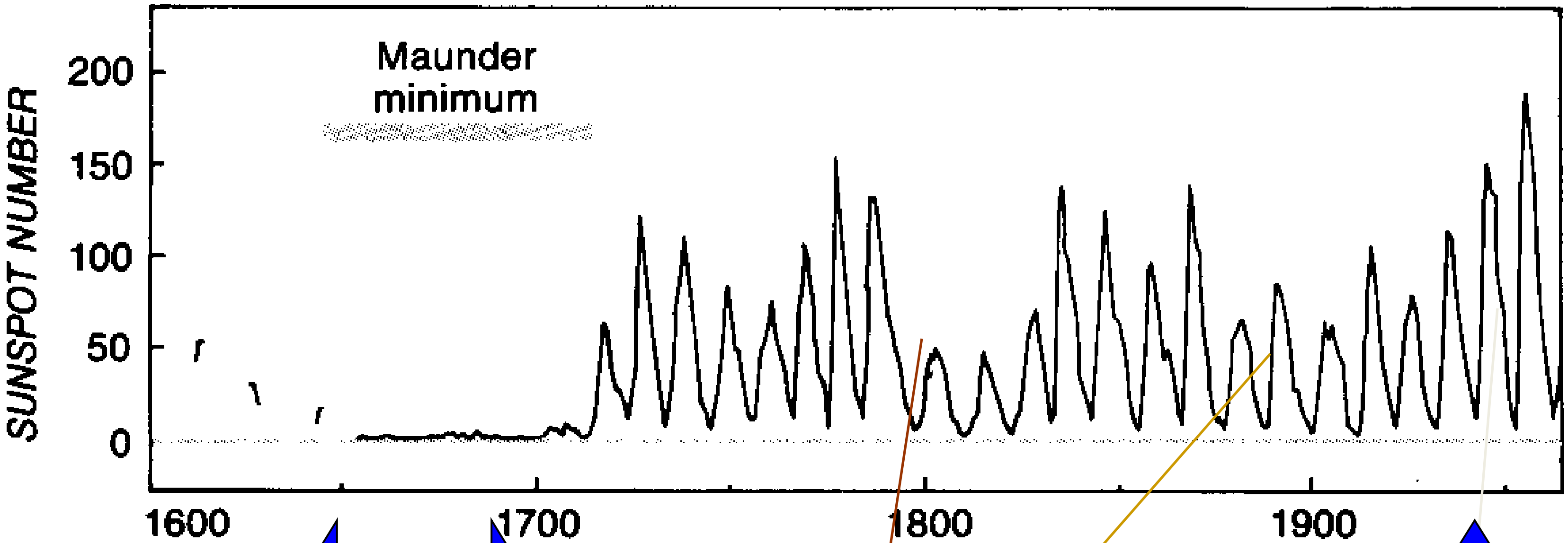
Owing to the present reduction in the solar wind pressure, one would expect that the stellar wind would push the heliosphere inward leading to its shrinkage.

In this paper we calculate the extent of the heliosphere at different solar wind status.

Backward estimation of the extent of the heliosphere since 1890 is done.

Most important is the forecast of the shrinkage and oscillations of the heliosphere and their implications on the earth.

Types of Solar Cycles



Maunder Minimum Type

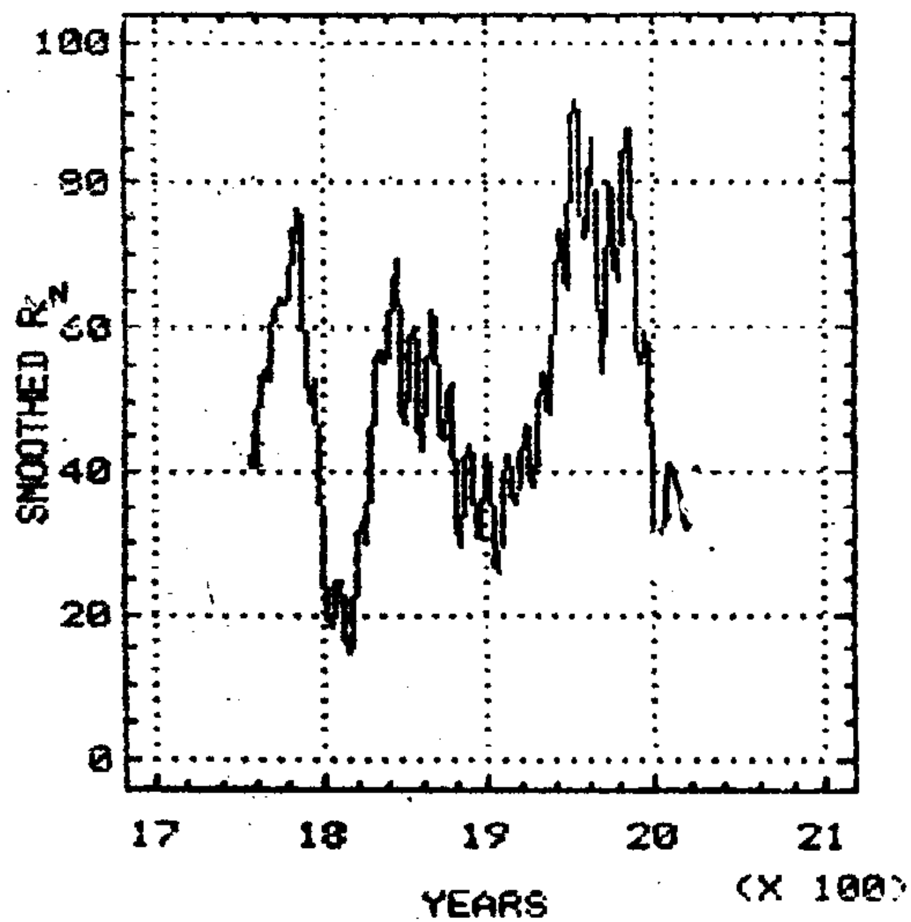
Weak cycles

Normal cycles

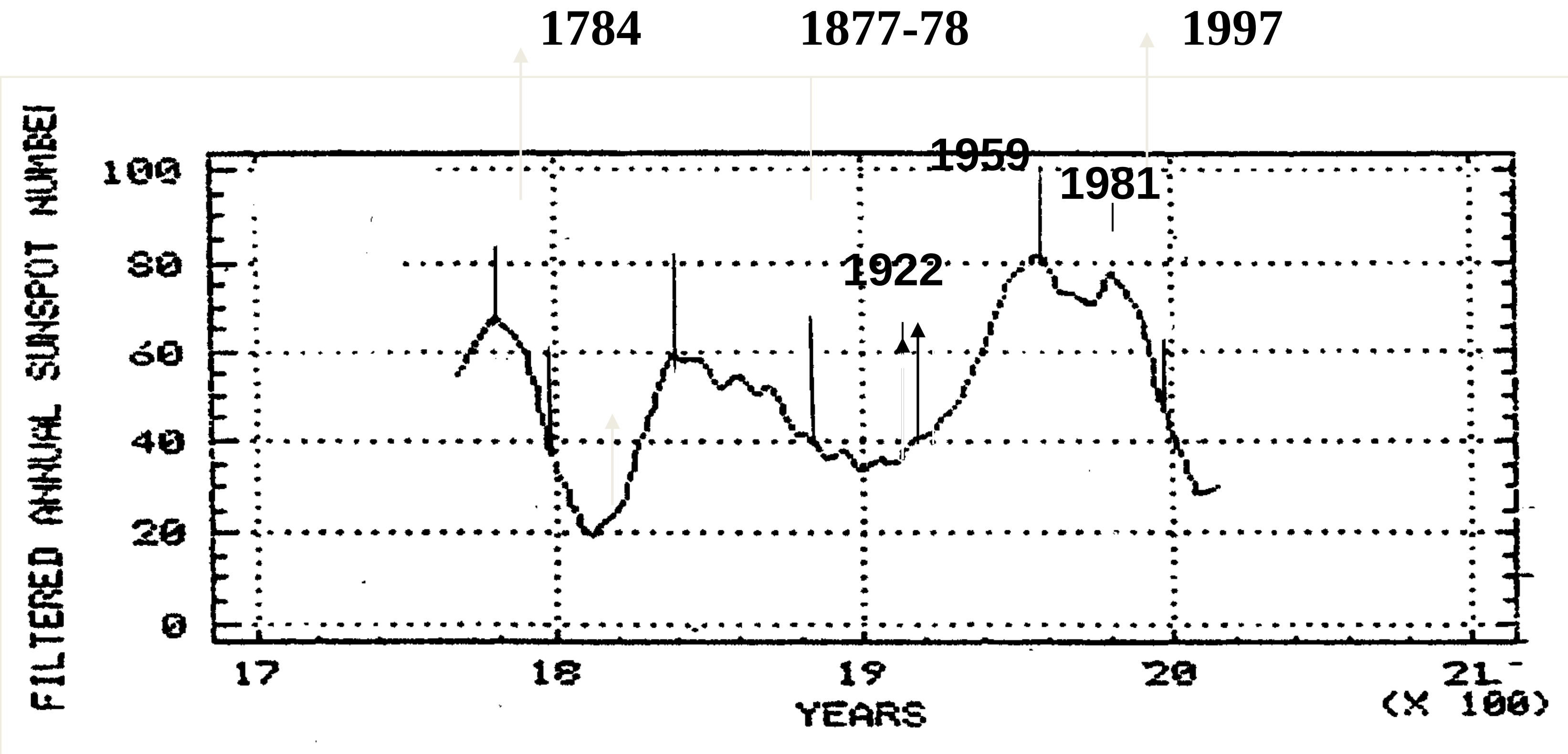
3

Wolf-Gleissberg Cycles (80-120) years

- On smoothing time series of sunspot number you get the Wolf-Gleissberg cycles.



THE OCCURENCE OF CLIMATE CHANGES AT THE TURNING POINTS OF WOLF –GLEISSBERG CYCLES



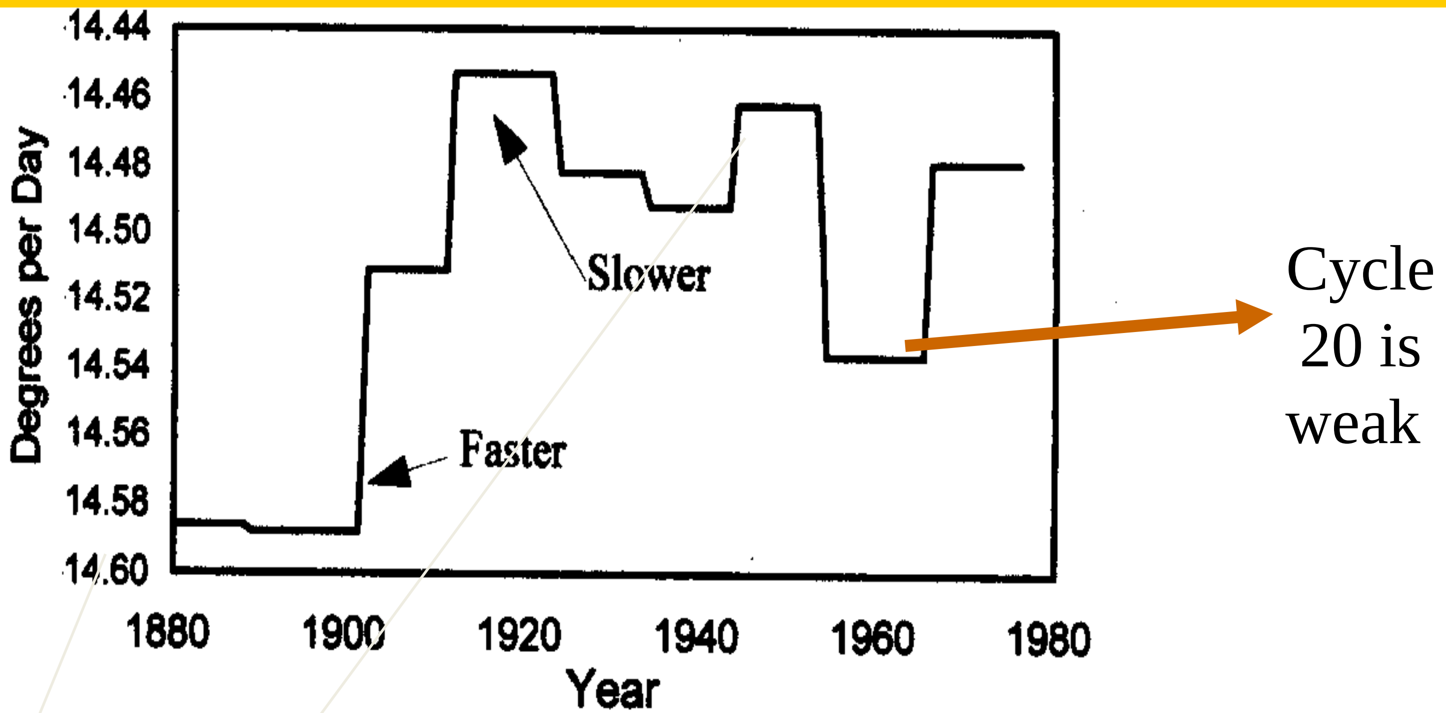
Solar induced climate changes occur maximum turning points, at start and end of weak solar cycles around 1800,1900,2000. Note that 1997 is a climate change year with start of weak solar cycle 23.

CHARETERISTICS OF WOLF-GLEISSBERG CYCLES (Minimum & Maximum Years)

Cycle	1	2	3	4
Min Yrs. **(weak solar cycles)**		1784-1823	1877-1922	1997-2032(2043)?
Max1 **(first max) strong cycles**	1727-28	1838-40	1957-58	
Max2 **Secondary max) strong cycles**	1778-80	1860	1981	

The solar equatorial rotation rate in degrees per day

change in solar rotation is an indicator that the deeper levels of convection are varying ,hence there is a variation in solar irradiance

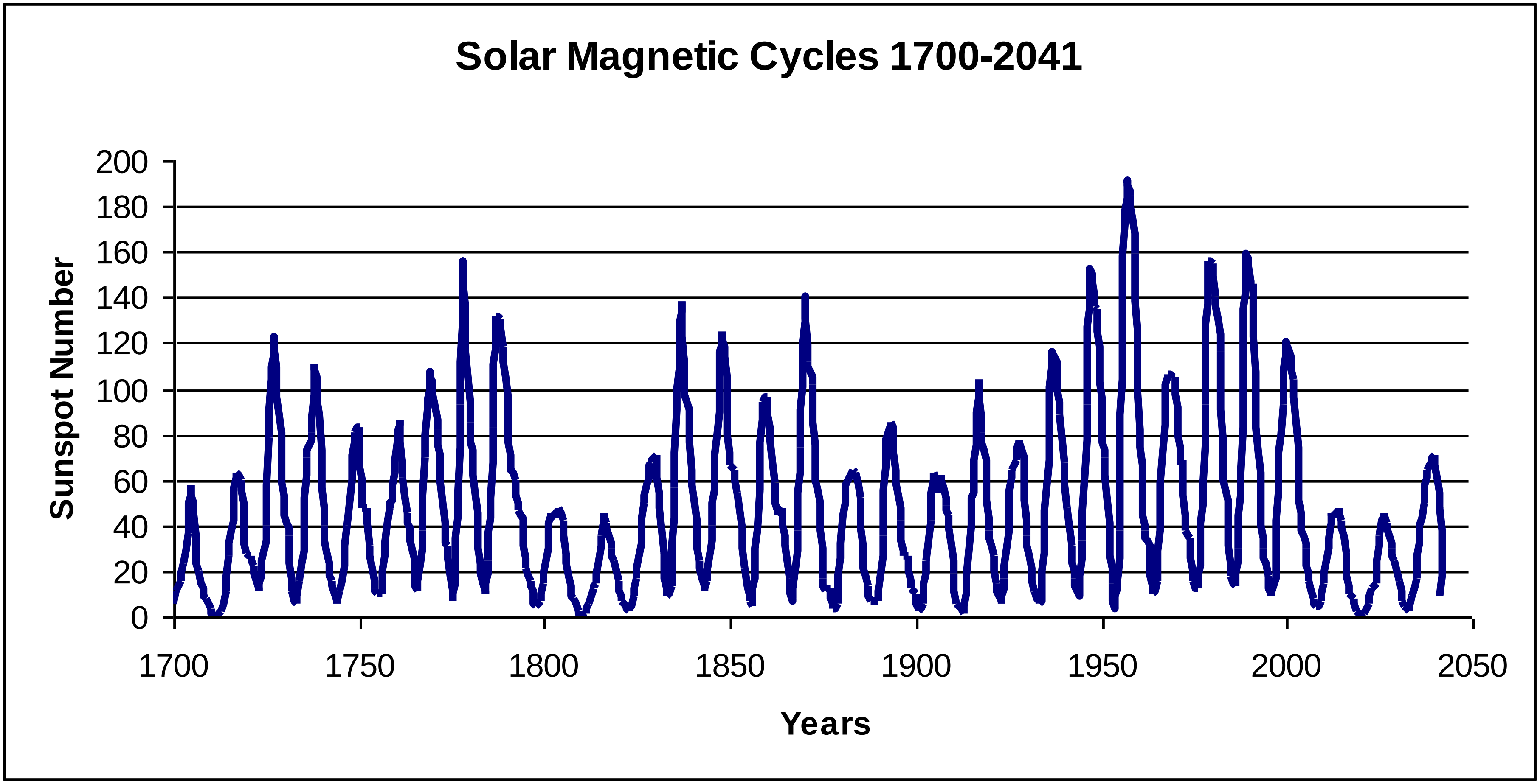


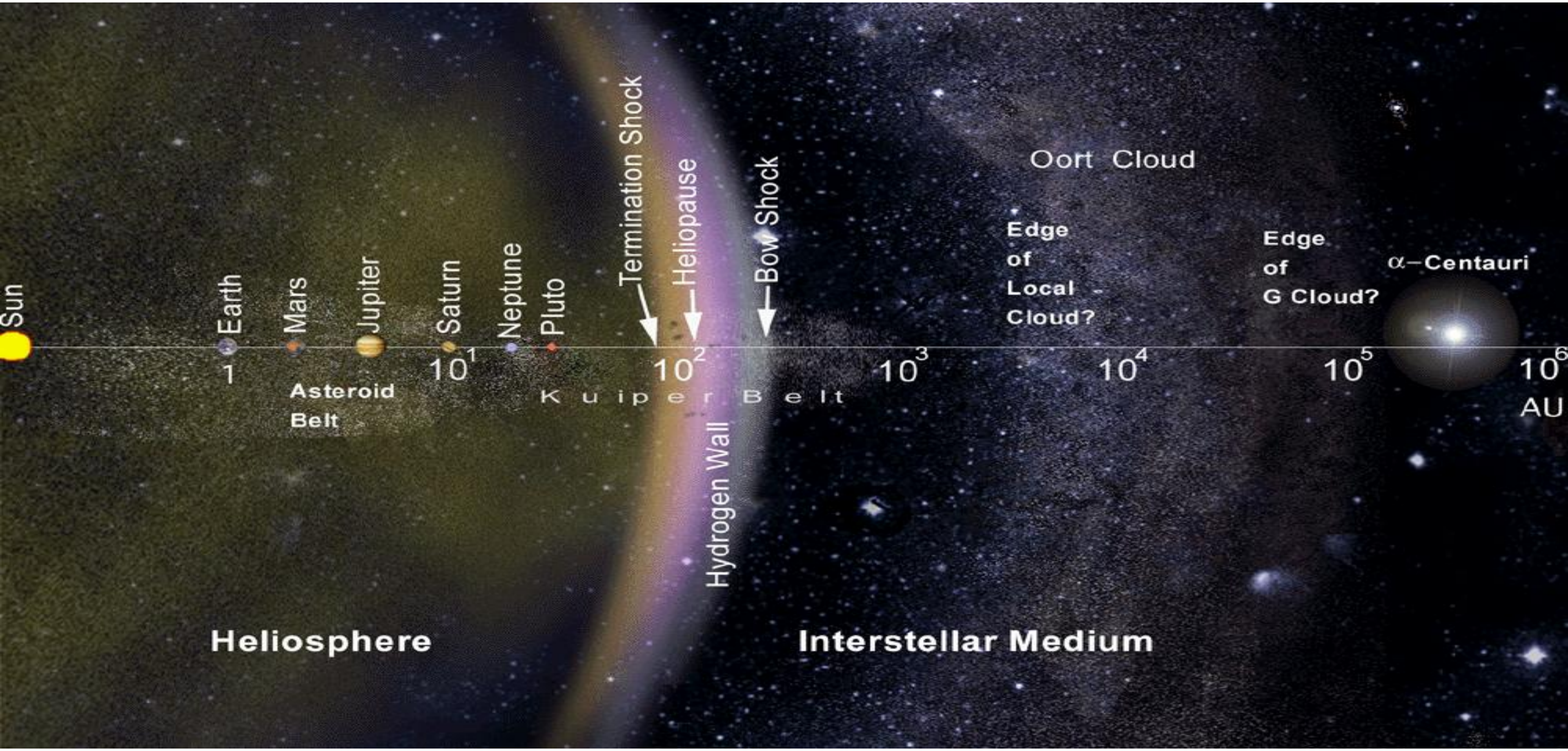
Weak solar cycles coincide with faster solar photospheric spin yet slower rotation
Solar Dynamo & The Tachocline

rotation leading to drop in solar magnetic cycles and reduced solar wind.

Solar Maximum, slow photosphric equatorial rotation yet faster **The Solar Dynamo & The Tachocline** n leading to strong solar cycles and faster solar wind

FIGURE 1. Time series of sunspot number illustrating the existence of weak solar cycle's series around 1700s, 1800s, 1900s and 2000s.The prediction of cycles 24, 25 and 26 is given at the extreme right of figure 1 as a repetition of cycles 4, 5 and 6 around 1800s





Sun
Earth
Mars
Jupiter
Saturn
Neptune
Pluto
Termination Shock
Heliopause
Bow Shock
Hydrogen Wall
Oort Cloud
Edge of Local Cloud?
Edge of G Cloud?
α−Centauri
1
10^1
10^2
10^3
10^4
10^5
10^6
AU
Asteroid Belt
Kuiper Belt
Heliosphere
Interstellar Medium

The solar wind carves out a cavity in the interstellar medium known as the heliosphere. The radius of the heliosphere can be estimated by determining the standoff distance, or stagnation point, in which the ram pressure, P_{sw} , of the solar wind falls to a value comparable to the interstellar pressure, P_I . As the wind flows outward, its velocity remains nearly constant, while its density decreases as the inverse square of the distance.

$$P_{sw} = P_{IAU} \times \left(\frac{IAU}{Rs}\right)^2$$

$$= (m_p N_{IAU} V^2{}_{IAU}) \times \left(\frac{IAU}{Rs}\right)^2$$

$$= P_I$$

The dynamic pressure of the solar wind therefore also falls off as the square of the distance, and we can use the solar wind properties at the Earth's distance of 1 AU to infer the pressure, P_{sw} , at the stagnation point distance, R_s. Equating this to the interstellar pressure we have:

where the proton's mass $m_p = 1.67 \times 10^{-27}$ Kg, the number density of the solar wind near the Earth is about $N_{IAU} = 5 \times 10^6$ protons m^{-3}

and the velocity there is about $V_{IAU} = 4 \times 10^5$ m s^{-1}

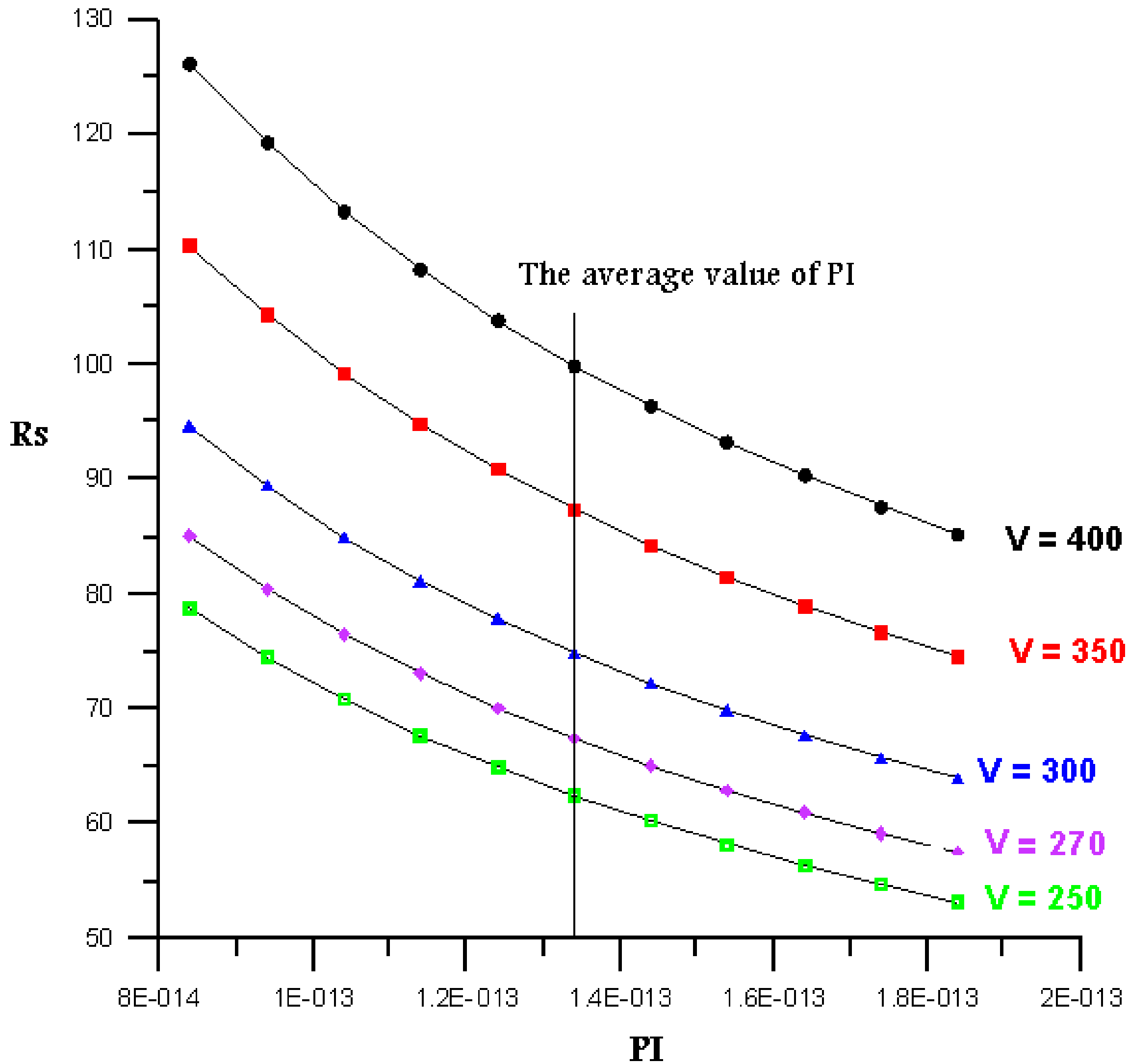
To determine the distance to the edge of the solar system, R_s , we also need to know the interstellar pressure, and that is the sum

of the thermal pressure, the dynamic pressure and the magnetic pressure in the local interstellar medium.

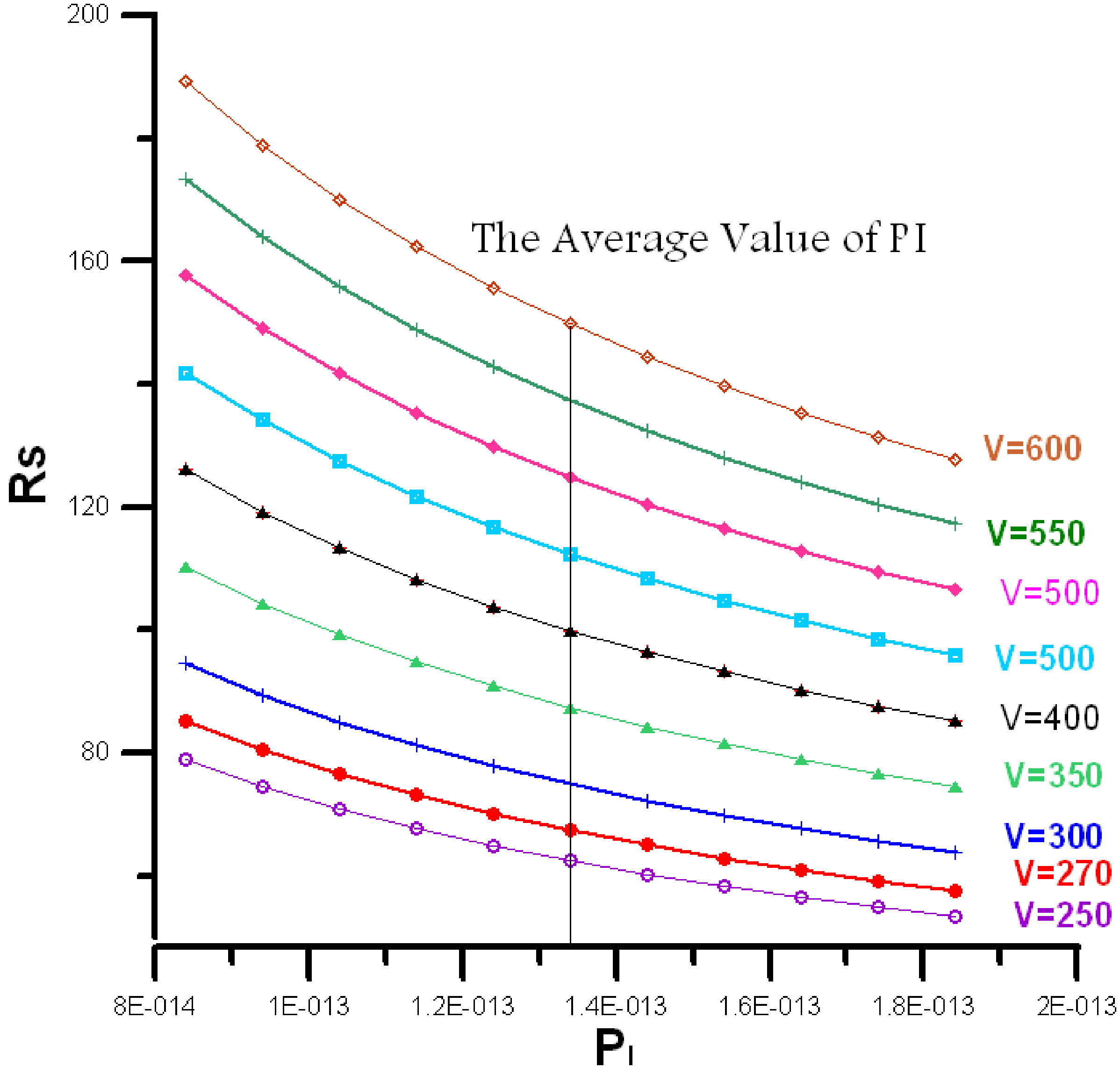
It is about $P_I = (1.3 \pm 0.2) \times 10^{-13}$ Nm^{-2}.

The estimate obtained from the equation is R_S = 100 AU, far beyond the orbits of the known outer planets. However, the estimates by different authors a broad range for the distance to the edge of the solar system, depending on the uncertain values of various components of the interstellar pressure (Lang Encyclopedia of the Sun).

The Shrinkage of the Heliosphere as a Function of Stellar Wind Pressure for a Normal and Reduced Set of Solar Wind Velocities



The Extent of The Heliosphere as a Function of Stellar Wind Pressure for a Normal Solar Wind Velocity of 400 km/s and Reduced and Enhanced Sets of Velocities



PI	V=400	V=350	V=300	V=270	V=250	450	500	550	600
8.40E-14	1.26E+02	1.10E+02	9.46E+01	8.51E+01	7.88E+01	1.42E+02	1.58E+02	1.73E+02	1.89E+02
9.40E-14	1.19E+02	1.04E+02	8.94E+01	8.05E+01	7.45E+01	1.34E+02	1.49E+02	1.64E+02	1.79E+02
1.04E-13	1.13E+02	9.92E+01	8.50E+01	7.65E+01	7.08E+01	1.28E+02	1.42E+02	1.56E+02	1.70E+02
1.14E-13	1.08E+02	9.47E+01	8.12E+01	7.31E+01	6.77E+01	1.22E+02	1.35E+02	1.49E+02	1.62E+02
1.24E-13	1.04E+02	9.08E+01	7.78E+01	7.01E+01	6.49E+01	1.17E+02	1.30E+02	1.43E+02	1.56E+02
1.34E-13	9.99E+01	8.74E+01	7.49E+01	6.74E+01	6.24E+01	1.12E+02	1.25E+02	1.37E+02	1.50E+02
1.44E-13	9.63E+01	8.43E+01	7.22E+01	6.50E+01	6.02E+01	1.08E+02	1.20E+02	1.32E+02	1.44E+02
1.54E-13	9.31E+01	8.15E+01	6.99E+01	6.29E+01	5.82E+01	1.05E+02	1.16E+02	1.28E+02	1.40E+02
1.64E-13	9.03E+01	7.90E+01	6.77E+01	6.09E+01	5.64E+01	1.02E+02	1.13E+02	1.24E+02	1.35E+02
1.74E-13	8.76E+01	7.67E+01	6.57E+01	5.91E+01	5.48E+01	9.86E+01	1.10E+02	1.20E+02	1.31E+02
1.84E-13	8.52E+01	7.46E+01	6.39E+01	5.75E+01	5.33E+01	9.59E+01	1.07E+02	1.17E+02	1.28E+02

At V = 600 PI = 3E+27Rs^2 - 1E+15Rs + 219.1

At V = 550 PI = 3E+27Rs^2 - 1E+15Rs + 243.5

At V = 500 PI = 3E+27Rs^2 - 1E+15Rs + 267.9

At V = 450 PI = 3E+27Rs^2 - 2E+15Rs + 292.2

At V = 400 PI = 2E+27Rs^2 - 1E + 15 Rs + 194.8

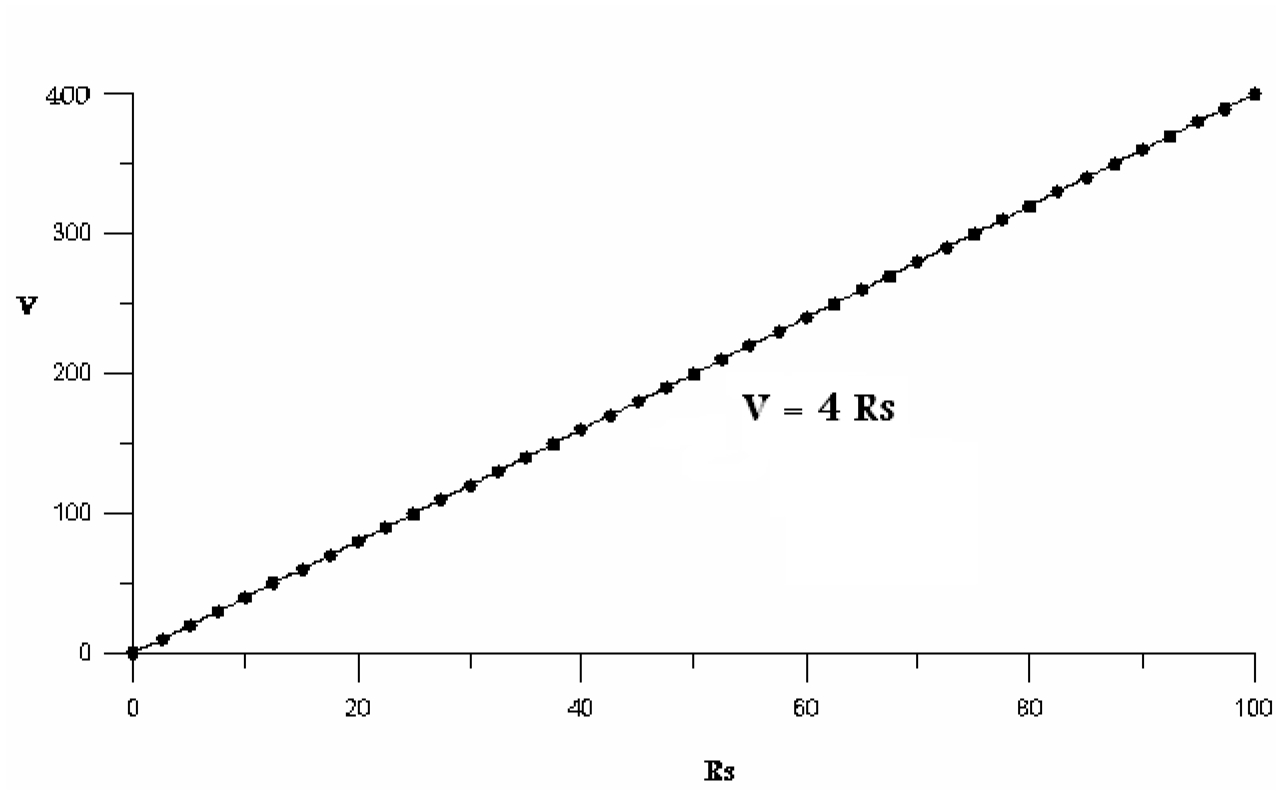
At V = 350 PI = 2E+27Rs^2 - 9E + 14 Rs + 170.4

At V = 300 PI = 2E+27 Rs^2 - 8E + 14 Rs + 146.1

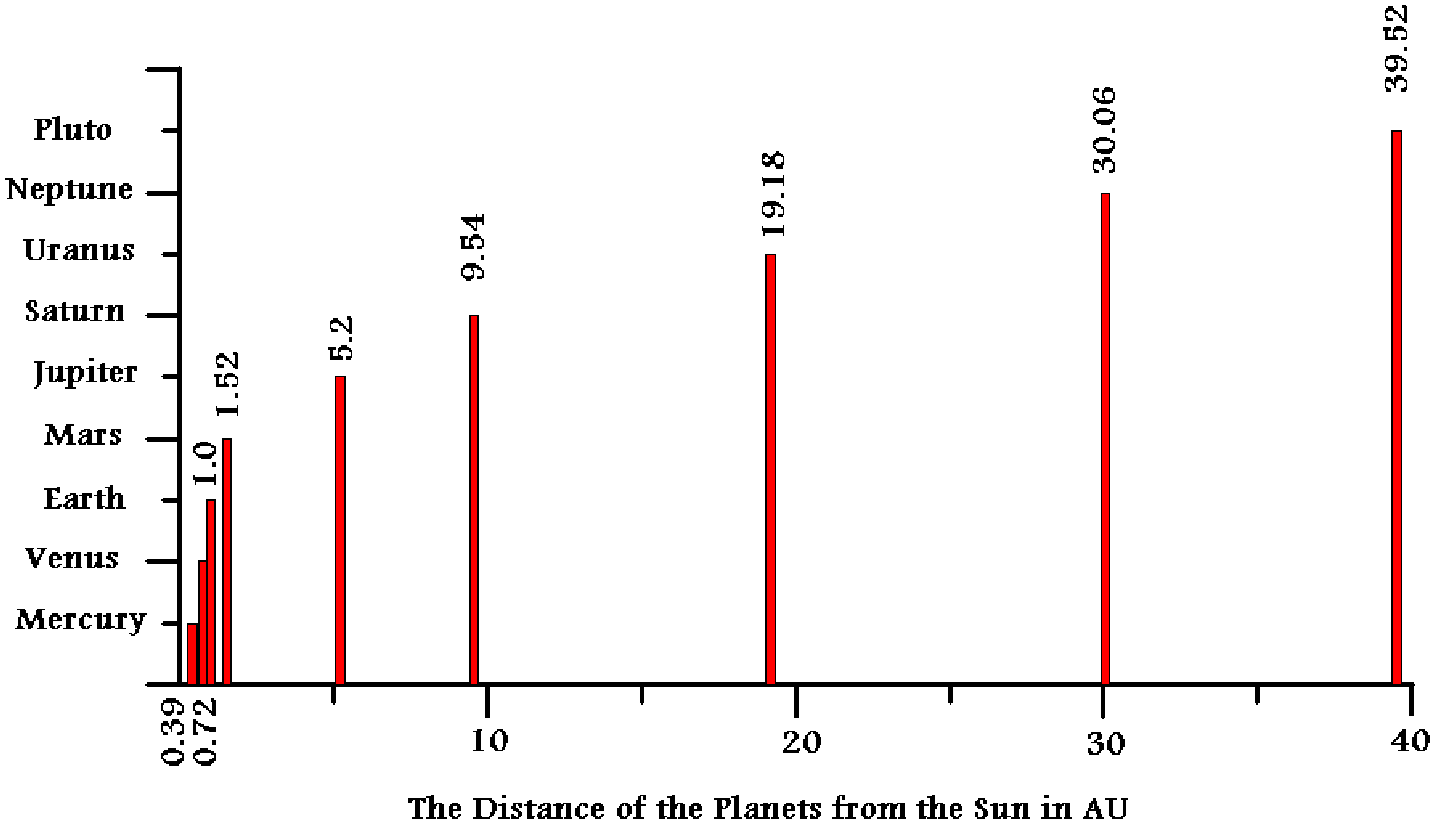
At V = 270 PI = 2E+27 Rs^2 - 7E + 14 Rs + 131.5

At V = 250 PI = 1E+27 Rs^2 - 6E + 14 Rs + 121.8

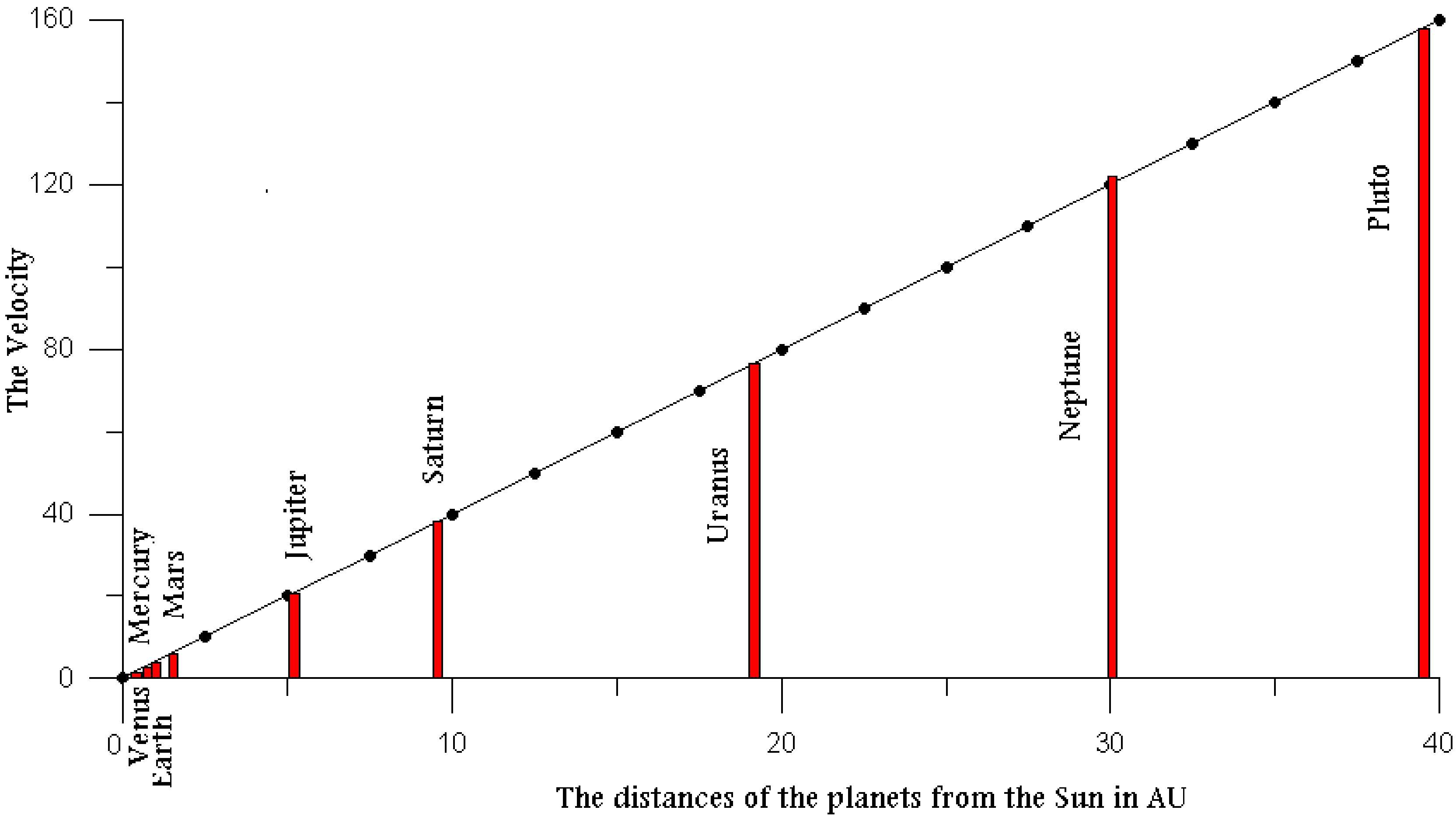
The Relation Between the Solar Wind Velocity and the Radius of the Heliosphere Rs=1/4V



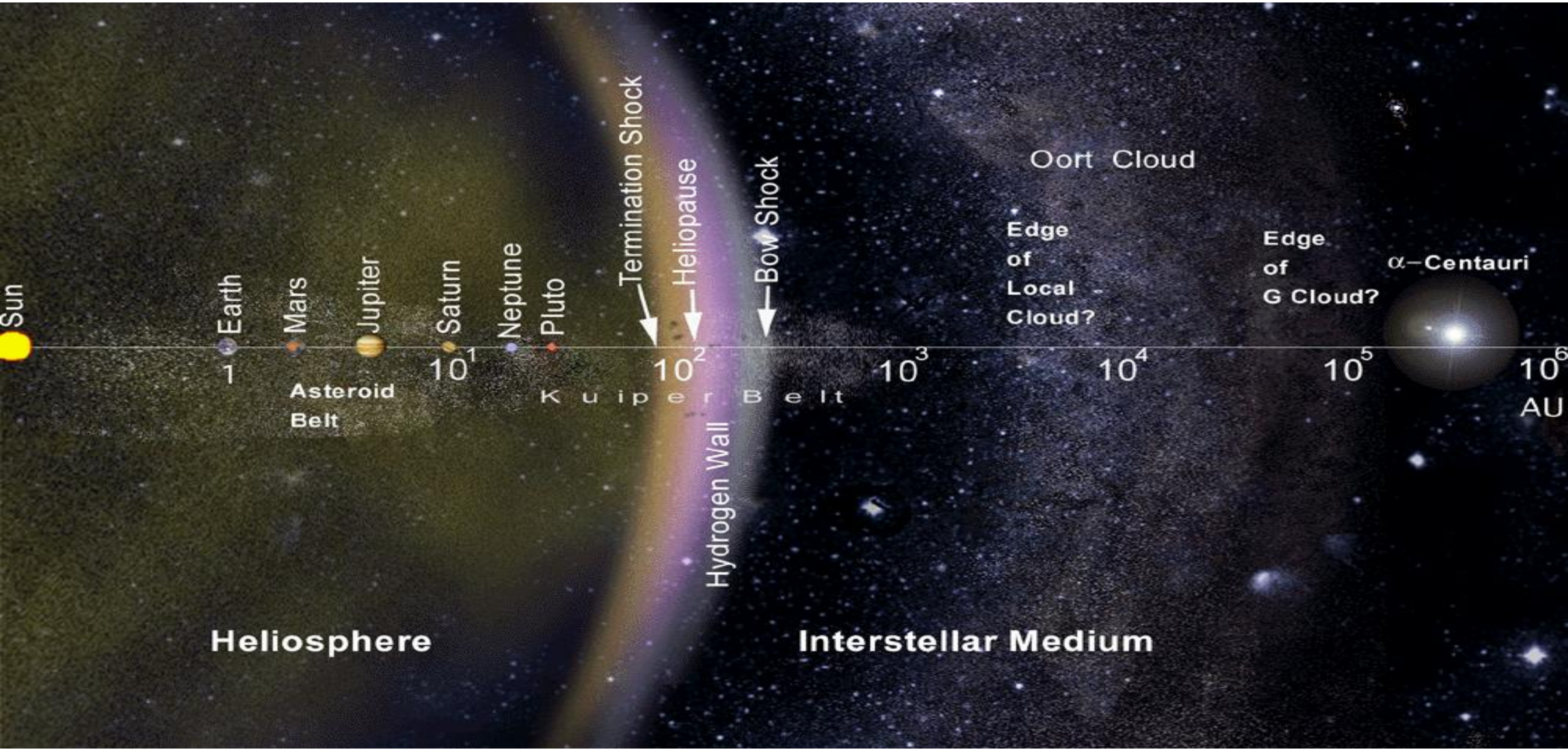
The Distance of the Planets from the Sun in Astronomical Units



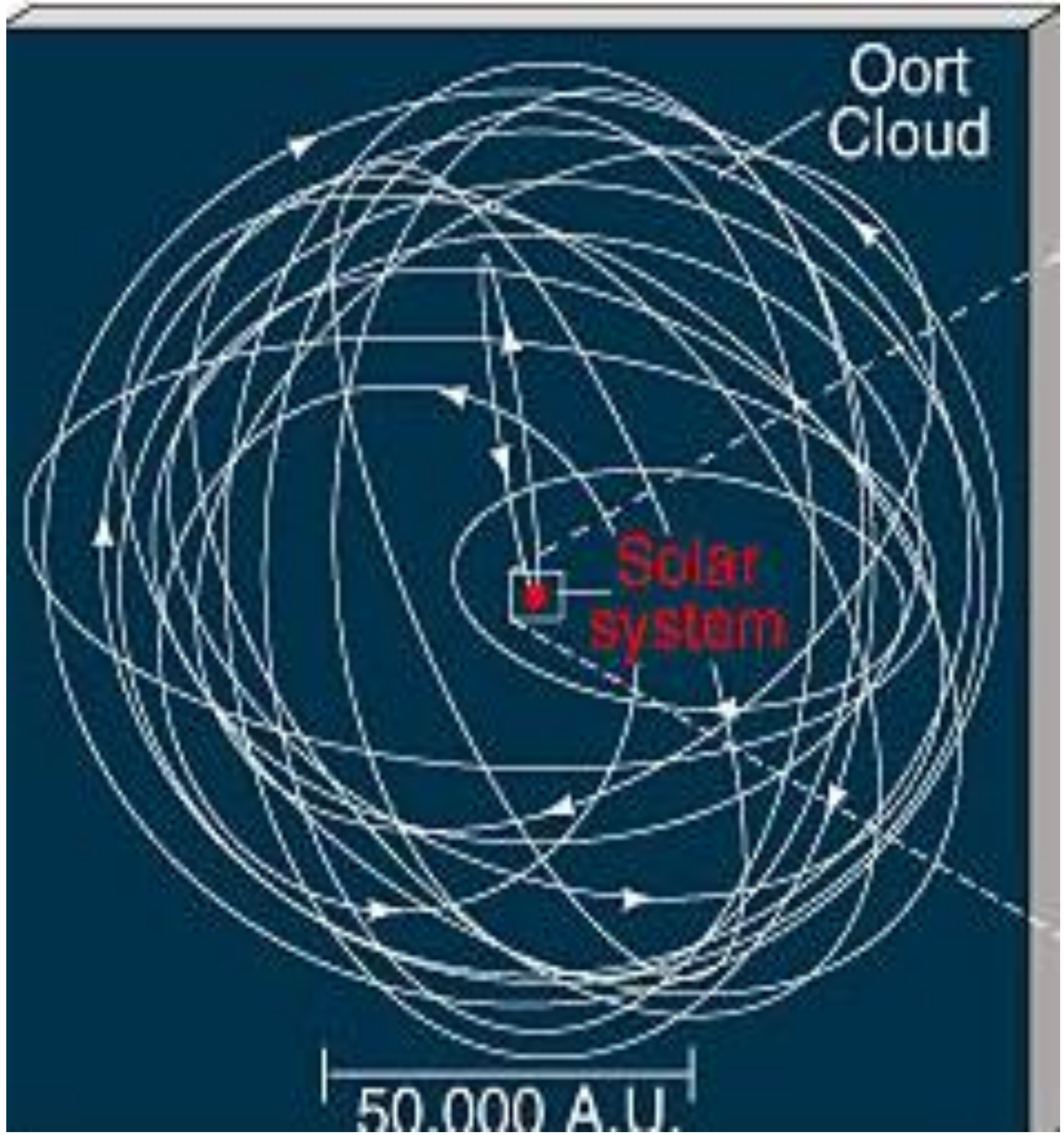
The estimated Solar Wind Velocity At Which The Boundary of The Heliosphere Will Encounter A Given Planet



Rs	V	Rs	V
1.00E+02	400	4.75E+01	190
9.75E+01	390	4.50E+01	180
9.50E+01	380	4.25E+01	170
9.25E+01	370	4.00E+01	160
9.00E+01	360	3.75E+01	150
8.75E+01	350	3.50E+01	140
8.50E+01	340	3.25E+01	130
8.25E+01	330	3.00E+01	120
8.00E+01	320	2.75E+01	110
7.75E+01	310	2.50E+01	100
7.50E+01	300	2.25E+01	90
7.25E+01	290	2.00E+01	80
7.00E+01	280	1.75E+01	70
6.75E+01	270	1.50E+01	60
6.50E+01	260	1.25E+01	50
6.25E+01	250	1.00E+01	40
6.00E+01	240	7.50E+00	30
5.75E+01	230	5.00E+00	20
5.50E+01	220	2.50E+00	10
5.25E+01	210	0.00E+00	0
5.00E+01	200		

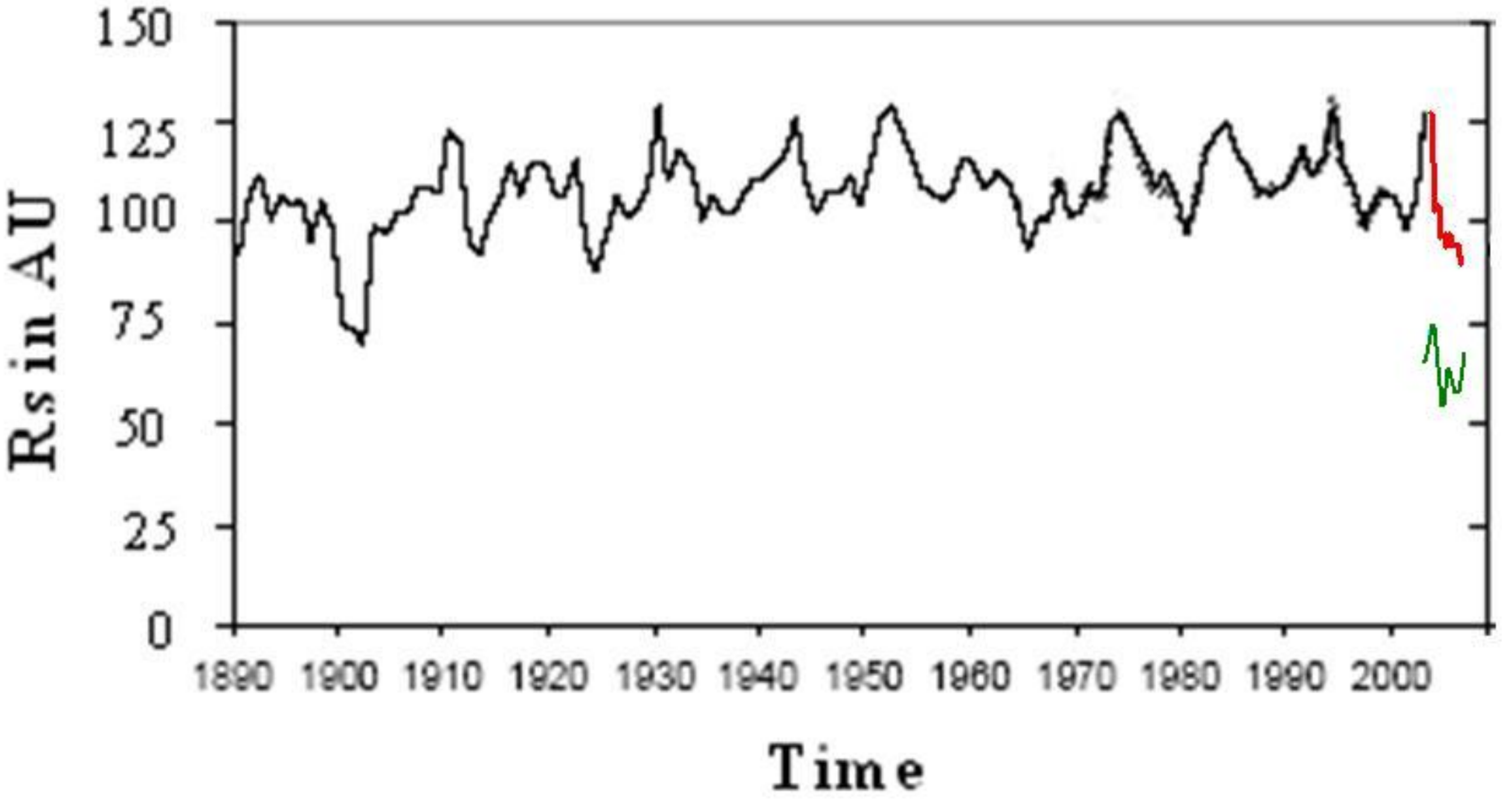


Sun
Earth
Mars
Jupiter
Saturn
Neptune
Pluto
Termination Shock
Heliopause
Bow Shock
Hydrogen Wall
Oort Cloud
Edge of Local Cloud?
Edge of G Cloud?
α−Centauri
1
10^1
10^2
10^3
10^4
10^5
10^6
AU
Asteroid Belt
Kuiper Belt
Heliosphere
Interstellar Medium



Oort
Cloud
Solar
system
50,000 A.U.

Reconstructed heliosphere radius from 1890 to 2003 according to the values of the solar wind speed of (Leif Svalgaard et al. 2003)



Sun's protective 'bubble' is shrinking

The protective bubble around the sun that helps to shield the Earth from harmful interstellar radiation is shrinking and getting weaker, Nasa scientists have warned.

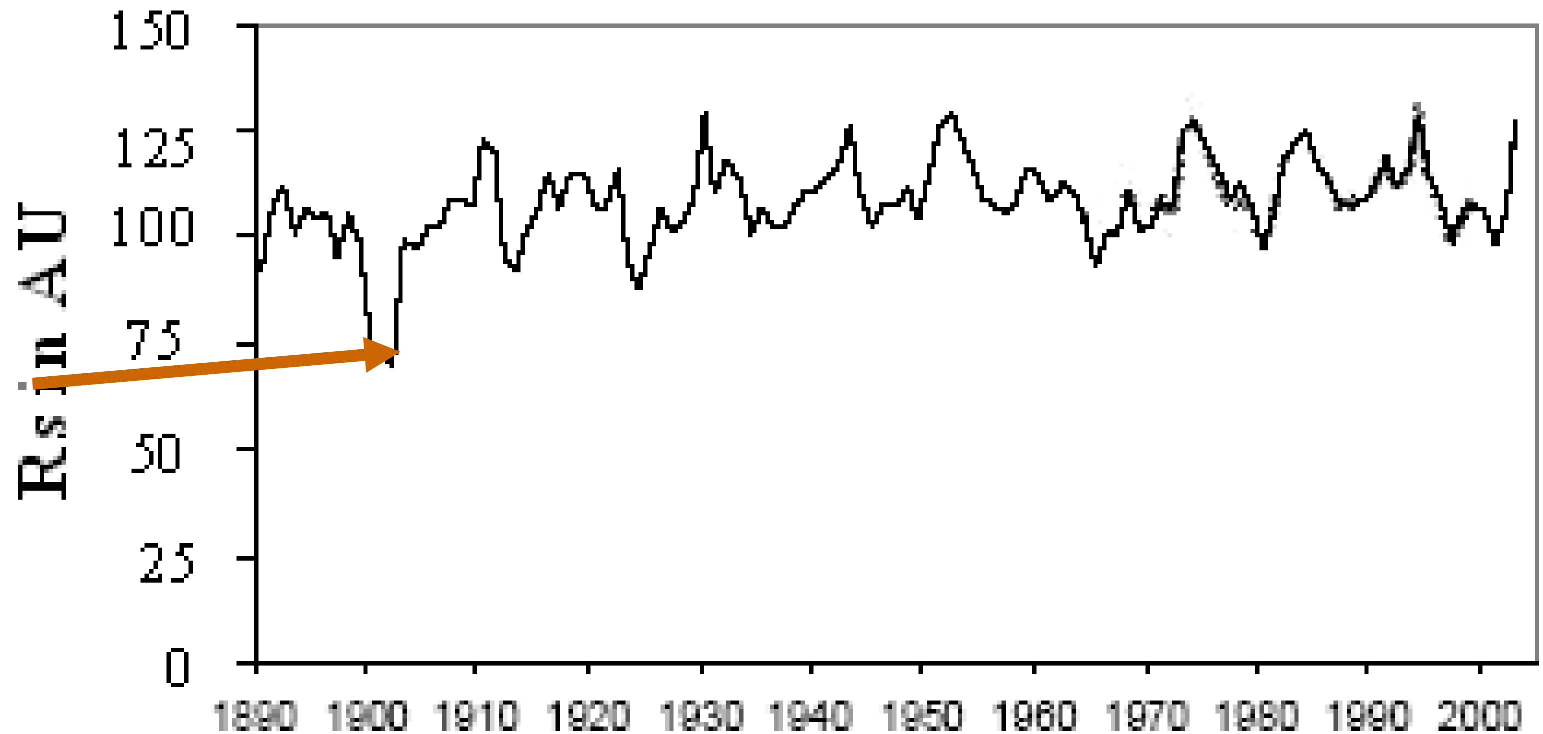
By Richard Gray, Science Correspondent
Published: 1:30PM BST 18 Oct 2008

New data has revealed that the heliosphere, the protective shield of energy that surrounds our solar system, has weakened by 25 per cent over the past decade and is now at it lowest level since the space race began 50 years ago.

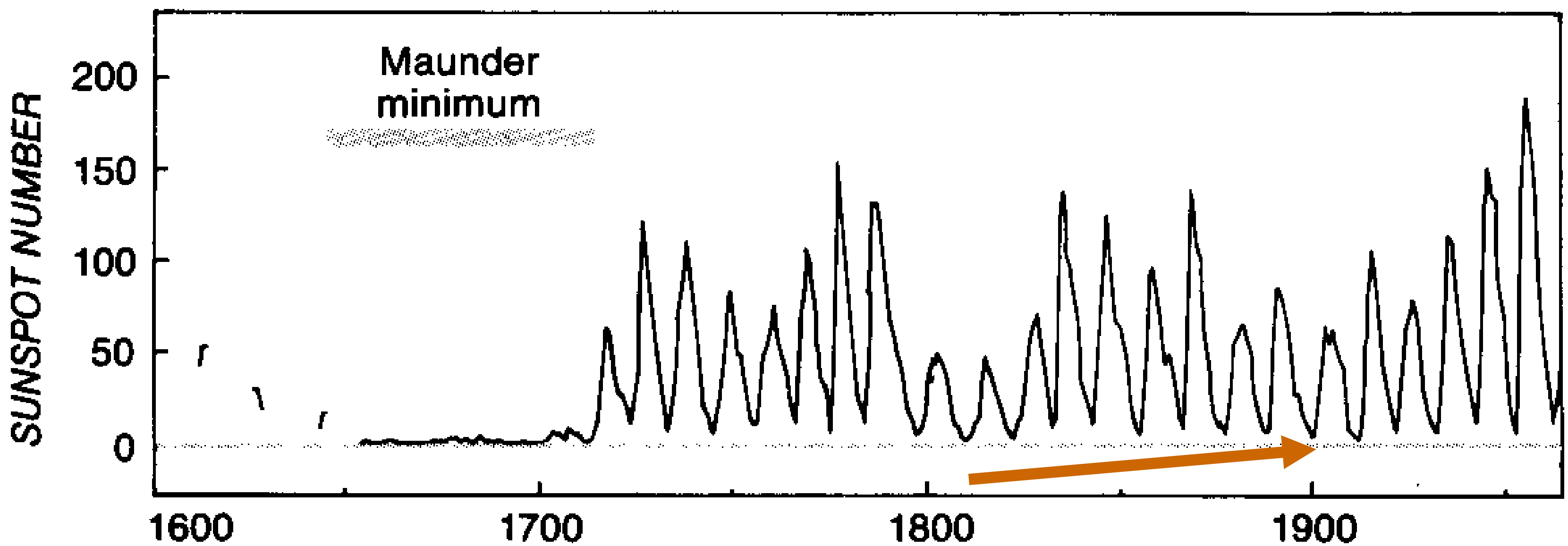
Scientists are baffled at what could be causing the barrier to shrink in this way and are to launch mission to study the heliosphere.

The Interstellar Boundary Explorer, or IBEX, will be launched from an aircraft on Sunday on a Pegasus rocket into an orbit 150,000 miles above the Earth where it will "listen" for the shock wave that forms as our solar system meets the interstellar radiation.

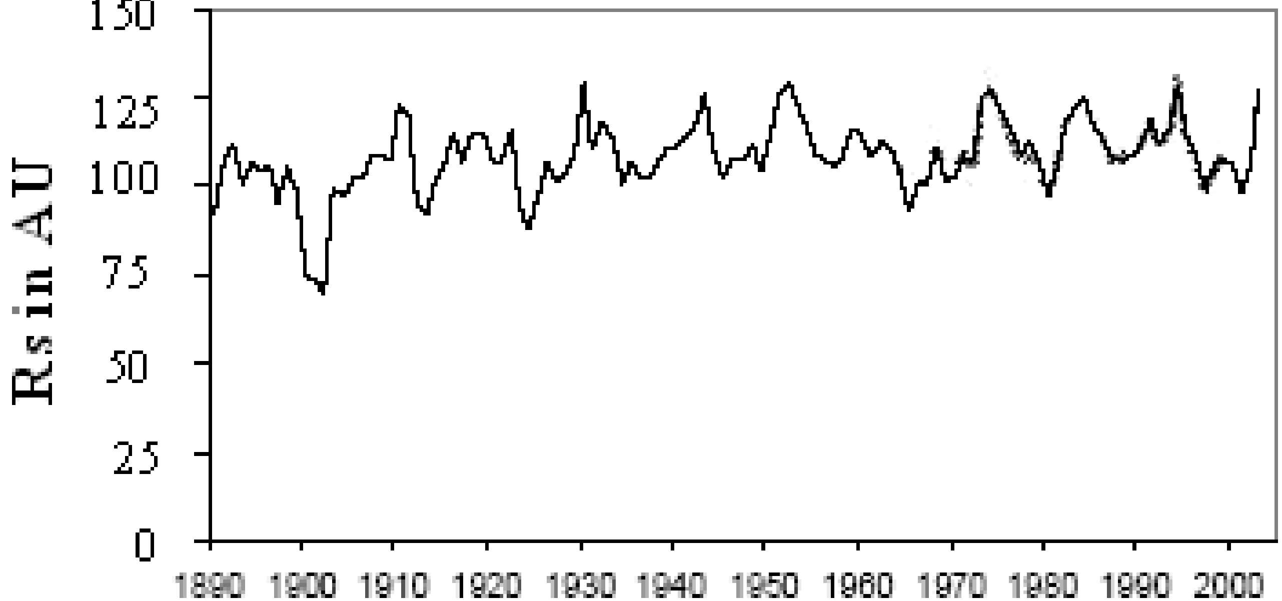
Dr Nathan Schwadron, co-investigator on the IBEX mission at Boston University, said: "The interstellar medium, which is part of the galaxy as a whole, is actually quite a harsh environment. There is a very high energy galactic radiation that is dangerous to living things.



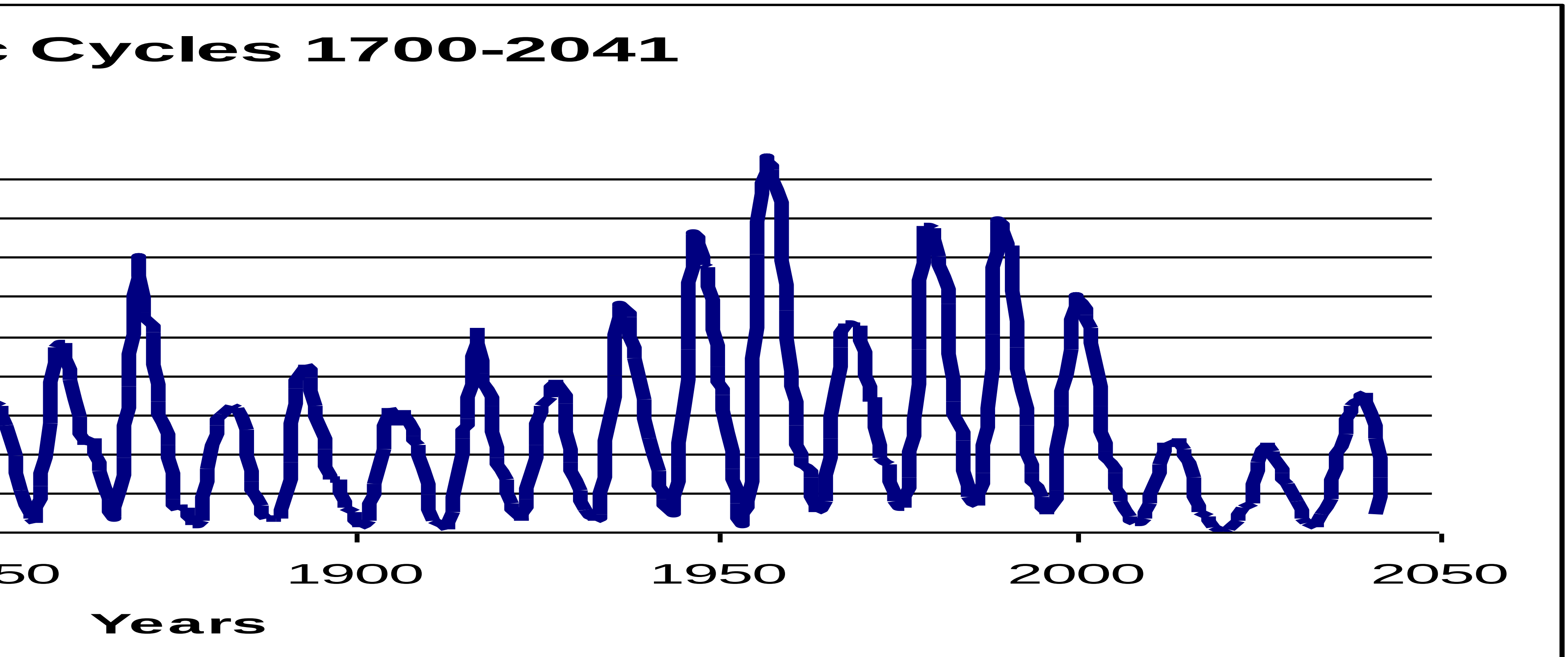
150
125
100
75
50
25
0
Rs in AU
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000



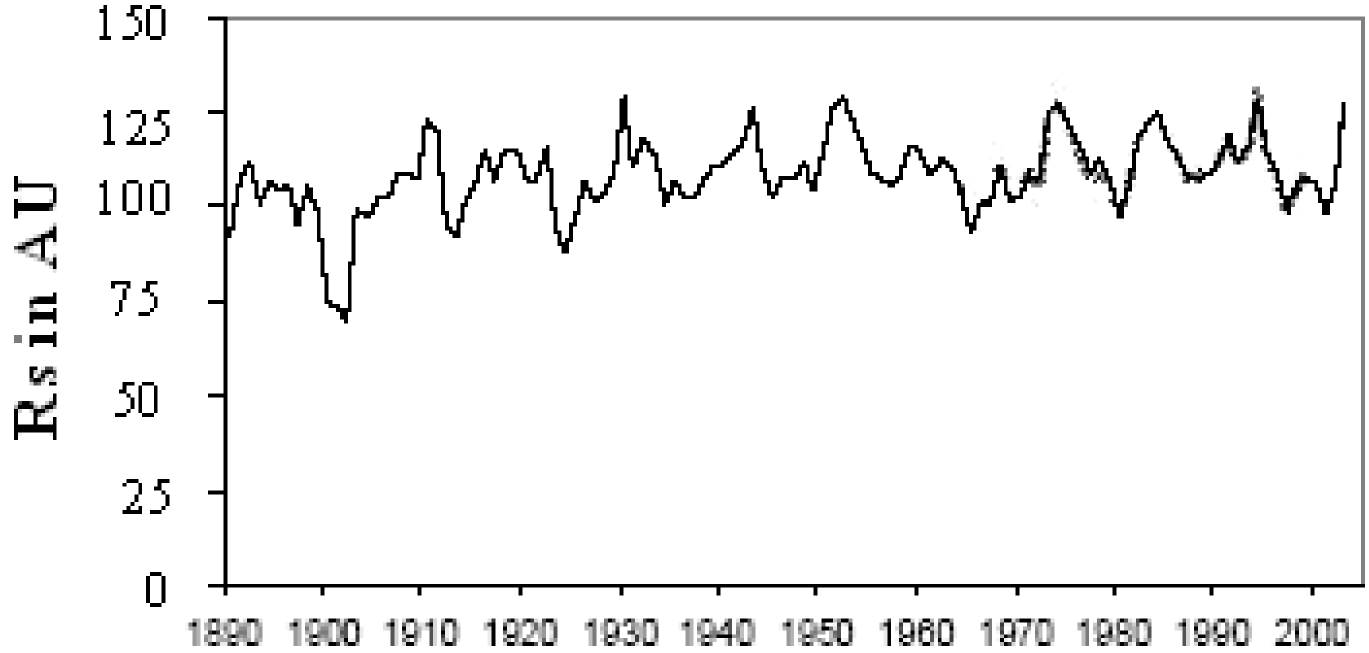
Maunder minimum
200
150
100
50
0
SUNSPOT NUMBER
1600
1700
1800
1900

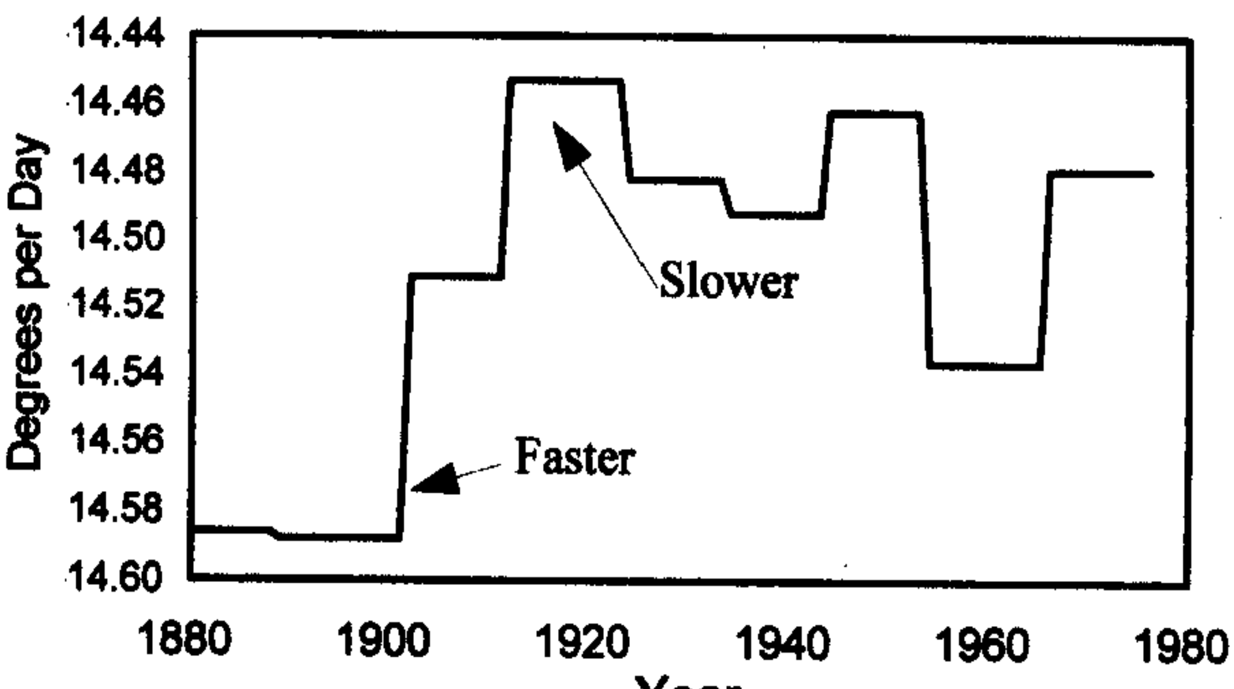


Rs in AU
130
125
100
75
50
25
0
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

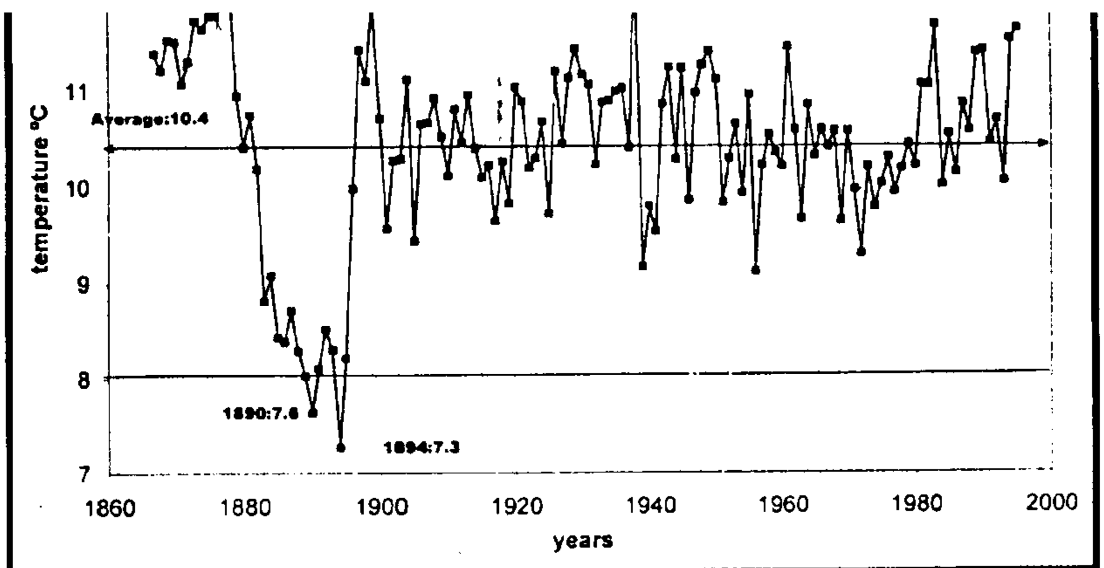


e Cycles 1700-2041
50
1900
1950
2000
2050
Years

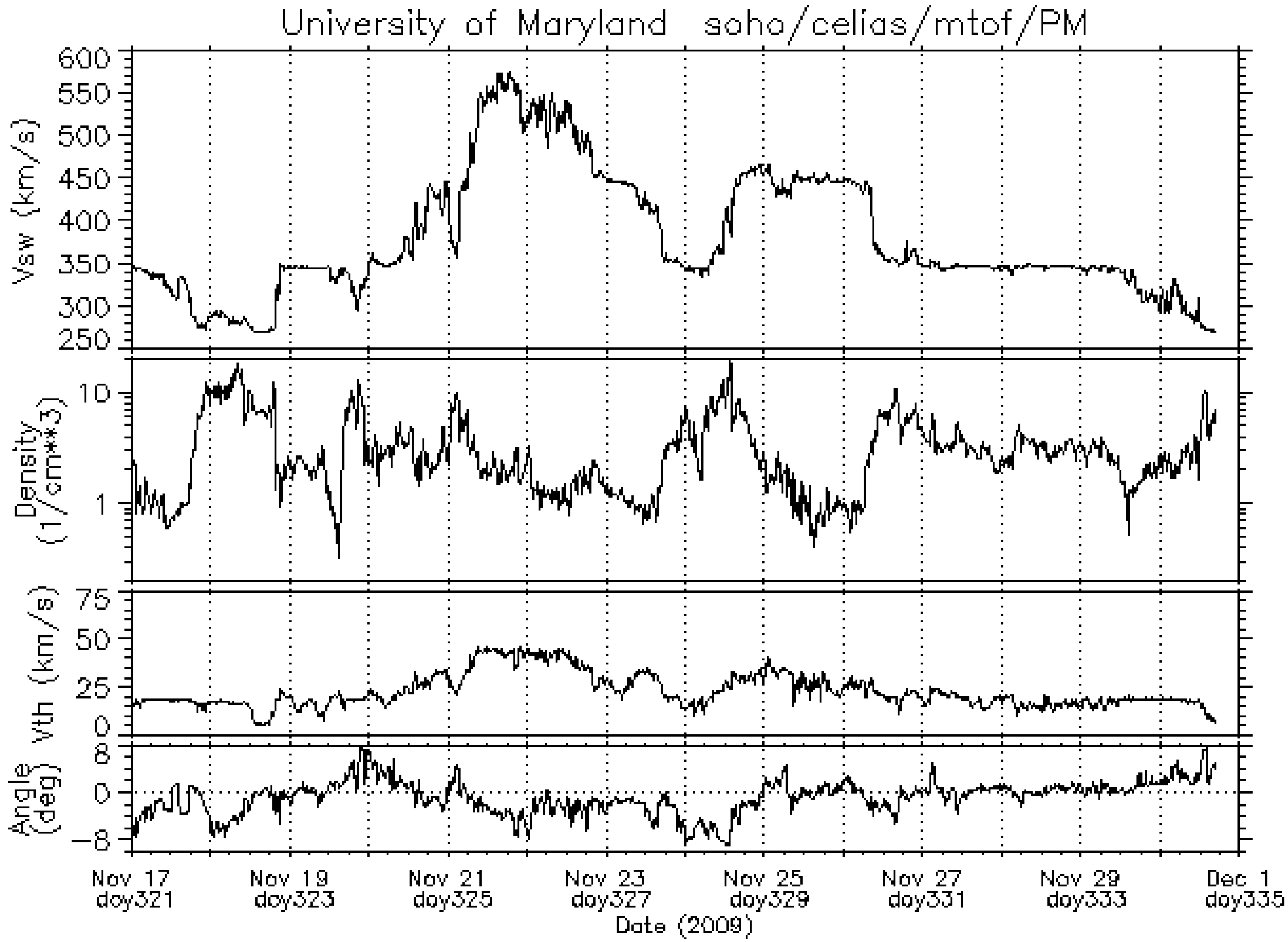

150
125
100
75
50
25
0
Rs in AU
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

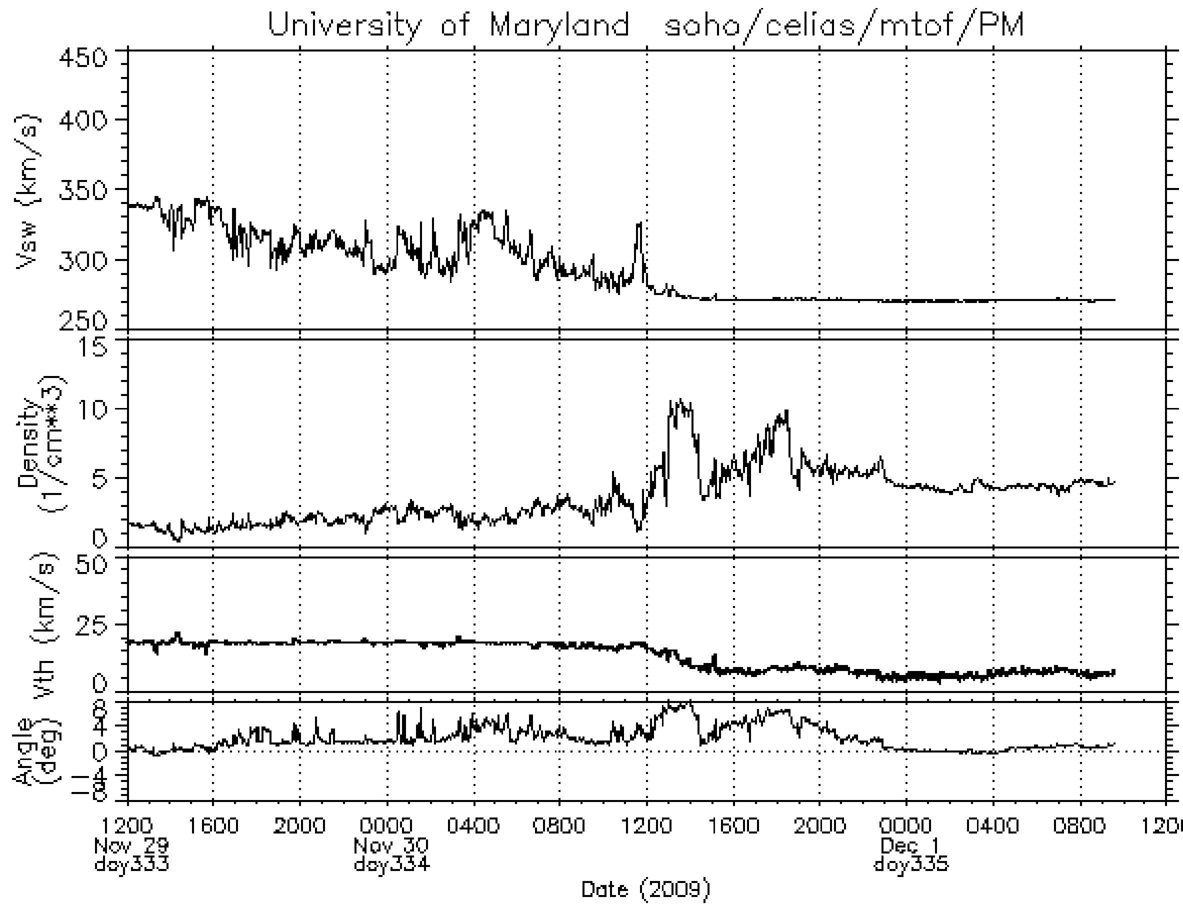

14.44
14.46
14.48
14.50
14.52
14.54
14.56
14.58
14.60
Degrees per Day
Slower
Faster
1880
1900
1920
1940
1960
1980


Rs in AU
150
125
100
75
50
25
0
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Time


temperature °C
11
10
9
8
7
Average:10.4
1890:7.6
1894:7.3
1860
1880
1900
1920
1940
1960
1980
2000
years

Fast Solar Wind From A Coronal Hole That Induced Flash Floods Over Mekka and Jedda In November 2009





University of Maryland soho/celias/mtof/PM
Vsw (km/s)
450
400
350
300
250
Density (1/cm**3)
15
10
5
0
Vth (km/s)
50
25
0
Angle (deg)
1200
1600
2000
0000
0400
0800
1200
1600
2000
0000
0400
0800
1200
Nov 29
day333
Nov 30
day334
Dec 1
day335
Date (2009)

Conclusions

Without the heliosphere the harmful intergalactic cosmic radiation would make life on Earth almost impossible by destroying DNA and making the climate uninhabitable.

- 1- Slow rotation of upper radiative zone at the

Tacochline which is the site of the solar dynamo

Induces weak magnetic cycles. This is accompanied by fast photospheric spin of the sun.

Conclusions

2- As a result slower solar wind is produced.

3- The consequence of this is the shrinkage of the heliosphere.

- 4- The earth would thus be subjected to more

Cosmic ray flux.

5- This would lead to more cloud cover ,i.e.

More precipitation and cooler earth.

Conclusions

- 6- backward investigation of the extent of the heliosphere based on computations of the solar wind velocity by Svallguard reveals that the heliosphere oscillated between about 75-125 AU between 1890-2003
- 7-The smallest heiosphere occurred around 1900 due to the presence of weak solar cycles.

Predictions

1- Owing to the 200 years solar cycle, It is anticipated that the present decline of solar activity would be about the same level of activity as cycles 5, 6 and 7 around 1800. These weak cycles are considerably lower than cycles 12,13,14 and 15 around 1900.

This implies that we should expect deeper drop in solar wind speed than those around 1900.

Predictions

Leading to further shrinkage of the heliosphere perhaps to 50-60 AU moving towards the inner part of the Kupier belt. Would this affect the frequency of periodic comets?

2- More invasions of cosmic rays to the earth are to be expected.

3- Cooling of the earth and other planets is anticipated with more precipitation on the earth

Predictions

4- expansion of the earth and planetary magnetospheres is to be expected. This must be taken into consideration in satellite heights

5- With the drop of solar activity, X-ray, UV, IR , irradiance and solar wind the ionization of the ionosphere will be greatly reduced that would affect broadcast etc.

Predictions

6- It is recommended that extensive study of the global environment 1784-1823 and 1877-1922 at different locations using scientific measurements, historical information as well as proxy data should be carried out for accurate prediction of what is expected to happen up till 2032 or 2043.

7- Owing to reduced solar activity, the tails of comets are expected to be shorter than average.

Yousef, S.1995 : The downturn of solar activity during the coming three solar cycles. Bull. Fac. Sci., Cairo University, 63, 185
.
Yousef Shahinaz 1998: A Warning Of Solar Inactivity During the Next Few Decades and Its Influence On IMF And Cosmic Rays. Proceedings of the Third SOLTIP Symposium, Oct 1996. Beijing , pp 569-575.

Yousef, Shahinaz Moustafa 2000 :An Overview Of Flood-Drought Hazards In The 21st Century. WMO International Workshop On Long Range Forecasting and Its Applications.,P81. Cairo ,January 23-27.

Yousef S.M 2000: 1997-998 Climate Fluctuations Attributed to The beginning of Intermediate Weak Solar Cycles. Journal of Environmental Sciences, The University of Mansoura - Egypt ,**Vol. 20**,PP 151-166.

Yousef, Shahinaz Moustafa 2003: Cycle 23, the First of Weak Solar Cycles Series and the Serious Implications on Some Sun-Earth Connections. Proceedings of ISCS, European Space Agency esa. SP-535. Solar Variability as an input to The Earth's Environment, 23-28 June , Tatranska Lomnica, Slovak Republic, pp177-180.

Yousef, S. and Amer M. 2003: Proceedings of ISCS, European Space Agency esa. SP-535. The Sharp Rise of Lake Victoria, A positive Indicator to Wolf-Gleissberg Cycle Turning Points. In Solar Variability as an input to The Earth's Environment, 23-28 June , Tatranska Lomnica, Slovak Republic pp397-400

Yousef, Shahinaz Moustafa 2006: 80-120 yr. Long Term Solar Induced Effects on the Earth, Past and Predictions, Physics and chemistry of the Earth. **31** pp.113-122. ElSEVIER, available online www.sciencedirect.com

Yousef, Shahinaz and A Hady 2006: On The Status Of Solar Wind During The Present Era Of Weak Solar Cycle. Invited Paper, IAU Symposium 233, Cambridge University. Press.

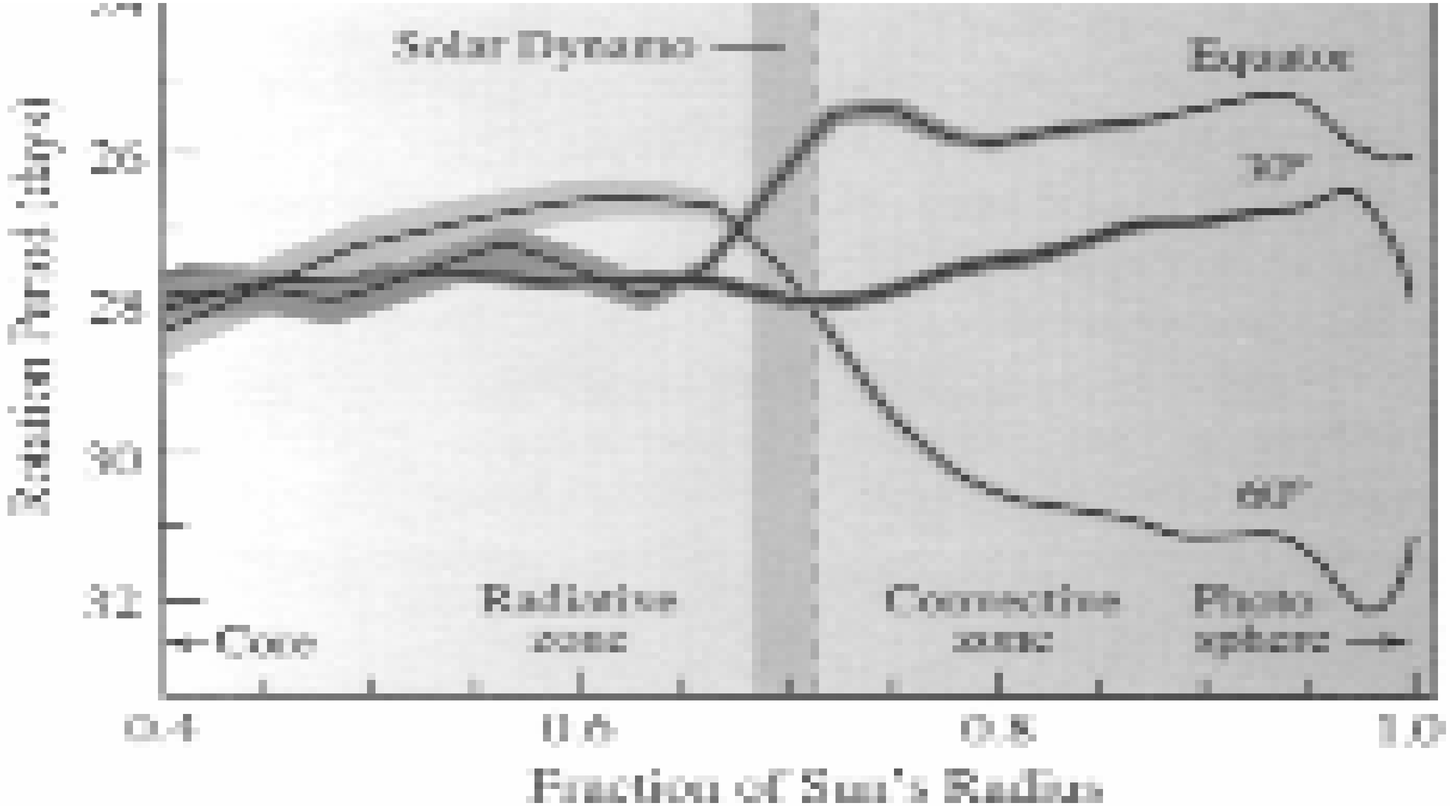
THANK YOU

Email: habibat_arrahman@yahoo.com

Web site: signsinhorizons.com

MDI Internal Rotation Of The Sun at Latitude

0-30&60



1- This differential rotation persists to the bottom of the connective zone

2- The rotation velocity becomes uniform from pole to pole

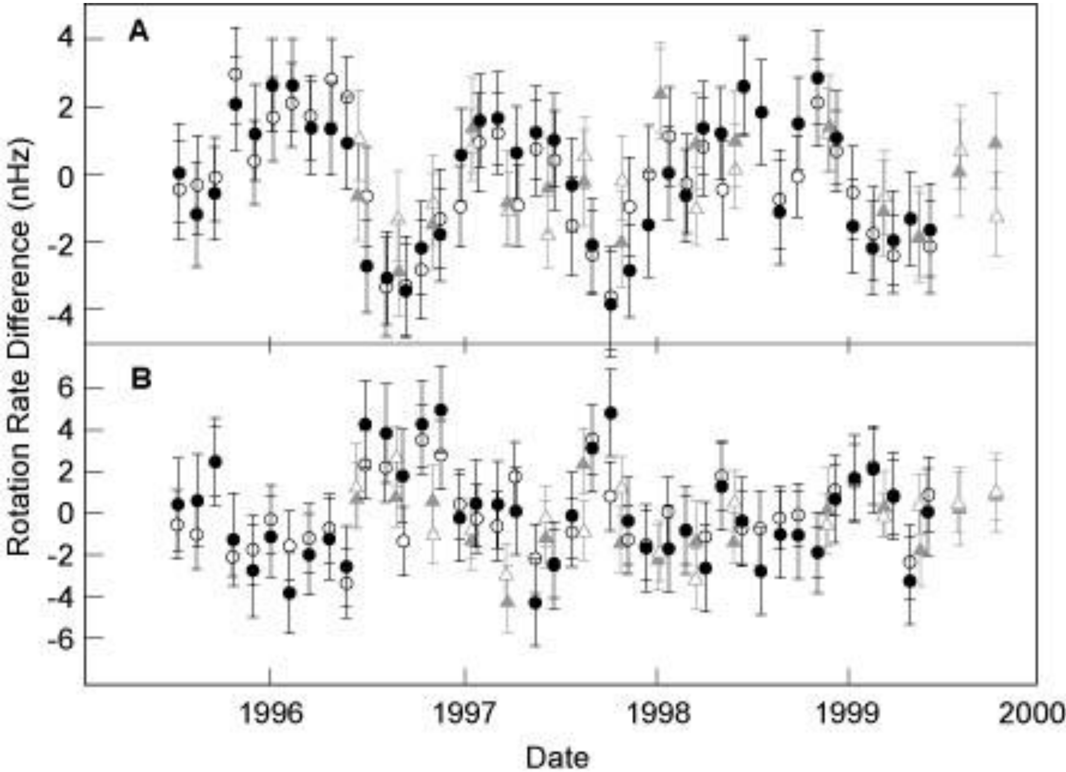
nearly 1/3 of the way to the core.

3- Lower down the rotation remains independent of lat. acting as if the Sun were a solid body.

4-Shearing motion along this interface may be the dynamo source of magnetism

Pulse of the Solar Dynamo

Temporal variation in the rotation of the Sun in base of the connective zone and close to the probable site of the solar dynamo in the equatorial regions,the rotation speeds up ,slows down and speeds up again with a period of 1.3 year



Here we display differences of the rotation rate from the mean at 0.72 R (A) and 0.63 R (B).

1- When the lower gas speeds up , the upper gas slows down and vise versa.

Solar radius R = 695.5 million m, base of connective zone at 0.713R