The sun can absorb large amount of energy from weak magnetic fields due to its low resistivity

Abstract

In reference 1 it was shown that the sun energy source is from magnetic eddies that propagate in the galactic disk from the super massive black hole at the galactic center. The solar cycle and stellar cycles of all the stars are driven by those magnetic eddies in the galaxy.
There are two difficulties that this theory has to overcome.
One is that the neutrino flux from the sun fits the fusion standard solar model, and the second is that the magnetic fields in the galactic disk are too weak to cause any considerable heat in the sun. The first difficulty was the subject of Reference 2, suggesting that the muon neutrinos from the sun are not due to neutrino oscillations, but are created by nuclear reactions in the sun that produce mass and new particles. This article will be centered on the second difficulty and will show that the changing magnetic field of the solar cycle is strong enough to produce not only the sun luminosity but also a substantial amount of mass. The measurement of the magnetic field of the sun, taken by probe Ulysses, will be used to calculate the energy absorbed by the sun and the mass the sun creates. The energy calculation suggests that stars are slowly growing by converting the energy from the magnetic fields to mass. The mass growth rate is used to estimate the age of the sun.

The sun can absorb large amount of energy from weak magnetic fields due to its low resistivity.

The solar cycle is the method by which the galactic center transfers energy to the sun by magnetic fields.
The solar cycle across 22 years change the magnetic field polarity through the sun.
From Ulysses probe data, shown graphically in Figure 1, the magnetic field at the peak of the solar cycle in year 2001 is about 4nT. This magnetic field is measured at a height of 1.4 AU from the sun surface. The distance 1.4AU in Meters is

$$R_{Ulysses} = 1.4 \cdot 1.49 \cdot 10^{11} = 2.1 \cdot 10^{11} \text{ M}$$

From Biot-Savart Law the magnetic field strength is inversely proportional to the distance squared so we can use it to find the strength of the magnetic field at the sun surface.

$$\frac{{R_{Ulysses}}^2}{{R_{Sun}}^2} = \frac{B_{Sun}}{B_{Ulysses}}$$

Rsun - The sun radius 6.96*10^8 M.
Bsun - The magnetic field at the sun surface.
Rulysses - The distance of the Ulysses probe from the sun when measuring the magnetic field.

Bulysse - The Magnetic fields measured by the Ulysses probe, 4nT from Figure 1.

So the magnetic field at the sun surface is:

$$B_{Sun} = \frac{R_{Ulysses}{}^2 \cdot B_{Ulysses}}{R_{Sun}{}^2} = \frac{(2.1 \cdot 10^{11})^2 \cdot 4 \cdot 10^{-9}}{(6.96 \cdot 10^{8})^2} = 3.64 \cdot 10^{-4}\,\mathrm{T}$$

The magnetic field near an iron magnet is about 100 mT, three hundred times than the above calculated value of the sun surface magnetic field.
In sunspots the magnetic fields can reach 1 T. So the above calculated value is reasonable.

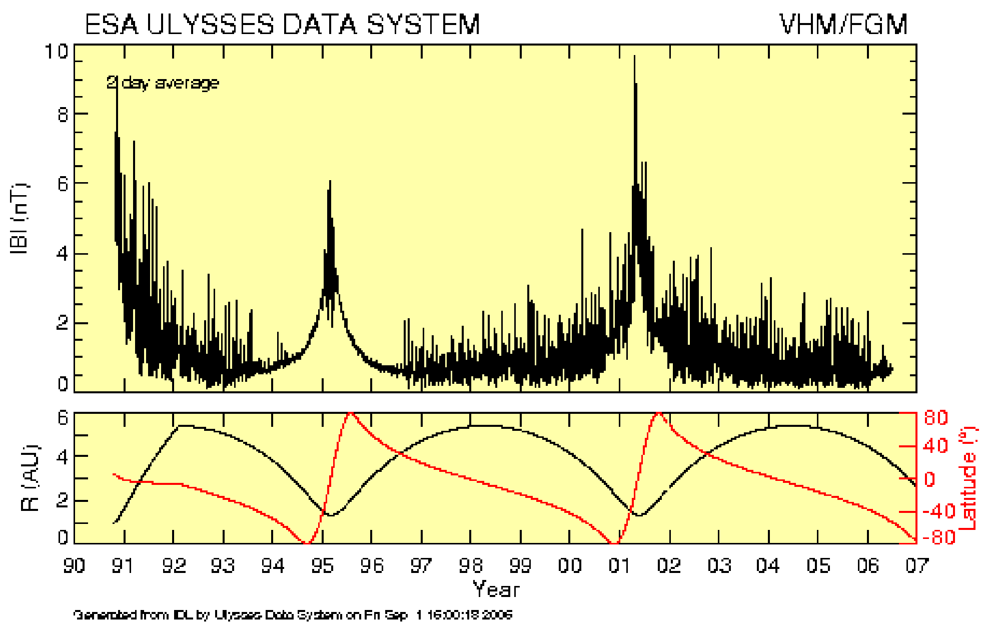

Figure 1: The magnetic field measured by the Ulysses probe near the sun. During 2001, when the sun was at solar maximum and the probe was relatively close to the sun, the magnetic field measured was extremely high.(Image by the Ulysses team)

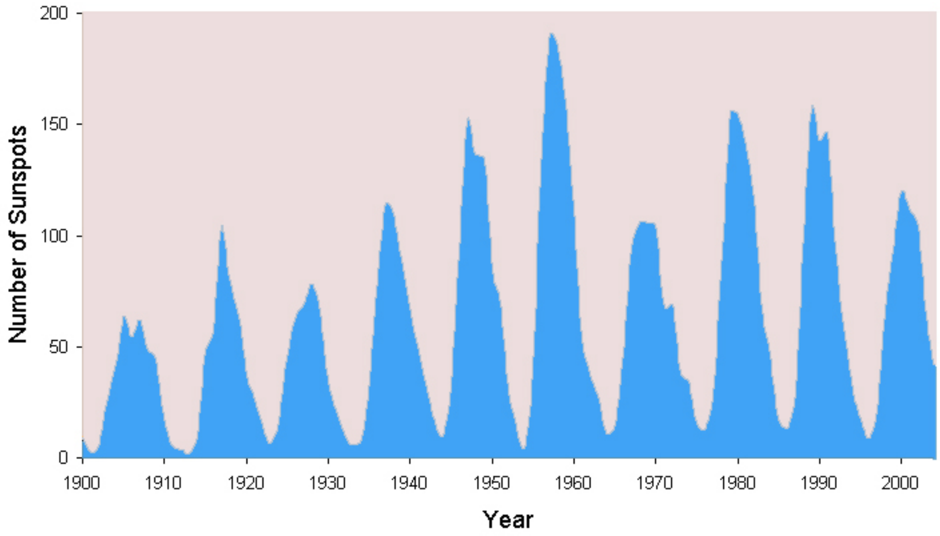

Figure 2: Century of solar cycles. During 2001 the number of sunspots indicates that the sun was at a solar maximum.

The sun was at solar maximum during the year 2001, as shown in Figure 2.
In 11 years the sun magnetic field will transform from the maximum in one polarity to the maximum in the reverse polarity. The maximum in one polarity is the calculated value above, therefore to get the change of the magnetic field during 11 years we need to multiple this value by two. To get the change of the magnetic field in one year we need to further divide by 11. From yearly value we can get the change of the magnetic field per second.

$$\Delta B_{Sun} = \frac{B_{Sun} \cdot 2}{11 \cdot 31536000} = \frac{3.64 \cdot 10^{-4} \cdot 2}{11 \cdot 31536000} = 2.09 \cdot 10^{-12} \mathrm{T} \cdot \mathrm{S}^{-1}$$

The magnetic field crosses the sun interior so we can use Faraday's Law to calculate the Electromotive Force (EMF). To get the magnetic flux that cross the sun we can multiply the magnetic field calculated above with the area of the sun. First we get the area of the sun.

$$A_{Sun} = R_{Sun}{}^{2} \cdot \pi = (6.96 \cdot 10^{8})^{2} \cdot \pi = 1.52 \cdot 10^{18} \ \mathrm{M}^{2}$$

The electromotive force from Faraday's Law is:

$$E = \frac{\Delta \phi}{\Delta t} = \frac{\Delta B_{Sun}}{\Delta t} \cdot A_{Sun} = \frac{2.09 \cdot 10^{-12}}{1} \cdot 1.52 \cdot 10^{18} = 3.17 \cdot 10^{6} \ \mathrm{V}$$

The electromotive force is applied on the circumference of the sun. If we know the resistance of the sun we can calculate the energy or power dissipated by the electric currents inside the sun. To find the resistance we can imagine a donut shaped ring inside the sun enclosed by the sun circumference. This ring will have a circular cross section with radius that is, for instance, 0.3 of the sun radius. We can find the resistance of the donut shaped ring from its cross section area and from its circumference. The circumference of the ring is a circumference of a circle that its radius is 0.7 that of the sun radius.

$$l = 2\pi R = 2\pi \cdot (0.7 \cdot R_{Sun}) = 2\pi \cdot 0.7 \cdot 6.96 \cdot 10^{8} = 3.06 \cdot 10^{9} \text{ M}$$

The cross section area of the donut shaped ring.

$$A_{Ring} = R^{2}\pi = (0.3 \cdot R_{Sun})^{2} \cdot \pi = (0.3 \cdot 6.96 \cdot 10^{8})^{2} \cdot \pi = 1.36 \cdot 10^{17} \text{ M}^{2}$$

To find the conductivity of the sun we can use the formula:

$$\sigma = 0.003 \cdot T^{3/2}$$

This formula is found in: "The Sun: An Introduction" by Michael Stix. 1989 page 308. Setting a temperature of 4000000 K that is found in the Sun upper radiative zone gives:

$$\sigma = 0.003 \cdot T^{3/2} = 0.003 \cdot 4000000^{3/2} = 2.4 \cdot 10^{7} \text{ S} \cdot \text{m}^{-1}$$

And the resistivity is:

$$\rho = \frac{1}{\sigma} = \frac{1}{2.4 \cdot 10^{7}} = 4.17 \cdot 10^{-8} \ \Omega \cdot \text{m}$$

Now we can find the resistance of the donut shaped ring.

$$R_{Ring} = \rho \cdot \frac{l_{Ring}}{A_{Ring}} = 4.17 \cdot 10^{-8} \cdot \frac{3.06 \cdot 10^{9}}{1.36 \cdot 10^{17}} = 9.38 \cdot 10^{-16} \Omega$$

This small resistance shows that stars are comparable to a superconductor.
The power collected by the sun from the magnetic fields can be found by the electromotive force and the resistance.

$$P = \frac{V^{2}}{R} = \frac{(3.17 \cdot 10^{6})^{2}}{9.38 \cdot 10^{-16}} = 1.07 \cdot 10^{28} \text{ W} \tag{1.1}$$

The radiation emitted or luminosity of the sun is 3.86*10^26 W.
The mass lose rate from the solar wind is 10^9 KG/S. The energy equivalent of this mass is:

$$E = MC^{2} = 10^{9} \cdot (3 \cdot 10^{8})^{2} = 9 \cdot 10^{25} \text{ W}.$$

The energy supplied to the sun by the magnetic fields associated with the solar cycle is higher then the radiation emitted by the sun and the energy equivalent of the mass loss of the sun.

The above calculation can be summarized with the following formula which states that the power absorbed by the star depend on the fifth power of the star radius.

$$P = 1.89 \cdot 10^{-3} \cdot T^{3/2} \cdot \left(\frac{\Delta Bstar}{\Delta t}\right)^2 \cdot R^5 \tag{1.2}$$

P - Is the power that the star absorbs from the magnetic fields.
T - Is the star temperature at 0.7 of its radius.
Bstar - Is the magnetic field of the stellar cycle.
R - Is the star radius.

The fifth power on the star radius can explain the observations of large stars like blue giants. The short wavelength color of blue giants and their high luminosity imply higher temperature and stronger energy source. The blue giants are also producing strong solar winds that disperse some of the mass created by the star.

It is also possible to show that the strength of the magnetic field, needed to sustain the energy consumed by the sun, is smaller then the magnetic field measured by the Ulysses probe. If we do not take into account the energy required to produce new mass in the sun, then the energy consumed by the sun is equal to the sum of the radiation emitted and the solar wind mass loss.

$$E_{Total} = 3.86 \cdot 10^{26} + 9 \cdot 10^{25} = 4.76 \cdot 10^{26} \text{ W}$$

Form this energy consumption and the resistance of the sun, we can find the electromotive force.

$$V = \sqrt{P \cdot R} = \sqrt{4.76 \cdot 10^{26} \cdot 9.38 \cdot 10^{-16}} = 6.68 \cdot 10^{5} \text{ V}$$

From Faraday's law we can find the magnetic field at the sun surface.

$$\Delta B_{Sun} = \frac{E \cdot \Delta t}{A_{Sun}} = \frac{6.68 \cdot 10^{5} \cdot 1}{1.52 \cdot 10^{18}} = 4.39 \cdot 10^{-13} \text{ T} \cdot \text{S}^{-1}$$

To find the magnetic field change during one year we can multiple the magnetic field change per second with the number of seconds in a year.

$$\Delta B_{Sun} = 4.39 \cdot 10^{-13} \cdot 31536000 = 1.384 \cdot 10^{-5} \text{ T/Year}$$

The magnetic field strength is inversely proportional to the distance squared so at altitude of 1.4 AU the magnetic field will be.

$$\Delta B_{Ulysses} = \frac{\Delta B_{Sun} \cdot R_{Sun}{}^{2}}{R_{Ulysses}{}^{2}} = \frac{1.384 \cdot 10^{-5} \cdot (6.96 \cdot 10^{8})^{2}}{(2.1 \cdot 10^{11})^{2}} = 1.52 \cdot 10^{-10} \text{ T/Year}$$

This value is smaller then the values typically measured by the Ulysses probe, so even though the magnetic fields are considered weak they sufficiently supply the energy consumption of the sun.

Estimating the sun age from its mass growth rate

Most of the energy used by the sun is converted to mass. To find the mass creation rate, we first find the energy available for creating mass by subtracting the energy associated with the sun luminosity and the solar wind from the total energy.

$$E_{mass} = 1.07 \cdot 10^{28} - 9 \cdot 10^{25} - 3.86 \cdot 10^{26} = 1.0224 \cdot 10^{28} \text{ W}$$

Then we use Einstein equation to find the mass created per second in the sun:

(1.3)

$$M = \frac{E}{C^{2}} = \frac{1.0224 \cdot 10^{28}}{(3 \cdot 10^{8})^{2}} = 1.136 \cdot 10^{11} \text{ KG} \cdot \text{S}^{-1}$$

The mass ejected by the solar wind 10^{9} KG/S is about 1% of the mass created inside the sun.
The mass created by the sun can be used to estimate the sun age. Dividing the total mass of the sun by the mass growth rate can give the time it took the sun to accumulate its mass.

(1.4)

$$\text{Sun Age} = \frac{M_{sun}}{M_{PerSecond}} = \frac{1.989 \cdot 10^{30}}{1.136 \cdot 10^{11}} = 1.75 \cdot 10^{19} \text{ S } = 554 \text{ Billion Years}$$

This age confirm the idea that universe is eternal as suggested by the steady state theory. The universe existed forever and will exist forever in a form and structure similar to what is found today.

This age is only an approximation. The sun size was gradually increasing, so when the sun was a red dwarf the mass growth rate was smaller. On the other hand, the sun could have passed near an area with strong magnetic fields like near blue giants, in the middle of a galactic arm or near the galactic center. In those areas the mass growth rate would be higher. The stellar cycle is variable and can stop for several hundred years like the recorded sun Maunder minimum. Those interruptions in the stellar cycle can decrease the mass growth rate of stars.

Conclusion

The magnetic fields of the solar cycle as measured by the probe Ulysses are strong enough to supply the energy for the sun luminosity and solar wind. The difference, between the energy received from the magnetic fields and the energy consumed by the sun luminosity, is producing new particles by converting energy to mass and increase slowly the sun mass. About 4% of the energy received is consumed by the sun luminosity and solar wind and the rest is converted into new mass. Dividing the sun mass by the growth rate enables to roughly estimate the sun age to be about 550 billion years. This old age indicates an everlasting universe, with no beginning or end, that is homogeneous and isotropic in space and time as was suggested by the steady state theory. The gradual growth of the sun and its old age invalidate the solar nebula hypothesis as the origin of the solar system, and suggest that the planets age is much older than the 4.6 billion years as is determined by the solar nebula hypothesis.

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Written by Dan Bar-Zohar Friday, October 15, 2010

To contact me please use the following email:
danbz@isdn.co.il
dan@pixelphase.com

Or call me by Skype: danbarzohar

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