International Journal of Materials, Mechanics, Mechatronics and Manufacturing
ISSN:2583-5688 Volume: 001 (2022), pp. 01-05

Mathematical Analysis of Solar Flare Comes Towards the Earth

Akash Kumar Patel[1] **&** Dr. Matsyendra Nath Shukla[2]

[1,2]*Rajkiya Engineering College Mainpuri, Mainpuri-205001, India*

Abstract

Generation of solar flare, this phenomenon occurs at the surface of sun there are continuously bombing are occurs due to this fusion of hydrogen atoms and other particles. When the solar wind flowing towards the earth the solar flares also comes with solar winds which have very high amount of light and heat energy. And these solar flares are carries magnetic charge particles in the form of hydrogen atoms. These charge particles most likely carries electron, proton and some other heavier particles. And our earth magnetosphere is providing us a strong magnetic shield protection which we called magnetosphere. This magnetosphere generates a strong magnetic pressure against the solar flare pressure. In this study, this paper analyses the mathematical models and calculations for solar flayers and at the last this paper will be able to find solar flares are fettle out (comes on earth surface) are not. And also this study will discuss these equations are valid for asteroid or obstacle which comes towards our planet earth from space.

Keywords: solar flares, magnetosphere, radius of magnetosphere, shifting of magnetic poles.

1. Introduction

1.1. Earth Magnetosphere

The magnetosphere of the earth is the major responsible factor to providing the protection against solar flare or any other obstacles comes from space towards the earth. It kept away solar flare and charge particles from our planet earth, due to the continuously striking the solar flare and solar wind the magnetosphere of the earth is compressed like balloons shape wise which face the sun, and these are the deep closer to 'earth magnetic poles' and flowing tails. The earth magnetic field create magnetosphere which block all the charge particles from most of the earth surface, while the solar flare pushes the magnetic field along the axis to the tail of magnetosphere.

Magnetosphere of the earth is the region surrounded over the planet earth which is generated by their own magnetic field. Mostly every planet has their own magnetosphere in our solar system but earth magnetosphere is the strongest magnetosphere in all of the planet present in our solar system. The magnetosphere of the earth is very big and wide which is eliptosphere in shape. Earth magnetosphere is play very important role in habitability of our planet. Life is continuously growing on earth and sustained due to the protection of the earth magnetic environment. Earth magnetosphere provide shield protection for our planet from solar flare and harmful radiations like cosmic particles which carries very high amount of energy and it also protect from erosion of the atmosphere by the solar flare.

Magnetosphere of the earth is the moving area around the planet earth and it is the part of our solar system which is responds against interstellar, solar flare and motion of the planet condition. Earth magnetic field is created by the rotation of the charge particles and the molten ionized materials present inside the outer surface of the earth core. Due to the continuously bombardment of the solar flare and solar wind the sun facing side of the earth magnetosphere is compressed and it have smaller magnetosphere radius. Which is generally 3 to 10 times of the radius of earth.

Published online on: January 28, 2022
Corresponding Author's E-mail ID: akash18405@recmainpuri.in

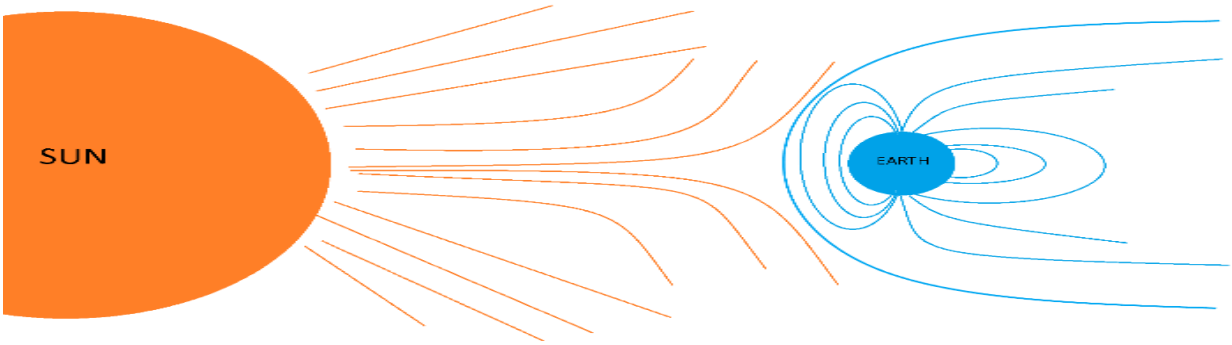

Fig. 1. Behaviour of solar flare and earth magnetosphere

2. Magnetic field of earth and variation in positions of magnetic Poles

2.1. Magnetic field generation

It is a mystery till now, but study says that the earth magnetic field is generated in side to the outer surface of the earth core. We all know that the radius of the earth core is about 1221 km which is approximately 19 percent of the earth radius. Inside the core is ionized molten charged particles is present which have most of the part is molten iron (Fe) and nickel (Ni) which is in the form of ionized molten mixture.
Due to the rotations of the earth, the molten materials also rotate which is present in side of the earth core. (according to the study when a charge particle is moving, it creates a magnetic field) the rotation of the ionized molten mixture it create a strong magnetic field which generate north and south poles. And the radius of this magnetic field is known as the **radius of magnetosphere**.

2.2. Earth magnetic poles are continuously changing its position

Speed of the earth and its rotation is stable, but in reality it is unstable. Now in current situations the magnetic field of the earth is continuously changing, according to the current study the north poles of the magnetic field are shifting towards the Siberia. Since the 1990s, north pole of earth magnetic field is change their positions which is about 35.5 (approximately 57 km) each year, according to a research in the year of 2019 which is published in the journal 'Nature'. Disturbances in the flowing, metallic magma and heavier ionized molten mixture might be the reasons for the unstable balance in the earth magnetic field it may reasons for shifting of the poles. The motion of the liquid molten iron present under Canada may be less strong in the comparison of other places the magnetic field at those location, which may be allowing the north pole of earth magnetic field to move along Siberia.

2.3. Shifting of earth magnetic poles

The poles of earth magnetic field are continuously shifting and they have also become completely opposite approximately it may become a few hundred times within the last 3 billion years, according to NASA During this process, this event happens every 200,000 to 300,000 years over the course of hundred to a few thousand years at this time, the earth magnetic field becomes crashed and a pull force generate and it create multiple poles sprouting up commonly across the surface of the Earth. The event which is change the earth magnetic poles completely opposite is occurred approximately 780,000 years ago. "Since the motion of Earth is a static and continuously changing their position, the rocks, and their magnetic records, have been created constantly over the geologic time, Scientist said that adding all these records and data can be conserve for the millions or billions of years.
The same type of event is initiate at the surface of the Atlantic Ocean where the ocean bottom surface is continuously being oriented at the backbone of mid Atlantic.
Due to the varying and shifting of earth magnetic poles life on our planet may be some changes are occurring it is common for all plant and animals. During the period of changing and decreasing in the earth magnetic field due to shifting of earth magnetic poles more solar flares and ionized particles and cosmic radiations were reach to the earth surface because of this harmful radiation the rate of genetic mutation is increase. And it may provide an evolutional

boost for the species of the earth.

3. Mathematical equation and calculations

There are three basic equations that defines the solar wind pressure, the pressure from a magnetic field and the magnetic field strength of the utopia.in the space is defined as follows:

$$P_w = \frac{1}{2} D v^2 \qquad (1)$$

(D= Solar flare density)
v=speed of solar flare
P_w is the solar wind pressure

$$P_m = \frac{1}{8\pi} F^2 \qquad (2)$$

P_m is the earth magnetic field pressure
F is the magnetic force

$$F = 6x10^{-5}\frac{1}{R^3} \qquad (3)$$

R is the radial distance which is compare to the radius of earth
Now from equation 3 put the value of F in equation 2 we get-

$$P_m = \frac{1}{8\pi}[6x10^{-5}\frac{1}{R^3}]^2$$

The next step is to balance the two pressures by setting their equation equals to each other so that
$P_w = P_m$

$$\frac{1}{2} D v^2 = \frac{1}{8\pi} [6x10^{-5}\frac{1}{R^3}]^2$$

$$\frac{1}{2} D v^2 = 36x10^{-10}\frac{1}{8\pi R^6}$$

$$R^6 = [(72x10^{-10}) \frac{1}{(8\pi D v^2)}]$$

$$\mathbf{R = [(72x10^{-10}) \frac{1}{(8\pi D v^2)}]^{1/6}} \qquad (4)$$

- Now substitute some typical values for the solar flare density (D) and speed of solar flare (V), to see what the distance is to this equilibrium point in space. The equations have been simplified in their form of selecting the quantity. Density (D) and velocity (V) in terms of kilogram per cubic meter (Kg/m^3) and meter per sec (m/sec). then the equation will provide the value of (R) in terms of distance of unites of earth radius. Example for R = 3.5 this means that the distance is 3.5 times of the earth radius or 3.5 x 6378 kilometre which is equals to 22323 km.
- The typical speed of the solar flare is 400 kilometers per sec or velocity = 4×10^5 m/sec. the typical density of the solar flare is about 8000 hydrogen atoms per cubic meter. Since one hydrogen atom has a mass of $1.67x10^{-27}$ kg. then the density of solar flare is equals to 8000 x 1.67 x 10^{-27} kg = 1.28 x 10^{-23} kg/m^3. If we put the value of density (D) and velocity (v) in the final equation, we get the value of R. the magnetosphere boundary is R times of the radius of earth.

4. Mathematical calculations

Table 1. density and velocity of the solar flare

Density of solar flare (kg/m^3)	**Velocity of solar flare (km/sec)**
1.28×10^{-23}	**200 km/sec**

1.28 x 10^{-23}	**2000 km/sec**
1.28 x 10^{-23}	**4700 km/sec**
1.28 x 10^{-23}	**5000 km/sec**

Case – 1

The density is 1.28 x 10^{-23} and the velocity is 200 km/sec

$$R= [(72x10^{-10}) \frac{1}{(8\pi Dv^2)}]^{1/6}$$

$$R= [(72x10^{-10}) \ (\frac{1}{8\pi \text{ x } 1.28 \text{ x } 10-23 \text{ x } (200 \text{ x } 1000)^2})]^{1/6}$$

R = 2.870

Which means the magnetosphere boundary is 2.870 times of the radius of our planet earth.
The magnetosphere radius for this condition is 2.870 x 6378 = 14,586.486 km. this is indicates that if any solar flare comes with this velocity and density it will not reach to earth (not fettle out)

Case – 2

The density is 1.28 x 10^{-23} and the velocity is 2000 km/sec

$$R= [(72x10^{-10}) \frac{1}{(8\pi Dv^2)}]^{1/6}$$

$$R= [(72x10^{-10}) \ (\frac{1}{8\pi \text{ x } 1.28 \text{ x } 10-23 \text{ x } (2000 \text{ x } 1000)^2})]^{1/6}$$

R = 1.3325

Which means the magnetosphere boundary is 1.3325 times of the radius of our planet earth.
The magnetosphere radius for this condition is 1.3325 x 6378 = 8,498.685 km. this is indicates that if any solar flare comes with this velocity and density it will also not reach to earth (not fettle out)

Case – 3

The density is 1.28 x 10^{-23} and the velocity is 4700 km/sec

$$R= [(72x10^{-10}) \frac{1}{(8\pi Dv^2)}]^{1/6}$$

$$R= [(72x10^{-10}) \ (\frac{1}{8\pi \text{ x } 1.28 \text{ x } 10-23 \text{ x } (4700 \text{ x } 1000)^2})]^{1/6}$$

R = 1.01 tends to 1

Which means the magnetosphere boundary is equals to the radius of our planet earth.
The magnetosphere radius for this condition is 1 x 6378 = 6387 km. this is indicates that if any solar flare comes with this velocity and density it will just reach to earth (fettle out) and this result show that the solar flare have limiting velocity 4700 km/sec either it will strike to the earth. Because the radius of the magnetosphere of the earth is equals to the radius of earth.

Case - 4

The density is 1.28 x 10^{-23} and the velocity is 5000 km/sec

$$R= [(72x10^{-10}) \frac{1}{(8\pi Dv^2)}]^{1/6}$$

$$R= [(72x10^{-10}) \ (\frac{1}{8\pi \text{ x } 1.28 \text{ x } 10-23 \text{ x } (5000 \text{ x } 1000)^2})]^{1/6}$$

R = 0.9976

Which means the magnetosphere boundary is 0.9976 times of the radius of our planet earth.
The magnetosphere radius for this condition is 0.9976 x 6378 = 6362.69 km. this is indicates that if any solar flare comes with this velocity and density it will definitely reach to earth (fettle out) because the radius of magnetosphere of the earth is less than the radius of the earth.

5. Result

This paper analyse the four conditions have same density and different velocity of solar flare. Result of analysis show that first two solar flare having velocity 200 km/sec and 2000 km/sec respectively. Both are not fettle out to the earth and third solar flare having velocity is 4700 km/sec this is the limiting velocity or we can say it is critical velocity of solar flare. If any solar flare having velocity greater than 4700 km/sec, then it will definitely fettle out to earth.
As this paper show in the fourth case of solar flare having velocity 5000 km/sec, it shows that the radius of magnetosphere of earth is less than the earth radius which means this solar flare is strike on earth.

6. Conclusion

If the value of R is less than or equals to 1 then the solar flare will come to earth (fettle out) if the value of R is greater than 1 then the solar flare will not come to earth (not fettle out) because the magnetosphere boundary is greater than the radius of earth.
If any obstacle comes from space, we can easily determine that the obstacle is fettle out on earth or not.

References

1. https://science.nasa.gov/heliophysics/focus-areas/magnetosphere-ionosphere/
2. https://www.livescience.com/64930-earths-magenetic-field.html
3. https://science.nasa.gov
4. https://en.wikipedia.org/wiki/Solar_flare#:~:text=They%20involve%20faster%20ejections%20of,to%202000%20kilometers%20per%20second
5. Joseph E. Borovsky, Juan Alejandro Valdivia, 2018
6. Shue, J.-H. Et al. Magnetopause location under extreme solar wind conditions. J. Geophys. Res. 103, 17691–17700 (1998).
7. Earth's magnetosphere and outer radiation belt under sub-Alfve´nic solar wind (Noe´ Lugaz1,2, Charles J. Farrugia1,2, Chia-Lin Huang1,2, Reka M. Winslow1, Harlan E. Spence1,2 & Nathan A. Schwadron1,2)