Effect of Solar Flares on Communication

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Abstract — **Solar flares are one of the most exciting phenomena but can have devastating effects as well. The work throws light on the concept of solar flares, their origin, classification and discusses the effect on communication systems. There is a need to understand and analyze the effect of solar flares on communication systems so that necessary remedial steps can be taken. The work throws a light on the problems that have already been caused by the phenomenon and the effect of coronal mass ejection (CME) on the electrical infrastructure and hence the communication setup.**

I. Introduction

Solar flares are defined as sudden intense variation in brightness. Solar flares occur when magnetic energy, that has built up, in solar atmosphere, suddenly releases from corona. Radiations are emitted across entire electromagnetic spectrum from radio waves of long wavelength to gamma rays of short wavelength. The amount of energy released is of the order of 10^{27}ergs/sec. Large flares can release energy up to 10^{32}ergs/sec [1]. The work explores the effect of above phenomena on communication systems. The causes of solar flares have been described in the following sections- the myth that the destruction due to solar flares is just a creation of human imagination has been busted using illustrations of tribulations that have been caused by the solar flares.

II. Causes

Flares occur when accelerated charged particles interact with plasma medium. Scientific studies indicate that magnetic reconnection is responsible for the acceleration of charged particles. As per Sun is concerned, magnetic reconnection can occur on solar arcades – a series of closely occurring loops of magnetic lines of force. These lines of force quickly reconnect into a low arcade of loops leaving a helix of magnetic field unconnected to the rest of arcade. This results in sudden release of energy leading to particle acceleration.

Flares extend out of sun's outermost layer – called as corona, which has a temperature of few millions of degrees of Kelvin. Corona is uniformly bright but concentrated around the solar equator in loop shaped features. The areas of strong magnetic field called active regions are located in these bright loops. Sunspots are located in active regions, from where flares erupt. The magnetic energy gets converted into particle kinetic energy.

The sun undergoes a 22 year cyclical pattern of magnetic poles reversibility [2]. This pattern is comprised of two 11 – year solar cycle phases [2]. In first phase magnetic poles reverse their polarity, and in second phase reverses back to original polarity. Solar storms are strongly phase dependent.

III. Components of Solar Storms

A solar storm consists of three major components. – Solar flares, solar proton event (SPE) and coronal mass ejection (CME).

1) Solar flares are magnetically driven explosions on the surface of sun. The arrival time of solar flares is instantaneous. Its effect duration is 1 to 2 hours [2].

2) SPE‘s are high energy solar cosmic rays (protons and ions) having energies ranging from 10 Mev to 100 Mev [2]. Its arrival time is 15 minutes to few hours [2]. Its effect duration is few days.

3) CME's are vast clouds of seething gases, charged plasma of low to medium energy particles with embedded magnetic field, being blasted into interplanetary space from the sun. Its arrival time is 2 to 4 days [2].

IV. Classifications

Solar flares are classified according to their brightness of X – rays. They are classified as A, B, C, M and X class flares, each being ten times of the previous ones. These broader classes are subdivided according to 9 pointer linear scale as A1, A2, A3, A4, A5, A6, A7, A8, A9 and so on, each being twice of previous ones [1].

Another category of classification is based on Hα spectral observations. This scheme uses both intensity as well as emitting surface. This quantative analysis classifies solar flares into f – faint, n – normal, b –brilliant.

A. Stages

There are typically three stages of solar flares.

1) Precursor stage – In this stage release of magnetic energy is accompanied with soft X – rays.

2) *Impulsive stage* – In this stage protons and electrons are accelerated to an energy exceeding 1 Mev [1]. Here CME is accompanied with hard X – rays and γ – rays.

3) Decay stage – In this stage gradual built up and decay of soft X – rays is noticed.

The time interval of these stages could vary from few sec to hours.

V. LITERATURE REVIEW

It has been established that 'space weather changes' is due to solar activity and can impact infrastructural systems. CME can cause geomagnetic storms which are capable of affecting many systems.

Recent US FERC, EMP commissions have noted that most power grids are potentially most severely affected infrastructures. Its effect will surely be there on communication systems as well.

In present scenario there is also a possibility that in uneasy circumstances if a missile is fired from one country to other country then electromagnetic pulses generated from above causes can detonate the nuclear weapon. E1 EMP and international electromagnetic interface can also damage control systems.

Geomagnetic storms can be referred to as magnetic disturbances in the earth's otherwise normal geo magnetic field.

On 13 March 1989, North American power grids were affected by geomagnetic super storm. The data confirms that effect was maximum. On the same day storm 7:39 UT which lasted for about 20 minutes, another starting from 2:39 EST – 21:40 UT lasting for about 50 minutes caused considerable damage to American and Atlantic power grids.

In present circumstances the effect on power grids can hamper the communication systems, thus halting the life and causing huge monetary damages. Even if point of devastation is not brought, the effect on communication lines and disruption in communication is not just a real possibility but also a prejudice.

Geomagnetic storms and their impacts on power grids have been widely studied. Its impact on North American power grids occurs at disturbances of around 500nT/minutes. Whereas the magnitude of effect in 1972 was greater than 2000nT/minutes. The disturbances on 14 May ,1921 is considered as largest storm of the previous century and according to present estimate , these storms can be anywhere between 4 to 10 times more than the observed ones.

Geomagnetic storm if of large severity will have larger planetary footprint. It has been estimated that geomagnetic induced current (GIC) are possible at low latitudes.

The ring current and ground level disturbances were observed on 15 July, 2000. In Japan on 6 Nov, 2001 the GIS flows in the network were observed.

In Nov, 2003, five major stations, 15 large transformers, encountered an unknown storm which led to the collapse. It is estimated that GIS activated the above storm. Going by this theory, we can state that larger storms will have higher impact on power grids and communication lines.

VI. EFFECT ON COMMUNICATION SYSTEMS

The communication systems that we are considering are wired systems. The wired set up relies heavily on the electrical set ups and power grids. The following discussion revolves around the effect of solar flares on communication systems.

As per the common knowledge the full solar cycle has two half life cycles of 11 years, in which sun reverses its polarity [2].

Peaks occur midway between the half cycles because sun spot's alignment opposes earth's magnetic field. Such peak occurred in 1989. These phenomena which are devastating in its effect and fascinating at the same time can generate induced mirror currents in men made telephone lines. In South Asia a big infrastructural change is underway to replace all the copper wires with optical fibers, but the work is far from over. It might take several years before the complete replacement is done, till then, the disruptions in communication due to solar flares as per the telephone lines are concerned is a real possibility. The point is supported by the fact that such disruptions were observed in US in 1989.

So how do we prepare to deal with such situations? The reality is that we can do a little about it because even if a system is developed which will tell us about an imminent solar flares, we'll not be able to change the infrastructure.

The remedies can be local. A robust local system can be developed, which is independent of magnetic field changes, therefore not affected by solar flares. At the same time the communication systems shouldn't be fully underground, so that the effect of natural calamities like earthquakes is least. The optimal solution will be – a midway approach which takes care of both the things equally. This approach will let us rebuild the devastated infrastructure in minimal time.

The idea; the whole set up should be underground so that the effect of solar flares is minimal; is skewed. In the above case the devastation could be caused by earthquakes etc. It should also not be the case that the whole system is wireless; because in this case the effect of solar flares is maximum.

The remedies must be local and regional as vulnerability of solar activity is a function of geographical latitude. GIC's flow in and out of power grids through various points. Currents have been measured due to the above phenomena in US and Finland.

The earth's horizontal geo electric field and its intensity along with nature of equipment is used to determine how devastating the effects of solar flares will be.

It is also established that some areas are affected more than others due to solar flares, coastal regions due to GIC's flowing in the ocean are more susceptible to such effects. During the peak cycle the effect will be all the more dangerous.

GIC's can cause transformers to be driven into half life saturation. Only a few amperes of current are required to disrupt transformer operations. Stray flux can enter the transformer tank and current windings which can lead to localized hot spots leading to premature failure of transformers. GIS's can lead to excessive gas evolution within the transformer which can lead to increased vibrations and noise levels.

VII. What can be done

There is a lot that can be done. For instance, series capacitors could be used to block the flow of GIC in transmission lines or neutral-blocking capacitors in transformer neutrals. This has been suggested in many papers as well. But the point remains that this would be expensive.

Today not many utilities as yet follow specific guidelines to protect themselves from the devastation. These guidelines are invoked to protect the security and stability of the power system.

For utilities to determine properly guidelines for what to do during GIC events, they must set up a process to be followed.

Some of the scientists have also suggested that they should include an evaluation of the risk of harmonic resonances

Generally, a utility can develop an appropriate mitigation strategy by collecting information from GIC monitors in the utility system and then following an organized approach in setting up operating guidelines.

VIII. Conclusion and future scope

Having analyzed the harms that can be caused by solar flares the aim now is to concentrate the electrical setup that would prevent the copper wires and grids from its effects. 5 papers have been selected and are being studied. Moreover it is intended to take the suggestions of the scientists who are working on the components of the solar flares so that the setup will be as robust as possible. The work is not the last word but a window to the exertion that will have to be done to minimize the effect of solar flares on the communication system.

References

[1] Davies, K. 1966. Ionospheric Radio Propagation. Dover Publication Inc.: New York.

[2] Davies, K. 1990. *Ionospheric Radio*. Peter Peregrinus, Ltd.: London

[3] Ratcliffe, J.A. 1960. *Physics of the Upper Atmosphere*. Academic Press: New York

[4] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[5] Scherer, K., H. Fichtner, T. Borrmann, J. Beer, L. Desorgher, E. Flukiger, H.-J. Fahr, S.E.S. Ferreira, U.W. Langner,

[6] M.S. Potgieter, B. Heber, J. Masarik, N.J. Shaviv and J. Veizer (2006) Interstellar-terrestrial relations: variable cosmic environments, the dynamic heliosphere, and their imprints on terrestrial archives and climate, *Space Science Review,* ***Vol. 127,***

[7] (2001) 400 years of large fluence solar proton events, *Proceedings of 27th ICRC at Hamburg,* ***8***, 2001, pp.3209-3212.

[8] Lakhina, G.S., S. Alex, B.T. Tsurutani and W.D. Gonzalez, (2005) Research on historical records of geomagnetic storms.

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