PRELIMINARY ALGORITHMS FOR SOLAR PROTON EVENT PARAMETERS PREDICTION

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ABSTRACT

From the solar events set of low metric intensity associated with proton events with E > 10 MeV and intensity $I_{>10} \geq$ 1-5 $cm^{-2}s^{-1}sr^{-1}$, new algorithms for proton flux maximum intensity near Earth were obtained. Microwave radioemission maximum and solar event heliolongitude were used as independent variables. An approximation to the directivity diagram of such events located at central solar meridian is presented and compared with the directivity diagram for solar events of high metric radioemission intensity before obtained. These directivity diagrams of proton flux maximum intensity near Earth and their relation with the solar event heliolongitude respect solar central meridian are in good agreement with the observations. This quantitative information about proton flux must be taken into account as a part of Spatial Weather Forecast.

Key Words : Proton Flare, Sun, Sun-Earth Prediction, Diagnostic, Prediction, Software, Radioemission.

INTRODUCTION

The study of solar proton events is very important to understand the radio emission processes involved in the dynamics of solar events. It is important to obtain an experimental relation of the solar proton flux intensity in terms of the microwave radio emission intensity and the flare's position at the Sun as an indicator of solar event location [7].

There are many experimental results about the attenuation of solar proton flux intensity as a consequence of the propagation of these particles in the interplanetary media, and there is also strong evidence of the dependence of the intensity with the position of the flare site at the Sun (heliolongitude). For solar proton events with a low metric component the attenuation factor variability is of the order of 10^2 [6], and for events of high metric component is of 10^4 in order as reported [5].

Quantitative and qualitative burst diagnostic and proton flux parameter prediction were obtained in 1989 [6]. Figure 1.

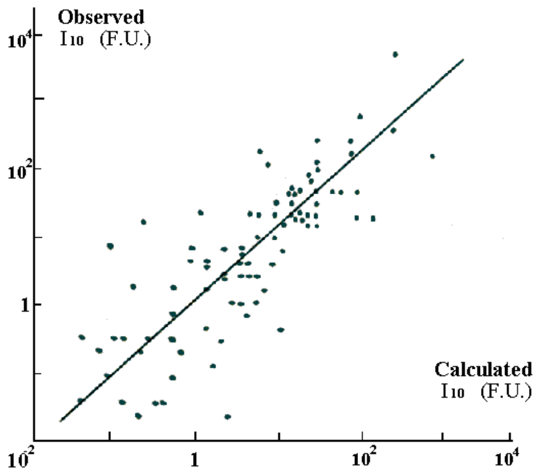

Figure 1: Proton Flux Intensity relation between observed and calculated values

A retrospective assessment with independent data (1987 - 1990), was made [9], while a first version software was developed [4].

From October 1991 to June 1993 the burst diagnosis and proton flux parameter prediction in operative time in Havana Radioastronomical Station were made, and results were used by our ionospheric service [10].

Later we obtain new preliminary algorithms for proton events of high metric component [5].

In the present paper new preliminary algorithms to improve solar proton event predictions is presented, along with a statistical approximation to the proton flux intensity for events with a low metric radioemission level at Sun high corona.

OBSERVATIONAL DATA AND ANALYSIS

The observational data are derived from time profiles of fixed frequency (6.7 GHz, 9.5 GHz and 15GHz). To obtain the algorithms, twenty solar events with low metric radioemission, which are clearly related with well measured proton events at Earth, were analyzed. They are proton events with energies $E > 10$ MeV and with intensity $I_{>10} \geq 1\text{-}5$ $cm^{-2}s^{-1}sr^{-1}$, which was well identify with solar events that shown a flare in visible solar disk [-90,90] reported by the Solar Geophysical Data (1966-1986) [8].

Microwave burst radioemission intensity maximum (S_F) and flare heliolongitude (θ) at Sun visible hemisphere $\theta \in$ [-90, 90] were used as independent variables. The relations were obtained by linear regression method.

The obtained relations for S_F at frequency 6.7, 9.5 and 15 GHz:

$\text{Log I7} = 2.20*(\text{LogS7}) - 1.53*10^{-4}*\theta^2 - 6.07$
$\text{Log I9} = 1.94*(\text{LogS9}) - 1.39*10^{-4}*\theta^2 - 5.48$
$\text{Log I15} = 1.49*(\text{LogS15}) - 1.34*10^{-4}*\theta^2 - 3.85$

The respective correlation and standard error for these relation:

Correlation.	Std. Error
0.86	0.54
0.82	0.60
0.81	0.62

These relations allows to calculation of the proton flux intensity using only one of these three observational frequencies at centimetric band, for solar events with burst of low metric radioemission intensity. These expressions also allows for the simplification of software algorithms to calculate the intensity parameters of the proton flux without loss in accuracy.

The approximately quadratic dependence with the heliolongitude of the proton flux intensity logarithm is clear in the obtained relations. This is a consequence of the strong interaction between interplanetary media and proton flux before it arrives to the Earth.

Using the iterative approximation method we obtain the directivity diagram.

$$\phi_7 = -1.53*10^{-4}*\theta^2 + 0.38$$

$$\phi_9 = -1.39*10^{-4}*\theta^2 + 0.30$$

$$\phi_{15} = -1.34*10^{-4}*\theta^2 + 0.99$$

The proton event directivity diagram in polar coordinates seen from the Sun at solar central meridian is shown in figure 2.

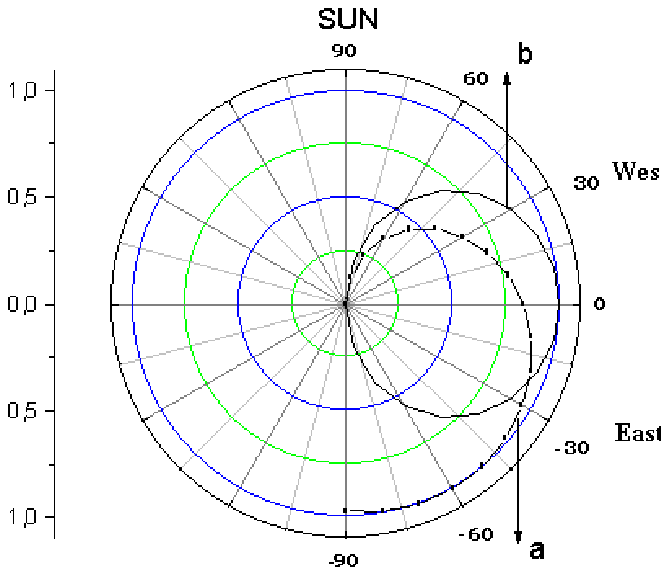

Figure 2: Proton flux intensity directivity diagram seen from the Sun (7 GHz)

a- *Solar events of high intensity metric radioemission component*

b- *Solar events of low intensity metric radioemission component*

The proton flux propagation difference between events at different radioemission level in metric band is shown.

From the Sun towards to the West the proton flux of low metric intensity events are better propagated; as a consequence, such events seen from Earth at the East side of solar central meridian are more dangerous.

Moreover in the case of the proton flux of high metric intensity events seen from the Sun are better propagates towards to the East than the low metric intensity events. This explains why the events seen from the Earth observed at the West side of solar central meridian are the most dangerous.

CONCLUSIONS

The relation between solar proton flare, coronal mass ejection from the Sun and magnetic configuration of magnetic field was considered in accordance with others results [1,2,3].

For the case of a low metric radio emission the magnetic configuration blocks the escape of particles from the lower corona active region, and in consequence the proton directivity diagram is enhanced.

The obtained algorithms exhibit the strong dependence of the proton flux intensity at the Earth with the heliolongitude parameter, and brings us the possibility of proton flux intensity prediction.

This quantitative information about proton flux must be taken into account as a part of Spatial Weather Forecast.

REFERENCES

[1] -Akinjian, S. T., V. V. Fomichev, y I. M. Chertok, (1977): "Solar proton flux parameters determination near the Earth by burst I: Intensity function. II: Heliolongitude weakness function", Geomagnetism and Aeronomy , 17(1,2): 10-15; 177-183.

[2] -Bazilievskaya G. A., Sladkova A. I., Fomichev V. V., Chertok I. M. (1990): "Possible relation between solar proton fluxes in the interplanetary space, and the formation of coronal loop systems after flare". Astronomicheski Zhurnal t. 67, No 2, pp 409-419.

[3] -Cyr O. C. St., Burkepile J. T. (1990): "A catalogue of Mass Ejections Observed by the Solar *Maximum Mission Chronograph High Altitude Observatory. National Center for Atmospheric Research, Boulder, Colorado, USA.

[4] -Del Pozo E. (1990): "Solar events diagnosis and proton flux parameter prediction at Earth, Software and Manual User". Unpublished.

[5] Del Pozo. E., Valiente J.F. "Directivity Diagram of the Protonic Flux Intensity in the Solar Events at the Level of the Earth Orbit", in Proceedings of IV Latin American Congress an Spaces Geophysic (COLAGE), 1996. (Eds) T. Heredia and A.G. Elias, Tucumám National University, Argentina.

[6] Fomichev V.V., Chertov I.M., Del Pozo E., (1989): "Proton Flux Intensity determination at Earth using Solar burst and its frequency spectra".

[
7] Fomichev V.V., Chertov I.M., Del Pozo E., (1989a): "Proton Flux energy spectral index determination at the Earth using the frequency spectra of microwave burst".

[8] -Solar Geophysical Data (1966-1986): National Geophysical Solar Terrestrial Data Center A, Boulder, Colorado,USA.

[9] –Del Pozo E., Chertok I.M. " Proton Events Analysis and Proton Flux Prediction of the Period of 1987-1990 on Bases of the Havana Radioastronomic Station and the GOES satellites Observations".

[10] Valiente J.F., Del Pozo E. "Solar Burst Diagnostic and Proton Flux Prediction in the Period from October 1991 to June 1993. Application", Unpublished.