INTERNATIONAL JOURNAL OF GEOMAGNETISM AND AERONOMY
VOL. 6, GI3006, doi:10.1029/2006GI000134, 2006

Discussion paper: Electrostriction and magnetostriction arising under the action of large-scale interplanetary magnetic field inhomogeneities on the Earth

N. N. Volodichev

Nuclear Physics Research Institute, Moscow State University, Moscow, Russia

Received 6 December 2005; accepted 9 August 2006; published 28 November 2006.

[1] When the interplanetary magnetic field polarity changes, the Earth experiences the influence of the interplanetary field, which gives rise to short bursts of intensity of neutron emission from the Earth. This is likely to be associated with deformation of the Earth's crust that can be caused by electrostriction and magnetostriction arising under the action of large-scale interplanetary magnetic field inhomogeneities on the Earth's magnetosphere. In all probability, no increase in the Earth's seismic activity occurs in this case. *INDEX TERMS:* 2134 Interplanetary Physics: Interplanetary magnetic fields; 2114 Interplanetary Physics: Energetic particles; 2784 Magnetospheric Physics: Solar wind/magnetosphere interactions; *KEYWORDS:* Interplanetary magnetic field; Electrostriction; Magnetostriction.

Citation: Volodichev, N. N. (2006), Discussion paper: Electrostriction and magnetostriction arising under the action of large-scale interplanetary magnetic field inhomogeneities on the Earth, *Int. J. Geomagn. Aeron., 6,* GI3006, doi:10.1029/2006GI000134.

1. Introduction

[2] During relatively quiet periods of solar activity, the interplanetary magnetic field (IMF) has the so-called sector structure, when the field is directed toward the Sun during several days, then away from the Sun, and so on. In order to describe these observations, the term "magnetic sector" was introduced. Depending on the phase of the solar activity period, the number of the sectors can vary from two to six. When the Earth crosses the boundaries of magnetic sectors, the reversal of the IMF polarity can occur during approximately 24 hours and even longer time. It should be noted that the notion of the boundary and its position between magnetic sectors is somewhat conventional. In the majority of cases, crossings of a fairly wide boundary region between sectors which is filled by "small" sectors whose number is more than that of "large" sectors takes place several days. Therefore the change of the IMF polarity near the Earth can also take place when the Earth crosses the boundaries between "small" sectors. As observations at about 1 a.u. have shown, the magnetic sectors are associated with high-speed solar wind streams, which rotate together with the Sun (like magnetic sectors) and have an occurrence period of about 27 days, i.e., they are as recurrent as magnetic sectors. Each powerful high-speed stream is connected with the magnetic polarity on the Sun, which determines the magnetic sector polarity. As a rule, the high-speed stream is observed at the Earth's orbit near the leading edge of the magnetic sector. Beginning from the undisturbed level (300–400 km s^{-1}), the stream velocity reaches its maximum value (600–700 km s^{-1}) during approximately a day, while relaxation to the undisturbed level requires several days. In addition, a short-term, but very strong, increase (in several times) of the plasma density occurs near the leading edge of the stream, after which the density decreases. During a slow decrease in the stream velocity the density is at a lower level than in the undisturbed solar wind. In the most high-speed stream, the proton temperature increases in several times, while variations in the proton temperature are similar to variations in the stream velocity. The observed magnetic polarity, i.e., the sign of the radial field component remains typically unchanged inside each high-speed stream. The duration of a typical stream is about 5 days [*Veselovskiy*, 1983; *Zeldovich*, 1983].

1524–4423/06/2006GI000134$18.00

2. Experimental Results

[3] Our investigations have shown that when the IMF polarity near the Earth changes, the Earth's crust is subjected to the action of the IMF inhomogeneities, which gives rise to the neutron emission from the Earth's surface in the form of short-term bursts. The mechanism of neutron production in this case can be supposed to be similar to that of the gravitational influence of the Moon and the Sun on the

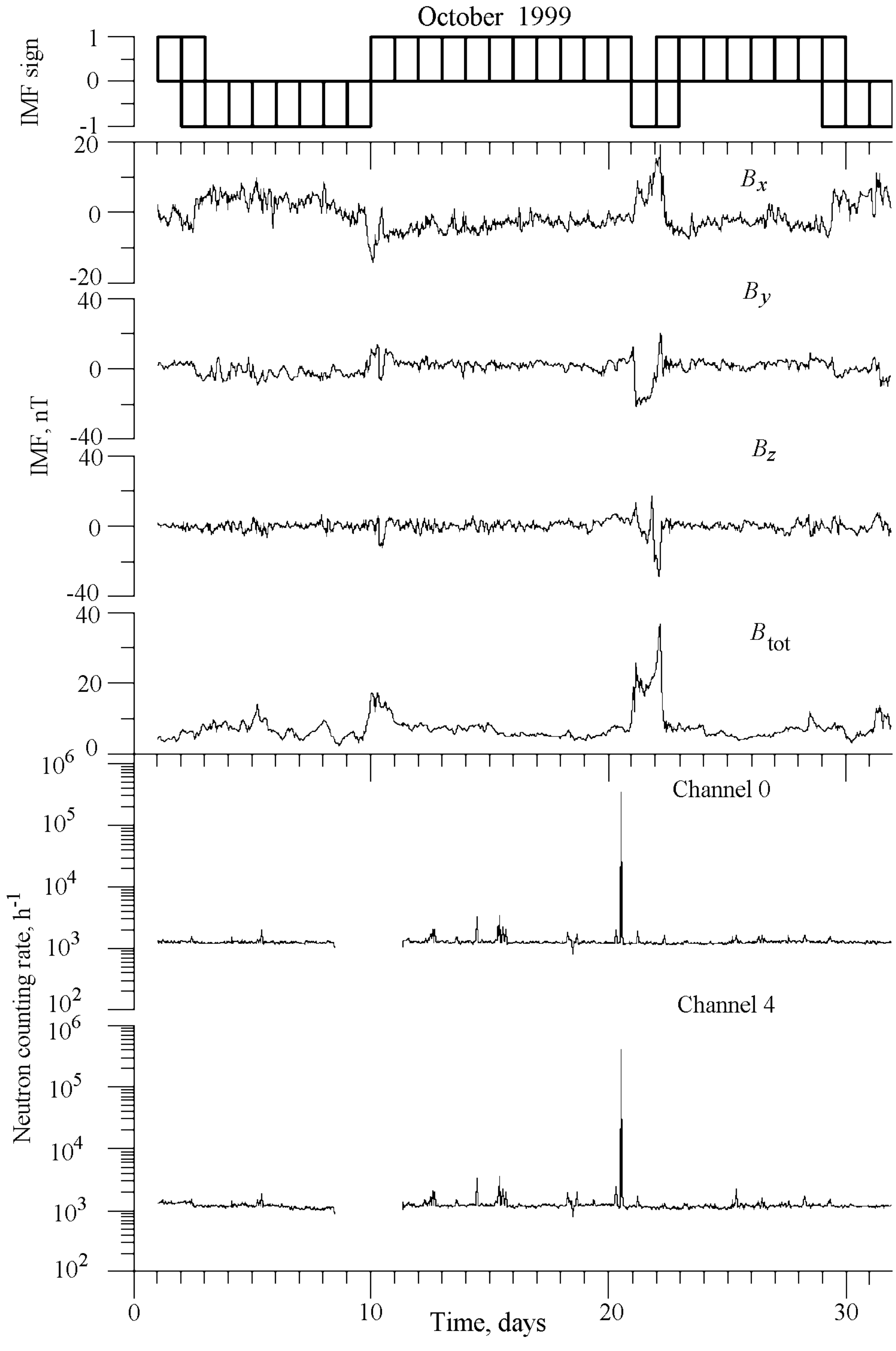

Figure 1. Burst of neutron emission intensity on 20 October 1999 in Moscow on the days of the IMF polarity reversal and variations in the IMF strength associated with it.

Earth at the new Moon and the full Moon, i.e., it is associated with deformation of the Earth's crust with a subsequent release of radioactive gases of radon isotopes. Then the interaction of alpha particles resulting from the decay of radon isotopes with nuclei of the constituents of air and the Earth's crust gives rise to neutron production [*Volodichev et al.,* 1997, 2003]. It can be believed in this case that when the IMF polarity changes, the Earth's crust is subjected to deformation and experiences, for instance, the electrostriction and magnetostriction influences of the IMF, which gives rise to minor changes in the linear sizes and volume of the Earth [*Frish and Timoreva*, 1953].

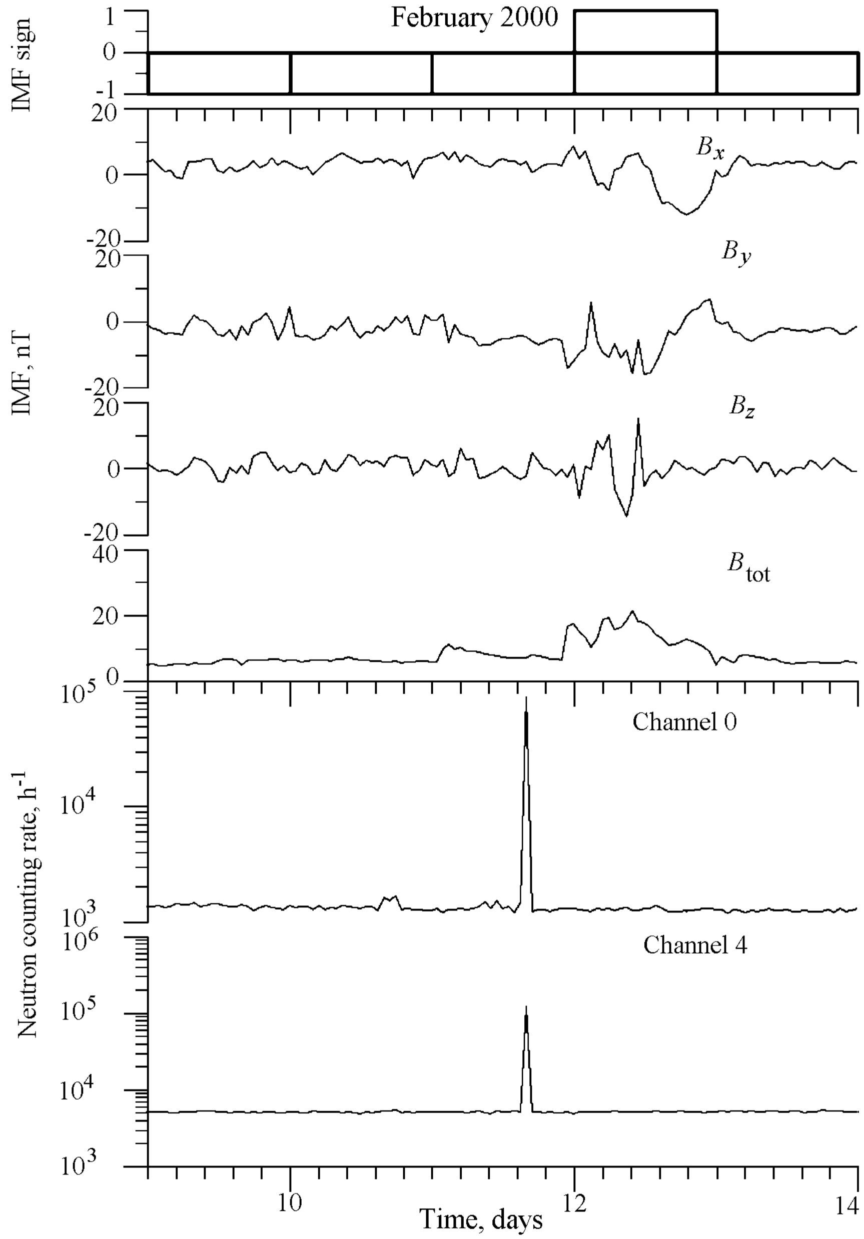

Figure 2. Burst of neutron emission intensity on 11 February 2000 in Moscow on the days of the IMF polarity reversal and variations in the IMF strength associated with it.

[4] We have analyzed information for 14 months: August, October, and November of 1999, January, February, March, and April of 2000, February of 2001, March, May, and December of 2002, and January, February, and March of 2003 [*Kuzhevskij et al.*, 2003]. During this period the IMF polarity near the Earth varied 70 times. As a rule (in 95% of the cases), the change in the IMF polarity was accompanied by variations in the IMF strength, the field strength changing in several times, and sometimes by an order of magnitude. The neutron instrument at the Institute of Nuclear Physics [*Kuzhevskij et al.*, 1996] detected 40 bursts of neutron emission intensity during this time. Eighteen of these bursts coincide in time with the time of the IMF polarity reversal and onset of the IMF strength variations. Figures 1, 2, and 3 show examples of detection of neutron bursts during the IMF polarity reversal and strength variations in Moscow in October of 1999 and February of 2000 and simultaneous detection of neutron bursts in Tien Shan and Moscow in August of 1999. In addition to neutron emission bursts, the figures schematically show the IMF polarity and the strength of the full field and its components (http://www.srl.caltech.edu). Figures 4 and 5 present the events of October of 1999 (Figure 1) and February of 2000 (Figure 2) mentioned above, but in contrast to these figures, Figures 4 and 5 give the so-

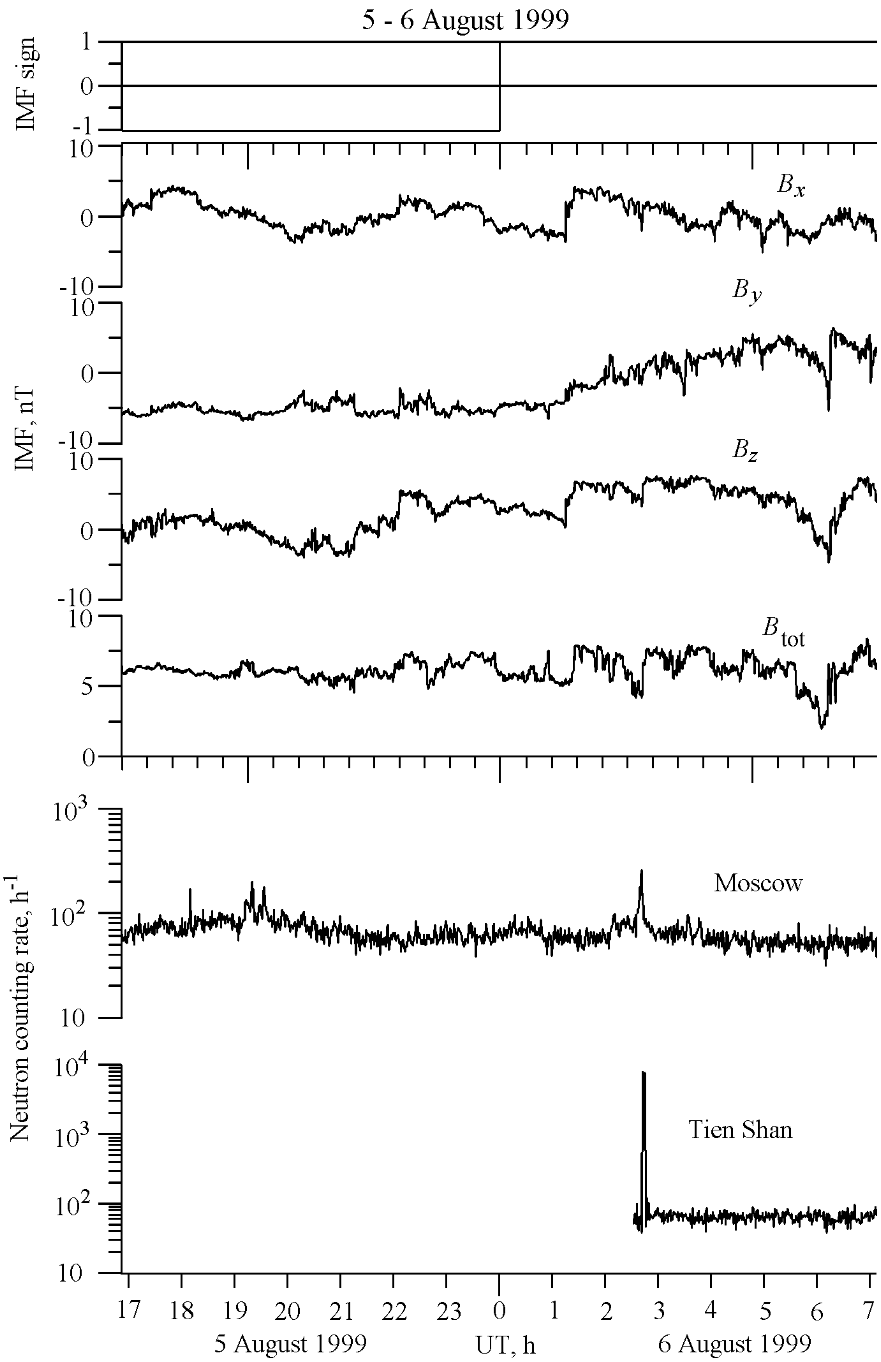

Figure 3. Bursts of neutron emission intensity on 6 August 1999 in Tien Shan and Moscow on the days of the IMF polarity reversal and variations in the IMF strength associated with them.

lar wind parameters for these time periods, i.e., solar wind velocity, density of solar wind protons, and temperature of solar wind protons (http://www.srl.caltech.edu). Neutron channels 1 and 2 (the first instrument) give information about the counting rate of the neutrons detected by two independent instruments, analogous information is provided by channels 0 and 4, respectively, of the second instrument. The onset of the neutron emission burst on 20 October 1999 is close in time to the beginning of crossing of the high-speed solar wind stream by the Earth (Figures 1 and 2), and this can be the reason for the IMF polarity change at that time. The same is true for neutron bursts on 11 and 23 February 2000 (Figures 3 and 4). The investigations have shown that the burst of 24 February 2000 (Figure 4) is due to electri-

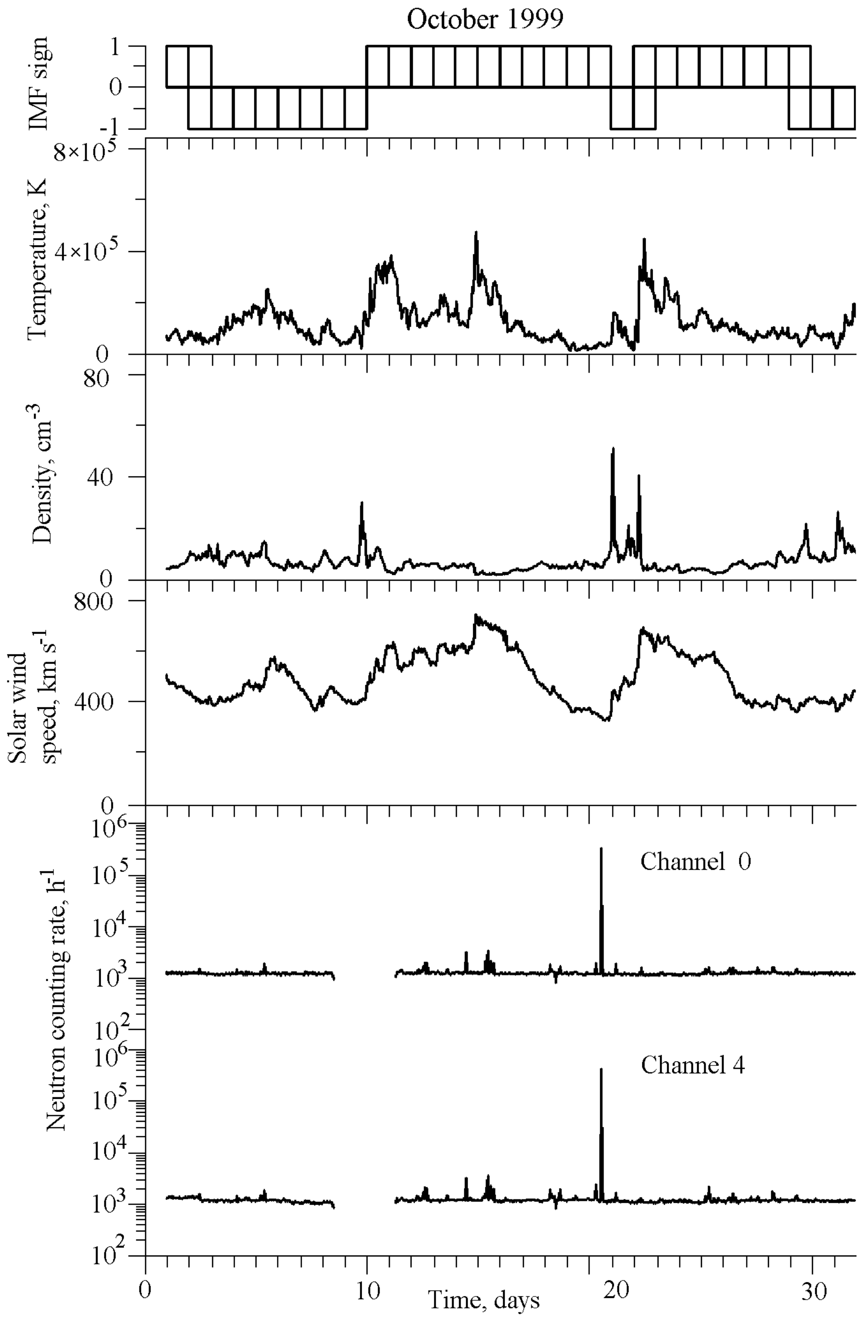

Figure 4. Burst of neutron emission intensity on 20 October 1999 in Moscow on the days of the IMF polarity reversal and crossing of the high-speed solar wind stream by the Earth.

cal interference. The neutron emission bursts on 6 August 1999 (Figure 5) can be caused by the change of the IMF polarity at crossing of "small" IMF sectors by the Earth. Therefore it can be concluded that when the Earth enters the inhomogeneous IMF, it experiences the electrostriction and magnetostriction influences of the IMF, and emission of neutrons by the Earth's crust is one of the responses to this influence.

3. Is the Seismic Activity of the Earth Associated With the IMF Sign Reversal?

[5] In order to estimate the degree of deformation of the Earth's crust at the IMF polarity reversal and crossing of the high-speed solar wind streams by the Earth and to under-

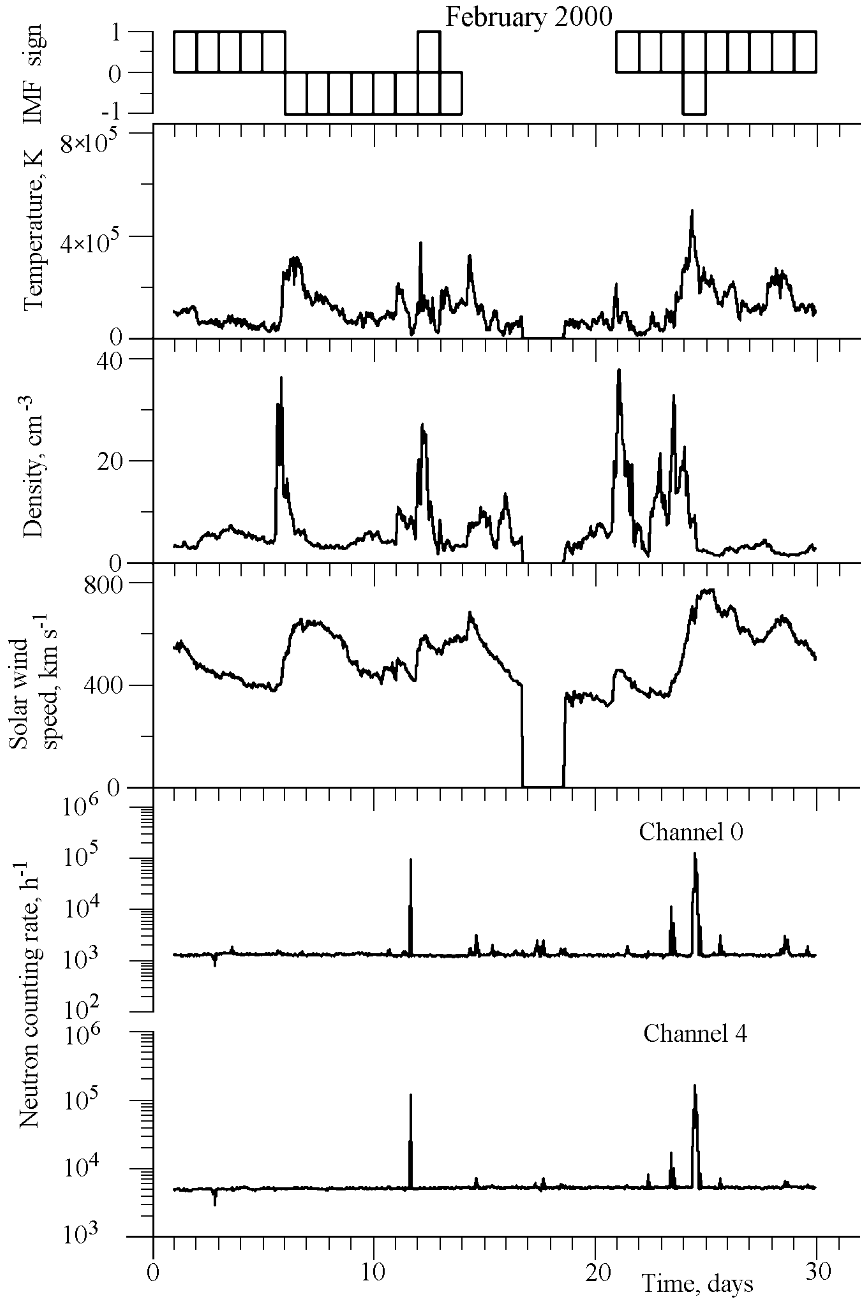

Figure 5. Bursts of neutron emission intensity on 11 and 23 February 2000 in Moscow on the days of the IMF polarity reversal and crossing of the high-speed solar wind stream by the Earth. The burst on 24 February is due to electrical interference.

stand whether the Earth's seismic activity can be initiated in this case, we plotted the distribution of the earthquakes with magnitudes $m(b) > 6.3$ detected over the Earth in 1970–1992 versus the interval between the day of the earthquake and the nearest day of the IMF polarity reversal near the Earth. The number of the earthquakes with magnitudes $m(b) > 6.3$ was 210 during this period. The obtained distribution is shown in Figure 6. The distribution maximum is seen to coincide with the day of the IMF polarity reversal. The distribution includes 144 earthquakes. The total number of the earthquakes in Figure 6 is limited because of insufficient data on the IMF polarity reversal near the Earth (the information was retrieved from http://www.srl.caltech.edu). The information about the earthquakes was taken from the Global database designed by the US Geological Survey National Earthquake Information Center. In order to understand the nature of the obtained distribution, we plotted another distribution versus the interval between an arbitrarily selected

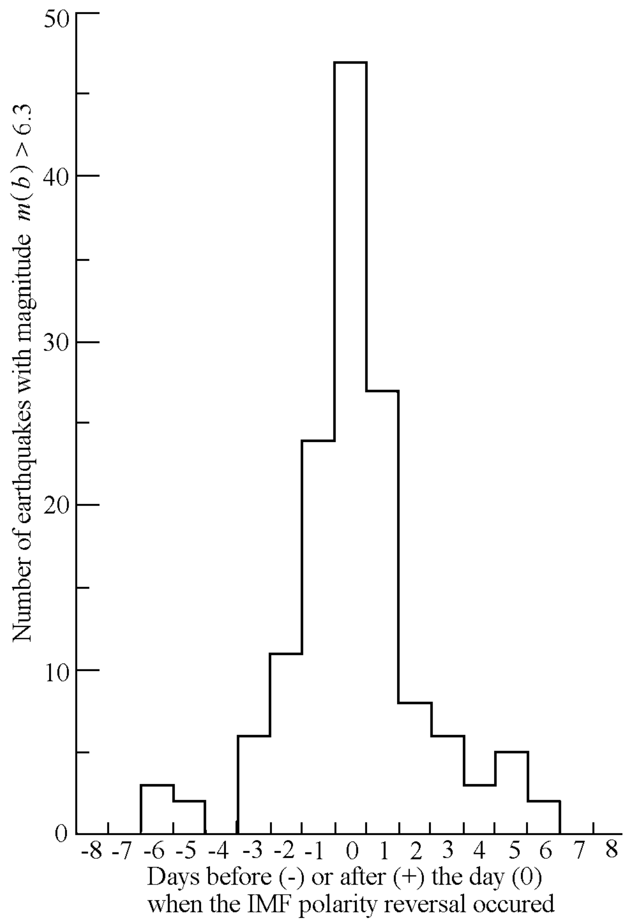

Figure 6. Distribution of earthquakes with magnitude $m(b) > 6.3$ over the Earth for 1970–1992 versus the interval between the day of the earthquake and the day of the IMF polarity reversal near the Earth.

day and the nearest day of the IMF polarity reversal near the Earth. The arbitrary days were chosen to be the first days of all the months in 1970–1992. Of 276 days selected in such a way, only three days coincided with the days of the earthquakes with magnitudes $m(b) > 6.3$. The obtained distribution is presented in Figure 7. The distribution includes 209 days, for 67 days the information on the IMF polarity was not available (the data on the IMF polarity were taken from the source mentioned above). If the distributions given in Figures 6 and 7 are reduced to the same statistics and statistical errors are taken into account, the distributions turn out to be similar to each other. This means that the seismic activity of the Earth is in no way associated with the IMF sign reversal. The obtained distributions simply demonstrate a randomness in the distribution of the IMF polarity reversals near the Earth.

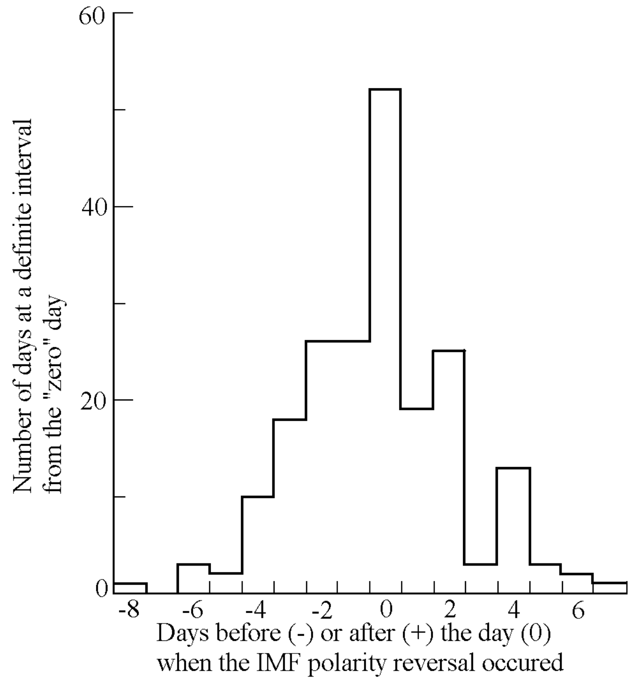

Figure 7. Distribution of time intervals between arbitrarily chosen days and the nearest days of the IMF polarity reversal ("zero" days) in 1970–1992.

4. Conclusions

[6] To summarize, it should be noted that the IMF polarity reversal near the Earth can result in the electrostriction and magnetostriction influences of the IMF on the Earth, which initiate short-term neutron emission bursts by the Earth's crust. It can also be stated that the distributions presented in Figures 6 and 7 demonstrate a random distribution of a multitude of fairly strong IMF discontinuities rather then an increase in the seismic activity of the Earth at the IMF polarity change.

[7] **Acknowledgments.** The author thanks I. S. Veselovskiy, E. I. Daibog, M. A. Zeldovich, and A. N. Podorolski for their participation in the discussion of the work. The work was supported by the Russian Foundation for Basic Research, project 05-05-65267.

References

Frish, S. E., and A. V. Timoreva (1953), *A Course of General Physics, vol. 2, Electrical and Electromagnetic Phenomena* (in Russian), 504 pp., Glavizdat, Moscow.

Kuzhevskij, B. M., O. Yu. Nechaev, P. I. Shavrin, E. A. Belyaeva, and I. I. Sirotkin (1996), *Variations in the neutron concentration in the field of thermal neutrons of the Earth's atmosphere, preprint 96-7/414* (in

Russian), 18 pp., Moscow State Univ., Moscow.

Kuzhevskij, B. M., O. Yu. Nechaev, M. I. Panasyuk, E. A. Sigaeva, and N. N. Volodichev (2003), Variations in the neutron field of the Earth and changes in the cosmic weather, paper presented at Conference of CIS and Baltic Countries, Inst. of Appl. Phys., Russ. Acad. of Sci., Nizhniy Novgorod.

Veselovskiy, I. S. (1983), Solar wind and the interplanetary magnetic field, in *Model of the Space, edited by S. N. Vernov* (in Russian), p. 148, Moscow State Univ., Moscow.

Volodichev, N. N., B. M. Kuzhevskij, O. Yu. Nechaev, M. I. Panasyuk, and P. I. Shavrin (1997), Occurrence of neutron intensity bursts during phases of the new Moon and full Moon, *Space Res.* (in Russian), *35*(2), 144.

Volodichev, N. N., B. M. Kuzhevskij, O. Yu. Nechaev, M. I. Panasyuk, A. N. Podorolski, and P. I. Shavrin (2003), Solar-lunar-terrestrial interaction: bursts of neutron emission and seismic activity, *Int. J. Geomagn. Aeron., 4*(3), 251.

Zeldovich, M. A. (1983), The structure of the interplanetary space and energetic particles, in *Model of the Space, edited by S. N. Vernov* (in Russian), p. 186, Moscow State Univ., Moscow.

N. N. Volodichev, Nuclear Physics Research Institute, Moscow State University, Leninskie Gory, 119992 Moscow, Russia. (nnvol@srd.sinp.msu.ru)