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160-MIN VARIATION OF THE RIOMETER ABSORPTION

S.N. Samsonov, V.D. Sokolov, N.G. Skryabin *(Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy, Yakutsk, Russia)*

Abstract. From the ground riometer measurements of cosmic radio noise level at the frequency of 32 MHz at Tixie station, the 160-min oscillation and its 80-min mode have been revealed. It is shown that such oscillations can arise due to pulsations of (1) radio noise source proper, (2) neutral atmosphere parameters, and (3) precipitation particle fluxes. The influence of each of the above factors on the level of cosmic radio noise oscillations is discussed.

Introduction

By now, a great number of studies have been devoted to the 160-min variations in the solar brightness and size [Didkovsky and Kotov, 1988; Kotov et al., 1988], relative radio brightness [Yeryushev et al., 1979], magnetic field [Demidov et al., 1990] and also in some extragalactic objects [Kotov and Lyuty, 1988, 1991]. Besides, on the ground, the oscillations with the 160-min period were registered in cosmic ray flux pulsations, atmospheric pressure [Novikov et al., 1985] and in geomagnetic field variations [Gulyelmi et al., 1977]. The nature of the 160-min oscillations is still an open question. In the studies [Severny et al., 1976, Kotov and Kotov, 1996] it is supposed that the 160-min oscillations have a cosmological origin. The aim of the present paper is to search for signatures of 160-min oscillations in the auroral absorption. The auroral absorption at high latitudes is mostly caused by the precipitation of energetic electrons from the Earth's magnetosphere and additional ionization of the ionospheric D-layer. It is registered on the Earth's surface with a riometer as a change in the cosmic radio noise level.

Data

Riometer measurements of cosmic radio noise at 32 MHz were performed at Tixie Bay station (71.6N, 129.0E) in December 2002. The antenna of "wave channel" type is directed to the North Star. The antenna field of view at the height of 90 km presents a slightly deformed circle of about 100 km in diameter. About 30 thousands of 1-min measurements in the time interval from December 6 to 31, 2002 were used in the treatment. All data were subject to the spectral analysis with using probabilistic filtration in order to decrease pulsations with periods greater than 200 min. To reveal the modes with the period shorter than 160 min, the following procedure was performed: all data were divided into 160-min intervals, then three periods before and after the chosen interval were treated using the superposed epoch technique. As a result, all oscillations with the same phases were summarized. Because of summarizing, the rest oscillations were smoothed out. The whole dataset was consistently treated by the technique analogous to sliding-average technique. As a result, we obtained a new dataset, in which the oscillations having the same phases were preserved and enhanced relative to the statistically distributed ones. This data file was exposed to the spectral analysis, which results are presented in Fig 1. The horizontal dashed lines correspond to the confidence level of 95% and 99%. Thus, the spectral analysis proves that in riometer data there exists the 160-min variation and its 80-min harmonics.

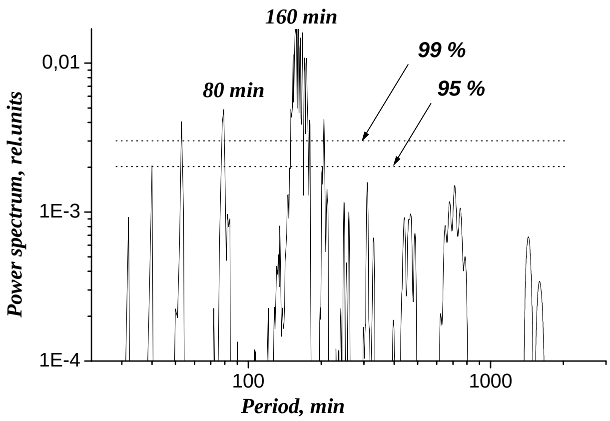

Fig.1. The power spectrum of riometer absorption oscillations. The horizontal dashed lines correspond to the confidence level of 95% and 99%.

To determine the type of 160-min variation, the data smoothed in the 10-min interval were treated using the superposed epoch technique with a 160-min period, starting from 0515 UT on December 6, 2002. Fig. 2a presents the results of such a treatment. The root-mean-square error of separate (minute) measurements is about 0.5 units of the instrumental count. The curve “a” is close to a sinusoid, with the variations of another period imposed. Supposing that this can be 80-min mode, the data were treated using the superposed epoch technique with a period of 80-min. The result is presented by the curve “b”(two 80-min periods are shown). In order to extract a “clear” 160-min variation, the curve “b” was subtracted from the curve “a”. The difference curve “c” essentially differs from sinusoid. The value of 160-min variation of the riometer absorption is equal to 8.5 units of the instrumental count, that is about 0.5% of the average cosmic radio noise level.

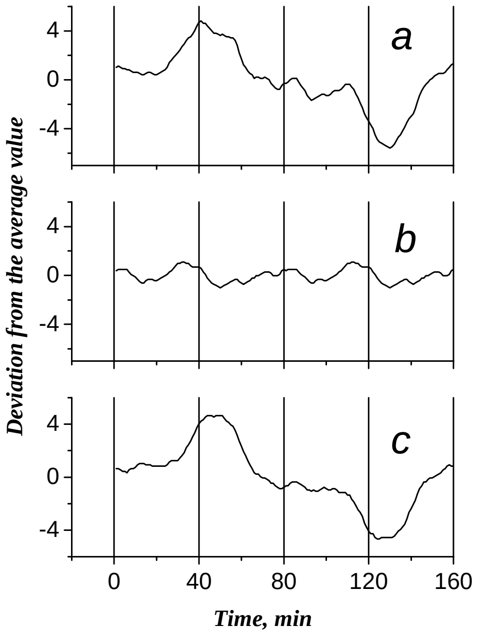

Fig.2. Signatures of riometer absorption oscillations obtained by application of superposed epoch technique with 160 (a) and 80 (b) - min periods to the riometer data. The curve (c) results from subtracting curve (b) from curve (a) and represents a “clear” 160-min variation.

Discussion

The level of cosmic radio noise measured on the Earth’s surface varies for a number of reasons.

1. The primary intensity of cosmic radio noise is subject to variation. At present, it is considered that beyond the atmosphere, cosmic radio noise intensity from a given direction of the firmament is a constant value.
2. The parameters of the neutral atmosphere, through which the radio wave passes, can vary. The absorption of radio wave energy depends on the electron concentration and frequency of collisions with neutral particles. Therefore, as the atmosphere parameters (density, temperature, chemical composition) vary, the cosmic radio noise level is also subject to variation.
3. There are changes in the flux of precipitating energetic electrons, leading to changes in the electron concentration.

In our opinion, three above reasons are principal, although there can be minor ones. If we adopt that the 160-min oscillation is of cosmological origin [Severny et al., 1976; Kotov and Kotov, 1996], then it is quite probable that cosmic radio noise primary intensity suffers the 160-min variation. In this case, its manifestation in the riometer absorption is quite natural.

In principle, a change of the background parameters, for example, of electron density under the action of solar light and hard electromagnetic radiation is possible. However, the data on riometer absorption during solar eclipse show that, when the solar source is totally absent, the effect is only 0.23 dB [Sokolov et al., 1998]. The best known effect of the solar eclipse in riometer data is 0.5 dB [Sears, 1965]. Curve “c” in Fig.2 indicates that the summary effect of 160-min variation in the riometer absorption is about 0.022 dB, i.e. 5÷10 per cent of the absorption change, when the solar source is absent. Hence, in order the fluctuations in the light and harder radiation from the Sun to be a reason of the observed 160-min variation of riometer absorption, it is necessary that they fluctuate at least over the same 5÷10%, which is not observed.

The precipitating electrons can be related to the 160-min variations in riometer data. For this to be the case, the electron precipitation mechanism or governing physical parameters, for example, the intensity of geomagnetic field or interplanetary magnetic field should exhibit fluctuations of the same period. Up to now there is no evidence whether this is true.

Conclusion

1. The 160-min variation in the level of cosmic radio noise has been found, which amplitude is about 0,5 per cent of the average level of cosmic radio noise on the Earth's surface.
2. Riometer data also exhibit the 80-min mode of 160-min variation.
3. By now, the nature of riometer absorption variation with a period of 160-min has not been revealed.

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References

Demidov M.A., Kotov V.A., Grigoryev V.M. On short-periodic variations of a global solar magnetic field // Issues of the Crimean Astrophysical Observatory. V.82. P.147-152. 1990.

Didkovsky L.V., Kotov V.A.. Periodic variations of Sun's brightness: the experience of observations with the 1024-channel matrix // Issues of the Crimean Astrophysical Observatory. V.80. P.124-130.1988.

Gulyelmi A.V., Vladimirsky B.M., Repin V.N. On a geoefficiency of solar surface oscillations // Geomagnetism and Aeronomy. V.17. №5. P.930-932. 1977.

Kotov V.A., Lyuty V.A. Photometry of Seyfert galaxy of MGC 4151 and quasar 3C 273: the period of 160,010 min // Issues of the Crimean Astrophysical Observatory. V.78. P.89-111. 1988.

Kotov V.A., Severny A.B., Tsap T.T. The 160-min solar oscillations: Observations for the 1974 to 1986 period // Issues of the Crimean Astrophysical Observatory. V.79. P.3-11. 1988.

Kotov V.A., Lyuty V.M. The 160-min oscillations of some extragalactic objects. // Issues of the Crimean Astrophysical Observatory. V.83. P.216-230. 1991.

Kotov V.A., Kotov S.V. On a solar seismology to the restrictions of the standard cosmology // Issues of Institutes of Higher Education. Radio physics. V.39. №10. P.1204-1209. 1996.

Novikov A.M., Rudnev Yu.F., Skryabin N.G., Starina V.A., Ulyanov V.P. Pulsations of cosmic rays and atmospheric pressure near the 160- and 80-min periods // Geomagnetism and Aeronomy. V.25. №3. P.494-495. 1985.

Sears R.D. Cosmic Noise Absorption and VF Phase Measurements on the Eclipse of May 30, 1965 // J.Geophys.Res. V.70. №23. P.5967-5969. 1965.

Severny A.B., Kotov V.A., Tsap T.T. Observations of solar pulsations. // Nature. V.259. P.87-89. 1976.

Sokolov V.D., Bezrodnykh I.P., Kuzmin V.A., Skryabin N.G. The effect of solar eclipse in riometer data in Yakutsk on March 9, 1997 // Geomagnetism and Aeronomy. V.38. №2. P.139-140. 1998.

Yeryushev N.N., Kotov V.A., Severny A.B., Tsvetkov L.I. Observations of pulsations of the solar radio emission with a 160-min period in the range of 1,9-3,5 cm // Letters to Astrophys. J. V.5. №10. P.546-551. 1979.