Methods for the Sensing and Evaluation of Ionosphere Changes and Their Impact on the Human Organism

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Abstract— The impact of the environment upon living organisms constitutes a crucial problem examined by today's science. In this context, research institutes worldwide have analysed diverse positive and negative factors affecting the biological system of the human body. One such factor consists in the influence of the surrounding electromagnetic field. This paper presents the results of an investigation focused on ionosphere parameter changes and their impact on the basic function of the nervous system. It is a well-known fact that the frequency of the alpha waves of brain activity [1] ranges within 6–8 Hz. Changes in the electromagnetic and chemical structure of the Earth's surface may cause variation of signals in the above-defined frequency region of 6–8 Hz. Detailed examination of the overall impact of environmental factors upon the human organism is performed within a large number of medical disciplines. The research presented in this paper is concentrated on the sensing and detection of changes in the region of very low frequencies of the electromagnetic field; the authors use both theoretical and experimental procedures to define the effects that influence brain activity.

1. INTRODUCTION

The low-level measurement of low frequencies (0.01–10 Hz) performed to evaluate the effect of magnetic fields on the human organism can be regarded as an interdisciplinary branch of science that embraces different types of research.

The set of provinces subsumed within the discussed subject comprises elementary research disciplines such as particle physics, geophysics, astrophysics, and metrology, which are all related to the investigation of the ionosphere and magnetosphere. Moreover, medical fields and problems, for example neurology and circadian rhythms, are also included in the scope of contributing elements. By further extension, the low-level measurements are interesting from the perspectives of theoretical electrical engineering and research of magnetic fields.

At this point, is is important to consider applied research disciplines, for example the measurement and radar technology in the following ranges: the ULF (Ultra Low Frequency Band: 300 Hz–3 kHz), SLF (Super Low Frequency Band: 30 Hz–300 Hz, and ELF (Extreme Low Frequency Band: 0.1 Hz–30 Hz). The group of auxiliary subjects or activities includes mathematical modelling of electromagnetic effects, the basics of biomedical research and biological feedback, and the influence of low-level magnetic fields on the human organism. The role of the above-mentioned disciplines is complemented by the fact that human beings do not exist as solitary entities but rather live in a wider community, which is influenced by each of its members. If the external magnetic fields influenced a human being to such an extent that the man or woman would change their behaviour within the social community at a higher level of statistical significance, it would be necessary to employ various questions of economics, mainly the evolution of economic value as a market phenomenon based on human behaviour and decision-making. Scientists and researchers are currently preparing to solve special tasks related to the objectivisation of the impact of low-level magnetic fields upon the human organism; such impact will be examined from the perspective of physical harm to cells [2] and mental condition of humans [3–6]. The current status of knowledge in this field is relatively unsatisfactory, and certain hasty conclusions have been made and found application even in hygienic standards. An example of such standards is the guideline issued by the Council of Europe and implemented by the ICNIRP (International Commission on Non-lonising Radiaction Protection) in 1999 to establish the boundary values of magnetic flux in relation to the speed of magnetic field changes for very slowly changing currents. More concretely, this guideline introduces the value of 50 mT/s as the maximum magnetic flux change acceptable in an environment with a

variable magnetic field at the frequency of 1 Hz and characterised by permanent presence of humans. This value is many millions higher than the largest changes hitherto measured during the processes referred to as magnetic storms, in which the Earth was exposed to charged particles from the Sun.

2. ORIENTATION OF THE METHODS FOR DETECTING IONOSPHERE DISTURBANCES

According to the conclusions of secondary research, there is mutual interaction between low-level electric or magnetic fields irradiated both by humans and the geomagnetic system of the Earth. However, this interaction can be scientifically validated only with difficulty [4, 7]. Some of the reasons for this situation may be inadequate cohesion between the complex description of a human being, his/her biological feedback related to the internal and external electromagnetic fields, the scope of interdisciplinary scientific knowledge, and the complicated structure of devices designed for the measurement of low-level ULF, SLF, ELF of electric, magnetic, and electromagnetic fields [8]. This paper presents a portion of the research conducted in this province by the DTEEE, FEEC BUT; the research is built upon the current knowledge of low-level magnetic fields generated by the geomagnetic system of the Earth and the solar system. The authors of this article have focused their attention on examining the effect of the changes in the Earth's geomagnetic system that are due to solar activity. In this context, the research was also centered on proving the existence of the effect as a result of geomagnetic storms, which substantially influence low-level magnetic fields affecting the human organism, including its behavioural patterns and decisioning.

The detection of changes in geomagnetic field disturbances could be performed by means of the Schumann resonances. Until recently, this oscillation was at the frequency of $f_{\mathrm{sch}} = 7.83\,\mathrm{Hz}$; this frequency changes as a result of the impact exerted by phenomena such as solar wind or greenhouse gases. In 1953, Professor W. O. Schumann of Munich university, Germany, had found out that the cavity between the ionosphere and the Earth's surface could be interpreted as a spherical resonator. After Schumann's results were published in the *Technische Physik* journal, Dr. Ankermueller, a medical specialist, immediately related the resonances to brain wave rhythm (EEG). In 1954, the measurements conducted by W. O. Schumann and Herbert Koenig, who was to become Schumann's successor, confirmed the pulsation of the Earth at the frequency of $f = 7.83\,\mathrm{Hz}$. Koenig then validated the correlation between the Schumann resonances and brain wave rhythms [12].

3. RESEARCH OF GEOMAGNETIC EFFECTS

In polar areas, the solar wind particles captured by the Earth's magnetic field travel along the lines of force to the upper layers of the atmosphere. Here, together with the ultraviolet radiation from the Sun, they excite and ionise neutral atoms. The excited atoms emit a distinctive glow, thus creating the well-known polar aurora. The ionised atoms are captured by magnetic lines of force and travel along them freely. But these are all merely traditional facts.

Ionosphere changes can be objectively measured using already known methods [Fiala, Hanzelka — PIERS2013], Fig. 1. Based on earlier observations, it is possible to demonstrate via secondary research that a connection exists between magnetic field changes and the social behaviour of groups of humans.

The effect of the environment on the human physical, emotional, mental and spiritual coherence was described by Rollin McCraty, who also proposed a link between these factors and the cardiovascular system, with its resonant frequency of 0.1 Hz (the ELF band between 0.04 and 0.26 Hz, given the condition of cardiac coherence) [16] (R. McCraty, 2011). According to Alexander Tchijevsky, 80% of the most significant events in human history occurred within the approximately five years of the maximum solar activity; this assumption is represented by the related diagram (1750–1922) [17] (A. Tchijevsky, 1971).

As further discussed below, changes in the environment can exert significant influence on the quality of decision-making, responses, and reaction times in humans. Variations (even insignificant) in geomagnetic fields are among the factors that, although generally underestimated, have the potential to change the behaviour of individuals and groups of humans. This applies to all areas of human activity, including transportation, international trade, and also the military, where the decisions and behaviour of individuals or small groups might bring major consequences of strategic character.

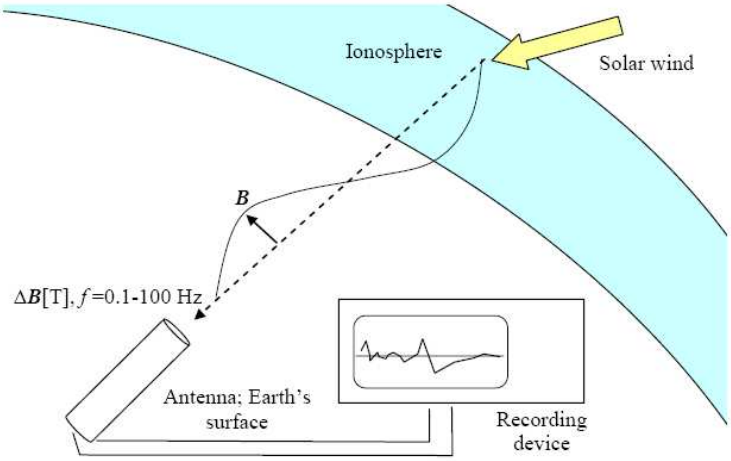

Figure 1: Schematic arrangement of the problem of detecting the changes in the Earth's ionosphere.

However, no research has been carried out thus far on a selected (homogeneous) group of humans to demonstrate the long-term effect of changes in the Earth's magnetic field and to eliminate the underlying influence of other aspects. Thus, within the preparatory stages of the investigation described in this paper, such a test group was formed in close collaboration with University of Defence in Brno, and its purpose is to facilitate the measurement and examination of psychophysiological effects exerted by geomagnetic fields upon military officers and personnel.

4. DESIGN OF THE EXPERIMENTAL MEASUREMENT

The measurement of low-level magnetic and electromagnetic signals in the ULF, SLF, and ELF bands is a unique scientific discipline. The ULF, SLF, and ELF waves exhibit wavelengths of thousands of kilometers. Generally, wavelength is expressed as $\lambda = v/f$, with units of [m; m/s, Hz], where v is the speed of the wave propagation in space, λ the length of the wave, and f its frequency. For an electromagnetic wave, v is the mean speed of light in vacuum.

In order to ensure the required sensitivity and operation in the ULF, SLF and ELF frequency bands, it is suitable to use a ferrite antenna, whose dimensions are significantly smaller than the wavelength of the incident electromagnetic wave. In such antennas, the phase φ_E of the electric field intensity E is practically identical at every point of the device, even when the incident electromagnetic wave is not planar. The directional characteristics of such antennas can be measured in the near electromagnetic field. Fig. 1 shows the experiment focused on the application of a ferrite antenna for the detection of changes in the Earth's ionosphere, its numerical model, and results otherwise introduced in Reference [15], Fig. 3.

The planned experimental research will be performed on a sample group of participants (men and women of approximately the same age), and it will consist in non-invasive physiological measurement of the human organism; this measurement process is conceived to include psychological methods sensitive to the mental changes in progress at the time of sensing.

In general terms, psychophysiological research is most often focused on factors that influence the activity of the autonomous nervous system; these factors include also parameters such as perspiration, skin temperature, pulse frequency changes, blood pressure variation, and alimentary tract contractions. In the given context, the orientation of these aspects to the central nervous system will be considered too [18] (A. Uherík, 1978).

The aim of the proposed experimental investigation consists in searching for relationships between characteristics of the ionosphere on the one hand and the examined psychophysiological or mental factors on the other. Regular connections will be sought between solar activity as a source of geomagnetic field disturbances and the variability of psychophysiological and mental characteristics.

With respect to physiological parameters, the processes to be measured involve skin impedance, muscle contraction, diaphragmatic and thoracic breathing intensity, ECG LO and HI frequencies, the perfusion of peripheral vessels, and EEG waves. The applied sensing apparatus will be Flex-Comp Infiniti, a device for physiological monitoring, bio-feedback, and the collection of psychophysiological data. The results obtained from the measurement of the physiological characteristics of

the human organism are invariably influenced by the momentary mental state of the collaborating individual, i.e., by the level of the person's positive or negative mental condition affected by life events, the environment, emotional stimuli, lunar cycles, and other aspects.

Primarily, the investigation is based on measurement models that describe the relationships between various external influences (which, in our case, are represented mainly by solar activity) and the level of physiological functions [22] G. Stemmler, 2001, p. 7.

A significant problem of the research is the identification of such physiological variables whose level variations exhibit a close relation to ionosphere changes. Secondarily, we will look for the relationship between the variability of physiological characteristics and the current degree of resistance to stress; these indicators can be classified as either objectively evaluated or subjectively experienced within the binary dimension of mental stress — relaxation. In the model, psychophysiological constructs then constitute the link/bridge/between solar activity and the concrete manner of human reactions and decision-making under stress (regarding, for example, life endangering situations or the handling of principal financial problems).

The diagnostics of the current mental state can be performed using methods whose ability to determine such state has been reliably proven (which means that, in the very least, the content and predictive validities are: a) sensitive to changes within the stipulated period of days; b) relatively resistant to the effect of repeated measurement; c) used for the given purposes. Furthermore, we will utilise the ASS-SYM technique by Günter Krampen, which is defined in the paper *ASS-SYM — Änderungssensitive Symptomliste zu Entspannungserleben, Wohlbefinden, Beschwerden- und Problembelastungen*. This method is suitable for the assessment of subjective experience. To evaluate the current level of resistance to stress and the disruption of mental balance, we will make use of *Lüscher Diagnostik*, the non-verbal testing tool by Max Lüscher.

We expect to find the relationship between the variability of solar processes and the variability of the level of psychophysiological parameters. Analogously to the existing knowledge related to the effects of the environment on the level of psychophysiological characteristics, it will be possible to define the different degrees of closeness in the relationship between solar activity and the individual psychophysiological characteristics. It is assumed that the relationships between solar activity and the current subjective/objective stress resistance will be discovered.

Simultaneously with the experimental investigation of the given problem, we will pursue secondary research based on analysing the data obtained from the monitoring of solar activity throughout history [17] (A. Tchijevsky, 1971). Moreover, correlation will be sought between these historical data and socioeconomic indicators of human behaviour and decision-making, and special emphasis will be put in this context on indicators that expose the mental factor as a significant element of the decision-making process.

Historically, the formation of geomagnetic storms has was daily monitored by the Royal Observatory, Greenwich since May 1874. In 1976, the continuous measurement began to be carried out by the Solar Optical Observing Network (SOON) under support from the US National Oceanic and Atmospheric Administration (NOAA).

In addition to these facts, it is also interesting to review in the given connection the development of capital markets during recent centuries, which has been recorded via specialised indexes (such as the Dow Jones established in 1896); notably, detailed comparison of the data comprised in these indicators with registered changes of the environment could further highlight the fact that capital markets are markedly sensitive to variations in the decision-making process resulting from environmental effects.

5. CONCLUSION

The outcome of the research will be compared with the hypotheses and results already published internationally; the main aim is to demonstrably measure the differences between instantaneous condition of the Earth's ionosphere as monitored at various locations of the planet.

The prepared experiments and measurement prove the influence of the above-mentioned aspects on the human emotional system, thus pointing to the hitherto applied boundary values of magnetic flux density B in relation to the alterations of the magnetic field for very slowly changing electric currents. The experiments also highlight the impact these currents might have on human beings permanently present in such environment.

The measured dependencies will be processed mathematically and graphically and published within a specialised paper at a later time. Similarly, we will interpret and release the results obtained

from the surveys and psychological tests, which will be used as instruments to simultaneously measure and eliminate the external influences that affect the human psychophysiological structure.

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REFERENCES

1. Ferris, J., "The brain generates an electric field that influences its own activity," *Scientific American Mind*, Vol. 21, No. 10, 2010, published online: Oct. 28, 2010, doi:10.1038/scientificamericanmind1110-10a.
2. Stuchly, M. S., 2000.
3. Scorretti, R., N. Burais, L. Nicolas, and A. Nicolas, "Modeling of induced current into the human body by low-frequency magnetic field," *IEEE Transactions on Magnetics*, Vol. 41, No. 5, May 2005, Dostpná z: 10.1109/TMAG.2005.846276.
4. Carrubba, S. and A. A. Marino, "The effects of low-frequency environmental-strength electromagnetic fields on brain electrical activity: A critical review of the literature. Electromagnetic biology ang medical," Vol. 27, No. 2, 83–101, Department of Orthopaedic Surgery, LSU Health Sciences Center, P. O. Box 33932, Shreveport, LA 71130-3932, United States, 2008.
5. Hashish, A. H., M. A. El-Missiry, H. I. Abdelkader, and R. H. Abou-Saleh, "Assessment of biological changes of continuous whole body exposure to static magnetic field and extremely low frequency electromagnetic fields in mice," Department of Physics, Faculty of Science, University of Mansoura, Mansoura 35516, Egypt Department of Zoology, Faculty of Science, University of Mansoura, Mansoura 35516, available online Feb. 21, 2008, Dostupná z: doi:10.1016/j.ecoenv.2007.10.002.
6. Gobba, F. M., A. Bargellini, M. Scaringi, G. Bravo, and P. Borella, "Extremely low frequency-magnetic fields (ELF-EMF) occupational exposure and natural killer activity in peripheral blood lymphocytes," Modena (MO), Italy Chair of Hygiene, Department of Public Health Sciences, University of Modena and Reggio Emilia, Via Campi 287, 41100, Modena (MO), Italy, 0048-9697/$ — see front matter ©2008 Elsevier B.V., all rights reserved.
7. Cocco, P. and R. J. Reiter, "Urinary 6-sulfatoxymelatonin excretion in humans during domestic exposure to 50 hertz electromagnetic fields," *Neuroendocrinology Letters*, Vol. 26, No. 2, 136–142, Apr. 2005, ISSN: 0172-780X.
8. Rose, L., "Review and assessment of select US space security technology proposals," Department of Materials Engineering, University of British Columbia, 309-6350 Stores road, Vancouver, British Columbia, Canada v6t 1z4, 0265-9646/$ — see front matter ©2008 Elsevier Ltd., all rights reserved. Dostupní z: doi:10.1016/j.spacepol.2008.09.007.
9. Cohen. M. B., "Elf/Vlf phased array generation viafrequency-matched steering of a continuous hfionospheric heating beam," Dissertation for the Degrre of Doctor of Philosophy, Oct. 2009.
10. www.nasa.gov.
11. Korepanov, V., G. Lizunov, O. Fedorov, Y. U. Yampolsky, and I. Ivchenko, "IONOSAT — Ionospheric satellite cluster," Lviv Centre of Institute of Space Research, Laboratory for EM Investigations, 5-a, Naukova str., Lviv 79000, Ukraine, Received Oct. 31, 2006; received in revised form Feb. 25, 2008; accepted Feb. 27, 2008, Dostupná z: doi:10.1016/j.asr.2008.02.022.
12. Gray, J. A., *The Neuropsychology of Anxiety: An Enquiry into the Functions of the Septo-Hippocampal System*, Oxford Univ. Press, Oxford, U.K., 1982.
13. Agrimson, E., S. Kim, N. Angelo, and R. Merlino, "Effect of parallel velocity shear on the electrostatic ion-cyclotron instability in filamentary current channels," Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, Received Mar. 31, 2003; accepted Jul. 31, 2003.
14. Barchanski, A., M. Clemens, H. Gersem, and T. Weiland, "Efficient calculation of current densities in the human body induced by arbitrarily shaped, low-frequency magnetic field sources," Received May 18, 2005; received in revised form Aug. 10, 2005; accepted Sep. 13, 2005 available online Nov. 11, 2005, Dostupná z: doi:10.1016/j.jcp.2005.09.009.
15. Steinbauer, M., P. Fiala, K. Bartusek, and Z. Szabo, "Experiments with accuracy of air ion field measurement," *PIERS Proceedings*, 1062–1066, Hangzhou, China, Mar. 24–28, 2008.

16. Mccraty, R., "Coherence: Bridging personal, social and global health," Institute of HeartMath, 14700 West Park Ave., Boulder Creek, CA 95006, USA, 2011.
17. Tchijevsky, A., "Physical factors of the historical process," 1971.
18. Uherík, A., "Psychofyziologické vlastnosti člověka," Psychodiagnostické a didaktické testy, n.p., Bratislava, 1978.
19. Woodworth, R. and H. Schlosberg, "Experimentálna psychológia," Vydavatel'stvo Slovenskej akadémie vied, Bratislava, 1959.
20. Lüscher, M., *Lüscher Diagnostik*, Color-Test Verlag, Luzern, 2009.
21. Krampen, G., *ASS-SYM. Änderungssensitive Symptomliste zu Entspannungserleben, Wohlbefinden, Beschwerden-und Problembelastungen*, Manual, Hogrefe Verlag, Göttingen, Bern, Wien, Toronto, Seattle, Oxford, Prag, 2006.
22. Stemmler, G., "Grundlagen psychophysiologischer Methodik," Rösler, Frank (Hrsg.), *Grundlagen und Methoden der Psychophysiologie*, 1, vyd, Göttingen, Bern, Toronto, Seattle, Hogrefe, Verlag für Psychologie, 2001, S. 1-84. Enzyklopädie der Psychologie: Theorie und Forschung, Biologische Psychologie Bd. 4, ISBN 3-8017-0551-X.