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High-frequency electromagnetic radiation action and influence resonators-converters on frequency of chromosome aberrations in bone marrow cells of male Wistar rats

高頻電磁輻射作用及其共振-轉換器對雄性 Wistar 大鼠骨髓細胞染色體畸變頻率的影響

N.A. Dyuzhikova - Doctor of Biology, Head of Higher Nervous Activity Genetics Laboratory, Pavlov Institute of Physiology of Russian Academy of Science (Saint Petersburg)

N.A. Dyuzhikova — 生物學博士，俄羅斯科學院巴甫洛夫生理研究所（聖彼得堡）高等神經活動遺傳學實驗室主任

E-mail: dyuzhikova@mail.ru
A.V. Kopyltsov - Doctor of Engineering, Saint Petersburg State Electrotechnical University (LETI) E-mail: kopyl2001@mail.ru

A.V. Kopyltsov — 工程博士，聖彼得堡國立電工大學（LETI） E-mail: kopyl2001@mail.ru

K.A. Korshunov - Programmer Engineer, Aires Human Genome Research Foundation (Saint Petersburg)

K.A. Korshunov — 程式設計工程師，Aires 人類基因體研究基金會（聖彼得堡）

E-mail: devpro@aires.spb.ru

電子郵件：devpro@aires.spb.ru

G.N. Lukyanov - Doctor of Engineering, Professor, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics

G.N. Lukyanov — 工程博士、教授，聖彼得堡國立資訊技術、力學與光學研究大學

E-mail: gnluk@rambler.ru **電子郵件：gnluk@rambler.ru**
V.A. Puchkova - junior research fellow, Higher Nervous Activity Genetics Laboratory, Pavlov Institute of Physiology of Russian Academy of Science (Saint Petersburg)

V.A. Puchkova — 初級研究員，俄羅斯科學院巴甫洛夫生理研究所高等神經活動遺傳學實驗室（聖彼得堡）

E-mail: vera_puchkova94@mail.ru
I.N.Serov - President of Aires Human Genome Research Foundation (Saint Petersburg)

I.N.Serov — Aires 人類基因組研究基金會會長（聖彼得堡）

E-mail: director@aires.spb.ru

Action of electromagnetic radiation (EMR) of a standard Wi-Fi router and influence of Aires Defender resonators-converters on frequency of chromosome aberrations in bone marrow cells of Wistar rats was studied. Increase of mitosis aberrations upon exposure to EMR was found. The most harmful mode of the router operation was identified. It was noted that the resonators reduced effect of EMR action on frequency of chromosome aberrations in bone marrow cells. Mathematical model of EMR conversion, using Aires Defender resonators, was presented. Possible mechanisms of EMR action on somatic cells and approaches to development of means, protecting from harmful exposure thereof were considered.

研究了標準 Wi-Fi 路由器的電磁輻射（EMR）作用以及 Aires Defender 共振器-轉換器對 Wistar 大鼠骨髓細胞染色體畸變頻率的影響。發現暴露於電磁輻射會增加有絲分裂畸變。確定了路由器運作中最具破壞性的模式。觀察到共振器能降低電磁輻射對骨髓細胞染色體畸變頻率的影響。提出了使用 Aires Defender 共振器進行電磁輻射轉換的數學模型。討論了電磁輻射對體細胞作用的可能機制及開發防護其有害暴露手段的方法。

Keywords: high-frequency electromagnetic radiation, resonators-converters, chromosome aberrations, bone marrow, rats.

關鍵詞：高頻電磁輻射、共振器-轉換器、染色體畸變、骨髓、大鼠。

The influence of electromagnetic radiation (EMR) of Wi-Fi router and resonators Aires Defender (RA) on the frequency of chromosome aberrations (FCA) in the bone marrow cells of Wistar rats was investigated. An increase in the FCA was observed under the influence of EMR and the operating mode of the router with the greatest damaging effect was revealed. RA reduced the damaging effect of the EMR on the bone marrow cells. The mathematical model of the transformation of EMP with the help of resonators Aires Defender is presented. The mechanisms of the action of EMR on somatic cells and the mechanisms of protection are discussed.

研究考察了 Wi-Fi 路由器之電磁輻射（EMR）以及共振器 Aires Defender（RA）對 Wistar 大鼠骨髓細胞染色體畸變頻率（FCA）的影響。在電磁輻射作用下觀察到 FCA 增加，並且找出了路由器的運行模式中產生最大損傷效應的模式。RA 能減少電磁輻射對骨髓細胞的損害。文中提出了利用 Aires Defender 共振器轉換電磁脈衝（EMP）的數學模型，並討論了電磁輻射對體細胞作用的機制以及防護機制。

Keywords: electromagnetic radiation, resonators, chromosome aberrations, bone marrow, rats.

關鍵詞：電磁輻射、共振器、染色體畸變、骨髓、大鼠。

Sharp increase in widespread use of ultra-high frequency (microwave) radiation over the last 20-30 years, resulting in increase of intensity thereof, and integration of such radiation sources into different devices (mobile phones, Wi-Fi routers) requires study of effect thereof on living organisms. Impairment of electromagnetic background of the environment, which is recorded everywhere, causes steady increase of various diseases, including microwave syndrome and hypersensitivity to electromagnetic radiation (EHS). The bibliography on EMR action on human and animals is quite extensive [1-3]. It is known that EMR enhancement affects genetic apparatus of cells of different organs of human and animal body. For the first time, mutagenic effect of certain electromagnetic fields frequencies was demonstrated in 1959 in Heller, Teixeria-Pinto's paper, published in Nature magazine [4]. Currently, there is evidence that electromagnetic fields of different ranges, including mobile phones and Wi-Fi ranges are able to induce a wide range of genetic damages, modify genes expression, affect structural and functional properties of cell nuclei [5, 6]. Thus, it was demonstrated that exposure to microwave

在過去 20 到 30 年中，超高頻（微波）輻射的廣泛使用急劇增加，導致其強度上升，且此類輻射源被整合進各種裝置（行動電話、Wi-Fi 路由器），因此需要研究其對生物體的影響。環境電磁背景的受損在各處都有記錄，這造成各種疾病的持續增加，包括微波症候群與電磁輻射超敏感（EHS）。關於電磁輻射對人類與動物作用的文獻相當豐富[1-3]。已知電磁輻射的增強會影響人體與動物不同器官細胞的遺傳機制。1959 年，Heller 與 Teixeria-Pinto 在《Nature》期刊發表的論文首次證明某些電磁場頻率具有誘變作用[4]。目前已有證據顯示，不同頻段的電磁場，包括行動電話與 Wi-Fi 頻段，能誘發廣泛的遺傳損傷、改變基因表現，並影響細胞核的結構與功能特性[5, 6]。 因此，研究顯示暴露於微波輻射下

radiation (frequency 7.7 GHz, power $0, 5, 10, 30\ \mathrm{mW/cm^2}$) within the exposure period 10. . .60 min causes increase of chromosome aberrations in human lymphocytes [7]. Upon extended exposure periods, signals with 5 W/kg specific radiation absorption rate (SAR) also cause damage of chromosomes in blood cells [8]. However, mechanisms of these processes are still not quite clear.

在暴露期間，頻率為 7.7 GHz、功率為 $0, 5, 10, 30\ \mathrm{mW/cm^2}$ 的輻射會導致人類淋巴球染色體畸變增加 [7]。在延長的暴露期間，具有每公斤 5 W 的特定吸收率（SAR）的訊號亦會造成血液細胞的染色體損傷 [8]。然而，這些過程的機制仍不甚清楚。

Creation of the systems, protecting from harmful EMR effect and study of mechanisms of action thereof on genetic processes in cells of central and peripheral organs of model objects is a pressing issue. Currently, Aires Foundation has designed devices, which efficiently redistribute EMR and produce therapeutic effect based on effects of incident EMR range conversion by the self-affine relief [1,2]. Still, mechanisms of the indicated devices protective action on chromosomal apparatus of cells have not been studied yet.

建立保護系統，以防止有害電磁輻射（EMR）影響並研究其對模式生物中樞及周邊器官細胞遺傳過程作用機制，乃一項迫切議題。目前，Aires Foundation 已設計出可有效重分配電磁輻射並藉由自相似浮雕對入射電磁輻射頻帶進行轉換而產生治療效果的裝置[1,2]。然而，該等裝置對細胞染色體裝置的保護作用機制尚未被研究。

Study objective: 1) to study EMR action on frequency of chromosome aberrations in dividing bone marrow cells in different modes of operation of a standard Wi-Fi router to find out conditions of mitotic disruptions induction, caused by high-frequency EMR in male Wistar rats; 2) to evaluate protective action of Aires Defender fractal-matrix resonators-converters on frequency of chromosome aberrations in bone marrow cells in male Wistar rates upon exposure to harmful EMR, generated by the router; 3) to construct a mathematical model of electromagnetic radiation conversion, using Aires Defender resonators.

研究目的：1）研究在標準 Wi-Fi 路由器不同運作模式下，高頻電磁輻射對分裂中骨髓細胞染色體畸變頻率的作用，以找出在雄性 Wistar 大鼠中誘發有絲分裂干擾的條件；2）評估 Aires Defender 分形矩陣共振器-轉換器在雄性 Wistar 大鼠暴露於路由器產生之有害電磁輻射時，對骨髓細胞染色體畸變頻率的保護作用；3）構建使用 Aires Defender 共振器進行電磁輻射轉換的數學模型。

Material and Methods **材料與方法**

The work was performed in male Wistar rates, weighing $250...300$ g. The rats were taken from the biological collection of FSBIS Pavlov Institute of Physiology of RAS (No ГЗ 0134-2016-0002). After the animals were received, they were held in the laboratory animal facility for no less than two weeks to ensure adaptation thereof. The males were kept in groups of six in standard cages on standard diet.

本研究在體重 $250...300$ g 的雄性 Wistar 大鼠進行。這些大鼠取自俄羅斯科學院巴甫洛夫生理學研究所（FSBIS Pavlov Institute of Physiology of RAS）生物標本庫（編號 ГЗ 0134-2016-0002）。動物入所後至少在實驗動物設施內飼養兩週以確保適應。雄性大鼠以六隻為一群，置於標準籠具中，並給予標準飼料。

The study was performed, using the Wi-Fi router (LinkSys E1200-EE/RU wireless router) with the following technical specifications: wireless communication frequency 2.4 GHz ; two built-in antennae; standard antenna power gain - 4 dBi .

研究使用的 Wi-Fi 路由器為 LinkSys E1200-EE/RU 無線路由器，技術規格如下：無線通訊頻率 2.4 GHz；內建兩支天線；標準天線增益為 4 dBi。

To study action of EMR, emitted by the router, the “home” cage with animals was put into the Faraday cage (Fig. 1). The router was placed under the upper cage cover in the center of the detachable shelf. The experimental groups were exposed to the router in the following modes: 1) one time during two hours (8 a.m. - 10 a.m.); 2) daily during four days, six hours a day (8.a.m. - 2 p.m.); 3) daily during three weeks, six hours a day (8.a.m. - 2 p.m.). The controls were groups of rats, which were placed into the Faraday cage for the same time, however, were not exposed to the router, and intact animals.

為了研究路由器所發出的電磁輻射（EMR）的作用，「家用」籠內的動物被放置於法拉第籠中（圖 1）。路由器置於可拆式層板中央的上層籠蓋下。實驗組暴露於路由器的模式如下：1）一次，持續兩小時（上午 8 時至 10 時）；2）連續四天每日暴露六小時（上午 8 時至下午 2 時）；3）連續三週每日暴露六小時（上午 8 時至下午 2 時）。對照組為被安置於法拉第籠相同時間但未暴露於路由器的老鼠群，以及未處理的自然對照動物。

Aires Defender fractal matrix resonators (special annular diffraction grids), serving as universal spatialwave Fourier filter [9], were also used in the experiment. The interaction of electromagnetic field with Aires Defender results in structural conversion thereof.

實驗中亦使用了 Aires Defender 的分形矩陣共振器（特殊環狀繞射格柵），作為通用空間波傅立葉濾波器 [9]。電磁場與 Aires Defender 相互作用會導致電磁場的結構性轉換。

Six resonators were used to assess the resonators influence on harmful effects of EMR, generated by the router. They were placed in the center of each plane of the Faraday cage (Fig. 1). One of the experimental groups was exposed to the router action in the Faraday cage according to the following schedule: four days, six hours of exposure to resonator per day.

使用六個諧振器來評估諧振器對由路由器產生之電磁輻射（EMR）有害影響的影響。它們被放置在法拉第籠每一面平面的中心（圖 1）。其中一組實驗組依照下列排程在法拉第籠內接受路由器的作用：四天，每天暴露於諧振器六小時。

Bone marrow cells specimens handling. Bone marrow cells were fixed 24 h after exposure in the freshly prepared Carnoy's fixative (1 part of glacial acetic acid per 3 parts ethanol) at least for an hour. The material was kept at $+4^{\circ}\mathrm{C}$ until specimens handling according to the standard procedure [10,11].

骨髓細胞樣本處理。暴露後 24 小時，骨髓細胞用新配製的 Carnoy 固定液（冰醋酸與乙醇比為 1:3）固定，至少固定一小時。材料被保存在 $+4^{\circ}\mathrm{C}$ ，直到依據標準程序處理樣本[10,11]。

Bone Marrow Specimens Analysis Bone marrow squash preparation was analized using Micromed -3 microscope with 640-1600 power magnification. Chromosome aberrations at anaphase - telophase stages (standard ana-telophase method) subject to additional recommendations [11] were recorded. At least 200 cells of each animal were analyzed. Number of normal and aberrant anaphases - telophases with the below mentioned disruptions were recorded: single displacements (fragment, bridge, laggards), multiple displacements (two and more disruptions of any type per cell).

骨髓標本分析 骨髓壓片製備使用 Micromed -3 顯微鏡，放大倍率為 640-1600 倍進行分析。記錄處於後期–末期階段的染色體畸變（標準後期–末期方法），並參照附加建議[11]。每隻動物至少分析 200 個細胞。記錄正常及畸變的後期–末期細胞數，並註明下列異常類型：單一位移（片段、橋狀、滯後染色體）、多重位移（每個細胞兩處或以上、任一類型的異常）。

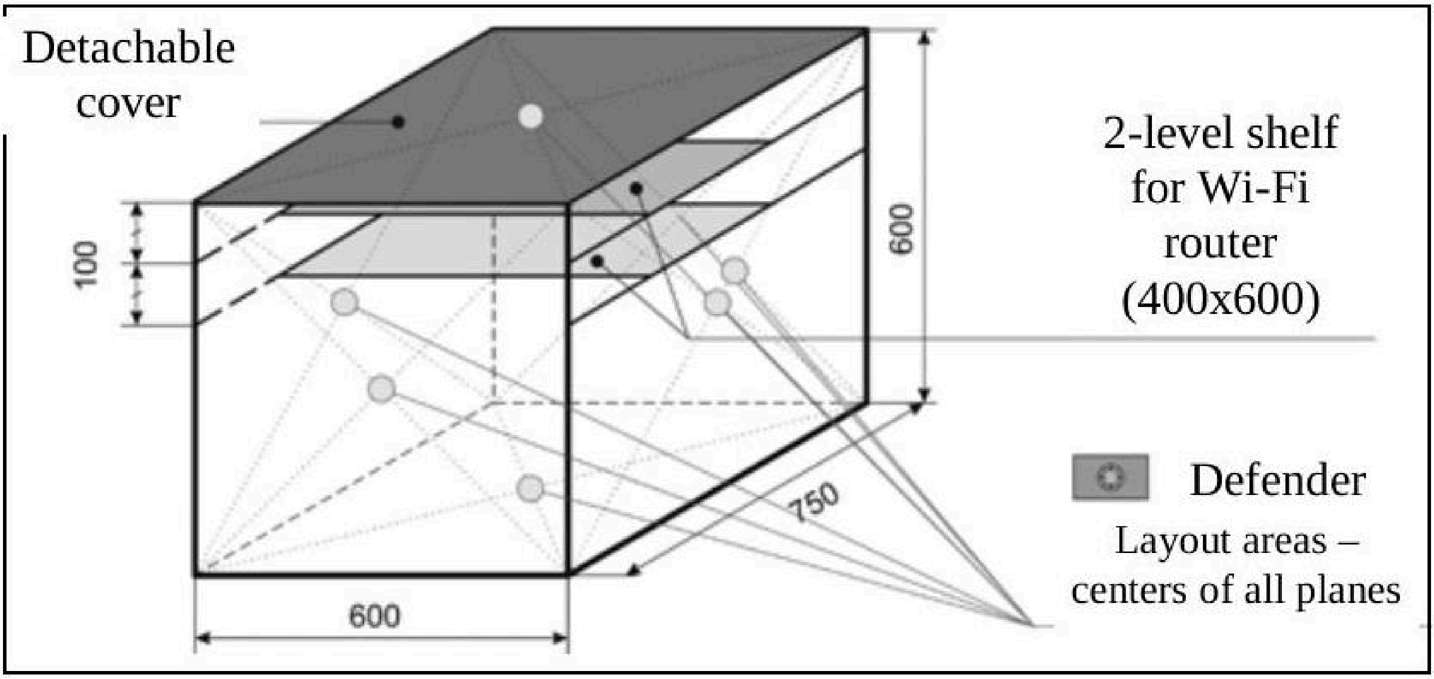

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Figure 1: Fig. 1.The diagram of the Faraday shield (cage) used for a study with a layout of the resonators placement.

圖 1：圖 1. 用於研究的法拉第遮罩（籠）示意圖及共振器擺放佈局。

Statistical analysis. The findings were checked for homogeneity by nonparametric multiple-field chi square method . Individual data were combined within groups based on check results. To arrange results in tables, frequency of detected mitosis aberrations, expressed as a percentage with percentage error, was calculated. Significance of differences among variants and comparison of mitotic disorders ranges were determined by chi square method [12] and by the rank test and analysis of variance (ANOVA), using Statgraphics Centurion XV11 and Statistica 6.0 software.

統計分析。以無母數多域卡方方法檢驗結果是否齊性。依檢驗結果將個別資料在組內合併。為編排表格，計算檢出有絲分裂異常的頻率，以百分比表示並附百分比誤差。變異間差異的顯著性及有絲分裂異常範圍的比較採用卡方檢定[12]、秩次檢定及變異數分析（ANOVA），使用 Statgraphics Centurion XV11 與 Statistica 6.0 軟體進行。

Effect of Different Modes of Wi-Fi Router Operation on Frequency of Chromosome Aberations of Marrow Bone Cells in Wistar Rats

不同模式的 Wi-Fi 路由器運作對 Wistar 大鼠骨髓細胞染色體畸變頻率的影響

It was shown that high-frequency electromagnetic radiation, emitted by the router in the four days, six hour a day exposure mode, resulted in the most severe destabilization of dividing bone marrow cells genetic apparatus in male Wistar rats: total frequency of mitotic disorders increased on an average by 4.5 times in comparison with control 2 (Faraday cage, 4 days $\times 6\ \mathrm{h}$) and by 3.9 times in comparison with intact control 1 (Table), degree of reliability of the indicated data was high according to all applied statistic criteria. Single exposure to the router within 2 hours caused increase of chromosome aberrations by 1.9 times in comparison with intact control 1 (Table), statistical significance was confirmed by the multiple range test (Multiple Range Test, Diff $= 6.03$, +/-Limits = 3.33) and ANOVA test ($\mathrm{F}=19.65, \mathrm{p}<0.004$), however, not chi square method. In comparison with the group of animals, exposed to the router in the four days, six hours a day mode, disorders frequency was 2.1 times less (Table). After animals exposure to electromagnetic radiation, emitted by the router, during three weeks, six hour a day, mitotic disorders frequency increased by 1.8 times in comparison with control 3 (Faraday cage, three weeks, six hours a day) (Multiple Range Test, Diff = 5.02, +/-Limits = 3.63; ANOVA, F = 3.13, p < 0.01) and by 1.5 times in comparison with intact control 1 (Multiple Range Test, Diff $= 4.1, +/-$ Limits $= 3.9$; ANOVA, ($\mathrm{F}=2.49, \mathrm{p}<0.04$), however, it decreased by 2.6 times in comparison with the group of animals, exposed to the router in the four days, six hours a day mode (Table).

研究顯示，高頻電磁輻射（由路由器在四天、每天六小時的暴露模式下所發射）導致雄性 Wistar 大鼠骨髓分裂細胞遺傳機制最嚴重的不穩定：有絲分裂異常的總頻率平均較對照 2（法拉第籠，4 天 $\times 6\ \mathrm{h}$ ）增加 4.5 倍，較完整對照 1 增加 3.9 倍（表），根據所有應用的統計準則，所示數據的可靠度均很高。單次路由器暴露 2 小時導致染色體畸變較完整對照 1 增加 1.9 倍（表），多重範圍檢定（Multiple Range Test, Diff $= 6.03$, +/-Limits = 3.33）和變異數分析（ANOVA, $\mathrm{F}=19.65, \mathrm{p}<0.004$ ）確認了統計顯著性，惟卡方法未達顯著。與以四天、每天六小時模式暴露於路由器的動物組相比，異常頻率低了 2.1 倍（表）。 在动物暴露於由路由器發出的電磁輻射三週、每天六小時後，分裂期異常的頻率較對照 3（法拉第籠，三週，每天六小時）增加了 1.8 倍（多重範圍檢定，差異 = 5.02，±界限 = 3.63；ANOVA，F = 3.13，p < 0.01），較未處理的對照 1 增加了 1.5 倍（多重範圍檢定，差異 $= 4.1, +/-$ 界限 $= 3.9$ ；ANOVA，($\mathrm{F}=2.49, \mathrm{p}<0.04$)），然而與以四天、每天六小時模式暴露於路由器的動物組相比，則降低了 2.6 倍（表格）。

Table 1: Table. Frequency of mitotic disorders of bone marrow cells in male Wistar rats after exposure to electromagnetic radiation, emitted by the router, in different modes, and after exposure to Aires Defender resonators

表 1：表。雄性 Wistar 大鼠骨髓細胞在不同模式下暴露於路由器所發射電磁輻射後，以及暴露於 Aires Defender 諧振器後的分裂期異常頻率

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<table>
<tr><th>Action variant 處理方式</th><th>Number of analyzed cells (number of cells with disorders among them)
分析細胞數（其中有異常的細胞數）</th><th>Total frequency of mitosis disorders ($\overline{x} \pm S$, %)
有絲分裂異常總頻率（ $\overline{x} \pm S$ ，%）</th><th colspan="4">Statistical significance $\chi 2$ ($v = 1, p < 0.01$)
統計顯著性 $\chi 2$ （ $v = 1, p < 0.01$ ）</th></tr>
<tr><td>Control 1 (intact animals)
對照 1（完整動物）</td><td>1378 (92)</td><td>6.7 ± 0.7</td><td rowspan="3" colspan="2">75.8
18.9</td><td rowspan="2" colspan="2">-</td></tr>
<tr><td>Control 2 (Faraday cage, 4 days x 6 h)
對照 2（法拉第籠，4 天 x 6 小時）</td><td>1986 (114)</td><td>5.7 ± 0.5</td></tr>
<tr><td>Router (4 days x 6 h)
路由器（4 天 x 每天 6 小時）</td><td>1360 (354)</td><td>26.0 ± 1.2</td><td rowspan="2">16.8</td><td rowspan="5">8.9
6.5</td></tr>
<tr><td>Router + resonators (4 days x 6 hours)
路由器 + 共振器（4 天 x 每天 6 小時）</td><td>1961 (127)</td><td>6.5 ± 0.6</td><td></td><td></td></tr>
<tr><td>Control 3 (Faraday cage, 3 weeks x 6 h)
控制組 3（法拉第籠，3 週 x 每週 6 小時）</td><td>1714 (96)</td><td>5.6 ± 0.5</td><td rowspan="2" colspan="2"></td><td></td></tr>
<tr><td>Router (3 weeks x 6 h)
路由器（3 週 x 每週 6 小時）</td><td>1789 (180)</td><td>$10.1 \pm 0.7^{*\#}$</td><td></td></tr>
<tr><td>Router (2 h) Router（2 小時）</td><td>1175 (149)</td><td>$12.7 \pm 0.9^{*}$</td><td colspan="3"></td></tr>
</table>

Notes: $^{\#}$ - difference from control 3 is significant (Multiple Range Test, ANOVA ($p < 0.01$), * - difference from control 1 is significant (Multiple Range Test, ANOVA ($p < 0.01$).

註： $^{\#}$ - 與對照組 3 之差異有顯著性（多重範圍檢定，ANOVA（ $p < 0.01$ ））， * - 與對照組 1 之差異有顯著性（多重範圍檢定，ANOVA（ $p < 0.01$ ））。

Findings of evaluation of chromosome aberrations level in bone marrow cells of Wistar rats showed that electromagnetic radiation, emitted by the router, under different exposure modes (2 h, 4 days, 6 h a day, 3 weeks, 6 h a day) is citogenetically active, it can induce mitotic disorders. It can affect functioning of immune system elements, related to bone marrow activity.

對 Wistar 大鼠骨髓細胞染色體畸變水準評估的結果顯示，無線路由器在不同暴露模式下（ 2 h, 4 天、每天 6 小時、3 週、每天 6 小時）所發出的電磁輻射具有細胞遺傳學活性，能誘發有絲分裂障礙，且可影響與骨髓活動相關的免疫系統成分之功能。

The most significant changes of the chromosome apparatus were detected after exposure of the animals in the Faraday cage when the router was switched on during four days, six hours a day, from 8 a.m. to 2 a.m. This very mode of the router operation can be used for pronounced induction of mitotic disorders by high-frequency EMR in Wistar rats for subsequent study of protective devices efficiency and study of underlying mechanisms thereof.

在法拉第籠內當路由器連續開啟四天、每天六小時（上午 8 時至凌晨 2 時）時，觀察到染色體構造的最顯著變化。此種路由器運作模式可用於在 Wistar 大鼠中明顯誘發高頻電磁輻射所致的有絲分裂障礙，以便後續研究防護裝置的效能及其作用機制。

Change of stability of dividing bone marrow cells genetic apparatus upon exposure to EMR, emitted by the router, can be seen as the result of cell oxidative stress, which mutagenic activity is based on genotoxic action of internal causes of humoral nature and free-radical products of peroxidation [13]. The indicated mechanisms may

暴露於路由器所發射之電磁輻射（EMR）時，可見分裂中的骨髓細胞遺傳機構穩定性發生改變，這可被視為細胞氧化壓力的結果，其誘變活性基於體液性內在成因的基因毒性作用及過氧化產物的自由基作用[13]。所述機制可能

result in immune system suppression, immunopoesis and hematopoesis depression, thus impacting body state. However, findings, showing that a long-term three-week exposure of animals to EMR results in decrease of mitotic disorders in comparison with a four-day session, indicates to possible existence of adaptive mechanisms, resulting in elimination of the cells with disorders and/or activation of reparative processes.

導致免疫系統抑制、造血與免疫生成受抑，從而影響機體狀態。然而，研究發現將動物長期（三週）暴露於電磁輻射下，與四天的短期暴露相比，減少了有絲分裂異常，這顯示可能存在適應性機制，導致有異常的細胞被清除與／或修復過程被啟動。

Influence of Aires Defender Fractal-Matrix Resonators-Converters on Frequency of Chromosome Aberrations in Bone Marrow Cells upon Damaging Effect of EMR, Emitted by the Router, on Male Wistar Rats

Aires Defender 分型矩陣諧振-轉換器對路由器發射電磁輻射損傷下雄性 Wistar 大鼠骨髓細胞染色體畸變頻率之影響

Protective action of Aires Defender fractal-matrix resonators was evaluated, using the four day, six hours a day mode of the router operation, producing the most severe damaging effect on chromosome apparatus of bone marrow cells. When resonators were used together with the router, frequency of bone marrow cells mitosis disruption decreased by 4 times in comparison with unprotected exposure to the router, and the indicated level was comparable to control 2 (Faraday cage, 4 days, 6 hours a day) and intact control 1 (see the Table).

使用 Aires Defender 分形矩陣諧振器的保護作用進行了評估，採用路由器運行四天、每天六小時的模式，該模式對骨髓細胞染色體結構造成最嚴重的損傷。當諧振器與路由器同時使用時，骨髓細胞有絲分裂受干擾的頻率與未受保護暴露於路由器的情況相比降低了 4 倍，且該值可與對照組 2（法拉第籠，4 天，每天 6 小時）及完整對照組 1 相當（見表）。

It is to be highlighted that this research paper is the first to show that Aires Defender fractal-matrix resonators have a protective effect on genetic apparatus of dividing bone marrow cells in male Wistar rats upon exposure to EMR, emitted by the router. The interaction of electromagnetic field with Aires Defender results in structural conversion thereof [9].

需要強調的是，本研究首次顯示 Aires Defender 分形矩陣諧振器在雄性 Wistar 大鼠暴露於路由器所發射的電磁輻射時，對分裂中的骨髓細胞遺傳物質具有保護作用。電磁場與 Aires Defender 的相互作用導致其結構發生轉換[9]。

Mathematical Model of Electromagnetic Radiation Conversion, Using Aires Defender Resonator.

使用 Aires Defender 諧振器的電磁輻射轉換數學模型。

Electromagnetic radiation falls on the Aires Defender plate and by means of free electrons, created on the plate, diffraction and mirror reflection in the environment, the transformed radiation is generated, which differs from the one falling on the plate. Principle of conservation for electrons in the plate can be formulated as follows [14]

電磁輻射落在 Aires Defender 板上，藉由板上產生的自由電子、在環境中的繞射與鏡面反射，產生轉換後的輻射，該輻射與落在板上的原始輻射不同。板內電子守恆原理可表述為如下 [14]

$$\frac{\partial n_e}{\partial t}=q-\mu_e\left(\frac{\partial E n_e}{\partial x}+\frac{\partial E n_e}{\partial y}+\frac{\partial E n_e}{\partial z}\right)+D_e\left(\frac{\partial^2 n_e}{\partial x^2}+\frac{\partial^2 n_e}{\partial y^2}+\frac{\partial^2 n_e}{\partial z^2}\right)-b n_e$$

where $E-$ electric field strength; n_e- free electrons concentration; D_e- electron diffusion factor; μ_e- electron mobility; q - rate of free electrons appearance; b - absorption coefficient of electrons; t - time; x, y, z - Cartesian coordinates.

其中 $E-$ 電場強度； n_e- 自由電子濃度； D_e- 電子擴散係數； μ_e- 電子遷移率； q - 自由電子產生速率； b - 電子吸收係數； t - 時間； x, y, z - 笛卡爾座標。

If the wave falls on the plate

若波作用於板上

$$E_{\text{пад}}=E_0 \cos \omega(t-z / c)$$

then **則**

$$E=E_0 \cos \theta+\Delta E_0 \cos (\theta-\pi / 2), \theta=\omega(t t c /), \Delta E_0=\frac{2 \pi k_0 n_e e^2 \omega}{c m_e\left(\omega_0^2-\omega^2\right)} E_0 \Delta z$$

$$\omega_0=\sqrt{\frac{4 \pi k_0 e \rho}{m_e}}$$

where e - electron charge; m_e - electron weight; ω_0 - frequency of electrons oscillation in the plate; Δz - plate thickness; c - light speed; $\rho=n_e e$ - charge of the unit plate volume; $k_0=9 \cdot 10^9 \mathrm{~N} \cdot \mathrm{~m}^2 / \mathrm{C}^2-$ constant [15].

其中 e - 電子電荷； m_e - 電子質量； ω_0 - 板內電子振盪頻率； Δz - 板厚； c - 光速； $\rho=n_e e$ - 單位板體積的電荷； $k_0=9 \cdot 10^9 \mathrm{~N} \cdot \mathrm{~m}^2 / \mathrm{C}^2-$ 常數 [15]。

In (3) the first summond is conditioned by reflection, the second summond is conditioned by free electrons. As there are narrow slots on the surface of the plate, it is necessary to take diffraction into account:

在 (3) 中，第一項為反射所致，第二項為自由電子所致。由於板的表面上有狹縫，因此必須考慮繞射：

$$\frac{I_\beta}{I_0}=\frac{\sin ^2[(\pi b / \lambda) \sin \beta]}{[(\pi b / \lambda) \sin \beta]^2},$$

where I_β - intensity of waves, propagating angle-wise $\beta ; I_0$ - intensity of waves, propagating angle-wise $\beta=0 ; b$ - slot width; β - angle; λ - wave length [15].

其中 I_β — 波強度，沿角度方向傳播； $\beta ; I_0$ — 波強度，沿角度方向傳播； $\beta=0 ; b$ — 狹縫寬度； β — 角度； λ — 波長 [15]。

Since wave intensity is proportionate to the amplitude square, $I=E^2$. Hence, the total intensity

由於波強度與振幅的平方成正比， $I=E^2$ 。因此，總強度為

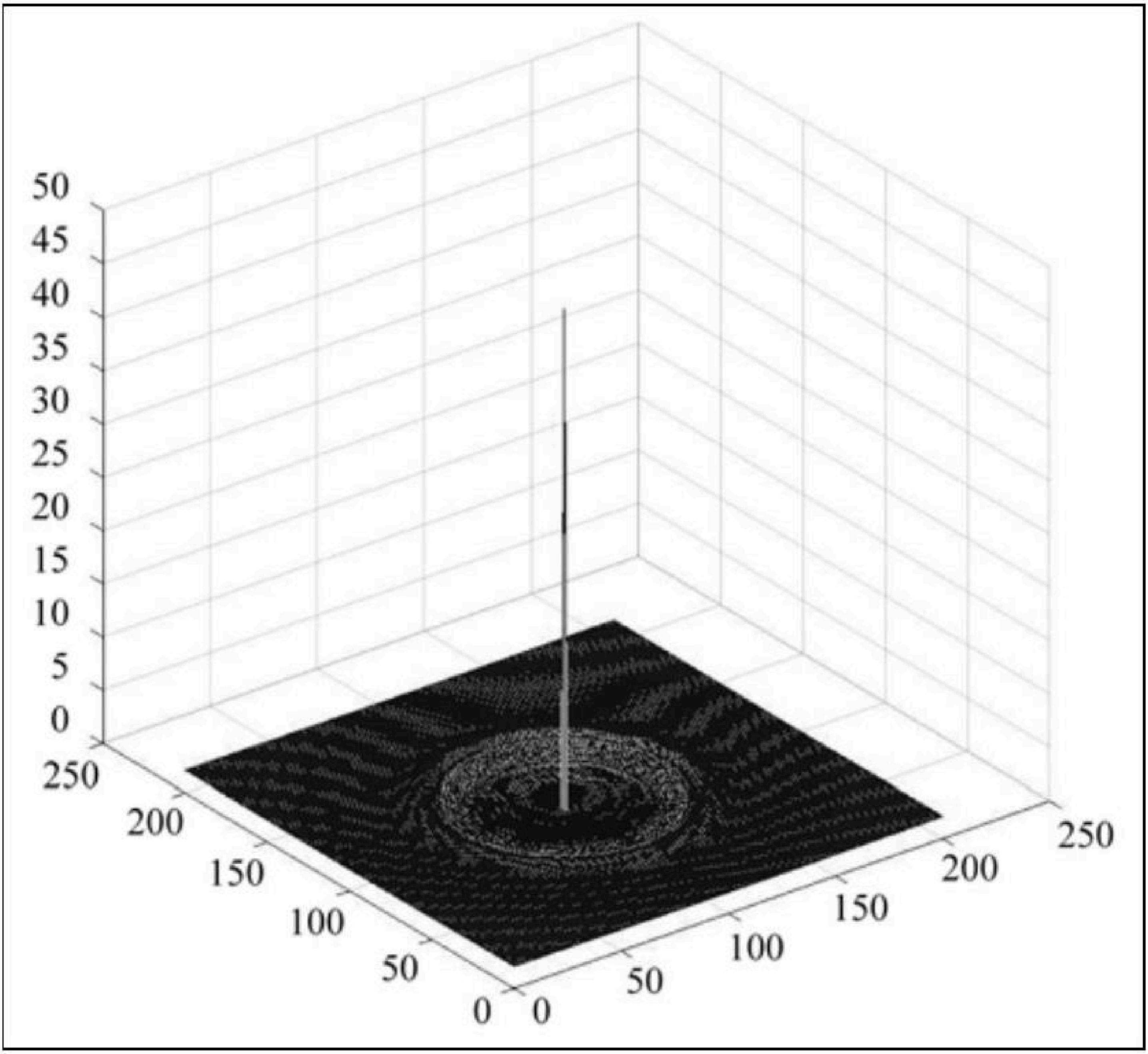
$$E=E_{\text{отражение}}+E_{\text{электроны}}+E_{\text{дифракция}},$$

where $E_{\text{отражение}}$ - by means of reflection; $E_{\text{электроны}}$ - by means of free electrons; $E_{\text{дифракция}}$ - by means of diffraction.

其中 $E_{\text{отражение}}$ — 由反射引起； $E_{\text{электроны}}$ — 由自由電子引起； $E_{\text{дифракция}}$ — 由繞射引起。

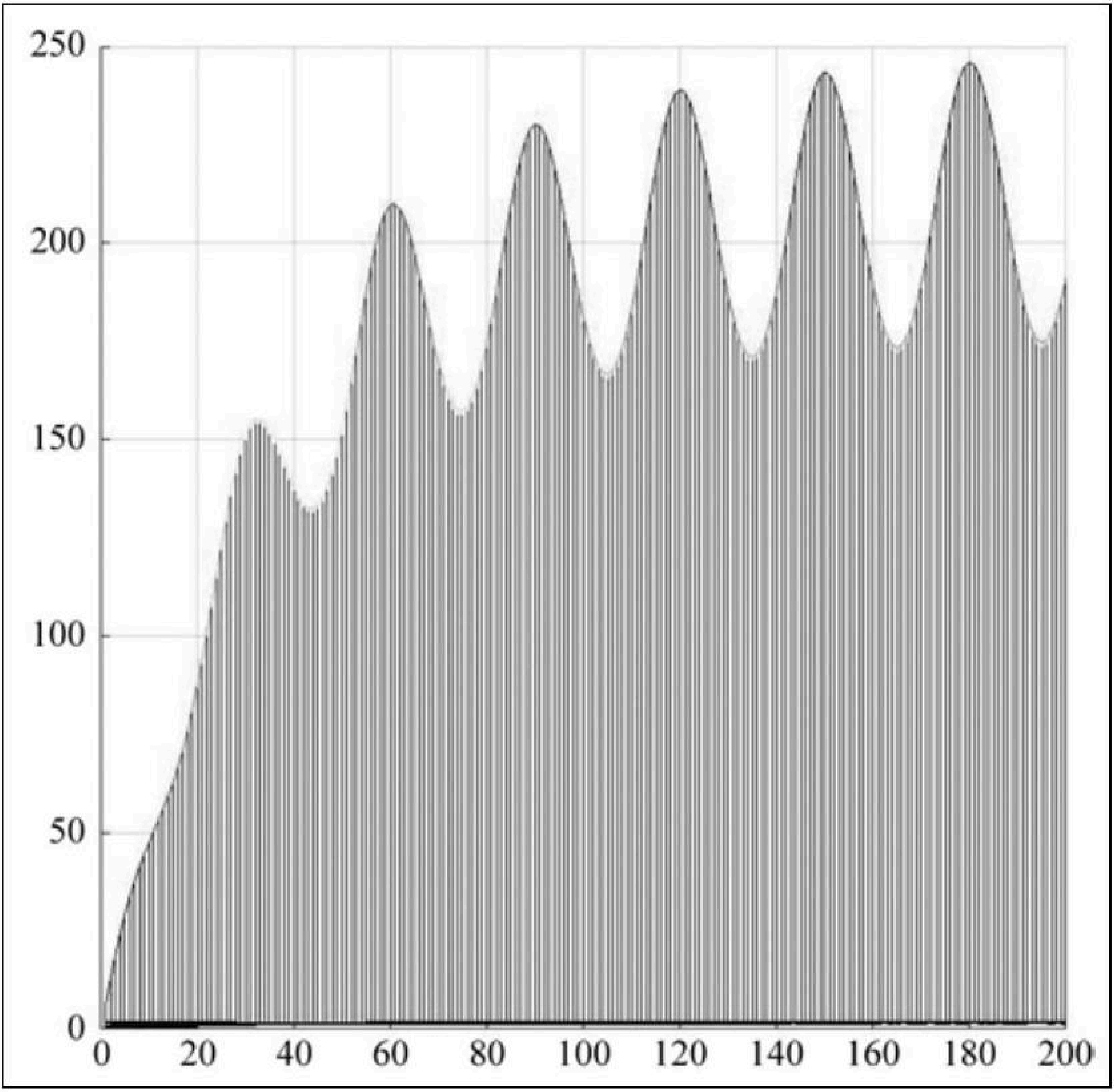
Solution of (1)-(6) set of equations by numeric techniques enables to find distribution n_e (in the plate) and E (in the space). Calculations were made, using high-performance parallel computing cluster under different initial and boundary conditions. Thus, it was assumed that there was no drain in the center and at the sides of the

利用數值技術求解方程組 (1)-(6) 得以找到板內的 n_e 分佈與空間中的 E 分佈。計算是在高效能平行運算叢集上，針對不同的初始與邊界條件進行的。因此，假設在板的中心與側邊沒有排放



\captionsetup{labelformat=empty}
Figure 2: Figure 2. Graphical form of intensity of waves, propagating over the plate

Figure 2: Figure 2. 圖示波在板上傳播的強度分布



\captionsetup{labelformat=empty}
Figure 3: Figure 3. Diagram, representing dependency on distance to the plate and waves intensity over the central part of the plate

Figure 3: Figure 3. 圖表，表示距離板面與板中央區域波強度的關係

Mathematical simulation shows that upon interaction of electromagnetic radiation and the plate with a certain pattern, applied thereon in a certain way, the plate emits the radiation, which is different by its structure from the incident radiation, into the environment. It is determined that the changes are most significant over the central area of the plate, they exceed parameters of the incident radiation by several times. It can be explained by the fact that the pattern on the plate is such that electromagnetic field strength is concentrated over the central area of the plate, while strength thereof considerably decreases over other areas of the plate, that in general results in attenuation of total electromagnetic effect (over the side parts of the plate), which is beyond the organism's electromagnetic radiation sensitivity threshold. Consequently, protective action of the resonators is, apparently, based on restructurization (conversion) of incident EMR, which diminishes its damaging action on dividing cells.

數學模擬顯示，当電磁輻射與具有特定圖案、以特定方式施加於其上的板材相互作用時，該板會向環境發射結構上與入射輻射不同的輻射。研究發現變化在板材的中央區域最為顯著，其參數較入射輻射高出數倍。這可解釋為板面上的圖案使電磁場強度集中於板的中央區域，而在板的其他區域強度顯著衰減，整體上導致總電磁效應（在板的側邊部分）被衰減到低於生物體對電磁輻射的敏感閾值。因此，諧振器的保護作用顯然基於對入射電磁輻射的重組（轉換），從而減少其對分裂細胞的損害作用。

The performed study enables to identify the most damaging mode of the router operation, to explain possible mechanisms of EMR action on somatic cells and to suggest approaches to develop means of protection against damaging ac-

所進行的研究能夠辨識出路由器運作中造成傷害最嚴重的模式，說明電磁輻射對體細胞可能的作用機制，並提出開發防護裝置以減少其損害的途徑。

tion thereof. Application of Aires Defender resonators enabled to decrease EMR effect on frequency of chromosome aberrations in bone marrow cells, to explain this phenomenon a mathematical model of EMR conversion by means of resonators was reviewed.

應用 Aires Defender 共振器可降低電磁輻射對骨髓細胞染色體畸變頻率的影響；為解釋此現象，本文檢視了以共振器實現電磁輻射轉換的數學模型。

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The effect of high-frequency electromagnetic radiation and the effect of resonator-converters and the effect of resonator-converters on the frequency of chromosomal aberrations on the frequency of chromosomal aberrations in bone marrow cells of male Wistar rats

高頻電磁輻射的影響以及諧振器—轉換器對雄性維斯塔大鼠骨髓細胞染色體畸變頻率的影響

N.A. Dyuzhikova - Dr.Sc.(Biol.), Head of Laboratory of Genetics of Higher Nervous Activity, Institute of Physiology named after I.P. Pavlov RAS (Saint Petersburg)

N.A. Dyuzhikova - 生物科學博士，聖彼得堡伊.彼. 巴甫洛夫生理學研究所高等神經活動遺傳學實驗室主任（Saint Petersburg）

E-mail: dyuzhikova@mail.ru
A.V. Kopyltsov - Dr.Sc.(Eng.), Professor, Saint-Petersburg State Electrotechnical University (LETI)

A.V. Kopyltsov - 工程科學博士、教授，聖彼得堡國立電工大學（LETI）

E-mail: kopyl2001@mail.ru
K.A. Korshunov - Part-programming Engineer, Human Genome Research Foundation «Aires» (Saint Petersburg)

K.A. Korshunov - 程式化局部設計工程師，人體基因組研究基金會 «Aires»（聖彼得堡）

E-mail: devpro@aires.spb.ru
G.N. Lukyanov - Dr.Sc.(Eng.), Professor, ITMO University (Saint Petersburg)

G.N. Lukyanov - 工學博士、教授，ITMO 大學（聖彼得堡）

E-mail: gnluk@rambler.ru
V.A. Puchkova - J unior Research Scientist, Laboratory of Genetics of Higher Nervous Activity, Institute of Physiology named after I.P. Pavlov RAS (Saint Petersburg)

V.A. Puchkova - 初級研究員，高等神經活動遺傳學實驗室，I.P. Pavlov 生理研究所（俄羅斯科學院，聖彼得堡）

E-mail: vera_puchkova94@mail.ru

I.N. Serov - President, Human Genome Research Foundation «Aires» (Saint Petersburg) E-mail: director@aires.spb.ru

I.N. Serov - 人類基因組研究基金會「Aires」會長（聖彼得堡） E-mail: director@aires.spb.ru

The influence of electromagnetic radiation (EMR) of Wi-Fi router and resonators Aires Defender (RA) on the frequency of chromosome aberrations (FCA) in the bone marrow cells of Wistar rats was investigated. An increase in the FCA was observed under the influence of EMR and the operating mode of the router with the greatest damaging effect was revealed. RA reduced the damaging effect of the EMR on the bone marrow cells. The mathematical model of the transformation of EMP with the help of resonators Aires Defender is presented. The mechanisms of the action of EMR on somatic cells and the mechanisms of protection are discussed.

研究了 Wi-Fi 路由器電磁輻射（EMR）及 Aires Defender 共振器（RA）對 Wistar 大鼠骨髓細胞染色體畸變頻率（FCA）的影響。發現 EMR 作用下 FCA 增加，並確定了路由器在某一工作模式下具有最大的損傷效應。RA 能減少 EMR 對骨髓細胞的損傷影響。本文提出了利用 Aires Defender 共振器轉換電磁脈衝（EMP）的數學模型，並討論了 EMR 對體細胞作用的機制與防護機制。

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