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Electromagnetic wave localization and scattering parameters investigation in a partially absorbing medium depending on the output tract geometric configuration

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Abstract: **The paper presents first results obtained on an experimental setup designed to study the parameters of localization, scattering and absorption of microwave radiation with a power of 1-4 mW at the 38 GHz when radiation propagates in variable-section waveguides. The parameters of localization and scattering of an electromagnetic wave in a partially absorbing medium were studied depending on the geometric configuration of the output tract. The interpretation of the obtained initial results was carried out within the framework of the (1+4)D extended space model (ESM). The extended space model is formulated in (1+4)-dimensional space time-coordinate-interval action. An additional spatial coordinate in the ESM is the interval, which in the ESM has the physical meaning of the action. In the dual (1+4)D space energy-momentum-mass, the interval (action) in the ESM corresponds to the mass. ESM considers the question of the emergence of a non-zero variable mass for a photon and its localization under the influence of an external field.**

Keywords: **electromagnetic field localization and scattering, radiation absorption, variable cross section waveguide, microwave radiation, (1+4)D extended space model**

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Contents

1. INTRODUCTION

In [1], published by us in 2021, we described the creation and testing of an experimental setup designed to study the localization parameters of electromagnetic microwave radiation with a power of 0.001-0.004 W in the range of 36.0-79.0 GHz when radiation propagates in metal waveguides of variable cross section filled with dielectrics with different refractive indices.

The results of measurements carried out on the created experimental stand, we will compare with the calculations of the electromagnetic field for microwave antennas, carried out using programs based on the method of moments (for example, NEC2, MININEC3 programs or using the HFSS electrodynamic modeling and design system (High Frequency Structure Simulator), IE3D, Microwave Office, Microwave Studio [2-5]).

In addition to comparing the obtained experimental results with generally accepted calculation models, we plan to evaluate the possibility of description using calculations based on the Extended Space Model (ESM) developed earlier in [6-10]. ESM is based on the physical hypothesis that the mass (rest mass) and its conjugate value – action (interval) are dynamic variables. The interaction of fields and particles determines the magnitude of these variables. Such a model is a generalization of the Special Relativity Theory (SRT). In SRT, the interval and rest mass of particles are invariants, while in the proposed ESM [6-10] they can change. For example, in ESM a photon can acquire mass (both positive and negative). Such a mass can appear and change due to electromagnetic interaction and generate gravitational forces. This allows us to consider gravity and electromagnetism as a single field in the ESM.

It should be noted that a five-dimensional model close to the ESM was developed by Paul Wesson et al. [11-14]. P.Wesson in his works proposed to use the "mass" as the fifth coordinate as an additional coordinate to the time and three spatial coordinates: [11] p. 10 "we ... consider mass on the same basis as time and space ..." and [11] on page 191 equation (7.40) "This means that the role of the uncharged 4D mass in 5D geometry is played by an additional coordinate". This approach to the introduction of the fifth coordinate seems to us illogical. For example, this leads to difficulties in generalizing the four-dimensional energy-momentum tensor to the five-dimensional energy-momentum-mass tensor in 5D space. In our opinion, the mass can be considered as the fifth coordinate, but not in the coordinate space. The mass must be considered in the momentum space, namely as an additional quantity to the energy and the three components of the momentum. In this case, in the coordinate space, the fifth coordinate must be a different value, which is associated with the mass. As a result of considering mass as the fifth coordinate, in addition to time and space, it was difficult in [11-13] to establish a connection between mass and experiments. Recently in [14] James Overduin (co-author Paul Wesson) and R.C. Henry proposed the same idea of introducing the fifth coordinate as Tsipenyuk D.Yu. and Andreev V.A. in 1999 [10].

An overview of various models on the topic of multidimensional fields can be found in the book [15]. The most famous pioneering approaches to the construction of five-dimensional models can be found in the works of Klein Felix [16], Einstein [17,22], Klein Oskar [18], Kaluza [19], Fock [20], Mandel [21].

In works on Rumer's 5-optics [23], the fifth coordinate is also introduced in the form of an action and a 5-dimensional space with metric (1;4) is considered. However, Rumer does not consider any transformations in this space that would confuse the coordinate with the other four coordinates of the Minkowski space. Therefore, in the conjugate to the 5-dimensional coordinate space, the mass in Rumer's five-optics remains constant and is not converted into energy and momentum.

In this paper, we present the first experimental results of measuring the localization parameters of microwave radiation with a frequency of 38 GHz and a power of 4 mW when propagating in waveguides of variable cross section filled with a dielectric material with a high refractive index and also compare the magnitude of the signal attenuation effect in a dielectric sheet absorber of microwave radiation of variable thickness. depending on the shape of the waveguides (convergent or rectangular in cross section). A qualitative interpretation of the results was carried out on the basis of previously published works on the possibility of overcoming the Coulomb barrier in the framework of ESM [24].

2. LOCALIZATION AND TRANSFORMATIONS OF FIELDS AND PARTICLES WITHIN THE ESM APPROACH

The localization of fields and particles, their transformations within the framework of the ESM approach are considered in detail in [6-10,24]. Some of the results of these works related to the topic of this article are briefly outlined below.

The extended space model makes it possible to describe the process of electromagnetic field localization when an electromagnetic wave enters from vacuum into an external space-variable field (for example, an electron) or into a converging (expanding) waveguide.

The ESM considers a generalization of Einstein's special relativity theory (SRT) to a 5-dimensional space, or rather to a (1+4)-dimensional space (*T, X, S*) with the metric (+ - - - -). The physical basis for such a generalization is the fact that in SRT the masses of particles are scalars and do not change under their elastic interactions. However, it is well known that a photon can be considered a massless particle and described by a plane wave only in infinite empty space. If a photon enters a medium or finds itself in a limited space, for example, in a resonator or waveguide, then it acquires a nonzero mass. This mass can appear and change due to electromagnetic interaction and generate gravitational forces. It is this circumstance that allows us to consider gravity and electromagnetism as a single field.

ESM is based on the assumption that the relationship between energy, momentum and mass is 5-dimensional if we take into account the possibility of changing mass in physical processes

$$E^2 - c^2 p_X^2 - c^2 p_Y^2 - c^2 p_Z^2 - m^2 c^4 = 0. \qquad (1)$$

At the same time, in the ESM, the length of the Lorentz-covariant 5-vector corresponding to objects satisfying (1) is equal to zero:

$$(ct)^2 - x^2 - y^2 - z^2 - s^2 = 0. \qquad (2)$$

It seems natural to expand the space of parameters characterizing the particle, taking into account the fact that its mass can change during the interaction. Let's take a simple analogy. A free particle moves in a straight line, so to describe its behavior, we can restrict ourselves to the (1+1)-dimensional space formed by the time *T* and the direction of its movement *X*, since the other *Y* and *Z* coordinates remain constant. If the particle begins to interact with other objects, so that it can leave the straight line and start moving also in the (*YZ*) plane, then this space is no longer enough and it has to be expanded to (1+3)-dimensional. Similarly, in our case, as long as the mass of the particle does not change, we can restrict ourselves to the 4-dimensional Minkowski space M(1,3), but if it starts to change, the space M(1,3) has to be extended to the 5-dimensional *G*(*T; X, Y, Z, S*).

An isotropic 5-dimensional mass energy-momentum vector is introduced in this space:

$$\tilde{p} = (E/c; p_X, p_{Y,}, p_Z) \qquad (3)$$

and a 5-dimensional isotropic current vector generating a unified electromagnetic-gravitational field:

$$\vec{\rho} = (j_0, \vec{j}, j_4) = \left[\frac{emc}{\sqrt{1-\beta^2}}, \frac{em\vec{v}}{\sqrt{1-\beta^2}}, emc \right]. \quad (4)$$

Similarly, a 5-vector potential A is introduced into the ESM:

$$A = (\varphi, \vec{A}, A_S) = (A_T, A_X, A_Y, A_Z, A_S). \quad (5)$$

The components of such a 5-dimensional vector potential are related in the ESM by the system of equations:

$$\Diamond_{(5)} A_T = -4\pi\rho, \quad (6)$$

$$\Diamond_{(5)} \vec{A}_{X;Y;Z} = \frac{-4\pi}{c} \vec{j}, \quad (7)$$

$$\Diamond_{(5)} A_S = \frac{-4\pi}{c} j_S, \quad (8)$$

$$\Diamond_{(5)} = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} + \frac{\partial^2}{\partial s^2} - \frac{1}{c^2} \frac{\partial^2}{\partial t^2}. \quad (9)$$

On the basis of the vector potential (5) in the ESM, one can construct the usual electric and magnetic fields $\vec{E}$ and $\vec{H}$,, as well as two new fields – the scalar Q and the vector $\vec{G}$ components of which are determined similarly to the construction of fields in the four-dimensional Minkowski space:

$$\|F_{ik}\| = \frac{\partial A_i}{\partial x_k} + \frac{\partial A_k}{\partial x_i};\ i,k = t,x,y,z,s, \quad (10)$$

$$\|F_{ik}\| = \begin{pmatrix} 0 & -E_X & -E_Y & -E_Z & -Q \\ E_X & 0 & -H_Z & H_Y & -G_X \\ E_Y & H_Z & 0 & -H_X & -G_Y \\ E_Z & -H_Y & H_X & 0 & -G_Z \\ Q & G_X & G_X & G_X & 0 \end{pmatrix}. \quad (11)$$

The external action in the ESM is described using rotations of three hyperbolic rotations (T, X), (T, Y), (T, Z) corresponding to the Lorentz transformations in the four-dimensional Minkowski space M(1,3) and new types of rotations – one hyperbolic (T, S) and three Euclidean (X, S), (Y, S), (Z, S) in the extended space G(1,4).

Rotations in G(1,4) have a clear physical meaning, so for example, hyperbolic rotations (T, X), (T, Y), (T, Z) are simply, according to (1) and (2), the change in particle velocity in corresponding X, Y or Z direction.

In the case of hyperbolic rotations in the plane (TS), according to (2), there is a simultaneous change in the mass and energy of the particle. For example, the dependence of the photon mass on the rotation angle θ is determined by the formula $mc^2 = \hbar\omega \mathrm{sh}\theta$ [6-10]. Expression for the localization parameter l in terms of the angle θ:

$$l = \frac{2\pi c}{\omega \cdot sh\theta}. \quad (12)$$

For Euclidean rotations in the plane (XS), the dependence of the photon mass on the rotation angle ψ is determined by the formula $mc^2 = \hbar\omega\sin\psi$, from which follows the expression for the localization parameter l in terms of the angle ψ:

$$l = \frac{2\pi c}{\omega \cdot \sin\psi}. \quad (13)$$

The speed of wave propagation c in vacuum is related to the propagation of speed in a medium or waveguide v refractive index n by the relation $v = c/n$.

In the case of rotations (XS), a photon under the influence of an external field acquires a mass related to the refractive index by the relation:

$$m_{(XS)} = \frac{\hbar\omega}{c^2} \cdot \sin\psi = \frac{\hbar\omega}{c^2 n}. \quad (14)$$

Rotation (XS) corresponds in ESM to a transition from a space with one optical density to a space with another optical density. In this case, no time processes occur, everything is considered at the same moment in time. Therefore, the energy of the particles is conserved, and all processes occurring with them are reduced to internal rearrangements. Conventionally, this can be understood in such a way that a particle entering a denser medium is deformed elastically, and leaving it, restores its characteristics.

In the case of hyperbolic rotations (TS), a photon under the influence of an external field acquires a mass related to the refractive index by the relation:

$$m_{(TS)} = \frac{\hbar\omega}{c^2} \cdot sh\theta = \frac{\hbar\omega}{c^2}\sqrt{n^2 - 1}. \tag{15}$$

The physical meaning of rotations (*TS*) is that we do not perform spatial movements, we are always at the same point, but the optical density at this point changes over time. In this case, the transformation (*TS*) means the transition to a different point in time and a different optical density. This can be interpreted in such a way that an external field arises in space, which, acting on a particle and doing work, changes its energy and mass.

From the point of view of ESM, the transition from a medium with one refractive index to a medium with another refractive index can be interpreted as a movement along the fifth coordinate of the Extended Space. This (1+4)-dimensional space can be understood as a set of 1+3-dimensional Minkowski spaces, each of which is characterized by some parameter, such as the refractive index n. And the transition from a medium with an index of n_1 to a medium with a refractive index of n_2 can be interpreted as a transition in a (1+4)-dimensional space from one (1+3)-dimensional subspace to another (1+3)-dimensional subspace. Thus, the geometry of the Expanded space turns out to be connected with the physics of those processes that we study in each specific problem. Namely, with the fields and environments that participate in these processes. The distribution of these media and fields in our ordinary Minkowski space determines the distribution of the "refractive index" in the Extended space, i.e. its geometry.

In [8] the solution of the system of equations (6)-(8) was found in the form

$$U(s,x,y,z,t) = u(s,x,y,z) \cdot e^{-iks} \cdot e^{i\omega \cdot t}, k = \frac{2\pi}{\lambda}. \tag{16}$$

Assuming that the desired function is stationary in time and changes slowly along the s axis compared to the change along the x, y, z axes. In this case, the solution has the form of a 3-dimensional Gaussian wave

$$u = u_0\left(\frac{w_0}{w}\right)^{3/2} \times \\ \times \exp\left[-i(ks+\varphi) - (x^2+y^2+z^2)\left(\frac{1}{w^2} + \frac{ik}{2R}\right)\right]. \tag{17}$$

Here w_0, the minimum wave radius at the point $s = 0$; w – is the wave diameter at point s_1 and R is the wavefront curvature radius at this point.

When a plane electromagnetic wave enters a medium or an external field, ESM predicts that, in accordance with (20), taking into account the above assumptions, the plane wave is localized into a sphere with radius w_0.

We also note that it was shown in [24] that the fields (11) transform into each other upon rotations in $G(1,4)$, which leads to the possibility of overcoming the Coulomb barrier in the framework of the ESM.

1. Hyperbolic rotations in the plane (T,X) lead to the following field transformation:

$$\vec{E}' = \vec{E} + \frac{1}{c}[v, \vec{H}],\ \vec{G}' = \vec{G} + \frac{v_S}{c}\vec{E}, \\ \vec{H}' = \vec{H},\ Q' = Q. \tag{18}$$

2. Hyperbolic rotations in the plane (T,S) lead to:

$$\vec{E}' = \vec{E} + \frac{v_S}{c}\vec{G},\ \vec{G}' = \vec{G} + \frac{v_S}{c}\vec{E}, \\ \vec{H}' = \vec{H},\ Q' = Q. \tag{19}$$

3. Euclidean rotations in the plane (X,S) lead to:

$$\vec{E}' = \vec{E} - \vec{u}Q,\ \ \vec{G}' = \vec{G} + [\vec{u}, \vec{H}], \\ \vec{H}' = \vec{H} + [\vec{u}, \vec{G}],\ \ Q' = Q + \frac{1}{c}(\vec{u}, \vec{E}). \tag{20}$$

here v, v_S, u are the velocities corresponding to the motion along the corresponding axis in $G(1,4)$.

It was shown in [24] that, within the framework of ESM, the field of a plane electromagnetic wave $\vec{E}, \vec{H}$, when turning in the φ^{YS} + φ^{ZS} planes by specially selected angles, can completely transform into the fields G and Q, which will make it possible to overcome the Coulomb barrier.

3. DESCRIPTION OF THE INSTALLATION AND THE RESULTS OF THE FIRST MEASUREMENTS

3.1. Description of the installation

A detailed description of the created experimental setup is given in [1].

The results of measurements obtained at the facility will be compared with the results of calculations based on existing models of microwave radiation propagation and predictions based on ESM. The facility also assumes the measurement of microwave localization parameters when radiation enters dielectric media with a refractive index greater than unity.

The installation diagram is shown in **Fig. 1**.

Microwave radiation with a frequency of 38 GHz is generated by generator 1 of the G4-141 brand (generation region 36-55 GHz). The output signal power is adjustable from 1 to $4 \cdot 10^{-3}$ W, the range of the output power level is 30 dB. The instability of the output frequency is not more than 10^{-3}. The limit of instability of the output power level is ±0.3 dB. After the microwave generator, the radiation propagates along a silver-plated copper output waveguide 2 30 mm long, having a rectangular cross section $a \times b$ = 5.5×2.5 mm.

Inside the waveguide 2, a dielectric rod 4 is installed, made of Teflon, which completely fills the waveguide and extends 135 mm outward from the waveguide. We used two types of dielectric Teflon rods of different profiles: No. 1 with a cross section from 5.5×2.5 mm at the beginning to 0.1×2.5 mm at the end of a rod 180 mm long and No. 3 with the same cross section of 5.5×2.5 mm along the entire rod 200 mm long.

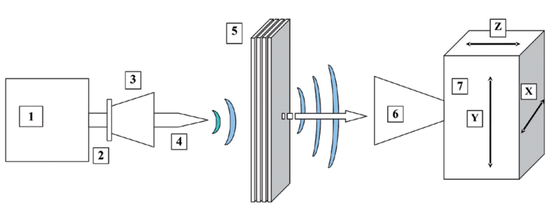

Fig. 1. *Installation diagram. 1 - microwave radiation generator 38 GHz, 2-output horn antenna, 4 - Teflon dielectric insert of constant or variable cross section, 5 - dielectric sheet absorber of microwave radiation of variable thickness 0-50 mm, 6 - receiving horn with a microwave radiation receiver connected to the ADC and control computer, 7 - system of 3-dimensional X-Y-Z positioning of the receiver.*

The installation has the ability to install a horn antenna 3 (output diameter 45 mm and length 75 mm), as well as a waveguide 2 with a wall thickness of 1.2 mm, made of copper and silver-plated from the inside.

The receiver 6 combined with a horn antenna (inlet diameter 35 mm, length 55 mm) can be precisely moved in three spatial directions (movement accuracy 0.1 mm in the range 0-140 mm) using the 3-dimensional positioning system of the receiver 7. Further, the signal is the received microwave signal processed by the ADC and transmitted to the control computer.

To study the possible difference in the absorption of microwave radiation depending on the degree of localization between the emitter 4 with a Teflon core installed with a constant profile No. 1 or a variable profile No. 3 and the receiver 6, a dielectric sheet absorber of electromagnetic microwave radiation 5 was installed, consisting of a set of dielectric plates with a thickness of 2 to 16 mm. The maximum thickness of the inlaid sheet dielectric absorber was 55 mm. The measured absorption coefficient of 38 GHz microwave radiation with a change in the total thickness of the inlaid sheet dielectric absorber from 2 to 55 mm was from 5 to 90% of the output signal. When setting the maximum level of the output power of the signal at the level of $4 \cdot 10^{-3}$ W, the amplitude of the recorded useful signal reaches the level of 350 mV at a distance of about 150 mm.

3.2. Measurement results.

Fig. 2 shows the first results of measuring the shape of the vertical profiles of a microwave wave with a frequency of 38 GHz emerging from a rectangular waveguide with a cross section of

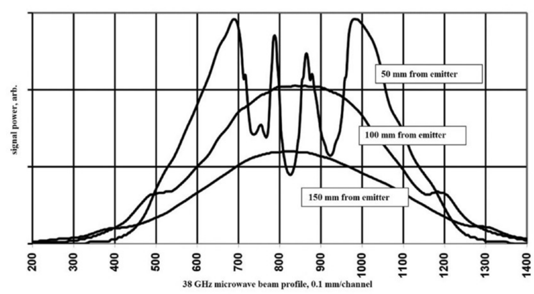

Fig. 2. *Comparison of the shape of the 38 GHz microwave beam profiles (without taking into account the relative magnitude of the signal), depending on the distance from the transmitter to the receiver 50, 100 and 150 mm. Output horn diameter 45 mm, horn length 60 mm and input horn 35 mm, horn length 50 mm.*

5.5×2.5 mm, combined with an output horn with a diameter of 45 mm and a horn length of 60 mm. The input horn combined with the radiation sensor had a diameter of 35 mm and a horn length of 50 mm.

Vertical profiles were measured both in the middle of the beam in the horizontal direction and with detuning every 5-10 mm from the middle section. Presented in Fig. 2 vertical wave profiles were measured at different distances of 50, 100, and 150 mm between the output and input sections of the horns.

On Fig. 2 are presented to compare the wave profile shape at different distances without taking into account the real value of the received signal. It can be seen that at a distance of 50 mm the wave has not yet formed completely, which corresponds to the near Fresnel diffraction zone for radiation with a frequency of 38 GHz (wavelength 7.89 mm). Already at a distance of 100 mm, the wave front is practically formed, which corresponds to the far Fraunhofer diffraction zone.

These results are in good agreement with theoretical ideas about the formation of a wave front during the emission of electromagnetic radiation, depending on the distance along the direction of radiation propagation.

At distances corresponding to the near diffraction zone, the theoretical calculation of the shape of the wave front presents significant difficulties; therefore, we carried out most of the measurements at distances of more than 100 mm between the transmitter and receiver. At the same time, we were limited in the ability to measure the wavefront at large distances, since the maximum possible precision movement of the receiver 6 used on the setup was limited to 140 mm with a positioning accuracy of the system 7 of 0.1 mm, see Fig. 1.

For an experimental assessment of the presence or absence of differences in the degree of absorption of electromagnetic waves with different degrees of localization in stacked dielectric absorbers of various thicknesses, the installation shown in Fig. 1 was assembled. A different form of the emitted electromagnetic wave was created by Teflon absorbers 4 having a constant or variable cross-sectional profile. Depending on the profile of the Teflon insert No. 1 or No. 3 in the output waveguide 2, the shape of the radiation wavefront at the half-intensity level was different. At a distance of 100 mm from the outer cut of the Teflon insert, after passing through the 18 mm thick dielectric absorber, the value of the vertical profile of the signal from the rectangular insert No. 1 is 316±3 mm at half-height of the maximum value. At the same time, from insert No. 3, which has a converging signal profile, the value at half height was 424±3 mm.

On **Fig. 3** the results of one of the conducted experiments on the absorption of microwave radiation with a frequency of 38 GHz in a dielectric absorber of variable thickness are presented. In this experiment, a Teflon insert with a converging profile No. 3 (from 5.5×2.5 mm at the beginning to 0.1×2.5 mm at the end) was inserted into the output waveguide 2 and protruded from it by 125 mm, while the output horn 3 was absent. see Fig. 1. An input horn of rectangular section 36×30 mm, 60 mm long, combined with receiver 6, was installed at a distance of 100 mm from the end of the Teflon insert. A stacked Teflon absorber with

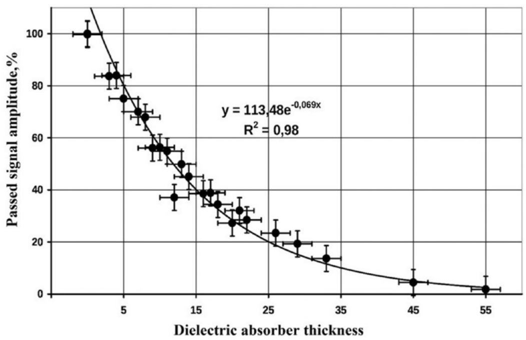

Fig. 3. *Dependence of the relative value of the transmitted signal of microwave radiation with a frequency of 38 GHz on the thickness of the stacked dielectric absorber.*

a thickness of 2 to 55 mm was adjusted in the range of 0.1–4 mm from the end of the Teflon insert so that the signal level in the receiver 6 from the radiation transmitted through the absorber was maximum. To reduce the level of interference from microwave waves scattered by the installation equipment, special absorbers of microwave radiation were attached at the emitter output and receiver input, which made it possible to significantly reduce the noise level in the receiving path.

On Fig. 3 in addition to the experimental data on the dependence of the transmitted signal when using a Teflon insert of a converging profile No. 3, an approximation based on the exponential formula of the data obtained and the value of the reliability of this approximation R^2 are given. Comparison of the obtained approximation formulas for Teflon inserts No. 1 (rectangular section) and No. 3 (converging section) showed a difference in the exponents at the level of 4-5% (–0.069 versus –0.074). At the same time, the exponent in the trend formula corresponding to the absorption of the localized wave emerging from the converging waveguide No. 3 is less than the exponent obtained by approximating the results of the Teflon rod No. 1 with a rectangular constant profile by the exponential law.

The accuracy of the data of the first experimental results and the total amount of measurements carried out so far only allows estimating and limiting the magnitude of the obtained effect of the difference in the absorption of electromagnetic microwave waves in the region of 35-50 GHz with different degrees of localization from above by a value of about 3-4% for a given experiment geometry.

4. DISCUSSION OF THE RESULTS AND CONCLUSIONS

The first qualitative results have been obtained, which make it possible to compare the absorption of electromagnetic waves of different degrees of localization in a dielectric absorber. Within the framework of ESM, the propagation of an electromagnetic wave along the Z axis in a waveguide of variable cross section converging along the X and Y axes filled with a dielectric with a refractive index greater than 1 corresponds to the case of a combination of rotations , and in the XS, YS and ZS planes [6,24]. With a combination of rotations in different planes, according to the ESM formalism, a plane electromagnetic wave consisting only of components passes partially (and under certain conditions, completely) into new fields.

So, for example, when rotating, the following changes occur in the components

$$E'_Y = \cos\varphi^{YS} E_Y + Q\sin\varphi^{YS};\; H'_X = H_X\cos\varphi^{YS} - G_Z\sin\varphi^{YS};$$
$$Q = Q\cos\varphi^{YS} - \sin\varphi^{YS} E_Y;\; G'_X = G_X\cos\varphi^{YS} - H_Z\sin\varphi^{YS}.$$

When and turning in the XS and ZS planes, according to the ESM, similar field transformations also occur [6-7].

According to the qualitative estimates obtained in the ESM of the processes occurring during the passage of a plane electromagnetic wave through a converging dielectric waveguide of variable cross section (wave localization), a new field object arises in which, due to the partial transformation of the initial fields into new fields, due to which it is possible to more effectively overcome the Coulomb material barrier. As a result, less efficient scattering of such localized waves in comparison with nonlocalized electromagnetic radiation should be observed in experiments according to ESM [24].

In our series of experiments, we obtained an estimate of the scattering of microwave radiation with a frequency of 38 GHz in dielectric absorbers of variable thickness for different shapes of the incident wave wavefront (different degrees of localization). If the initial microwave radiation from the generator passes through a converging dielectric waveguide, a smaller scattering of radiation during propagation through a dielectric absorber is recorded in comparison with experiments in which the microwave from the generator passed through a Teflon rod of constant cross section.

To compare the obtained experimental data with the results of model calculations, we plan to carry out calculations based on existing software packages, such as NEC2, MININEC3 and HFSS (High Frequency Structure Simulator), IE3D, Microwave Office, Microwave Studio [2-5].

In order to more fully study the expected effect, measurements will be carried out using silicone dielectric materials, which have a significantly higher refractive index for electromagnetic waves in the microwave range.

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