## SPHERICAL WAVE-TYPE SOLUTION IN RELATIVISTIC THEORY OF GRAVITATION

A. Leonovich[1], Yu. Vyblyi[2]

1 Belarusian State University of Informatics and Radioelectronics, Minsk, Belarus

2 Institute of Physics, National Academy of Sciences, Minsk, Belarus

vyblyi@gmail.com

### I. INTRODACTION

As known, in General Relativity (GR) the energy of gravitational field is described with help the energy-momentum pseudotensor, but expression for corresponding tensor is absent. It is one of reasons for which the gravitational interaction may regarded as a tensor interaction in Minkowsci space-time. The most consistently such approach was realized in relativistic theory of gravitation (RTG) [1,2]. This theory can regarded as a gauge theory of the group of Lie variations for dynamic variables. The related transformations are variations of the form of the function for generally covariant transformations. That the actions be invariant for this group under the transformations of the dynamical variables alone requires replacing the "nondynamical" Minkowski metric $\gamma^{ik}$ with expression $g^{ik}$ : $\tilde{g}$ $g^{ik} = \sqrt{-\gamma}\,(\gamma^{ik} + k\psi^{ik})$, where $\gamma = det\gamma_{ik}, g = detg_{ik}$, $k^2$ - is the Einstein constant, and thus introducing the gauge gravitational potential $\psi^{ik}$. The expression $g^{ik}$ is interpreted here as the metric of the effective space-time, from which the connection - the Cristoffel brackets can be uniquely constructed. The RTG field equations at its massless variant are the Einstein ones for the effective metric, added the conditions, restricting the spin states $D_i \tilde{g}$ where $D_i$ is the covariant derivative in Minkowski space. This conditions plays the significant role in RTG. It removes the gauge arbitrariness of Einstein equations and coincides with the Fock harmonic conditions in Galilean coordinates [3]. Note that the approach to gravitation in Minkowski space-time has a long history. This approach was considered in detail by R. Feynman in [4].

Although RTG field equations locally coincides with General Relativity ones, their global solutions, generally speaking, will be different, since this solutions are defined on the various manifolds. RTG, being founded on the simple space-time topology, allows to introduce the global Galilean coordinate system, that distinguishes RTG from bimetric theories, in which the flat space plays the auxiliary role and its topology does not define the character of the physical processes. This distinction may take place at interpretation of the field solutions, since the coordinate system is defined by Minkowski metric in RTG, but it is fixed by noncovariant coordinate conditions in GR. Just this situation takes place for spherically-symmetrical gravitational fields. In GR according the Birkhoff theorem any spherical gravitational field in vacuum is a static one. The proof of this theorem is grounded on the transformation of certain spherically-symmetrical metric to the coordinates in which it has a static form. But in RTG such transformation is the transfer from the spherical coordinates in Minkowski space to some "nonstatic" coordinates. The Birkhoff theorem means that in the case of spherically symmetry the coordinate system in which the vacuum metric depends from one coordinate always exists, but it is not means that the field was static in the starting coordinates. Hence the task of the investigation of nonstatic spherically symmetric solutions arises. In this paper one of the possible nonstatic spherically symmetric wave solutions in implicit form is founded and its energy characteristics is considered.

## II. METHODS AND RESULTS

To find the spherically symmetric wave solutions we use the Birkhoff theorem and present a nonstatic spherical wave solution in certain coordinate system $(\tau, R, \theta, \phi)$ in the Schwarzschild metric form

$$ds^2 = (1 - \frac{2m}{R})d\tau^2 - (1 - \frac{2m}{R})^{-1} dR^2 - R^2 d\Omega^2 . \quad (1)$$

To find this solution in spherical coordinates of Minkowski space $(t, r, \theta, \phi)$ we use the coordinate transformation $t = t(\tau, R), r = r(\tau, R)$ and the transformation coefficients will be found from the condition (1). The corresponding equations , connecting the variables (t, r) and $(\tau, R)$, will have the form

$$\frac{R}{R - 2m} \frac{\partial^2 t}{\partial \tau^2} - R^{-2} \partial_R [(R^2 - 2mR) \frac{\partial t}{\partial R}] = 0 , \quad (2)$$

$$\frac{R}{R - 2m} \frac{\partial^2 r}{\partial \tau^2} - R^{-2} \partial_R [(R^2 - 2mR) \frac{\partial r}{\partial R}] + \frac{2r}{R^2} = 0 . \quad (3)$$

We search the partial solution of this equations in the form $\tau = t + T(u), R = r + m, u = t + f(r)$, where u is retarded argument, which is finite at any values of *R*. In result the metric components of the spherical wave have the form

$$g_{00} = \frac{r - m}{r + m}(1 + T_u)^2 , g_{01} = \frac{r - m}{r + m} T_u (1 + T_u) f_u , g_{11} = \frac{r - m}{r + m} (T_u)^2 (f_u)^2 - \frac{r + m}{r - m} , \quad (4)$$

$$g_{22} = -(r + m)^2 , g_{33} = -(r + m)^2 \sin^2 \theta , \quad (5)$$

the function $f$ is defined from the equations (2-3). We show also that this solution have the positive-definite density of energy and momentum [5].

## III. CONCLUSIONS

In relativistic theory of gravitation the nonstatic spherically-symmetrical solutions and in particular such wave solutions have a physical sense as far as the temporal coordinate of the Minkowski space-time has it. Although the receiving wave solution has enough formal character, it illustrates the possibility of existence of spherical gravitational waves. The realistic model must include also interior solution and matching it with the finding exterior one.

## REFERENCES

[1] A.A. Logunov, M.A. Mestvirishvili, “Relativistic Theory of Gravitation”, M. Mir, 329 p., 1989 (in Russian).

[2] A. Logunov, “The Theory of Gravity”, Nova Scifnce Publ., N.Y., 342 p., 1998.

[3] V. Fock, “The Theory of Space, Time and Gravitation”, 2nd edition. Pergamon Press, Macmillan Comp., 448 p.,1964.

[4] R.P. Feunman, F.B. Morinigo and W.G. Wagner, “Feunman Lectures on Gravitation”, Addison-Wesley Publishing Company, 280 p., 1995.

[5] A. Leonovich and Yu. Vyblyi “Spherical gravitational waves in the weak gravitational field”, In Proc. of the IX International Conference Bolyai-Gauss-Lobachevsky, Minsk, p.130-135, 2016.