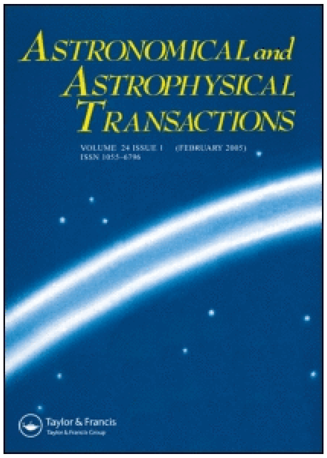

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A certain cosmological solution and search for possibly related astronomical objects

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Certain cosmological solution to the equations of the general theory of relativity is considered. It is shown that we may expect concentration of matter along lines representing singularities of the solution. Evidence for possible related astronomical objects is presented.

Keywords: Cosmology; General theory of relativity

This work is devoted to the search for cosmic objects corresponding to a certain cosmological solution to the equations of the general theory of relativity.

Let us consider this solution [1].

The solution should be applied to space-time without matter. A small part of space with matter is not considered. Einstein's equations $R_{ij} = 0$, where R_{ij} is the Ricci tensor, should be fulfilled in the main part of space without matter. A partial case of this solution is flat space-time. Such a solution does not have any interest if it is simply the usual global flat space-time. However, it is possible that there are solutions that represent flat space-time only locally. Such solutions are flat everywhere, except on special lines. Then the topology of space (in space-time) may be significantly different from the usual topology of space in flat space-time. Let us consider in more detail these solutions and their physical meaning.

For demonstration we consider first, a symmetrical two-dimensional surface – the surface of a cube. At first sight it seems that it contains eight separate flat sides. These sides cannot be regarded as a unified smooth surface. But every side can be extended continously and smoothly onto the neighbouring side with a common edge. We do this by changing the angle between two sides from 90 degrees to 180 degrees (to unfold the angle). The two

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sides then become a unified flat surface. This surface may be analogously extended onto the next side, and so on. After this procedure the surface of the cube becomes a unified smooth surface with eight special points. These eight points are the vertices of the cube. In the neighbourhood of these points the surface of the cube is a cone, and the vertices become vertices of cones (a cone is a flat surface that can be unfolded). The angle passing around these points differs from 2π. This closed flat surface with weight particular points is an example of locally flat symmetrical two-dimensional Riman space. The same can be done with the surface of an infinite two-dimensional polyhedron embedded in tree-dimensional pseudo-Euclidean space.

Locally flat three–dimensional symmetrical Riman spaces can be constructed analogously. To do this we connect the sides of regular tree-dimensional polyhedrons in 4-dimensional Euclidean or pseudo-Euclidean space. Then every polyhedron is extended smoothly and continuously onto the neighbouring polyhedron with a common edge. As a result we obtain a unified locally flat three-dimensional Riman space with a net of straight lines with singularities. These lines are the edges of polyhedrons. The singularity is revealed by the fact that the angle obtained passing around these lines differs from 2π. Analogously, the angle passing around the vertices differs from 4π.

It is important that locally flat Riman spaces, similar to those described above, should not necessarily be symmetrical. Any two-dimensional surface in three-dimensional Euclidean or pseudo-Euclidean space may be approximated by a set of connected irregular triangles (or another flat figures). These triangles together compose a unified locally flat two-dimensional space. The vertices are peculiar points, for which the angle obtained passing around is different from 2π. Three-dimensional locally flat Riman spaces can be treated in the same way. It should be noted that two-dimensional spaces placed in three-dimensional Euclidean or pseudo-Euclidean space and three-dimensional spaces placed in four-dimensional Euclidean space are not necessarily closed.

In [1] it was shown that three-dimensional locally flat Riman spaces can be considered as limiting cases of some four-dimensional space-time, which satisfies the Einstein equations of the general theory of relativity. Indeed, if three-dimensional locally flat Riman space is considered in time, then we will have locally flat four-dimensional space-time, which satisfies the Einstein equations (without a cosmological term), except for points of singularities in three-dimensional space. In order to smooth out these non-physical singularities, it is enough to fill the regions of space close to the net of lines by cosmic matter. In this case, the cosmological term [1] should be taken into account or by matter corresponding to calibrating strings [2]. In the case of a string, an infinitely long string is replaced by a system of lines, connected by the end points (in this case the cosmological term equals zero). Certain stationary space-time corresponds to the calibrating string [2] as the result of solutions of general relativity equations. Three-dimensional space in this solution is locally flat space except for a small region around a certain straight line; the angle passing around this line is less than 2π. Other solutions with similar properties are also interesting. There are stationary solutions, the three-dimensional part of which is locally flat space, except the region around a particular straight line, for which the angle passing round is different from 2π.

As a supplement, let us consider the stationary solution of the general theory of relativity with axial symmetry in space-time without matter. The axis is a peculiar line, which can be replaced by a cylindrical body with small radius compared to characteristic sizes. In a certain region, except the part of space near the axis, the solution can be approximately regarded as locally flat [1]. In this solution only the diagonal elements of the metric tensor are not equal to zero: g_{00}, g_{11}, g_{22}, g_{33}. They depend only on the radius, while $g_{22} = a = \text{const}$. The coordinate $x^0 = t$ corresponds to the time, $x^1 = \varphi$ – to the angle, $x^2 = r$ – to the radius, $x^3 = z$ – to the axis. If we substitute $p = (1)/(g_{00})(dg_{00})/(dr)$, $f = (1)/(g_{11})(dg_{11})/(dr)$,

$\delta = (1)/(g_{33})(dg_{33})/(dr)$, the Einstein equations will take the form:

$$2p' + 2p^2 + p(f + \delta - p) = 0,$$
$$2f' + 2f^2 + f(p + \delta - f) = 0,$$
$$2\delta' + 2\delta^2 + \delta(p + f - \delta) = 0,$$
$$2p' + 2f' + 2\delta' + p^2 + f^2 + \delta^2 = 0,$$

where primes denote first derivatives by r. These equations have an analytical solution of the form:

$$g_{00} = c_0 r^A,\ g_{11} = c_1 r^B,\ g_{22} = a,\ g_{33} = c_3 r^F,$$
$$A = \frac{2k}{(k^2/k+1)+1},\ B = \frac{2}{(k^2/k+1)+1},\ F = \frac{2k/k+1}{(k^2/k+1)+1},$$

where $a, c_0, c_1, c_3, A, B, F, k$ are constants.

The search for cosmic objects, corresponding to strings, was discussed in [3], where the discovered double luminous object was considered. It was shown in [3], that the objects in front of certain spatial line with the angle passing around differing from 2π should bifurcate. The corresponding estimates are presented.

We have searched for cosmic objects that could correspond to the solution described here. The solution was connected with straight lines, that is why we were looking for objects which were like straight or curved lines (distorted real solution with regard to the considered ideal solution). The lines may by luminous or dark. We have found some images of the region of Andromeda nebula (M31) with linear objects.

We used photographic plates of Andromeda nebula obtained by the 50 cm meniscus telescope of the Crimean laboratory of Sternberg Astronomical institute. The dates of observations

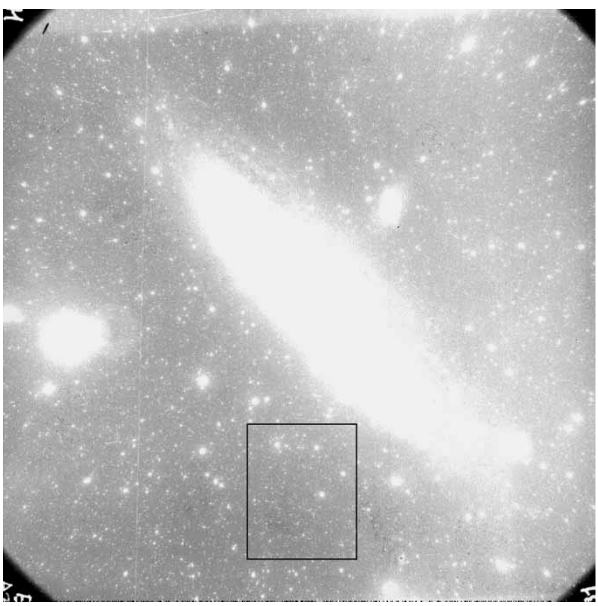

Figure 1. Image of Andromeda nebula from plate obtained on 22/23 December 2000. North is at the top, east to the left. The region where luminous and dark lines can be seen is marked. The coordinates of the centre of this region are $\alpha = 0^{\rm h}43^{\rm m}20^{\rm s}$, $\delta = +40°08'$ (2000.0), the size is approximately $30' \times 30'$.

Figure 2. Magnified view of the marked region from figure 1. The position of the luminous lines is indicated.

were 22/23 and 23/24 December 2000. The plates were scanned, and brightness and contrast were adjusted for better identification of faint features. The resulting image is presented in figure 1, which shows the plate obtained on 22/23 December, the image from the other plate is very similar. In the marked region of the image, luminous lines can be seen, which contain individual stars. Much wider dark strips are also seen. They may represent clouds of gas and dust which have linear shapes. Figure 2 shows a magnification of the marked region, with the position of the luminous lines indicated. Note that these structures can be at any distance, but not further than Andromeda galaxy.

We draw the attention of observers to these features, which deserve study at high resolution and using different filters.

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