Scale Dimension as the Fifth Dimension of Spacetime

Sergey G. Fedosin

Perm, Perm Region, Russia
intelli@list.ru

Abstract
The scale dimension which is discovered in the theory of infinite nesting of matter is studied from the perspective of the physical implementation of well-studied four-and n-dimensional geometric objects. Adding of the scale dimension to Minkowski space means the need to use the five-dimensional spacetime.
Keywords: scale dimension; multi-dimensional space; theory of infinite nesting of matter.

Intensively developed in recent years the theory of infinite nesting of matter, which studies the entire hierarchy of space systems, faced with the necessity of introducing of scale dimension into the everyday life of science. This paper aims to analysis of properties of the new dimension and its relationship with the geometric theory of *n*-dimensional spaces.

In contrast to geometry, physics are not dealing with mathematical points, but with the specific material objects. Infinite division of the objects into parts does not lead to the emergence of mathematical points, but instead there are new objects which are smaller. Although these objects seem more and more similar to the points, they contain an infinite number of matter carriers and the smallest field quanta. If the movement inward of objects is regarded as the motion along the scale axis, then the axis is a special dimension of space.

During the motion along the scale axis the transition between the scale levels of matter take place and it is seen that objects of lower levels are parts of the objects of higher levels of matter. As a result scale dimension can be represented as dimension characterizing the complexity of space systems, in the sense of composition of the systems of lower order.

The theory of infinite nesting of matter and the idea of the scale dimension acquired its modern form through the efforts of Robert Oldershaw [1] (self-similar cosmological model), Sergey Sukhonos [2-3] (scale similarity of cosmic systems) and Sergey Fedosin [4-5] (similarity of matter levels).

Spatial relations are perceived by the observer through the shape of objects and their configuration relative to each other, and the temporal relationship is determined as the changes of shapes and configurations, the angular and linear changes. Owing to the fact that objects at different levels of matter evolve and change relatively independently of each other and the speed of the processes and the characteristic sizes and masses of objects differ significantly, scale dimension is considered as a new dimension of space-time. At the same time shapes and configurations of many three-dimensional objects at different levels of matter in many respects are similar to each other. This is fixed by relations of similarity for various physical quantities and SPΦ-symmetry, which states the similarity of physical laws at different levels of matter [4].

In four-dimensional space-time as the fourth dimension is used not time t itself, but the product of c t, where c is speed of light (since for the exact space-time measurements are commonly used electromagnetic waves). Section of such space-time that is perpendicular to time axis at some time point, defines the hyperplane in the form of three-dimensional geometrical space at the given time. If in the three-dimensional space an object move to the future upcoming events through the point of present time, the four-dimensional space-time movement from time 1 until time 2 is seen as a trace from point 1 to point 2 that is associated with the object. The possibility of observing such trace in the coordinate system means that the motion can be described as a set of three-dimensional images of the object at different times.

The introduction of scale dimension takes into account that at different levels of matter flow rates of the time, regarded as the speeds of typical processes of similar objects, differ from each other. However, it is possible to enter the total coordinate time, based for example on periodic processes in an electromagnetic wave. In this case, the hyperplanes which are perpendicular to the scale axis will be gauging the single four-dimensional space-time at different levels of matter. By analogy with the four-dimensional Minkowski space-time, now we can introduce the five-dimensional coordinate system and for every world event to write its vector form: $dX^i = (ct, \boldsymbol{r}, w)$, where $\boldsymbol{r}$ is a three-dimensional radius-vector, w − the coordinate along the scale axis.

Scale dimension allows us to understand and justify the possibility of existence of the real four-dimensional bodies in the five-dimensional space-time. For constructing such bodies may be used the method of induction, reasoning as follows:

– One edge is a line segment bounded by two points (vertices);

– Three edges in the plane give a triangle with three vertices, in the form of a facet;

– Six edges with four vertices in three dimensions give a tetrahedron (triangular pyramid) with four faces;

– Ten edges with five vertices, with ten faces and the five tetrahedrons in four-dimensional space represent an object called pentachoron (4-simplex).

For a n-dimensional tetrahedron or simplex with increasing dimension n per unit the number of vertices increase too, and the number of vertices is $n + 1$. Each edge is a connection between two arbitrary vertices of the tetrahedron, so that the number of edges depends on the number of vertices on the formula for the combination of two of the k vertices. To determine the number of faces of n-dimensional tetrahedron in the form of triangles we need to find a combination of three of the k vertices. In general, the formula for r combinations of k elements expressed in terms of factorials and has the form:

$$C_k^r = \frac{k!}{r!(k-r)!}. \qquad (1)$$

Equation (1) allows finding the number of edges, faces, *k*-polyhedrons in the composition of *n*-dimensional tetrahedron.

For a *n*-dimensional cube (hypercube), we can assume that he has the number of vertices, depends on the dimension *n* on the formula: $k = 2^n$, where the dimension of the point space is zero, a linear space has dimension 1, a flat space has dimension 2, and etc. Consequently, the tesseract (tetracube) as a hypercube in four-dimensional space must have 16 vertices, and according to (1) 120 edges. If from this number to remove the internal edges between vertices of different faces, as well as the diagonal edges lying in the plane of faces, then there remain only 32 external edges, are responsible for form of tesseract as a geometric figure. Besides tesseract has 8 external three-dimensional face-cubes and 24 external faces of the two-dimensional-square limiting him to four-space. The common name of *n*-dimensional body is the *polytope*, for four-body adopted the term *polychoron*, whereas for the three-dimensional bodies is used the term *polyhedron*, and for two bodies – *polygon*.

In the space of *n* dimensions one can construct a variety of figures, and find their properties, including the *n*-dimensional angles, areas and volumes. In particular, the volume of the *n*-sphere can be expressed in terms of its radius *R* and the gamma function, as in [6]:

$$V_n = \frac{\pi^{n/2} R^n}{\Gamma\left(\frac{n}{2}+1\right)}.$$

This formula has been known in the 19 century in the writings of the Swiss mathematician Ludwig Schläfli.

Currently, the branch of mathematics which studies geometric objects in the space of *n* dimensions is developed so well that all possible objects are divided into classes according to symmetry properties [7]. There are online resources, for visually showing the projection of multidimensional bodies on the plane or in three-dimensional space [8-9], found by computer simulation.

From the mathematical point of view, any space of smaller dimension, which is part of the space of higher dimension, is a hyperplane on which is possible to have projections of points of *n*-dimensional body. If the simplex or tesseract orient strictly along the fourth spatial dimension, then at each three-dimensional hyperplane perpendicular to the axis of the fourth dimension, you'll find a tetrahedron, or cube, respectively. Similarly, if to dissect a tetrahedron or a cube perpendicular to their bases, then on the section plane (two-dimensional hyperplane) will be a triangle, whose size depends on the cutpoint, or square. During passing of the four-dimensional body through the three-dimensional space one would expect the sudden appearance and disappearance of the projections of the body, changing their size. As in everyday life such examples are not commonly found, it is seen that the fourth spatial dimension does not reveal itself directly.

From the above it follows that the scale axis, discovered in the hierarchy of cosmic systems is the physical embodiment of the fourth spatial dimension [10]. A set of three-dimensional objects at different levels of matter represents a four-body oriented along the scale axis, so that each cross section of the axis represents a three-dimensional hyperplane, which may contain three-dimensional objects.

In contrast to the mathematical idealization, the objects of a natural system because of limitations of their total number are not located on the scale axis with identical probability, but inhomogeneously, grouped into separate levels of matter. In addition, physical properties of objects substance change at different levels of matter and that fact in the geometry is usually ignored. At those levels of matter, where gravitational force is dominated cosmic objects have spherical shape. Any set of objects, consisting of spherical galaxies, globular star clusters, individual stars, planets, nucleons, etc. forms definite single four-spherical body, stretching along the scale axis as along the fourth spatial coordinate. This four-dimensional body is found not in terms of its projections as a result of its passage through our three-dimensional world, but in the opposite situation, when the observer himself is moving relative to the body and examines its components in various hyperplanes. Thus, scale dimension confirms the possibility of real existence of four-dimensional geometric objects in nature. This enables the application of mathematical methods for *n*-dimensional spaces for the study of composite physical objects at different scale levels of matter.

References

1. Oldershaw Robert L. Self-Similar Cosmological Model: Introduction and Empirical Tests // International Journal of Theoretical Physics . – 1989. – Vol. 28 . – No. 6. – P. 669-694. http://www.amherst.edu/~rlolders/OBS.HTM .
2. Сухонос С.И. Взгляд издали // Знание-сила. – 1981. – № 9. – С. 31-33.
3. Сухонос С. И. Масштабная гармония Вселенной. – М.: Новый центр. – 2002. – 312 с. ISBN 5-89117-096-5. http://www.trinitas.ru/rus/002/a0209004.htm .
4. Fedosin S.G. Fizika i filosofiia podobiia: ot preonov do metagalaktik. – Perm: Style-MG, 1999. – 544 p. ISBN 5-8131-0012-1.
5. Fedosin S.G. Fizicheskie teorii i beskonechnaia vlozhennost' materii. – Perm, 2009. – 844 p. ISBN 978-5-9901951-1-0. http://serg.fedosin.ru/knen.htm .
6. Араманович И.Г., Гутер Р.С., Люстерник Л.А. Математический анализ. Дифференцирование и интегрирование. – М.: ГИФМЛ, 1961. – 309 с.
7. Coxeter H. S. M. Regular Polytopes. – 3-rd ed. – NY: Dover Publications, 1973. – 321 p. ISBN 0-486-61480-8.
8. The fourth dimension. Comments on behalf of the mathematician Ludwig Schläfli. – http://dimensions-math.org/ (Retrieved 2011-01-02).
9. Newbold Mark. HyperSpace Polytope Slicer. – http://dogfeathers.com/java/hyperslice.html (Retrieved 2010-12-30).
10. Wikiversity, Scale dimension. – http://en.wikiversity.org/wiki/Scale_dimension .