Relational statistical spacetime and theory of quantum gravity

Vladimir V. Aristov

Moscow Institute of Physics and Technology (State University),
Dorodnicyn Computing Centre of Russian Academy of Sciences,
Dolgoprudny, Moscow Region 141700, Russia
[†]*E-mail: aristovvl@yandex.ru*

Construction of relational statistical spacetime through developing the theoretical models of fundamental devices, namely clocks and rods is considered. This model introduces an apparatus based on description of physical properties of these instruments. New equations lead to traditional physical equations according to the correspondence principle. The proposed more general approach allows us to describe in the unique equation quantum and gravitation effects. Some cosmological coincidences are deduced and a possible testing of predicted gravitational effects can be discussed. The general relational statistical model permits us to suggest a notion of the irreversible time, which can exclude some paradoxes in General Relativity.

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The way to solve several problems of theory (quantum gravity etc.) is through the construction of models of space and time. Relational statistical spacetime introduces new physical and mathematical apparatus for describing both gravity and quantum effects. In this model the properties of time are treated through properties of physical clocks, and properties of space are treated through properties of scale rules (rods). In contrast to the string theory and the loop quantum gravity, in the relational statistical approach it is supposed that the violation of the classical spacetime start not at the Planck scales (as in the mentioned theories) but at the atomic level of description and quantum phenomena can be explained through the properties of this spacetime. Moreover, in this way one can construct a joint model of relational statistical spacetime for mutual description of both quantum and gravitation effects.

This approach realizes a version of a generalized Mach's principle. A moment (instant) of time and a time interval is defined on the basis of an "ideal camera" which can obtain "pictures" of all the particles. It provides information concerning spatial positions of the particles if a coordinate system is given. This instantaneous "snapshot" implies a global set of particles from all visible distances in Metagalaxy and we have $r_1,...,r_N$, where r_i is a radius vector, and $i=1,...,N$ (N is the number of particles).

The constructing introduction of an instant (moment) of time allows us to define the individual moment through N coordinate parameters. So it is almost impossible to come back to this multi-parametric state. In other words, the statistical model of time overcomes the time paradox of GR. It confirms Hawking's chronology protection conjecture [1].

A passage of time may be introduced if we consider a series of "pictures". A time increment measured by a clock is modeled in the following manner:

$$d\tau^2 = \frac{a^2}{N}\sum_{i=1}^{N} dr_{abs\,i}^2, \tag{1}$$

where

$$dr_{abs\,i} = dr_i - \frac{1}{N}\sum_{i=1}^{N} dr_i \ .$$

Velocities of particles are introduced by a natural way. Taking into account an invariance of $d\tau$ under the translational transformation we derive the analogues of kinematic and dynamic equations of Newtonian mechanics and equations of special relativity theory, see [2]. The constant $a=1/c$ (c is a speed of light in vacuum).

A model of relational statistical space expresses a length in terms of masses, through the configuration of masses of the system under consideration and appropriate averaging in the ideal model of a rod. A rod is placed alongside the object under consideration, so the particles of the rod are related to the particles of the object. There is a restriction for a distance related to the mass of a particle (element, atom)

$$r_e = b\ m_e. \tag{2}$$

The constant $b=\hbar\ /(m_e^2 c)$ is expressed through fundamental constants including the Planck constant because the quantum theory is reproduced in the relational approach. With the use of (1) and (2), we have the following inequality for a finite increment of time

$$\Delta\tau > a\ d_\tau r_e\ , \tag{3}$$

where $d_\tau \sim 1$. When all Δr_i tend to a limiting value r_e, the interval $\Delta\tau$ does not tend to zero and is restricted according to (3). We find that $u_x \sim r_e/\tau_e \sim 1/a = c$ (recall that c is the mean square velocity; this is a consequence of Eq. (1)). We obtain $\Delta p_x \Delta x \sim m_e \Delta u_x \Delta x \sim m_e r_e c$. Thus we have an analogue of the uncertainty principle. If we assume the equality of this value and the Planck constant, we find $m_e r_e c=\hbar$ or $r_e=\hbar/(m_e c)$ and thus a constant b, see [3].

At small distances for discrete structure of matter we use the graph formalism. The length is determined as a set of particles on the straight line of a rod (defined as a shortest path on a graph). A straight line may be non-unique, and we are led to a version of non-Euclidean geometry. This results in the indeterministic description of motion. For deriving the motion equation we use Nelson's formalism [4]. The motion equations according to (3) undergo some fluctuations. In this stochastic process due to our model of spacetime one can obtain that a particle of mass m_e is subject to Brownian motion with diffusion coefficient $\nu = \hbar/(2m_e)$. That corresponds to the similar coefficient of the Nelson's approach. In Nelson's theory this coefficient had been inserted *ad hoc*. In this method the motion of a particle of mass m_e is described kinematically, as in the Einstein-Smoluchowski theory by the Markov process in the coordinate space with this diffusion coefficient. The dynamics is given by Newton's law, as in the theory of Ornstein-Uhlenbeck. According to previous note the ordinary velocity does not exist but one can define two velocities as the appropriate "forward" and "back" limits b and b_*. The current velocity V and the "osmotic velocity" u are defined respectively: $V=0.5(b+b_*)$, $u=0.5(b-b_*)$. According to [4] one can obtain equations for these two velocities and after using complex variables derive the Schrödinger equation in the ordinary form.

A sum of the gravitation potential can be derived using the limit theorems of the probability theory. A manifestation of Mach’s principle results in obtaining some cosmological coincidences. From the statistical relations we derive (see also [5])

$$R = Ar_e = \sqrt{N} r_e, \qquad e^2 / (Gm_e^2) = \sqrt{N}, \qquad N \sim 10^{80}.$$

Here N is the Eddington number and e is an elementary charge. For the “macroscopic limit” one can describe the gravitation effects because the basic relations between a distance and a configuration of masses and time and spatial values result in the curved spacetime.

The idea of a certain background space and time gives a uniformly and isotropically distributed set of elements that also move chaotically relative to each other, preserving the symmetrical distribution. This spacetime leads to the ratios accepted in the Special relativity for which is valid

$$dt_c = dt, dr_c = dr.$$

Here subscripts “c” denotes readings by clocks and rules (rods). These relations mean that in the obtained analogues of the equations of motion where the real distributions of particles appear, it is possible to replace statistical quantities dt and dr in terms of the quantities measured by the clock and rods. But if the distribution of masses differs from the uniform distribution of masses intrinsic to the scale rules the last equalities should be invalid. If there is a body of mass M, then a distance determined by averaging the real distributions of masses is larger in comparison with a distance measured by a scale ruler. It is determined by a relationship taking into account an additional contribution to the “distance-mass”. With the use of the relationships of the cosmological coincidences we have changing of the metric due to mass M. Therefore we obtain expressions similar to the components of the metric tensor. The time retardation also appears if the nonuniform motion of masses differs from the uniform motion of masses intrinsic to the clocks. For spherical symmetry an analogue of the Schwarzshild metric is obtained, see [6]. The components of the metrical tensor are the same as the appropriate components of the Schwarzshild metric tensor in the first order of the ratio of the gravitational radius r_g to the radius r (but there are differences in the second order of this ratio). All effects of General relativity are reproduced with the accuracy of the modern experiments. But the relational statistical concept predicts deviations from these classical effects, for observations the accuracy of the experiments can be more in the 3-4 orders.

For the general case, taking into account two non-Euclidean geometries for micro- and macroscopic scales one can obtain for description of quantum and gravitation effects

$$d\tau_{cgrqu}^2 = a^2 \frac{1}{N} \sum_{i=1}^{N} (g_{iqu\,gr} dr_{cigrqu} - \frac{1}{N} \sum_{j=1}^{N} g_{jqu\,gr} dr_{cjgrqu})^2, \qquad (4)$$

where $g_{iqugr} = g_{iqu} g_{igr}$. Here measurements dr_c and dt_c are related to the fundamental instruments, g_{iqu} is a stochastic value due to the statistical nature of spacetime in microscales that leads to quantum effects, g_{igr} is an analogue of the component of a metric tensor. This description is valid until atomic scales. For subatomic scales until the Planck distances it needs to develop this theoretical construction.

References

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