Pulsar: Metric Generalization of Time-Space of Celestial and Quantum Mechanics

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ABSTRACT

In the article, from the unified positions of the theory of relativity, physical processes are generalized that occur synchronously in the space of inertial coordinate systems in the entire range of possible movements - from the observed movements of celestial bodies to intra-atomic interactions of electromagnetic fields and quantum particles. Atomic objects manifest and fixed by direct detection of elastic wave interactions on a pulsar time scale in their natural states, excluding particle collisions. In the inertial frame, the body moves according to the Kepler-Newton laws (inertiality in the usual mechanical sense).

During the passage of the wave front, the electromagnetic field of the pulsar, interacting with the electromagnetic field of microparticles, fixes their discrete mechanical states on its scale with an accuracy of up to a quantum of time allowed by the pulsar scale. The discrete mechanical states of microparticles measured on the pulsar scale are multiples of the constant value ∂T = 5.5511151231257 80E-17s, they are repeated in any inertial coordinate system. Their number is finite, regardless of the duration of the measurements.

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It is proved that the solution of the missing inverse problem of celestial mechanics in the time domain, based on the observed propagation of the pulsar electromagnetic radiation front, also determines the inertiality with respect to the field in measurements of discrete states of microparticles, generalized in 4-dimensional space on the pulsar time scale.

Axiomatic transformations of the space-time states of the material world as a whole strictly correspond to the fundamental physical principles - the integral laws of conservation of energy momentum and angular momentum. Thus, the physical processes of celestial and quantum mechanics proceed in the space of inertial coordinate systems synchronously in the entire range of possible movements - from the observed movements of celestial bodies to the interactions of electromagnetic fields and quantum particles. Atomic objects are manifested and fixed by direct detection of elastic wave interactions on a pulsar time scale in their natural states, excluding particle collisions, similar to collisions in a collider.

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I. INTRODUCTION

Space and time are primary concepts, the essence of the forms of existence of matter. These concepts are obtained by appropriate abstractions from the concept of space-time connections between material processes. The simplest concept related to space and time is a material point of space, considered at a certain point in time. To mark a point in space, you need to place a material body of sufficiently small dimensions there. When a frame of reference is chosen, this position can be given by three coordinates referring to a certain point in time, counted by the base clock.

It should be especially noted that both the coordinates themselves and the mutual distances, angles and other quantities calculated with the help of them, characterizing the relative positions of bodies, take on a certain meaning only on the assumption of a certain basis. In the same way, moments of time, which include coordinates and distances, as well as time intervals, become certain only on the

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assumption of a certain basis and a certain time on the basis, that is, on the assumption of a certain frame of reference. It is enough to measure a certain basis in the sense of ordinary triangulation and detect directions to an object from different points of this basis using an electromagnetic wave in order to calculate, according to the laws of Euclidean geometry, the distance to the object and all other data characterizing its position "with a huge degree of accuracy" [1].

All these requirements are fully satisfied by Poincare's theory of relativity, in which the laws of Euclidean geometry for real physical space are valid with absolute accuracy. Einstein's theory of universal gravitation, which he called the general theory of relativity (GRT), on the contrary, allows for the inhomogeneity of space and, as a consequence, deviations from the physical laws of Euclidean geometry. This manifested its metrical contradiction with Poincaré's theory of relativity, based on axiomatic transformations of coordinates and time in inertial frames.

A.A. Logunov, referring to the work [2], drew attention to the fact that in it Poincaré, having formulated his fundamental idea, attributed it completely to Lorentz. Poincaré always highly appreciated and noted everyone who gave impetus to his creative thought. However, in no article did he write about Einstein's role in the creation of the theory of relativity. It is inconceivable that Poincaré, having read Einstein's 1905 papers, would not understand them. On the contrary, Einstein's work simply contained nothing new for him. Based on his previous works, as well as on the studies of Lorentz, Poincaré formulated everything that is the content of the theory of relativity, discovered the laws of relativistic mechanics, and extended Lorentz's transformations to all forces of nature.

After the appearance of Einstein's works on the theory of relativity (1905), Poincaré stopped publishing on this topic. Their personal meeting took place only once - in 1911. About this, Einstein himself wrote to his Zurich friend Dr. Zangger:

"Poincare in relation to the relativistic theory] rejected everything completely and showed, for all his subtlety of thought, a poor understanding of the situation."

In his characterization of Einstein, which Poincaré gave in November 1911 at the request of the Zurich ETH in connection with Einstein's invitation to a professorship, he wrote:"Einstein does not hold on to classical principles and, when faced with a physical problem, is ready to consider any possibilities. Thanks to this, his mind anticipates new phenomena, which in time can be experimentally verified. I do not mean to say that all these predictions will stand the test of experience when possible; on the contrary, since he seeks in all directions, it is to be expected that most of the paths he enters will turn out to be dead ends; but at the same time, one must hope that one of the directions indicated by him will turn out to be correct, and this is enough. That is exactly what should be done. The role of mathematical physics is to ask questions correctly; only experience can solve them".

What happened next only confirmed this assessment of Einstein's theory and Poincaré's prediction. Its metrical contradiction with Poincaré's theory of relativity, which has survived experimental testing, and based on the postulate of the independence of phenomena from the unaccelerated motion of a closed system within which they occur, appeared. At the same time, in the practice of physical research and their expert assessments, preference is often given to the mathematical theory of Einstein, without taking into account its features and fundamental limitations in physical applications. So, for example, the Nobel Prize in Physics in 2020 was awarded "*for the discovery that the formation of a black hole is a reliable prediction of the general theory of relativity*", and in the next year, 2021 - "*for the discovery of the interaction of disorder and fluctuations in physical systems from atomic to planetary scales*". The existence of massive black holes thus became a necessary condition for the inhomogeneity of space declared in Einstein's theory, which allows for chaos and fluctuations in the physical systems of celestial and quantum mechanics.

II. RESONANCE STABILITY OF OSCILLATORY SYSTEMS OF CELESTIAL AND QUANTUM MECHANICS

The laws of motion of the planets of the solar system, discovered by Kepler (1571-1630) based on the results of measurements made by him directly from the observations of the planets, later found their equivalent expression in the form of solutions of differential equations in the form of Newton, which are a solution to the inverse problem of celestial mechanics.

The inverse problem was reduced to the calculation of the elliptical (Keplerian) motions of the planets with the allocation of the main component of the motion, which is a mathematical description of the translational motion of idealized bodies and can be expressed purely kinematically, without considering the causes of motion (mass, forces generating it, etc.), in terms of space and time only.

From the point of view of mathematics, translational motion in its final result is equivalent to parallel translation - a special case of motion in which all points of space move in the same direction for the same distance. In the general case, translational motion is considered as a set of rotations, that have not ended.

In this case, rectilinear motion is understood as a limiting case, as a rotation around a center of rotation infinitely distant from the body.

The principle of relativity states that the process in both cases will proceed in exactly the same way and be described by the same functions of coordinates and time, since it is generally deterministic. Since the perturbing forces are random and small compared to the attraction of the central body, then on large time scales in real orbits the main, stable component of motion dominates, which is determined by the equations of the Kepler-Newton laws and is not sensitive to random effects of perturbing forces. A.M. Molchanov [4] formulated a hypothesis about the existence of a resonant structure (full resonance) of the solar system, according to which evolutionarily mature oscillatory systems are inevitably resonant, and their state is determined, like quantum systems, by a set of integers. Orbital resonance, according to this hypothesis, is provided by small dissipative forces: tidal forces, braking from interstellar dusty matter, etc. These dissipative forces are very small, orders of magnitude smaller than weak perturbations due to planetary interactions. However, acting for millions or more years, they lead the motions of the planets to stationary resonant orbits.

Resonances in celestial mechanics are expressed by the relation:

$$n_1 w_1 + n_2 w_2 + \dots + n_k w_k = 0, \qquad 2.1$$

Here $w_1, w_2, \dots w_k$, are the revolution frequencies (or average angular velocities) of the corresponding planets around the Sun, or satellites of the planet around it, or planets (satellites) around their axis; $n_1 \dots n_k$, are integers, positive or negative.

The fundamental difference between resonant dissipative celestial systems is the anomalously high level of kinetic energy stored at the stage of their formation, whether they are planetary systems or rotating neutron stars - pulsars. Thus, the solar system, for hundreds of years of observations, has been stably and predictably reproducing the regular spin-orbital motions of the planets in accordance with the laws of Kepler-Newton-Galileo.

A pulsar is a unique galactic object with pronounced spin-resonance properties. The quality factor of its resonant oscillatory system exceeds the quality factor of the resonant planets of the solar system by several orders of magnitude. Therefore, a pulsar as a source of periodic electromagnetic radiation propagating in the form of an electromagnetic radio wave front in galactic space has every reason to claim the role of a physical standard of the fourth coordinate - time in three-dimensional space. And, as a result, to bring the metrics of four-dimensional space-time in line with the kinematic laws of physical processes in inertial coordinate systems.

The estimated quality factor of a pulsar as a source of electromagnetic radiation is about $10^{15}/10^{21}$, and the stored energy of rotation of the pulsar $E_{rot} = I\Omega^2$ ~$10^{45}/10^{52}$ erg is quite enough for $E_{rot}=I\Omega\Omega$ ~$10^{31}/10^{34}$ $_{эрг \cdot с}$$^{-1}$ observed periodic emission of pulsars remained coherent during the entire interval $10^6/10^7$ years characteristic of neutron stars. Our observations of pulsars at the BSA FIAN radio telescope in Pushchino are consistent with these estimates [7].

III. PHYSICAL GENERALIZATION OF INERTIAL COORDINATE SYSTEMS IN THE TIME DOMAIN

There is a limiting speed of propagation of any kind of action. This speed is numerically equal to the speed of light in free space.

The propagation equation for a wave front of any nature coincides with the propagation equation for a light wave front.

This equation is a generalization of Maxwell's equation in some frame of reference, which is inertial in the sense of mechanics and in which, along with this, the equations for the propagation of an electromagnetic wave front are valid [1]:

$$\frac{1}{c^2}\left(\frac{dw}{dt}\right)^2 - \left[\left(\frac{dw}{dx}\right)^2 + \left(\frac{dw}{dy}\right)^2 + \left(\frac{dw}{dz}\right)^2\right] = 0 \qquad (3.1)$$

In this expression, the inertial reference frame is characterized by the following two principles:

1. In the inertial system, all points of the body in the absence of forces describe the same trajectory according to the laws of Kepler (direct problem) and Newton (inverse problem), while maintaining the parallelism of any segment to itself, which in its end result is equivalent to a parallel transfer that determines the inertiality in in the usual mechanical sense.
2. In an inertial system, the equation for the propagation of an electromagnetic wave front determines the inertiality with respect to the field as well.

The basic postulate of the theory of relativity asserts the independence of phenomena from the unaccelerated motion of a closed system within which they occur. Thus, the translational movement of the material system as a whole does not affect the course of physical processes occurring within the system.

The principle of relativity is confirmed by the totality of our knowledge about nature. In the field of mechanics, it has long been known as Galileo's principle of relativity. The theory of relativity can be built on the basis of two postulates: the principle of relativity of Galileo and the principle of independence of the speed of propagation of an electromagnetic wave from the speed of the source. The second of these principles was taken into account from the very beginning, since the law of propagation of the front of an electromagnetic wave was taken as the basis for constructing the theory of relativity. The independence of the speed of light from the speed of the source directly follows from this law: *there is a limiting speed of propagation of any kind of action. This speed is numerically equal to the speed of light in free space.*

V.A.Fok, who analyzed in detail the physical foundations of the theory of relativity, gives estimates of possible alternative approaches. In principle, it is possible, for example, to transmit signals with the help of extremely fast particles and the matter waves corresponding to them in the sense of quantum mechanics. It is also conceivable (although practically unrealizable - V.A. Fok), the use of gravitational waves, the existence of which follows from Einstein's theory of gravitation.

The formulated principle, which affirms the existence of a general limit for the speed of transmission of any actions and signals, gives the speed of light a universal value, not related to the particular properties of the agent transmitting signals, but reflecting the objective property of space and time. This principle is in logical connection with the principle of relativity. If there were no single limiting speed, and various agents, for example, light and gravity, would propagate in emptiness (free space) at different speeds, then the principle of relativity would be violated with respect to at least one of these agents.

The differential equation (3.1) is a generalization of Maxwell's equation in some frame of reference, which is inertial in the sense of mechanics and in which the propagation equations for the front of an electromagnetic wave are also valid. In such a system, the body moves according to the laws of Kepler (direct problem) and Newton (inverse problem) - in accordance with the concept of inertiality in the usual mechanical sense. In an inertial system, the equation for the propagation of an electromagnetic wave front also determines the inertiality with respect to the field.

The physical generalization of inertiality with respect to the field, displayed on the left side of the equation, is achieved by the so far missing solution of the inverse problem of celestial mechanics in the time domain. V.A.Fok solved this problem purely theoretically by introducing a harmonic coordinate system for calculations in space at infinity. We have adopted a pulsar as a physical source of electromagnetic radiation - a galactic source of periodic radio emission that satisfies the principle of inertia with respect to the field. The propagation of the wave front of the electromagnetic radiation of a pulsar in time is completely determined by the measurable parameters of its rotation, and the stored energy of rotation of the order of $10^{45} | 10^{52}$ erg with its gradual scattering of $10^{31} | 10^{34}$ $_{эрг \cdot с}$$^{-1}$ neutron stars within an interval of $10^{6} | 10^{7}$ years.

IV. AXIOMATICS OF COORDINATE PULSAR TIME SCALES IN INERTIAL FRAMES OF REFERENCE

The physical generalization of inertiality with respect to the field, displayed on the left side of equation (3.1), is achieved as a result of the so far lacking solution of the inverse problem of celestial mechanics in the time domain.

We have proved that the only and sufficient source by which the pulsar rotation parameters are determined is the measured time of arrival of the pulsar radiation pulses observed with a radio telescope. V.A.Fok previously solved this problem theoretically by introducing a harmonic coordinate system for calculations in space at infinity. We have adopted a pulsar as a physical source of electromagnetic radiation - a galactic source of periodic radio emission that satisfies the principle of inertia with respect to the field. The propagation of the front of a wave of electromagnetic radiation of a pulsar in time is completely determined by the measurable parameters of its rotation.

Einstein, when creating the general theory of relativity (the theory of gravitation), suggested that not only mechanical motion, but also any physical processes under the same initial conditions proceed in exactly the same way in the gravitational field and outside it, but in an accelerated reference frame (equivalence principle). However, it should be taken into account that this principle is local, i.e., the identity of the gravitational field to the accelerated reference frame is valid only in a limited region of space, in which the gravitational field can be considered uniform and constant in time. Therefore, during measurements, conditions inevitably arise for violating this principle and, as a result, discrepancies between the measured and calculated values appear, in particular, in the form of residual deviations of the moments of arrival of radiation pulses of the pulsar at the radio telescope. The process of timing pulsars is thus fundamentally dependent on an accurate description of everything that affects the time of arrival (ToAs).

In order to avoid distortions of the measured ToAs, we took into account the fact that the intervals between radiation pulses depend on the parameters of the monotonically slowing down rotation of the pulsar, the period P and its derivatives P and P .

There is a combination of rotation parameters P and its derivatives P and P, unique for each pulsar, the sequence of measured radiation intervals can be expressed analytically in terms of the observed rotation parameters, as an index of neutron star deceleration $n=2\ pp/p^2$.

Thus, each pulsar has its own combination of rotation parameters, which is generalized by the neutron star deceleration index.

According to our timing data at the BSA FIAN radio telescope, the numerical values of the deceleration index are limited by the limits n = –(0.9 ± 0.2), which corresponds to monotonic deceleration of the rotation of neutron stars ($P > 0$, $P > 0$).

For comparison, according to the well-known work of Hobbs, G., Lyne, A.G., Kramer, M. (2010) [6], *the value of the braking index estimated from the residual timing deviations is in the range –287986 < n < +36246 with its average value nav = –1713.*

Out of a sample of 366 pulsars, 193 pulsars have a positive second derivative of the rotation frequency, while the remaining 173 have a negative one.

V. PHYSICAL PULSAR TIME SCALES

The only unique combination of measurable parameters of pulsar rotation, corresponding to its monotonic slowdown in time, cannot be established within the framework of Einstein's theory of gr`1avitation, which does not extend directly to the time domain of real physical processes. The braking index is thus independent of the time and location of observations and is a fixed measurable quantity for each pulsar in a rather narrow range of physical values corresponding to the coherent periodic radiation of the pulsar.

The time scale in ephemeris astronomy is considered as some material system that has a continuous and stable movement and represents a certain measurable parameter P, which changes as a function of an independent time variable (V.K. Abalakin, 1978) [5].

The time of passage of the front of the wave of electromagnetic radiation of the pulsar is fixed on the pulsar time scale PT within any selected interval and is expressed as a digital series of intervals as a function of the pulsar rotation period for the selected initial epoch and its derivative (1):

$$PT_{tj} = \frac{1}{P^{*}_{0}} \int_{tj}^{tj} P(t)dt \qquad (1)$$

$$P(t) = P_0^* + P^* t;\ -\infty < t < +\infty \qquad (2)$$

The differential pulsar scale (2) is a sequence of daily increments of the pulsar rotation period within any observation duration.

$$P_i = P_0^* \pm \Delta P_i;\ -\infty < i < +\infty \qquad (3)$$

The time scale is set to any arbitrarily chosen origin of time, determined by a fixed value of the period for this epoch, and is axiomatically transferred to any other epoch of the future (for $i > 0$) or the past (for $i < 0$) within any chosen interval (3).

VI. DETECTION OF QUANTUM STATES OF ELEMENTARY PARTICLES

The quantum world consists of many small blocks, each of which is an indivisible elementary particle - an atom. The size of a simple hydrogen atom is approximately: 1A = 100 pm = m. The detection of quantum states consists in detecting the interference of two or more coherent waves when they are superimposed on each other.

The time interval for the passage of the pulsar electromagnetic wave front within the hydrogen atom is $0.33 \cdot 10^{-18}$ s. Hence the required resolution of the time scale is $\Delta t < 10^{-18} s$.

The resolution of the pulsar time scale 10^{-25} s therefore satisfies the condition for detecting discrete states of physical quantum systems within the physical boundaries of their existence in space. Thus during the passage of the wave front, the electromagnetic field of the pulsar, interacting with the electromagnetic field of microparticles, fixes their discrete mechanical states with an accuracy of up to 10^{-25} s resolved by the pulsar time scale.

Since the Schrödinger equation, which plays the same role in quantum mechanics as Newton's equations in classical mechanics (the inverse problem of celestial mechanics), is invariant under Lorentz transformations based on the Galilean relativity principle, this implies the existence of a number of quantum mechanics operators and the existence of quantum mechanical invariants associated with Galilean transformations, similar to those in celestial mechanics.

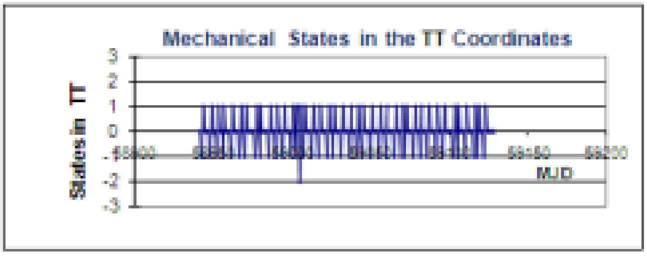
Thus, the wave front of electromagnetic radiation of a pulsar, which determines the pulsar time scale, when interacting with microparticles with wave properties, fixes the change in time of their mechanical states, and according to the observed sequence of changing discrete states, fixes their movement along a certain trajectory.

In quantum mechanics, quantum oscillations in molecules, atoms, and nuclei can occur only for a fixed set of discrete energies in the spectrum of levels of a quantum oscillator. The levels of discrete energies are equidistant and are determined by Planck's constant. The value of ω, which determines the fundamental tone of a quantum oscillator, is related to its potential energy by the classical relation /

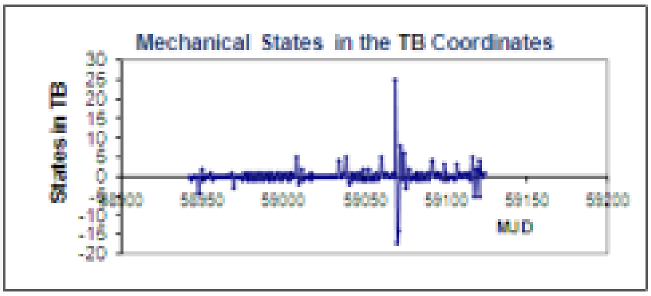
$$mw^2x^2/2 = kx^2/2$$

Quantum harmonic oscillators as energy emitters have energies not as continuous variable motions, like the motion of bodies in celestial mechanics, but as regularly ordered discrete values of the energy of wave processes, which are multiples of the energy quantum $\hbar\upsilon$; ($\upsilon = \omega/2\pi$).

From long-term observations of the B0950+08 pulsar at the BSA FIAN radio telescope in Pushchino, we took daily timing data in the topocentric (TT) and barycentric (TB) coordinate systems. Pulsar B0950+08 in a supernova remnant (age 1.7×10^7 years) in the vicinity of the solar system (distance 0.26 kpc) can be attributed to older stars, the lifetime of which, together with the solar system, is estimated to be approximately 4.6×10^9 years, as well as Sun [9].



a) in topocentric coordinates TT



b) in barycentric coordinates TB

Figure 1: Measured mechanical states of microparticles

Discrete states of microparticles are multiples of a constant value, which is the same in any inertial coordinate system. Considered by M. Planck, quantum harmonic oscillators as energy emitters have energies not as continuous variable movements, like the movement of bodies in celestial mechanics, but as regularly ordered discrete values of the energy of wave processes that are multiples of the energy quantum ħυ; (υ= ω/2π).

Quantum oscillations in molecules, atoms, nuclei can occur only for a fixed set of discrete energies in the spectrum of levels of a quantum oscillator. The levels of discrete energies are equidistant and are determined by Planck's constant. The value of ω, which determines the fundamental tone of a quantum oscillator, is related to its potential energy by the classical relation $mw^2x^2/2=kx^2/2$.

By analogy with a photon - a fundamental massless particle moving at the speed of light, transferring local electromagnetic interaction in the quantum world of microparticles, a neutron star - a pulsar also performs the function of transferring electromagnetic interaction, but, unlike a photon, it is not limited only by the quantum world of microparticles, but extends to the material world as a whole, including the solar system, the Galaxy, etc.

Thus, the wave front of electromagnetic radiation of a pulsar, which determines the pulsar time scale, when interacting with microparticles with wave properties, fixes the change in time of their mechanical states, and according to the observed sequence of changing discrete states, fixes their movement along a certain trajectory.

VII. TO THE PHYSICAL GENERALIZATION OF THE MATERIAL WORLD AS A WHOLE

The physical processes of the material world of quantum and celestial mechanics are inseparable in their conditioning and sequence.

The quantum world - beginningless, omnipresent, eternal and indivisible, became the basis of the material world of the Universe as a whole, laying the foundation for it and remaining in its beginningless state forever.

The axiomatics of measurable spatial states of matter means the omnipresence of the material world of the Universe as a whole.

The axiomatics of measurable temporal states of matter means the perpetuity of the material world of the Universe as a whole.

Axiomatic transformations of the space-time states of the material world of the Universe as a whole strictly correspond to the fundamental physical principles - the integral laws of conservation of energy momentum and angular momentum.

The metric variety of the material world and physical processes occurring in celestial and quantum mechanics is finite and gen eralizable a s a whole.

There are no physical reasons for the crisis of celestial and quantum mechanics. There is a problem of correspondence of mathematical theories of time-space to the objective laws of nature.

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