GAMOV MEMORIAL INTERNATIONAL CONFERENCE
DEDICATED TO 100-TH ANNIVERSARY OF
GEORGE GAMOV

«ASTROPHYSICS AND COSMOLOGY AFTER GAMOV – THEORY AND OBSERVATIONS»

Odessa, August 8–14, 2004

A B S T R A C T S

Odessa
«Astroprint»
2004

TU THE QUESTION OF THE PRINCIPLE OF EQUIVALENCE IN THE EINSTEIN'S GTR

Potjekhin A. F.

Department of Theoretical Mechanics, Odessa National Maritime University

It is consider two classes of the frame of reference – dynamical and kinematical one. If the considered system of material particles is moving together with the frame of reference Σ, which in turn is moving relative to the absolute (in Newton's sense) frame of reference Σ^0, then Σ is called the dynamical frame of reference for the given process. If the considered system of material particles does not participate in transport motion together with the frame of reference Σ', the last is called kinematical for the given process.

It is shown that well-known proofing of the general equation relative motion of the particle in the accelerated frames of reference is true only in the kinematical frame of reference. It is given the proofing of this equation also in the dynamical accelerated frames of reference. It has been found that the transport and Coriolis forces of inertia is fictive (kinematic) in the first case and real (dynamic) in the second case. In this, the Einstein's principle of equivalence of the gravitational field and the field of forces of inertia is true only in the dynamical accelerated frames of reference.

****

TU THE QUESTION OF THE PRINCIPLE OF EQUIVALENCE IN THE EINSTEIN'S GTR

Potjekhin A. F.

Odessa National Maritime University, Odessa, Ukraine

e-mail:a_potjekhin@osmu.odessa.ua

Abstract

Two classes of reference systems - dynamical and kinematical, - are considered. It is shown that the generally accepted derivation of the basic equation of dynamics of a particle in accelerated frames of reference appears valid only in the kinematical frames of reference. A derivation of this equation is given for the dynamical accelerated frames of reference also. There was revealed, that the transport and Coriolis forces of inertia, appearing at this, are fictive (kinematical) in the first case and real (dynamical) in the second case. Thus Einstein's principle of equivalence of a gravitational field to a field of forces of inertia appears fair only in the dynamical accelerated frames of reference.

Keywords: frames of reference, inertia forces, Einstein's principle of equivalence.

1 Introduction

At the beginning of XX century Newton's concepts of absolute space and absolute time in physics [1] were disclaimed and, as a result, that stable foundation, on which the classic physics have been based up to the end of XIX century, was left. Physics has stepped on a shaky soil of a kinematic relativism of Poincare-Einstein. And only to the beginning of XXI century it was finally established [2]-[8], that the relativistic theory of Einstein gives the erroneous solution just of those problems, which essentially have stipulated its appearance.

Example first. According to the contemporary relativistic notions, the field of electric charge, resting in a physical laboratory, is described in the frame of reference of a tram, driving with constant speed, by the same equations, as a field of the same charge resting in this tram, relatively to the frame of reference of the laboratory. The experiment refutes this, registering a magnetic field only in the second case. As a result, the entire building of Einstein Special relativity theory falls down.

Example second. In agreement with the contemporary relativistic notions, oscillation of a mathematical pendulum with a fixed point of suspension in physical laboratory is described in the reference frame of a tram, driving with acceleration, by that very equation of dynamics of the relative motion of a particle, as oscillation of the same mathematical pendulum with fixed point of suspension in this tram relative to the frame of reference of physical laboratory. The experiment refutes this, registering deviation of a local vertical (equivalence of inertia force to gravity) only in the second case. As a result, all building of Einstein General theory of relativity falls down.

The equivalence principle of Einstein is the statement about identity of a gravitational field to a field of inertia forces, appearing as a result of kinematical transformation of reference frames: "Hereinafter we shall assume a full physical equivalence of a gravitational field and a relevant acceleration of a frame of reference. The heuristic value of this assumption is, that it allows to exchange a homogeneous field of gravity by the uniformly accelerated frame of reference, which to a known degree gives way to the idealized consideration" [9]. The sources of the given statement of Einstein ascend to Mach: "The fundamental laws of mechanics can be perceived so that centrifugal efforts could follow from them at relative movements as well" [10]. Being rest on his principle of equivalence, Einstein comes to a conclusion, that absolutely smooth ball on the absolutely smooth rotating table will direct away from the rotation axis of the table [11]. But this contradicts the experiment. The ball will direct away from the rotation axis of the table only in the event that it will be placed into a radial groove of the table and, thereof, will be involved in rotation of the table relatively to the Newtonian "absolute space".

2 Newtonian Absolute space

The cause of Mach's fallacy and, as a consequent, Einstein's, is rejection of the allocated in dynamic relation, by Newton absolute, frame of reference. In the conceptual apparatus, laid down by Newton in the foundation of classic physics, the concepts of absolute or fixed space and absolute or universal time play the special role. By introducing of these concepts Newton, at first, eliminated influence of selection of the relative space (bodies of reference) and relative time (approximately uniform motion) on the description of motion of bodies. Secondly, he took into account availability in the nature of the dynamically allocated frame of reference, rotation relative to which is accompanied by the tendency of particles to move away from the axis of rotation (experiment of Newton with the rotated bucket with water).

As the fact of rotation of the Earth relative to a sphere of remote stars was known to Newton, he practically used a Heliocentric frame of reference as an absolute one. However Newton, despite of what was assigned to him, perceived all the conditionality of selection of an absolutely unmovable frame of reference: "It may appear, that actually there is no resting body, to which would be possible to attribute places and motions of the other ones" [1]. One can speak only about the hierarchy of the "fixed" or "absolute", enclosed one into another like a nest-doll, frames of reference: for the propagating ship the fixed frame of reference is that one bound with a surface of the Earth; for the surface of the Earth the fixed frame of reference is that one, the beginning of which coincides with the center of the Earth, and axes are directed to remote stars; for this, in turn, the fixed is the Heliocentric frame of reference, and so on. Thus, the concept of an absolute frame of reference is a relative concept. In the process of globalization of the "fixed" frames of reference, we come nearer to the absolute space of Newton only as a limit. To criticize Newtonian absolute space and absolute time is as senseless as to criticize other scientific abstractions, for example, concept of perfect fluid or gas, of absolute solid or material point.

Further, after Newton, development of physics has allowed, to some extent, to explain the cause of existence of the dynamically allocated absolute space. It has come to light, that everything existing in the nature, is a matter, either substance or field. If the substantial characteristic of the matter is density of mass, then the substantial characteristic of a field is density of energy (do not confuse with the concept of energy, as a measure of motion!). The universal and all-penetrating is a gravitational field. Density of energy of a gravitational field is stipulated by all the mass of a matter of the Universe, thus the contribution at a macro level into this density of a separately taken body is depreciatingly small. In the process of globalization of systems of reference density of energy of a gravitational field in them becomes more and more uniform, this determining, finally, the background gravitational field and allocated absolute frame of reference.

As an experimental fact, it is necessary to recognize, that material particle, driving uniformly and rectilinearly relative to the absolute frame of reference, does not interact with a background gravitational field. But the particle, driving under acting of the applied force $\overline{F}$ with acceleration $\overline{a}$ relative to the absolute frame of reference, does interact with this field. As a result of this interaction arise volumetric or mass forces of inertia, applied to the body particles. But they reveal as a surface force of inertia $\overline{J} = -m\overline{a}$, applied to the constraints, so that $\overline{F} + \overline{J} = 0$. Here exists a full analogy with the body weight, which shows as a surface force, applied to a thread or a bearing.

Let us note, that Space microwave radiation $2,7°K$, found in 1963, allows to define the absolute frame of reference also as that, relative to which the given radiation is homogeneous and isotropic.

3 Inertial and non-inertial frames of reference in a contemporary physics.

The concept of a frame of reference is fundamental in the theoretical physics. Generally accepted is the following definition: coordinate system, serving for indicating of a position of particles in space, together with clocks, bound with this system and serving for indicating of time, is deemed as a frame of reference. Modern physical notions are based on splitting of all frames of reference into two classes - inertial and non-inertial. Let us remark, that such classification of frames of reference has appeared only at the beginning of XX century.

Newton extended the law of motion of the bodies due to inertia on the smooth surface of the Earth, discovered by Galilei, onto motion of celestial bodies relative to the Heliocentric frame of reference. The specificity of a Heliocentric frame of reference is that the bodies of a solar System, interacting one with another and being displaced from each other, are simultaneously involved in the motion of this frame of reference as a unit. With this, the Heliocentric frame of reference is filled with the physical contents, being the dynamic concept.

At the end of XIX century it was obtained from the kinematic considerations, that the material particle moving due to inertia relative to the Heliocentric system of reference, preserves value and direction of its speed relative to any of frames of reference, which move translationally, uniformly and rectilinearly relative to the Heliocentric system. All such frames of reference obtained the name inertial. Thus remained unnoticed, that the dynamic aspect of such systems of reference (motion of an observed particle together with the given frame of reference) was omitted. As a result, name inertial was assigned to all unaccelerated frames of reference, relative to which the first Newton's law, law of inertia, i.e. relative to which the insulated (essentially already geometrical) point is moving with the speed constant by value and direction. As the second Newton's law is covariant concerning the kinematical transformation of Galilei, the erroneous conclusion was made, that in dynamic relation all unaccelerated frames of reference are equivalent also, and any of them can be accepted as the fixed one. On this basis at the beginning of XX century in Einstein's Special relativity theory the frame of reference, dynamically allocated, absolute by Newton, was discarded. It was the fatal mistake that avalanchely entailed a chain of principled errors.

All the accelerated frames of reference were referred to the non-inertial. Esteeming motion of the same material particle relative to unaccelerated and accelerated frames of reference, equation of motion of a particle in accelerated frames of reference was obtained by the kinematic transformation of these frames of reference. So by mistake appeared the "fundamental law of relative motion of a particle" in all accelerated frames of reference.

Basing on such notions, the theoretical physics of XX century advanced very much far in a false direction, by identifying among themselves a series of kinematical concepts with dynamical concepts [2] – [8]: kinematical and dynamical relativity principle; kinematical and dynamical frames of reference; a kinematical (fictive) and dynamical (real) magnetic field in unaccelerated frames of reference; kinematical (fictive) and dynamical (real) inertia forces in accelerated frames of reference; field of kinematical "forces of inertia" and dynamical gravitational field, and so on. As the total, to the beginning of XXI century the theoretical physics has not yet resolved those principled problems, which have arisen exactly hundred years ago in the electrodynamics and gravitydynamics of moving bodies.

4 Dynamical and kinematical frames of reference according to Newton.

If the considered system of material particles is moving together with a frame of reference Σ, which, in turn, is moving relative to the absolute frame of reference Σ^0, then Σ is called a dynamical frame of reference for the given process. If the considered system of material particles does not participate in the transport motion together with a frame of reference Σ', then the latter is called a kinematical for the given process. It is necessary to point out the relativity of these concepts: the same frame of reference for one process can be dynamical, while for other – the kinematical.

The dynamical frames of reference, in turn, are subdivided into two classes - inertial and non-inertial. Just in dynamics a concept of inertial frames of reference appears. Specific feature of dynamic inertial frames of reference is the uniformity of flow and description of identical processes taking place in each of them separately. According to the experimentally established relativity principle of Galilei, inertial frames of reference move translationally, uniformly and rectilinearly concerning the sphere of remote stars, therefore, concerning each other as well. In each of such frames of reference, according to experiment, physical laws of not mechanics only, but also of the electrodynamics, are stated and written down equally to within notation of coordinates. Equations of motion of physical processes in dynamical inertial frames of reference never include speed of their motion relative to the other frames of reference.

5 Fundamental equation of relative motion of a particle in dynamical non-inertial frames of reference

Generally accepted is the following conclusion of the fundamental dynamic's equation of relative motion of a particle in all accelerated systems of reference. Basic equation of motion of a particle is written down in unaccelerated system of reference Σ, which is taken as a fixed one

$$m\bar{a} = \sum \bar{F}_k \,, \tag{1}$$

The motion of the same mass point is esteemed relative to another, arbitrarily moving frame of reference Σ'. Applying known kinematic transforms of reference systems, from (1) "the basic equation of dynamics" of the particle in a frame of reference Σ' is obtained

$$m\bar{a}' = \sum F_k + \bar{F}^{trans} + \bar{F}^{Cor} \tag{2}$$

Equation (2) is only the other form of a record of equation (1). Appearance in equation (2) of the transport and Coriolis forces of inertia is a result of pure mathematical manipulation. Therefore these "forces of inertia", not being the results of dynamical interaction, are fictive forces, appearing owing to mutual motion of systems of reference.

Let us consider now the case of a dynamical accelerated frame of reference. The fundamental dynamic's equation of relative motion of a particle can not be in this case obtained by kinematical transformation of frame of reference, as that body, with which one this frame of reference is connected, dynamically interacts with the given mass point. This equation should be obtained directly with the aid of initial principles of Newton.

Let relatively to the inertial frame of reference Σ, esteemed as a fixed one, the inertial frame of reference Σ' is moving, which is dynamic for the considered mass point. Motion of this point in Σ' is described by the equation (1). Let us now give this dynamic stroked system of reference arbitrary motion relative to Σ. The material particle, moving relative to the stroked system of reference, participates in accelerated motion of this frame of reference. In this case, in a direction of transport and Coriolis accelerations the material particle interacts with that body, to which one the reference Σ' is connected. Then in a direction of transport acceleration acts force $\bar{N}^{trans}$, and in a direction of Coriolis acceleration acts force $\bar{N}^{Cor}$. According to the second Newton's law,

$$m\bar{a}_{dyn}^{trans} = \bar{N}^{trans} \tag{3}$$

$$m\bar{a}_{dyn}^{Cor} = \bar{N}^{Cor} \tag{4}$$

Adding left-hand and right parts of equations (1), (3), (4), i. e. applying a principle of independence of operating of forces in classic mechanics of Newton, we shall obtain

$$m\bar{a}' = \sum \bar{F}_k + \bar{N}^{trans} + \bar{N}^{Cor} + \bar{F}^{trans}_{dyn} + \bar{F}^{Cor}_{dyn} \tag{5}$$

The equation (2) of motion of a material particle in a kinematical non-inertial frame of reference differs essentially from the equation (5) in a dynamic non-inertial frame of reference. Firstly, the equation (2) is obtained as a result of formally mathematical transformation of systems of reference, while the equation (5) is proved on the basis of initial principles of Newtonian mechanics. Secondly, in (2) transport and Coriolis forces of inertia are kinematical or fictive, whereas in (5) transport and Coriolis forces of inertia are dynamical or real, conditioned by the relevant reaction forces $\bar{N}^{trans}$ and $\bar{N}^{Cor}$.

6 Summary

The inertia forces in accelerated frames of reference are equivalent to real physical gravitational forces only in the event that these frames of reference are dynamical. For example, the transport force of inertia of weight of a pendulum with fixed point of suspension in physical laboratory in the frame of reference of a tram moving with acceleration is fictive. Solving equation (2), we shall not obtain neither additional tension of a thread of a pendulum, nor deviation of a local vertical. While the transport force of inertia of weight of a pendulum with fixed point of suspension in this tram moving with acceleration, according to equation (5), will cause both indicated effects, i. e. additional tension of a thread of a pendulum, and deviation of a local vertical. Absence of these effects in the former case and their availability in the latter case will be equally observed both in the frame of reference of a tram, and in the frame of reference of laboratory.

7 References

[1] I. Newton, Mathematical principles of natural philosophy (In Russian), Nauka Publishers, Moscow (1989).

[2] A. F. Potekhin, A short course of theoretical mechanics in questions and answers with the analysis of basic concepts (Textbook, in Ukrainian), Novy svit Publishers, Lvov (2004).

[3] A. F. Potjekhin, Classical theory of relativity (In Russian), Majak Publishers, Odessa (2003).

[4] A. F. Potjekhin, Relativity in Physics, (In English), Majak Publishers, Odessa (2003).

[5] A. F. Potjekhin, Theoretical mechanics. The methodological introduction to dynamics: inertial frames of reference (In Russian), Majak Publishers, Odessa (2004).

[6] A. F. Potjekhin, About dynamical and kinematical frames of reference (In Russian). Izvestija VUZ'ov (Higher schools news). Physics, (2004). In print

[7] A. F. Potjekhin, Objective and subjective aspects of a relativity in physics (In Russian), Paper Abstracts to the XYII International readings: Great transformers of natural sciences: Henri Poincare, Minsk 28-29 of November 2001, BSU Publishers, Minsk (2001).

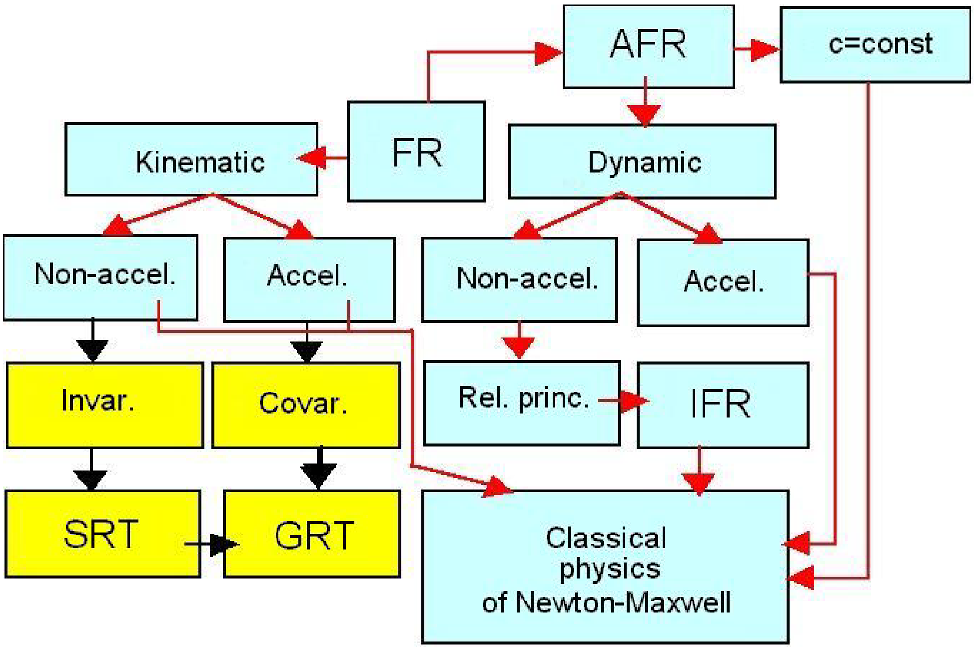
[8] A. F. Potjekhin, About an exclusive circle of concepts science-education–science on an example of physics (In Russian), The Scientific Bulletin of Academy of sciences of a higher school of Ukraine, No. 28 (2004)

[9] A. Einstein, Collection of Scientific Papers, Vol. 1 (1965). P. 106

[10] E. Mach , Mechanics. Historical-critical essay of development (In Russian). S.-Pb., (1909). P. 193.

[11] A. Einstein, Collection of Scientific Papers, Vol. 4 (1965). P. 453.

Appendix



The skeleton diagram of frames of reference (FR) in Classical physics
and Einstein Relativity theory

Explanations to the skeleton diagram.

1. The absolute frame of reference (AFR) Σ^0 is the frame of reference relative to which radiation found experimentally in the world space $2,7°K$ is homogenous and isotropic. As a first approximation by Newton, AFR is realized by a Heliocentric frame of reference of Copernicus, bound to asters of our Galaxy, in the following approximation - to the centers of Galaxies, further - to the centers of groups of Galaxies and so on. In dynamic aspect AFR is allocated and often called "fixed".

2. If the considered system of material particles is moving together with a frame of reference Σ, which, in turn, is moving relative to the AFR Σ^0, then Σ is called as a dynamical frame of reference for the given process.

3. If the considered system of material particles does not participate in the transport motion together with a frame of reference Σ', then the latter is called kinematical for the given process.

4. Dynamical accelerated (unaccelerated) FR move with acceleration (without acceleration) in relation to the AFR allocated by dynamic sign (experiment of Newton with the bucket with water, which is rotating about its axis of symmetry).

5. In a kinematics all frames of reference are equivalent and kinematical accelerated or unaccelerated FR are moving with acceleration or without acceleration one relative to another.

6. In Classical physics of Newton - Maxwell the limitation is superimposed over the dynamical unaccelerated systems of reference: the experimentally established relativity principle of Galilei is valid in them. Such frames of reference are called inertial (IFR).

7. In Einstein theory of relativity the limitation on the form of a record of equations of motion is superimposed: they should be invariant in the kinematic unaccelerated (STR) and covariant in the kinematic accelerated (GTR) frames of reference.