Relation between the Newton Principle of Action and Reaction and Gravitational Waves, together with the Heisenberg Indeterminacy Principle, as a possible Key to an Explanation of the Quantum Nature of our World

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Abstract

Initially it is proposed to interpret the fact that the delay of gravitational interaction in a binary system causes the emanation of gravitational waves, as a generalization of the Newtonian Principle of action and reaction. Then, the impact of such a concept is shown for a situation with mutual and simultaneously acting electromagnetic and inertia force, as well as consequences for a possible validity of the Mach principle. Further, the same phenomenon of retardation of the physical interactions is applied on the mechanistic Bohr model of the hydrogen atom together with the Indeterminacy principle, which results in a realistically adequate quantum description of the atom involving the pertinent de Broglie wave. Finally, the physical conclusions made before are discussed from a philosophical point of view; a new 'para-deterministic' concept is presented being an alternative to both the deterministic and holistic views of our world.

This paper was published in the Proceedings "Meze formalizace analytičnosti a prostoročasu" ("Limits of the formalisation of analyticability (the ability to be analysed) and of the space-time") of the conference "Dny Kurta Gödela" ("Kurt Gödel Days"), Brno, May 2006, Filosofia (FÚ AV ČR) Havlík, J. and Novotný, J. (editors), Praha 2007.
This text is completed with Figure 2 and the Note.

1. Gravitational aberration and generalization of the Newtonian Principle of action and reaction

It is possible to show that in the situation where a test body, with such a small mass that its own gravitational field is negligible, is moving geodetically (i.e. freely) in the gravitational field of a massive body (inclusive the possibility of general relativistically (GR-) strong sources of such a field), any manifestation of gravitational aberration (proposed, e.g., by Van Flandern, 1996) is self-eliminated, already within the frame of the Special relativity theory (SRT), which is – anyhow – a fact verified by astronomical observations. Nevertheless, it is not the aim of this Essay to present here the corresponding arguments and deduction, since we want to concentrate our attention to the situation where, in a system of (at least) two geodetically moving massive sources of gravitational field, the gravitational aberration manifests itself in some form. It is a consequence of the finite velocity of propagation of the gravitational information, equal to the velocity of light in vacuum. This circumstance appears already in classical physics, where, in the more profound formulation and explanation of the Newtonian Principle of action and reaction (see e.g. Alonso and Finn, 1967, Vol. I, p. 162), its consequence arises in a form of limitation of the validity of the Principle: It is valid only where the time necessary for the interaction is negligible. Expressed in other words (Horák and Krupka, 1976, Vol. 2, p. 443): The Principle is valid in situations where the relative velocity of the sources of the field is zero (contingently, it is negligible under the given circumstances) or when the sources are co-local (contingently, their mutual distance does not play any role under the given circumstances). For the sake of simplicity let us consider here two sources of the gravitational field bound in a binary system. (See also Note.)

Under such conditions, usually considered to be non-relativistic, it is possible to investigate the origin of inertia, since it is quite evidently manifesting under circumstances adequate to the classical mechanics. Nevertheless, the problem is still pertaining to the GRT as the inertia is determined – in accordance with the Mach principle – by boundary conditions having a cosmological character.

According to Misner *et al.* (1973, p. 976), a direct relation exists connecting the retardation of mutual gravitational information, propagating between the components of the binary system, with the origin of gravitational waves. As disclosed by one of the authors quoted above (J. A. Wheeler, private communication, 1980), an almost unknown (since it was unnoticed), even if very interesting, paper exists focusing on such an idea (Kalckar and Ulfbeck, 1974), where it is shown that the origin of gravitational waves is a direct consequence of the retardation of mutual gravitational information; see also Wheeler (1999, p.187). In such a case it is possible to draw a very important conclusion: *The origin of gravitational waves, as presented by Kalckar and Ulfbeck (1974), is a GRT-generalization of the Newtonian Principle of action and reaction.* (See also Appendix.)

2. Application of the Principle of action and reaction on two different kinds of physical interaction simultaneously, resulting in a connection with the Mach principle

Taking into account the restrictions made in the previous Section (i.e., non-relativistic relative velocities and/or a selective co-locality of the described phenomena), one can claim that the following analysis is compatible with the GRT despite the use of concepts pertaining to Newtonian physics, being modified here in such a sense that four basic physical interactions exist, of which two – electromagnetic and gravitational, both propagating through space

with mutually equal finite velocity – will be applied here. Owing to the assumed absence of close significant sources of gravitation in this Section, the *inertial frame of reference* of the Newtonian and SRT-mechanics used here can consequently be considered to be identical to the GRT-concept of the *local Lorentz reference frame*.

In order to explain our idea, it is necessary to choose a model situation where the delay of information pertaining to a relevant kind of physical interaction is huge, while, for the sake of simplicity, the situation by itself would be as easy as possible, still in a degree sufficient and acceptable for our aim. Thus, let us imagine a situation where an electron is moving in a static homogenous magnetic field; it is moving non-relativistically slowly, while its velocity vector is perpendicular to the vector of magnetic induction. The pertinent Lorentz force causes the electron to follow a circular path, or – more precisely – to move in an involving spiral as it constantly loses its energy in form of the synchrotron radiation. The moving electron is directly (locally) exposed to the influence of a pair of forces being in mutual equilibrium, quite in accordance with the Principle of action and reaction in its classic original Newtonian form, since the forces are acting co-locally. The forces, however, (purposely) do not pertain to the same kind of physical interaction: The centripetally directed Lorentz force of action is determined by the electromagnetic interaction, while it is balanced by the centrifugally directed inertia force. (We assume here that any dynamic interaction between the electron and the generator of the magnetic field is *a priori* excluded; e.g., as much as a period of the (quasi-)circular movement of the electron can be generally much shorter than the time-interval necessary for an interaction between the generator and the electron, in spite of the (vacuum-)light-velocity of the pertinent information.) It is why the electron emanates synchrotron radiation, i.e., electromagnetic waves: The Lorentz force is balanced by a force pertaining to a qualitatively different interaction; the situation is analogous to that in the binary system, but here, moreover, the retardation of the pertinent electromagnetic information is practically infinite.

On this place, it can be objected that a single oscillating electric charge is radiating electromagnetic waves without any relevant phenomenon of retardation. (Imagine, e.g., an electrically charged body with negligible mass attached with an insulator to an oscillating string.) Such a query can nonetheless be explained, at least in the Machian (i.e. closed) universe considered here: Recalling the cosmological electroneutrality, every electric charge (monopole) must have its oppositely charged counterpart somewhere in the Universe. The existence of such a counterpart then represents a determinative condition for the origin of the pertinent delay.

The reactive inertia force, however, represents a more complicated problem deserving caution: The first question is, which of the four known physical interactions it pertains to. When the method of successive exclusions is used, one arrives to the gravitational interaction. On the other hand, in all textbooks (known to the author) the problem is explained/avoided in such a way that it is a force appearing only in non-inertial frames of reference and thus, it is a fictitious force balancing there the external force of action; as a consequence, it has not any sense to look for its link to some kind of physical interaction. Such an argumentation, however, owns up to be false, since more objections immediately arise: The inertia force must be acting even in the inertial frame of reference through relation $F = m_i\, a$ (F being an external real force, i.e. – the action, and a the pertinent acceleration of a test body); there, the existence of the inertia force is rather 'hidden', but it is determining the constant of proportion m_i denoting the inertial mass of the body. Without the existence of any real reactive inertia force in that frame, mass m_i would be equal to zero there, and – followingly – acceleration a of the test body would become infinite. In such a situation, the external force would have the character of a so-called *pure force*, which means the force without any

pertinent co-local reaction.

Another objection, which to us seems to be the most serious, is as follows: How can the inertia force, being presumably fictive, be balanced by a force that is quite real (the Lorentz force)? The Lorentz force can in fact exist even in an inertial frame of reference; imagine only a situation where an electron under the above described circumstances would be constrained to follow a rectilinear path owing to an external force being in dynamic equilibrium with the Lorentzian one. One more objection arises, e.g., in the situation where two bodies, connected together with a wire are orbiting around their common center of gravity, being at rest in an inertial reference frame. The pertinent centrifugal forces acting on the bodies are transferred through the wire into the point on it, which coincides with the center of gravity. A frame of reference with only the *pure rotation* (i.e., the one rotating relative to the cosmic frame of reference, but with a zero or negligible/infinitesimal radius) is – in fact – to be considered as being the inertial one (see Horák, 1969, or Voráček, 1983); as a consequence, the pair of opposite inertia forces were transferred into the inertial frame of reference (the center of gravity and of rotation) where they act; it means again that the presumably fictive forces appear to be real. It is difficult to imagine that the act of transfer of the forces could change their character from fictitious to real. (We realize here that whatever point on the wire can be considered to be the one to where the pair of forces were transferred, but it is only the center of gravity that is the one being at rest in an inertial frame of reference.) Surely, it is possible to find more objections, the one most lapidary could even be the question how some object being at rest relative to the Earth can be damaged owing to a collision with a moving object (e.g., a tree damaged by a moving vehicle, or a person injured when hit by a stone or a bullet; try to persuade him – if still actually possible – of the fictitious character of the force which acted). Here, the *fictive* inertia force performed the *real* work necessary for compensating the negative binding energy determining the organized structure of the matter before the object was damaged, which states a contradiction. (Another 'contradiction' would be especially important for physics: Sir Isaac Newton would never have felt the impact of the famous apple on his head.)

It is then possible to conclude that the inertia force can arise only in a non-inertial frame of reference; but once arisen, it really exists for all observers in all reference frames – even in the inertial ones, to which it can be transferred and perform real work there. The inertia forces are thus real, and the mediating physical interaction, which is the only one remaining, is – indeed – gravitation; ... and quite in the sense of the Mach principle, they can exclusively be determined by the cosmic gravitational field. As a consequence, analogously to the origin of the electromagnetic synchrotron radiation, the orbiting electron also radiates the gravitational waves, which are, however, extremely weak. Nevertheless, the manifestation of the retardation of interaction between the electron and other cosmic bodies is really illustrative in our model situation.

3. The basic postulate of Quantum physics as a possible consequence of application of the Principle of retardation on the hydrogen atom

We start from a well-known mechanistic concept – the Bohr simplified planetary model of the hydrogen atom. Then, applying the Heisenberg indeterminacy principle together with the Principle of retardation (described in the previous Section), the Bohr model necessarily will be modified: In the Bohr model of the hydrogen atom two elementary particles orbit around a common center of gravity. Considering then, that the mass of the nucleus is 1836

times greater than that of the electron, we can assume the nucleus being a physical point of reference for the position and momentum of the electron, while realizing that we are still on the level of a rough mechanistic concept of the planetary model. Now, however, let us apply the influence of retardation of the electromagnetic interaction between the nucleus and the electron. A delay Δt is determined by correlation between the Bohr radius r_0 and the velocity of light in vacuum c :

$$r_0 = c\,\Delta t\ . \tag{1}$$

In accordance with the Heisenberg principle, the indeterminacies in position and momentum of the electron (e.g., in the space-dimension x), denoted respectively with Δx_e and Δp_{e_x}, are linked together through equation

$$\Delta x_e\,\Delta p_{e_x} = \hbar\ . \tag{2}$$

(It is considered, that the here existing observation-free situation implies the sign of equivalence, not the sign $\geq$, since Δx_e and Δp_{x_e} represent values of intrinsic uncertainties; $\hbar = h/2\pi$, where h is the Planck constant.) On this place we presume that retardation Δt determines – through relation (1) – indeterminacy Δx_e in the position of the electron, i.e.,

$$\Delta x_e = r_0\ . \tag{3}$$

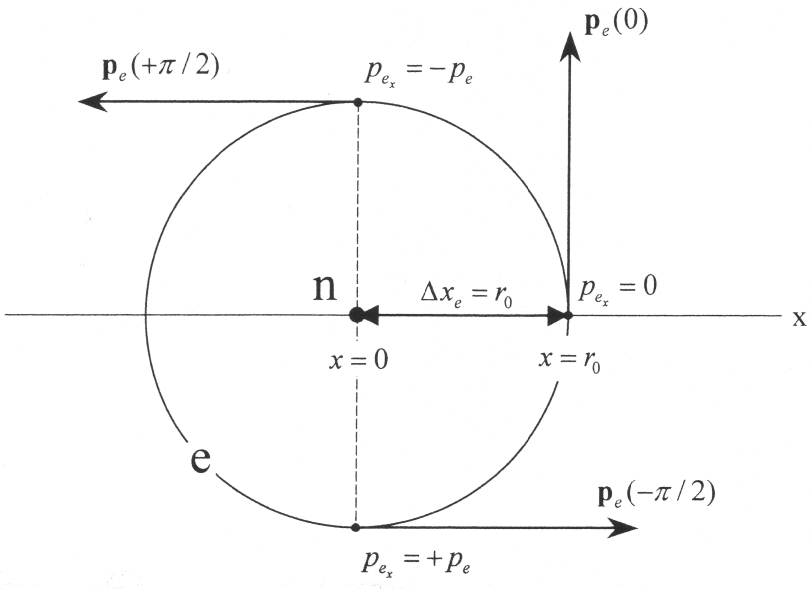

Figure 1: The Bohr mechanistic model of the hydrogen atom

For x-coordinate of the position x_e of the electron within interval $\langle 0, r_0\rangle$, its corresponding momentum is $p_{e_x} \in \langle -p_e, +p_e\rangle$, where p_e is the magnitude of vector $\mathbf{p}_e$.

Analyzing Figure 1, we conclude that the indeterminacy of the momentum of the electron is:

$$\Delta p_{e_x} = p_e\ . \tag{4}$$

Relations (2), (3), and (4) result in equation

$$r_0\,p_e = \hbar\ . \tag{5}$$

The analysis of Figure 1 yields, moreover, the following important informations modifying the Bohr mechanistic model of the hydrogen atom, at least in its ground state:

(i) The position of the electron on its path around the nucleus is charged by a 100% indeterminacy.

(ii) As a consequence of (i) it is not possible to determine the direction of orbital motion (revolution) of the electron.

(iii) The same conclusion is analogously valid for all three space-dimensions x, y, z ; then, it is not possible to determine the plane of orbit of the electron.

(iv) Consequently, the electron has not an orbital magnetic moment.

(v) The force of the electron acting on the nucleus (being exclusively the Coulomb attraction force) has a 100% indeterminacy; consequently, it loses the character of a vector quantity. In the case of the force, further, it entirely loses any meaning and it is even possible to claim that it does not exist intrinsically. Followingly, the statement about the orbital motion of the proton and electron around a common center of gravity in the mechanistic Bohr model becomes superfluous, while the approximative view of the model, where the nucleus is a physical point of reference for the position and momentum of the electron, becomes justified on this place, namely, recalling that no observations are influencing the magnitude of uncertainties (being then purely intrinsic), and that uncertainties related to the nucleus are quantistically transferred to those of the electron (and there combined with them) when, on the right-hand side of relation (2), constant $\hbar$ is used in place of $\hbar/2$. (It is why the nucleus, not being the goal of an observation, can be considered to be an uncertainty-free point of reference, as is done in our analysis.) The analogous conclusion is valid for the forces influencing the orbiting electron in the mechanistic Bohr model; the Coulomb force of action (by which the nucleus acts) and the reactive inertia force, being in dynamic equilibrium, are mutually opposite, but at the same time their direction is charged by a 100% indeterminacy when they are considered as one entity. As a consequence, they disappear intrinsically and this is why the 'orbital motion' of the electron around the nucleus causes neither the emanation of electromagnetic nor gravitational radiation/waves.

(vi) Any 'squeezing' related to the Heisenberg principle is excluded, since the condition $\Delta x_e < r_0$ would mean $\Delta p_e > p_e$, which is impossible in our situation. (This could be the case if the presumption made in connection to relation (1) were false. Nevertheless, the only logical alternative could be $\Delta x_e = v\,\Delta t$, where v is a magnitude of the orbital velocity of the electron, then $v < c$ and, as a consequence following from (1), $\Delta x_e < r_0$.)

Considering the Bohr radius (r_0) and the magnitude of the velocity vector (v) (where $p_e = m_e\, v$) as being average statistical values, we realize, hereby, that the Bohr model was modified into a realistic quantum model of the hydrogen atom, since the conclusions made in points (i) to (vi) pertain to the quantum mechanistic view on the situation.

Nonetheless, when looking at the same situation from the view of macrophysics, it is not possible to deny, in spite of the conclusions made above, that the interaction between the nucleus of the atom (the proton) and the 'orbiting' electron is mediated by means of electromagnetic interaction. The scalar quantities r_0 and v (considering their 'average-character' of stochastic values) are then playing their roles in the 'envelope-laws' of macrophysics, where the quantum substance is hidden, and where any quantistic description would also be quite irrelevant. It seems that in the case of the hydrogen atom we are in the zone where the realms of quantum physics and macrophysics are mutually overlapping and – as a consequence – the relevant description of reality is necessarily dualistic. Therefore, when deducing velocity v,

it is still possible to use the classical equation of equilibrium of forces pertaining to the Bohr model as a relevant approach:

$$F_{Coul.} = F_{inert.} \tag{6}$$

$$(4\pi\,\varepsilon_0)^{-1}\,e^2\,r_0^{-2} = m_e\,v^2\,r_0^{-1} \tag{7}$$

$$v^2 = e^2(4\pi\,\varepsilon_0\,m_e\,r_0)^{-1} \tag{8}$$

(ε_0 being the permitivity of vacuum, m_e the mass of the electron, and e is its electric charge). From relation (5) follows directly:

$$r_0 = \hbar\,(m_e\,v)^{-1}\ , \tag{9}$$

which, together with (8), yields the generally known formula

$$r_0 = 4\pi\,\varepsilon_0\,\hbar^2(m_e\,e^2)^{-1}\ . \tag{10}$$

The most important and really astonishing fact is that conclusion (5) is identical to the result of a deduction following from the concept of the de Broglie wave from 1924 (see, e.g., Beiser, 1969); there its wavelength

$$\lambda_{deB.} = h\,p_e^{-1}\ , \tag{11}$$

in the same situation of the hydrogen atom, is considered to be equal to the circumference of the orbit of the electron. According to that concept, the wave originating from the orbiting electron prevents its own extinction only if

$$\lambda_{deB.} = 2\pi r_0\ . \tag{12}$$

Such an explanation, being – in fact – the very base of quantum physics, remains, however, its vague and problematic point. Further, according to many experts, the concept of the de Broglie waves still loses any more profound physical interpretation, even if, on the other hand, their interference patterns are physically highly real. On the contrary, the deduction of relations (9) and (10) made above, yields then a new and – perhaps – even more acceptable option, as it has its own physical logic.

4. Philosophical impact of the presented view

According to Bohr, the microworld is reductionalistic, i.e., the Quantum physics governing such a world adequately describes reality (and can – moreover – successfully predict, until the present time unknown phenomena), even if it can not logically explain it/(them). Such an explanation would need introduction of new sub-elements, but it is impossible by principle, since they have not an objective reality at all (consequently, they are 'reduced away').

On the other hand, according to Einstein, the world is objectively real, which is a rationalistic view: We will discover new, up to this time unknown, hidden philosophic categories, which will serve as explanatory elements useful in order to approach the basic substance of our world, even if we (perhaps) never will arrive to that substance.

As the analysis presented above suggests, there could exist another option, more approaching that of Einstein than that of Bohr. In such a view, the world would be objectively real and rationalistic in such a sense that we already have the necessary explanatory tools,

but they have remained unnoticed until now. Nevertheless, it is also possible to see that the Einstein deterministic view is not quite relevant, since the principal moment of our view presented above is characterized by the involvement of the (holistic) Heisenberg indeterminacy principle, which is – by itself – a consequence of the stochastic character of the (prevalently micro-)world. This circumstance slightly changes the purely causal logic of the deterministic view to a new kind of logic pertaining to a 'para-deterministic' view of the world, where the Bohr holistic view is primarily only apparent, while it is relevant only when becoming secondary, which here means on a deeper level, in a situation where it is necessary that the Indeterminacy principle would be recalled. Followingly, the laws of probability – paradoxically – would represent the basic substance of our world as meant by Einstein.

5. Conclusion

In spite of the restriction to the hydrogen atom only, we believe that the linkage described above can not be casual. We hope the idea will be developed in order to raise our understanding of the world in its whole complexity on a more profound level.

Appendix

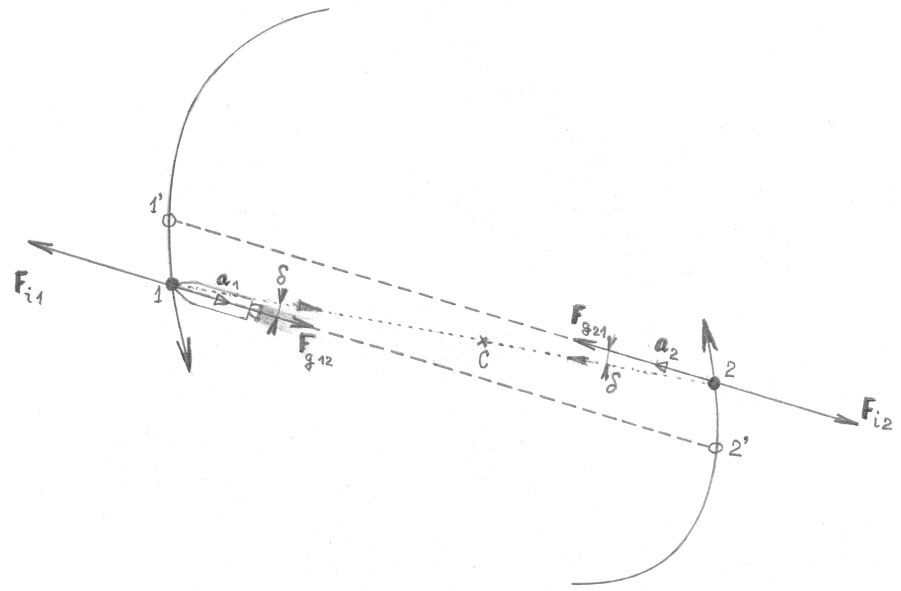

Figure 2: Generalized Principle of action and reaction.

It is necessary to point out that it is possible to question the validity of the Principle of action and reaction in a binary system, since centrifugal inertia force $\mathbf{F}_{i_1}$ – arisen thanks to centripetal acceleration $\mathbf{a}_1$ of one component (1) – is not transferred to the second component (2), where it would be possible to identify it as a centripetal force causing the centripetal acceleration, which is the case when two bodies with negligible gravitation, connected with a wire, are orbiting around a common center of gravity. Such a statement is possible to sustain with the fact that, in a binary system of gravitationally bound bodies, a short elimination of centrifugal inertia force $\mathbf{F}_{i_1}$ arising in component 1 (eliminated thanks to the action of an external force compensating gravitational force $\mathbf{F}_{g_{12}}$ of/from component 2, e.g. with the help of a centrifugally pushing rocket engine) would not cause centripetal force $\mathbf{F}_{g_{21}}$, evoked in component 2 (owing to the gravitational interaction mediated by the spacetime curvature), to vanish (after the pertinent delay); in the opposite case it would cause - as a direct consequence - its centripetal acceleration $\mathbf{a}_2$ to disappear. On the other hand, however, in a binary gravitationally bound system the origination of centripetal force $\mathbf{F}_{g_{12}}$ in body 1 (resulting in its centripetal acceleration $\mathbf{a}_1$, as well as the reaction to this acceleration in the form of the origination of centrifugal inertia force $\mathbf{F}_{i_1}$) is determined by the presence of body 2, which (by means of its matter) evokes the spacetime curvature. The force of action $\mathbf{F}_{g_{12}}$ on body 1 thus has its origin in the matter of body 2 and vice versa. This process is going on with a retardation of the gravitational interaction. As a consequence, one can consider such a process to be a manifestation of the generalized Principle of action and reaction.

The shortly applied external force of the rocket engine is equal to force $\mathbf{F}_{i_1} = -\mathbf{F}_{g_{12}}$.

In the Figure, dots 1 and 2 represent the actual positions of the first and second component of the binary, respectively; denoted 1' and 2' are their retarded positions. Point C is the gravity center of the binary; δ is the abberational shift of the gravitational force in the binary system caused by the delay of the gravitational information.

Note

The author is convinced that the adequate description of the Higgs particle and of its working mechanism necessarily needs to be compatible with the Mach principle and with the conclusions presented above.

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