ON THE INCOMPATIBILITY OF EXPERIMENTS CONFIRMING CERTAIN CONCLUSIONS OF THE GENERAL RELATIVITY

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Qualitative arguments are presented which show the incompatibility of the positive results obtained in experiments on the gravitational redshift of photons and in experiments investigating the behaviour of clocks in the gravitational field.

The present note[1] originated when the author had been preparing proposals of experiments aimed at using in fundamental research the effects of coherent exitation of fast atoms or nuclei passing through the crystal [1] - [4]. In particular, the interest was in verification of the equivalence between the gravitational field and accelerated frame at the values of acceleration $10^{20} \div 10^{21}$ cm/sec^2. Trying to analyse possible results of such experiments and their relation to the wellknown experiments on certain predictions of the General Relativity (G.R.) the author encountered and interesting and somewhat paradoxical situation.

Unfortunately discussions which were initiated by the author and which lasted for quite a long time did not resulted in a reasonable clarification of the paradoxical situation. Hence the author considers it necessary to focus on the attention of scientific media on the question to be explained in what follows.

As it is wellknown experiments now considered as classical [5] -[10] have confirmed the predictions of the G.R. on the frequency shift of photons moving along the gradient of the gravitational potential and on the difference of the frequencies of the clocks placed at the points with different gravitational potential. The gravitational shift of the photon frequency $\Delta\nu/\nu = g\cdot H/c^2$ has been measured in the known experiments of Pound and Rebka [5], [6] and Vessot and Levine [7] – see Fig. 1.

The frequency shift $\Delta\nu$ of photons emitted by Fe^{57} nuclei [5], [6] or by hydrogen atoms in the hydrogen frequency standard (HFS) [7] during the elevation (or descend) to the altitude H in the gravitational field was detected by comparison with the reference frequency of the "generator" placed at the point where the photon was detected. In [5] the role of the "generator" of the reference frequency placed at the altitude H was played by Fe^{57} nuclei (identical to the nuclei-emitters with the energy 14 keV at $H = 0$), while in [7] it was played by HFS-emitter of photons placed at the earth level. In both experiments it was considered as obvious that the level spacing in nuclei [5], [6] or atom [7] does not depend upon the gravitational potential (G.P.).

We remind that the stability of the frequency of the emitted photons and the accuracy of the determination of the frequency of the detected photons is undoubtedly defined by the stability of level spacing in nuclei [5], [6] or atoms [7].

Without this implicit assumption on the independence of the level spacing on the G.P. the interpretation (and even the performance) of these experiments is impossible since the small shift of the photon frequency can be detected only comparing it with the constant reference frequency which is determined by the constant level spacing of nuclei or atoms.

It seems that three alternative interpretations of the experimental results on the gravitational frequency shift of photons are feasible:

a) when moving upwards the photon frequency changes in line with the equation of G.R. $\Delta\nu/\nu = g\cdot H/c^2$, while the level spacing of nuclei and atoms does not depend on G.P.;
b) the photon frequency remains unchanged, while the levels of nuclei and atoms follow the G.P. according to $\Delta\nu/\nu = g\cdot H/c^2$;
c) both the photon frequency and the nuclear levels are changed (in these case different options are possible depending upon the sign and the value of the above changes when moving in the gravitational field).

As one can infer from [5], [6], [7] these paper tacitly and with no doubts imply the option a).

The dependence of the clock rates on the G.P. (quantitatively it is given by the twin-equation $\Delta T/T = \Delta\nu/\nu = g\cdot H/c^2$) was investigated in experiments [8], [9], [10] by the comparison of the counts of the two high-accuracy frequency standards at the point with certain fixed value of the G.P. and subsequent elevation of one of the frequency

[1] Russian variant of thise preprint had been published in 1998 (Preprint ITEP-27-98)

standards for a certain period of time to the point with different value of the G.P. (to the altitude *H* of several kilometers).

The difference in the run of the two devices after they were returned to the same point (Fig. 1) quantatively confirms the dependence of the clock rate on G.P. in line with the G.R. prediction.

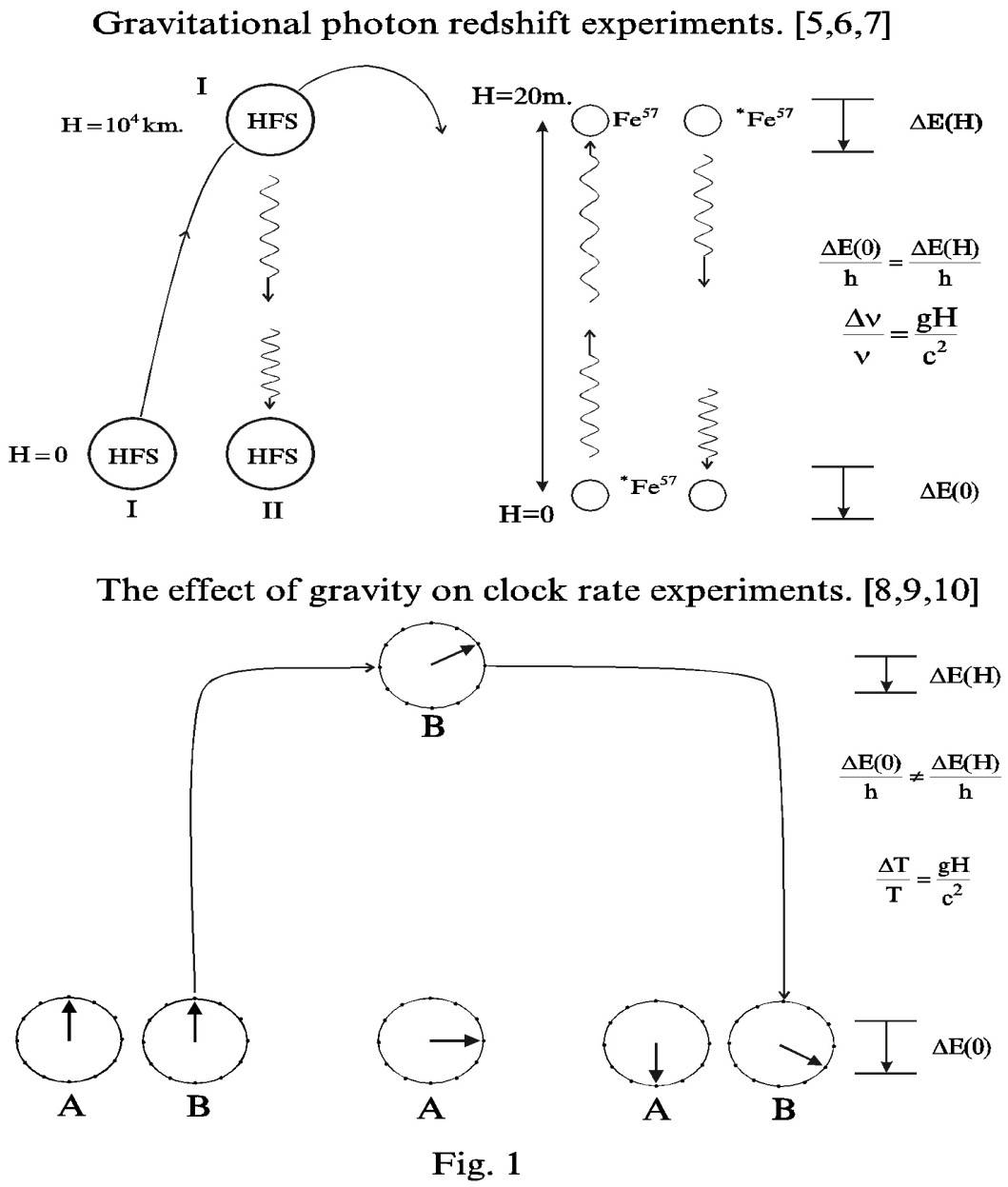

Fig. 1

The interpretation of these experiments is directly related to the fact that the positions of the levels (which determine the rates of the frequency standards) depend on the value of the G.P. at the point where the atoms are placed. The atoms play here the role of `clocks' which measure how the time runs at different altitudes in the gravitational field of the earth.

Thus the interpretation of the Pound and Rebka [5] and Vessot and Levine [7] experiments is based on the "seemingly evident" assumptions (the invariance of the nuclear and atomic levels with the G.P. variations), which are in sharp contrast with the known G.R. result on the different clock rate at the points with different G.P. This G.R.

result was also experimentaly confirmed in [8], [9], [10], where it was shown that the levels of at least atoms change with G.P. (the atoms are in fact clocks which react to the change of the G.P.!).

Thus the positiv experimental results on the gravitational photon frequency shifts [5], [6], [7] on one hand, and experimental results on the gravitational change in the clock rate [8], [9], [10] on other hand, are unfortunaly incompatible.

If the atomic and nuclear levels do not depend on the G.P. - then experiments [5], [6], [7] must yield positive result, while [8], [9], [10] - negative. If on the contrary the positions of the atomic and nuclear levels do depend on the G.P., then experiments [5], [6], [7] can not lead to positive result to which lead [8], [9], [10]. Getting simultaneously positive results in experiments [5], [6], [7] and [8], [9], [10] is impossible since the positions of the atomic and nuclear levels can not at the same time be dependent and independent upon the G.P.

The paradoxical and problematic physical situation which has emerged practicaly `from nothing' results in the whole chain of important physical consequences which are yet precocious to discuss. Still one point worth reminding - it is just the movement in the effective gravitational field due to acceleration (the equivalence principle!) which is at the core of the twin-paradox [11].

The above incompatibility between the results of experiments which are already considered as being classical calls for the necessity of additional experimental confirmation using alternative methods. This role may be played by the experiments on the coherent exitation of the levels of the fast atoms and relativistic nuclei in crystals [1] - [4]. In such experiments the projectile nuclei serves as a clock and its rate is compared to that of the atoms in crystal by means of subsequential interactions.

The sharp resonance form of the interaction enables to single out from the level shift of the moving nuclei the component which is due to the changing G.P. which is in turn caused by the effective deacceleration of the nuclei inside the media.

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