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The Mössbauer rotor experiment and the general theory of relativity

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ABSTRACT

In the recent paper Yarman et al. (2015), the authors claim that our general relativistic analysis in Corda (2015), with the additional effect due to clock synchronization, cannot explain the extra energy shift in the Mössbauer rotor experiment. In their opinion, the extra energy shift due to the clock synchronization is of order 10^{-13} and cannot be detected by the detectors of γ-quanta which are completely insensitive to such a very low order of energy shifts. In addition, they claim to have shown that the extra energy shift can be explained in the framework of the so-called YARK gravitational theory. They indeed claim that such a theory should replace the general theory of relativity (GTR) as the correct theory of gravity.

In this paper we show that the authors Yarman et al. (2015) had a misunderstanding of our theoretical analysis in Corda (2015). In fact, in that paper we have shown that electromagnetic radiation launched by the central source of the apparatus is redshifted of a quantity $0.\bar{6}\frac{v^2}{c^2}$ when arriving to the detector of γ-quanta. This holds independently by the issue that the original photons are detected by the resonant absorber which, in turns, triggers the γ-quanta which arrive to the final detector. In other words, the result in Corda (2015) was a purely theoretical result that is completely independent of the way the experiment is concretely realized. Now, we show that, with some clarification, the results

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of Corda (2015) hold also when one considers the various steps of the concrete detection. In that case, the resonant absorber detects the energy shift and the separated detector of γ-quanta merely measures the resulting intensity.

In addition, we also show that the YARK gravitational theory is in macroscopic contrast with geodesic motion and, in turn, with the weak equivalence principle (WEP). This is in contrast with another claim of the authors of Yarman et al. (2015), i.e. that the YARK gravitational theory arises from the WEP. Therefore, the YARK gravitational theory must be ultimately rejected. We also correct the confusion of the authors of Yarman et al. (2015) concerning their claims about the possibility to localize the gravitational energy and, in turn, to define a stress–energy tensor for the gravitational field. In fact, we show that these claims are still in macroscopic contrast with the WEP.

1. Introduction

In [1] we gave a correct interpretation of a historical experiment by Kündig on the transverse Doppler shift in a rotating system measured with the Mössbauer effect (Mössbauer rotor experiment) [2]. The Mössbauer effect (discovered by R. Mössbauer in 1958 [3]) consists in resonant and recoil-free emission and absorption of gamma rays, without loss of energy, by atomic nuclei bound in a solid. It resulted and currently results very important for basic research in physics and chemistry. In [1] we focused on the so called Mössbauer rotor experiment. In this particular experiment, the Mössbauer effect works through an absorber orbited around a source of resonant radiation (or vice versa). The aim is to verify the relativistic time dilation for a moving resonant absorber (the source) inducing a relative energy shift between emission and absorption lines.

In a couple of recent papers [4,5], the authors first re-analyzed in [4] the data of a known experiment of Kündig on the transverse Doppler shift in a rotating system measured with the Mössbauer effect [2]. In a second stage, they carried out their own experiment on the time dilation effect in a rotating system [5]. In [4] it has been found that the original experiment by Kündig [2] contained errors in the data processing. A puzzling fact was that, after correction of the errors of Kündig, the experimental data gave the value [4]

$$\frac{\nabla E}{E} \simeq -k\frac{v^2}{c^2}, \tag{1}$$

where $k = 0.596 \pm 0.006$, instead of the standard relativistic prediction $k = 0.5$ due to time dilatation. The authors of [4] stressed that the deviation of the coefficient k in Eq. (1) from 0.5 exceeds by almost 20 times the measuring error and that the revealed deviation cannot be attributed to the influence of rotor vibrations and other disturbing factors. All these potential disturbing factors have been indeed excluded by a perfect methodological trick applied by Kündig [2], i.e. a first-order Doppler modulation of the energy of γ-quanta on a rotor at each fixed rotation frequency. In that way, Kündig's experiment can be considered as the most precise among other experiments of the same kind [6–10], where the experimenters measured only the count rate of detected γ-quanta as a function of rotation frequency. The authors of [4] have also shown that the experiment [10], which contains much more data than the ones in [6–9], also confirms the supposition $k > 0.5$. Motivated by their results in [4], the authors carried out their own experiment [5]. They decided to repeat neither the scheme of the Kündig experiment [2] nor the schemes of other known experiments on the subject previously mentioned above [6–10]. In that way, they got independent information on the value of k in Eq. (1). In particular, they refrained from the first-order Doppler modulation of the energy of γ-quanta, in order to exclude