УДК 548.1:533.9

THE FEATURES OF NUCLEAR GAMMA-RESONANCE OBSERVATION OF ROTATING OBJECTS AND EXTENDED RELATIVISTIC THEORY

Yu.I. Gofman[2], V.G. Kirichenko[1], O.V. Коvalenko[1], T.A. Коvalenko, V.N. Leonov[1]

[1]Kharkov National Karazin University, High Technology Institute
31 Kurchatov St., Kharkov, 61108, Ukraine
E-mail: val_kir48@mail.ru
[2]Jerusalem College of Technology, Department of Applied Physics
P.O. B. 16031, Jerusalem 91160, Israel
E-mail: gofman@jct.ac.il
Received 1 November 2011

We consider briefly the problem of increasing the accuracy of observation of the effects of displacement energy gamma rays in nuclear gamma-resonance. Set out the reasons for the need for repeated experiments, described the theory of relativity and gravity on Earth at a higher level of accuracy (above 1%). The method of detecting nuclear γ-resonance spectra of rotating objects with high accuracy was proposed. The evaluation of the experimental results obtained under different conditions was carried out. The possibility of experimental verification of a brand new approach to relativistic phenomena description was considered. It is the extended relativistic theory (ERT) that predicts the existence of the maximum acceleration.
KEY WORDS: Mössbauer spectroscopy, accuracy, gravitational redshift, relativistic uniformly accelerated motion, extended relativistic theory

ОСОБЛИВОСТІ СПОСТЕРЕЖЕННЯ ЯДЕРНОГО ГАММА-РЕЗОНАНСУ ОБЕРТОВИХ ОБ'ЄКТІВ ТА РОЗШИРЕНА ТЕОРІЯ ВІДНОСНОСТІ

Ю.Й. Гофман[2], В.Г. Кіріченко[1], О.В. Коваленко[1], Т.А. Коваленко[1], В.Н. Леонов[1]
Харківський національний університет імені. В.Н. Каразіна, Інститут високих технологій
61108, м. Харків, пр. Курчатова, 31
[2]Єрусалимський політехнічний інститут - Махон Лев, Кафедра прикладної фізики
п.с. 16031, Єрусалим 91160, Ізраїль
Коротко розглянуто проблему підвищення точності спостереження ефектів зміщення енергії гамма-квантів в ядерному гамма-резонансі. Викладено причини необхідності проведення повторних експериментів, описуваних теорією відносності і гравітації в земних умовах на більш високому рівні точності (вище 1%). Запропоновано метод детектування ядерних γ-резонансних спектрів обертових об'єктів з підвищеною точністю. Наведено оцінку експериментальних результатів, отриманих в різних умовах. Описуються можливості експериментальної перевірки принципово нового підходу до опису релятивістських явищ – розширеної теорії відносності (РТО), яка передбачає існування максимального прискорення.
КЛЮЧОВІ СЛОВА: месбауерівська спектроскопія, гравітаційне червоне зміщення, релятивістський рівноприскорений рух, розширена теорія відносності

ОСОБЕННОСТИ НАБЛЮДЕНИЯ ЯДЕРНОГО ГАММА-РЕЗОНАНСА ВРАЩАЮЩИХСЯ ОБЪЕКТОВ И РАСШИРЕННАЯ ТЕОРИЯ ОТНОСИТЕЛЬНОСТИ

Ю.И. Гофман[2], В.Г. Кириченко[1], О.В. Коваленко[1], Т.А. Коваленко[1], В.Н. Леонов[1]
[1]Харьковский национальный университет имени В.Н. Каразина, Институт высоких технологий
61108, г. Харьков, пр. Курчатова, 31
[2]Иерусалимский политехнический институт - Махон Лев, Кафедра прикладной физики
п.я. 16031, Иерусалим 91160, Израиль
Кратко рассмотрена проблема повышения точности наблюдения эффектов смещения энергии гамма-квантов в ядерном гамма-резонансе. Изложены причины необходимости проведения повторных экспериментов, описываемых теорией относительности и гравитации в земных условиях на более высоком уровне точности (выше 1%). Предложен метод детектирования ядерных γ-резонансных спектров вращающихся объектов с повышенной точностью. Приведена оценка экспериментальных результатов, полученных в различных условиях. Описываются возможности экспериментальной проверки принципиально нового подхода к описанию релятивистских явлений – расширенной теории относительности (РТО), предсказывающей существование максимального ускорения.
КЛЮЧЕВЫЕ СЛОВА: мессбауэровская спектроскопия, точность, гравитационное красное смещение, релятивитское равноускоренное движение, расширенная теория относительности

The unique resolution of the Mossbauer effect [1] is expressed by the ratio ΔE / E ($\Gamma = \Delta E$ – line width and the energy of gamma - quanta E) and for the isotopes Fe^{57} and Zn^{67} reaches $3.1 \cdot 10^{-13}$ and $5.2 \cdot 10^{-16}$, respectively. Application of the Mossbauer Effect (nuclear gamma - resonance) for the experimental verification theory of relativity and theory of gravity continues to these days [2-6]. This made it possible to verify the presence of the gravitational red shift [2] with achieved an accuracy of $5 \cdot 10^{-16}$ on the energy of gamma - rays. This proved the principle of equivalence with accuracy to within 1%.

The analysis of the interpretation the Pound and Rebka [2, 3] experiments was carried out to test one of the equations of the theory of gravitation – the central field of the Schwarzschild equation [6]. It is noted that in experiments using the Mossbauer Effect for information on the spatial curvature it is necessary to use more accurate experiments, which should include the measurement of geometrical lengths and angles.

Thus, the improvement devices of measurement and control the speed and acceleration of moving objects in space is an actual problem. We have previously created gyroscopic device based on the Mossbauer Effect, which allowed more accurate measurement [7-9].

Besides this, an extended relativistic theory (ERT) based on a new approach to the analysis of relativistic effects, based on the symmetry of space-time [10, 11] is developed. This theory predicts the existence of a maximal acceleration [12]. This fundamentally new relativistic phenomenon, which relates the special and general relativity, requires a careful verification. A maximum acceleration effect is more shows at high accelerations values ***a*** and that it is at high power and small masses. And of course, this requires the use of high-precision experimental techniques. Estimates carried out in [13] show that the greatest acceleration is realized in nature, in particular, the accretion on to a black hole or neutron star, nuclear phenomena, including the decay of particles nuclear stopping. Possibility of experimental determination the maximum acceleration is discussed in detail in [12, 13].

The aim of this study is to improve the accuracy of the determination of small energy shifts at the observation of the Mossbauer Effect in physical systems related with moving and rotating objects.

EXPERIMENTAL RESEARCH METHOD

As the source of the Mossbauer isotope Fe^{57}gamma - rays was used the nuclei Co^{57} in Cr matrix. The refined wavelength with energy 14.4 keV is λ = 0.860 255 75 (26) Å [14]. The Doppler shift energy of gamma - rays for the laboratory coordinate system, i.e. the frequency υ of γ - rays, is given by:

$$\nu = \nu_0 (1 + \frac{\vartheta}{c}\cos\alpha - \frac{1}{2}\frac{\vartheta^2}{c^2}). \quad (1)$$

Here ν_0 – frequency of γ - rays for fixed relative to each other the source and absorber, α – the angle between the recording γ - rays and the velocity vector of the relative motion of the source or sink, υ – the relative velocity of source on to the absorber.

The rotating body in form of a disk is the absorber of gamma rays. It takes a fixed absorber crossing the axis of the beam γ - rays emitted by the peripheral part rotor-source [14]. As the objects of experimental study were used the foils and powders of iron enriched with isotope Fe^{57} up to 85%, austenitic steel foils.

RESULTS AND DISCUSSION

The source and absorber, characterized by single lines of emission and absorption, and a rotor rotating at a frequency ω were used. The dependence of the resonant transmission of gamma rays on the parameter X = nα [10^{-3} rad/s] for the determination of small displacements was obtained, where the α- plane tilt angle of the rotor disk for different frequencies of rotation of the disk n (Fig. 1, 2). The reached accuracy evaluation is $6\cdot10^{-6}$ rad/s at measurement accuracy of the resonance transmission a within the statistical error.

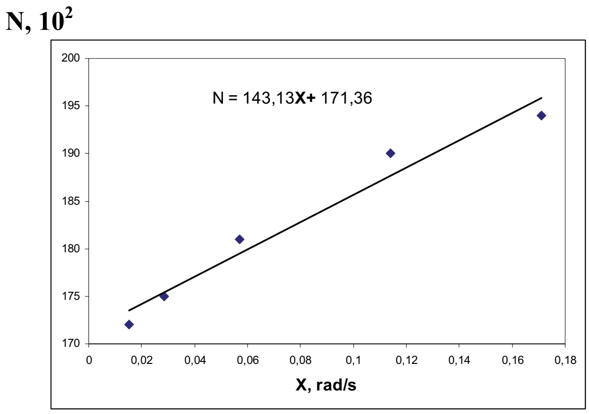

Fig.1 Dependence of the resonant transmission from the rotation angle of the rotor for frequency of rotation 0.7 Hz

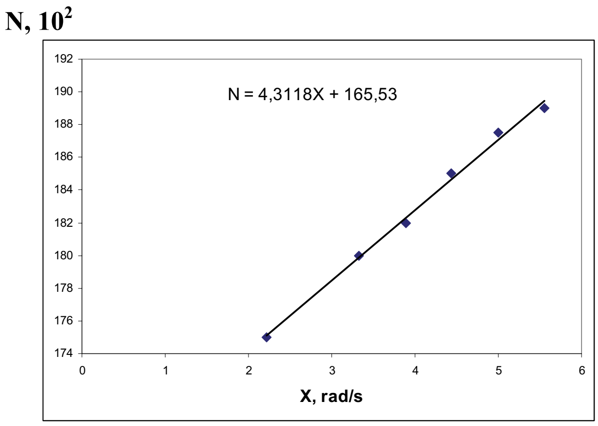

Fig. 2. Dependence of the resonant transmission of the rotation angle of the rotor for frequency of rotation 50 Hz

The values of the contributions from the quadratic Doppler Effect for Fe^{57} nuclei (Fig. 1) are small and approximately equal to 0.00005 mm/s [15]. We note that at the measurement of small linear and angular displacements of objects the cross Doppler effect with the Mössbauer technique obstacles arise first of all due to the vibrations, the pulses, disturbance of the strict orientation of objects in space, the inhomogeneous distribution of resonant nuclei on the surface of the object.

In this case, in the expression (1) it is necessary to take the instantaneous values $\vec{V}(t)$. It is necessary to search for ways to effectively eliminate its influence on the instrument readings as to get rid of these vibrations is impossible. In addition to measuring the linear velocity and displacement by nuclear gamma - resonance it is possible to carry out measurement and control of angular velocities and accelerations.

The maximum high accuracy of electromagnetic irradiation frequency measurement using Mossbauer effect allows to test of one of the consequences of special relativity – "transverse Doppler effect" [5]. As shown [12] in the ERT Doppler shift between inertial system K' and accelerated system $\tilde{K}$ moving together is determined by the coefficient (1 - a/A) due to the acceleration $\tilde{K}$ relatively K'. Evaluation of maximum acceleration a = (1.006 ± 0.063) 10^{19} m/s², using experimental data [5] was carried out. Such a significant acceleration it is possible to reach at modern experimental installations, at particular, at CERN's the muon storage ring [16].

CONCLUSIONS

We reached the values of minimum measurable linear velocity of about $5 \cdot 10^{-5}$ mm/s and angular velocities of $6 \cdot 10^{-6}$ rad/s using the isotope Fe^{57}. It confirms the real possibilities of measurement method Doppler shift using the Mossbauer effect to determine the maximum acceleration and the prospects for development of such researchers.

REFERENCES

1. Mössbauer R.L. Kernresonanzfluoreszenz von Gammastrahlung in Ir191 //Zeitschrift für Physik. – 1958. – Vol.A 151 (2). – P.124–143.
2. Pound R.V., Rebka Jr.G.A. Gravitational Red-Shift in Nuclear Resonance //Physical Review Letters. - 1959. – Vol.3 (9). – P.439–441.
3. Pound R.V., Rebka Jr.G.A. Apparent weight of photons //Physical Review Letters. -1960. – Vol.4 (7). – P.337–341.
4. Pound R.V., Snider J.L. (November 2, 1964). Effect of Gravity on Nuclear Resonance //Physical Review Letters. – 1964. – Vol. 13 (18). – P.539–540.
5. Kůndig W. Measurement of the Transverse Doppler effect in an Accelerated System //Phys.Rev. –1963. –Vol.129, №6. – P.2371–2375.
6. Smorodinskiy. Ya.A. Effekt Messbauera i teoriya otnositel'nsti //UFN. –1963.-T. LXXIX.-V.4. –S.590–598.
7. Kirichenko V.G. Sposob izmereniya uglovoy skorosti / Kirichenko V.G., Chekin V.V. - A.S. SSSR, №782501, – 1980. – 6s. Zayavka №2683000. prioritet.4.11.78.Zaregistrirov.25.07.80.
8. Chekin V.V., Kirichenko V.G., Rogov V.S., Kharchenko A.V. Izmerenie malykh uglovykh smeshcheniy s pomoshch'yu effekta Messbauera, 1980. - 12s. Dep. TsNII "Rumb" 25.02.80. "Parus-330".
9. Kirichenko V.G., Chekin V.V. Vliyanie poperechnogo dvizheniya na parametry messbauerovskoy linii // Zavodskaya laboratoriya. – 1980. –T.46, №7. – S.608–610.
10. Friedman Y., Gofman Y. Why Does the Geometric Product Simplify the Equations of Physics //Int. J. Theoretical Physics. – 2002. – Vol.41, № 10. – P.1841–1855.
11. Friedman Y., Gofman Y. Relativistic Linear Space-Time Transformations Based on Symmetry //Foundations of Physics. – 2002. – Vol. 32. – Iss. 11. – P.1717–1736.
12. Friedman Y., Gofman Y. A new relativistic kinematics of accelerated systems //Phys. Scr. – 2010. – Vol.82. – P. 015004 (6pp).
13. Gofman Y. Maximal acceleration and the Physical Phenomena in Extreme Condition//Bull. Isr. Phys. Soc. – 2007. – Vol. 53. – P.175.
14. Lucht M. The Wavelength of the 14.4 keV M.ossbauer Radiation in 57Fe:A Novel Length Standard For Atomic ScalesDissertation zur Erlangung des Doktorgrades des Fachbereichs Physik der Universit.at Hamburg. Hamburg. –2005. – 104p.
15. Kirichenko V.G., Kovalenko O.V., Leonov V.N., Kovalenko T.A., Gofman Yu.I. The nuclear gamma-resonance in research of gravitation and relativistic uniformly accelerated motion. detecting of Mossbauer spectra of rotating objects //The Journal of Kharkov National University, physical series "Nuclei, particles, fields", Issue 2/50/. –2011. - Vol. 955. - P. 15–23.
16. Mueller R. Decay of accelerated particles //Phys. Rev D. – 1997. –Vol. 56. – P.953–960.