LIGHT FREQUENCY CONVERSION BY THE RITZ EFFECT
IN SPACE AND LABORATORY

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One of the methods for converting the frequency of light is based on imparting motion to a source or charged particles re-emitting light [1, 2]. In this case, to change the frequency of light by times or orders of magnitude, the Doppler effect is usually used, which in the framework of the special theory of relativity (SRT) requires speeds V of the order of the speed of light c, that is, the use of powerful accelerators of charged particles [2, p. 171]. On the contrary, within the framework of the Ritz ballistic theory (BTR), the frequency of light can be effectively converted even at relatively low velocities of sources and re-emitting media [1].

According to the ballistic theory, the source increases the speed of light c' by the value of its speed V according to the classical vector law of addition of velocities: $\mathbf{c'} = \mathbf{c} + \mathbf{V}$. This law is indirectly confirmed by the results of astronomical observations, space radar, GPS and GLONASS [3, 4]. Thus, one of the main arguments against the ballistic theory, based on the analysis of the motions of binary stars, does not contradict the Ritz theory [1, 5]. When the speed V of the stars was reported to the light emitted by them, their apparent motion and radial velocity graphs would be distorted so that in the far parts of the orbit the motion of the stars would seem to be accelerated, and in the near ones - slowed down, as if the orbits were stretched towards the Earth. In 1913, De Sitter noted that the effect was not observed, but in the same year astronomers Guthnick and Freundlich, studying the statistics of binary stars, showed that the effect was indeed discovered in the form of the so-called Barr effect, according to which most of the orbits appear to be elongated in side of the Earth [1, 5]. As shown in monograph [6], it is precisely the distortion of the radial velocity graphs that takes place. A similar effect was found in exoplanets [1, 7], and in a number of them the observed abnormally high eccentricities of orbits may be just a consequence of these distortions.

The small magnitude of the observed distortions, which led De Sitter to the conclusion that the ballistic theory was erroneous, was explained by J. Fox in 1965 by the re-emission of light from binary stars in interstellar gas at a distance $l = \lambda/2\pi(n - 1) \sim 1$ light year [8], where λ is the wavelength of light, n is the refractive index of the gas. As a result, the light rays pass only the initial part of their path l (about 10^{-3} of the total distance of the stars $L \sim 10^3$ light years) at a speed different from c. And the distortions accumulated along this path are of the order of $k = l/L \sim 10^{-3}$ from the theoretical, in accordance with the analysis of De Sitter [1]. This also explains the absence of distortions in binary X-ray pulsars, for which, according to K. Brecher [9], the value of distortions is $k < 10^{-9}$ of the theoretical value. However, this value agrees with the ballistic theory, if we take into account, according to Fox [8], that X-rays are re-emitted in the general atmosphere of X-ray pulsars. For the Cen X-3, Her Xl, SMC Xl systems considered by Brecher, at orbital periods $P \sim 1$ day and velocities $V \sim 100$ km/s, the radii of the pulsar orbits will be $R \sim PV \sim 10$ million km, that is, the orbits lie inside the corona main star. Indeed, the distance R is comparable to the size of the outer atmosphere - the corona of stars, where, for example, for the Sun [10, p. 625], the ion concentration is $N \approx 10^8$ cm^{-3}. According to [9], $l \approx (\lambda a_0 N)^{-1} \sim 2 \cdot 10^{11}$ m ~ 200 million km ~ 1 AU, where the X-ray wavelength $\lambda \approx 2 \cdot 10^{-11}$ m, the classical electron radius $a_0 = e^2/mc^2 \approx 2.82 \cdot 10^{-15}$ m. This length l is comparable to R and the characteristic size of stellar crowns. That is, in such X-ray pulsars, re-emission occurs inside the corona of the main star. And at a pulsar distance $L \sim 10$ kpc [9], within the BTR $k = l/L < 10^{-9}$, in agreement with the result of Brecher. In addition, the re-emission of X-rays by interstellar gas is underestimated. So, the arguments of Brecher and De Sitter testify not against, but in favor of the ballistic theory.

The results of space radar also testify in favor of the Ritz theory [3, 4]. For example, the distance of Venus measured by the radar systematically exceeded the calculated one when the Earth was moving away from Venus, due to a decrease in the speed of the radio signal and an overestimation of the distance L measured by the delay. When the concentration of electrons in the interplanetary plasma is $N \sim 0.1$ cm^{-3} [10, p. 398] and a working wavelength $\lambda \sim 0.3$ m ($f = c/\lambda \sim 1$ GHz), the re-emission length $l \approx (\lambda a_0 N)^{-1} \sim 12 \cdot 10^9$ m, which is comparable with the minimum distance between the planets $L \sim 42 \cdot 10^9$ m. Apparently, due to this, with an increase in the distance between the Earth and Venus, when it reached the value $L \sim 10^{10}$ m, the magnitude of the measurement errors L stopped growing [4].

Likewise, in the satellite navigation systems GPS and GLONASS, systematic errors in measuring distances were found. At the moments when the radial velocity of the satellite is zero, and according to ballistic theory, the signal velocity is exactly c, the error in measuring the distances is minimal [3, 4]. It is also discovered that for receivers in high latitudes, the error in measuring satellite distances is higher than in temperate and equatorial ones. From the point of view of ballistic theory, the reason for this is that radio signals in space reach a receiver located at high latitudes without re-emission (Fig. 1). After all, the concentration of ions in the Earth's plasmasphere (extending to 2 Earth radii) is $N = N_1 \sim 10^2$ cm^{-3}, whence, at the operating wavelength $\lambda \sim 1$ cm and the frequency of radio signals $f = c/\lambda \sim 30$ GHz, the re-emission length $l \approx (\lambda a_0 N)^{-1} \sim 356{,}000$ km, which is much longer than the total radio beam path $L \sim$ 20,000 km, and there is no re-emission. In the ionosphere, with an ion concentration of $N \sim 10^6$ cm^{-3} at an altitude of ~ 100 km, we obtain $l \sim 35$ km. However, the height of the ionosphere is ~ 100 km, and the main part of the path, radio signals in space move with an excess of speed c'. Accordingly, the error in measuring the distance L is maximum - about ten meters.

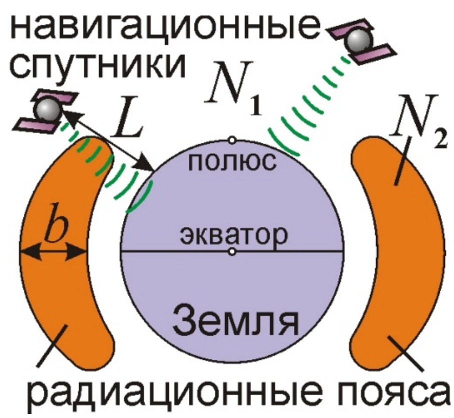

Fig. 1. Diagram of the Earth's radiation belts and GPS-radar.

For receivers in temperate and equatorial latitudes, the radio signal crosses the Earth's radiation belts (Fig. 1), where $N = N_2 \sim 10^7$ cm^{-3}, and the re-emission length $l \approx (\lambda a_0 N)^{-1} \sim 4$ km. That is, re-emission in belts with a thickness of $b \sim 1000$ km will have time to bring the speed of the radio signal c' to the nominal c: the signal will be re-emitted approximately half way L between the satellite and the receiver, and the errors will decrease significantly. Other radar measurements, for example at the Pioneer-10, -11, also support the Ritz theory [3, 4]. Thus, astronomy and space radar data confirm the dependence of the speed of light c' on the speed V of the source.

If this dependence is satisfied, the Ritz effect will be valid [1, 4]. According to him, a source moving from the observer with acceleration a (its projection onto the line of sight r is the radial acceleration $a_r > 0$), at each subsequent moment of time imparts to the light an ever lower speed, and the light fronts lag behind each other, increasing the wavelength λ to the value $\lambda' = \lambda(1 + La/c^2)$, reducing the frequency of light f and its concentration in space in proportion to the path L, thereby reducing its brightness W [1]. On the contrary, a source moving towards the observer with acceleration a (radial acceleration $a_r < 0$) gradually imparts to the light an ever greater speed, and the light fronts catch up with each other, reducing λ to $\lambda' = \lambda(1 - La/c^2)$, increasing the frequency f and concentrating light in space, increasing its brightness W. In the general case [1, 7], the change in the wavelength λ', the frequency of light f' and the recorded radiation power W' has the form, respectively,

$$\lambda' = \lambda(1 + La_r/c^2), f' = f/(1 + La_r/c^2), W' = W/(1 + La_r/c^2). \quad (1)$$

The effect is confirmed by the redshift of galaxies $\lambda' = \lambda(1 + LH/c)$, which grows in proportion to the distance L [1, 5]. And the measured value of acceleration in the visible regions of galaxies $a_r < 0$ gives the proportionality coefficient a_r/c close to the measured value of the Hubble constant H.

A number of physically variable stars also support the effect: Cepheids, supernovae, etc. According to La Rosa's hypothesis, these objects are ordinary binary stars that regularly change their brightness and spectrum due to variations in a_r when moving in orbit. In some cases, the conversion of the frequency of light is so great that the optical radiation of the star is transferred to the radio range (if f' is reduced by 10^3–10^7 times relative to f) or to the X-ray and gamma range (f' is increased by 10^3–10^7 relative to f). This explains the nature of the sources of radio, X-ray and gamma radiation: pulsars, busters, quasars, radio galaxies, Seyfert and exploding galaxies. According to Ritz's theory, they may turn out to be ordinary stars and galaxies [11], with the optical spectrum translated by the Ritz effect into other frequency ranges.

This casts doubt on Brecher's argument, who believed that the re-radiation effect would not affect the speed of X-rays and gamma rays, because for them $l >> L$ [9]. If the X-ray pulses of pulsars are ordinary light of stars, converted by the Ritz effect, then on the section of the path where the light has not yet been converted into the X-ray range, the re-emission occurs at a length of $l \sim 1$ light year. Brecher believed that the mechanism of generation of gamma radiation is synchrotron, and the velocity of its sources-electrons is $V > 0.1c$, from which, from the duration of dt gamma-ray bursts, he found $k = (c^2/2V)(dt/r) < 10^{-20}$ [12]. But the real mechanism of generation of gamma-ray bursts of bursters (GRB), as noted by Brecher, is not clear. And if gamma radiation is the optical radiation of stars, which increased the frequency according to the Ritz effect, then the true velocities V are orders of magnitude lower, and k is orders of magnitude higher and corresponds to the forecast of the ballistic theory.

The same is true for galaxies - sources of radio, gamma and X-rays. The gravitational force in the nuclei of galaxies creates centripetal accelerations a, and on the side of galaxies and stars close to the Earth, where $a_r > 0$, the light is converted by the Ritz effect into the radio range, and on the back side, where $a_r < 0$, the light is converted into the X-ray and gamma ranges ... Then ordinary galaxies are observed as quasars, radio galaxies, Seyfert galaxies, and for them the Ritz effect is confirmed by the comparability of the power of their radio emission, X-ray and gamma radiation with the typical power of optical radiation of galaxies. The role of the Ritz effect confirms the identification of these objects only from certain distances L, since the frequency shift according to the effect (1) is proportional to L, and light is transferred to other frequency ranges only from a distance $L \geq c^2/a$. For the same reason, the concentration and radio brightness of quasars and radio galaxies grows with distance [13] from the transfer of an increasingly large part of the light into the radio range.

For a long time it was not possible to explain the rapid variations in the brightness of quasars and radio galaxies. Within the framework of the Ritz effect, they can be explained by the fact that light, crossing the clouds of intergalactic gas, is re-emitted and is not further transformed. Depending on the concentration of ions N of the interstellar medium, l, the re-emission efficiency and the apparent brightness of the galaxy in the optical and radio ranges will change rapidly, without changing the true radiation power of the galaxy. The concentration of ions can change rapidly in a large volume, for example, when passing the front of ionizing radiation. As a result, light that has crossed such a volume of gas on Earth will seem to instantly change its brightness. In a similar way, the light of the stars seems to flicker rapidly, changing frequency, due to refraction and re-emission in the rapidly changing atmosphere of the Earth, although the true brightness of stars does not change over such a short time.

The contribution of re-emission is especially great in our Galaxy, where the concentration of atoms is higher: $N \sim 1$ cm^{-3}. This explains the spectrum of cosmic masers and emission nebulae around stars [14, 15]. Since the efficiency of absorption and scattering of light increases near the resonant frequencies of the line spectrum of atoms and molecules, the light of stars, which smoothly changes the frequency according to the Ritz effect (1) as it moves, will be effectively absorbed and re-emitted when the light frequency f' reaches these resonant frequencies f_{0i}. Indeed, the refractive index n grows rapidly near the resonance frequencies $f_{0i} = c/\lambda_i$:

$$n = \sqrt{1 + \sum_i \frac{S_i}{(f_{0i}^2 - f^2)}},$$

where S_i are the coefficients characterizing the concentrations, masses, charges and forces of oscillators in gas molecules. As a result, for these frequencies, the re-emission lengths $l_i = \lambda_i/2\pi(n-1)$ are reduced: light is effectively absorbed and re-emitted near these frequencies, and then the Ritz effect does not change the light frequency. Then a significant fraction of the star's radiation power is emitted in the form of bright emission lines at frequencies f_{0i}. This explains the existence of emission nebulae, including those around Cepheids and supernovae, for which the Ritz effect is especially strong [15]. In the case of converting optical radiation by effect (1) into the radio range, almost all the energy of the star is emitted in the form of radio lines of molecules OH, H_2, H_2O, etc. A similar effect is observed in cosmic masers, the nature of which has not yet been clarified [10]. The Ritz effect elementarily explains such a transformation of the frequency of light and why the effect is observed in red giants and variables such as Mira Ceti, in which the variability can just be explained by the Ritz effect. On the contrary, the radiation energy of stars, which increased the frequency according to the Ritz effect, can be highlighted in the form of X-ray and gamma lines of atoms and nuclei, which is actually observed [10].

The Ritz effect (1) can be tested in terrestrial laboratories at lengths $L \sim 1$ m, including for the purpose of converting laser pulses into X-ray, terahertz and microwave pulses [1, 5]. For this, laser radiation must pass through a bunch of electrons accelerated by an electric field E. In the case of conversion of light into the X-ray or THz range, it is sufficient to accelerate electrons in a field of strength $E = 10^6$–10^9 V/m [1].

The acceleration $a_c \sim c^2/L \sim 10^{17}$ m/s^2, sufficient to change the frequency of light by several times, can also be imparted to electrons by a magnetic field in synchrotrons, since at an orbital radius $R \sim 1$ m, the centripetal acceleration $a = V^2/R$ reaches $a_c \sim 10^{17}$ m/s^2 at an electron velocity $V \sim c$, attainable in synchrotrons (Fig. 2). Frequency conversion occurs after light is scattered by accelerating electrons, which become secondary radiation sources. In this case, the frequency and wavelength of light are converted according to formula (1), but the radial acceleration $a_r \neq a = V^2/R$ and the dependence $\lambda' = \lambda(1 + La/c^2)$ looks more complicated [7], since changes not only the direction of the velocity, but also the direction to the source A.

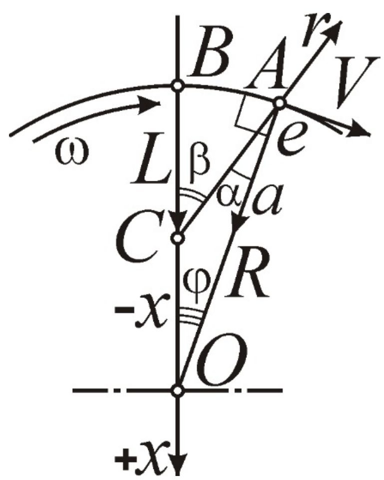

Fig. 2. Diagram of the movement of electrons in the orbit of the synchrotron and changes in their radial velocity for the receiver C.

Indeed, from Fig. 2, which shows the electron's orbit *e*, it can be seen that the radial velocity (the projection of the velocity *V* onto **r** - the line of sight *CA* from the receiver *C*) is equal to $V_r = V\sin\alpha$, where $\alpha = \beta - \varphi$. With small angles β and φ, based on a common base *AB*, we obtain $\beta \approx \varphi OB/CB = \varphi R/L$. Hence $V_r = V\sin[\varphi(R - L)/L] \approx -V\varphi x/L$, where $x = (L - R)$ is the displacement of the receiver *C* from the center of the electron orbit *O*. Radial acceleration $a_r = dV_r/dt \approx -V\omega x/L$, where $\omega = d\varphi/dt$ is the angular velocity of the electron, whence

$$f' = f/(1 + La_r/c^2) = f/(1 - xV^2/Rc^2). \quad (2)$$

In the limiting case ($x = 0$), if the receiver *C* is in the center of the orbit *O*, $f' = f$.

In another limiting case, if the receiver lies near the line of flight of the electron ($L = 0$, $x = -R$), and in the immediate vicinity of point *B* this motion can be considered rectilinear, we get $f' = f/(1 + V^2/c^2)$. In fact, the Ritz effect turns into an expression of the transverse Doppler effect, but doubled in magnitude. For rectilinear motion, the frequency does not change from variations in the velocity *V*, but from a change in the direction of *CA* to the source. Earlier, the same result was obtained within the framework of the classical Doppler effect in the receiver frame of reference [16, 17]. This shows the partial equivalence of the Doppler and Ritz effects, in some cases passing one into another, depending on the frame of reference [15].

Finally, in the third limiting case, when the distance $L >> R$ ($x \approx L$), one can use the classical formula (1), taking $a_r \approx a = V^2/R$, since when the source moves, the direction towards it practically does not change, due to its distance ... It is this case that is realized for stars and galaxies, where the orbital radii *R* are vanishingly small in comparison with the distances *L* to them. The most general case of conversion of the frequency of light for different versions of the source and receiver movement is considered in the work of V.P. Zolotukhin [17]. Note that, in Ritz's theory, the properties of synchrotron radiation (directional pattern and spectrum) correspond to the experiments and conclusions of the STR if we take into account that in the classical case for ultrarelativistic electrons the velocity is $V \approx \gamma c$ [15]. This also explains the dependence of the electron radiation power *W* on the γ factor: $W \sim a^2 = V^4/R^2 = \gamma^4 c^4/R^2$, in agreement with the experimental results.

With the accelerations of light sources attainable in the laboratory, the change in the wavelength by the Ritz effect is so small that it can be recorded only by the Mössbauer effect. Indeed, the effect was recorded, say, for a gamma-ray source and absorber on a rotor rotating with an angular velocity ω [18]. So, when placing the source on the rim of the rotor, and the absorber - in the center *O*, the frequency $f' = f$, according to (2). However, the wavelength of γ-radiation at the absorber $\lambda' = c'/f'$ is transformed in comparison with the initial $\lambda = c/f$, since the speed of light recorded at the absorber is $c' \neq c$. At the absorber speed $V = \omega R$, we obtain

$$c' = \sqrt{c^2 - V^2} = \sqrt{c^2 - \omega^2 R^2}, \tag{3}$$

whence $\lambda' = c'/f \approx \lambda(1 + \omega^2 R^2/2c^2) \approx \lambda(1 + V^2/2c^2)$, which coincides with the results of experiments and general theory of relativity and with the conclusion of STR about the magnitude of the transverse Doppler effect [15, 18] ...

In general, if source 1 is at a distance R_1 from the center of the rotor O, and receiver 2 is at R_2 (Fig. 3), the recorded frequency does not change ($f' = f$, since distance 1-2 is unchanged), the speed source $V_1 = \omega R_1$, and receiver $V_2 = \omega R_2$. From (3) in the laboratory frame of reference, the speed of light c' going in the direction of the absorber,

$$c' = \sqrt{c^2 - V_1^2} = \sqrt{c^2 - \omega^2 R_1^2}\,.$$

And for the speed of light c'' entering the absorber, in its frame of reference, we obtain from the parallelogram of velocities (Fig. 3)

$$c'' = \sqrt{c'^2 + V_2^2} = \sqrt{c^2 - \omega^2 R_1^2 + \omega^2 R_2^2} \approx c(1 + \omega^2 (R_2^2 - R_1^2)/2c^2)$$

In this case, $\Delta\lambda = \lambda'' - \lambda = c''/f - c/f = \lambda\omega^2(R_2^2 - R_1^2)/2c^2$ and $\Delta\lambda/\lambda = \omega^2(R_2^2 - R_1^2)/2c^2$, which coincides with the results of all known experiments using the Mössbauer effect [15, 18].

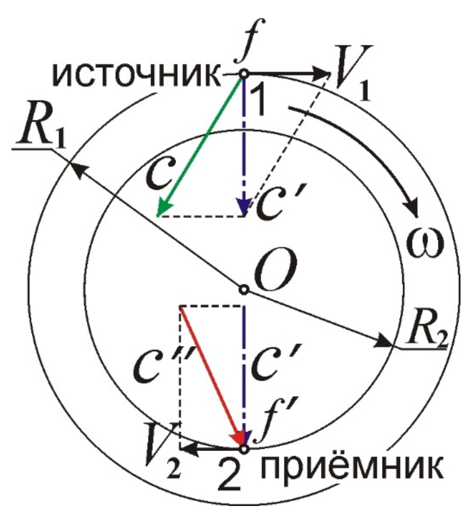

Fig. 3. Scheme of changing the speed of light and wavelength on the rotor according to the Mössbauer effect.

Thus, the conclusions of the ballistic theory correspond to the results of astronomical observations and laboratory experiments. For an unambiguous test of the ballistic theory, one should directly measure the speed of light c' from a moving source and the transformation of the frequency of light by the Ritz effect when light is scattered by charged particles moving with acceleration.

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