International Journal of Advanced Research in Physical Science (IJARPS)
Volume 1, Issue 2, June 2014, PP 8-13
ISSN 2349-7874 (Print) & ISSN 2349-7882 (Online)
www.arcjournals.org

Wave Effects Caused by Mechanical Motion

Branko Mišković

Independent
Novi Sad, Serbia
aham.brami@gmail.com

Abstract: *Instead of various explanations of particular wave effects, they are here unified into the same theory. Going from the simpler, towards more complex effects, each following relies on the preceding explanation. Not only that these explanations are thus more understandable and convincing, but their similarities and distinctions are compared through a few classification principles. Though physical essences of particular waves slightly influence the exposition, some artificial exceptions are here overcome and finally refuted.*

Keywords: *Doppler, Mach, Cherenkov, Fizeau, Michelson, Sagnac.*

1. Introduction

Unlike the ideally homogeneous medium, each its structural non-homogeneity causes partial reflection and/or refraction of the propagated waves. In the case of the sharp discontinuity, the two sides are treated as the two distinct media, separated by the boundary surface. Starting by the waves initialized in the former medium, these considerations are reduced to mutual relations of the direct and reflected wave beams. One or more *reflectors* may be found on the beam path, from its *emitter* – up to the signal *detector*. If reflective surfaces be perpendicular to the direct beam, the reverse one propagates in the opposite direction of the same path.

At motion of one of the mentioned types of technical elements – with respect to the medium of propagation – there appear some variations of the physical parameters of the propagated wave and/or – of the received signal. During the development of physics, from one to another opportunity, such particular cases were registered, as the separate wave effects. Irrespective of their full or partial explanation, these effects are usually applied in technical practice. The arrangement of the science and respective education demand their convenient unification into one theory. Possible particular inconsistencies or mistakes would be thus also overcome.

Such a problematic situation aroused at introduction of special relativity. Namely, any medium of light propagation could not be fitted into the postulates of this speculative theory. Formerly understood vacuum medium of EM waves is denied and proclaimed as the misconception of the classical physics. Moreover, by the concept of the dual light nature, physical essence of EM waves is totally mystified. Though the vacuum medium was thus expelled from the science, the influence of matter, as the cruder medium layer, could not be neglected. With artificial formal simplifications, respective approximate or un-testable equations were then formulated.

2. Possible Classifications

Irrespective of their separate registrations and distinct explanations, the wave effects can be classified according to a few division principles: 1. a moving technical element, 2. the form of its motion, 3. the variable and invariant quantities and 4. some chronological order of their registration. Each of these principles emphasizes the similarities and distinctions in the pairs of the effects, enabling thus their exhaustive comparison.

1. The technical details of measuring equipment are plunged into the natural medium of the wave propagation. Some of these details can be moved in space. The continuous and

conditionally resting medium, as the wave substratum, represents the most natural frame of reference. Possible its own motion must be referred to some implicit, external local frame. Separate motions of the particular elements, or of the equipment in the whole, determine the parameters of the emitted and received signals, including the propagating wave. The complete or fractional motion of the medium is also considered.

2. We here will restrict to the uniform, mainly – rectilinear, motion of the elements, in the direction of the wave motion, along the line generator-receiver, or at least in very small angle with respect to this line. Approximately or in the limiting process, the last case is reduced to the circular motion and propagation, along the circle perimeter. In one particular case, the longitudinal and transverse wave beams are compared. Out of the frame of the treated effects, the accelerated motion may be also considered.

3. As the variable and invariant physical quantities, the known wave parameters are here observed: oscillating period (τ) – as the time of an oscillating cycle, phase $(\varphi = t/\tau)$ – the observed time expressed in the cycles, frequency $(f = 1/\tau)$ – the cycle number in a second, speed of wave propagation (c) and wave length $(\lambda = \mathrm{c}\tau)$ – the path taken for a cycle. The oscillating process, expressed by the phase, is copied by the wave lengths along the path of propagation. The speed of propagation, determined by the medium features (elasticity and density), is naturally referred to the medium itself.

4. The historical development of this scientific topic, expressed by the years of the effect registrations and denoted by their investigators, just accords to the logic of exposition. Though this need not be ever the case in the science, the simplest effect was primarily registered, described and explained. It was then successively followed by all the other effects, each succeeding for a little complicated than the preceding. The names of the investigators are here followed by the years of investigations: Doppler – 1842, Fizeau – 1851, Michelson – 1881/87 and Sagnac – 1913. This fact enables the logical exposition, so that the explanations sequentially and gradually develop.

3. Simple Doppler's Effects

Wave propagation through a medium carries the alternating signal, from the *emitter* to the *receiver*. However, its native frequency can be changed by motion of each of these two technical elements. Though the two final results may be similar in the range of their usual measurements, their wider functions and respective physical processes are essentially distinct. In the aim to cover these distinctions by the sequence of following explanations, we thus distinguish a few Doppler's effects.

Let us start by the moving emitter, as the wave generator. By its motion at a speed (u) – in the direction of propagation, each following signal phase starts from the point a little displaced forward, with respect to the former phase start. This fact causes some squeeze of the wave along the path, with respective diminution of the wave lengths. In fact, the path covered by the emitter is thus subtracted from that covered by the wave. This simple logic finally determines the new wave length:

$$\lambda' = \mathrm{c}\tau - u\tau = (\mathrm{c} - u)\tau = (\mathrm{c} - u)/f \qquad (1)$$

The opposite motion stretches the wave and its length. At least in homogeneous non-dispersive media, the speed of propagation is invariant. The frequency is inversely proportional to the wave length, with their invariant product (c):

$$f'(\mathrm{c} - u)/f = \mathrm{c}, \quad f'/f = \mathrm{c}/(\mathrm{c} - u) \qquad (2)$$

At the positive speed, the new frequency is greater, and vice versa. If this speed tends to c, the emitter follows its wave in space, and the frequency tends to infinity. The wall of the dense energy is thus formed in the emitter front, obstructing its acceleration. By sufficient force, however, the emitter can break this wall.

The breaking of (Mach's) sound wall is followed by a shot. Though the speed of light cannot be reached, Cherenkov realized the light wall break. Instead of the particle acceleration, the effect arises at sudden diminution of the speed of propagation, on the boundary of two media. Of course, the particle speed must be between the speeds of propagation in the sparser and denser media. The negative speed difference (2b) is manifest by the light, discharging the kinetic energy excess.

Though the detector speed (v) does not influence the propagating wave, it changes the received signal frequency. This effect results from the new mutual speed by which the wave approaches the detector. The ratio of the two frequencies just accords to the ratio of the new and old mutual (wave-detector) speeds.

$$f''/f' = (\mathrm{c}-v)/\mathrm{c} \tag{3}$$

At $v > \mathrm{c}$ the detector escapes the wave signal, but the opposite motion causes the linear frequency increase, without limitation. Though distinct in general, the corrections (2) and (3) are similar at small speeds of the elements.

4. COMPLEX DOPPLER'S EFFECTS

At simultaneous motion of more elements, respective simple effects are combined. In the case of the emitter and detector, the functions (2) and (3) mutually multiply, thus expressing the ratio of the received and emitted signals:

$$\frac{f''}{f} = \frac{f''}{f'}\frac{f'}{f} = \frac{\mathrm{c}-v}{\mathrm{c}-u} \tag{4}$$

Nevertheless, the wave parameters on the path depend only on the emitter speed. At the same speed of these elements, the two effects finally cancel each other. The effect of the wave squeezing is finally annulled by its slower receiving. At the common speed $v = u = \mathrm{c}$, the equation (4) is reduced to the undetermined ratio $0/0$: with the wave wall formed on the emitter, the detector escapes the signal.

Doppler's radar represents these two joined elements. It sends the waves through the space, and receives the signals reflected from the objects. At motion of this device, (2) and (3) are multiplied again, but with the opposite signs of the common speed with respect to the direction of reverse wave courses:

$$\frac{f''}{f} = \frac{f''}{f'}\frac{f'}{f} = \frac{\mathrm{c}+u}{\mathrm{c}-u} \tag{5}$$

Unlike mutually compensated effects (4), the increased denominator and decreased nominator give similar effects. At the positive speed, the frequency increases twice: by the squeezing of direct wave, and the rapid signal receiving.

The reflecting object, as the third element, may also move, e.g. – at a speed v. It thus plays the roles of the receiver of the direct, and transmitter – of reflected waves. The effect (5) is thus repeated, but with the opposite speed signs, as if $v = -u$. At the speed $v = \mathrm{c}$, the object escapes the wave and its reflection, but at $v = -\mathrm{c}$ it reflects the doubled frequency, with the wave wall of the reflected wave.

At the simultaneous motion of the radar and its object, as the opposite elements, the respective effects in the form (5) are mutually multiplied:

$$\frac{f'''}{f} = \frac{f'''}{f''}\frac{f''}{f} = \frac{\mathrm{c}-v}{\mathrm{c}+v}\,\frac{\mathrm{c}+u}{\mathrm{c}-u} = \frac{\mathrm{c}(\mathrm{c}+u-v)-vu}{\mathrm{c}(\mathrm{c}-u+v)-vu} \cong \frac{\mathrm{c}-v'}{\mathrm{c}+v'} \tag{6}$$

Of course, the reflector plays its two opposite roles. There is finally some simplification in (6). Neglecting the product uv of the two relatively small speeds, the mutual speed $v' = v - u$ – between the object and radar, is thus used.

In the case of the common motion $(u = v)$ of the two elements, the two pairs of effects mutually annul. Of course, this is the final ratio of the received and emitted signals, with the squeezed direct, and stretched reverse waves.

5. RELATIVISTIC EQUATION

Under imperative of a direct empirical verification, special relativity does not accept the wave propagation in the medium, but considers only the formal ratios of the received and emitted frequencies. Apart from the denied medium, the temporal comparison of the distant events is avoided, on the pretext of the insolvable empirical limitations. By artificial equaling in law of the radar and its object, the symmetry of the two effects (7a) is unfoundedly postulated. The geometric average of the two apparently symmetric processes is finally applied (7b) – to the simplified result (6):

$$\left(\frac{f_r}{f}\right)^2 = \frac{f'''}{f''}\frac{f''}{f}, \quad \frac{f_r}{f} = \sqrt{\frac{c - v'}{c + v'}} \tag{7}$$

At relatively small mechanical speeds, the square root of the value being close to unit is difficult to distinguish from this value itself. Moreover, the particular four effects – in the beginning of (6), can be identified by the additional detectors placed on the wave path and/or moving object, without relativistic mystifications.

6. FIZEAU EFFECT

Possible motion of the complete medium, as the physical substratum and the frame of wave propagation, is equivalent with the opposite motion of the technical equipment (6), at $u = v$. Depending on the motion course with respect to the direct and reverse waves, there appears the squeeze or stretch of the wave lengths. Nevertheless, the received one equals to emitted frequency, as if being invariant. Instead of it, some of the variable parameters, as the phase, may be observed.

In the *resting* or *moving* medium, the phase represents the ratio of a distance covered and the wave length: $\varphi = d/\lambda$ or $\varphi' = d/\lambda'$. The final phase variation can be obtained by comparison of such two phases. By convenient technical solution, Fizeau compared the phases of the two signals passing through the same running water, but in the opposite courses, with superposition of their effects (9):

$$\varphi' = \frac{d}{\lambda'} = \frac{fd}{c - v}, \quad \varphi'' = \frac{d}{\lambda''} = \frac{fd}{c + v}; \tag{8}$$

$$\delta\varphi = \varphi' - \varphi'' = \frac{2fdv}{c^2 - v^2} \cong \frac{2fdv}{c^2}. \tag{9}$$

The opposite speed signs in (8) concern the two opposite beams. Neglecting the small speed square, (9) is the linear function of v. However, the measurement gave less than a half of this value. The result between the two extreme expectations – resting frame and its full draw by matter – confused the physicist so that they rather forgot it. Our explanation relies on the moving media theory [1].

7. NEW EXPLANATION

The above consideration understood the motion of the complete medium, consisting of the vacuum and material layers. The corrective factor in dielectric media (j) equals to the ratio of respective two electric fields:

$$\mathrm{j} = \frac{\mathbf{P}}{\mathbf{D}} = \frac{\mathbf{D}-\varepsilon_o\mathbf{E}}{\mathbf{D}} = 1-\frac{1}{\varepsilon_r} \tag{10}$$

Here $\mathbf{P}$ is the polarization of matter, and $\mathbf{D}=\mathbf{P}+\varepsilon_o\mathbf{E}$ – of the total medium, including vacuum. The corrective factor is thus the function of relative electric constant. In water, as the dielectric medium, the refraction factor, electric constants and corrective factor are: $n=1.33=4/3$, $\varepsilon_r = n^2 = 16/9$, $j=1-9/16=7/16$.

8. Michelson's Effect

The resting vacuum medium at Fizeau effect was implicitly connected to the ground. In the absence of the complete explanation, this obvious fact was not noticed at all. There aroused the question of its own dependence on the Earth and its orbital motion. The former such experiment also used Fizeau method, but instead of the medium, the technical device was moving with Earth. Instead of the medium draw by the Earth, it was expected to be at rest, irrespective of the Earth motion.

The measurement consists in the two light beams, sent from the common point, into two perpendicular directions, *longitudinal* and *transverse*, with respect to the orbital Earth motion. After reflections from equally distant mirrors, their phases are compared at the same point. The phases of the *direct* and *reverse* paths of the longitudinal beam are expressed by (8). There just follows their sum:

$$\varphi_l = \varphi' + \varphi'' = \frac{2fd\mathrm{c}}{\mathrm{c}^2 - v^2} = \frac{2fd}{\mathrm{c}g^2}, \quad g^2 = 1-(v/\mathrm{c})^2 \tag{11}$$

The transverse beam phase was considered as invariant, thus used in the role of the comparative phase. However, no phase difference was noticed.

This 'negative' result stimulated some further considerations. Thus Lorentz noticed that the transverse beam phase was also variable. When the orbital motion covers the basis of the triangle (vt), the light covers its two legs, in the summary length of $(\mathrm{c}t)$. Pythagoras theorem applied to the triangle half gives:

$$\left(\frac{\mathrm{c}t}{2}\right)^2 - \left(\frac{vt}{2}\right)^2 = d^2, \quad t = \frac{2d}{\mathrm{c}g}; \tag{12}$$

$$\varphi_t = ft = \frac{2fd}{\mathrm{c}g}, \quad \delta\varphi = \varphi_l - \varphi_t = \frac{2fd}{\mathrm{c}}\frac{1-g}{g^2} \tag{13}$$

The transverse beam phase is obtained in the value (13a). With respect to some its distinction from the longitudinal phase, there is their difference (13b). Irrespective of the new explanation and further advanced device, the result again equals to zero. The additional device improvements during 20th century gave some phase difference, a few percents of the expected value. Not only that its speculative explanation, in the form of special relativity [2], was already widely accepted, but nobody had any alternative explanation. With respect to above explanation, the stratification of vacuum medium, amongst nearby celestial bodies [3], may be proposed.

9. Sagnac Effect

Fizeau effect is here applied to the perimeter of a polygon or circle, rotating in its own plain. Two beams sent in the opposite direction meet each other at the starting point. The phase difference depends on the peripheral speed, in accord to (9). This device is applied to registration of angular speeds on airplanes.

In fact, the explanation of this effect is in essence nothing new. However, not only that this device by itself represents very effective technical solution, but it obviously and convincingly denies the invariance of the relative light propagation, as the main result or even – postulate of special relativity. The phase difference just results from the two different speeds of propagation with respect to the rotating perimeter. In other words, these two speeds are in fact equal in the medium of propagation, but the mechanical rotation causes the effects already described above.

The relativistic objection, of restriction of special relativity to rectilinear motion, may be expected. However, this restriction was introduced in the classical mechanics, where centrifugal forces disturb relativistic logic. Even if we let the action of such the forces on light, the two beams will be thus equally influenced.

10. CONCLUSION

A number of mutually similar wave effects are sequentially explained, by reasonable classical logic. These explanations are sufficient and complete, without any use of the relativistic bases. Moreover, they convincingly deny the relativistic principles. In fact, all the explanations are founded on the mutual light-device speed, with the invariant speed of propagation through the medium. The explanations concern all the types of waves, without exception of light or EM waves in general.

REFERENCES

[1] Mišković B, Systematic Foundation of EM Theory, International Journal of Electromagnetics and Applications, Vol. 4, No. 1, 2014, http://article.sapub.org/10.5923/j.ijea.20140401.02.

[2] Mišković B, Boundary Questions of EM Theory, International Journal of Theoretical and Mathematical Physics, Vol. 4, No. 3, 2014, http://article.sapub.org/10.5923/j.ijtmp.20140403.01.

[3] Mišković B, Medium of Natural Phenomena, International Journal of Theoretical and Mathematical Physics, Vol. 4, No. 4, 2014.

AUTHOR'S BIOGRAPHY

In the period 1970-75 studied Technical Physics at University of Beograd, ex-Yugoslavia. Being unsatisfied by engineering practice, tried to compose a consistent text-book on EM theory. Owing to a sequence of unexpected difficulties, this job has been prolonged up to 30 years. Not only that EM theory is now finally considerably elaborated, but its new consequences call in question the majority of modern physics. The above article is a typical example.