SOME FEW SPECIFICATIONS ABOUT THE DOPPLER EFFECT TO THE ELECTROMAGNETIC WAVES

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*This paper presents, shortly, a new and original relation to calculate the Doppler Effect exactly. This relation, (8) (18) or (***20***), is the exact form and the classical expression, (10), is an approximate relation. The classical approximate relation (10 but in the form 15) can't foresee the Doppler Effect for the case when the angle* $\varphi=90^0$. *For this reason it was introduced the relativity effect, where the period* T_0 *take the form* T_0/α. *Before utilize the theory of relativity it's strongly necessary to test the relation (8), (18) or (**20**), and the particular form (14) (for the angle* $\varphi=90^0$*), for testing the Doppler exact effect without the relativity theory. The Doppler Effect represents the frequency variation of the waves, received by an observer which is drawing (coming), respectively it's removing (going), from a wave spring (source). If a bright spring is drawing to an observer, the frequency of waves received by the observer is bigger than the emitted frequency of source, such that the respective spectral lines are moving to violet. On the contrary, if the light source is removing from the observer, the spectral lines are moving to red. One proposes to study the Doppler Effect for the light waves, generally for the electromagnetic waves.* ***The paper proposes for the Doppler Effect the relation 20 which can replace the classical form 10.***

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Introduction

The Doppler Effect represents the frequency variation of the waves, received by an observer which is drawing (coming), respectively it's removing (going), from a wave spring (source). If a bright spring is drawing to an observer, the frequency of waves received by the observer is bigger than the emitted frequency of source, such that the respective spectral lines are moving to violet. On the contrary, if the light source is removing from the observer, the spectral lines are moving to red. One proposes to study the Doppler Effect for the light waves, generally for the electromagnetic waves.

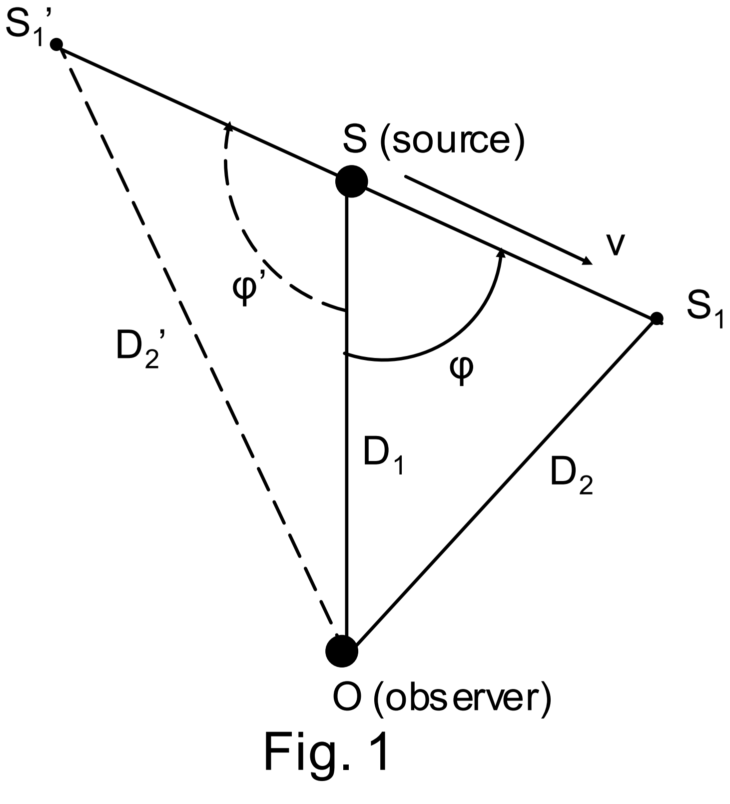

Fig. 1

The new relations

We wish to calculate the period (T [s]) of the waves received by an observer O (figure 1) from a waves source S, which is moving in relation with the observer, on the direction SS_1 with the relative speed v [m/s].

T_0 [s] is the period of waves emitted by the source S.

At the moment t_0 [s], determinate by the observer O, from the source S bend a bright wave; this wave traverse the distance D_1=SO [m] and arrive in O at the moment t_1 [s].

$$t_1 = t_0 + \frac{D_1}{c} \tag{1}$$

where c is the light speed in vacuum: $c \cong 3.10^8$ [m/s].

After a T_0 period, from the source S (arrived now in S_1), from the source S_1 starts a second wave. The distance SS_1 [m] is:

$$SS_1 = v.T_0 \tag{2}$$

The observer O, receive the second waves at the moment t_2 [s]:

$$t_2 = t_0 + T_0 + \frac{D_2}{c} \tag{3}$$

The period T is equal with the difference between the two moments:

$$T = t_2 - t_1 = T_0 + \frac{D_2 - D_1}{c} \tag{4}$$

The angle φ [rad] between the two vectors, SS_1 and SO is knew and the distance D_1=SO is knew too.

With the Cosinus theorem in the certain triangle SOS_1 one obtains the distance D_2 [m]:

$$D_2 = \sqrt{D_1^2 + SS_1^2 - 2.D_1.SS_1.\cos\varphi} \tag{5}$$

With SS_1 from (2) the relation (5), become the expression (6):

$$D_2 = \sqrt{D_1^2 + v^2.T_0^2 - 2.D_1.v.T_0.\cos\varphi} \tag{6}$$

With the expression (6) in relation (4) one obtains:

$$T = T_0 + \frac{\sqrt{D_1^2 + v^2T_0^2 - 2D_1vT_0\cos\varphi} - D_1}{c} \tag{7}$$

The relation (7) can be writhed in the form (8):

$$T = T_0(1 + \beta\frac{v.T_0 - 2.D_1.\cos\varphi}{\sqrt{D_1^2 + v^2T_0^2 - 2D_1vT_0\cos\varphi} + D_1}) \tag{8}$$

where β is the ratio between the two speed, v and c:

$$\beta = \frac{v}{c} \tag{9}$$

Conclusion

In this paper one proposes to exchange the classical relation (10) (see [1], p. 114) with the new relations (8), (18) and (20).

$$T = T_0.(1 \pm \beta.\cos\varphi) \tag{10}$$

The classical relation (10) is very simply, but it's an approximate relation. The expression (8) is more difficult but it's a very exact relation.

Some aspects

a) When the source S is removing from the observer, the angle φ (see the figure 1) take the values (φ') comprised between 90^0 and 180^0, cosφ become negative, the numerator of expression (8) become positive and the period of observer O (T) it'll be always bigger than T_0 (the period of source): $T>T_0$ and $\nu<\nu_0$. (spectral lines are red)
When the source S is drawing to the observer, the angle $\varphi\in[0^0,90^0)$ and $\cos\varphi>0$. In this case one analyzes (11) the numerator of expression (8) and we can have two case (b and c):

$$N = v.T_0 - 2.D_1.\cos\varphi \tag{11}$$

b) If N<0, then $v.T_0<2.D_1.\cos\varphi$ or

$$\cos\varphi > \frac{v.T_0}{2.D_1} \tag{12}$$

and $T<T_0$, or $\nu>\nu_0$ (spectral lines are violet)

c) If N>0, then

$$\cos\varphi < \frac{v.T_0}{2.D_1} \tag{13}$$

and $T>T_0$, or $\nu<\nu_0$ (spectral lines are red)

This case it wasn‘t knew by the classical expression (10).

d) The most interesting case is then the angle $\varphi=90^0$, and $\cos\varphi=0$, when the source is moving perpendicular at the axle SO (see the figure 2). In this case the relation (8), become the expression (14):

$$T = T_0 (1 + \frac{\beta . v . T_0}{\sqrt{D_1^2 + v^2 . T_0^2} + D_1}) \qquad (14)$$

$T > T_0$ and $\nu < \nu_0$. (spectral lines are red)

This fact can't be seen by the classical relation (10) which (for the $\varphi=90^0$), takes the form (15):

$$T = T_0 \qquad (15)$$

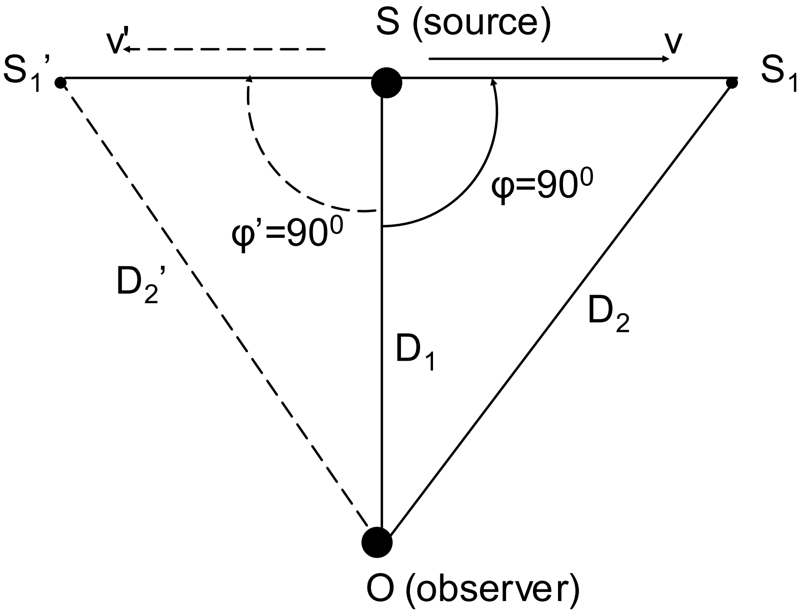

Fig. 2

The classical approximate relation (10, form 15) can't foresee the Doppler Effect for this case, but the effect virtually exist, and for this reason on was introduced the relativity effect (or the Lorentz transformation), where the period T_0 takes the form T_0 / α (see [1]), and the relation (15) take the form (16):

$$T = \frac{T_0}{\alpha} \tag{16}$$

where α is:

$$\alpha = \sqrt{1-\beta^2} \tag{17}$$

If v<c, the expression $\sqrt{D_1^2 + v^2 \cdot T_0^2 - 2 \cdot D_1 \cdot v \cdot T_0 \cdot \cos\varphi} \rightarrow$D and the relation (8) can be approximate by the expression (18):

$$\frac{\gamma_0}{\gamma} = \frac{T}{T_0} = 1 - \beta \cdot \cos\varphi + \beta \cdot \frac{v \cdot T_0}{2 \cdot D_1} \tag{18}$$

The distance D (D_1) can take different values for the same frequency γ_0(One can’t determine D from 8 or 18; D is indeterminate. Practically, the frequency γ is a real function of γ_0 and β; γ is a function of γ_0, T_0, or $\lambda_0 = c \cdot T_0$; The distance D can’t takes any value; It must be a multiple of λ_0). The relation (18), take the form (19) for a quantum distance (D_1=n.c.T_0), and (20) when n takes the basic value one (1) (one utilize just the basic frequency for n=1, see the final relation 20):

$$\frac{\gamma_0}{\gamma} = \frac{T}{T_0} = 1 - \beta \cdot \cos\varphi + \frac{1}{2} \cdot \beta^2 \cdot \frac{1}{n} \tag{19}$$

$$\frac{\gamma_0}{\gamma} = \frac{T}{T_0} = 1 - \beta \cdot \cos\varphi + \frac{1}{2} \cdot \beta^2 \tag{20}$$

First, the approximate relation (20) can be utilized to determine the period T when one knew the source period T_0 and the source velocity, v ($\beta = \frac{v}{c}$).

Second, if one knows the two frequencies (γ, γ_0), one can determine the source velocity v in relation of the observer (β and v=β.c), with the new relation (20) or more rapidly with the classical (10).

Bibliography

[1]. BĂRBULESCU, N., “*Bazele fizice ale relativităţii Einsteiniene*”. Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1979, p. 142-148.