

Optics. - The Doppler phenomenon and the ballistic principle on
speed of light (answer to a Note by Prof. W. De Sitter).

Note of the Correspondence M. La Rosa (¹).

In the latest issue of the "Bulletin of the Astronomical Institutes of the Netherlands (²)" Prof. De Sitter takes care of my astronomical tests (³) in favor of the applicability to light, of the speed composition rule of classical mechanics and of the general explanation of the phenomenon of the "variability of the stars" which I deduced.

While acknowledging the accuracy and novelty of my deductions, he believes that they bring no argument in favor, but that they add one again against the ballistics hypothesis.

He observes, that if the *variability* of the stars were due to the effect predicted by me - i.e., dependent changes in light intensity by the periodic motion of the source - should be accompanied by displacements of the spectral lines (due to the Doppler effect). enormously larger of those measured up to now, because *photometric effect* (as I will call that one predicted by me) and the Doppler effect would depend *similarly* on one *same size*.

If this were correct, it is natural that the ballistics hypothesis would be in full swing contradiction with the results of astronomical observations, which show us shifts of lines that are always very small (fraction of the Angstrom unit) and changes in intensity that can reach the ratio of 60,000:1; which are those corresponding to jumps of about 10 steps in the scale of apparent size of the stars.

Therefore, it falls to me the dutiful task of examining the basis of the claim of the prof. De Sitter, and to look for those elements of judgment which serve to comfort or contest it. The essential key to reasoning of De Sitter, is expressed in the following lines:

"If the waves emitted by the source during the time interval dt reach the observer during the intet time $dt' = dt (1 +q)$ then the observer will ascribe to the mobile star, on the one hand, the intensity $i = i_0/1 +q$, if I am the *true* intensity, and

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(²) Vol. II, no. 57 p. 121, May 31, 1924.

(³) Rend. Acc. Lincei, vol. XXIII, pag. 119 (1923); Zeitsch. fur phys., Bd. XX (1924); for a more extensive report, Nuovo Cimento, new series, ann. I, no. 1st, 1924.

on the other hand, the radial velocity will ascribe to it $v = cq$ in accordance with the Doppler principle. . . Both effects therefore, they depend on the same factor q "⁽¹⁾.

Now here, one important question immediately arises: is it possible to calculate the measurement of the Doppler effect on the ground of ballistic theory, using the simple ratio dt'/dt , used by the classical theory (and that of relativity)?

In other words, the profound has no influence on how to calculate this effect change that brings with it the ballistic hypothesis, for the fact of variability of the speed of light that it puts as a foundation?

Now that there must be an influence it is easy to guess.

In the case of the classical theory the link between the starting time Δt of a certain group of waves from the source, and the time $\Delta t'$ of arrival at the observer, cannot contain other elements, apart from the relative speed of the source and of the observer, due to the supposed *constancy of the light speed*. In the case instead of the ballistic hypothesis, the same bond must contain the successive changes of this speed, and the distance d between source and observer.

Therefore, it is necessary that exactly the part that these are new is studied factors - i.e., the law of variation of the propagation speed of the light, and distance d - can have on the Doppler effect as it was I have already analyzed the part that they have on the photometric effect.

I will therefore redo from the foundations the reasoning that leads to predict the Doppler effect and to establish its laws, both in classical theory and in the ballistics one; and I will go the purely kinematic route, not just because more elementary and therefore clearer and easier, but because – it alone – does unless the aid of extraneous hypotheses, more or less artificial.

Let's start with the classic:

Suppose the source has radial velocity v with respect to the observer. If n is the number of waves emitted in one second by the source, then along the visual ray the n waves are distributed over one length $c+v$ (v speed of removal of the source from the observer) instead of on the length c , and however c being the speed of propagation of the waves, the observer receives in one second as many waves as there are over a length c , i.e., a number n' given by the relation:

$$\frac{n}{n'} = \frac{c}{c-v}$$

⁽¹⁾ The same reasoning had been made by Dr. Zurhellen, how kindly to me had made) know the prof. Kobold, to whom I offer here my warmest thanks (Zurhellen A. N., vol. 198, p. 4739, 1914).

which, within the 1st order of ratio v/c , gives:

$$(1) \quad n' = n \left(1 - \frac{v}{c} \right).$$

We can also say that the observer receives in one second the waves that the source emits in the time $c/(c+v)$, that is, with the usual approximation over time, $(1-v/c)$.

But this reference *to time*, rather than to the number of waves, is not essential: it is justified only by the *constancy* hypothesis of the speed wave propagation; because this alone can guarantee us the *intact conservation of the order of succession*, in time and space, of the waves traveling; which is an indispensable condition required and to be able to pass from the condition relating to the number of waves, to that relating to the times.

This hypothesis *of the intact conservation of the sequence of the waves is*, therefore, *implicitly admitted* when it is assumed as a *general norm* evaluation of the Doppler effect, the relationship between the two times (finite or infinitesimal) of departure and arrival of a certain number of waves.

Now we come to the *ballistics theory*.

If n is the number of waves given by the source in one second (not necessary declare that it is no longer possible to speak here of "waves" in the sense itself where we talk about it in the elastic theory, but we should talk about impulses bullets, etc. ...) and if there is the speed with which they are expelled from source, while this recedes (with respect to the observer) with the speed v ⁽¹⁾, the n waves will always be distributed over an independent length c from v , and will rush towards the observer with the speed $c - v$. This, therefore, can receive, in one second, as many as there are on the length $c - v$, and therefore a number n' given by:

$$(1') \quad n' = n \frac{c - v}{c} = n \left(1 - \frac{v}{c} \right)$$

result that *coincides* (within the usual order) *with the same expected one in the classical theory*.

The ballistic hypothesis therefore keeps the law of dependence unchanged of the Doppler effect from the observation conditions; that is, it suits *his independence* from the relationship between source velocity and time, and from

⁽¹⁾ Given the extreme smallness of the *periods* of the luminous vibrations with respect to the period of rotation of the celestial body (whatever it is) one can always make the hypothesis that in the time in which the n waves considered are emitted - and for example in one second - the radial velocity of the celestial body does not change.

distance between source and observer; maintains the same link ⁽¹⁾ between the n and v . But the transition from the ratio of numbers n to the ratio of times, in this case, it is no longer legitimate.

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The variability of the speed of propagation evidently draws with it the consequence that *the order of succession with which the waves arrive at the observer it is not the same as those of emission.*

Waves that start at a certain instant reach and pass over waves games earlier; they are reached and overtaken by waves that leave later.

On the other hand the position of the line in the spectrum does not depend on the number *total of waves* that reaches the spectral device in a very short time interval ΔT ⁽¹⁾, but it depends on the *rhythm* with which they follow one another. Change of propagation speeds generates thickening and thinning of waves, and therefore causes the density with which they go to increase and decrease to crowd forward to the spectral apparatus, but the function of this is precisely that of unraveling the tangle, of analyzing and isolating the single ones overlapping components, for ordinary according to the magnitude of their rhythm; according to that quantity "time interval between two successive pulses" which *characterizes each elementary radiation*. And this greatness of interval can only undergo changes due to the movement of the source above calculated and represented by the formula (1) or (1').

In other words: the thickening and thinning of light I predicted, and which arise due to the variability with time of the radial velocity of the stella, are in all analogous to those that we could artificially produce hiding for example with a periodic law any part of the surface of a luminous body located at a distance from the spectral apparatus. To measure that the uncovered surface is growing, the intensity is undoubtedly growing of the luminous flux. Again, on the spectral device they overlap and overlap each other waves starting from different points of the emitting body, but no one has ever thought that such a thickening should be followed by one shift of the spectral lines. The line position does not change, since the rhythm of the waves does not change, despite the undeniable increase in *number total* of waves arrived in one second.

This leaves *completely clarified the inaccuracy* in which one incurs the calculate the Dopplet effect based on the ratio $\Delta T/\Delta t$ on the basis of the theories of

⁽¹⁾ We use the symbol ΔT , instead of the other $\Delta t'$ previously used, to put more importantly, the entirely different link which links these two quantities to the starting interval Δt . of the waves.

ballistics, and therefore the objections raised by Dr. Zurhellen before, and by prof. DeSitter now. I could stop here, if I didn't think it advisable to take advantage of this opportunity to express my opinion - which I have already expressed in another I could stop here, if I didn't think it advisable to take advantage of this opportunity to express my opinion - which I have already expressed elsewhere occasion - over an objection, manifestly more founded, than to ballistic theories it is usually done, also taking the Doppler effect as a basis.

We have seen earlier that in the ballistic hypothesis (being the speed of the "waves" with respect to the source independent of its motion) we must have that the n waves emitted in a second are distributed over one length c , both in the case of the still source and in that of the source moving with respect to the observer. This tells us that the *length of the wave* - according to the ballistic hypothesis - *remains independent of speed* of the source, that is - the opponents conclude - that the Doppler effect it should be missing. But this objection assumes that the position of the rows spectral depends precisely on the *wavelength*, while - as is well known - the end at the present time, the classical theories have not been able to decide whether such position depends on the wavelength or the number of vibrations. And in the meantime, it is very important to note this, both in the study of the phenomenon of dispersion, as in the *calculation of the Doppler effect*, the elastic theory and the theory electro-magnetic are forced to always refer to the *number of vibrations* and not the wavelength.

But apart from this important point, we must bear in mind that the *concept of wavelength* is not a primitive element of the luminous phenomenon, which it is made known to us by the whole complex of acquired experiences. These only teach us that light has periodic properties; that is, that the phenomena presented by a beam of monochromatic light they are all related to a *certain time*: the *period* of the particular radiation.

The length of the wave is our superstructure, a fiction entirely linked to the image, to the *arbitrary* mental scheme, that of the phenomenon we have formed, and it falls as soon as we leave this image.

Talking, therefore, of constancy of the wavelength in the field of *ballistic theories make no sense*; and the relative objection cannot make sense to the Doppler effect, it must necessarily be agreed; unless you want to *recognize a priori to a particular arbitrary scheme* value and strength of indisputable "truth".

Before closing, allow me to respond in a few words to another small objection moved to me by the prof. DeSitter. He doesn't believe legitimizes the

statement that I made, that the only stars for which Kepler's laws have been highly verified are double optics; and it reminds me that even for *spectroscopic* doubles those laws can *be verified*, given that *these laws are admitted in the determination of the orbits* made by means of the measurements of the radial velocities.

In my turn I will observe that in order to be able to consider these as *verified* laws also for the spectroscopic ones, those orbits would have to be known otherwise entirely independent of the use of the laws of Kepler. Now that's not the only way those orbits have been calculated is based on velocity measurements *and admits as true the laws of Kepler*. But without insisting on this point I will again remember that in mine work is written: the doubles for which Kepler's laws were *directly verified* are the *double* telescopic ones; and that only interested me to establish, in order to give as demonstrated that in the case of *telescopic observations* (the only ones that could suffer those disturbances feared by Prof. De Sitter in his Note of 1914) the condition Kb less than $1/30$, indicated in the my work was more than satisfied.

In conclusion: I am very convinced that these explanations of mine will suffice to clarify any doubts and to prove the unsustainability of the objections made to me. But I would like more; I wish they would give occasion to some able astronomer to know my ideas and *to take care of them*, to submit them to rigorous exam. It takes into account, in fact, that my daring attempt to oppose *solids arguments of fact to the abstractions of "relativity"* and to give a coordination to the grandiose and obscure phenomena of the "variable stars", be it or shot down, or confirmed.

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