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New proof of dependency the speed of light from the motion of the light source.

Ballistic Explanation of the Law by Miss *Leavitt*. By ***M. La Rosa***.

1. Some recent writings[1]) on validity of the "Ballistic Principle" in the propagation of light give me opportunity on this item with which I been busy for a long time to return.

The goal I set myself in this work is investigation, whether the explanation scheme of the phenomena of variable stars arising from this principle derives [2]) able, the interesting, from Miss *Leavitt* discovered the law of belonging to one and the same star cluster to explain the δ Cephei stars belonging to it.

And I was all the more willing to let myself be tempted to open to return the ideas I've championed for years as I have confidence that my efforts now a less unfavorable reception on the part of those who were interested in the question, and one less will find skeptical on the part of others.

The profound changes that have taken place since 1923 to today in the theories about the "light" have taken place, and especially the basic ideas of "quantistic mechanics" and the "wave mechanics", have the bottom of the essential prerequisites of the classical wave theory which has stubbornly persisted in physical thinking for so long was bound, made free and with it also a number of objections raised against me, which almost generally considered "decisive" and "incontestable" against the application of the ballistic principle to light were put in the right light.

I am particularly referring to the one on the Doppler effect clipped objections to which mine repeated hints proved in vain, and wrongly so. They pointed out that the same only value had in the field of classical wave theory, i.e., around that theory against which the ballistic postulate (and which one therefore wisely had to let rest as soon as one had the factual elements wanted to examine the for or against the applicability of the principle could fight towards the light). As even the explicit explanation proved in vain at the end of the communication [3]) proof. *Levi-Civita* and *Corbino*, through which attention was drawn to the fact that the developed in their writing on the basis of the new theories considerations could not be considered valid.

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[1]) *Timpanaro*, Rend. Acc. Lincei; *Crenna*, Rend. Acc. Lincei

[2]) As I have repeatedly written, this deduction is obtained so immediately and necessarily that we are permitted to regard the results of the observations as an exceedingly powerful system of evidence in their favour.

[3]) Rend. Acc. Lincei **3**. 707 (1926).

While indeed the explanations of the Doppler effect, later given in the field of these theories, agreeing too closely with those of the classical theory scores drove what the speed effect as far as they are concerned, they leave no room for the acceleration effect, which is due to the sheer magnitude that he had assumed in the case of certain variable stars have to consider the ballistic hypothesis flatly refuted let.

Of the other objections raised against me were, none had a prejudicial and conceptual character. They pointed to specific discrepancies between certain details that my theoretical sketch[4]) of the phenomenon of star variability foresaw, and the direct data of observation became. I have these objections, despite them, mainly from the insecurity of those "data" dependent weaknesses in detail and thoroughly checked, and I have always succeeded turn them off and sometimes make new ones out of them arguments, true shining proofs of the ballistic raw principle.

Only one point alone has not yet been answered by me stayed because he did not allow me to continue a polemic seemed to earn, which was beginning to become astringent and tiring; but now that the opportunity presents itself, I won't fail to enlighten him after I have explained which is the main subject of this communication.

2. According to Miss *Leavitt*, there is a relationship between the absolute greats and the periods of the to a and δ Cephei stars belonging to the same star cluster. And it is true that the absolute ones turn out to be for these variables Star sizes noticeably proportional to the logarithm the periods of light change.

This important law applicable to the δ Cephei stars of the Small Magellan Cloud was discovered by on the other hand also confirmed in stars of other star clusters been and forms one of those strange and mysterious Regularities in the field of variables, for which one has searched in vain, any element to grasp the reason for which, on the other hand, it is immediately possible to state a simple and immediate reason, once you get from the point of view of ballistic explanation of the phenomenon of "variability".

To achieve this goal, some simple and interesting sentences are prefaced that immediately arise from my theoretical scheme.

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[4]) Needless to say, I do not pretend to consider my theoretical sketch perfect. It will for sure need to be greatly improved and supplemented in order to be able to fit all concrete cases.

I would therefore first like to remind you that after this scheme each variable star a "double star" (or a "multiple star") and that the rotation of each the bodies forming the star around the common center of mass only lead to a change in the light intensity would if between sizes that the movements characterize, certain relationships exist[1]). Offset we look at the simplest case, in which the movement of the central star (at least with regard to the change of light, which could result from this) can be neglected and in which the motion of the companion in relation to that center of the other celestial body as circular and regular can be viewed; and let's call it

d is the distance of the center of rotation from the observer,

v the numerical value of the web speed,

τ the time of rotation,

c the speed of light (of a at rest located body in relation to the observer),

thus, one finds that the variability of luminous intensity and therefore the stellar magnitude can only occur when between the above quantities the relationship

$$Kb \sim 1/2\pi$$

consists where

$$K = \frac{d}{c\tau} \qquad b = \frac{v}{c}$$

and where the character $\sim$ indicates that the product Kb is within fairly wide limits, around the value $1/2\pi$. The latter is the value at which the phenomenon of variability occurs most intensely and the greatest amplitude and by a quarter period with respect to the maxima of the radial speed has shifted light maxima.

I want to further recall that the special form the light curve and the amplitude of the light change as bound to each other and as dependent at the same time prove of the value of our product, such that one on reason of the values of this latter a rational classification the variable would have to be able to make and the opposite. So, we can say - always according to my scheme - that one and the same for all variables type when the classification is based on an exact manner is constructed according to the aforementioned criteria and must get the same value of Kb[2]).

In other words, the relationship

$$Kb = p_0/2\pi \qquad (1)$$

expresses not only the necessary and sufficient condition for the occurrence of the phenomenon of "variability" depending on the movement, but it serves if p_0

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[1]) Fr. *M. LaRosa*. Z. f. Phys. **21**.333 (1924); N. Cim., genn. 1924
C. Cannata. Rend Acc. Lincei **6**.296 (1927), **7**.337 (1928).

[2]) In reality, if one wants to set up more exact criteria of classification, one will also of the movement of the central celestial body and possibly the other companions and the light resulting from the sum of the light changes of the individual bodies have to construct a curve. In general, however, one can proceed in the manner assumed by us, by most significant changes and includes the changes that depend on the motion of the other bodies and the assume the character of

represents one numerical value rather than another, to determine the "different types" of variables, such that each type corresponds to a certain value p_0 and the opposite. We will therefore call this factor p_0 the "parameter" of the type[3]).

Suppose now that among the variable of a certain type consider those separately wool belonging to a very distant "star cluster"; it then suffices to insert the condition into equation (1), that d is also practically constant, and one gets; the condition:

$$v/\tau = 1/2\pi \cdot \gamma p_0 \qquad (2)$$

where $\gamma = c^2/d$ is a substantially constant quantity that we call the "constant of the heap" for brevity want.

By multiplying (2) by 2π and $2\pi/\tau = \omega$ and $v = \omega r$ set we get

$$\omega^2 r = \gamma p_0 \qquad (3)$$

These formulas express two extremely important derivations of the ballistic theory.

Formula (2) says:

Among all present in a heap Double stars (or multiple stars) can us as "mutables" of a particular one type only those appear for which the ratio v/τ is equal to the product of the constant the heaps divided by the type parameter 2π is.

Formula (3) says that as variables of a given type only those binary stars of the cluster may appear for which the middle one acceleration of the rotating companion from the side is subject to that of the other celestial body is equal to it product of the constants of the heap times the parameter of the type.

And since this acceleration is that of movement of the companion in relation to the center of the main star, so we see that it depends on the mass of these bodies and their mutual distance in the Newtonian expressed in a law, so that we can use formula (3) can give the following expression

$$v\,M/r^2 = \gamma p_0 \qquad (4)$$

where $M = m_1 + m_2$ the total mass of the system and r the radius of the companion when rotating around the other orbit described by the celestial body.

If one then writes in (2) $2\pi r/\tau$ instead of v and is eliminated from GI. (2) and (4) r, one finds the exceedingly important relationship

$$M/\tau^4 = p \qquad (5)$$

where p is a new constant (which I call "*Leavitt*'s constant" wants to name), given by

$$p = 1/v \cdot (1/2\pi)^4 \gamma^3 p_0^3$$

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disturbances.

[3]) The ellipticity of the orbits complicates these considerations insofar as it makes p_0 variable; but you can without serious difficulty make this extension by referring to the average values.

The latter ratio tells us that among all double stars (or multiple stars) of a cluster us as variables of a given type only those may appear in which the case occurs that the masses of the centers of attraction are proportional the fourth power of the companion's rotation period (in other words the "light change"), since the constant of proportionality equal to (for that type and calculated for that cluster) is *Leavitt*'s constant.

Now corresponds to among all known variables the group of δ Cephei-stars very well with those indicated above criteria of classification and one can therefore assume that the condition *Kb*=constant (practically) satisfied is. It's a bunch of stars very clearly characterized light curves and little among themselves have different amplitudes of variation.

So, if we take the δ Cephei-stars of one and the same Heaps closer look, so we must after that ballistic scheme expect that the relationship (5) satisfies will, namely that

$$M = p\,\tau^4 \tag{5'}$$

is. And moreover, we could verify the existence of a connection between the absolute star size (which, as is well known, is given by 2.5 log *E*, where *E* is the one through the star total amount of light emitted) and the variability period τ foresee, if we could, *M* and *E* among themselves connect to.

Now the existence of an inner connection between these two magnitudes, on one and the same star related, has been established for several years.

Prof. *Eddington*[1]) led first, based on the now theoretical knowledge that has become a secure possession about the inner state of the stars and their radiation balance the most remarkable relationship from:

$$-m = f(M) + b_0 \tag{6}$$

where *m* is the absolute stellar magnitude of the celestial body and *f*(*M*) gives a function of its mass, which is a first approximation is expressed in the direct proportionality to the log *M* and where b_0 is a parameter containing all elements of uncertainty absorbs that, both from observation as less influential also from the game and in theory neglected factors.

However, this conclusion is not universally accepted been. Professor *Jeans*[2]) came when discussing the question of internal state and the radiative balance of the stars for his part to the conclusion that the bond between *m* and *M* one dependent on *T* (absolute temperature of the star's surface layer) for reasons inherent in the problem member must contain, and put in the place of *Eddington*'s relationship the following:

$$-m = \Phi(M) + a_2 \log T + a_3 \tag{7}$$

[1]) MN 84.104, 308, 372 (1924). [2]) MN 85.196, 394, 792 (1925).

where $\Phi(M)$ is still appreciably log$M$ proportional, a_2 a appreciably constant coefficient, which in practice (i.e. at the application to the specific cases where a direct comparison with observation has been possible) itself has always shown I to be very obvious, and a_3 a constant. By writing $a_1 \log M$ in place of $\Phi(M)$. and setting a_2 = I, we get:

$$-m = a_1 \log M + \log T + a_3 \qquad (7')$$

In discussing his equation and comparing it with however, Prof. *Jeans* has the most reliable observation data himself recognized that the results one arrives at are not appreciably different from those obtained from *Eddington*, at least what the correspondence with the concrete data concerned, in the cases for which the knowledge of the parallax and the masses reached those limits of rapprochement that are necessary to the numerical verifications a certain to give strength.

Despite the conceptual divergences between the both theories are therefore, and in an indisputable way, the existence of a simple bond between our sizes a binding (such as the practical application has not deviated from *Eddington*'s formula and which is certainly represented by the *Jeans* marriage formula very approximated opens.

By comparing *Eddington*'s formula with that of ours connect (5) placed, we find [3]):

$$-m = 4a \log \tau + b', \text{ where } b' = b_0 \log p' .$$

And by doing the same for *Jeans*' Law, get we

$$-m = 4a_1 \log \tau + \log T + a_3' \text{ , where } a_3' = a_3 + a_1 \log p' .$$

The first expresses in a rigorous form an interesting law, which is a generalization of Miss *Leavitt*'s for the δ Cephei stars found law; the same conditional in indeed up to a constant the proportionality between the absolute stellar magnitudes of the variables of one and the same type and one and the same bunch and the logarithm of the period of light change; the other arrives at the same result except for the addition of the log$T$ contained member. And one understands that if for the stars of one and the same cluster T from case to case does not vary much, the influence of this limb turns out to be small can prove enough to -just as *Eddington* wants- in to be absorbed by the uncertainty of the second limb.

In any case, his role will always be that of a humble one to be the corrective in this type of relationship, which by their very nature differ from the character more severe remove laws will make little felt. Anyway, it will not be superfluous to put the data of observation in the most suitable form for comparison with the formulas to have in mind; maybe some one will come of it Find item for judging.

In order to get as many elements as possible from the calculations to eliminate uncertainty, it is advisable to comparison star (belonging to the group in question)

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[3]) For simplicity of notation and language, we have treated expression (5) as an equation, but we shall always keep in mind that it only has to be fulfilled within not too narrow approximation limits.

serve and towards him all observations in the following manner relate:

If m_0 , M_0 , τ_0 , T_0 those belonging to the comparison star are magnitudes, then by difference we get the relationships:

$$m_0 - m = 4a \ \log(\tau/\tau_0)$$

according to *Eddington*'s law, or

$$m_0 - m = 4a_1 \ \log(\tau/\tau_0) + \ \log(T/T_0)$$

after the *Jeans*.

So after first we would have a constant ratio between (m_0-m) and $\log(\tau/\tau_0)$[1]), while we after another marked and erratic variations of this ratio, depending on the regular variation of $\log(\tau/\tau_0)$ along the series of observations, and find sudden changes in $\log(T/T_0)$ would have to.

Using the observational data from which the law was derived from Miss *Leavitt*, we received for the relationship

$$n = \ (m_0 - m)/(\log\tau - \ \log\tau_0) \qquad (8)$$

the figures given in the table below:

Max.	Min.	Med.	Per.	n_1	n_2	n_3
$14^m.8$	$16^m.1$	$15^m.45$	$1^d.25$	—	1.061	1.55
14.8	16.4	15.60	1.66	—	1.631	1.91
14.8	16.4	15.60	1.76	—	1.722	1.97
15.1	16.3	15.70	1.88	—	2.07	2.15
14.7	15.6	15.15	2.17	—	—	1.62
14.4	15.7	15.05	2.91	—	—	1.78
14.7	15.9	15.30	3.50	—	—	2.62
14.6	16.1	15.35	4.29	—	—	3.01
14.3	15.3	14.80	4.55	2.03	—	1.990
14.3	15.5	14.90	4.99	1.62	—	2.406
14.4	15.4	14.90	5.31	1.53	—	2.575
14.3	15.2	14.75	5.32	1.740	2.71	2.129
13.8	14.8	14.30	6.29	2.417	—	1.307
14.1	14.8	14.45	6.65	2.055	2.182	1.920
14.0	14.8	14.40	7.48	1.968	2.412	2.20
13.9	15.2	14.55	8.40	1.600	1.187	3.29
13.6	14.7	14.15	10.34	1.934	2.126	2.258
13.4	14.6	14.00	11.64	1.955	2.236	2.229
13.8	14.8	14.30	12.42	1.573	1.310	—
13.4	14.4	13.90	13.08	1.994	2.206	—
13.4	14.3	13.85	13.47	2.02	2.257	—
13.0	14.6	13.80	16.75	1.88	1.943	—
12.2	14.1	13.15	31.94	1.976	2.08	1.90
11.4	12.8	12.10	65.8	2.249	2.431	2.553
11.2	12.1	11.65	127.0	2.145	2.258	2.270

The first, second and fourth columns contain the from Observation data communicated to Miss *Leavitt*, namely the Star size at the moments of light maximum and minimum and the period in days; the third column contains the mean of the numbers in the first and second columns, these are used in the absence of

[1]) The constancy spoken of is to be understood with that breadth of meaning explained in note (3) on P-373·74, both because of the character of Eq. (5) as well as because of the variability shown by the quantity b' of *Eddington*'s formula given under also foresees the inclusion of a temperature dependent corrective term.

more precise information as a measure of absolute stellar magnitudes assumed; the numbers of the three last columns contain the values obtained for the quantity *n*, where three different reference systems were used. To partly those contained in the elements of the reference star eliminating errors, we took them out as such average data obtained from the three asterisms are marked with a { at the edge of the first column; and consequently the ratios of column n_1 are those which were obtained by taking as reference the average data the first group from above, made up of the 2nd, 3rd and 4th star, were taken; have the numbers in column n_2 as a reference, the average data of the second group (the stars 9-12); and those denoted by n_3 have as reference the average dates of stars 20 and 21.

The numbers in columns *n* show that Miss *Leavitt*'s law is far from, the character of a to have a strict relationship.

The ratios *n* are not only not constant, but exhibit a low and general dependence on the data of the comparison star, which agrees well with that what formula (8) requires. They also show wide fluctuations and some very noticeable swings that are well in tune with the character of our relationships, which are only approximations. The correspondence between this type empirically discovered regularities and our theoretical one *scheme* couldn't be better. The Law of Miss *Leavitt* may justly be considered a special case of those noted above general bond are considered.

Now that the basics of our considerations are the *Eddington-Jeans* relationship between *m* and *M* and the application of the ballistic principle to speed of the light, one should be able to conclude that Miss *Leavitt*'s law is conclusive evidence for the correctness of these conditions.

The ballistic principle goes out so strongly strengthened this new check with the observed "reality" out.

Nevertheless, I am well aware that its inclusion in the theory still faces serious obstacles will find.

The "relativity" has undoubtedly modern development rendered great service to physical theories; and it is not possible to do without it. But it seems to me that the assumption of the "ballistic principle" not necessarily to the condemnation of that theory must lead, at least in its most essential part, the so has been fruitful as an aid to the more recent theoretical ones developments. The really useful achievement, the one has played a major role is that of the dependency of Inertial reaction (of a body) from the speed concerning the movement; in other words what the Revision of the foundations of the second requirement of the classical mechanics concerned. On this point, the *Einstein* marriage Theory secured a flawless success.

Now I think that would have achieved the same result can be made by direct and expedient modification the basic relationships between force, mass and acceleration and most importantly without the need to the unjustified way out of constancy of the speed of light to grasp the source of the so much discussed and complained about oddities and the *Einstein* even in the later development of his theory has fallen have to leave. A theoretical attempt in this sense would perhaps be very fruitful and certainly very instructive.

In the hope that someone else would like this task can take over and that soon a ground of reconciliation if I want to be found, I have to - with the firmest belief - on the extraordinary great value now exist the factual evidence for the ballistic principle (or at least the further held hypothesis of some influence of the movement of the light source to the speed of light). The whole field of phenomena of the variability of Stars with the appearances being the same in the different types exhibits, with the peculiarities that they have with these types and confirms some of their statistical laws today this hypothesis.

Among the many objections raised against me only the last one from *Salet* is still waiting for an answer. After that, the ballistic hypothesis would be in any case simply discard because the luminous intensity of certain Stars in certain cases through infinity would have to go.

Except for the expediency, or rather duty, this momentary entering passage through the infinite, which in certain cases represents the ratio *dt/dT* of my theoretical sketch (to which the intensity proportional to the stars) occurs, "cum grano salis" construed as one would in so many other analogous cases both in physics and in other sciences; apart from the legitimate opportunity to rely on that Principle of the conservation of energy extended to the whole period of light change, to support the true amplitude of the maximum as I use it in mine working advised, it is as it stands our knowledge does not allow the ballistic principle despite so many secured confirmations because of this to dismiss a circumstance. Admittedly also that one by superimposing the speed of the star and that of the light be led to foresee that at a certain moment and at certain points of space an extremely large concentration of "photons" could occur, so one can with the present views not readily conclude that this will occur could, without reactions between the different "photons" arise without mutual clashing would come without creating new relationships in any way between these would arise, aiming at the state of emergency that aspires to form, more or less to modify.

If one adds to these not only possible ones, but more than probable circumstances add that to the other we are prevented in the specific case, the current ones modalities of the phenomenon to be established in relation on which we take a mean of what is in a conscience interval occurs (an interval that not only must be

finite, but always very large in relation to the times when studying these elementary reactions come into play between photons), you can see how presumptuous and unfounded is the demand of those who, closing their eyes to the secured facts, on behalf of such obscure and intricate strangers want to explain the current of thought in the ban, which has proved so fruitful, albeit, like all of them human conceptions, is not capable of everything coordinate, make everything understandable, explain everything.

Palermo, 1931 April 18. *M. LaRosa.*