NEW THEORETICAL AND EXPERIMENTAL
RESEARCH WORK ON GRAVITY

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Memoir to compete for the yearly prize of the "Gravity Research Foundation"

No decisive progress in the field of gravity can be accomplished as long as the present theory will not be carefully reexamined and new experimental researches will not be carried out in view of determining on the one hand if the present theory can be considered as satisfactory, and this up to which approximation and on the other hand if new complementary terms should be taken into consideration.

The present memoir intends to briefly account for:

a)   research work on the gravity theory in view of taking into account on the one hand the propagation times and on the other hand an absorption effect depending on distance.

b)   Observations made on the movement of the paraconical pendulum borne by an anisotropic support during the total sun eclipse of June 30th, 1954, which tends to suggest the existence of a screening effect of the sun by the moon, which screening effect would justify the suggested change to the gravity theory.

c)   periodical anomalies experimentally found in the movement of the paraconical pendulum.

d)   research work carried out on the experimental anomalies previously found in the field of gravity on the one hand, and on the degree of approximation with which gravity laws have been actually verified on the surface of the earth and in the field of astronomy as well, on the other hand. As a result of the theoretical and experimental research work carried out under consideration of a) b) c) d) above, it follows that in the present state of things the present theory of gravity cannot be considered whatsoever as fully accounting for observed experimental facts, that new research

work of both theoretical and experimental nature should be undertaken and that said research work do condition any decisive progress in the field of the gravity theory.

I - GENERALIZATION OF THE PRESENT GRAVITY THEORY TO TAKE INTO ACCOUNT TIMES OF PROPAGATION AND OF AN ABSORPTION EFFECT DEPENDING UPON DISTANCE

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1) One knows how the indefinite equation of newtonian potentials

$$(1) \qquad \Delta \varphi + 4 \pi \kappa \delta = 0$$

(where φ designates the newtonian potential, δ the density and κ the constant of universal gravity) has been generalized in two ways, by Lorenz on the one hand in order to take into account times of propagation and by Yukawa on the other hand in order to take into account a damping effect during propagation. A synthesis of these two standpoints has been made by Mr. Hély who has indicated that the indefinite equation

$$(2) \qquad \Delta \varphi - \frac{1}{c^2} \frac{\partial^2 \varphi}{\partial t^2} - \frac{2 k_\rho}{c} \frac{\partial \varphi}{\partial t} - k_\circ^2 \varphi + 4 \pi \kappa \delta = 0$$

in which coefficients c and   are considered as <u>constants</u> admits as a solution the expression

$$(3) \qquad \varphi (x_1, x_2, x_3) = \int \kappa \delta (\xi_1, \xi_2, \xi_3, t - \frac{\lambda}{c}) \frac{e^{-k_\circ \lambda}}{\lambda} d\tau$$

the integral being extended to the whole space and r being the distance between points M (x_1, x_2, x_3) and $m (\xi_1, \xi_2, \xi_3$). Space E_f considered is euclidian.

In said space the propagation of disturbances takes place along a straight line at a constant speed c and with a constant rate of damping $k_\circ$.

This conception is very interesting and quite natural but unfortunately is valid only in the case of c and $k_\circ$ being constant.

2)   One can easily show (1) that with the usual tensorial notations the equation which generalizes equation (2) in case of variable coefficients can be written

$$(4) \qquad \frac{1}{\sqrt{|g|}} \, \partial_i \left(\sqrt{|g|} \, g^{ij} \, \partial_j \varphi \right) - \frac{1}{c^2} \frac{\partial^2 \varphi}{\partial t^2} - \frac{2k_o}{c} \frac{\partial \varphi}{\partial t} - k_o^2 \varphi + 4\pi k \delta = 0$$

and that this equation admits as a solution the expression

$$(5) \qquad \varphi(y_1, y_2, y_3) = \int \sqrt{|g|} \, \kappa(\eta_1, \eta_2, \eta_3) \delta\left(\eta_1, \eta_2, \eta_3, t - \frac{\rho}{c}\right) \frac{e^{-k_o \rho}}{\rho} \, d\tau'$$

with

$$(6) \qquad \rho = \int_M^m ds$$

this integral being calculated along the line joining M and m and minimizing said integral, together with

$$(7) \qquad ds^2 = g_{ij} \, dy^i dy^j$$

Whereas the disturbances represented by equation (1) are propagating along a straight line with an infinite speed and that the disturbances represented by equation (2) are propagating along a straight line with a constant speed c and a damping rate k_o , the disturbances represented by equation (4) propagate along curved trajectories and with a speed and a damping rate depending upon the considered point and direction.

3)   Equation (4) generalizes equation (1) and can particularly explain on the one hand an effect of gravity absorption established in the experiments of Majorana (9) and on the other hand suggested by the observations made on the movement of the paraconical movement during the total sun eclipse of June 30th 1954 (3) (5). It can also very simply explain anomalies of gravity of which a pseudo-explanation has been given up to now by the theory of isostasy.

II - DISTURBANCE OF THE MOVEMENT OF THE PARACONICAL PENDULUM WITH ANISOTROPIC SUPPORT ESTABLISHED DURING THE TOTAL SUN ECLIPSE OF JUNE 30th 1954

Experimental arrangement

During the years 1954 up to 1958 a series of systematic experiments have been carried out with a paraconical pendulum (pendulum suspended by a ball) with anisotropic support (support which elasticity and inertia are different in two rectangular plans) in an underground laboratory at Saint-Germain.

The weight of the pendulum made up of a disc is of about 12 kg and the length of the equivalent simple pendulum is of about 83 cm. The pendulum is entirely made of bronze. The observed data is the azimuth of the oscillating plane of the pendulum. Observations are taking place day and night during a period of time of about one month.

Observed Effect.

During the series of continuous observations of June - July 1954, a very remarkable disturbance of the movement of the paraconical pendulum with anisotropic movement was established during the total sun eclipse of June 30th 1954.

The phenomenon should be considered as having given way to forces which order of magnitude are those of the Foucault effect and nothing in the present theory does allow to explain interference of said forces neither as to their order of magnitude nor as to the screening effect apparently performed by the moon viz. the sun (5).

III. - PERIODICAL ANOMALIES OF THE MOVEMENT OF THE PARACONICAL PENDULUM WITH ANISTROPIC SUPPORT

1) Experiments made in St. Germain from 1954 up to 1958.

The statistical analysis of several monthly series of observations

carried out day and night of the azimuth of the paraconical pendulum here-above described in my laboratory of Saint-Germain located underground during the years 1954-1955, has made evident the existence of periodical components, the periods of which are close to 24 hours 50 minutes (wave of diurnal lunar type), 24 h. and 12 h. (waves of diurnal solar type and semi-diurnal solar type), and the amplitudes of which are statistically significant (4) (7).

Discussion of results.

The thorough theoretical and experimental analysis of the experiments carried out have led me to the following conclusions (8) (9) (12) (13)

1) that the established periodical effects do really exist and are not due to accidental causes.

2) that said effects cannot be identified with the periodical lunisolar effects foreseen by the admitted theory of gravity, as the observed effects are about hundred million times greater than theoretical effects.

3) that these effects cannot be assigned to the indirect influence of anyone of the following phenomena: earth tides, temperature, atmospheric pressure, earth magnetism, microseismic agitation, cosmic rays, periodical character of human activity.

The whole of this analysis has been presented in my memoir of May 1958 about the anomalies of the paraconical pendulum.

3) Simultaneous experiments of Saint-Germain and Bougival of July 1958.

These experiments have been carried out again day and night in two laboratories at the same time, the first one being the one already used at Saint-Germain, and the second one being a new laboratory located at Bougibal, at 6.5 km from the first one, in an underground gallery of a chalk deposit, recovered by 57 m. of clay and chalk, protected against any extremal disturbance and particularly any thermical variation. Pendulums used and suspen-

sions as well were the same.

The anomalies previously ascertained kept on being observed. In the attached graph I am accounting for the harmonic analysis results obtained by the Buys Ballot filter method for a filter which period is of 24 h.50 min., from the observations simultaneously made in the two laboratories during one month.

This graph enables one to compare the results obtained in the two laboratories. The two waves have very slightly different amplitudes and are almost perfectly in phase (10).

Waves of 24 h. and 12 h. do correspond also to each other but are 180° out of phase.

From one series of observations to the other one finds out important differences in amplitude, in the observed periodical effects. The standard deviation Σ of series of observations has been respectively of about 18,2 - 17,8 - 19, 9 and 5,4 grades in June-July 1954, November-December 1954, June-July 1955 and July 1958 at St-Germain, and of about 4 grades at Bougival in July 1958. For these five series the ratio $2R/\Sigma$ of the amplitude of the wave of 24h.50 min. to the standard deviation has been about 0,18 - 0,72 - 0,70 and 0,52 (9)(10)(11).

4) State of discussion.

The main elements of discussion are the following ones (9).

a) The practical identity of the periodical effects of 24h.50 min. simultaneously found out in the two laboratories alone allows one to eliminate any explanation of the effect through a fortuitous cause.

b) The conditions of temperature practically invariable as they are established in Bougival allow to eliminate any thermal effect.

c) The practical indentity of periodical effects of 24 h.50 min. found out at Bougival and Saint-Germain allows elimination of any influ-

ence exclusively based on the influence of the Saint-Germain building or for any other cause such as wind.

d) Alone the comparatively great variability of the amplitudes of periodical found out effects in relationship with the period of time allows to eliminate any explanation based upon the presently admitted laws of gravity.

e) The observed phenomenon is the only one of the presently known geophysical phenomena for which the amplitude of the wave of lunar-diurnal type is of the same order of magnitude as the amplitude of the wave of solar-diurnal type and very much bigger than the amplitudes of the waves of semi-diurnal solar and lunar types. This very particular periodical structure alone allows to eliminate as a possible cause any one of the geophysical phenomena presently known.

In the present state of things one must infer the existence of a new phenomenon involving the existence in the laws of gravity of complementary terms which up to the present time have remained unnoticed.

5) Order of magnitude of found out effects.

For average speeds of the pendulum of about 15 cm. per second, the order of magnitude of found out effects is of 5.10^{-6} of gravity (9), that is to say very small, but experimental results seem to suggest that said effects do increase with the amplitude that is to say with the speed.

Under this assumption the revealed effects would have a considerable importance for earth missiles and for space rockets. It's still up to experiment to decide upon.

IV - ANOMALIES ALREADY FOUND OUT IN EXPERIMENTS ON GRAVITY
AND DEGREE OF APPROXIMATION OF THE VERIFICATION OF FUNDA-
MENTAL PRINCIPLES OF MECHANICS.

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1) <u>Anomalies found out in mechanical phenomena</u>

Anomalies that have been found out in the movement of the para-
conical pendulum seem to me to be in close connection with the diffi-
culties and anomalies met with in the explanation of numerous dynamic
phenomena and which have remained up to now unexplained (9):

1) Anomalies of the theory of tides

2) Movements of the top of the Eiffel tower

3) Importance of the deviations toward the South observed in
the fall of bodies

4) Variations in the amplitude of deviations toward the East
in the fall of bodies

5) Anomalies found out in the action of terrestrial revolution
upon the flow of liquids (experiment of Tumlirz)

6) Anomalies found out in the movement of the horizontal
gyroscope of Fopp 1

7) Anomalies found out in the experiments carried out with the
isotomsograph

8) Anomalies found out in the experiments carried out with the
suspended pulley

9) Various anomalies found out in geophysical measures and
imputed up to now to experimental errors

10) Results apparently inexplicable obtained by General Doctor
Felix Pasteur in his experiments upon the oscillation

of pendulums (1954)

    11) Remarkable features of the solar system up to now remaining without any explanation.

To these anomalies bound to movement are to be added some anomalies of static nature:

    1) anomalies of gravity: there is an excess of gravity above oceans and deficiency above continents. The isostasy theory has given of these anomalies according to me only a pseudo-explanation.

    2) anomalies in the experiments upon the newtonian attraction: on the one hand there exists an absorption of gravity (experiments of MAJORANA) and above all a variation of the newtonian force depending upon the medium where it exercises itself (experiments of CREMIEU)

2) Accuracy of verification of gravity laws

Therefore it is not without any interest that one can put to himself the question with what accuracy gravity laws are verified in the field of astronomy as well as on the earth surface. So astonishing as it might appear, all treaties of Mechanics and Astronomy are remarkable mute on this fundamental question. This is an essential gap and an evident deficiency from the point of view of scientific discipline. Any law has in fact no meaning whatsoever if one does not know the degree of accuracy with which it has been verified.

The consideration of residuum of adjustments by the least square method which served to establish the tables now used in Astronomy does show in fact that the order of magnitude of the relative deviations found out for angular displacements between observation and theory is at least of about $3 . 10^{-6}$ during the revolution period of a heavenly body.

Moreover the comparison of measures of g obtained either by ob-

servation of the oscillations of the pendulum, or by the fall of invar rulers, shows that the order of magnitude of the relative accuracy with which laws of mechanics are verified on the earth surface is about 10^{-5}.

As a result the anomalies which I think I have rendered evident are not at all contradictory with the previous data of experience neither on the earth surface nor even in the field of astronomy (9).

3) Meaning of the anomalies that have been found.

From the scrutiny of the anomalies I have hereabove recalled and from the discussion of the accuracy with which the principles of mechanics have been established, it results quite evidently that these principles do not have at all the absolute value which a too common opinion seems to attach to them. These principles have presently acquired some kind of metaphysical quality beyond any discussion. In reality mechanics is not at all a perfect science, a pure science in which nothing else is to be found any more. It is and remains an experimental science which can and must be improved.

It's time in fact to think over these phenomena again. This additional scrutiny appears obviously to be of a capital interest for building up a unitarian theory which can synthesize in a single theory, theories of gravity, of electromagnetism and of quantum. It is not at all the same thing to state that we have

$$\Delta \varphi + 4\pi \kappa \delta = 0 \qquad \text{(a)}$$

or to state we have

$$\Delta \varphi + 4\pi \kappa \delta (1 + \epsilon) = 0 \qquad \text{(b)}$$

with

$$|\epsilon| \leqslant 5 \cdot 10^{-6}$$

Any one who has worked out these difficult matters knows that equation (a) could not be substituted without great danger to equation (b) because in the integration process of partial differential equations

corrective terms have a very great importance.

This at a moment when the building up of a coherent unitarian theory of physics appears perhaps to present a greater difficulty than ever before, the exhaustive scrutiny, both in the experimental and theoretical fields, of all the hereabove anomalies appears to me to be of the highest interest, because it seems to me liable to entail the revision of certain postulates which rigid validity has been accepted without an effective support of experimentation .

Only facts must guide us and not momified principles, however useful they might be in first approximation. The only source of our knowledge is experience and any thought which locks up itself in abstract principles precisely by doing so condemns to sclerose itself (9).

CONCLUSIONS

If one wishes to make effective progresses in the knowledge of the gravitic laws in sight of controlling them for terrestrial or astronautical appliances, it seems to me that the results of the previous indications is, firstly, to think again thoroughly the gravity theory and, secondly, to follow up the experimental researches here above analysed or reminded.

Experiment is the single origin of our knowledge. Only in the experimental field, we are able to make effective and quick progresses. The experimental results I have obtained are alone sufficient for cheering us up in this way. Effectively they show that Mechanics is not an achieved science, they are complementary terms which are able in certain circumstances, to play a very important part and it is suitable in the shortest time to determine the general properties of these complementary terms and to bet up their theory.

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