Dynamic Gravity Experiment with Accelerated Masses

D. Sarkadi*
Research Centre of Fundamental Physics, Vaci M. 8., H-7030 Paks, Hungary
(Dated: May 28, 2019)

The nearly 300-year success of the Newtonian gravitation theory has always been based on the implicit assumption that the gravitational force is the same strong between standing and moving masses. In the 1990s, in Hungary, gravitational experiments were carried out in which gravitational effects were studied between moved masses. Surprisingly, by the outer force moved source masses generated more powerful gravitational force than Newtonian gravity. In addition, depending on the direction of moved masses, gravitational repulsion has been observed. Theoretical studies have shown that the newly discovered gravitational phenomenon appears when the interacted masses are moved artificially by inner and/or outer forces.

PACS numbers: 04.80.Cc
Keywords: experimental gravity, gravity of moving masses, repulsive gravity, gravitational anomalies

I. INTRODUCTION

In this paper, a previously unknown form of gravity is presented what has been named by "dynamic gravity". Under dynamic gravity, we mean the phenomenon of gravitation between artificially moved masses. The nearly 300-year success of the Newtonian gravitation theory has always been based on the implicit assumption that the gravitational force is the same size between standing and moving masses in non-relativistic cases. In the Newton's gravitational theory has central role of the universal gravitational constant G. Over the past centuries, many G determination have been made, in a wide range of measurement methods, in laboratories and beyond. In each of the gravitational experiments, the so-called "source masses" that created the measuring gravitational field were static (standing) masses. In the 1990s, gravitational experiments were carried out in Hungary in which the gravitational effects were studied between moving masses. Surprisingly, the moving source masses generated more powerful gravitational force than expected by the Newtonian gravity. In addition, in these experiments gravitational repulsion also appeared with the usual attraction, depending on the moving direction of the interactive masses. Finally, the experienced strong gravitational force has been named dynamic gravity.

II. THE DYNAMIC GRAVITY EXPERIMENT

Our unconventional gravity measuring method is illustrated in FIG. 1. The m_s source mass is periodically moved by outer force which causes modulation in the movement of the physical pendulum through an unknown (suspected gravitational) interaction with the lower mass m_p of the pendulum. Some of the technical features of the realised physical pendulum are

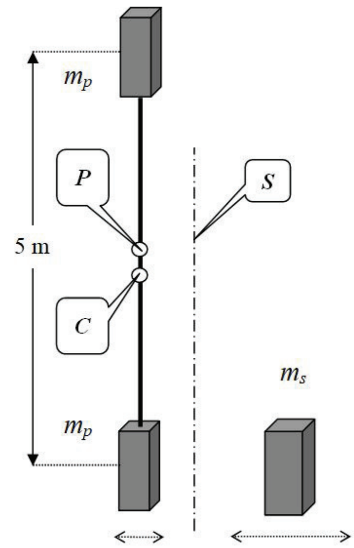

FIG. 1: Setup for gravity measurement. (P: pivot point, C: mass-center, S: iron isolation plate, m_p: pendulum masses, m_s: source mass).

Pendulum arms: 2.5 + 2.5 m,
Upper and lower masses: 24 - 24 kg, cubic leads,
Pendulum frame: made of aluminum,
Total mass with frame: 54.7 kg,
Support of pendulum: two hard steel wedges,
Damping: hydraulic damper,
Pendulum period: 60 - 80 s,
Position detector: optical + electronic.

Due to the relatively large dimensions, the period adjustment of the pendulum is relatively easy. The small pendulum amplitude results an acceptable low level of friction. The test masses used were made of lead cubes. During the control tests, we put an iron isolation plate into the gap between the moved source mass and pendulum to prevent magnetic and air-draft disturbances. Reliable grounding of the apparatus is necessary for protecting it against the electrostatic disturbances.

*Electronic address: dsarkadi@gmail.com

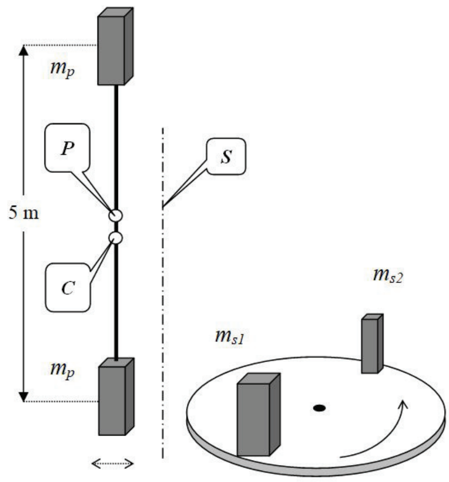

FIG. 2: Setup for a resonance measurement of the dynamic gravity (P = pivot of pendulum; C= mass center of pendulum, S: iron isolation plate, m_p: pendulum masses, $m_{s1,s2}$: source masses).

The pendulum movement was recorded on-line by personal computer, and was displayed in zoomed graphic form on computer screen. For the recording of the pendulum movement, an optical measuring system was developed. Our laboratory was situated at about 500 meters from the nearest traffic road, in a low gravitational and mechanical noise environment. The building of the laboratory was hermetically closed against the outer air draft. Nevertheless, on the floor of the laboratory continuous small mechanical vibrations could be observed, and the coupled vibration energy was transferred to the pendulum. This is a finally not removable background noise as the source of minimal chaotic pendulum movement (about 2-3 mm in amplitude).

III. THE RESONANCE MEASURING METHOD

For the purpose of detailed investigation of the dynamic gravity we have realized a resonance method [1] in our physical pendulum experiment. The setup of the measurement is shown in FIG. 2.

An important part is not shown on FIG. 2, a plastic container filled with water, in which rides a light plastic damping sheet of about 500 cm^2 surface area connected to the lower arm of the pendulum. This works as a hydraulic damper that minimizes the high frequency disturbances of the pendulum.

The two source masses (m_{s1} = 24 kg, m_{s2} = 12 kg,) placed diametrically on a rotating table driven by a small electric motor. The round-table is made of hard wood in our particular case, but generally any non-magnetic material could be used for this purpose. The round-table and its driver system are placed on the floor, while the suspension of the pendulum is fixed to the ceiling of the laboratory. This solution gives a good isolation against the coupled vibrations of the whole instrument.

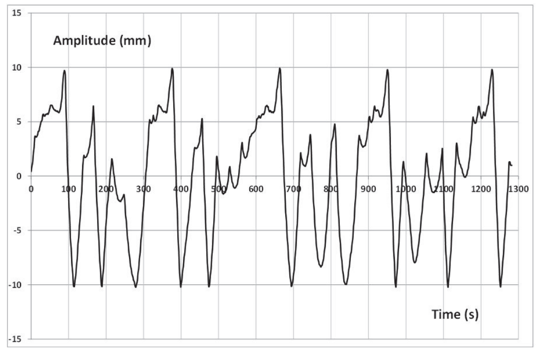

FIG. 3: A part of gravity measure with resonance method.

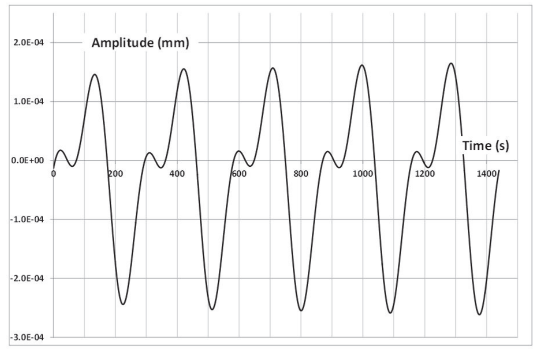

FIG. 4: The calculated pendulum movement by the Newtonian gravity.

The preliminary control tests proved that there was no measurable mechanical coupling between the round-table and the pendulum. It has also been shown that the automatic driver system for the source masses movement did not affect the pendulum movement. The radius of the round-table was 0.5 meter; the minimum distance between the source masses and the pendulum lower mass was about 0.25 meter. In our most successful measurement, the period of the pendulum was about 72 s, and the rotation period of the round-table was about 4 x 72 s = 288 s. The pendulum amplitude increased up to 10 mm from the background noise amplitude (2 - 3 mm). The moving source masses produced energy transfer to the pendulum amplitude by the dynamic gravity effect.

FIG. 3 shows a part of the pendulum movement obtained from this dynamic gravity experiment. The resulting measurement record is heavily disturbed, however the 288 second period of the rotating rotary table is clearly visible. What was obvious from the outset, the amplitude of the gravitationally excited pendulum was much larger than what could be expected from the Newtonian gravity. The measured pendulum amplitude was approximately 10 mm as can be seen in FIG. 3. In contrast, the calculation made by Newton's gravitational force law led only about to 0.2 mm (FIG. 4).

Our experiment has been repeated many times excluding any disturbing side effects and we have always achieved the same result: the strong excitation of the pendulum can only be of gravity. In the measuring processes the interactive masses were electrically and magnetically neutral what was always checked.

IV. THEORETICAL BACKGROUND OF THE DYNAMIC GRAVITY

After the successful pendulum experiments, a detailed study was carried out to prove that the phenomena experienced were really real and not some interfering effects of any other origin. We were sure that the experienced pendulum movements were not the result of either mechanical or electromagnetic effects. Only the supposed gravitational effect was involved into the investigation of the experiment. In the determination of the force law of dynamic gravity, two aspects have been enacted: the force law must include the Newtonian gravitational constant, and the force expression in the marginal case must return the Newtonian (static) gravitational law.

Over time, we had to realize that dynamic gravitational effects are associated with accelerations of interacting masses. Newton's gravitational law can be formally written in a form containing an acceleration square

$$\mathbf{F}_s = -2Da_0^2 \frac{mM}{r^2}\frac{\mathbf{r}}{r},\ where\, G = 2Da_0^2. \tag{1}$$

In this equation D is a unit dimensional factor and a_0 is a constant acceleration determined by the Newtonian constant of gravitation. We can introduce the next forces for the two interactive masses

$$\begin{aligned} \mathbf{F}_m = m\mathbf{a}_m = ma_0\sqrt{(M/m)}\mathbf{r}/r; \\ \mathbf{F}_M = -M\mathbf{a}_M = -Ma_0\sqrt{(m/M)}\mathbf{r}/r, \end{aligned} \tag{2}$$

so the Eq.1 can be written into form

$$\mathbf{F}_s = 2D\frac{\mathbf{F}_m\mathbf{F}_M}{r^2}\frac{\mathbf{r}}{r}. \tag{3}$$

For the introduced forces the next equation is fulfilled

$$\mathbf{F}_m + \mathbf{F}_M = \mathbf{0}. \tag{4}$$

In the cases of dynamic gravitational interaction, this equation is not necessarily fulfilled.The reason of this is because the one or both of the two gravitating masses are influenced by external and/or internal, dominantly non-gravitational forces. The force expression for the dynamic gravity will be the next

$$\mathbf{F}_{dyn} = 2D\frac{\mathbf{F'}_m\mathbf{F'}_{M,}}{r^2}\frac{\mathbf{r}}{r}, \tag{5}$$

where the force variables with apostrophes are

$$\mathbf{F'}_m = \mathbf{F}_m + \mathbf{F}^*_m,\ \mathbf{F'}_\mathrm{M} = \mathbf{F}_\mathrm{M} + \mathbf{F}^*_\mathrm{M}. \tag{6}$$

Here the signalized forces by asterisk are the "strange" forces acting to the interactive masses beside the Newtonian gravity. The dynamic gravity force is in detailed form

$$\mathbf{F}_{dyn} = -2D\frac{mM\mathbf{a}'_m\mathbf{a}'_M}{r^2}\frac{\mathbf{r}}{r} = -G_{dyn}\frac{mM}{r^2}\frac{\mathbf{r}}{r}, \tag{7}$$

where the extended accelerations are

$$\mathbf{a}'_m = \mathbf{a}_m + \mathbf{a}^*_m,\ \mathbf{a}'_\mathrm{M} = \mathbf{a}_\mathrm{M} + \mathbf{a}^*_\mathrm{M}. \tag{8}$$

The first acceleration terms are from the Newtonian gravity force by Eq.2, and the signalized by asterisks accelerations are the consequences of the strange forces what can be calculated or measured.

V. COMPUTER SIMULATION OF THE PENDULUM EXPERIMENT

The motivation of our computer simulation was to prove the validity of the dynamic gravity force expression (7) of our pendulum experiment. It was supposed that the free pendulum movement is nearly harmonic, considering the relatively very small amplitude of its motion. From the theory of the mechanics, the movement of the excited pendulum is determined by an in-homogeneous second order differential equation

$$\ddot{x} = -\omega^2 x - 2\lambda\dot{x} + f_{dyn},\ (f_{dyn} = F_{dyn}/m_{eff})\,. \tag{9}$$

Here ω is the natural frequency of the pendulum, λ is the damping factor, F_{dyn} is the exciting dynamic gravity force, m_{eff} is the effective mass of the pendulum. From the measured pendulum movement (FIG. 3.) we calculated the dominant pendulum frequencies with *Fast Fourier Transformation* (FFT). In the FFT calculation the 288 and 144 seconds periods mainly dominated in the motion movement, which are from the 288 seconds period of the rotating round-table. In addition, the 216 and 192 seconds periods also appeared in the FFT with rather lower intensities. Thus for all four harmonics has to solve the motion equation of the pendulum, and then the resulting solution functions must be added together.

To summarize, the following periods and angular speeds were involved into the computer simulation of the pendulum motion

$$\begin{aligned} T_n \Rightarrow 288\ s,\ 216\ s,\ 192\ s,\ 144\ s, \\ \omega_n \Rightarrow 2\pi/T_n,\ (n = 0, 1, 2, 3). \end{aligned} \tag{10}$$

At the first stage of the simulation process, the pendulum amplitude was set for a small value, and after the periodic excitation the pendulum amplitude was continuously growing with its acceleration, which was feed backed to the input of the computer program. The reachable maximum amplitude was limited by the damping factor of the pendulum. The excitation of the pendulum movement harmonics

$$\ddot{x}_n = -\omega_n^2 x_n - 2\lambda\dot{x}_n + f_{dyn},\ (n = 0, 1, 2, 3). \tag{11}$$

For the solving these equations, *Verlet* [2] integration method was chosen. In the simulation program two fitting parameters played determinant role; the pendulum damping factor and the nearest distance between the

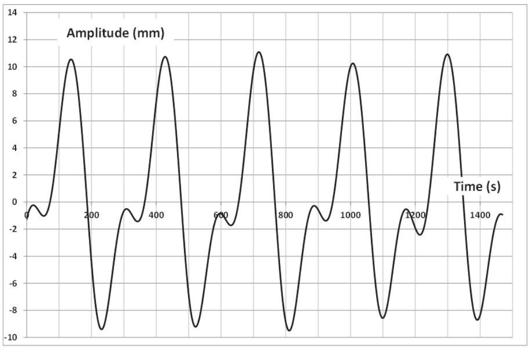

FIG. 5: The calculated pendulum movement by the dynamic gravity.

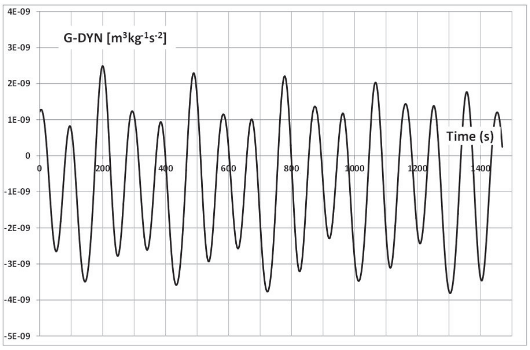

FIG. 6: The used G_{dyn} dynamic gravity function vs. time in the pendulum experiment computer simulation.

pendulum lower mass and the the rotating source masses. The computer program gave values for them

$$\lambda = 1/1700 \text{ s}, \ \mathrm{r_{min}} = 250 \text{ mm}. \tag{12}$$

The pendulum movement is the sum of the harmonics

$$x(t) = \sum_{n=0}^{3} x_n(t). \tag{13}$$

FIG. 5 shows the result of the pendulum movement calculated by the newly introduced dynamic gravity. It is important to note that both the measurement and the simulation gave the pendulum amplitude about 10 millimeters on contrary the calculation with the Newtonian gravity what gave amplitude about 0.2 mm. Factually, in this experiment the dynamic gravitational effect was thus about fifty times stronger than the Newtonian gravity. This special circumstance made it possible to detect the dynamic gravity with a physical pendulum whose sensitivity is much lower comparing to the well-known Cavendish's torsion balance. We can introduce the dynamic gravity function leading to the Newtonian constant of gravity in limit case

$$G_{dyn} = 2D\mathbf{a}'_m\mathbf{a}'_M. \tag{14}$$

FIG. 6 shows the actual G_{dyn} function used in our pendulum experiment simulation. The positive range belongs to the attractive force, while the negative range belongs to the repulsive force of gravity. It seems that the repulsive force was dominant in our experiment providing the energy transfer to the pendulum.

VI. CONCLUSION

Based on the experiments carried out so far and by the theoretical investigation, it can now safely assert that the strong gravitational effect, i.e. the here described dynamic gravitational interaction really exists in the nature. The minimal condition for the appearance of dynamic gravity is that at least one of the interactive masses is exerted by an internal or external force. External force can be a gravitational force whose source mass is artificially moved. The internal force may be non-gravitational origin, such as a rocket drive. Obviously, in these cases, the dynamic gravity function (14) will be different from the Newtonian gravitational constant G.

The phenomenon of dynamic gravity does not appear in the ordinary experience as spectacularly as Newtonian gravity. At the same time, space research has, in recent years, been confronted with anomalies that may be caused by the phenomenon of dynamic gravity. When directing space vehicles into their planned orbit, auxiliary rockets are frequently operating, which certainly have dynamic gravitational effects. These can cause strong gravitational repulsion which is capable significantly to increase the kinetic energy of the space vehicles [3,4].

Anomalous radial velocity distribution of spiral galaxies is also an unresolved problem in astronomy. There are different theories for explanation of this mystery, and we can add to them the newly recognized dynamic gravitational effect [5].

Independent repetition of dynamic gravitational experiments in various international laboratories is desirable, which would, on the one hand, reinforce the reality of the dynamic gravity described in this work, but could also produce further results in understanding the nature of dynamic gravity.

[1] L. Facy and C. Pontikis, C. R. Acad. Sci. **272**, 1397, (1971)
[2] `https://en.wikipedia.org/wiki/Verlet_integration`
[3] `https://en.wikipedia.org/wiki/Pioneer_anomaly`
[4] `https://en.wikipedia.org/wiki/Flyby_anomaly`
[5] `https://en.wikipedia.org/wiki/Galaxy_rotation_curve`