

COMMUNICATSON SYSTEM BASED ON THE GRAVITATIONAL FIELD USING FOR INFORMATION TRANSMISSION

This study examines an innovative concept for transmitting information through gravitational interactions, presenting a fundamentally different approach from conventional electromagnetic communication systems. The authors propose a hypothetical model to explore the feasibility of utilizing gravitational forces for discrete signal transmission. The concept is illustrated through an analogy involving two individuals who cannot communicate visually or audibly, with using of a heavy ball, a rod, and a thread to exchange binary information. This method draws inspiration from Cavendish's experiment, which measured gravitational forces and highlights the foundational physical principles underpinning the proposed communication system.

The study acknowledges the practical challenges associated with implementing such a system, including high energy requirements, slow transmission speeds, and limited applicability in conventional scenarios. However, it emphasizes contexts where electromagnetic communication encounters significant limitations, such as in underground environments, through plasma layers, or in submarine communications. In such scenarios, the attenuation of electromagnetic signals presents substantial difficulties. Gravitational communication systems (GCS) offer a distinct advantage due to the universal and undistorted nature of gravitational forces, which remain unaffected by the medium or physical barriers.

The paper further outlines a potential framework for the practical implementation of GCS, drawing comparisons to the principles of radio technologies. A spring pendulum is proposed as a receiver, leveraging mechanical resonance to detect subtle variations in gravitational force. The transmitter design involves the movement of massive bodies to modulate gravitational force magnitudes, thereby encoding binary signals. The authors discuss both static and dynamic methods for transmitting signals, emphasizing the benefits of dynamic oscillations in achieving resonance and effectively differentiating signal amplitudes.

While the initial system is described as rudimentary, the study suggests that advancements in sensor technologies, materials science, and engineering could pave the way for GCS to become a viable solution in specialized applications. These applications could address critical communication needs in scenarios where traditional systems fail to operate effectively. This investigation opens new possibilities for harnessing gravitational interactions in communication technologies, potentially reshaping the paradigms of signal transmission in extreme or otherwise inaccessible environments.

Keywords: gravitational communication system, information transmission, gravitational field, cavendish experiment

Introduction and problem statement

Traditional communication systems, predominantly reliant on electromagnetic wave transmission, have become the cornerstone of modern information exchange [1]. These systems are efficient, versatile, and have enabled remarkable advancements in technology and connectivity [2]. However, they are not without limitations, many of which become pronounced in specific environments or under extreme conditions [3].

One major drawback is signal attenuation, which occurs when electromagnetic waves propagate through materials such as water (especially for salted sea water), soil, or dense structures. Overall, it can be asserted that there is a direct correlation between the attenuation coefficient and the electrical conductivity of the continuous medium through which the signal propagates. This attenuation increases exponentially with depth or material thickness, making

communication with underground facilities or submerged objects like submarines particularly challenging. While efforts to enhance signal strength or optimize frequencies can mitigate these issues to some extent, the solutions often prove costly, energy-intensive, or technically impractical [4].

Another significant limitation arises in environments with strong electromagnetic interference, such as plasma layers in the Earth's atmosphere or electrically noisy industrial settings (elements of power plants, welding and induction installations, radar systems, and so on). In such cases, electromagnetic signals can be distorted, scattered, or absorbed, compromising the reliability and accuracy of communication. Furthermore, these systems are vulnerable to intentional jamming, a growing concern in security-critical applications.

Environmental and health-related concerns also come into play, as the increasing density of electromagnetic signals may contribute to electromagnetic pollution. Additionally, the finite spectrum of electromagnetic frequencies necessitates careful allocation, often leading to congestion and limitations in available bandwidth.

Given these constraints, it becomes evident that alternative principles for information transmission deserve exploration. Investigating non-electromagnetic methods, such as those leveraging gravitational interactions or other physical phenomena, could offer robust solutions for extreme environments where traditional systems fail. Pursuing these avenues not only diversifies communication technologies but also enhances resilience and expands the range of applications in extreme or unconventional settings.

Main part

The exploration of alternative communication methods, distinct from conventional electromagnetic-based communication, can be initiated through the following thought experiment. Consider two individuals, A and B, who are unable to perceive their surroundings through sight or hearing. They are situated in a room containing only three objects:

- a heavy object (preferably a ball, as it should be easy to manipulate);
- a lightweight rod with weights of a certain mass attached at its ends;
- a thread attached to the ceiling.

Faced with the challenge of communicating, how might they convey information to one another? One possible approach draws inspiration from Cavendish's experiment, originally devised to demonstrate Newton's law of gravitation [5].

To establish communication, the two individuals would need to prearrange a simple protocol: the position of the ball would correspond to binary states "1" (true, high level, etc.) and "0" (false, low level, etc.), as illustrated in Figure 1. The rod should be suspended on a thread and balanced in a horizontal position. In this scenario, the first individual A takes on the role of transmitting information by manipulating the ball's position. At intervals, for example, of one minute, ind.A moves the ball to either the "One" or "Zero" position, depending on the binary information he wishes to transmit [6].

For instance, to transmit the ASCII code for the letter "A" (which corresponds to 65 code, or 1000001 in binary), the transmitter would follow a specific sequence:

- first, he places the ball in the "1" position for one minute; during this period, the rod should have enough time to rotate into the position corresponding to the "1" level (which essentially replicates the principles demonstrated in Cavendish's experiment), and to stabilize in this position, allowing the second ind. B to determine that the first transmitted bit is indeed equal to 1;
- then ind.A moves the ball to the "0" position and leaves it there for five consecutive minutes; during this time ind. B determines position of the rod (five times, for every minute) and finds that transmitted bits are 00000;
- finally, ind. A returns the ball to the "1" position for one last minute.

Thus, throughout the entire time during which ind. A transmits the signal by moving and stabilizing the ball in the required positions, the second individual monitors the movement of a rod suspended by a thread, which rotates in response to the gravitational influence of the ball's position.

The rod's behavior mirrors the ball's sequence: it shifts in one direction for the first minute, then moves to other direction and remains stationary for the next five minutes, and then moves back to its original position in the final minute.

This process effectively achieves the transmission of discrete signals using time as the discretization parameter, with the signal values being read at one-minute intervals. By leveraging simple physical principles and prearranged protocols, the two individuals successfully establish a basic communication channel.

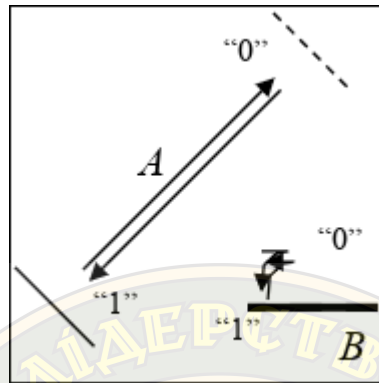


Figure 1 - A schematic representation of the proposed communication system that utilizes the gravitational field for information transmission, based on the principles of Cavendish's experiment

Thus, we have outlined a highly primitive communication system, whose fundamental characteristic lies in its reliance not on electromagnetic or sound waves, but on gravitational interaction. The question naturally arises: how can we be certain that such a system would function as intended (i.e., that the rod would respond by rotating after the ball is moved)? The answer lies in the underlying principles, which are directly inspired by the well-established Cavendish experiment [7]. As is known, in this classical experiment, massive spheres, moving from a distance, were positioned in a specific location, which caused a clearly detectable torsion of the thread on which the rod was suspended (i.e., a rotation of the rod was observed) [8-9].

While the described communication system is theoretically feasible, its practical application may seem counterintuitive at first sight due to its apparent inefficiencies. Firstly, it requires a significant amount of energy to transmit a single bit of information. Secondly, the transmission process is extremely slow. Lastly, it is difficult to envision real-world scenarios where such a system would be necessary. However, this final point is not entirely accurate. Traditional communication systems, particularly those based on electromagnetic waves, sometimes fail to provide stable connections in specific environments.

For instance, establishing communication in subterranean settings, even at shallow depths of just a few meters, presents significant technical challenges and expenses. Increasing the transmitter's wavelength and power could mitigate the issue to some extent, but this approach becomes increasingly inefficient as depth increases, due to the exponential attenuation of electromagnetic signals with material thickness.

Another intriguing yet realistic example is the need to establish communication with an object located beyond a plasma layer. Plasma, known for its complex electromagnetic properties, can significantly distort electromagnetic signals, making stable communication extremely challenging. Similarly, submarines experience communication difficulties during submersion because seawater, as a good conductor of electricity, causes high attenuation of electromagnetic signals, which also increases exponentially with depth.

These scenarios highlight the limitations of traditional electromagnetic communication systems in certain environments. This brings us back to the initial premise: information can, in principle, be transmitted using gravitational interaction. A unique feature of gravitation is its all-penetrating nature – it can pass through any medium without attenuation or distortion. A gravitational communication system (GCS) would function just as effectively through a 10-meter-thick metal plate as it would through ordinary air. For such systems, there are no barriers or distortions, making them an almost ideal form of communication.

The primary challenge lies in designing and implementing a practical gravitational communication system. In the rudimentary example presented earlier, one individual affected the “receiver” of the other by altering the position of a ball, thereby changing the direction of the gravitational force at the receiving point. However, this approach is impractical for establishing communication between two fixed points (because if the sender’s position is fixed at a single place, he will not be able to create different directions of the gravitational field at the location of the information receiver). Nevertheless, gravitational force, as a vector quantity, not only has direction but also magnitude, which can potentially be modulated and detected.

The key question is how to measure extremely small variations in gravitational force [10]. To address this, we propose drawing inspiration from the early developments of radio technology: utilizing resonance – though in this case, mechanical resonance rather than electrical resonance as in traditional radios [11]. Throughout this discussion, we will continue to draw analogies with radio systems wherever applicable, including the transmission of analog and discrete signals, the use of various modulation techniques, and other similar principles [12].

First mechanical system with resonance that comes to mind is spring pendulum (but we can use also others: particularly various constructions of physical pendulum). From the oscillation theory it is known that any system resonance frequency is $\omega_r = \sqrt{\omega_0^2 - 2\delta^2}$, where ω_0 and damping coefficient are parameters those depend on pendulum characteristics (three main of them are: spring rigidity k , moving body mass m , and mechanical resistance coefficient r). Substituting to resonance frequency we’ll have:

$$\omega_r = \sqrt{\frac{k}{m} - \frac{r^2}{2m^2}} \quad (1)$$

As is well known, in a real spring-pendulum system, the mechanical resistance force is not strictly proportional to velocity. Therefore, the relationship described in equation (1) is significantly more complex in practice, and the provided formula can only be applied as a first-order approximation.

The receiver in this system can be designed as a spring-pendulum mechanism, which facilitates maintaining receiving at a fixed resonance frequency, as described in equation (1). This approach allows for substantial energy savings during signal transmission over a given distance. Let us now turn to the organization of the transmitter.

Previously, we established that the signal would be transmitted by modulating the magnitude of the gravitational force. This can be achieved by moving one or more massive bodies within the transmitter. Naturally, this process must be automated, necessitating the use of electric motors to reposition the massive body or bodies. To optimize the system and minimize unwanted effects, we propose that the masses move in a symmetrical manner. This arrangement ensures that the transmitter remains stationary as a whole and reduces bending stresses on its structural components.

In our view, two massive bodies are sufficient for this design. These bodies would move along a single linear segment, transitioning between two positions: from the edges (representing “1”) to the center (representing the transmission of “0”), as illustrated in Figure 2.

As it is seen from figure 2, when massive bodies 3 are near the center of segment (at the point O) spring pendulum fixes resultant force that is equal to simple algebraic sum of separate forces modulus F_1 and F_2 :

$$F = F_1 + F_2 = 2F_1.$$

If body 4 experiences force $2F_1$, it means transmitting of “0”. If we need to transmit “1” then bodies 3 must be placed to the edges of segment (at the points lying at the distance A from point O). Then as it is shown on figure 2 resultant force will be

$$F = F_1 \cos w + F_2 \cos w = 2F_1 \cos w,$$

that is smaller than $2F_1$ and receiver must distinguish this difference (also modulus of forces F_1 and F_2 becomes smaller as distance to pendulum bob lightly increases; we don't take into account this circumstance but it will increase difference between two resultant force values). Of course this difference (equal to $\cos w$) depends on A to d ratio, where d is distance between transmitter and receiver. In practical applications this ratio may be smaller than one percent and so on, but if we will use precise sensors 7 (like piezoresistive strain gage) it can be possible. Anyway if d is 100 m and A is taken as 1 m such difference between force of “0” and “1” can be picked up, so at the start we can review Popov's experiments of wireless words transmitting using electromagnetic waves and oscillatory circuit (as well-known first transmission was carried out in 1896 on 100 m distance and now we have very highly developed electromagnetic communication).

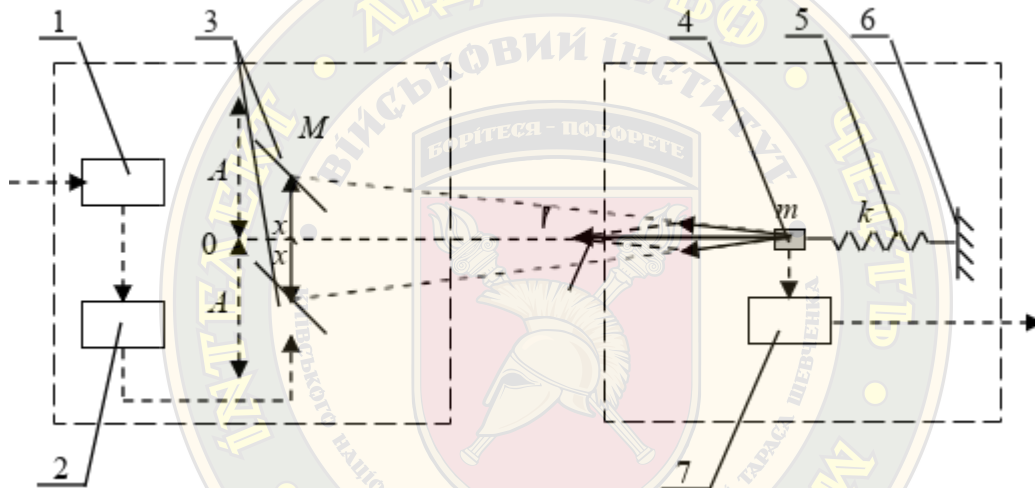


Figure 2 - A possible design option for a gravitational communication system focused on measuring the magnitude rather than the direction of the gravitational force

Fig. 2 also shows simple structure of proposed communication system. 1 – is control device that receives input chain of bits and works out control commands to powerful motors 2 that move massive bodies 3. On the other side of communication system receiver consists of spring pendulum bob 4, that experiences gravitation force and moves to two different places according to position of massive bodies 3. Precise sensor 7 picks up position of bob 4 and forms output bit chain. Also at the receiver there are spring 5 and fixed bearing 6.

System may work in simple static way with discretization by time: at the agreed time bodies 3 are placed to the point O (and it means transmission of “0”) or to the distance of A from point O (and it means transmission of “1”). During adjusted time interval bodies 3 rest in appropriate position and then may be moved to other position (if during next time interval must be transmitted other bit value) or stay motionless (if during next time interval must be transmitted the same bit value). This static method is equivalent to transmission of bits by setting some magnitude of electrostatic field intensity: high magnitude equals to “0” and low equals to “1” (or vice versa). Receiver measures magnitude (is it high or low level) and realize what is transmitted. From the

wide experience of electromagnetic communication it is clear that this method has many disadvantages:

- static fields superposes very well and it is impossible to isolate signal from various transmitters;
- transmission rate cannot be high because we need to wait for some time after magnitude changing in view of transient processes;
- difference between two (or many – during impulse coding) levels must be considerable because in this static case we cannot use resonance amplification as it was claimed earlier.

Other more realizable way of proposed system functioning is to use dynamic positioning of bodies 3 that allows to use resonance. When we need to transmit “0” bodies 3 must be moved sinusoidal with big amplitude A_1 for some oscillations (amplitude of bodies 3 oscillations must be enough to establish stable oscillations of bob 4). When we need to transmit “1” bodies 3 move with small amplitude A_2 . In the first case bob 4 also oscillates with big amplitude and in other its oscillation amplitude is small. This amplitude is measured by sensor 7 that forms output bit (bit chain). Calculations show that bob 4 amplitude will be:

$$A_B = \frac{F}{r \sqrt{\frac{k}{m} - \frac{r^2}{4m^2}}} = \frac{2F_1}{r \sqrt{\frac{k}{m} - \frac{r^2}{4m^2}}} \cdot \frac{A^2}{4d^2} = \frac{2GMm}{r \sqrt{\frac{k}{m} - \frac{r^2}{4m^2}}} \cdot \frac{A^2}{4d^4} = \frac{GMm^2}{r \sqrt{4km - r^2}} \cdot \frac{A^2}{d^4}$$

and if damping is small:

$$A_B = \frac{GMm^2}{r \sqrt{4km - r^2}} \cdot \frac{A^2}{d^4} \approx \frac{GMm}{2r} \sqrt{\frac{m}{k}} \cdot \frac{A^2}{d^4}$$

As it is seen dependence of bob 4 amplitude AB on massive bodies 3 amplitude A is square, so even small change of A from A_1 to A_2 causes much more great change of AB that is fixed by precise sensor 7. In this way, amplitude modulation can be implemented, analogous to that traditionally used in radio transmission.

Also using of dynamic oscillation allows to use concrete frequency of transmission, so various gravitation devices may work in parallel.

Conclusion

In conclusion, the study presents a novel concept of communication with using gravitational interactions, offering an alternative to traditional electromagnetic-based systems. While the proposed gravitational communication system remains largely theoretical and faces numerous practical challenges, it opens new avenues for addressing scenarios where conventional methods fail. The unique properties of gravitational forces, such as their immunity to attenuation and distortion across different environments, provide a promising foundation for robust and reliable information transmission, especially in extreme or inaccessible conditions.

The work emphasizes that, despite its current limitations (such as the need for significant technological advancements in sensitivity and efficiency) the concept of gravitational communication has the potential to revolutionize the way we think about connectivity. By drawing analogies with the early development of radio technology, the study highlights the feasibility of overcoming technical barriers through innovations in mechanical resonance, precise sensors, and efficient system designs.

Ultimately, this exploration underscores the importance of investigating alternative physical principles for communication, aiming to supplement and enhance existing technologies. As the field advances, gravitational communication may evolve from a theoretical possibility into a practical solution, addressing critical communication needs in specialized and challenging environments.

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СИСТЕМА ЗВ'ЯЗКУ ОСНОВАНА НА ВИКОРИСТАННІ ГРАВІТАЦІЙНОГО ПОЛЯ ДЛЯ ІНФОРМАЦІЇ

У цьому дослідженні розглядається новітня концепція передачі інформації через гравітаційну взаємодію, представляючи принципово відмінний підхід від традиційних електромагнітних систем зв'язку. Автори пропонують гіпотетичну модель для дослідження можливостей використання сил тяжіння для передачі дискретного сигналу. Концепція проілюстрована за допомогою аналогії за участю двох осіб, які не можуть спілкуватися візуально або на слух, за допомогою важкої кулі, стрижня та нитки для обміну двійковою інформацією. Цей метод заснований на принципах, що є основою експерименту Кавендіша, який виміряв гравітаційні сили та підкреслив фундаментальні фізичні принципи, що лежать в основі запропонованої системи зв'язку.

Дослідження висвітлює практичні проблеми, пов'язані з впровадженням такої системи, включаючи високі потреби в енергії, повільну швидкість передачі та обмежену застосовність у звичайних сценаріях. Однак тут наголошується на випадках, де електромагнітний зв'язок стикається зі значними обмеженнями, наприклад, у підземних середовищах, при необхідності передачі інформації через плазмові шари або при організації підводного зв'язку. У таких сценаріях ослаблення електромагнітних сигналів представляє значні труднощі. Гравітаційні комунікаційні системи (ГКС) пропонують явну перевагу завдяки універсальній та всепроникній природі гравітаційних сил, на які не впливає середовище чи фізичні бар'єри.

Далі в роботі окреслюється потенційна основа для практичного впровадження ГКС, проводячи порівняння з принципами радіотехнологій. Пружинний маятник пропонується як приймач, який використовує механічний резонанс для виявлення тонких коливань сили тяжіння. Конструкція передавача передбачає рух масивних тіл для модуляції величин сили тяжіння, таким чином кодуючи двійкові сигнали. В статті обговорюються як статичні, так і динамічні методи передачі сигналів, наголошуючи на перевагах динамічних коливань у досягненні резонансу та ефективній диференціації амплітуд сигналів.

Хоча перша запропонована система описується як надзвичайно елементарна, дослідження показує, що прогрес у сенсорних технологіях, матеріалознавстві та інженерії може прокласти шлях для того, щоб ГКС стала життєздатним рішенням у спеціалізованих додатках. Ці рішення можуть задовольнити критичні потреби зв'язку в сценаріях, коли традиційні системи не працюють ефективно. Це дослідження відкриває нові можливості для використання гравітаційних взаємодій у комунікаційних технологіях, потенційно змінюючи парадигми передачі сигналу в екстремальних чи інішим чином недоступних середовищах.

Ключові слова: Система гравітаційного зв'язку, Передача інформації, Гравітаційне поле, Дослід Кавендіша.