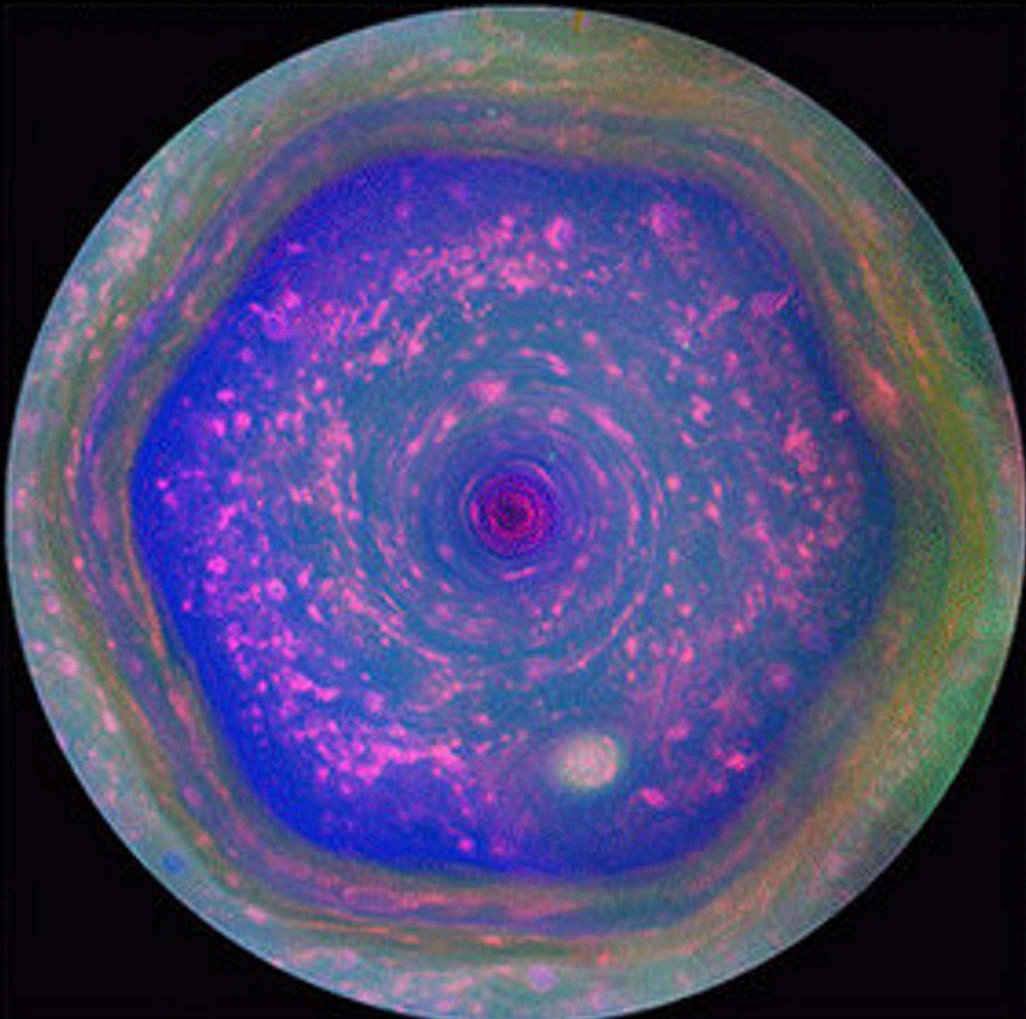

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Gravitomagnetism: Nature's Phenomena, Experiments, Mathematical Models

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Chapter 3. About the Possibility of Using Gravitational Forces to Perform Work

It is proved below that the source of conservative forces (including gravitational forces) performs work on **closed** trajectories of multiple bodies' motion, if these bodies are not rigidly connected and between them forces dependent on the speed of these bodies are acting. A shortened version of this study has been published in [1, 2, 3] as an appendix.

We shall begin with considering some examples.

Example 1. There is an electrical charge Q and another charge q_1 much smaller by its value: $q_1 << Q$. The Coulomb forces acting of the charge q_1 from the side of the charge Q do not perform any work on a closed path of the motion of the charge q_1. Let there be another charge $q_2 << Q$, and both the charges q_1 and q_2 are moving along closed paths that are near to each other. Then the Lorentz forces are acting between the charges. Let the medium, in which the charges q_1 and q_2 are moving, provides some resistance to their motion. Then under the influence of the Lorentz forces a certain work will be performed. The energy for this work is provided from the electrical charge Q. This is similar to the fact that the Lorentz forces acting as the Ampere forces perform work by the energy of the electrical current source. Thus, the source of the Coulomb forces performs work on closed paths of the two charges' motion.

Example 2. There is a DC motor with self-excitation, in which the armature winding and the electromagnetic field are connected in series or in parallel. In such a motor, the energy source is a DC voltage source, i.e. a source of the Coulomb forces. This source explicitly performs work.

In the general case from these examples it follows that the source of the Coulomb forces performs work on the closed trajectories of multiple unconnected charges' motion. As the Coulomb forces are conservative, then the previous conclusion is equivalent to the following:

0) The source of the conservative forces performs work along the **closed** trajectories of multiple bodies' motion, if

- the body represents something, on which the conservative force is acting,
- The bodies are not connected rigidly,
- The forces are acting among the bodies and depend on the speed of these bodies' motion.

The conservative forces (by definition) do not perform work on a closed trajectory. The force of gravity is a conservative force (which is proved mathematically). Hence the conclusion is reached that

> 1) there does not exist a motor using only conservative forces (specifically, the force of gravity) to perform work.

Next *an unproven* conclusion is made that

> 2) there **does not exist** a motor using **the energy** of conservative forces' source (including the gravity forces) for performing the work.

The Coulomb forces are also conservative. From this by analogy one can make conclusion 1 written above. However, conclusion 2 is easily refuted by previous assertion 0. Therefore, in the general case, assertion 2 is incorrect, and the true statement is as follows:

> 3) **There can exist** a motor using **the energy** of conservative forces' source for performing work.

Nevertheless, the existence of the motor that uses energy of the **electrical** <u>conservative</u> forces' source (ECF) does not mean that there is a motor that uses the energy source of the **gravitational** <u>conservative</u> forces (GCF).

The electrical forces create the charges' motion along a closed trajectory, namely the *electric current* that forms a magnetic field. Due to this the energy of ECF turns into magnetic energy. It occurs even if the energy is not expended <u>for the motion</u> of the charges on the closed path. Thus, the ECF energy exceeds the energy of the mechanical motion of the charges. This is the reason for the existence of a motor using the ECF energy.

The gravity forces also can create a mass motion on a closed trajectory, i.e. the *mass current*. Let us assume that the mass current also forms a *gravitomagnetic* field. This is shown in Chapter 1. Then by analogy with the previous we may assume that

> 4) **there can** exist a motor using the **energy** of the source of **gravity** conservative forces for performing work.

This does not contradict the law of conservation of energy: the energy of GCF is converted into work, and the GCF energy source loses some of its energy. It cannot be said here that the GCF energy may be used <u>only</u> for the movement of the masses.

Let us approach the treated subject on the other hand.

The gravity force is a conservative force. This means that the gravitational work is not influenced by the motion trajectory and determined only by the initial and final positions of the point of this force application. This statement does not consider the velocity of this point. As a rule, the gravitational work is not influenced by this velocity. For instance, the gravitational work can be spent on both overcoming friction and changing the velocity of the point. In this case, the spent potential energy of the body is equal to the work of the frictional force (directed **opposite to** the force of gravity) and the increase of the body kinetic energy does not depend on both the trajectory and the motion velocity.

Let's call the work of the force of gravity, which is independent of velocity and trajectory, the **conservative** work of the force of gravity. Apparently, in mechanics there is no example when the speed of movement affects the work of the gravity force, i.e. when the work of the gravity force is not conservative.

However, formally such an example can be found. Suppose that the "quasi-frictional" force is directed **along** the force of gravity and depends on the velocity. In addition, this "quasi-frictional" force is formed due to some movement under action of the gravity force. This is similar to the creation of the force of ordinary friction. Then the increase in the kinetic energy of the body is equal to the sum of the conservative work and the work of the "quasi-frictional" force. However, the latter is also performed by the gravity force (on the assumption just adopted). Consequently, in this case the work of the gravity force is greater than the conservative work, i.e. the work of the gravity force is not conservative.

Apparently, one cannot find the aforementioned case in a purely mechanical system. However, this case is possible in the electromechanical system. Let us consider the motion of charged bodies representing heavy electric charges (HEC) in the field of the gravity force. Such charges are affected by the gravity forces, the electric attraction / repulsion forces, and the Lorentz forces. As it is known the Lorentz forces do not perform work, but they use the work of external forces. In this case, these are gravity forces because the electric forces can be neglected. Since the Lorentz force depends on the velocity, in this case the gravity forces' work also depends on the velocity of motion of the HEC along the considered trajectory.

Thus, **in the electromechanical system the forces of gravity are not conservative**. Note that there is another case of fundamental difference between the laws in mechanics and electromechanics: Newton's third law is observed in mechanics but not in electromechanics because of the existence of the same Lorentz forces in the latter.

It follows from the basic equations of the general relativity theory that in a weak gravitational field at low velocities, i.e. on the Earth, one can use the MGM equations to describe gravitational interactions. This means that there are gravitational waves, and the gravitomagnetic Lorentz force (GL force) affect the mass m moving in the gravitomagnetic field with the velocity v.

So, in the mechanical system (as well as in the electromechanical system) the Lorentz forces can arise, i.e. **in the mechanical system the forces of gravity are not conservative if motion under the action of gravity causes the appearance of the gravitomagnetic Lorentz forces.**

Thus, **the force of gravity can do work**.

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