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# GRAVITATION, ROTATION AND MAGNETISM

by

J. W. Gardner, Ph.D.
Staff Hotel
Deep River, Ontario, Canada

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Summary

The connections between gravitation, rotation and magnetism are examined in terms of both classical and quantum physics. The concept of "gravitons" introduced by quantum theory is found to fit in logically with certain macroscopic phenomena. In particular, the fact that when a massive body rotates its gravity decreases and its magnetic moment increases, both in proportion to the speed of rotation, is readily understood if we assume that gravitons may be "polarised" i.e. have magnetic moments which may be aligned by a sufficiently strong magnetic field. From this it follows that gravity insulators are most likely to be found among intensely magnetic substances.

# GRAVITATION, ROTATION AND MAGNETISM

Newton in formulating his laws defined "force" as that which causes a change of motion, whether in magnitude or direction. This led to conceptual difficulties about action at a distance in the case of gravitational and electrical forces which could be shown to act between bodies even when there was no material medium between them to transmit the force. An attempt to overcome this difficulty by the introduction of an all-pervading "ether" only introduced new difficulties about the improbable and almost self-contradictory properties of the ether itself. (For example, in order to transmit electromagnetic waves with their observed speed of $3 \times 10^{10}$ cm./sec. the ether would have to have an elastic strength far, far greater than that of the strongest materials known, yet at the same time it would have to be so tenuous as to evade all attempts to observe it directly). Gradually, however, it was found that all the equations of motion could be written down without bringing in forces. What was observed was a certain relation between acceleration and configuration: thus the acceleration towards each other of two masses $m_1$, $m_2$ is proportional to $m_1m_2/r^2$, where r is the distance separating them. To say that this acceleration is due to the "force" of gravitation, while it may sometime be a verbal convenience, adds nothing to our knowledge.

This identification of gravitational force with acceleration is usually illustrated by inviting the student to imagine himself in an elevator of which the cable has broken. Since he and the elevator are both falling freely to earth with the same acceleration of about 32 ft./sec. there is no reaction between his feet and the floor of the elevator - in other words gravity has "vanished" for the occupant of the elevator. A less drastic, and almost as convincing demonstration of the same principle may be experienced at fun-fairs by means of a device which is essentially an outsize cylindrical barrel with a receding bottom. Thrill-seekers enter this barrel which is then rotated about its (vertical) axis. The passengers, because they are carried around with the barrel are having the direction of their motion changed continuously: they experience an acceleration towards the centre, this acceleration being communicated to them by the walls of the barrel. In popular parlance they would say that "centrifugal force" presses them against the sides of the barrel. At sufficiently high speeds of rotation this lateral pressure is so great that the floor of the barrel may be withdrawn, leaving the passengers in mid-air, as it were, still pressed against the sides, the friction called into play by the pressure being sufficient to hold them there against gravity.

The connection between gravitation and rotation is also evidenced by the rotation of the earth. The centrifugal force - let us call it that for verbal economy - due to the earth's rotation acts in opposition to gravity: it is greatest at the equator, where the tangential velocity is greatest, but even here it is still so small that one is not sensible to any reduction in gravity. However, it is well established by observations with sensitive gravity-meters at various latitudes that this reduction in gravity does occur, and is greatest at the equator. Moreover, a calculation in elementary dynamics shows that if the earth were speeded up to rotate eighteen times instead of once a day the centrifugal force at the equator would almost exactly balance gravity; an even greater speeding up would result in objects at the earth's equator being flung off into space.

Recently a connection between the rotations of massive bodies and their magnetic moments has been disclosed by the observations of Blackett and others (1-4) on the earth and on certain stars. There is an approximate proportionality between the angular momentum and the magnetic moment and - what is probably significant - the constant of proportionality involves the universal gravitational constant G. Now we have just seen that if the earth's rotation were speeded up the gravity experienced by objects at its surface would be reduced; Blackett's result tells us that this reduction of gravity would be accompanied by an increase in the earth's magnetic moment. Conservation of energy would have told us that the "lost" gravitational energy must go somewhere, and we now see that it reappears as magnetic energy.

We have talked above about speeding up of rotation, but in the evolution stars slowing down is more common, this being accompanied by a flow of magnetic energy into gravitational energy. This must have happened in the case of our own planet, and in this sense Rideout's (5) conjecture that gravity originates from magnetic energy is correct. However, we should bear in mind that the flow may take place in either direction depending on circumstances; thus the statement that gravity derives from magnetism and the statement that magnetism derives from gravity are the same. Gravitation and magnetism are but different aspects of the same basic physical entity.

So far we have been considering the connections between gravitation, rotation and magnetism on a macroscopic scale only. Do these connections also apply on the ultramicroscopic - the subatomic - scale, or do we have to revise our views completely, as so often happens on passing from classical to quantum physics?

According to modern quantum-field theories any interaction (gravitational, electromagnetic or nuclear) between two bodies must occur by mutual emission and absorption of certain ultramicroscopic particles which are fundamental and peculiar to the field in question. In the case of the gravitational field these particles are called gravitons (6,7): they obey certain equations of the field, and it follows from the nature of these equations that each graviton has an intrinsic angular momentum of $2\hbar$, where $\hbar$ is the "quantum" of angular momentum and has the value $1.054 \times 10^{-27}$ erg.sec.*. It has been found that many other particles of quantum physics also have intrinsic angular momentum, and it seems to be an empirical rule that this angular momentum occurs in association with magnetic moment. Although the angular momentum and magnetic moment are not simply proportional to each other, as on the macroscopic scale, there is nevertheless some correlation: particles with large angular momentum tend to have large magnetic moments, and vice versa; in particular zero angular momentum is always associated with zero magnetic moment. Now the graviton's angular momentum of $2\hbar$ is relatively large on the quantum scale - electrons and nucleons for example have only $\hbar/2$, while some kinds of mesons have zero angular momentum. Hence we should certainly expect gravitons to have <u>some</u> magnetic moment, and would not be surprised if it turned out to be relatively large.

We have considered the macroscopic and microscopic aspects of gravitation, and its connection with angular momentum and magnetic moment. Let us now try to piece these two sets of considerations together to obtain an overall understanding of the mechanism by which gravity acts. If we understand this mechanism, even partially, we may hope to see more clearly how to influence gravity and harness it for human needs.

First let us consider the inverse square law of gravitational attraction: this is a macroscopic effect, but it can be understood very simply on the microscopic theory. On the latter theory the gravitational attraction between two bodies A and B is envisaged as the mutual emission

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* $\hbar$ is used to denote Planck's constant, h, divided by $2\pi$ .

and absorption of gravitons: body A emits a graviton which is absorbed by body B, or vice versa. This process repeated continuously with vast numbers of gravitons gives rise to the macroscopic attraction; the more gravitons from A absorbed by B per second the stronger is the pull of A on B, and conversely. Since the gravitons are emitted uniformly in all directions their flux per unit area across the surface of a sphere having the source (A or B) at its centre must fall off inversely as the surface area of the sphere, for the larger this area the more thinly are the gravitons spread over it. But the surface area of a sphere is $4\pi r^2$ where r is its radius. Hence the flux of gravitons, and therefore the gravitational attraction, falls off as $1/r^2$ i.e. inversely as the square of the distance from the source. Thus the inverse square law, which at first sight appears rather mysterious, is seen to be a necessary consequence of the 3-dimensional world in which we live. (In a hypothetical n-dimensional world the surface area of a sphere varies as $r^{n-1}$ which would give rise to an inverse $(n-1)^{th}$ law of gravitation).

Now let us enquire whether the theory of gravitons can give us any deeper insight into the other macroscopic phenomenon discussed earlier, namely the fact that when a massive body rotates its gravity decreases and its magnetic moment increases, both in proportion to the speed of rotation. If, as we have seen it to be entirely plausible, gravitons have magnetic moments these moments may be aligned by a sufficiently strong magnetic field; in particular, since a massive rotating body has a magnetic field it follows that the gravitons emitted by such a body will have their moments to some degree aligned, instead of being randomly directed as they would if the body were at rest and there were no other magnetic fields present. By analogy with optics we say that a beam of gravitons with all their moments aligned is "polarised" and one in which the moments are randomly arranged is "unpolarised"

Now it is well known in optics that a polarising agent reduces the intensity of a beam of light at the same time as polarising it. If the same applies to a beam of gravitons we have an immediate explanation of the weakening of gravity by rotation: the magnetic field induced in a massive body by its rotation partially polarises the beams of gravitons, whether incoming or outgoing, by which it interacts with other gravitating bodies, and this polarisation is accompanied by a weakening of the gravitational intensity of the beam. Even if this optical analogy were proved untenable by future research we would still feel reasonably confident that, whatever the mechanism, a weakening of gravitational attraction is somehow a necessary concomitant of the polarisation of the graviton beam: it would be too great a coincidence if these two phenomena occurring side by side in massive rotating bodies had nothing whatever to do with each other - Nature just does not work that way!

From the foregoing discussion it seems very likely that a profitable line of enquiry in the search for a partial gravity insulator would be in the direction of developing intensely magnetic materials which would act as polarisers of the earth's graviton beam. First it is suggested that experiments be conducted with the strongest magnetic alloys already known. A differential arrangement could be set up to measure the gravitational attraction between two massive (and, of course, non-magnetic) bodies (a) when separated by an air gap, and (b) when separated by an equal thickness of some intensely magnetic alloy, such as ticonal. We should not, of course, expect a very dramatic effect in this experiment since if an existing alloy were any more than a slight gravity insulator this would already have been noticed; the experiment would, however, reveal an effect too small to show in everyday experience yet large enough to register on delicate gravity instruments*. The result

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* We saw one example of such an effect in the reduction of gravity at the equator, due to the earth's rotation.

of such a test may indeed be quite negative, but this is no argument for not making it. A negative result may simply mean that even the most intensely magnetic materials at present known are not sufficiently effective in polarising gravitons for the resulting reduction in gravity to be measured with existing apparatus. However, we may be confident that more intensely magnetic alloys will in time be produced for, quite apart from their possible use as gravity insulators, there is a continuing scientific and industrial demand for magnetic alloys as such.

The Gravity Research Foundation should urge that whenever a new and powerfully magnetic substance is produced a sample automatically be despatched to an approved laboratory (e.g. The National Bureau of Standards) for routine testing as a gravity insulator by the most sensitive apparatus available. This would not involve any large outlay of funds as would a new research project - although even if it did, it seems to the author that such outlay would be well justified in view of the untold possible benefits to mankind. Even the smallest degree of gravity insulation once definitely established by reputable laboratory tests should give powerful stimulus to industry to produce a more effective insulator.

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