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DETECTION OF NON-NEWTONIAN GRAVITATIONAL EFFECTS WITH QUANTUM FLUIDS

Robert L. Forward

Hughes Research Laboratories
Malibu, California

ABSTRACT

Quantum fluids, such as the superfluid component of liquid helium and the superconductive electrons in a superconductor, have the property that once a current flow is generated, it will not decay. These fluids therefore have the capability of integrating small continuous forces acting on the superfluid component. It is found that superconductive devices may be able to measure the non-Newtonian gravitational drag effect of a rotating mass.

It was pointed out in a previous essay[1] that the General Theory of Relativity predicts many non-Newtonian gravitational effects, in addition to the usual Newtonian attraction if the attracting mass is in motion. These effects will cause forces on a nearby body that depend in a complicated way on the position and motion of the body and the attracting mass.

If we have a rotating mass, then besides the radial force exerted by the Newtonian gravitational attraction

$$\dot{v}_r \propto \frac{GM}{r^2}$$

which is of zero order in v/c, there is a tangential coriolis type force that is exerted if the body is moving

$$\dot{v}_t \propto \frac{GM}{r^2} \frac{\omega r}{c} \frac{v}{c}$$

which is only of first order in the rotational velocity of the rotating mass. However, it is also dependent upon the velocity of the sensing body, so it is really of second order in v/c. This is the well known Lense-Thirring effect. There is also a radial centrifugal type force exerted on a stationary body by a rotating mass

$$\dot{v}_r \propto \frac{GM}{r^2} \frac{\omega^2 r^2}{c^2}$$

which is of second order in the rotational velocity of the rotating mass. These forces, which imitate centrifugal and coriolis forces, are the ones that are usually mentioned.in the literature.

The only tangential force on a stationary body near a rotating mass is

$$\dot{v}_t \propto \frac{GM}{r^2} \frac{\omega^3 r^3}{c^3}$$

which is of third order in the rotational velocity of the rotating mass. (This was obtained from Eq. 8 of Ref. 1).

All of these forces are very small, so it would be desirable to devise detectors that integrate these forces over long periods of time in order to obtain a measurable quantity.

Quantum fluids, such as the zero viscosity superfluid component of liquid helium below the lambda point and the zero resistive component of the conduction electrons in metals below their superconductive transition point, have the property that once a current flow is started, it will persist indefinitely. These fluids therefore have the capability of integrating small continuous forces acting on the superfluid component.

If we have either a superconducting [illegible] or a tube of liquid helium II near a rotating body, then these non-Newtonian effects will exert forces on the various components. The forces on the container or the normal portions of the fluid will be counteracted by elastic restoring forces or dissipated by frictional effects, but the forces on the superfluid component will be integrated and will build up a flow of current.

However, to use these quantum currents, it is necessary to have a continuous closed circuit for the current. It has been found that if a circuit is arranged to sense the radial non-Newtonian forces, then the the forces in one part of the circuit will be opposed by forces in another part of the circuit. If, instead, we arrange the circuit to sense the tangential part of the non-Newtonian forces, then the tangential forces will transfer energy and angular momentum from the rotating mass to the quantum fluid. Unfortunately, this effect is of third order in v/c, but integration over long periods of time will help to overcome this.

As a specific example, let us take a rotating mass of about 10^3 kg and radius 1 foot (1/3 meter), and rotate it to nearly the breaking point. Beams[2] has shown that this point is independent of the size of the rotating object and occurs when the tip speed is approximately 10^3 m/sec ($v/c = 3 \times 10^{-6}$). The non-Newtonian tangential acceleration for any object along the perimeter of the wheel is then approximately

$$\dot{v}_t \propto \frac{GM}{r^2} \frac{v^3}{c^3} \approx 10^{-23} \text{ m/sec}^2$$

If we let this acceleration build up for ten days (10^6 sec), then the induced velocity will be

$$v_t \approx 10^{-17} \text{ m/sec}$$

This is a very, very slow velocity and one would think that it would be unobservable. However, if we place a bundle of superconducting wires with an effective cross sectional area of 1 cm^2 near the perimeter of the rotating wheel and lower the temperature of the wire sufficiently below the critical temperature so that most of the electrons are superconducting, then the total current due to the motion of the superconducting electrons moving at this very slow velocity is

$$I = n_s \, e \, v_t \, A \approx 10^{-11} \text{ amps}$$

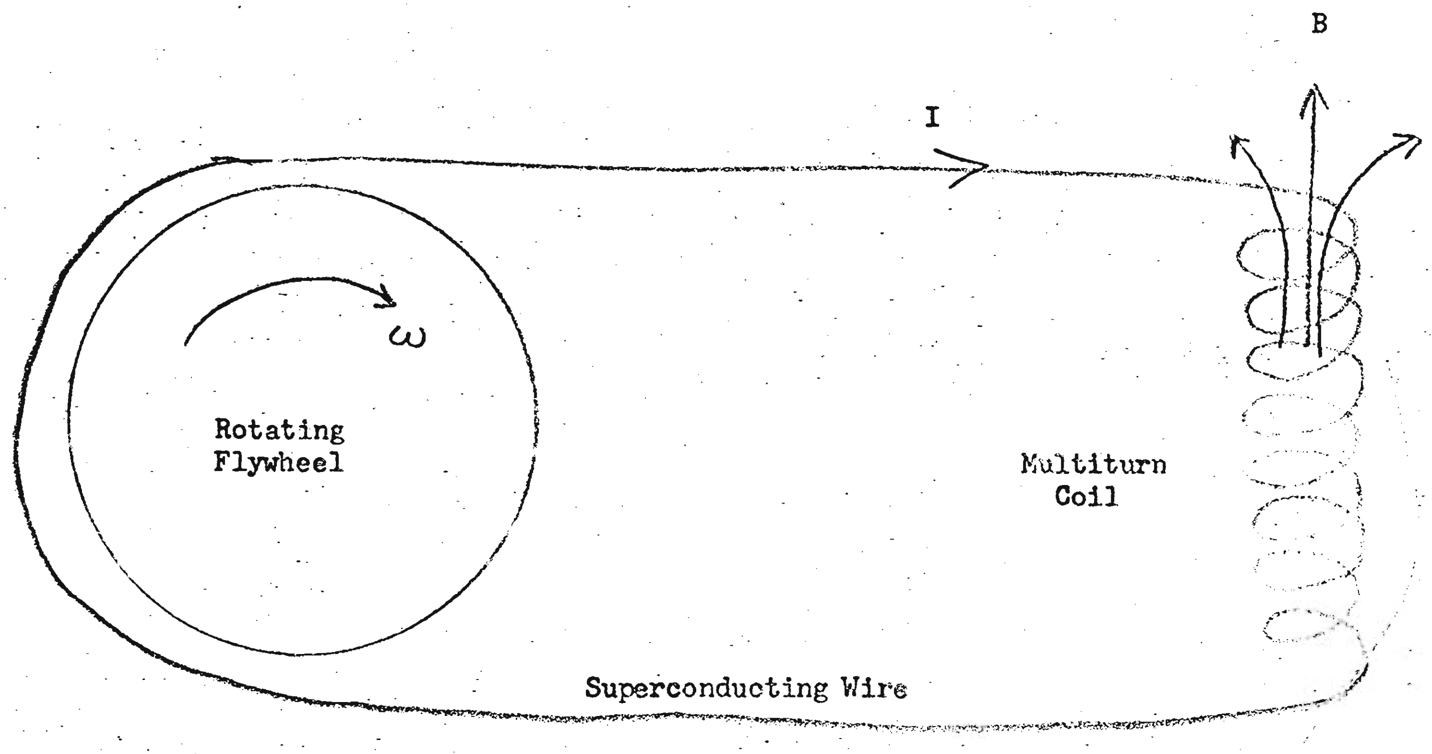
This is a very small current, but even smaller ones can be measured in high impedance circuits by commercial electrometers.

One way of measuring these small currents is to run them through a multiturn coil and create a magnetic field. If we assume a 10^4 turn coil on a 1 cm radius coil form, then the magnetic field is

$$B = \frac{\mu N I}{2 r} \approx 10^{-7} \text{ gauss}$$

which is small, but measureable.

Similar experiments could be considered with liquid helium superfluid. Although there are no easily measured properties to indicate superfluid flow due to the electrical neutrality of helium, there is also less likelyhood of unwanted interference. It is possible that the angular momentum amplification properties of superfluid flow as described by Reppy and Depatie[3] could be of aid in amplifying the very small motion induced by the non-Newtonian gravitational forces.



SUPERCONDUCTIVE DETECTION OF NON-NEWTONIAN
GRAVITATIONAL DRAG EFFECTS

1. Robert L. Forward, "Guidelines to Antigravity", Am. J. Phys. 31, 166-170, (March 1963); also Gravity Research Foundation Essay for 1962.
2. J. W. Beams, "Ultra High Speed Rotation", Sci. Am., 204, 134-137, (April 1961)
3. J. D. Reppy and David Depatie, "Persistent Current in Superfluid Helium", Phys. Rev. Let., 12, 187-189 (24 Feb 1964)