H. David Froning, Jr., Terence W. Barrett and George Hathaway

Laboratory investigations of specially-conditioned EM fields*

SECOND PLACE IN THE ELECTRIC SPACECRAFT COMPETITION WAS AWARDED TO H. DAVID FRONING, JR. AND TERENCE W. BARRETT FOR THEIR PAPER, "ELECTRIC SPACECRAFT PROPULSION BY SPECIALLY-CONDITIONED EM FIELDS." (SEE *ESJ* 24:17-22.) THIS IS AN UPDATE. PRELIMINARY TESTS OF SOME OF THE CONCEPTS PRESENTED IN THE ORIGINAL PAPER HAVE BEEN COMPLETED IN A COLLABORATIVE EFFORT WITH GEORGE HATHAWAY AT HATHAWAY ASSOCIATES, TORONTO. THE LATEST FINDINGS ARE PRESENTED WITH AN OUTLINE FOR THE DIRECTION OF FUTURE EXPERIMENTATION.

DEFINITIONS

In its most general sense, **symmetry** is defined as that property of a physical system which allows it to remain unchanged through transformation (translation, rotation, or reflection). The symmetries used to group similar particles in quantum physics apply to the mathematical expression of such properties as isospin and strangeness. One type of symmetry, SU(2), describes the interactions of the weak nuclear force among elementary particles and therefore gravity. Another type, U(1), describes the electromagnetic field.

An **abellan** group is a set of objects over which an operation on two elements yields the same result, regardless of which element acts on the other. Over the real numbers, addition is abelian, $a + b = b + a$; but subtraction is not, $a - b = -(b - a)$. According to modern physics, gauge fields are responsible for transmitting the conventions of symmetries from one part of space to another. The gauge field associated with electromagnetic radiation appears to be abelian, but the gauge field associated with gravity is believed to be nonabelian.

Froning *et. al.* are trying to modify the symmetry and commutativity of EM radiation to make it compatible with gravity. They hope that the specially-conditioned EM radiation thus produced will then interact with gravitational fields by means of A-vector potentials. The **A-vector potential** is a concept introduced to the field of magnetostatics in order to simplify problem solving. Paralleling electrostatics equations, a potential concept **A** was introduced, the curl of which is the magnetic field vector: $\mathbf{H} = \nabla \times \mathbf{A}$. The **A**-vector potential can be used to calculate magnetic field vector quantities, but it is not known how it would directly manifest itself.

Gravitational fields do not strongly couple with ordinary electromagnetic fields because they are of a different form and symmetry. To increase such coupling for favorable manipulation of gravity or inertia, Froning and Barrett have investigated the possibility of altering the form and symmetry of electromagnetic fields to make them more similar to gravitational fields. At present, two ways of altering EM fields are being considered: polarization-modulation of EM energy emitted from radars or lasers, and generation of vector potential-wave patterns by driving AC current through appropriate toroidal shaped coils.

POLARIZATION-MODULATED RADIATION (PMR)

A means of creating specially-conditioned EM radiation of SU(2) symmetry and nonabelian form by means of polarization modulation was described by Barrett.[1] Input EM wave energy would be divided into three fractions. One fraction would have its polarity rotated 90° and its phase modulated. Another fraction would be expended in the process of phase modulating the polarization-rotated wave energy. The remaining fraction of the input wave energy would then be combined with the polarized and phase-modulated wave energies at a mixer, and the emission of specially-conditioned EM radiation with continually-varying polarization with respect to time would result.

It is not yet obvious what portions of the EM spectrum will be most appropriate for interacting with the spacetime metric/gravitation by means of polarization-modulated radiation, or what degree of polarization modulation would maximize the interaction. For a given

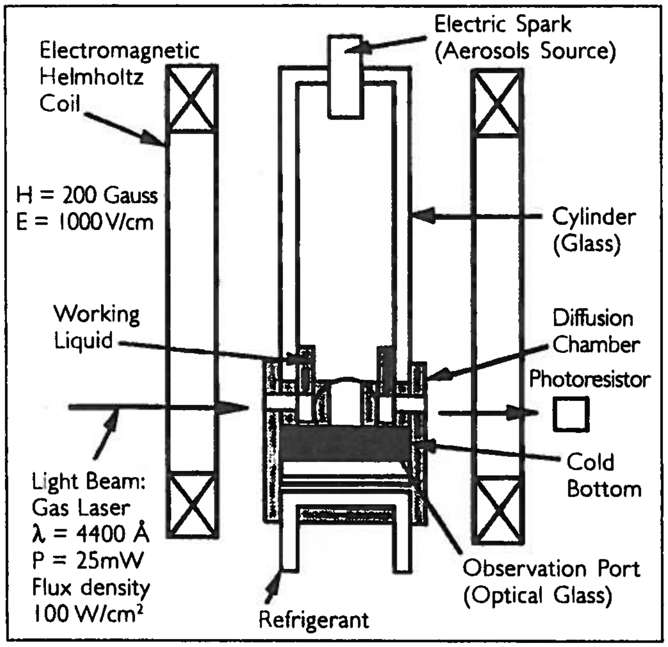

Fig. 1 Ferromagnetic Aerosol Experiment Apparatus

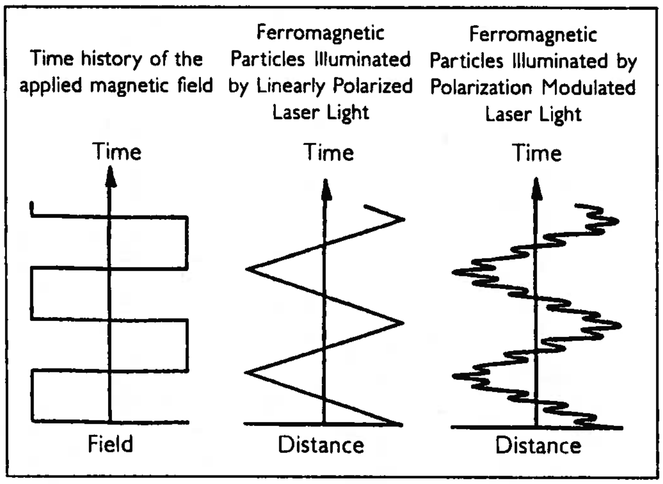

Fig. 2 Ferromagnetic Aerosol Experiment Results

input power, polarization-modulated radiation can be focused into beams of the narrowest widths and highest intensities with laser systems, but it can affect a greater volume of space with the broader beam widths of microwave systems. Polarization modulation of both laser and microwave systems are therefore being studied.

PRELIMINARY EXPERIMENTS WITH PMR

Experimental work by Mikhailov[2] has provided a degree of confirmation of Barrett's ideas about the possibility of creating EM fields with different forms and higher field symmetries than ordinary EM fields; as well as the possibility of coupling such specially-conditioned EM fields with EM fields of comparable form and symmetry. Here, experiments by Mikhailov, which used apparatus similar to that shown in Fig. 1, have shown that ferromagnetic aerosols in solution behave as if they possess a magnetic charge, reversing their motion with reversals in magnetic field direction. (See Fig. 2.) Barrett[3] noted that spherical boundary (cavity) conditions and global ordering of electron spins could cause the ensemble to react to magnetic influences just as many isolated magnetic monopoles would. He also determined that a nonabelian EM field of SU(2) symmetry would be associated with polarization-modulated EM radiation of similar SU(2) form.

Taking this suggestion, Mikhailov[4] varied the polarization-modulated laser beam used to track particle trajectories. He found that fixed polarization of the laser beam caused negligible perturbation of the straight line motion of the particles as they responded to the magnetic field. Polarization modulated light, however, caused the particles to oscillate with respect to their motion in the magnetic field direction. Unfortunately, Mikhailov's report contains insufficient information for ascertaining what degree of polarization modulation was actually achieved. But, Mikhailov reported that oscillations were maximized when a given polarization frequency was reached, and oscillations appeared to be in synchrony with the polarization modulation frequency.

FUTURE PMR EXPERIMENTS

Polarization modulation of both radar and laser transmission systems is being studied because it is not yet evident what portion or portions of the EM frequency spectrum would produce the most favorable type of specially-conditioned EM radiation. Studies are being restricted to already-developed systems that (a) would require only modest modifications for the polarization modulation of their emitted radiation, and (b) would use the same test facilities that the already-developed systems use. Examples of such an approach for radar and laser test possibilities will now be described.

One potential experiment for testing polarization modulated microwave radiation would involve the modification of a radar system that is currently under development for naval shipboard use. This system uses multiple radar frequency bands and transmitting antennas, which would relatively easily allow the orthogonal polarization of two EM wave forms and provide the necessary phase modulation capability (at least ten percent) needed for a significant degree of polarization modulation. Testing of the modified radar system could be performed in the facilities currently used for its development, and the same type of data, signal patterns and signal strengths as functions of angle and range would be obtained. However, additional equipment, such as gravitometers and ring laser gyros would also be used to detect gravitational/inertial perturbations, if any, within the polarization-modulated radar beam.

Another potential experiment for testing polarization modulated microwave radiation would involve the modification of a k-band radar transmitter that is currently being considered by NASA for supersonic wind tunnel tests. Tests would investigate the ability of high-power radar emissions to reduce high-speed drag via breaking down microwaves and ionizing air. Since currently-planned wind tunnel tests involve linearly-polarized radar radiation, we are studying the possibility of modifying the currently-considered systems for follow-on tests that could involve other degrees of polarization. (See Fig. 3.) Emission of polarization modulated radiation from the currently-envisioned horn antenna would employ orthogonally-polarized waveforms with a frequency difference of at least ten percent of the selected k-band frequency. Superposition of the waveforms would occur at a mixer prior to their propagation from the antenna.

If polarization modulated microwave radiation couples/interacts perceptibly with gravitation to change particle mass, inertia and momentum, one would also expect density and pressure perturbations to be detectable. Wind tunnel test instrumentation would be used to monitor air pressure, density, velocity, and flow structure in the vicinity of the emitting body, as well as the pressures and drag forces acting on it.

Experiments involving polarization modulated laser radiation could involve the modification of lasers currently being used for laser propulsion testing by the USAF and NASA at the White Sands Missile Range. Current studies are investigating propulsion via pulsed laser light that is focused into an annular region of the craft (See Fig. 4.), where thrust is produced from air heating and magneto-gas-dynamic (MGD) effects. We are studying the possibilities of modifying the lasers involved in these tests for polarization modulation, and of measuring the effects, if any, of specially-conditioned laser radiation on model thrust and acceleration.

Modifications to be made to the laser would include the addition of mirrors and lenses capable of forming

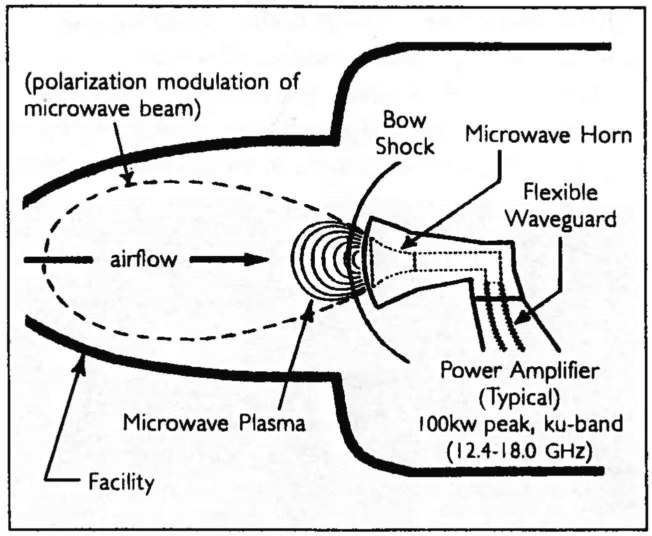

Fig. 3 Wind Tunnel Test Possibility

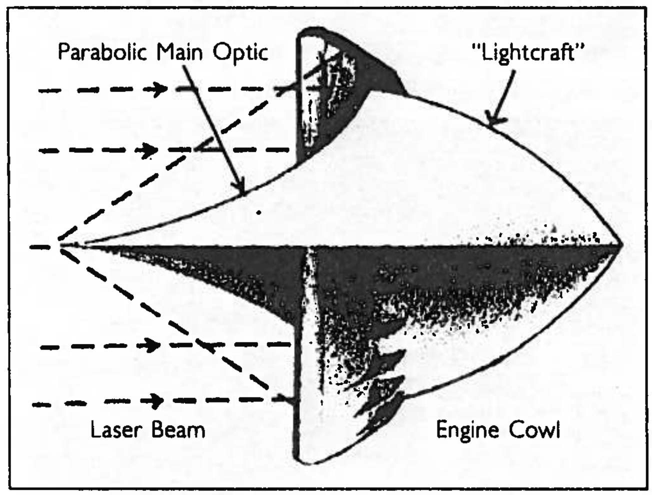

Fig. 4 Lightcraft/Laser Propulsion

orthogonally polarized waveforms that are out of phase by at least ten percent. If the polarization modulated laser radiation is found to interact perceptibly with gravitation, then one would expect a perceptible change in the mass of the model bathed by the incident radiation as well. One might also expect some change in thrust due to changes in air density/heating or MGD effects. Thus, existing White Sands ground test instrumentation would be used to detect any changes in vehicle mass and thrust generation, while flight test instrumentation would detect trajectory changes due to changes in vehicle acceleration.

VECTOR-POTENTIAL WAVE PATTERNS

Specially conditioned EM fields of SU(2) symmetry and nonabelian form can be created, as described by Barrett,[5] by driving alternating current through a toroid with single windings. (See *ESJ* 24.) The resulting magnetic and electric fields do not extend significantly outside the toroid. However, the alternating current flow through the toroidal geometry produces overlapping **A** vector potential patterns which extend outward from the toroid over significant distances and combine into phase factor waves which represent disturbances in **A** vector potential. The pattern of these disturbances becomes almost spherical in shape at distances from the toroid on the order of its diameter or greater. The maximum disturbance in **A** vector potential occurs as phase factor wave intensity peaks at the resonant frequencies where **A** vector potential patterns are exactly out-of-phase.

Resonant frequencies are determined by the geometrical dimensions of the toroid and the speed at which the alternating electric current propagates through it. Interactions with the spacetime metric/gravitation would be expected to be the most intense at the various resonant frequencies, if an **A** vector potential field underlies the essence of gravitation.

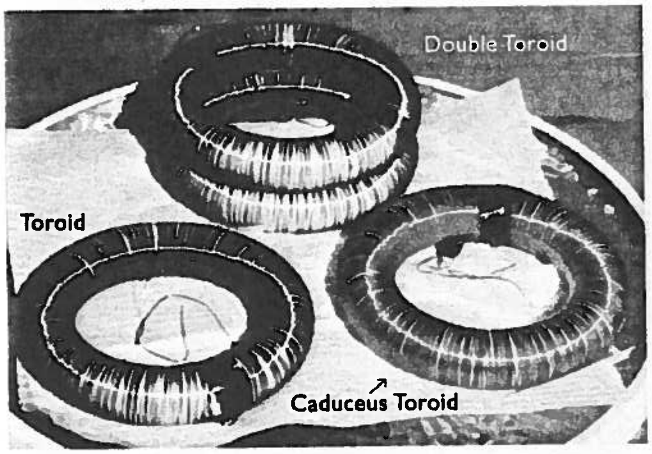

Fig. 5 Toroid Configurations Tested

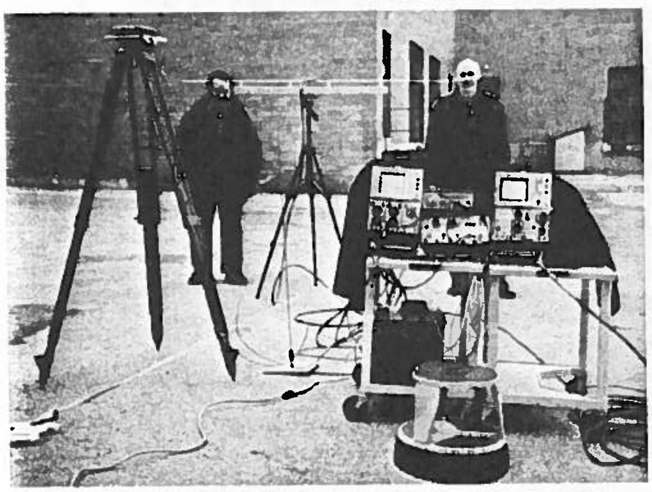

Fig. 6 Outdoor Test Equipment

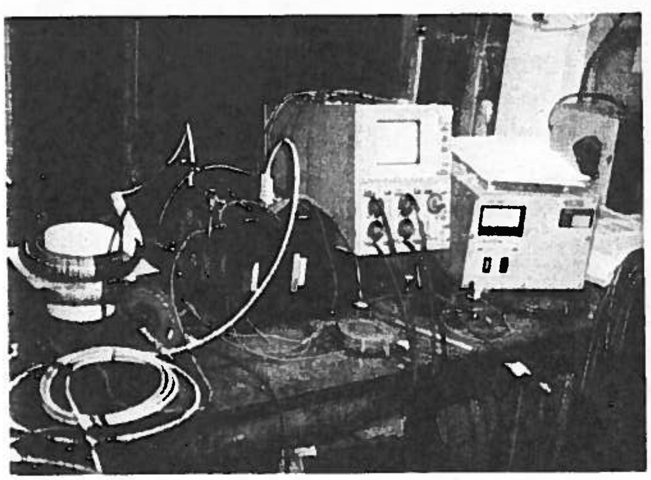

Fig. 7 Indoor Test Equipment

PRELIMINARY EXPERIMENTS

Initial work, which involved the fabrication and testing of toroid antennas that emanate specially-conditioned EM radiation in the form of electromagnetic and **A** vector potential disturbances, has been carried out at the laboratories of Hathaway Associates in Toronto. The general goals of this initial work, which was performed on March 6 and 7, 1998, were to: perfect techniques for fabricating toroidal coils; verify that **A** vector potential resonances can be established with such coils; determine the signal strength attenuation in air and within metallic structures; and identify problems associated with driving alternating currents through toroidal coils over wide frequency ranges and at significant power levels. The different toroid antenna configurations that were fabricated and tested are shown in Fig. 5, and typical test setups are shown in Figs. 6 and 7.

Most of the general goals were achieved. Toroidal antennas with conventional and caduceus windings were successfully fabricated, and **A** vector potential resonances were detected at frequencies that closely corresponded to predicted values. It was also found that toroids could function as both transmitters and receivers of specially-conditioned EM radiation. Toroid signal strength variation was as expected at near-range, but less than expected at longer distances. Insufficient power amplification capability at extreme alternating current frequencies prevented the detection of **A** vector potential resonances in these regimes, and lack of test time precluded tests to determine signal strength attenuation by metal structures.

FUTURE EXPERIMENTS

The initial experiments identified issues that must be addressed in future experiments. First, additional power amplification capability must be added to existing resources at Hathaway Associates in order to detect **A** vector potential resonances and measure signal variation with distance at very high and low AC frequencies. We have determined that this can be done at a very modest cost. Next, the transparency of various metallic, composite and ceramic materials to specially-conditioned radiation from toroid antennas must be determined to assess the feasibility of enclosing toroidal antennas within aerospace vehicle structures. It must also be done to determine the ability of toroid radiation to penetrate gravitometer enclosures to change the weight of test masses within them.

Heat generated by current flow within the toroids limited their power carrying capability to about 100 watts in the initial experiments. Since much higher levels of power will surely be required to cause any significant gravitational interaction, we are considering pulsing the power. We will first find the **A** vector potential resonances throughout the entire available frequency spectrum with low power. Then we will rapidly increase the power to a much higher level and rapidly decrease the power level at each resonance, allowing a cool-down period after each power pulse. If this technique will be used in operational field propulsion systems, it will probably require cryogenic superconducting technologies to maximize current flow and power.

If **A** vector potential wave patterns are found to penetrate gravitometer enclosures, we will use the precision gravitometer available at Hathaway Associates to look for gravitational perturbations caused by specially-conditioned EM radiation from toroid antennas. A successful electrical interfacing of a toroid and a gravitometer (with all test equipment interconnected and operating) has already been accomplished. (See Fig. 8.) A ring laser gyro will also be procured as a backup means of detecting gravitational perturbations.

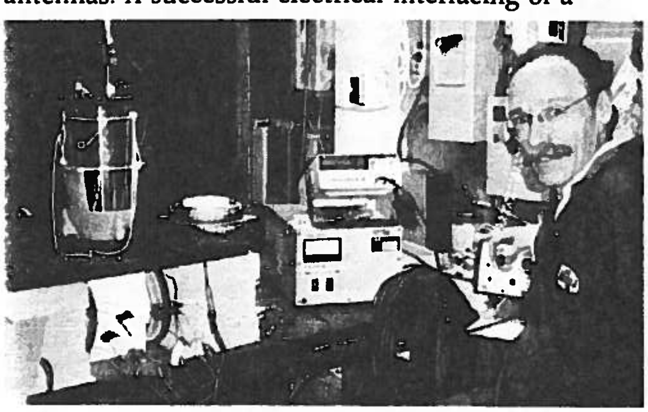

Fig. 8 Toroid/Gravitometer Interface

CONCLUSIONS

Ordinary EM radiation does not interact intimately with the gravity/spacetime metric because the fields that underlie them are of different essence and form. Thus, an exorbitant expenditure of ordinary EM field energy appears to be required to interact with gravity to produce a significant propulsive effect.

Ordinary EM radiation can be conditioned to have the same field essence and form as that which may underlie gravitation. Such radiation may possibly couple propulsively with gravity through something that may be common to each: the **A** vector potential.

The efficacy of specially-conditioned EM radiation in accomplishing field propulsion depends upon the underlying essence of gravity, which is not yet understood. In the meantime, it may be possible to prove or disprove its propulsive potential by the kinds of tests that have been described.

ADDENDUM

In a recent conversation with George Hathaway, he indicated that the A-vector potential results reported in this paper were inferred from theory. Because there is no known means of detecting **A**, the researchers could never be sure if they were indeed producing it. He conclusively stated, however, that no gravitational field interactions were observed in this series of tests.

1 Barrett, T. W., "Electromagnetic Phenomenon not Explained by Maxwell's Equations," *Essays on Formal Aspects of Electromagnetic Theory*, World Scientific Publ. Co. (1993), p. 6.

2 Mikhailov, V. F., "Experimental Detection of Dirac's Magnetic Change?" *J. Phys. D* 29 (1996), p. 801.

3 Barrett, T. W., "The Ehrenhoft-Mikhailov Effect Described as the Behavior of a Low Energy Density Magnetic Monopole-Instanton," *Annales de la Foundation Louis de Broglie*, 19 (1994), p. 2921.

4 Mikhailov, V. F., "Experimental Detection of Discriminating Magnetic Charge Response to Light of Various Polarization Modulations," *Annales de la Foundation Louis de Broglie*, 19 (1994), p. 303.

5 Barrett, T. W., "The Toroid-Solenoid as a Conditioner of Electromagnetic Fields into Gauge Fields," BSEI Report 1-97, obtainable via e-mail from: barrett506@aol.com

* Excerpted from the American Institute of Aeronautics and Astronautics Paper No. AIAA 98-318, given at the 34th Joint Propulsion Conference and Exhibit, July 1998, Cleveland, OH.