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M E M O R A N D U M

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TO: R. M. Wood, A-830

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SUBJECT: SPACE PROPULSION CONCEPTS

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INTRODUCTION

The purpose of this memorandum is to describe potential propulsion concepts which could be used primarily for propulsion in space, but also possibly could be used in the atmosphere or underwater.

Some of the concepts described have not been analyzed to any appreciable extent and, in fact, could be considered as more of a gleam-in-the-eye rather than actual concepts. However, it appears worthwhile to write down these concepts in order to provide some management insight into the research approach being followed, to provide a better communication among those working on the concepts, and to provide proprietorship dates in case a need arises for such things as patent claims. This memorandum can thus be considered as a working document which will be updated continually as additional analysis results are obtained, while some concepts undoubtedly will be discarded as further analyses indicate lack of promise. One final comment is that the concepts are written in the framework of physics as described in Advanced Physics, Third Edition.

PROPULSION REQUIREMENTS

Vehicle mission propulsion requirements always depend upon the range and always require acceleration. Some missions require deceleration, also. The next significant mission requirement is the transit times. Currently, there are effective propulsion systems for almost any range. In fact, there usually are several types available for a given mission range. However, as transit time requirements are diminished, many known systems are eliminated. The known systems which remain may become quite expensive. The primary motivation for obtaining new propulsion concepts then becomes a matter of lowering the cost and lowering transit time.

The propulsion forces for long range space propulsion systems are used primarily for acceleration and deceleration. For shorter range

systems, the forces are required for acceleration and deceleration and for overcoming gravitational fields (principally the earth's gravitational field). At even shorter ranges, atmospheric friction becomes significant. In atmospheric propulsion systems, gravitation and air friction are the principal propulsion energy dissipators. For earth surface (terrestial and water) systems, and for underwater systems, friction produced by the gravitational field is the principal energy user. In earth systems (atmospheric, surface, and underwater), friction is not only a propulsion energy dissipator, but is also generally used to provide the propulsion force.

SPECTRUM OF SPACE PROPULSION CONCEPTS

In order to propel a vehicle in space, energy in the form of moving particles must either be supplied from an active or natural existing external source, must be stored on the vehicle and emitted in a given direction, or must be collected by the vehicle from the (omni-directional) background and released in a given direction.[1]

The first active concept is illustrated by a beam of particles in a pipeline (e.g., wire or open beam) from the ground. A natural existing source is photons from the sun , which impinge on a vehicle (solar sail) to produce motion. Other possibilities are to use existing electrostatic, magnetic, or gravitational fields.

Stored energy, again in the form of moving particles, can be in the form of elastic energy, charged particles, thermal energy, chemical energy, nuclear energy, or stored fields. All concepts require momentum exchange between the released mass and the vehicle for propelling the vehicle. Elastic energy results when one continuum is confined by another continuum of particles (which can be neutrally charged) and can produce propulsion upon release. The amount of energy released per unit mass of the continua involved is very low. Charged particles can be released to provide an impulse and, since they achieve a much higher velocity when they are released than elastic particles, the impulse per unit mass released is higher than for elastic storage. Also, taking into account the total mass of particles which can be stored, along with their individual velocity, gives a greater total impulse per unit mass than can be obtained from elastic energy. Thermal energy is realized by storing mass in a continuum of matter which can be released (again, directionally) in the form of photons. For a given continuum, the maximum amount of releasable mass is obtained when the continuum is a plasma. Photons then can be released until the continuum cools to ambient conditions, and the continuum may end up in the solid state.

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1. These laws probably could be generalized to a non-particle universe. However, this would cause extra effort and would not be useful for this working document -- at least, at this time.

The temperature which maximizes total impulse is the temperature at which the total mass of the container and the heated continuum is a minimum. The total impulse per unit total mass is very small and the system will not be considered further. Chemical energy results in the release of photons or electrons which themselves can be directionally accelerated, or can be used to directionally accelerate neutral particles. The technology for this latter mechanism, i.e., directional acceleration of neutral particles, is well known and will not be explored further at this time. Nuclear energy can be accomplished by a rearrangement, without annihilation, of existing protons and neutrons which make up neuclei (fission and fusion), or by the annihilation of electrons, protons, or neutrons of a neucleus. The technology for achieving this latter process is not well known. However, the available energy from the "working fluid" is two orders of magnitude greater than any of the other concepts. The final stored energy concept possibility is to store a field (probably only a magnetic field), and then to directionally release the energy in this field. The field is presumed to consist of an ordered arrangement of the background gas (the brutino free field). Impulse is provided by releasing this field of particles in a given direction. The amount of energy which can be stored, per unit mass of matter, in this manner is probably miniscule, and will not be considered further. No other forms of stored energy propulsion are known.

The last family of propulsion concepts consists of collecting brutinos, or gas molecules, from the free field which are moving omnidirectionally and then releasing them in a given direction. In this concept, in order for momentum for the complete system (vehicle and background) to be conserved, the vehicle must be accelerated in the direction opposite the release of particles. The mechanism for collecting free particles is believed to be known, but only for very small collection rates. Directional release at the small rates also can be achieved. However, methods for increasing the rate to levels providing high vehicle accelerations are not known.

The more promising concepts are discussed in the following sections, to provide additional sifting and to outline future efforts. The concepts which are not discussed further are listed below, with the reason for rejection:

Concept	Rejection Reasons
Active External Source	Low Efficiency - Low Flexibility
Sun Photon Source	Low Efficiency - Low Flexibility
Atmospheric Motions	Low Efficiency - Low Flexibility
Stored Energy - Charged Particles	Low Efficiency
Stored Energy - Elastic	Low Efficiency
Stored Energy - Thermal	Low Efficiency

Concept	Rejection Reasons
Stored Energy - Chemical	Low Efficiency
Stored Energy - Nuclear Fission	Low Efficiency
Stored Energy - Nuclear Fusion	Concept Being Pursued By Others
Stored Energy - Magnetic Fields	Low Efficiency

The concepts remaining for consideration are:

External Sources - Earth Magnetic Field
External Sources - Earth Electrostatic Field
- Earth Gravitational Field
Stored Energy - Nuclear Annihilation
Free Field Energy - Brutino Field
- Air Molecules

EXTERNAL SOURCES

The mechanisms of the interaction of vehicle magnetic and electrostatic fields (stationary or moving) with the earth's magnetic and electrostatic fields are known and are predictable from currently available physical theory. The upper limits of efficiency of such systems are not predictable by currently available physical theory. A new theory, such as the brutino theory, has a low, but not negligible, probability of resulting in significant increases of efficiency of such systems. The following actions could be pursued in the area of vehicle magnetic-electrostatic fields interacting with the earth's magnetic-electrostatic fields:

1. Wait for the rigorous photon-electron, etc., build up to electro-magnetic theory. Then, apply the results to determine efficient configurations.

2. Try to conjecture the electromagnetic results of the brutino theory, and apply them to determine efficient configurations.

3. Try experiments to test conjectures in 2.

4. Try experiments to extend existing electro-magnetic theory, independent of 1, 2, and 3, above.

Gravitation is presumed to be due to the radiation of neutrinos and anti-neutrinos. Gravitational forces on a vehicle, thus, can be negated by capturing, or randomly rebounding (which transmits the same momentum) the earth-emitted neutrinos and anti-neutrinos. The only method of radically affecting the interaction of neutrinos (and anti-neutrinos),

which I can think of, is with a magnetic field (on the vehicle). Pursuance of anti-gravity propulsion thus could be along the following routes:

1. Rigorous step-by-step buildup of the brutino theory.
2. Try to conjecture the neutrino and anti-neutrino interactions with magnetic fields (moving and stationary), and apply the results to make up a configuration.
3. Try experiments to test conjectures in 2.
4. Try experiments to determine gravitational interactions, independent of 1, 2, and 3, above.

STORED ENERGY

Nuclear annihilation consists of converting the individual electrons (orbital and those making up the nuclei) into photons. The only concept for accomplishing this under steady state conditions, that I can think of, is by using intense magnetic fields. A magnetic field may be in the wrong direction for annihilation since, when the field is applied, the electrons line up so that their binding force is strengthened instead of weakened, as a result of the field. However, if the field strength can be increased sufficiently (and focused in some way), it may be possible to annihilate matter in the way that matter accelerated close to the speed of light is annihilated. Another possibility, is to accomplish annihilation by transient magnetic fields. The possible approaches, here, are:

1. Rigorous step-by-step buildup of the brutino theory.
2. Try to conjecture the matter-magnetic field stability mechanism, and conjecture a configuration.
3. Try experiments to test conjectures in 2.

FREE FIELD ENERGY

The free-field energy concepts use gas molecules (of the atmosphere) or brutinos for propulsion. Both concepts collect omni-directionally and emit directionally. Both concepts obey the conservation of energy and momentum laws, but violate the second law of thermodynamics. The collector for the brutino field is an electron. The propulsion problem is to increase the collection rate, and then invent some scheme for directional emission. The problem using the atmosphere is to invent an omni-directional gas collector, which provides a stable growing vortex that will emit a slug of

air in a predictable direction. The approaches are:

1. Rigorous step-by-step brutino theory development.
2. Conjecture stability-emission and try to get a configuration.
3. Run experiments on the configuration.

The first type of experiments which could be run here are the photon stability-drag simulation, using volumes of air, compressed and accelerated to sonic speed.

RECOMMENDATIONS

I strongly recommend that the rigorous brutino theory be supported to as great an extent as possible. For example, a good mathematician should be assigned to the problem nearly full time. I should continue tightening up my analysis of all of physics, and to conjecture all the interactions and mechanisms idscussed here. I should explore earth magnetic and electrostatic field interactions along the line of the paper you are currently preparing -- possibly dig deeper into each area to define and push the boundaries. Photon stability-drag experiments are recommended, but not strongly.

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