Breakthrough Propulsion: It's furture.

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Abstract: A relook at what is needed for the realization of breakthrough propulsion.

"Breakthrough" propulsion can only be implemented in one of two ways. The first is to find a way to "convert" electromagnetic fields directly into gravitational/inertial fields. But there is no credible evidence that localized electromagnetic fields can be directly converted into *strong* gravitational fields that couple to distant matter even though suggestions based upon Mach's principle(1) have shown it is theoretically possible. The simplest math treatment being:

$$\nabla.\phi - (1/c^2)(\partial^2\phi/\partial t^2) = \Box\phi = 4\pi G\rho_o + (\phi/\rho_o c^2)(\partial^2\rho_o/\partial t^2) - (\phi/\rho_o c^2)^2(\partial\rho_o/\partial t)^2 - c^{-4}(\partial\phi/\partial t)^2,$$

where G is Newton's constant of universal gravitation,

$$\rho_o$$

the restmass density, and c the vacuum speed of light. In this approximation,

$$\phi = c^2.$$

The total, time-dependent matter density is:

$$\rho(t) \approx \rho_o + (1/4\pi G)[(\phi/\rho_o c^2)(\partial^2\rho_o/\partial t^2) - (\phi/\rho_o c^2)^2(\partial\rho_o/\partial t)^2].$$

The first time-dependent term

$$(1/4\pi G)[(\phi/\rho_o c^2)(\partial^2\rho_o/\partial t^2)]$$

can be both positive and negative when

$$\rho_o$$

is in flux. The second time-dependent term is always negative. This allows very short bursts of negative energy which are governed by certain energy conditions. The **strong energy condition** stipulates that for every future-pointing *timelike vector field* the trace of the tidal tensor measured by the corresponding observers is always non-negative(2). This has always remained one of the strongest arguments against Warp Drive's, Wormholes, etc.

The second alternative is shortcuts through either a bubble of modified vacuum where C is different or string and Brane world modifications to the Israel junction condition. The central problem with the last is no one has an exact brane or string model supported by physics' findings to go on and the problem with the first is that one needs a provable

physical mechanism to generate such an altered bubble of space-time that does not involve negative energy itself. One suggestion that has arisen on the first is that generally an inflation field can duplicate the effects of negative energy. But some of these require at least a transient amount of negative mass. Other's rely upon certain quantum effects to be produced at large scales.

In general, we are left with needing physics beyond the standard model before any major advancement in the area of Breakthrough Propulsion occurs which leads one back to a case where both paths have possible merit. Or we must look to solutions that do not invoke exotic energy to achieve our goal.

References

1.) Woodward and Mahood, 1999; Woodward, 2001 and Sciama (1953 and 1964).
2.) Carroll, Sean M. (2004). *Space-time and Geometry: An Introduction to General Relativity*. San Francisco: Addison-Wesley. ISBN 0-8053-8732-3.