Gravitational Field Propulsion Techniques

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Abstract. Two broad sets of classes of gravitational field propulsion techniques are investigated: classical general relativity field propulsion, and the quantum manipulation of spacetime. Classical approaches in this paper include a Forward Coil, which concentrates an acceleration field in the center of the coil, the use of wormholes, and a tokamak plasma quadrupole oscillator, creating gravitational waves which can then rectified via quadrupole rectification. Classes of quantum approaches include the direct stimulation of graviton emission, and the stimulation of metamaterials to engineer the quantum vacuum. A nomenclature is suggested to categorize these classes.

Keywords: Gravitational Waves, Quadrupole Rectification, Lense Thirring, Forward Coil, GASER, Spacetime, Metamaterials

PACS: 04.20.-q, 04.30.-w, 04.40.Nr, 04.50.+h, 04.60.-m, 04.80.Cc, 4.80.Nn, 14.70.Kv

INTRODUCTION

Two broad sets of classes of gravitational field propulsion techniques are described, along with suggested nomenclature:

Classical approaches covered in this paper include:

1.1 GRFC, Gravitomagnetic acceleration fields produced by mass flow toroids, dubbed “Forward Coils”
1.2 GRPQ, Plasma quadrupole oscillators to create gravitational waves (GW), such as may be achieved in specially prepared fusion tokamaks
1.3 GREM, the classical conversion of an EM wave into a GW via passage through a static EM field
1.4 GRWD, warp drive solutions to Einstein’s General Relativity (GR) field equations
1.5 GRWH, wormhole solutions to Einstein’s General Relativity (GR) field equations
1.6 GRTB, tractor beam or pressor beam solutions to Einstein’s General Relativity (GR) field equations

The classes of quantum approaches include:

2.1 QMGE, The direct stimulation of graviton emission
2.2 QMMM, The stimulation of metamaterials to engineer the quantum vacuum
2.3 QMTP, Quantum mechanically triggered teleportation

1.0 CLASSICAL GENERAL RELATIVITY FIELD PROPULSION

1.1 Forward Coil (GRFC)

The GRFC case is conceptually composed of just a mass flow toroid, first conceived of in 1962 Robert Forward [1] and extended to electron mass flow withing superconducting magnetic energy storage devices in 2019 Stephenson [2]. It is designed to concentrate a gravitomagnetic acceleration field in the center of the coil, while spreading it out along the outer rim. If a flying craft were to encompass only the coil inward it would experience only the upward spiraling acceleration, excluding the downward as external to the craft. 2021 Stephenson [3] enhanced the coupling effect by placing high index material in the throat of the toroid. See figure 1 for depictions of this concept.

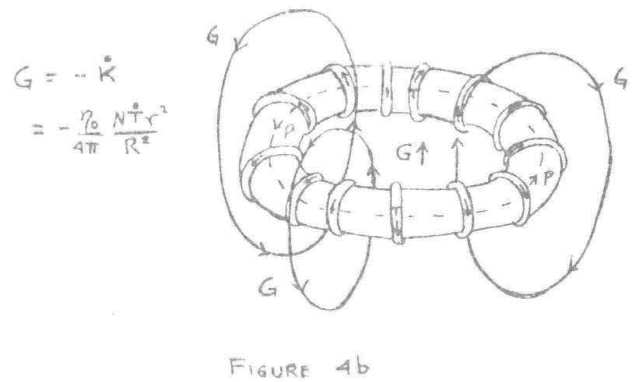


Figure 1a, from 1962 Forward [1]

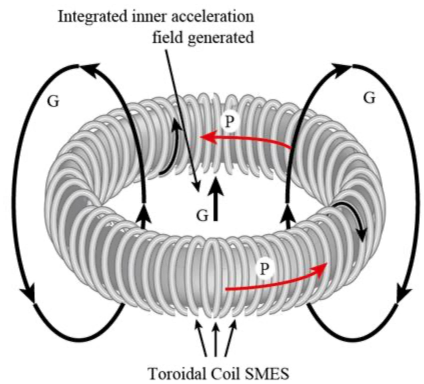


Figure 1b, from 2019 Stephenson [2]

FIGURE 1, DEPICTIONS OF FORWARD COILS

1.2 Tokamak Plasma Quadrupole Flow (GRPQ)

In this concept category a Tokamak plasma quadrupole oscillator could create gravitational waves (GW), which could then be rectified via quadrupole rectification.

This idea was first expressed in 1975 Grishchuk and Sazhin [5] using only the energy oscillations of an electromagnetic (EM) standing wave in toroid experiencing a quadrupole oscillation. The effect would be stronger will oscillating mass, as expressed in 2017 Stephenson [7] which proposed quadrupole oscillations of plasma in possible in a specially modified fusion tokamak. The effect could be strengthened by using burning nodes of actively fusing plasma in tokamak, alternating in a quadrupole fashion.

It is this latter design concept that is depicted in figure 2. If we define the polar position of burning plasma nodes within the tokamak cavity according to clocking position, we wish to first see burning plasma – plasma engaged in active fusion – first at the 12 o'clock and 6 o'clock positions, the pressure of which then forces nodes of burning plasma to form at 3 o'clock and 9 o'clock. Ideally this process continues to alternate between these two extremes, giving rise to a quadrupole moment and thus to radiated gravitational power, according to the square of the quadrupole moment's third derivative, as described by the equation (1), as given in Landau & Lifshitz (1975), eqn. 110.16 [4].

$$d(E)/dt = -(k/45c^5)[d^3(D\alpha\beta)/dt^3]^2 \tag{1}$$

Where E is gravitational energy, d(E)/dt is gravitational wave power, k = gravitational constant, c = speed of light, and $D\alpha\beta$ is the mass-energy quadrupole tensor.

The radiated gravitational wave frequency will correspond to the pulse repetition rate of the polar node changes between the 12 & 6 o'clock positions and the 3 & 9 o'clock positions, and vice versa.

However a gravitational wave (GW) on its own does not represent the kind of gravitational field useful for propulsion. Two methods are suggested for creating a scalar gravitational field or spacetime warp potentially useful for propulsion from a GW: (a) perform quadrupole rectification, or (b) leverage the Christodoulou memory effect.

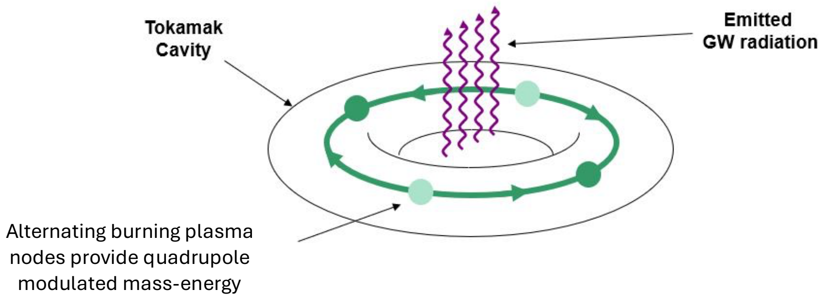
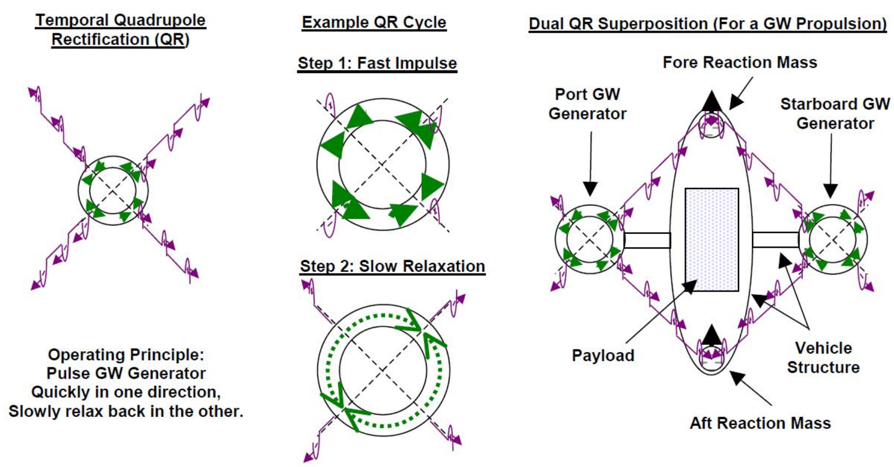


FIGURE 2, TOKAMAK BURING PLASMA QUADRUPOLE PATTERN

Quadrupole Rectification

In quadrupole rectification (QR) two GW generators are used in tandem to produce negative and positive going gravitational impulses, see figure 3. If arranged properly the negative going pulses could be directed at a forward reaction mass, and the positive going pulses could be directed at an aft reaction mass. The appropriate QR cycle would consist of a highly nonlinear and asymmetric fast quadrupole node formation in one direction, and a slow relaxation for the orthogonal nodes. Since GW power goes as the square of the third derivative of the mass-energy quadrupole moment, the GW will be stronger in one direction over the other, resulting in net thrust.



(a) Quadrupole Rectification. **(b)** QR Cycle. **(c)** Dual QR Propulsion.

FIGURE 3, QUADRUPOLE RECTIFICATION [6]

Christodoulou memory effect

The Christodoulou memory effect would be another way to create relative motion from a gravitational wave. The Christodoulou effect predicts persistent changes in the relative position of pairs of masses in space due to the passing of a gravitational wave. Thus a continuous and longtime exposure to gravitational wave will cause test masses to drift apart, indicating relative motion due to the "memory" of the GW's passing. This effect can be observed in the measurement of merger ringdowns as indicated in Fatava [8].

1.3 Classical EM wave to GW Conversion in Static EM Fields (GREM)

1962 Gertsenshtein [9] envisioned a solution the Einstein's field equations predicting electromagnetic (EM) to gravitational wave (GW) in the presence of a static B field, an experimental concept of which is depicted in figure 4. 1970 Boccaletti [10] extended these predictions to cover EM to GW conversions in both static E or B fields. In practice the effect may be too weak for laboratory scale work with current technology, but may be observable at astronomical scales.

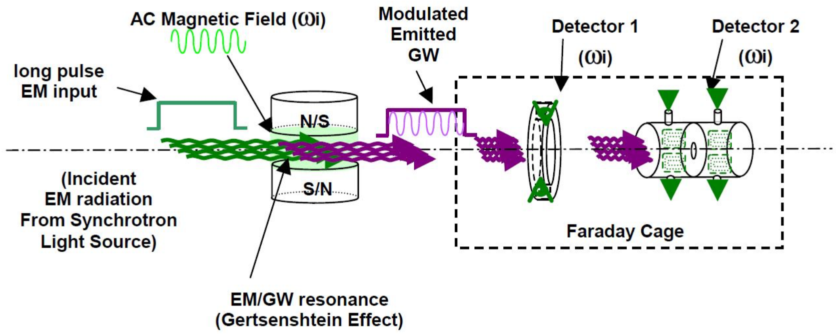


FIGURE 4, CONCEPTUAL TEST OF THE GERTSENSHTEIN EFFECT [6]

1.4 Classical General Relativity Warp Drives (GRWD)

Warp Drives are topologically S0 surfaces that support faster than light travel. 1994 Alcubierre [11] original warp drive solution, depicted in figure 5 [11].

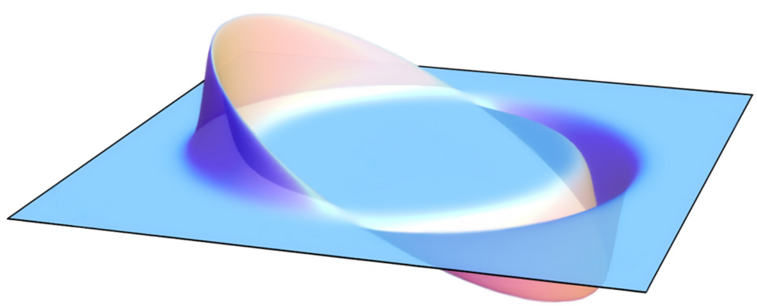


FIGURE 5, THE ALCUBIERE WARP DRIVE SOLUTION [11]

1998 Krasnikov [13] offered a solution with a non-tachyonic warp bubble, and1999 Van Den Broek [14] a warp drives with more reasonable energy requirements. 2002 Natário [15] presented an Alcubierre like solution but without expansion or contraction requirements. 2018 Loup [16] developed 6 different Natário metrics, some of which included globally acceleration cases. 2020 Lentz [17] offered a completely different route to 'Breaking the Warp Barrier' using hyper-fast soliton solutions in Einstein – Maxwell – Plasma theory. 2022 Carneiro 18] examined the total energy conservation of the Alcubierre spacetime using Teleparallel Equivalent of General Relativity, TEGR, and determined the need for negative energy might be a reference problem. There are now even "Warp Factory" websites offering tools to assist with the development of new warp drive solutions [19].

1.5 Classical General Relativity Worm Holes (GRWH)

Wormholes are topologically S1 surfaces that support a foreshortened route distance when compared to flat spacetime, depicted in figure 6. 1935 Einstein & Rosen [20] first developed the idea of an Einstein Rosen "bridge," what was later dubbed a wormhole by Wheeler, who published with Fuller in 1962 on associated causality issues [21]. 1988 Morris & Thorne [22] popularized the notion of the wormhole with the solution presented in their paper "Wormholes in Spacetime and Their Use for Interstellar Travel: A Tool for Teaching." 1995 Visser [23] presents a survey of Lorentzian wormhole in "Lorentzian Wormholes: From Einstein to Hawking." 1998 Davis [24] considered

Wormhole Induction Propulsion, (WHIP). More recently 2017 Lopo [25] compiled a collection of "Wormhole Basics," and 2023 Madacena [26] a traversable wormhole solution in 4 dimensions.

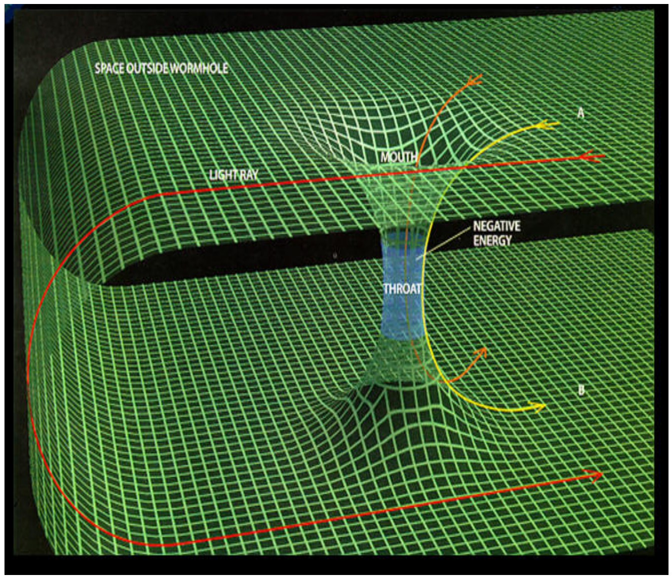


FIGURE 6, A HYPOTEHICAL WORMHOLE [27]

1. 6 Classical General Relativity Tractor Beams (GRTB)

In 2021 Santiago J, Schuster S, & Visser [28] presented "Tractor Beams, Pressor Beams and Stressor Beams in General Relativity." This work presented what are essentially special cases of warp drives in which a negative gravitational field is developed in front of a target to create a "tractor beam," a positive gravitational field is developed in front of a target to create a "pressor beam," of some combination of these are positioned around a target for a "stressor beam."

2.0 QUANTUM MANIPULATION OF SPACETIME

In contrast with using the distribution of mass and energy to shape spacetime for propulsion via Einstein's Field Equations, another set of options worth exploring are in the areas of the quantum manipulation of spacetime.

2.1 Quantum Stimulated Emission of Gravitons (QMGE)

One possible method for the quantum manipulation of spacetime would involve the direct emission of gravitons. This notion was first explored in 1964 Halpern and Laurent [29], where all quantum transitions leading to electromagnetic and gravitational emissions were cataloged and radiation patterns derived. Gravitational radiation by quantum systems were further explored in 1982 Ford [30]. Forcing specific spin 2 transitions in specially prepared superconducting junctions was the topic explored in detail by 2007 and 2012 Fontana [31], [32], dubbed a GASER, for a gravitationally amplified stimulation of emitted radiation, directly emitting spin 2 particles. 2019 and 2023 Atanasov predicts gravitational wave emission from rapid mass oscillations setup in a pair of superconducting Josephson Junctions, depicted in figure 7. If these ideas are confirmed experimentally, they would be obvious candidate sources for gravitational field propulsion.

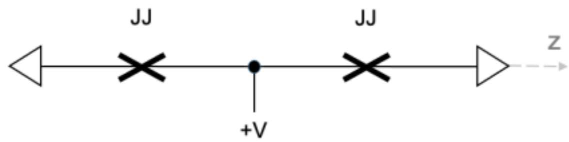


FIGURE 7, QUADRUPOLE JOSEPHSON JUNCTION PAIR [34]

2.2 Spacetime Metamaterials (QMMM)

Another possible method for the quantum manipulation of spacetime would be through the use of space metamaterials, best cataloged to date in 2020 Caloz [35], [36], which describes how metamaterials via their unique indices of refection can reshape the light cones with which they interact, thus reshaping spacetime. This notion is further explored in 2021 Sarfatti [37] in which the author proposes altering Einstein's field equations to allow for a non-vacuum term accounting for matter and meta-material effects.

2.3 Quantum Mechanical Teleportation (QMTP)

While warp drive and wormholes are quasi-static solutions, the notion of a teleportation would be more of a episodic and highly dynamic event-based phenomenon. In this section quantum mechanical means for creating teleportation events are explored.

2.3.1 Vacuum metric engineering for teleportation (QM-vmTP)

One possible method of creating a teleportation even would be via short term manipulation of the quantum vacuum metric. 1990 Scharnhorst [38] focused solely on the special case of limiting the vacuum field between plates; 2002 Puthoff [39] explored how to engineer the zero-point fields thus creating a polarizable vacuum, and how that might be used for interstellar flight. 2021 Balytskyi [40] more fully explored the role of negative scalar field energy in vacuum solutions.

2.3.2 Quantum entanglement as used for teleportation (QM-qTP)

Could quantum entanglement be used to support teleportation, either of information or matter? 1993 Bennett [41] explored the teleportation of quantum states via Einstein-Podolsky-Rosen channels. 2002 Mavromatos et al. [42] looked at modeling implied quantum teleportation in biological systems. 2003 Rarity [43] explored the broader topic of free space entanglement and the possible control thereof.

2.3.3 Exotic extra dimensions or parallel universes leveraged for teleportation (QM-eTP)

Finally we explore briefly the notion of using extra dimensions to propel us through the standard 4. Kaluza-Klein would be a natural starting point, as both 1921 Kaluza [44] and 1926 Klein [45] sought to reconcile electromagnetism with general relativity. 1985 Green [46] attempted the same unification via extra dimensions in superstring theories. 1998 and 2002 Arkani-Hamed, Dimopoulos, Davli [47], [49] sought to use 'ADD M-theory' to add dimensions at either very small or very large scales, as did 1999 Randall & Sundrum [48]. None of these theories have to date seen any experimental verification, although 2024 Boyd [50] may shed some experimental light, if it survives peer review.

CONCLUSION

An overview has been provided to describe possible gravitational field propulsion techniques, for both classical general relativity approaches, and for the quantum mechanical manipulation of spacetime.

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