Monopole waves in general relativity

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Abstract. It can be verified, even by hand, that Rindler coordinates can be augmented with a wave term to give the appearance of monopole waves emitted from an evaporating Rindler horizon. By equivalence principle, if all required currents are conserved, this is equivalent to a test observer with an otherwise anomalous acceleration decay under the action of a constant proper force. Experiment to detect this acceleration decay would be a test of metric tensor symmetry.

1. Introduction

1.1. General considerations

General relativity is one of the most successful physical theories of the past one hundred years, if not the most. Its rich mechanics seem to follow from three key and basic assumptions: the constancy of the speed of light to all inertial observers [8], the equivalence of mechanical and gravitational inertia [7], and (perhaps with less obvious motivation and implication) the symmetry of the metric tensor [7].

Introducing some form of "monopole" to the theory of gravity is not an alien concept, as it might be an attractive proposal to solve critical open problems in the theory of gravity and cosmology [4] [11] [16]. By analogy with the rank 1 tensor potential of the spin-1 photon, we expect a spin-2 graviton from the rank 2 objects of Einstein's theory. We have every indication this theory correctly predicts observed gravitational waves [1] [5]. We will show that general relativity *requires* at least one scalar particle monopole solution, simple enough to derive and verify by hand. Then, a scalar must result from the extended mechanics of the spin-2 graviton. This implies composite grouping of gravitons with canceling anti-aligned spins, and therefore an asymmetry of the metric tensor.

(There is simple intuition to support the requirement of symmetry of the metric tensor: we expect both legs of a round-trip between fixed locations to be of equal distance. This intuition might fail, for space-time intervals, at least in trying to reverse the "thermodynamic arrow of time," for example [13].)

1.2. A student's introduction

At outset, let us try to phrase the argument of this paper as conversationally as possible, but briefly.

In developing the theory of relativity, Einstein would have noticed the prolonged failure of "aether theory" to explain the "constancy" of the speed of light that was assumed by Maxwell's theory of electromagnetism. "Aether theory" assumed light's speed was constant relative some preferred medium, "the aether," and failed to detect it, so Einstein asserted there was no such medium. Constancy of the speed of light without preferred medium resulted in "special relativity," which found experimental success. Hence, Einstein, and eventually the world, came to adopt the assumption of the constancy of the speed of light to all inertial observers [8].

In the "special" mechanics, there was no obvious mechanical extension to accelerating observers, nor mechanical unification with Newton's gravity. (It is debatable, with the benefit of about a hundred years of research, whether the "special" theory of relativity on its own is compatible with acceleration; the required extension is "Rindler coordinates," describing the way flat space-time appears to a point-of-view with constant acceleration.) To start to unify the electromagnetic theory of special relativity with gravity, Einstein assumed the equivalence of gravitational acceleration ("$9.8 m/s^2$," as I feel my weight, pushed upward by the ground at Earth's surface) and uniform mechanical acceleration (as I would feel my weight in an elevator accelerating $9.8 m/s^2$ "upward," far from any gravitating body) via "proper force" [7]. Within the available mathematical framework of "differential geometry," the theory following from this assumption, with the constancy of the speed of light to all inertial observers, proved immensely predictively successful, and it is called "general relativity," nearly.

The third "new" assumption of general relativity (besides all that physicists daily take for granted) was the symmetry of the metric tensor, which represents the measure of distance and time intervals, in space-time. While this could be born of simple geometric intuition, of equality of distance from point "A" to "B," with "B" to "A," intuition sometimes fails us, as in trying to "turn back time," if "A" and "B" are separated in both space and time, and Einstein himself spent considerable time and energy developing an asymmetric theory, with Cartan [21]. (Symmetry fixes the torsion-free Levi-Civita connection as unique between metric tensor and tangent bundle, making our personal choices much simpler, but not necessarily most correct.)

For the same reason it is not obvious why or how general relativity contains and describes human fallibility, is as how general relativity does not obviously speak to quantum theory. In the paper before you, the author asserts a solution to the governing equations of general relativity that foregrounds the interface between the relativistic "equivalence principle" and the statistical theory of "indistinguishable" quantum particles, casting doubt on the assumption of symmetry of the space-time metric tensor, again. Our solution to the Einstein field equations relies on the "equivalence" of gravitational fields and uniform mechanical accelerations to show that general relativity requires gravity waves that are only compatible with an "asymmetric" metric tensor, perhaps incompatible with "general relativity" proper, unless experiment favors symmetry of the metric tensor over the combination of statistical quantum particle mechanics and equivalence principle.The following math is "merely mortal." It is as simple as rendered here, and the integrated wave term is "only a spectral decomposition" of an arbitrary function.

2. Theory

We assume Planck units for all that follows. Consider flat space in the Rindler coordinates,

$$ds^2 = -\left(\alpha x\right)^2 \, dt^2 + dx^2 + dy^2 + dz^2. \tag{1}$$

These coordinates can represent an observer with constant acceleration in Minkowski space. (This has reached common knowledge and acceptance in the study of relativity, but see a pedagogical resource such as [6], and also for broader context.) We pose an extension:

$$ds^2 = -\left\{ x \left[\alpha(t) - \int_0^{M(t)} b(k,t) \sin(kt) \, dk \right] \right\}^2 dt^2 + dx^2 + dy^2 + dz^2 \tag{2}$$

is a functional minimization of the Einstein-Hilbert action (i.e. Ricci scalar $R = 0$). It satisfies the boundary conditions of the action, with vanishing extrinsic curvature and an induced metric of flat space [18]. (We will define $M(t)$ below.) As the distance from the implied observer to the Rindler horizon appears infinite, consider $b(k,t)$ an arbitrary parameterization such that the Rindler horizon's implied mass at a sufficiently (infinitely) eariler time emits a gravitational field that affects the observer at t, delayed by the speed of light. Also, take $\alpha(t)$ as a similar arbitrary parameterization, beyond the requirement

$$\frac{d\alpha}{dt} = -\int_0^{\infty} k \frac{\partial b}{\partial t} \, dk, \tag{3}$$

to conserve energy. $\alpha(t)$ responds "instantaneously" to local changes in the acceleration, but this "change" in the metric tensor is an apparency we expect from varying a first-person acceleration, as the constant α of Rindler coordinates implies in the first place, relative flat space in an inertial frame. (All of the above is easily confirmed by the reader, by hand or with aid of commonly available software.)

There are at least two obvious interpretations of this metric. One is of energy-conserving gravity monopole waves emitted from an evaporating Rindler horizon at the limit of infinite distance from the origin in these coordinates, taken as $x \to -\infty$, for example. (Momentum of the waves is equal and opposite the change in momentum of the horizon, but this has no effect on the metric.) The other interpretation is of an observer with sinusoidally time-varying and damped acceleration in Rindler coordinates. By a rather literal reading of equivalence principle, there is no difference between these two interpretations. Reading equivalence principle so literally, monopole gravity waves are required in the theory of general relativity. (See [12], for example, for an overview of the equivalence principle, and see [20] for a recent experimental test.)

Appeal to equivalence principle is sleight of hand, if only the latter interpretation is valid, of an observer varying their acceleration by the calculated local application of a force. Indeed, we need not choose our coordinates as above, or impose any further constraint than equation 1, to satisfy the Einstein field equations. Hence, the appearance of monopole waves might not be of any greater physical significance than coordinate and parameterization choices for equation 1 that lack them. However, if appropriate currents are locally conserved, as by our given energy constraint and coordinates, we can argue that the interpretation as gravity monopole waves is valid. This argument is semantic without experimentally distinguishable difference.

"Bremsstrahlung" is the physically measurable difference between these arguments. An otherwise anomalous braking force should by felt by a test observer, when acted upon by a constant locally applied force. This would experimentally prove the existence of a gravitational monopole interaction.

The Rindler coordinates are closely related in form to those of Schwarzschild for a static, stationary black hole [6]. Unlike the Schwarzschild coordinates, the apparent infinite extent of the flat Rindler horizon (as opposed to spherically periodic, for Schwarzschild) implies by argument from Gaussian surfaces that the "surface gravity" of the Rindler horizon appears uniform throughout all space, to the accelerated test observer, such that

$$\alpha(t) = -\frac{1}{4M(t)}, \tag{4}$$

as if $M(t)$ were the mass of a Schwarzschild black hole. Fermi's golden rule and the form of the metric given in equation 1 suggest an ultraviolet catastrophe causing a nearly immediate breakdown of all acceleration into braking radiation, as $E_P/(2t_P)$, a power of half a Planck energy per Planck time. However, this suggests that masses much greater than the Planck mass, arbitrarily larger than the size of an active galactic nucleus, are emissible as single graviton monopole (quasi-)particles! For black holes, thermal radiation, as these monopole waves, add an amount of entropy, offset by reduction in the event horizon area [2]. Per these considerations, the threshold for thermodynamic favoribility of emission of these particles would be roughly or exactly the Planck energy. Therefore, the braking force on an accelerated observer should be inversely proportional to its apparent "mass," such that the power of emission from the horizon should be

$$P(t) = \alpha(t). \tag{5}$$

At the threshold of $M(t) \leq m_P$, apparent mass of the horizon less than or equal to the Planck mass, the full apparent mass of the horizon *is* emissible at once, such that the rate per unit surface area is $E_P/(2t_P)$. This threshold can also be rendered $|\alpha(t)| \geq \frac{1}{4}$.

Given the infinite extent of the Rindler horizon, we are really speaking of a power density per unit of surface area, where the area unit is equivalent to the event horizon of a Schwarzschild black hole of this equivalent mass:

$$\sigma(t) := \frac{P(t)}{4\pi r_s^2(t)} = \frac{\alpha^3(t)}{\pi}. \tag{6}$$

This radiation occurs along with an independent component due to Hawking radiation, sometimes called the "Fulling–Davies–Unruh effect," in this case [24]. In fact, as we argue here from conservation of energy that the Rindler horizon should evaporate due to Hawking radiation alone, under the action of a constant proper force, Hawking radiation must already locally vary the metric connection from Levi-Civita, and therefore Hawking radiation and the assumption of metric tensor symmetry cannot both be correct.

3. Experiment

In the simplest generality, we should observe a particular quantitative anomalous reduction in the acceleration of a test body with known profile of applied proper force, according to the mathematical treatment given above, if gravitational monopole waves can be produced in general relativity. If the math of our *a fortiori* argument follows, the null hypothesis might be experimental proof of the symmetry of the metric tensor, as the only bar to monopole production.

It is beyond the scope of this paper and resources of the author to propose or mount a specific astronomical experiment to measure this effect. However, this might be an alternative explanation for the Pioneer (or flyby) anomaly. We apologize, for we admit that this proposal is presumptive given the exhaustive research behind the best accepted model of that effect [23]. We support a dedicated mission, as that team and others did at a much earlier time [22].

Closely related monopole wave modifications to the Schwarzschild and Reissner–Nordström solutions are developed in work not yet published, by the same author as the paper before the reader. That research is lent support by the comparative simplicity of the immediate work. The Reissner-Nordström modification suggests a novel experimental test, perhaps in “table-top” [19]. The same principle has measurable implications for the electromagnetic temperature of stellar mass black hole candidates [19].

4. Discussion

4.1. Quantum field theory

Observation of gravitational waves as according to the conventional theory has been experimentally confirmed, by [1], recently by [5], and several other detection events. New theory must explain this success. The established theory asserts that the graviton primarily couples to the mass quadrupole, because it has 2 fundamental units of spin. Monopole waves require a scalar particle, spin-0. Then, we assume the established theory is correct, but it requires augmentation by a composite scalar. This likely requires that the spin-2 graviton can be produced in sets of two (or more) gravitons with identical quantum numbers *except for exactly anti-aligned spins* that cancel overall. This behavior is not observed in photons, due to the inability of a rank-1 tensor potential to accommodate antisymmetry or torsion. Electromagnetism therefore does not couple to the charge monopole, but this behavior of gravity is specifically similar to an electromagnetic laser, where stimulated emission produces sets of photons with entirely identical quantum numbers.

Identical except spin-anti-aligned states imply an antisymmetric component to the metric tensor. Einstein-Cartan theory, as explained in [21], or some very similar asymmetric gravity theory, might therefore represent a better large-scale limit to a quantum theory of gravity than general relativity. While Einstein-Cartan is thought to reproduce virtually all experimental predictions of general relativity, the monopole waves developed in the paper before the reader might represent exactly a key difference in experimental prediction.

4.2. Black hole evaporation observer dependence

Under the influence of the gravity of a black hole, or any gravitating body, local gravitational accelerations must appear to decay at different rates depending on their magnitudes. Geometry and/or mass of the body must change, to accommodate this. At the limit of an observer staying on the changing event horizon radius of a black hole, the change should follow only from the radiation of equivalent mass and corresponding change in area of the event horizon and volume of the black hole. The same should be true for non-extremal bodies, such as we rest at the surface of the Earth.

Due to the *non-tensorial* nature of the gravitational stress-energy-momentum that follows from equivalence principle [15], this decay is observer dependent. While a body resting on the surface of the Earth sees the planet emit mass as monopole waves, a free-falling observer in the same gravitational field sees *no* monopole wave emission whatsoever, in the ideal. This seems to break general covariance, except that we posit the mass loss is *monopole* in nature.

Emission of scalar quasi-particles interacting with the mass monopole term must excite the Higgs field, as well as cause such excitations to decay. (The existence and role of the Higgs field in determining fundamental rest masses have been extensively theoretically developed [9] [10] [14] and experimentally confirmed [3].) Emission by particles deeper in the gravity well and absorption by fundamental particles further out appear to *change the rest masses of fundamental particles* independent of other quantum observables and solid state structure, at least in the large-scale physical limit.

This picture is covariant. It might also explain and predict anomalous deviations of fundamental particle rest masses in strong gravitational fields, as well as a cosmological background gas of massless force carrier particles that mediate this interaction, (i.e. "dark matter" and "dark energy," or at least a significant component thereof). If the rest mass and energy components are at a thermodynamic critical point for phase transition, evaporation of rest mass into energy as the universe expands might give the appearance of a weakly-interacting constant energy density and "extra" galactic mass, over long periods of cosmological time. A scalar interacting with "fundamental" rest mass could be the "inflaton." [17].

5. Conclusion

We present a functional minimization of general relativity's action with apparent gravitational monopole waves, satisfying the action principle's boundary conditions, which is trivial to verify. We can distinguish these "new physics" from "merely a coordinate artifact" by the general, but quantitative and measurable, implication by equivalence principle of anomalous acceleration decay. Hawking radiation from Rindler horizons, alone, is necessarily incompatible with metric tensor symmetry, by a qualititatively corresponding treatment. Quantum particle physics ramifications suggest a self-contradiction in general relativity's assumption of an exactly symmetric metric tensor, perhaps easily corrected with the extension to torsion, as in the "Einstein-Cartan theory."

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References

[1] Benjamin P Abbott, Richard Abbott, TD Abbott, MR Abernathy, Fausto Acernese, Kendall Ackley, Carl Adams, Thomas Adams, Paolo Addesso, RX Adhikari, et al. Observation of gravitational waves from a binary black hole merger. *Physical review letters*, 116(6):061102, 2016.

[2] Jacob D Bekenstein. Black-hole thermodynamics. *Physics Today*, 33(1):24–31, 1980.

[3] Serguei Chatrchyan, Vardan Khachatryan, Albert M Sirunyan, Armen Tumasyan, Wolfgang Adam, Ernest Aguilo, T Bergauer, M Dragicevic, J Erö, C Fabjan, et al. Observation of a new boson at a mass of 125 Gev with the CMS experiment at the LHC. *Physics Letters B*, 716(1):30–61, 2012.

[4] YM Cho. Theory of gravitational monopole. Technical report, 1990.

[5] LIGO Scientific Collaboration, Virgo Collaboration, et al. Gwtc-1: a gravitational-wave transient catalog of compact binary mergers observed by ligo and virgo during the first and second observing runs. *arXiv preprint arXiv:1811.12907*, 2018.

[6] A Dabholkar and S Nampuri. Lectures on quantum black holes. *arXiv preprint arXiv:1208.4814*.

[7] Albert Einstein. *The Meaning of Relativity*. Routledge, 2003.

[8] Albert Einstein et al. On the electrodynamics of moving bodies. *Annalen der Physik*, 17(891):50, 1905.

[9] François Englert and Robert Brout. Broken symmetry and the mass of gauge vector mesons. *Physical Review Letters*, 13(9):321, 1964.

[10] Gerald S Guralnik, Carl R Hagen, and Thomas WB Kibble. Global conservation laws and massless particles. *Physical Review Letters*, 13(20):585, 1964.

[11] Alan H Guth. *The Inflationary Universe: The Quest for a New Theory of Cosmic Origins*. Random House, 1998.

[12] Mark P Haugan and Claus Lämmerzahl. Principles of equivalence: their role in gravitation physics and experiments that test them. In *Gyros, Clocks, Interferometers...: Testing Relativistic Graviy in Space*, pages 195–212. Springer, 2001.

[13] Stephen Hawking and Michael Jackson. *A brief history of time*. Dove Audio Beverly Hills, 1993.

[14] Peter W Higgs. Broken symmetries and the masses of gauge bosons. *Physical Review Letters*, 13(16):508, 1964.

[15] LD Landau and EM Lifshitz. *The Classical Theory of Fields*. 1951.

[16] Andrei Linde. Inflationary cosmology. In *Inflationary Cosmology*, pages 1–54. Springer, 2008.

[17] David H Lyth and Antonio Riotto. Particle physics models of inflation and the cosmological density perturbation. *Physics Reports*, 314(1-2):1–146, 1999.

[18] T Padmanabhan. A short note on the boundary term for the Hilbert action. *Modern Physics Letters A*, 29(08):1450037, 2014.

[19] Daniel Strano. An augmented canonical gravity wave. *http://ultraphrenia.com/wp-content/uploads/2017/12/Strano2017Augmentedv3.pdf (preprint)*, 2017. Accessed on 8 Aug. 2019.

[20] Pierre Touboul, Gilles Métris, Manuel Rodrigues, Yves André, Quentin Baghi, Joël Bergé, Damien Boulanger, Stefanie Bremer, Patrice Carle, Ratana Chhun, et al. Microscope mission: first results of a space test of the equivalence principle. *Physical review letters*, 119(23):231101, 2017.

[21] A Trautman. Einstein-cartan theory. Technical report, 2006.

[22] Slava Turyshev, John Anderson, and Michael Martin Nieto. Pioneer anomaly put to the test. *Physics World*, 17(9):21, 2004.

[23] Slava G Turyshev, Viktor T Toth, Gary Kinsella, Siu-Chun Lee, Shing M Lok, and Jordan Ellis. Support for the thermal origin of the pioneer anomaly. *Physical review letters*, 108(24):241101, 2012.

[24] William G Unruh. Notes on black-hole evaporation. *Physical Review D*, 14(4):870, 1976.