Mostly-Destructive Consequences of Non- and Nowhere-Analyticity of the Spacetime Metric

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Abstract: This paper will explore consequences of the discovery in my previous paper (http://vixra.org/abs/2507.0097 Smith 2026) that Einstein vacuum solutions are *not* necessarily real-analytic, and indeed can be (and therefore presumably generically are, since the analytically-smooth spacetime metrics form an infinitesimally tiny subset of the much wider class of permitted functions) *nowhere-analytic*. These consequences are hugely destructive for many former physics ideas that implicitly or explicitly depended upon analyticity assumptions – such as "ER=EPR," "AdS-CFT," or "maximal analytic extensions" – and I will duly obliterate them! However, in an unexpected brief creative interlude during that apocalyptic demolition, I invented the promising new "mirror paradigm," which might be crazy, but if valid offers a simple and nice way to resolve most or all famous "paradoxes" associated with black holes.

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1. Preliminaries

Concerning analyticity and analytic continuation, one good reference is Henrici 1974-1986. Note that adding a non-analytic function to an analytic function – even if the non-analytic one is multiplied by an arbitrarily tiny number such as 10^{-100} – yields a non-analytic function. Similarly, adding even the slightest amount of nowhere-analytic-function "pollution" to an analytic function yields a nowhere-analytic function.

Counting and measuring functions. The Cantorian count of the number of *analytic* self maps of [-1,1] is the same as the cardinality $2^{\mathbb{N}}$ of the continuum $\mathbb{R}$, because analytic functions are specifiable by a countable sequence of reals: their Maclaurin series coefficients; and in the other direction any constant in [-1,1] is such a function. [Cardinality=$(2^{\mathbb{N}})^{\mathbb{N}}=2^{\mathbb{N}\cdot\mathbb{N}}=2^{\mathbb{N}}$.] The number of *continuous* maps of [-1,1] to itself also is $2^{\mathbb{N}}$ because a continuous function is specified by its values at all rational arguments, which is a countable set of reals (listable by concatenating all Farey sequences), and all analytic functions are continuous. $2^{\mathbb{N}}$ also counts the number of maps of [-1,1] to itself with continuous k^{th} derivatives, for any particular k≥0 (proof: integrate). However, if a "random" such k-differentiable function is chosen, for any particular k≥0 (even if we insist that its k^{th} derivative be monotonic), then the *probability* that any open subinterval will exist on which it is analytic, equals zero. For example, if we let $F^{(k)}(-1)=-1$ and $F^{(k)}(1)=1$ and then for n=1,2,3,... we at step n we assign the value of $F^{(k)}(x)$ at the n^{th} rational number in [-1,1] to be a random real chosen uniformly from the reals within the real interval whose endpoints are the previously chosen values of $F^{(k)}(x)$ at the two nearest previously-used rationals to our left and right... then the resulting function F(x) will have probability=0 of being analytic. Indeed, its Chebyshev series $F(x)=\sum_{j\geq 0} a_j T_j(x)$ will, with probability=1, have *sub*exponentially decreasing a_j, meaning $\limsup_{j\to\infty} j^{-1}|\log|a_j||=0$. Examples: $\sum_{j\geq 0}\exp(-\sqrt{j})T_j(x)$ and $\sum_{j\geq 0} j^{-53} T_j(x)$. If so, F(x) will be analytic *nowhere* within [-1,1] and its Chebyshev series will converge only on the real interval [-1,1] and nowhere else in the complex plane.

My **previous paper** (Smith 2026) constructed general relativity scenarios, which could even have initial conditions analytic everywhere except at a single point, which then would time-evolve to solutions analytic *nowhere* within a positive-measure open set of spacetime locations spreading outward from that initial point at lightspeed. Since nowhere-analytic behavior is *possible*, it presumably should be *generically expected.* So in the "dirty" real physical world, expect non-analyticity.

Although some physics-related partial differential equations, such as the so-called 1D heat equation $\partial U/\partial t=\partial^2 U/\partial x^2$ started at time t=0 have the property that *all* their solutions U are analytic functions of both x and t (when t>0), the EVFEs (Einstein vacuum field equations) evidently do *not* enjoy that property.

And indeed, one well known class of exact solutions of the EVFEs, discovered by Hans Brinkmann in 1925, are the "pp-wave" spacetimes

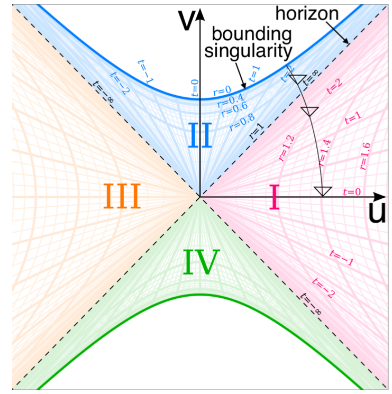
$$ds^2 = 2\, du\, dv + dx^2 + dy^2 + H(u,x,y)\, du^2$$

where H(u,x,y) is an *arbitrary* twice-differentiable function satisfying $\partial^2 H/\partial x^2+\partial^2 H/\partial y^2=0$. (Pp-waves are a subclass of the wider "Kundt class," discussed in ch.31 of Stephani et al. 2003.) An important particular special case is the "exact vacuum plane waves"

$$H(u,x,y) = A(u)\,(x^2-y^2) + 2B(u)\,xy$$

for arbitrary twice-differentiable functions A(u) and B(u) called the "+ and × polarization profiles." Notice that it is perfectly ok with the EVFEs if the dependence of H(u,x,y) on u, e.g. the functions A(u) and B(u), are nowhere-analytic, e.g. $A(u)=\sum_{j\geq 0} 5^{-j}\sin(2^j u)$ which is nowhere-thrice-differentiable but everywhere second-differentiable. [This series converges for all real u, but for no complex u with $0<|\mathrm{im}(u)|<1$.] Another class of exact solutions depending on arbitrary functions capable of exhibiting nowhere-analyticity are the "Einstein-Rosen cylindrical waves."

There has been a large body of work by many authors (but not me) on "maximal analytic extensions" of important GR vacuum (or in some cases nonvacuum) exact solutions. However, there usually is *no such thing* as a "maximal analytic extension" of a *non*analytic function. Nowhere-analytic functions cannot be analytically continued at all. Therefore we now see that all work, by all general-relativists, on the topic of "analytic extensions," presumably has zero physical relevance. Let us now review some of that work.



First came Martin D. Kruskal's 1960 "Maximal extension of the Schwarzschild" eternal nonrotating uncharged black hole metric, which involves four regions wikipedia calls

I. exterior region (u>|v|)
II. interior black hole (v>|u|)
III. parallel exterior region (u<-|v|)
IV. interior white hole (v<-|u|).

(Picture adapted from wikipedia article, in turn based on fig.2 in Kruskal 1960. All 45° inclined lines are null geodesics.) The initial investigators, including K.Schwarzschild and J.Droste, had only been aware of regions I and II. Kruskal's other two regions III and IV are not deducible from parts I and II of the spacetime by using the EVFEs, in the sense if any point in I or II emits a flash of light, that light classically can never reach anyplace in III and IV. No signal traveling at speeds≤c (where c=299792458 meter/sec is the speed of light) can ever reach anyplace in III and IV from anyplace in I and II. However Kruskal's metric in III and IV nevertheless is deducible by *assuming* – a better word might be "hoping" – that the spacetime metric is analytically smooth, so we can use "analytic continuation" to make the deduction.

"Einstein-Rosen (ER) bridges" aka "wormholes," named after Einstein & Rosen 1935, are connections between "two different universes" (or perhaps between faraway places in the same universe). These, according to wikipedia, "now are understood to be intrinsic parts of the maximally extended version of the Schwarzschild metric." Wikipedia's claim, however, was *false*, because the metric proposed by Einstein & Rosen is *not* equivalent to Kruskal's metric. Einstein & Rosen 1935 had simply employed the most-usual mass-M Schwarzschild coordinatization

$$ds^2 = -c^2[1-R_S/r]dt^2 + [1-R_S/r]^{-1}dr^2 + r^2[d\theta^2 + \sin(\theta)^2 d\varphi^2]$$

with circumferential radial coordinate r (where $R_S=2GMc^{-2}$ is the Schwarzschild radius and $G\approx6.674\times10^{-11}$ meter^{3}kg^{-1}sec^{-2} is Newton's gravitational constant; this is E&R's EQ 5), then changed variables from r to w with $w^2=r-R_S$ and therefore 2wdw=dr, thereby obtaining two exterior-Schwarzschild metrics (one with w>0, the other with w<0) *glued* together on their common horizon-spheres w=0. E&R claim on their p.75 that their metric is analytic ("regular") everywhere, unlike Kruskal's which has two boundary-curve singularities (the hyperbolas at the top and bottom of the picture, corresponding to r=0 in the Schwarzschild coordinatization). However, $g_{tt}=0$ on E&R's horizon w=0, causing $\det(g_{ab})=0$ there [although $g_{tt}>0$ and $\det(g_{ab})<0$ everywhere else], which as far as I am concerned causes the whole horizon surface to *be* a singularity in E&R's metric, which therefore is *non*analytic when w=0. Einstein & Rosen then try to claim that the Einstein vacuum field equations $R_{k\ell}=0$ (here $R_{k\ell}$ is the Ricci curvature tensor while g_{ab} is the metric tensor) could equally validly, as far as they knew based on experimental evidence, be replaced by $\det(g_{ab})^2R_{k\ell}=0$ [or for that matter $\det(g_{ab})^pR_{k\ell}=0$ for an arbitrary even integer p≥0]; and E&R's metric is an exact solution of these alternative field equations; so therefore they do not care about Warren D. Smith's judgment that the w=0 surface is singular. Warren D. Smith, however, thinks this is not legitimate: Einstein & Rosen **cheated**. Almost the whole point of Einstein's original derivation of general relativity had been his demand that everything be *invariant* if you change your coordinatization of the metric. Their alternative field equations $\det(g_{ab})^p R_{k\ell}=0$ disobey that demand if $p\neq0$. E&R's metric and coordinatization are bad in the sense that $\det(g_{ab})=0$ when $w=0$. If E&R changed coordinates to a better coordinate system (e.g. resembling Kruskal's), with $\det(g_{ab})\neq0$ there, then their spacetime would *not* satisfy $\det(g_{ab})^p R_{k\ell}=0$ on its horizon! Meanwhile, Kruskal's re-coordinatization of the Schwarzschild metric *does* satisfy $R_{k\ell}=0$ on its horizon, and indeed everywhere between the two hyperbolas.

To make a lower-dimensional analogy: if you have two flat sheets of paper, and cut a 1-inch diameter circular hole in each, then glue the two sheets together along the perimeter of that circle ("throat"), then are the gluing points "regular points" on the resulting 2-manifold? I contend they are not, i.e. are a metrical singularity (albeit a rather weak kind of singularity). If we had cut and glued square rather than circular holes, everybody would agree that the square-corners were metrical singularities, since they are surrounded by 540°, not 360°, of angle. But all other points on the perimeter of the square are metrically-regular. It we replace the "square" hole by a regular N-gon, then again points on the N-gon edges are metrically regular, but the corners are N metrical singularities with angle excess 720°/N each. If we make N large, then each of these singularities becomes weaker in the sense that their angle-excesses each approach zero. In the limit $N\to\infty$ we get a circular hole, whose entire perimeter consists of singular points, albeit each of them is "infinitely weakly" singular. Analogously, I claim E&R's metric actually is *not* a solution of the Einstein *vacuum* field equations. E&R hid that fact with their "multiply by $\det(g_{ab})^p$" sophistry. In fact, E&R's metric solves Einstein's *non*vacuum field equations with an infinitesimally-thin spherical shell of "flattened exotic matter," with negative areal mass-density proportional to $1/M$, located on the wormhole-throat $w=0$ surface while everyplace *else* is vacuum. In contrast, Kruskal's is a genuine, no-cheating, solution of the *vacuum* field equations.

E&R's metric has *no* positive-measure intermediate region lying inside all horizons, while Kruskal's "maximal analytic extension" does have such regions, namely II and IV in the picture. So clearly, the E&R and Kruskal metrics are *inequivalent*. Alternatively, E&R could have differently-defined w via $(R_S^2+\tilde{w}^2)^{-1/2}\tilde{w}^2=r-R_S$ (but didn't) which still would have caused the left hand side to be proportional to $w\tilde{w}^2$ for small $|w\tilde{w}|$, but for large $|w\tilde{w}|$ would, more intuitively and simply, cause $w\tilde{w}$ to asymptotically equal r. That would have been a different coordinatization of E&R's same metric. Another, which makes it maximally clear that E&R's metric is non-analytic at $w=0$ (now $p=0$), arises from changing coordinates from r to p where $r=|p|+R_S$. Then

$$ds^2 = -c^2[1-R_S/(|p|+R_S)]dt^2 + [1-R_S/(|p|+R_S)]^{-1}dp^2 + (|p|+R_S)^2[d\theta^2 + \sin(\theta)^2 d\varphi^2].$$

By their same kind of transformation applied to the r-coordinate of the Reissner-Nordström instead of Schwarzschild metric, Einstein & Rosen also could and did obtain electrically-*charged* wormhole metrics (automatically positively charged on one side, negatively on the other). They also could have done this, even more generally, for the full Kerr-Newman spinning/charged black hole metric family, but did not since Kerr & Newman were ≤6 years old at the time. Einstein & Rosen's main objective was not to create "wormholes," but rather to alter the Schwarzschild black hole metric to *remove* its singularity at the centerpoint $r=0$ of the original metric, while keeping it unaltered everywhere outside its horizon-sphere. (It has been claimed that Ludwig Flamm in 1916 already realized "Einstein Rosen" wormholes existed, but Matt Visser says "you definitely need hindsight" to detect that realization inside Flamm's paper.) But E&R *failed* in their singularity-removal goal if you agree with me that E&R's wormhole "throat" *is* a metrical singularity: E&R's removal of the centerpoint singularity came at the cost of creating a new metrical singularity on the (previously metrically-regular) horizon.

Unfortunately, apparently in most modern (ER=EPR and post-1970?) usage, most people talking about "Einstein-Rosen" wormholes *really* have in mind *Kruskal 1960's* maximal-analytic-extension metric, although they very rarely actually say so, and never mention the fact E&R cheated. For example, this is revealed around 52:41 in Susskind's video-recorded 4 Nov. 2014 Stanford lecture on ER=EPR that he put on the internet; and also in the first line of the "conclusion" of the Maldacena-Susskind 2013 paper – albeit unfortunately *without* explicitly saying so, *without* citing Kruskal 1960 (although M&S, in order to maximally confuse their readers, did cite E&R 1935) and Maldacena-Susskind 2013 do not actually *state* a metric. That unstated renaming convention is infuriating, obnoxious, and disgusting.

At about one hour and 26 minutes into this same 4 Nov. 2014 lecture on ER=EPR at Stanford, Susskind correctly says that a very large ("Schwinger limit") electric field can create (then separate) e^+e^- pairs from vacuum. Each such pair has quantum-entangled (since opposite) spins. At 1:30 Susskind then says an "extreme version of this same Schwinger process" will create a pair of + and - charged *black holes* from vacuum, completely quantum-entangled – everything about one may be deduced by measuring the other – and with an ER bridge between them. Susskind assures the audience that "you can calculate the probability for [this creation process] and you can calculate how it behaves afterwards." But Susskind doesn't actually *do* or cite any such "calculation"; and after searching the literature up to 4 Nov. 2014 I do not believe any such calculation exists. Au contraire: I claim that there is no, and never will be, and never can be, any solution of the Einstein-Maxwell vacuum equations featuring *topology change* such as this (allegedly induced by an electric field in vacuum), for the simple reason that it is mathematically *impossible*. So presumably Susskind has in mind a solution, *not* of the Einstein-Maxwell equations, but rather of some completely reliable more advanced theory of "quantum gravity" combined with electromagnetism, which apparently Susskind possesses but kept secret from everybody else.

Later, at 1:33:30 in the same lecture, Susskind claims that two black holes can and normally will have *many* Einstein-Rosen bridge*s*, note the plural, connecting them. (Where again, I think Susskind really meant "Kruskal.") This multibridge notion has never been justified, by anybody, by any metric solving Einstein's equations. Can such metrics exist and persist? Susskind simply *asserted* so, with no justification whatsoever. Indeed, in this entire (nearly 2 hours long) lecture, Susskind never wrote down a single formula, instead contenting himself with drawing on the board, in the manner of a comic book, rather sloppy pictures of fantasies such as this, apparently under the impression it might convince somebody of something.

The point that Kruskal wormholes are "non-traversible," i.e. it is not classically possible for a signal to travel from one external region to the other, was made by Fuller & Wheeler 1962, although this paper was entirely unnecessary because that already was obvious from my picture copied from fig.2 of Kruskal 1960. F&W claim on p.920 with no cite, and no metric justifying it, that "wormholes" can exist as in their fig.1 joining two locations in the *same* near-Euclidean universe via a possibly-much-shorter route. F&W's actual mathematical analysis, however, concerns the *Kruskal* metric, which does *not* join two locations in the same near-Euclidean universe. It joins two *different* universes. F&W blissfully ignore that contradiction, falsely pretending it is so minor that it does not deserve even a single sentence of discussion.

Meanwhile, Einstein & Rosen 1935's eternal-wormhole metric (also joining two *different*, not the same, universes) *is* traversible, i.e. contains timelike geodesics connecting their two universes. (Yet another confirmation that E&R's and Kruskal's metric are inequivalent.) However, if you fall into E&R's black hole from one universe, then when you emerge in the other, the "direction of time reverses." That is, E&R's metric's t-coordinate *in*creases in our universe as we go into the "future." But in their other universe (with $w<0$), we need to regard t as *de*creasing into the future. The reason I say this is Smith 2003, where I pointed out that general relativity, despite its field equations naively appearing to be time-reversal-symmetric, asymmetrically self-generates a definition of "future" thanks to irreversible phenomena such as the theorem that (if "negative mass" cannot exist) black holes can merge but not bifurcate. Falling *inward* into black holes always corresponds to the "future" time-direction. Then, if we adopt Feynman's view that an electron traveling backward in time is equivalent to a positron moving forwards in time: An electron that falls into E&Rs hole, then emerges on the other side, on both sides with continually increasing t-coordinate, really should be regarded as an electron falling in from our side *and* a positron falling in from the other side, both annihilating at $w=0$. Note: the gamma rays produced by that annihilation classically could never escape the $w=0$ horizon surface; and from the point of view of an external observer, the electron "never" reaches $w=0$, but rather has $w>0$ forever, only asymptotically approaching $w \to 0^+$ when $t \to \infty$. But from the point of view of a different observer riding on the electron, $w=0$ and $w<0$ both are reached in finite time as measured by his own clock. (That's discussed in Misner, Thorne, Wheeler 1973.) Susskind about 57:30 in his lecture claims the "ER" wormholes he has in mind are non-traversible, providing more confirmation that what Susskind falsely called "Einstein-Rosen" really meant "Kruskal."

Important new observation about Einstein-Rosen (and Kruskal). It is today well known (see discussion in Smith 2003) that the Schwarzschild metric is *stable* to small perturbations. All such perturbations die out exponentially ("quasimodes"). However, if small perturbations of the horizon surface die out like exp(-t) on our side, then on the other side of the Einstein-Rosen version of Schwarzschild, they also must behave like exp(-t), which means they actually are *increasing* exponentially as we go into the "future" (for that other-side's reversed notion of "future"). I conclude from this that the Einstein-Rosen metric must be **unstable** and/or that small perturbations to it are generically **illegal** (i.e. cannot exist without destroying the property of being an exact EVFE solution). Either way, we conclude that the ER metric necessarily is **unphysical**. However, note that this kind of time-reversal does *not* need to happen with Kruskal's spacetime (yet another reason it is inequivalent to Einstein-Rosen), and therefore this argument does not exclude Kruskal's metric from being physical. (It still might well be unphysical, but not because of *this* argument.) Nevertheless, it *could* happen with Kruskal, i.e. we *could*, if we wanted, insist that in regions I and II of the Kruskal picture, the "future" is the *in*creasing-u direction, while in regions III and IV, it is the *de*creasing-u direction. (Although I've never seen any previous author consider that "**bi-future**" option.) If so, then my unphysicality argument would apply to Kruskal too. The single- and bi-future Kruskal metrics differ in the following sense: With bi, no particle from our universe (I) can ever interact with another coming from the other universe (III). With single, both particles can enter region II and interact there before hitting the upper singularity.

"ER=EPR." Mark Van Raamsdonk in 2010 supposedly claimed that an AdS-Schwarzschild black hole metric if "maximally analytically extended" to feature an "*E*instein-*R*osen bridge" aka "non-traversable wormhole" to another faraway such hole, via Maldacena's "AdS/CFT-correspondence" corresponds to a pair of "maximally quantum-entangled" thermal conformal field theories. (Actually: I did not see such a claim when I looked in Van Raamsdonk's paper. More likely, this claim instead traces to Maldacena 2003.) Maldacena & Susskind 2013 then proclaimed that "ER=EPR," meaning that all "quantum-entangled" qubit-pairs were somehow secretly connected by an enormous number of invisible Einstein-Rosen (actually Kruskal) "wormholes" that were really responsible for the whole notion of quantum entanglement, and this brilliant insight was going to resolve both the EPR paradox (Einstein Podolsky Rosen 1935) that measurements of quantum-entangled far-distant particles naively apparently could "transmit information faster than light" – as well as later black hole "Hawking information-loss" and ""firewall" quantum-entanglement paradoxes. (More about ER=EPR: Gharibyan & Penna 2013, Jensen & Karch 2013, Sonner 2013.)

> "Two black holes which are [quantum] entangled will necessarily have [an Einstein-Rosen, by which he apparently really means Kruskal] bridge between them, two black holes which are unentangled will not. This was a major discovery. It seemed ludicrous at first, but very quickly caught on and is now standard lore."
> – Leonard Susskind, 11 May 2022 Oppenheimer Lecture at UC Berkeley. [For similar hype see Grant 2015, Lin, Ouelette & Cole 2015, and ch.6 of Cowen 2019.] Two other quotes, now from the 4 Nov. 2014 video lecture at Stanford by Susskind:
> "The two [ER 1935 and EPR 1935] papers apparently had nothing to do with each other [but] it has turned out that they are so deeply related that one can almost put an equal sign between them, they are so deeply connected, joined at the hip."
> "Lots of other people have different thoughts than I do [but] they're all wrong. They are."
> To be clear, as of 2026 I am *not* ready to regard this as "standard lore," and not willing to accept the second or third quotes either – and based on Susskind's perpetual use of ER when he means Kruskal, it appears to me that Susskind never actually read the Einstein-Rosen 1935 paper. That's a pity because both ER and EPR 1935 papers are excellent and well-written.

2. Destruction commences

Once we agree that "analytic extensions" are physically-irrelevant nonsense, then **all that about "ER=EPR," wormholes, Kruskal regions III and IV, and probably the "AdS-CFT correspondence" too** (which I think also implicitly depended upon analytic continuation) are **utter hogwash**. Indeed, even if

1. AdS-CFT were set in a correct-dimensional universe, *and* even if
2. our universe were anti-de-Sitter (AdS) instead of plain de Sitter, *and* even if
3. conformal field theories had any physical validity, *and* even if
4. all experimental evidence were not against supersymmetry (SUSY is used/assumed by Maldacena 1998 in his "derivation"), *and* even if
5. Maldacena's "derivation" of the AdS-CFT correspondence came anywhere near achieving mathematical rigor

(none of which look true, but even if they had been) – AdS-CFT & etc. *still* would be **bunk**. That is because Maldacena 2003 and Maldacena & Susskind 2013 certainly both depended upon analytic continuation, e.g. see M&S's appendix A's sentence "These become Rindler coordinates after we analytically continue τ to Lorentzian time." Maldacena 1998 is so completely packed with speculation to such an unbelievable degree that it is hard to say what it depends on – if the term "depends" even has any meaning in such a logic-free environment – but its followup paper by Witten definitely did involve analytic continuation.

Berezin, Dokuchaev, Eroshenko 2016 found the "maximal analytical extension of the **Vaidya** metric," which is a nonvacuum exact GR solution that can be regarded as representing, or modelling, a *Hawking-evaporating* Schwarzschild black hole. This work too must be thrown in the garbage as "physically irrelevant."

A number of authors, including Carter 1966 & 1968, Boyer & Lindquist 1967, Kim 1996, and Bakun et al 2017, attempted to find/understand the maximal analytic extension of the Kerr (or Kerr-Newman) metric representing a rotating (and in Newman's generalization also electrically *charged*) black hole. The results were astonishing, indicating **Kerr** holes really are doorways connecting an infinitude of other universes! And inside the inner horizon is a "time machine" region containing closed timelike curves! But again: with even the slightest nowhere-analytic pollution, all this is utterly unjustifiable; and presumably no extrapolation whatsoever into the region inside the Kerr hole's infinitely-blueshifting "inner horizon" can be expected to have any physical validity. (Morris & Thorne 1988 had already made similar critical remarks about Kerr's inner horizon in their §IA, but their attack is massively bolstered by the non-analyticity juggernaut.)

Also Schwarzschild can be redone with a general nonzero electric **charge** (Reissner-Nordström) and cosmical constant Λ (Schwarzschild had assumed charge=0 and Λ=0), see Mokdad 2017 who again finds a doorway connecting an infinitude of other universes (and Mokdad's metric is *not* equivalent to Einstein-Rosen 1935's, which has no such infinitude of universes) – but again I presume that, with the slightest amount of pollution of the spacetime metric by a nowhere-analytic function, no extrapolation into the region inside the infinitely-blueshifting inner horizon can be expected to enjoy any physical validity.

More criticism of "ER=EPR." An **objection by Nikolic 2013**, which as far as I can tell remains unanswered as of year 2026: "Convincing justification of [the ER=EPR] interpretation would require quantitative evidence that *correlations* between two ends of the wormhole are equal to those between the members of the EPR pair. As long as [there is no] such evidence, interpretation of wormholes as EPR pairs does not seem justified." Let me now elaborate on Nikolic's objection, plus invent my own objections.

Imagine we begin with two faraway (lightyears apart) un-entangled Schwarzschild black holes A and B. Midway between them we generate an entangled pair of two photons, e.g. one has helicity +1, the other -1 (but we do not know which) flying in opposite directions toward A and B. (Another version: a neutrino-antineutrino pair with helicities ±1/2.) After the two photons fall into the two black holes, those two holes acquire quantum-entangled spins: One hole has spin +1, other -1, but we do not know which. Therefore according to Susskind, the holes now are joined (but were not formerly) by an Einstein-Rosen bridge. How did this spacetime topology-change suddenly spring into being wormhole-linking two lightyears-apart black holes? It did not. If "physics is local" ("Mach's principle"), then the only way this could have happened is that the two photons, were *generated* with an ER bridge connection, which lengthened as the photons moved apart, ultimately becoming the ER-bridge connecting the two holes A and B. So we see that if ER=EPR is valid for entangled pairs of black holes, it *must* be the explanation for entangled photon-pairs, and indeed entangled pairs of *any* two qubits that would, if dumped into black holes, result in quantum-entangled measurable properties (mass, spin, and/or charge) of those holes.

First ER=EPR problem. Einstein-Rosen, and Kruskal, bridges only work for two *equal-mass* Schwarzschild black holes, since the maximally-extended Schwarzschild exact-GR-solution is unique (by "Birkhoff's theorem") and has only *one*, not two, mass-parameters. So if A and B originally had different masses – always true in practice – that whole story simply does not work. This trivially simple objection, incredibly, is nowhere discussed in Maldacena & Susskind's 31-page paper!

Now consider a fancier thought-experiment. Perhaps with the aid of one of Susskind's favorite devices, a hypothetical "quantum computer," we generate N spin-based qubits (N arbitrarily large), entangled such that the sum of those 01-qubits is *even*. I.e. all 2^{N-1} classical N-bit-states with even-sum are present in quantum superposition, all equally likely; but the 2^{N-1} odd-sum states have zero probability. With this fancier kind of entanglement, if you measure one of the qubits, then the remaining N-1 qubits are reduced to a fixed (known) sum-parity state; if you measure a second qubit the remaining N-2 then are in a known-sum-parity state, and so on. All qubit measurements act, as far as any measurer can tell, like perfect "fair coin tosses," *except* for the last; once N-1 qubits are measured, the final N^{th} qubit's state is determined. If we drop all *those* N qubits into N mutually-far-separated black holes, we get a state in which all N black holes must somehow be connected by wormholes!

Second ER=EPR problem. Einstein-Rosen and Kruskal bridges inherently only work for *two* Schwarzschild black holes, *not* an arbitrary number N>2 of them. That is another trivially simple objection, again incredibly nowhere discussed in Maldacena & Susskind 2013.

Now at this point an imaginary Susskind appeared on my shoulder and said "the maximal analytic extension of the Kerr metric (Boyer & Lindquist 1967) involves an *infinite* number of Kerr black holes in 'different universes' (or one perhaps could imagine them, or some of them, as being in the same universe, but far separated) metrically linked together inside." And Kerr holes, of course, are really what one should be considering if spin is involved. "So therefore," (continued the imaginary Susskind) "your N-fancily-entangled spins thought-experiment could be handled."

Third ER=EPR problem of the same ilk. The trouble with that is: the maximal analytic extension of the Kerr metric requires that all the Kerr holes have the ***same*** **mass, |spin|, and |charge|.** Also, "infinity" is *not* the same thing as "an arbitrary integer N>2." Also, if you look in Boyer & Lindquist's paper about the specific pattern of how the infinitude of Kerr holes are metrically linked (which is much *less* symmetric than the group of all N! permutations of N things), then you'll see that if we *measure* the spin of one arbitraily-selected hole, causing it instantly to "divorce" from the N-way "marriage," leaving an (N-1)-way marriage... and so on for a succession of more spin measurements done in any of the N! possible time-orderings... well, this is something that as far as I can see, just cannot happen.

Fourth foundational ER=EPR problem. Kruskal 1960's analytic extension of Schwarzschild metric is an *exact* solution of the GR vacuum field equations. "Exact" means it is not necessarily ok to perturb it. (And you'd better take this worry seriously in view of our refutation of the physicality of Einstein-Rosen 1935 despite 91 years of unqualified praise for it, and the Morris-Thorne-Yurtsever argument that it would yield paradoxes.) The reader may find it helpful to consider the function $F(z)=10^{-100}\exp(-z)$ for complex z with $re(z)\geq 0$. This function is very close to the function $G(z)=0$. However, they are not exactly equal. If we now consider the analytic continuations of these two functions into the complex z-plane, in particular into the region $re(z)<0$, then F(z) and G(z) are no longer close approximations. Indeed $|F(z)-G(z)|$ grows *unboundedly exponentially large*. This is not because I chose an atypical nasty F(z). Instead, the well known Liouville's theorem from complex analysis states that every function both analytic and bounded on the entire complex plane, must be constant. In other words, *every* nonconstant analytic perturbation you can make to *any* analytic function in the right halfplane (even if its absolute value is bounded below 10^{-100} everywhere!), will yield *unboundedly huge* perturbations when we use analytic continuation to extend the domain to the left halfplane.

> More strongly, it is known that any function F(z) both analytic and with absolute value bounded *below a polynomial(|z|)* on the entire complex z-plane, must *be* a polynomial(z). Therefore, *every* nonpolynomial analytic perturbation you can make to an analytic function in the right halfplane (even if its absolute value is bounded below 10^{-100} everywhere!), will yield, when we use analytic continuation to extend the domain to the left halfplane. perturbations so huge that they cannot be bounded by any polynomial. An even stronger result arises by combining that with this Paley-Wiener theorem; "The F(z) analytic and bounded in the closed upper halfplane are the functions F(z) that, when restricted to real z, have Fourier spectrum supported on a nonstrict subset of $[0,\infty)$." We deduce from those that any nonconstant analytic F(z) bounded within one halfplane must grow at least *exponentially* along rays into the other halfplane. And matters often are even worse than that: consider the function $H(z)=10^{-100}\sum_{j\geq 0}3^{-j}\exp(-2^j z)$. This function is tiny everywhere in the right halfplane $re(z)\geq 0$, and analytic wherever $re(z)>0$. But all along the imaginary axis, H(z) is everywhere differentiable but nowhere second-differentiable; and no analytic continuation into the left halfplane $re(z)<0$ exists *anywhere*.

Analogously, if a slight perturbation (e.g. caused by "dirt," or some faraway gravitating mass, perhaps another black hole) is made to the Schwarzschild metric on one side of an Einstein-Rosen or Kruskal bridge, it is entirely possible that it will often (usually? always?) cause *unboundedly enormous* perturbations on the other side. For that reason, it was **utterly unjustified** for Maldacena & Susskind (or anybody) to simply *assert* that an Einstein-Rosen bridge could join two holes in the *same* universe. The Kruskal exact solution is *only* valid for a bridge joining *two* – not one, and not three – universes, each asymptotically flat, and each an *exact* Schwarzschild metric. If there is any faraway hole somewhere else, then we do *not* have an exact Schwarzschild metric anymore. No matter how tiny this perturbation is, it might unavoidably destroy validity of the metric as an EVFE solution. So as far as I can tell *no* justification – whether theoretical or via a computer numerical calculation – has ever been given (and certainly not by Maldacena & Susskind in their 2013 ER=EPR paper) of the claim that such "vacuum wormholes" linking faraway holes in the *same* asymptotically-flat universe, could mathematically exist.

Do not be fooled by Misner 1960, which claims to provide "initial conditions" for a wormhole linking two faraway regions in the same universe. *Obviously*, 3-dimensional (*timeless*) metrics mathematically exist (with no physical-reality constraints, e.g. no demand they obey Einstein equations) exhibiting that topology. So what? What matters for physics is whether (3+*1*)-dimensional wormhole space*times* exist, which are long-lasting and nearly time-invariant solutions of the Einstein field equations. (If the two holes circularly orbit, they would be *exactly* time-invariant if it were not for the very gradual decay of that orbit due to energy-loss into gravitational waves, which by separating the holes far enough could be made arbitrarily slow. Also, presumably in *de Sitter* space, there presumably would be an unstable but *exactly-time-invariant* two-holes solution held apart at just the right fixed separation by the repulsion caused by the Einstein cosmical constant Λ.) *That* question – the question that matters – was nowhere addressed by Misner.

Fifth: Probable circular-logic problem: Examining Van Raamsdonk 2010's

> ABSTRACT: In this essay based on [0907.2939](), we argue that the emergence of classically connected spacetimes is intimately related to the quantum entanglement of degrees of freedom in a non-perturbative description of quantum gravity. Disentangling the degrees of freedom associated with two regions of spacetime results in these regions pulling apart and pinching off from each other in a way that can be quantified by standard measures of entanglement.

even if VR's arguments were acceptable mathematical proofs (which they are not), I think there still would be a severe risk that they are "circular." I.e. VR's arguments that you need quantum entanglement to get "classically connected spacetimes" are based on physics that *assumed*, as step 1, that we have a classically connected spacetime! For example, the very fact AdS is an exact solution of the Einstein vacuum field equations with attractive-signed cosmical constant Λ rests on an assumption we *have* a classical spacetime manifold. AdS underlay Maldacena's attempts to show "holography," which underpinned VR's arguments. And the very existence of quantum mechanics itself (e.g. Schrödinger equation) rested on assumptions we have a smooth spacetime manifold. If VR wants to convince me his arguments are not circular, then he'd presumably need to redo all of general relativity and quantum field theory, starting from sticks and stones, in a way that did not depend on any assumptions we have a smooth spacetime manifold (or anyhow made it clear there was no circularity involved – probably not easy because there historically were *many* logical steps to worry about) before he could even get started. No noncircularity demonstration anything like that ever happened, and VR's approach was to blissfully ignore this entire worry.

"Evil conspiracy theory" Historical note. Kruskal 1960 was actually written and submitted (and its figures drawn) by J.A.Wheeler, *not* Kruskal, but only Kruskal appears as an author! That is because Kruskal showed his mathematical work underlying the paper to Wheeler, requesting his feedback as a GR expert, whereupon Wheeler said "not important." [Both Kruskal and Wheeler were Princeton professors – Kruskal in applied maths, Wheeler in physics.] Years later, Wheeler decided it actually was very important hence wrote & submitted the paper with Kruskal's name on it, as repentance. (Kruskal, in Europe at the time, was astonished to receive *Physical Review*'s acceptance letter!) I believe that if Kruskal had written it, then it would have included some of the internals of his calculations, rather than merely their results; and some discussion of his motivations. More importantly, I suspect that "Kruskal's" **unjustified claim in fig.1 that the two Schwarzschild holes could alternatively be regarded as residing, *not* in two different universes, but rather only one (in the limit of far separation) was *invented solely by Wheeler*.** Why? First, I doubt Kruskal would have made such a nonrigorous claim sans critical examination.

Second, Wheeler was an excellent artist and draftsman and drew that figure. Kruskal was not and did not. (Incidentally, I knew Kruskal personally fairly well.) Third, Wheeler had an evil ulterior motive (in which Kruskal was uninvolved) for introducing same-universe wormholes: they set the stage for his elaborate "geometrodynamics" physics-fantasy. The Kruskal "wormhole" is "non-traversible" meaning it lacks timelike curves that enter one hole and emerge from the other.

> Such curves exist, but only if they include acausal, aka spacelike, segments. Inequivalent metrics representing *traversible* wormholes were later found mathematically (Morris & Thorne 1988), *but* all known examples are *non*vacuum solutions involving "exotic" matter with "negative mass." Indeed on p.405 Morris & Thorne sketch an argument by Don Page that negative-mass matter is *necessary* for any traversible wormhole. Exotic matter presumably cannot exist since if it could, then the vacuum could – and thermodynamically would be expected to – decay into it, contradicting all observations indicating the vacuum is stable. Also, the Morris-Thorne-Yurtsever followup paper argued than any traversible wormhole could be used to construct a "time machine" enabling you, paradoxically, to kill your newborn grandmother.

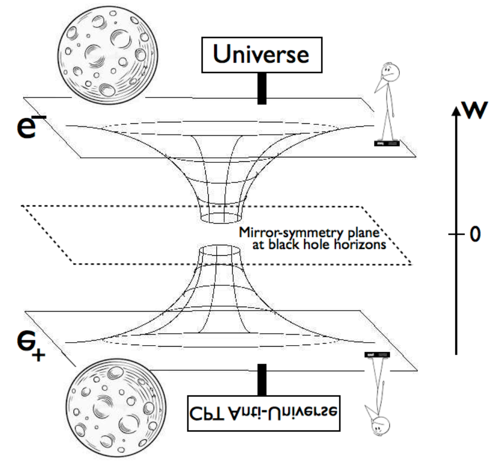
Fourth, Wheeler repeated his error on p.920 of Fuller & Wheeler 1962 whereupon Morris & Thorne 1988 repeated it again in their fig.1b. My theory of the history of Kruskal's paper thus explains how and why Wheeler snuck a completely mathematically-unjustified (but unfortunately self-propagating) idea into the physics literature in a paper by another author who never wanted to, and did not, propose that idea!

If we consider the diagonal line u+v=0 in Kruskal 1960's fig.2 separating the traditional half u+v>0 of the Schwarzschild picture from the "new universe" u+v<0 (null geodesics correspond to 45°-inclined lines in this picture), then hypothetical analytic complex-valued perturbations of forms $10^{-100}\exp(-K[1\pm i][u\mp iv])$ with K>0 would be tiny throughout the old universe, but assume unboundedly enormous values in the new one.

The logical **error** repeatedly commited by Wheeler was that he took the limit of far-separation *first*, then considered a Kruskal wormhole metric linking the two faraway locations *second*. Really, you need to have Kruskal-like wormhole metrics linking two (*not* necessarily far apart) locations first, then consider the far-distance limit second. That way, your limit can hope to exist. Wheeler's wrong way, no wormhole solution need exist, and therefore no limit need exist. Mathematicians call this "unjustified reordering of limits." It is not allowed. No valid argument has ever been produced by Wheeler or any later wormholer that any wormhole EVFE solution can mathematically exist linking two locations in the same asymptotically-flat universe.

W.Rindler in 1965 (and others later, e.g. G.'t Hooft 2018) suggested *not* interpreting Kruskal's metric as a wormhole joining two universes (or two exterior-anythings), but rather *identifying* Kruskal's "two" spacetime points ±(u,v). This option would (to quote Rindler) "destroy the arrow of time within the [black hole] interior." But note that the sufficient analytic extensions of the Kerr metric include closed timelike curves inside the inner horizons, so it would be surprising if the Schwarzschild limiting case lacked them. Also, for Kerr, Kerr-Newman, and Reissner-Nordström, the central singularity is *timelike*, meaning timelike geodesics generically permanently avoid hitting it ("repulsion") unlike the spacelike singularity in Kruskal/Schwarzschild, which every infalling geodesic is doomed to hit after a bounded amount of time measured by a clock carried by the infaller. With Rindler's re-interpretation, that doom can be avoided, or at least postponed, by an infaller equipped with good-enough rocket engines. Furthermore (**'t Hooft**) within that region quantum field theories would need to be CPT-invariant, causing antimatter and matter to be the same thing. These both suggest the possibility that the laws of physics inside and outside black holes radically *differ*! There is no classical way for external experimental physicists to decide that. But neither Rindler or 't Hooft said *what* could possibly cause the *laws of physics* to thus drastically change when you pass through a not-metrically-special horizon surface. And 't Hooft overlooked my bi-future suggestion, which, if combined with the Rinder two-point-identification trick, would *not* yield closed timelike curves whereupon there would *not* be any need for antimatter and matter to be the same inside the horizon, and infallers would resume all being doomed.

3. Interlude: New possibly-revolutionary (or crazy) self-consistent "mirror paradigm" for black holes.



I now point out that an analogue of Rindler's same point-identification trick could be applied not to Kruskal 1960's, but rather to the Einstein-Rosen 1935 metric: identify points with w and -w coordinate (but otherwise same), while reversing our notions of charge, parity, and time-direction for each particle with negative w. (This time-direction switch is in *addition* to the one I already argued was necessary with Einstein-Rosen, and causes increasing-t to again point into the "future" on both sides of w=0.) The w<0 side then, quite literally, would be a CPT "mirror anti-universe" with black hole horizons playing the role of the "mirror." Masses falling into the horizon then could *not* "pass through to the other side" but rather would instantly annihilate into pure energy with their antimatter mirrored versions (also falling in, from the other side). That energy then would *stay* on the w=0 horizon *surface*. There would be ***no* black hole "interior,"** only a surface that effectively would be an impassable but absorbing *boundary* for our universe.

The mirror paradigm offers the potential to explain, very simply, both Bekenstein-Hawking black hole "surface entropy" and "Hawking radiation" much more naturally, perhaps now without "paradoxes," while also getting rid of the singularities that resided inside (former) black hole notions, and *not* using (utterly unjustifiably) analytic continuation and related ridiculous "AdS-CFT holography" fantasies. E&R's full spacetime metric (both universes combined) does *not* rest on any need for analytic continuation, since their wormhole is traversible, so pollution of the metric by nowhere-analytic functions is not a devastating objection (in fact not an objection at all) to the mirror paradigm. For example, Hawking's "information loss paradox" had *been* paradoxical because an encyclopedia tossed into the black hole would fall *deep inside* the horizon, where it could no longer communicate its information up to that horizon and then into Hawking radiation. If there *is no* black hole interior, that paradox is avoided. The question of how black hole entropy possibly could be proportional to *surface area* while the information constituting that entropy instead presumably sat far inside, while the horizon was metrically not special? Again, no longer a problem. "Firewall" proposal? Kind of happens automatically (plus anyhow is not needed since no interior) and the horizon surface *is* made special: as I pointed out, with Einstein & Rosen 1935's metric, the horizon is a (mild) metrical singularity while everyplace else is regular. And as the mirror-symmetry-plane between the universe and mirrored anti-universe, it plays a special role as a surface of sure-annihilation, at which energy is trapped; and all observers agree about its location. Hawking radiation? Viewing it as "quantum tunneling" now actually makes some intuitive *sense*. "Time stopping" singularities such as the Schwarzschild r=0 point demanded to exist inside "trapped surfaces" by Penrose theorems? Banished. "Wormholes" to faraway places in the same universe (a fantasy which might be mathematically impossible)? No longer needed nor present. And the mirror paradigm version of E&R's wormholes are *not* traversible, e.g. in the sense that you get annihilated then your gamma rays are trapped; hence cannot incur "time machine" paradoxes. My instability or unperturbability objections about Einstein-Rosen? Gone due to the extra time-reversal causing perfect mirror-symmetry. Indeed black holes of *non*-Kerr-Newman metrical form (e.g. swiftly dying perturbations thereof) still could be "mirrorified" by the same sort of Einstein-Rosen trick involving defining, via squaring, a coordinate 0 on the horizon, positive above it, and there is nothing below. CPT-invariance of quantum field theories? Actually now has a useful purpose. The paradoxical fact that a black hole formation from a (>99.9% baryonic) star ultimately yields, after Hawking-evaporation, >99.9% *non*baryons (contradicting experimentally confirmed laws of baryon-number and lepton-number conservation), and indeed should output antimatter and matter equally? No longer a contradiction, because the mass-energy content of the black hole is pure-energy, which is allowed to be converted into any particle type.

In contrast, the faraway "cosmological horizon" in de Sitter spacetime (which also has a positive temperature and quantum-radiates, according to Gibbons & Hawking 1977) is *not* observer-independent; but since it never was troubled by "paradoxes" we presumably do not need any analogous special treatment for it.

Is the mirror paradigm a **brilliant** answer, or **crazy**? The main reason to suspect it is crazy is the fact Einstein & Rosen 1935 "cheated" and were wrong, i.e. their metric is *not* an EVFE solution. To overcome that objection, I need to hypothesize as a **new law of physics** that the "flattened" energy trapped on the E&R horizon surface can "*act* exotic" i.e. act for the purposes of its effect on the metric via the Einstein field equations, as though it had negative mass-density. By "dimensional analysis," the "effective mass areal-density" for this purpose, for a spherical black hole with mass M Planck-mass units should be proportional to 1/M Planck masses per Planck area unit. That is, the effective areal mass-density on the horizon surface ought to equal -K/(2πM), where

$$K = c^4 G^{-2} \approx 1.813\times10^{54}\ \mathrm{kg}^2/\mathrm{meter}^2$$

assuming I managed to get the constant 2π right (by trying to use Morris & Thorne 1988). In addition to negative effective areal mass-density, there should also be effective negative pressure in the radial direction (Morris & Thorne call this "radial tension") as well as large |pressure| in angular (perpendicular to radial) directions.

Whyever should that effective negative density and pressure happen? Well, the E&R horizon is a special place. It is a metrically weakly-*singular* surface. Therefore, Einstein's ordinary laws (which are partial differential equations) cannot be mindlessly applied. Mass-energy located on it, is "flattened" to be 2- not 3-dimensional. There is no time, in the sense that the time-time entry g_{tt} of E&R's metric tensor equals zero on the horizon. I had said any particle entering the horizon instantly annihilates with its antiparticle (entering from the other side) into pure energy, but given that there is no time, perhaps such particles are permanently trapped in a state of being "half-annihilated, half not-yet-annihilated." All this specialness suggests to me that some *new* law of physics *must* be hypothesized to handle this. The law that I am suggesting – i.e. that we get Einstein-Rosen-style metrical and CPT "mirroring" at horizons, arguably is the "simplest" possible such law.

What happens to a star collapsing into a black hole? I would guess that, at the moment each of its particles got cut off from the external universe, it would annihilate with its mirrored anti-particle and "flatten." But I would like to see a calculation of that process, rather than a guess; and I would like to know if there is any purely-*local* way the first particle could "know" it is on a horizon in order to start that process.

Is my whole mirror paradigm fantasy/proposal "science" at all, i.e. susceptible to experiment? Classically, there is no way for an external experimenter to tell what happens inside, or on the horizon of, a black hole. So the classical answer is "no." However, "quantum tunneling" effects such as "Hawking radiation" might in principle, at least partly, convert that into a "yes." Also, even with no experiments at all, we still are allowed to dismiss physical theories containing logical contradictions. As Hawking pointed out, the combination of Einstein general relativistic gravity with semiclassical quantum analyses yielding "Hawking radiation," "Hawking temperature," and "Bekenstein-Hawking entropy," appear to yield contradictions among previously-accepted laws of physics. *Therefore, those laws of physics must change.* The mirror paradigm is such a change, and a very minor and simple one, which seems to get rid of all those contradictions. And if it is correct, then it would be part of future "theories of everything" – some of which hopefully would have experimentally checkable consequences.

Bottom line: I think the mirror paradigm *is* pretty crazy, but certainly far less than "ER=EPR" and "AdS-CFT"; and I presently see no way to attack its putative validity.

4. Destruction resumes

The two key innovative concepts in **Misner & Wheeler's "geometrodynamics" vision** had been "mass without mass" and "charge without charge." That is: all "mass" was postulated to really be wormholes which look *externally* like two Schwarzschild black holes ("localized masses") but actually there never was any "mass" (in the old sense of the word) there – the wormhole is hollow and there is "nothing inside" – the stress-energy tensor shows pure-vacuum everywhere. (Actually this is not really true, since a curvature singularity exists forming a boundary for the Kruskal metric. On this boundary, null and timelike geodesics *end*. However, "mass without mass" really would be true using Einstein-Rosen wormholes, which E&R claimed singularity-free; but Wheeler did not use the latter and I criticized E&R's solution as not really being a *vacuum* solution of the field equations, and not really singularity-free, at all.) Similarly, all "charges" were postulated to really be wormholes with electric field lines heading into one black hole, and emerging from the other, thus giving the *illusion* of two faraway point charges (one -, other +) but without any actual source of charge – the $\vec{E}$-field is divergence-free everywhere. There remained the minor matter of somehow explaining why all electrons have the *same* charge and mass, presumably via some sort of quantum-addition to his vision – and explaining why there are far more electrons than positrons – small tasks left to future authors.

But: I suspect that **no GR vacuum solution exists** that describes a wormhole connecting two far-separated black holes in the same universe. More generally I suspect that no solution of the

Einstein-Maxwell equations exists describing a wormhole connecting two far-separated oppositely-electrically-charged black holes in the same universe. I.e: **There is no "mass without mass"! There is no "charge without charge"!** Anybody who wants to shove the "geometrodynamics" vision down our throats (such as Wheeler 1963), needs, as a first step, to refute my suspicions by **proving existence** of such GR-solutions. As a second step, you'd want to argue that they can somehow survive the onslaught from nowhere-analytic metrics. Neither underhanded stunts *pretending* to provide such an existence proof "trivially," and with another author's name conveniently on it; nor 3D-only papers like Misner 1960 attempting to fool the reader into thinking wormhole existence was "proven," are acceptable substitutes.

Sixth objection to ER=EPR: How could we have two *electrons* with entangled spins, when geometrodynamics would instead want electrons to be wormhole-linked to *positrons*? One way to generate two spin-entangled electrons is a double beta-decay of, say, ^{100}Mo→^{100}Ru (halflife=7.1×10^{18} years; both these isotopes have nuclear spin=0 and parity=+). And under the as-yet-unproven hypothesis that some nuclei can experience "*neutrinoless* double beta decay," the two emitted electrons necessarily would be *maximally* entangled.

Seventh objection to ER=EPR: Electrons, protons, and atomic nuclei have too great charge, and also too great spin (the latter also is true about neutrons), in comparison to their masses, to *be* Kerr-Newman black holes. Instead, any Kerr-Newman-like attempt to model them as point particles via classical Einstein-Maxwell necessarily would conclude they are naked singularities with *no* event horizon anywhere for anybody to attempt to "extend" the metric across. So: question: how can two of these particles be entangled via ER=EPR, if no ER or Kruskal (nor any other metrical kind of) "bridge" is classically possible?

5. Conclusion

As far as I can tell, the whole ER=EPR and geometrodynamics ideas are completely unjustified smoking rubble, with "AdS-CFT" and everything depending on "analytic continuation" dead meat. The fact that the Maldacena 1998 paper introducing "AdS-CFT" was claimed in Cowen 2019 to be the *most-cited theoretical physics paper of all time* (although I consider it "10 out of 10 on the bullshit meter"!) is an embarrassment for physics.

And when I emailed a draft of this paper to both Maldacena and Susskind, requesting their response (e.g. did they have any defense of ER=EPR?), after 5 weeks none came. [UPDATE: Javed & Wilson-Ewing 2026 argue that the ER=EPR hypothesis can be, or is, experimentally ruled out by precision measurements of hydrogen atoms.]

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