WORMHOLES AND SCIENCE FICTION

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ABSTRACT

This article is the transcript of the audio-visual presentation titled 'Wormholes: Science Fiction or Pure Fantasy?' [7] prior to Hollywood's release of the movie 'Interstellar', the plot of which involves astronauts travelling through a wormhole to save the Human Race. It is explained in simply terms why the wormhole has no relation to reality, just as the black hole has no relation to reality.

According to the astrophysical scientists, a wormhole is a tunnel-like connexion between two different parts of the Universe or between two different universes. It is claimed that wormholes enable time travel, if one end of the wormhole is, somehow, accelerated and brought back to its starting position. Thus, the wormhole tunnel is also a time tunnel! There are a variety of wormholes alleged; some are unidirectional whilst others are bidirectional. Generally speaking, it is said that the unidirectional types are unstable, but the bidirectional types are stabilised by the presence of what is called *exotic matter*. This 'exotic' matter is not like that of our everyday experience, not like 'antimatter', and not even like the 'dark matter' imagined by astrophysical magicians. Exotic matter is said to possess *negative energy density* and large *negative pressure,* or *negative mass-energy.* Wormholes not stabilised by exotic matter are not two-way tunnels; only exotic matter wormholes are *traversable* so that things can travel either way through the tunnel. Traversable wormholes are, it seems, bidirectional oral-rectal passages. In view of the latter there might well be tapeholes which might be stabilised by tapeworms. On the other hand, tapeworms are not made of exotic matter, as we know from examination of them in the laboratory, and so how they might stabilise a tapehole is not yet understood by cosmologists. It seems that this is however a question that cosmologists are investigating with much vigour.

Exotic matter has all the appearances of ghosts, yet some even suggest that exotic matter is actually the elusive dark matter which sets astrophysical scientists feverishly afire, despite other scientists claiming that exotic matter is not dark matter.

Like black holes, wormholes are supposed to exist on scales from the microcosm on up to the macrocosm. The microcosm wormholes, down to 10^{-31} metres, it is said, can flash in and out of existence in time of the order of 10^{-43} seconds, whereas the macrocosm manifestations can last for a long time; at least long enough for things to go in one end and be spat out the other end. Some astrophysical scientists, such as Maldacena and Susskind [1] even claim that a wormhole is a quantum entangled pair of black holes. Others assert that the supermassive black hole supposedly lurking at the centre of any galaxy is most likely not a black hole at all, but a wormhole.

How is a wormhole supposed to form? Well, like a black hole, it requires gravitational collapse, unless it is primordial. A black hole has an infinitely dense singularity, where

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spacetime is infinitely curved. But in the case of a wormhole, some say that collapsing matter produces the wormhole oral-rectal cavity, reaches a very large but finite density, and then rebounds (whatever that is supposed to mean) to form another oral-rectal cavity somewhere else in the Universe, or synchronously with the same process in another universe. On the other hand others still, such as Misner, Thorne and Wheeler [2], say that matter can be entirely dispensed with so that only infinite spacetime curvatures in geometry need be considered for the formation of a wormhole. This is done by first assuming that there are two asymptotically flat universes, each having an infinite spacetime curvature without anything to cause the infinite curvature. According to Misner, Thorne and Wheeler [2], in Section 32.1 of their book titled 'Gravitation',

"The story that unfolded in the previous chapter was fantastic! One began with the innocuous looking Schwarzschild line element which was derived originally as the external field of a static star. One asked what happens if the star is absent, i.e., one probed the nature of the Schwarzschild geometry when no star is present to generate it. One might have expected the geometry to be that of a point mass sitting at r = 0. But it was not. It turned out to represent a 'wormhole' connecting two asymptotically flat universes. Moreover, the wormhole was dynamic. It was created by the 'joining together' of two 'r = 0' singularities, one in each universe; it expanded to a maximum circumference of $4\pi M$; it then recontracted and pinched off, leaving the two universes disconnected once again, each with its own 'r = 0' singularity."

Note that although they ask "*what happens if the star is absent*" the mass M of a star still figures in the expression for the circumference of the throat of their wormhole. This is another case of having and not having something simultaneously and at the same place, of which proponents of black holes and wormholes are so fond. And what did they say in their previous chapter you ask? This,

"Qualitatively speaking, the two asymptotically flat universes begin disconnected, with each containing a singularity of infinite curvature (r = 0). As the two universes evolve in time, their singularities join each other and form a nonsingular bridge. The bridge enlarges, until it reaches a maximum radius at the throat of r = 2M (maximum circumference of $4\pi M$; maximum surface area of $16\pi M^2$). It then contracts and pinches off, leaving the two universes disconnected and containing singularities (r = 0) once again. The formation, expansion, and collapse of the bridge occur so rapidly, that no particle or light ray can pass across the bridge from the faraway region of the one universe to the faraway region of the other without getting caught and crushed in the throat as it pinches off."

Apparently the wormhole Misner, Thorne and Wheeler allege is not traversable, because it is fleeting, owing to the absence of 'exotic matter' to stabilise it. In fact, according to them, there is no matter present at all. They disinherit mass from Hilbert's spacetime and play only with the mathematical singularity they had previously reified to generate a black hole in the first place. This is also at odds with the claims for matter being present at a wormhole, such as that by Maldacena and Susskind that wormholes are two quantum entangled black holes, since black holes are said to have mass, and that Einstein's gravity is spacetime curvature induced by the presence of matter.

But what is a singularity you ask? It's merely a place in an equation where the equation is undefined, such as by a division by zero. Singularities have been reified by astromathemagicians because they can't tell the difference between an equation and physical reality. For instance, you can go to a toy store and buy a bag of marbles, but you can't buy a

bag of infinitely dense centres of masses of marbles because a centre of mass is a mathematical artifice.

Are you confused yet? If so, don't worry, because, despite appearances, so are the wormholers. Their tall tale has come to us directly from fantasyland, with which they seem to have a direct telephone connexion. But there is a medicine at hand to remedy the ailment, as we shall soon see.

A Hollywood blockbuster movie named '*Interstellar*' is scheduled to be released in November 2014. The plot involves saving the Human Race from oblivion by sending some astronauts on a fantastic voyage through a wormhole. It must be a traversable wormhole, if they are to get back to tell tales of their adventures and to save the Human Race. Just like the black hole, the wormhole is the stuff science fiction movies are made of, and just like the black hole, the wormhole is indeed only science fiction. It is not without irony that one of the stars of the movie, Michael Cain, playing the part of a wormhole boffin, tells one of the other stars of the movie, Matthew McConaughey, "*trust me*". Apparently Cain's character is a professor of astrophysics. Wormholes, like black holes, are great for selling science fiction movies to the impressionable tender minds of children and an audience overcome by awe, diffidence, or both, but they have nothing whatsoever to do with reality.

Since the wormhole is supposed to involve a black hole in some way or another, let's first review the character of a black hole to see if it makes any sense.

The first thing of note is that a black hole constitutes a universe because it is defined as being either asymptotically flat or asymptotically curved. Since there is no bound on asymptotic, for otherwise it would not be asymptotic, the spacetime associated with a black hole is spatially infinite. Proponents of black holes don't even know their own theory. For instance, Dr. Robin Barnard [3], a post-doctoral astrophysical scientist at Harvard University has asserted, quite incorrectly, that the spacetime of a black hole is tiny. However, without the asymptotic condition no mathematical expression that can be misconstrued as a black hole even obtains. This is illustrated by the following figure for a black hole.
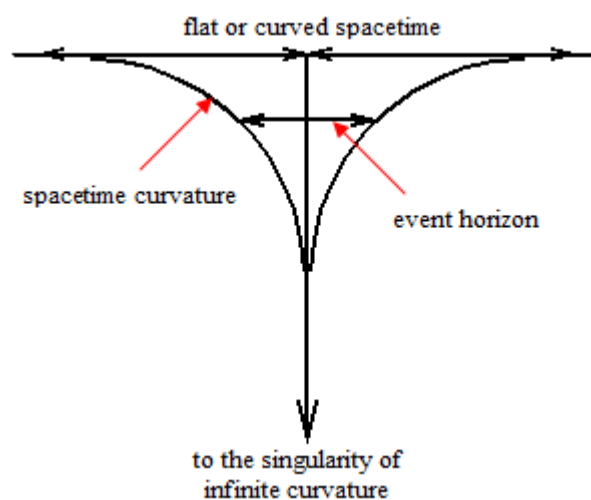
Note that as the radial distance increases indefinitely from the infinitely dense singularity, where spacetime is infinitely curved, the spacetime of the black hole universe gets closer and closer to some finite curvature (zero for flat, non-zero for curved). The spacetime associated

with the black hole is obviously spatially infinite. This is a defining characteristic of the black hole universe.

The second thing of note is that owing to the asymptotic condition there can't be multiple black holes. Consider this figure of just two supposed black holes.
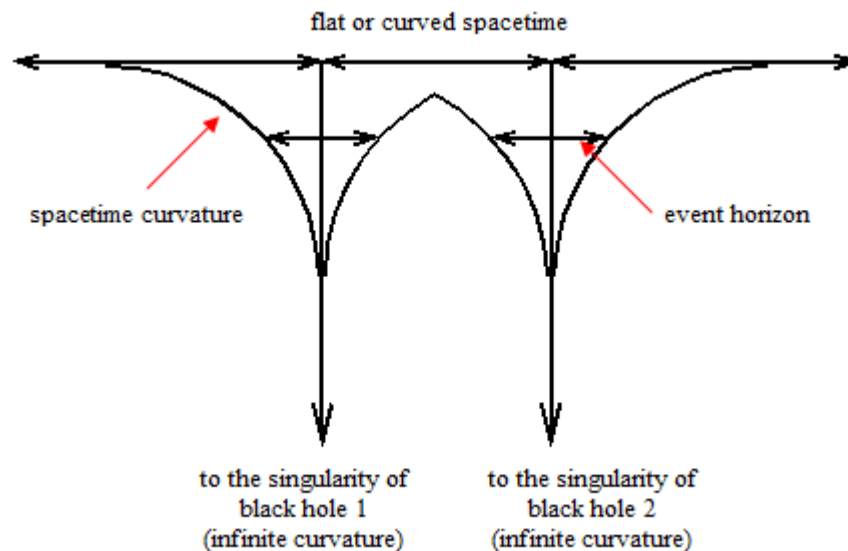
Note that the spacetime of neither of these black holes is asymptotically anything because the presence of the one destroys the asymptotic nature of the spacetime of the other, thereby violating the very definition of a black hole. In fact each black hole encounters an infinitely curved spacetime at the singularity of the other. Now consider the millions of black holes the astrophysical scientists claim to have found all over the cosmos! That's millions of infinite spacetime curvatures encountering millions of other spacetime curvatures, and so none are asymptotically anything.

The third thing of note is that according to all proponents of black holes, black holes have and do not have an escape speed (or escape velocity) simultaneously at the same place (at the event horizon). Well, that's impossible too. No proponent of black holes even understands the meaning of escape velocity.

The fourth thing of note is that all black hole universes are eternal, but no big bang universe is eternal. The astrophysical scientists tell us that all big bang universes are of finite age, ~13. 8 billion years. Thus, they insert an eternal black hole universe inside a universe that is supposedly ~13.8 billion years old. That's not possible.

The fifth thing of note is that no black hole universe is expanding; however all big bang universes are expanding.

The sixth thing of note is that all black hole universes are spatially infinite but the three alleged big bang universes are either spatially finite or spatially infinite. The spatially infinite black hole universe can't fit inside the spatially finite big bang universe. The two different spatially infinite big bang universes either have a constant negative curvature or a constant

zero curvature. But no black hole universe possesses such a constant curvature and so can't fit into either of the spatially infinite big bang universes.

The seventh thing of note is that the Principle of Superposition does not hold in General Relativity. For instance, let **X** be some black hole universe and let **Y** be some big bang universe. Then the superposition **X** + **Y** is not a universe. In fact, **X** and **Y** pertain to completely different sets of Einstein's field equations and therefore have nothing whatsoever to do with one another. Now let **X** and **Y** be black hole universes. Then **X** + **Y** is not a universe. Finally let **X** and **Y** be big bang universes. Then **X** + **Y** is not a universe either. Without having to resort to any detailed mathematical equation describing a black hole universe or a big bang universe it is clearly evident that black hole universes and big bang universes are mutually exclusive, and both are devoid of any connexion to reality. They are both products of mysticism. It therefore does not look very promising for the wormholes either; which we shall now investigate.

The wormhole was first conjured up by Albert Einstein and his colleague Nathan Rosen [4], in a paper titled 'The Particle Problem in the General Theory of Relativity', published in volume 48 of the journal *Physical Review* on the 1st of July 1935. Some say that Einstein and Rosen discovered the wormhole, but that's not true, because they just made it up, with some mathematical high jinks. There is actually a difference between discovering something and making something up *ad arbitrium*. The motivation for their paper was the removal of what has since become known as the 'event horizon' of a black hole, pertaining to the solution to Einstein's field equations in the absence of matter. Indeed, according to Einstein and Rosen [4],

"The question with which we are concerned can be put as follows: Is an atomistic theory of matter and electricity conceivable which, while excluding singularities in the field, makes use of no other field variables than those of the gravitational field ($g_{\mu\nu}$) and those of the electromagnetic field in the sense of Maxwell (vector potentials, $\varphi_{\mu\nu}$)?"

Einstein and Rosen called their tunnel a 'bridge', and so the wormhole is also known as the Einstein-Rosen Bridge. Their construction does not contain a black hole, and so there are none to be quantum entangled. In fact, they used a form of Schwarzschild's solution [5], which also does not contain a black hole. That which is usually called 'Schwarzschild's solution' is not his, but a solution due to Hilbert [6], which is not equivalent to Schwarzschild's on account of two alleged singularities, where in both cases a division by zero occurs, whereas Schwarzschild's actual solution has only one singularity, where a division by zero occurs.

Here are two images of wormholes that are freely available on the internet and typically used to represent wormholes.
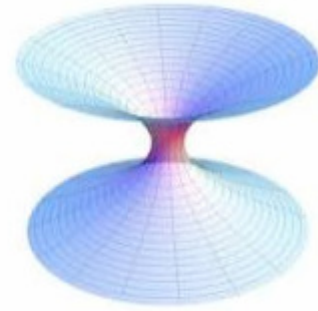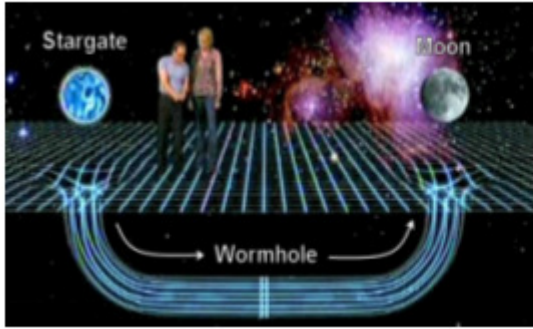
The image on the left is a supposed wormhole that connects two places in the same universe, whereas that on the right connects two different universes. However, these images do not reveal their surreptitious mathematical construction. We shall therefore consider the following two figures.
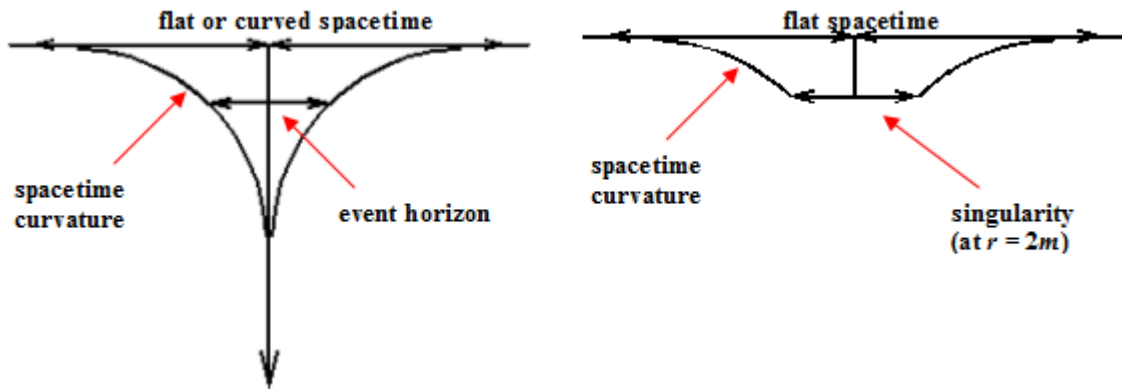

The diagram on the left represents a black hole, as we have already seen. Einstein and Rosen rejected the existence of black holes and so the vertical line going off to the singularity of infinite spacetime curvature was disregarded by them, since it does not manifest in Schwarzschild's solution, only in Hilbert's solution. Recall that Einstein and Rosen utilised Schwarzschild's actual solution, not Hilbert's. So the diagram on the right depicts the starting place for their 'bridge' construction.

Einstein and Rosen sought to remove the singularity at $r = 2m$ in their notation for the form of Schwarzschild's solution they used, as indicated in the diagram on the right. They simply set $u^2 = r - 2m$. Then they said this [4],

"As u varies from -∞ to +∞, r varies from +∞ to 2m and then again from 2m to +∞. If one tries to interpret the regular solution (5a) in the space of r, θ, φ, t, one arrives at the following conclusion. The four-dimensional space is described mathematically by two congruent parts or 'sheets' corresponding to u > 0 and u < 0, which are joined by a hyperplane r = 2m or u = 0 in which g vanishes. We call such a connection between the two sheets a 'bridge.'"

Note that mass, denoted by m, still appears in the Einstein-Rosen construction using Schwarzschild geometry. Also note that u is defined on the whole real number-line, and the

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expression Einstein and Rosen obtain by using it is not singular anywhere because no division by zero occurs in it. Let's now illustrate the "*two sheets*" they say they have constructed to form their 'bridge'.
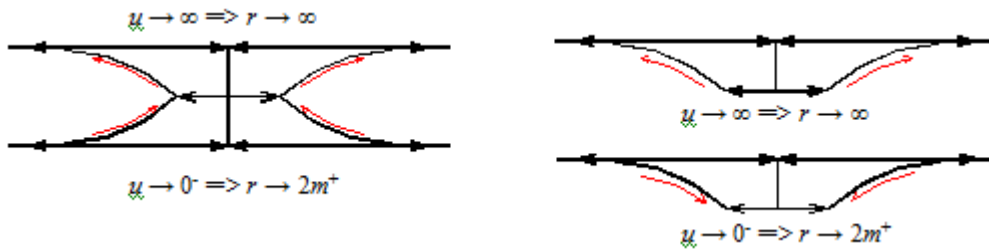
Einstein and Rosen interpret their analytic construction as depicted in the diagram on the left. The part below the throat they say is generated as u approaches zero from below zero (denoted by $u \rightarrow 0^-$) whereby r approaches its minimum $2m$, and at $u = 0$, $r = 2m$. Recall that Misner, Thorne and Wheeler [2] also say that $r = 2m$ is the "*maximum radius at the throat*". Misner, Thorne and Wheeler also assign to this throat the circumference of a circle and the area of a spherical surface, using the value $r = 2m$. Now as u greater than 0 grows without bound, r also grows without bound, as shown in the top part of the left side diagram. However, the diagram on the right shows that as u approaches zero from below zero r approaches $2m$ from above $2m$, and as u greater than zero grows without bound not only does r too grow without bound, the result is a retracing of the lower right diagram, but in the opposite direction, so that there is only one spacetime which is described twice.

According to Einstein and Rosen [4] their bridge,

"*represents a gravitational field … which ends in a plane covered with mass and forming a boundary of the space.*"

Thus, by their analytic construction, Einstein and Rosen transform what is alleged to be a point mass of the Schwarzschild solution into a plane mass of a wormhole. However, neither points nor planes have a volume and so they cannot contain any mass. The Einstein-Rosen Bridge does not connect two different universes, but different parts of the one universe.

According to Misner, Thorne and Wheeler [2] the two sheets derived from Schwarzschild geometry for a wormhole between two universes are each asymptotically flat. Now all black hole universes, as we have already seen, are by definition either asymptotically flat or asymptotically curved. Schwarzschild spacetime is asymptotically flat, and Hilbert's spacetime too is asymptotically flat. However, the mathematical expression produced by Einstein and Rosen for their wormhole is not asymptotically anything. This is easily seen by comparing Schwarzschild's solution in the form used by Einstein and Rosen with their bridge construction.

$$ds^2 = \left(1 - \frac{2m}{r}\right)dt^2 - \left(1 - \frac{2m}{r}\right)^{-1}dr^2 - r^2\left(d\theta^2 + \sin^2\theta\, d\varphi^2\right)\quad Schwarzschild$$

$$2m < r$$

$$ds^2 = \frac{u^2}{u^2 + 2m}dt^2 - 4\left(u^2 + 2m\right)du^2 - \left(u^2 + 2m\right)^2\left(d\theta^2 + \sin^2\theta\, d\varphi^2\right)$$

$$0 \leq u$$

It is evident from these mathematical expressions that as *r* grows without bound the coefficients of dt^2 and dr^2 approach 1, but as the magnitude of *u* grows without bound the coefficient of du^2 does not go towards 1 but instead grows without bound. Consequently the Einstein-Rosen sheets are not asymptotically anything, let alone asymptotically flat.

Although mass is present in the Einstein-Rosen Bridge, it is not present in the wormhole of Misner, Thorne and Wheeler. The latter mean by the term 'Schwarzschild geometry' that which is obtained by means of the so-called Kruskal-Szkeres coordinates, which they allege extends Hilbert's solution in such a way as to remove the singularity at *r* = 2*m* therein and produces a black hole. They say of their Schwarzschild geometry that [2],

"*when appropriately truncated, it is the spacetime geometry of a black hole and of a collapsing star – as well as of a wormhole.*"

It is now plain that the wormhole is nothing but a fantastic voyage into magic and wishful thinking effected by high jinks with mathematical expressions for black holes which in their turn have no physical meaning. Nonetheless, in their paper Einstein and Rosen extended their method to that for the Reissner-Nordström solution which according to the cosmologists describes a charged, non-rotating black hole. Once again they did not accept the black hole and set to removing the singularity they focussed on by eliminating mass from the Reissner-Nordström solution. From this they conjured up massless charges, and made them the space in a wormhole. They said,

"*The neutral, as well as the electrical, particle is a portion of space connecting the two sheets (bridge). … It appears that the most natural electrical particle in the theory is one without gravitating mass. One is therefore led, according to this theory, to consider the electron or proton as a two-bridge problem.*"

In other words, Einstein and Rosen claimed that a wormhole constitutes a neutral mass and another wormhole independently constitutes a charge, so that an electron or proton must be a combination of at least two wormholes, one for mass and one for charge! It is this nonsense they say makes their "*atomistic theory of matter and electricity conceivable*" [4].

Despite the mass and charge wormholes of Einstein and Rosen, and the quantum entangled black holes of Maldacena and Susskind, all generated from the nonsensical black hole equations, in the movie 'Interstellar' astronauts travel through not an empty wormhole of the type alleged by Misner, Thorne and Wheeler, but a traversable wormhole sustained by mysterious 'exotic matter'. Wormholes, like black holes, are the figment of irrational imagination and manipulations of physically meaningless mathematical expressions.

Hollywood will most likely make a lot of money from their blockbuster wormholes, but science will secure by them nothing but more irrelevance and detachment from reality.

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