

The "Spacetime Map" as a Model of Juan Maldacena's 5-Dimensional Holographic Universe

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Abstract

In 1997 the Argentinean physicist Juan Maldacena produced a mathematically rigorous model of a hypothetical 5-dimensional Universe which conforms to certain principles of the holographic metaphor. In Maldacena's model a 4-D Universe (3 space, 1 time) is the boundary membrane of the 5-D "bulk" Universe (4 space, 1 time). The physics in the two Universes are virtually indistinguishable, except that the 4-D Universe lacks gravity while the 5-D Universe is gravitational. Maldacena's model seems to fit my own "[Spacetime Map of the Universe](#)", which I have consequently come to interpret as a map of a 5-dimensional Cosmos, incorporating 4 large spatial dimensions and 1 time dimension.

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Introduction

As recounted in Brian Greene's new book, "The Fabric of the Cosmos" (Knopf, 2004) (pages 482 - 485), there have been serious suggestions by illustrious, ordinarily conservative, and very "establishment" physicists that our Universe might be constructed along the lines of a hologram. A hologram is produced by the interference pattern of a split laser beam, one half of this beam illuminating a subject, and the other half (the "reference" beam), recombining with the "subject" beam to form an interference pattern which is recorded on a transparent photographic plate. When another laser or reference beam is later directed at the developed plate, a 3-dimensional image of the original subject is projected into space. A characteristic feature of a holographic plate is that every part of it contains enough information to reconstruct the entire image - much as every cell in the body contains the DNA information of the whole organism.

The holographic model has attracted interest because a 2-dimensional surface (the transparent photographic plate) holds the information content necessary to produce a 3-dimensional image. This in turn is relevant to the finding of Hawking and Bekenstein that the entropy of a black hole is proportional to its surface area, and that therefore the maximum information any part of spacetime can contain is proportional to its 2-dimensional area, not its 3-dimensional volume.

According to Greene, in 1997 the Argentinean physicist Juan Maldacena (currently at the Institute for Advanced Study, Princeton) produced a mathematically rigorous model of a hypothetical 5-dimensional Universe which conforms to certain principles of the holographic metaphor. In Maldacena's model a 4-D Universe (3 space, 1 time) is the boundary membrane of the 5-D "bulk" Universe (4 space, 1 time). The physics in the two Universes are virtually indistinguishable, except that the 4-D Universe lacks gravity while the 5-D Universe is gravitational. Greene believes Maldacena's Universe does not correspond to reality, but I think this assessment is too pessimistic. In fact, Maldacena's model (at least as described by Greene) seems to fit my own "[Spacetime Map of the Universe](#)", which I have consequently come to realize is a map of a 5-dimensional Cosmos, incorporating 4 large spatial dimensions and 1 time dimension (or perhaps 3 spatial dimensions and a 2-dimensional historical dimension - history or "bulk" time as a surface rather than a line.)

The Spacetime Map as a 5-D Model

In the "[Spacetime Map](#)", history acts like a 5th spacetime dimension - and as in Maldacena's model, our usual 4 spacetime dimensions are the boundary membrane for 5-D historical spacetime: the latter is the conservation domain of information and matter's "causal matrix". In the Map, the area beneath the "light line" is the area of the Earth observer's "causal matrix" - the area traversed by all our earlier light lines, from which influences could potentially have traveled to us in the past, coincident with the area potentially visible to us in the past, but which we can no longer see. What is visible to us and directly (rather than indirectly) influential today is the bounding surface of this historic causal domain, our "light line", which is a 4-dimensional volume consisting of 3 spatial dimensions and one temporal historic sequence, visible as a whole, cohesive unit in each successive instant of the observer's eternally moving "Present Moment". The temporal sequence, which forever advances forward second by second like the frames of a film, consists of a fleeting glimpse of a single moment in the history of each earlier time period of the Universe (time sliced into units as thin as you like), receding back through the eons to the beginning of the Cosmos in the Big Bang (here we are thinking of the cosmic view obtained through our giant telescopes).

Upon analysis, we find our light line consists of the inner surfaces of a stacked series of 2-dimensional spatial shells, hollow concave spherical surfaces concentric upon the observer, receding like a nested set of "Russian Dolls" from the present moment to the "Big Bang". The actual spatial thickness (if any) of these shells is arbitrary, depending upon the light-time (ct) unit chosen for consideration (one light-second, one light-hour, one light-year, etc.). Hence we recover in the surface of these concentric light shells the 2-dimensional information-containing membrane of the holographic model. The 3-dimensional spatial aspect consists in the sequential layering of the shells, or if you prefer, in the intrinsic motion of a transverse, 2-dimensional light wave sweeping out a third spatial dimension. Finally, the temporal component of the sequence consists in the recessionary parade of history from the observer's present moment to the beginning of time in the Big Bang, the light line sinking deeper into history as it recedes into space.

In this panorama of historic spacetime, we see but a single moment in each earlier slice of the Universe; consequently, each retreating spherical 2-D shell contains but a vanishingly small sample of the 3-D spatial content of its associated Universe of that single, unique age. We can never see the entire spatial Universe as it existed at one particular time or age.

The Universe as it exists everywhere "now" in the outermost spatial circle of the Map is almost completely invisible to us. The "Universal Present Moment" (UPM), in the sense of equivalent age or distance from the Big Bang, is a concept made possible by the presumption that the whole Universe is born in a single instant in the Big Bang. Our only real contact with the present Universe is through touch, and within our own physical bodies. This is why touch is so special - with touch we enter a different dimension of reality, the Universal Present Moment.

The historic causal domain constitutes a (mostly) invisible fifth spacetime dimension, which in the Map lies both below and above our light line, consisting of the history (including our own) we have seen or could have seen (below the line), and the history (already formed but not including our own) we have not yet seen but will eventually see (above the line). Since our 4-dimensional light line is represented in the map by a one-dimensional line, it is evident that the area surrounding it must be one higher dimension, that is, 5-dimensional. This is the historic domain of everybody's "yesterday", which while invisible to us (other than the thin time slice of our own light line), is visible (likewise in thin slices) to other observers via their light lines. It corresponds to the summation of all possible light lines or the histories of all possible observers in the Universe, so in a real sense it corresponds to our light line "squared", again indicating a 5th (large) spacetime dimension, hidden under our noses as the historic domain of spacetime. Historical spacetime is the conservation domain of information and matter's "causal matrix", web, or network. For example, this dimension fills the "Andromeda Gap" (see below), the spacetime gap of 2.2 million years of already formed history which exists between Earth and the Andromeda galaxy. (Our past is (partly) visible now to the inhabitants of Andromeda, and vice versa; similarly, their past lies (partly) in our future, and vice versa. Our historic causal realm remains real and is visible to others, but not to us - and vice versa.)

Physics in the 4-D Boundary vs the 5-D "Bulk" Cosmos

According to Maldacena's model, the physics of the 5-dimensional "bulk" Universe is the same as the physics of the 4-dimensional boundary layer, except that the boundary layer, which corresponds to our light line in the Spacetime Map, does not contain gravity, while the 5-D Universe does - exactly the situation indicated by the map. The light line has no associated gravitational field: although light is affected by a gravitational field, [light](#)

produces none of its own. The bulk or 5-D Universe of historic spacetime, however, is deformed by gravitational warpage and deceleration. Nevertheless, the physics of the two domains is the same (or at least similar), because the bulk Universe contains light and electromagnetic energy as its primary energy form. The light line itself is just an historic record of past physics in the bulk Universe. And because we all live not in the "bulk" interior of the Universe, but on its edge in the Universal Present Moment (at the intersection of our time line, our light line, and the outermost spatial line of the Map), we give up no freedom of action in the Spacetime Map model. We initiate the action which becomes projected onto spacetime at velocity c (traveling in the UPM of the outermost spatial circle), although we are also reactive to our causal history. It is because we are able to utilize and direct energy that we can arrange (some of) our causal links to our liking and actually lay plans for the future.

Yesterday, Today, and Tomorrow

Our yesterday must remain real because our yesterday is someone else's "today" and light line - and vice versa. We are all immortal in the historic and causal domain of spacetime. The areas above and below the light line are, and always will be, equal areas by the law of reciprocity - we see other observer's pasts just as they see our past. It is interesting to note that fully $1/2$ of the Universe lies below our light line, hence within our causal matrix; this is, of course, also true for all other observers, so we conclude that we share parts of this area with all other observers in the Universe - because we can see them all (in some part of their history), therefore they all can see us (in some part of our history). In other words, all parts of the Universe are to a greater or lesser extent interconnected causally and historically: even those parts of the Universe which lie above our light line now, lay (partially) below our light line in some earlier segment of their history (as exemplified by the interconnection of Earth and observer "B" in the Map). This web-like connectedness is another indication of the realization of the holographic model. Time, space, light, gravitation and causality bind together the material Universe of entropic, historic, dimensional conservation domains.

It is the continuing reality of yesterday which upholds the reality of today, and of the "Universal Present Moment" for matter and observers everywhere. Establishing matter's time dimension and the causal historic domain which upholds matter's UPM is a fundamental rationale for gravitation, its universal association with bound energy, and its long-range

character. Gravity binds together space and time into spacetime, the entropic, compound, dimensional conservation domain of free and bound electromagnetic energy. Light is connected by space; matter is connected by history; all are connected by gravity. (See: ["A Description of Gravitation"](#).)

The Intrinsic Motions c, G, T

The "Spacetime Map" must be understood in the special geometric context and perspective of material observers (such as ourselves), for whom time ("velocity T") and light ("velocity c") are linked metric equivalents, producing a fixed relationship between the increase of time (history) and the increase of space (cT). Gravity ("velocity G") affects the linkage between time and space by influencing the gross shape (curvature) of the map. Natural law allows us to see spacetime in only a certain way; recall we are not seeing the objects themselves - we are only seeing *lights in spacetime* produced by objects which actually exist in *some other location* - a typical holographic effect (we see things where they were (on the map's lightline), not where they are in the UPM (on the map's outermost spatial circle)).

The expansion of the spatial Universe is produced by the intrinsic motion of light (as gauged by "velocity c"); the expansion of the historic Universe (historic spacetime) is produced by the intrinsic motion of the time dimension (as gauged by "velocity T"). The intrinsic motion of gravity (as gauged by "velocity G") [creates time from space](#). All of this spacetime activity depends upon the presence of bound energy: in a Universe of pure radiation (light, free energy) there is neither time, causality, history, location, nor gravity. The intrinsic motion of light (c), the intrinsic motion of time (T), and the intrinsic motion of gravity (G), are the entropy drives which create the 5 dimensions of spacetime: c creates the 3 spatial dimensions, T creates history (the temporal analog of space), and G creates time and spacetime, the compound dimensional conservation domain of free and bound electromagnetic energy. Together, c, G, and T create historic spacetime, the 5-dimensional conservation domain of information and matter's causal matrix, the "bulk" Universe. [G is the entropy conversion gauge](#), creating time via the annihilation of space, and light and space via the annihilation of mass (as in the stars). (See: ["Entropy, Gravitation, and Thermodynamics"](#) and: ["A Description of Gravitation"](#).)

Summary

While we do not yet understand how the full holographic metaphor applies to our Universe, in many respects the analogy works rather well: the displaced, 3-D image suspended in space, produced by a 2-D transverse wave or spherical surface, and the web-like interconnected information matrix of historical spacetime, are all typical holographic effects. One possible translation of the photographic plate and the reference vs the subject beam is found in our common experience of vision: 2-D light (the reference beam) reflects from objects around us, enters our eyes as the subject beam, and our brains (photographic plate) create and "project" a 3-D image of the world. Nor do we lose our ability to initiate actions in this model because we, like all observers, live and act only in the UPM on the very edge ("surface") of spacetime, not in its "bulk" interior.

The Spacetime Map fits Maldacena's 5-D Universe model even better than it fits the holographic analogy, with historical, causal spacetime playing the role of the 5th large but hidden spacetime dimension, and the light line playing the role of the 4-D boundary layer, whose non-gravitational physics becomes, in summation, the equivalent of the gravitational physics of the "bulk" spacetime Universe.

The Andromeda Gap

Andromeda, our nearest galactic neighbor, lies approximately 2.2 million light years from our own Milky Way. Andromeda is the furthest object visible to the naked eye. We see Andromeda not where and as it is, but where and as it was 2.2 million years ago. The view, of course, is reciprocal: Andromeda sees us as we were 2.2 million years ago, when our ancestors were still "ape men". Our view of Andromeda is like a hologram, projected upon the screen of space by light emitted by that galaxy during a particular moment of its existence, light whose large but finite velocity requires 2.2 million years to reach Earth. Thinking about the displacement of Andromeda in space and time from where and how we see it now, to where and how it "really" is "now" in the UPM, can give one a definite sense of the large historical (and causal) 5th dimension of spacetime interposed between us and our great galactic neighbor (the "Andromeda Gap"), which is almost entirely hidden from our view.

The finite velocity of light actually provides us with a 5th spacetime

dimension (exemplified above as the "Andromeda Gap"), the historic (and causal) dimension of spacetime. This 5th spacetime dimension allows us to see the distant galaxies with an extra degree of freedom, not where and as they are (the position of the always-advancing outermost spatial surface, or UPM of the Spacetime Map), but where and as they were (the historical record of the always-advancing light line). But this lightline is just a 4-D "surface view" of the 5th dimension, as we see only a moving instant of its history, while the vast bulk of its depth, including that of our own history, is hidden from us.

The holographic principle illustrated by the Andromeda galaxy lies not only in projections of historical, delayed light signals upon spacetime, but in the causal nature of those histories: "today" is a causal projection of "yesterday". Similarly, the Andromeda we see is a causal, historical projection onto the screen of spacetime, not just a light image; the image is required to be there by causality. The future existence of Andromeda (invisible from our perspective, but already formed) demands that the historical Andromeda we see continue to exist and exert its influence - so the future "pulls" and the past "pushes", and both are causal. Andromeda is an historical, causal hologram, projecting its image upon space as it moves forward in time, but it also exists in a future we cannot yet see - the area above our light line. Thus our current view of Andromeda is balanced between the real past and the real future (already formed) of this galaxy, both of which demand the continued causal existence of this apparently holographic image in our sky.

The 5th Dimension and the "Accelerating" Universe

The "hidden" historic (causal) 5th spacetime dimension constitutes an additional, large spacetime dimension which may have something to do with the current difficulties of cosmology, namely the "accelerating" Universe, and its consequential relatives, "dark energy" and "dark matter".

When we view distant, red-shifted galaxies, while it is generally understood that we see them not as they are but as they were, it is perhaps not fully appreciated that we do not see the Universe to which they are responding, that is, the Universe of their light line. Now while we and the distant galaxy both share the same Universe, we are responding to it gravitationally in a very different stage of its development. The distant galaxy is seen responding to a younger, hotter, smaller, denser Universe containing more mass and total gravitational energy than our current

Universe - because some of the gravitating mass of that younger, distant Universe will have been converted to non-gravitating light (free energy) over the intervening eons by the stars, quasars, supernovas, particle decays, and other processes which universally drive toward the conversion of bound to free energy; there is no compensating force which creates new atoms. Furthermore, this distant galaxy must respond to the gravitational influence and environment of its own time - which will also be greater in a smaller Universe due to the inverse square gravitational force law.

Hence we would expect to see evidence of an increasing gravitational environment as we look back in time - which is exactly what the observational data shows when plotted against the no-gravity expansion rate calculated from the map ([see graph](#)). The "accelerating Universe" is therefore seen as simply the natural consequence of decreasing gravitational mass in a Universe which is also spatially expanding. "Dark energy" is just a decreasing gravitational field and environment - essentially light liberated from mass - the expansive energy or intrinsic motion of light replacing the gravitational energy of converted mass. I should also point out that whatever "dark matter" may be, we expect it to obey the usual conservation laws, and hence by some process known or unknown, also convert its gravitating bound energy to non-gravitating free energy (in obedience to the symmetry conservation principles of "Noether's Theorem"). Since there is presumed to be something like 5 times as much dark matter as visible matter in the Cosmos, this provides a great deal of leeway for the processes of ordinary physics to express their influence through the "accelerating" expansion of the Cosmos.

Postscript

The Octonion Number System: is our Universe actually 8-dimensional?

(This article is (partially) copied from: "[The 'Tetrahedron Model' vs the 'Standard Model' of Physics: A Comparison](#)".)

(See: Ian Stewart: "*Why Beauty is Truth*" (2007 Basic Books) for a discussion of the "octonion" and other number systems)

It is possible to construct a number system and do meaningful mathematics in up to 8 dimensions (the "normed division algebra" of the

"octonion" number system), but not more. This suggests that energetic conservation domains of up to 8 dimensions may be physically possible. Indeed, our own Universe may be just such a domain. We live in 4 familiar spacetime dimensions, but there appears to be another set of 4 "historical spacetime" dimensions which we cannot see or access. For example, we see the Andromeda galaxy not as it is "now" in our time, but as it was more than two million years ago. Similarly, Andromeda observers (if any) see us (or could see us) more than two million years in our past. (The concept of a "Universal Present Moment" is reasonable because the Universe began at a single instant in the "Big Bang". Hence all observers are "now" the same age or distance from the Big Bang, assuming a uniform entropic expansion due to light's intrinsic motion. The "Universal Present Moment" is what we would see if we could flood the Universe with light that traveled with an actually infinite velocity.)

This "missing" 2 million year chunk of 4-D spacetime between us and the Andromeda galaxy is what I refer to as "historical spacetime". (We cannot see or access our own past, and likewise, Andromeda cannot see or access its past. We can, however, see a constantly advancing record of each others' histories.) Historical spacetime seems to constitute an additional set of 4 large but invisible dimensions, in fact constituting the "bulk content" of the Universe, by far the largest portion of spacetime, perfectly real but completely inaccessible and invisible to us. Other observers do (or could) live in this spacetime (which includes a moving record of our past) and experience it, just as we live in and experience our own "present moment" of spacetime, which includes a moving record of their past. A view of our past is a portion of their present reality, and vice versa. Although our past has receded into historical spacetime which we cannot access directly (because time travels into history as fast as light travels into space - both intrinsic motions are [metrically equilibrated entropy drives](#) of effectively infinite velocity, expanding and aging historic spacetime), our past nevertheless remains causally active and thus real - both to us and to other observers. Today (the "effect") is real only because yesterday (the "cause") remains real.

Every observer in the Universe is reciprocally related to every other observer, and while each exists in a "present moment" that is of the same universal age, all see only the 4-D "surface" of an 8-dimensional "bulk" historical spacetime formed of the past history of all events which have ever occurred, everywhere, since the common beginning of time in the "Big Bang". (See: "[A Spacetime Map of the Universe](#)" for a diagrammatic

representation of our "present moment", the universal "present moment", "bulk" historical spacetime, and where we are located in, and how we see, our Universe.) Elsewhere I have referred to this historical spacetime as a 5th dimension, but now, having learned (from Ian Stewart's splendid book) of the "octonion" number system mentioned above, I wonder if it represents a full extra set of 4 spacetime dimensions - because the octonions represent a formal conservation mechanism (both a geometric and an accounting system) which can accommodate them. They are energetically possible if conservation is possible.

The fact that these extra astronomical dimensions are apparently only light and space, without particulate reality (we can see them but not touch them), also seems to accord well with the loss of complete mathematical rigor in the octonions as compared to number systems of lesser dimensionality.

Others have suggested that these extra dimensions (implied by the existence of the octonions' number system) might be used to construct "strings" - that is, these are micro rather than macro dimensions. Could they possibly accommodate both? For example, during the "Planck Era", when spacetime, particles, light, and gravity are all joined together in Gamow's primordial "Ylem"?

Links:

Cosmology

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[A Spacetime Map of the Universe \(text - updated copy\)](#)

[A Spacetime Map of the Universe \(short text of conference talk\)](#)

[A Spacetime Map of the Universe \(updated pdf diagram\)](#)

[A Spacetime Map of the Universe \(original gif diagram\)](#)

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[Commentary on the Physical Parameters of the "Spacetime Map"](#)

[The Analogy Between Inflation and the "Big Crunch"](#)

[The Connection Between "String" Theory and the "Spacetime Map"](#)

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References:

Brian Greene: *The Fabric of the Cosmos*. Knopf, 2004
 Juan Maldacena: "The Illusion of Gravity". *Scientific American* Nov., 2005 pp 57 - 63.
 Ian Stewart: *Why Beauty is Truth*. Basic Books, 2007.

Fig. 1: A Spacetime Map of the Universe

