The Destruction of Information

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The Destruction of Information

Is information destroyed in a black hole? This question is debated in Leonard Susskind's recent book: "The Black Hole War" (Little, Brown, and Co., 2008). From the overview of the "Tetrahedron Model" and Noether's principle of the conservation of symmetry, it appears that information should be destroyed in a black hole. There are several reasons to think so (contrary to the conclusions of Susskind's book). First, on the premise that the universe begins as light, devolves to matter, and finally evolves and resolves to light again, conserving the original perfect symmetry of free electromangetic energy, information must be destroyed in any physical process which returns matter (and the information which matter contains) to light (because information is an asymmetric state of energy). Such final symmetry-restoring (conserving) reactions and processes include: 1) (actual) matter-antimatter annihilations due to the electromagnetic force; 2) (hypothetical) proton decay due to the strong and weak nuclear forces; 3) (theoretical) "evaporation" of black holes due to "Hawking radiation" (gravitational force); 4) (possible) "Big Crunch" gravitational collapse of the cosmos.

All four processes are driven by symmetry conservation acting through the charges of the four forces of physics. *The charges of matter are the symmetry debts of light* (Noether's Theorem). Light is a perfectly symmetric form of energy, containing no charges, no time dimension, no gravitational field, and no information. Information is necessarily an asymmetic form or configuration of energy, and hence must be destroyed with charge when charges are annihilated and material energy forms are returned to their original symmetric state, light (in obedience to Noether's Theorem). If the universe begins with light (which contains no information) and returns to light, then information must be destroyed in the process of the final return to (conservation of) symmetry. This is the long or generalized view of information destruction during the process of symmetry conservation as visualized in the "Tetrahedron Model".

A somewhat more detailed view of these same (above) processes takes note of the fact that even though a particle or a system is swallowed by a black hole, the prior history of that paticle or system remains extant (except in the case of the "Big Crunch"). So both positions in the "black hole information war" may be correct - black holes do indeed destroy particular information systems, but those systems and the information they contain nevertheless survive (at least partially) in a real historical sense - if not as actual records, then as light visible to distant observers, and/or as influences and "karmic consequences" which propagate endlessly in causal chains and dendritic repercussions throughout spacetime.

This latter view is very similar to the "holographic boundary" vision of information conservation as

put forward in Susskind's book. For example, light always travels in the "universal present moment", which forms the spacetime boundary of our universe - the outermost spatial line of the "Spacetime Map of the Universe". The boundary 2-D holgraphic surface which contains all the information necessary to reconstruct the "bulk" 3-D universe (including its historical development) is apparently stored in the 2-D light waves which propagate forever throughout the "universal present moment" of the cosmos. Hence there is no need to "rescue" Quantum Mechanics from a crisis caused by the destruction of information in black holes - the information lives on anyway in the causal history of spacetime and in the propagating light waves of the "universal present moment" of spacetime. (See: "A Spacetime Map of the Universe" (text).)

Reconstituting the original information from such historical records or from propagating causal effects or light rays is certainly no less improbable or challenging than decoding the hidden messages in Hawking radiation, as Susskind suggests is possible. Furthermore, if the holographic principle is true to the model, then only a fragment of the original hologram is necessary to reconstitute an image of the whole, and such fragments should be abundantly present in the historical record. For example, we have been able to reconstruct the age of the dinosaurs from fossils, the evolutionary history of the cosmos from starlight, and the ontogeny of humanity from DNA.

Bekenstein and Hawking have put forward the notion that entropy and information are proportional to the surface area of a black hole's "event horizon" (see: *Scientific American,* August 2003, page 58-65). But of what is this information composed? If a "bit" (quantum unit) of information is taken as the answer to a yes/no question (such as the heads vs tails of a coin toss), then the information content of a black hole's event horizon answers the question of space vs time. Gravity is a dimensional force converting space into time (and vice versa), sensitive only to a system's content of bound energy (Gm), and recording only dimensional and quantitative metric information of the most basic kind: gravity itself can't distinguish between an elephant and an equivalent weight of rocks. In the extreme case of a black hole, each bit of information on the event horizon announces that this is a completely temporal domain, where g = c, with no spatial component at all, even though black holes are typically situated within predominately spatial environments.

INFORMATION CONSERVATION

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In his book *The Black Hole War* (Back Bay Books, Little, Brown and Co., 2008), Leonard Susskind maintains that information cannot be destroyed - due to a theorem of reversibility/causality in quantum mechanics. Although Susskind does not distinguish between micro vs macro information states, in my view the question of information conservation must distinguish between primary (micro - quantum mechanical) and secondary (macro - biological) forms of information. Primary forms, which are preeminently atomic charges, are strictly conserved, whereas secondary forms, built upon the foundation of charges, and consisting preeminently of bio-molecular information (such as RNA/DNA), are not strictly conserved.

Take the example of chopping up and burning a tree in your fireplace. The tree is reduced to ashes, smoke, and hot gases, via an exothermic, self-propagating, and one-way oxidizing chemical reaction. This reaction cannot be reversed - the living tree and its huge store of biological information cannot be reconstituted from its oxidation products - the ashes, smoke, and hot gases. Hence this type of elaborated biological "tree information" is destroyed beyond any conceivable possibility of restitution by a commonplace chemical reaction - we don't need to go to the extreme of throwing the tree into a black hole to destroy its molecular biochemical information content.

Surviving the fire are all the tree's atoms, their charges, masses, and other permanently conserved parameters of the atomic, quantum mechanical, and thermodynamic realm. The total energy of the tree is conserved, while the entropy of the tree has gone from a very low value to a very high value, releasing heat to the environment during the transformation.

Nevertheless, biological information has its own means of conservation, which is at a molecular level (and above), through DNA, genes, seeds, and the whole mechanism of biological replication and reproduction. Higher levels of biological organization also involved with information conservation can be distinguished (organisms, families, societies, species, ecosystems, etc.). (See: "The Information Pathway" and "The Information Ladder".) The tree burned in your fireplace has nevertheless escaped complete destruction via the seeds it had previously produced (and perhaps via root sprouts), and via the gene pool of its species still extant in the forest and larger environment. It has become obvious that certain genetic components of all living organisms have persisted on this planet for billions of years, despite the repeated destruction of the individual and ephemeral carriers of this biological information. And yet this type of conservation can only be characterized as a kind of dogged persistence, not as "true" or "eternal" conservation, such as the absolute conservation of charge, for example. Even a black hole cannot destroy atomic charges, although it may help to gather and neutralize them. A hierarchy of temporal conservation, on a scale of absolute to ephemeral, might therefore read: energy/entropy -> symmetry/charges -> atoms -> molecules/DNA/genes -> higher biological organizational levels.

We can also distinguish these two types of information as *primordial vs evolved*. Primordial information is what emerges with matter from the Big Bang - as a consequence of the conversion of all-symmetric light and space into asymmetric matter and time. These primordial information forms are necessary to bring the universe into existence, and (eventually) to see it out again. They include the atomic charges of the 4 forces (electric, color, identity, location) - which are all *symmetry debts of light,* awaiting and demanding payment via antimatter charge cancellation - whose purpose is to return the asymmetric material system to its symmetric origins (light). Primordial particles include the proton, neutron, electron, neutrino, and various mesons (all serving as mass and charge carriers), and the field vectors of the four forces. There are also antiparticles and heavy versions ("flavors") of some particles. In addition, there are quantized thermodynamic conservation parameters such as energy and entropy, the spacetime dimensions, various physical constants, coupling constants, gauges, particle masses, and many other free parameters of the "Standard Model" of particle physics. (See: "Symmetry Principles of the Unified Field Theory" and "The Particle Table").

Evolved information is created by nuclear, atomic, and molecular combinations after the Big Bang, consisting mostly of the 92 elements of the periodic table and the hugely elaborate and temporary

structures of biology. Primordial information is strictly, permanently, and perfectly conserved, but evolved information is only partially, temporarily, and imperfectly conserved. The purpose of the evolved information content of the universe is evidently to allow the universe to know and explore itself, and to develop new creative modes and new forms of beauty (as in beautiful biological forms, including humans and their works of art). Whereas the primordial information content is required for the creation and the (eventual) annihilation of the universe, the evolved information content is required only for the evolution of life and humanity. Humans in turn have developed new forms of information and methods for its conservation, such as language, art, writing, printing, photography, libraries, museums, social structures (schools, academies, universities, etc.), and most recently the telegraph, radio, television, computers and the internet, and other electronic, optical, magnetic, and chemical forms of information creation, communication, processing, recording, and storage - including vast scientific, military, political, communication, and entertainment industries and infrastructures. (See: "The Fractal Organization of Nature".)

But all these secondary forms of information are ephemeral and readily destroyed. They persist only through continual and intentional replication and reproduction and "artificial" storage devices. There is also a sense in which all information is permanently stored in the historical domain, both directly in spacetime and indirectly via causal chains. Nevertheless, this historical information is also subject to entropic degradation.

The black hole "event horizon" has been described by Bekenstein, Hawking, and Susskind as a sort of 2-Dimensional skin or membrane covering the black hole, which is visualized as a seamlessly conjoined surface of Plank-sized units of pixelated (quantized) spacetime, representing and encoding the entropy content of the energy contained within the back hole. (See: Jacob D. Bekenstein: "Information in the Holographic Universe" *Scientific American* Aug. 2003 p. 58 - 65.)

In our view these entropy pixels are purely temporal in character, their spatial component having been squeezed out by gravity. The event horizon is an ultimate boundary between the domain and metric of space and light, and the domain and metric of time and matter. It is defined as the spacetime layer surrounding the black hole where g = c, where the local acceleration of spacetime due to gravity equals the electromagnetic constant "c". Nothing can escape from within this time curtain since nothing, not even light, can exceed velocity c. Time stands still at the event horizon - seconds become infinitely long - while distance shrinks to nothing in the direction of motion. Hence at "g = c", matter becomes two-dimensional and this ultimate temporal metric created by gravity for matter is analogous to the ultimate spatial metric created by electromagnetism for light: in both cases all energy forms move at velocity c, are two-dimensional, and their clocks are stopped.

At the black hole's central "singularity", my presumption is that everything and anything is reduced to photons of light via proton decay and the mutual annihilation of all charges and anti-charges gathered by the universally attractive and irresistible gravitational force. A black hole may be filled with nothing but gravitationally bound light, standing in fair comparison to a superconducting medium in which photons acquire mass. What emerges from black holes, either by quantum "tunneling" of the light trapped inside, or by "Hawking radiation" extracted from virtual particles outside, is hopelessly scrambled light, which codes only for the gravitational and temporal entropy of the mass energy contained within. No details of the in-falling matter beyond the barest thermodynamic information

(energy/entropy) can be deduced from this raw output, which is but a meager payment on the gravitational symmetry debt of the confined energy.

The black hole is the final gravitational mechanism for paying matter's "location" symmetry debt - the primordial symmetry debt acquired by matter when immobile "local" mass (bound electromagnetic energy) was created from the free electromagnetic energy of "non-local" light with "intrinsic motion c". The "location" charge of matter thus represents and codes for matter's asymmetric, concentrated distribution in space vs the perfectly symmetric distribution of the light-energy from which it was created. By Noether's theorem, such continuous symmetries of light must be conserved, hence the gravitational "location" charge carried by every form of massive "local" (immobile) bound energy. Note that the gravitational charge identifies the exact spacetime location, quantity, and density of the offending concentration of immobile - and hence asymmetrically distributed - mass-energy.

The early stages of "location" debt repayment by gravitation are seen in stars like our Sun where bound electromagnetic energy is converted back to light; not only the Sun's mass, but also its associated gravitational field is reduced, as we should expect upon payment of any debt. Later stages of repayment are seen in supernovas and quasars, and the final (and complete) stage of repayment is seen in black holes via "Hawking radiation". Since freely moving light produces no gravitational field, the total conversion of the black hole to light via Hawking radiation vanishes both the black hole's mass and its associated gravitational field, completely repaying bound energy's distributional symmetry debt and cancelling its "location" charge.

We also see in the black hole the temporal, gravitational metric completely replacing the spatial, light metric and creating its own version of an "ideal" symmetric energy state in which all energy forms are massless and move at velocity c. The black hole reduces matter to light both inside and outside the event horizon, and establishes an internal metric and domain in which all energy forms are effectively massless and move at c (g = c). Once g = c there is probably no further acceleration inside the hole - with time standing still, what would be the point or the mechanism?

No wonder black holes are so slow to evaporate - what conservation incentive does this ideal temporal state have for changing? Gravity has been driving toward the black hole "ideal temporal state" since the beginning, creating a metric of bound electromagnetic energy (as gauged by "G") which is the equivalent of the metric of free electromagnetic energy (as gauged by "c"). One difference is that temporal entropy, being one-way (due to causality), is less symmetric than spatial entropy, which is "all-way". Hence "Hawking radiation" is ultimately obedient to Noether's Theorem - even the symmetry of light's entropy is conserved.

At the event horizon, all spacetime pixels have been converted to purely temporal pixels. (The frequency or temporal component of the electromagnetic wave completely replaces the wavelength or spatial component.) This temporal component has intrinsic one-way motion into the historic domain (at right angles to all spatial dimensions), producing the flow of the gravitational field as it drags space along with it. Space self-annihilates at the point-like entrance to the time line, producing a metrically equivalent temporal residue which repeats the self-feeding process. *Gravity is the spatial consequence of the intrinsic motion of time*. (See: "The Conversion of Space to Time"; "A Description of Gravity"; "A Rationale for Gravity"; "The Double Conservation Role of Gravity"; "Introduction to the Gravity

Papers".)

I list below a hierarchy of effects in the inexorable march of gravity toward the black hole. At first, there is only the production of spherical astronomical bodies, like the Earth and Moon. Crystalline forces producing angular shapes have been overcome by the sheer gravitational weight of accumulating matter. Elliptical astronomical orbits are also formed in free space, such as our solar system, and the great galactic systems are produced from gravitationally condensing primordial gas clouds (perhaps including "dark matter" consisting of a heavy leptoquark neutrino). Next, with sufficient mass accumulation, the nuclear fusion begins in stars - the first stage of actually "paying down the principle" of the gravitational symmetry debt of matter through the nucleosynthetic conversion of mass (bound electromagnetic energy) to light (free electromagnetic energy) - reducing the star's total gravitational field in the process. In lesser objects such as the Earth and Moon, the weak gravitational field only pays the "entropy interest" on matter's distributional symmetry debt (despite the continual action of gravity, none of Earth's mass is actually converted to light, so the Earth's gravitational field and symmetry debt remains unaffected - analogously to the effect of an interest payment on the principle of a debt).

In stars, gravity is strong enough to overcome the electrical repulsion between protons, allowing fusion to take place, producing helium as the first step along the nucleosynthetic pathway of the stars and the periodic table of the elements. When stars the size of our Sun burn up their nuclear fuel and die, they leave behind a "white dwarf" cinder, a condensed matter remnant or core in which gravity is so strong that it has crushed the electron shells of atoms into an electron gas. Stars heavier than our Sun may produce a supernova explosion and leave behind a neutron star, essentially a stellar-mass atomic nucleus, in which gravity is so strong that electrons are forced into protons to produce neutrons. Still heavier stars produce supernovas which leave behind black holes - in which gravity is so strong that the spacetime metric itself is crushed and becomes a purely temporal metric, apparently contain no space at all.

Super-massive black holes also form at the center of (all?) galaxies, producing quasars which convert mass to light even more efficiently than fusion reactions. We observe the relentless takeover by gravity of every binding function of the electromagnetic force, beginning with the crystal lattice of planets, proceeding to the electron shells of stars, thence to the nuclear structure, and finally and completely to the spacetime metric and entropic conservation domain of light itself - space. In the final stage gravity achieves a temporal metric which is apparently the symmetric equivalent of light's spatial metric, in which massive matter moves at velocity c, clocks stop, and meter sticks shrink to nothing in the direction of motion.

The recently observed "acceleration" of the universe is the consequence of the reduction of the total gravitational energy field of the universe by the conversion of mass to light by the major astrophysical phenomena - stars, quasars, supernovas. Of course, to the outside spatial universe, the black hole still represents a grossly asymmetric concentration of undistributed mass-energy, even though internally it has achieved a satisfactory symmetric energy state in terms of its temporal metric.

References

Bekenstein, J.D. Information in the Holographic Universe. *Scientific American* Aug., 2003, pages 58 - 65.
Gleick, J. *The Information*. Pantheon, 2011.
Greene, B. *The Hidden Reality*. Knoph, 2011. Pages 238-273.
Susskind, L. *The Black Hole War*. Back Bay Books, 2008.

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