

Super Cosmos

Sarfatti Lectures on Making Star Trek Real
Star Gate Engineering 101 for 21st Century Space Force Cadets
Including a Study Guide to Stephen Hawking's
"The Universe in a Nutshell"

This introductory theoretical physics course of mine is for physical science, engineering, bio-med and math/computer science undergraduate majors and gifted motivated high school students in Advanced Placement. A simpler non-math version would be for "Physics for Dummies" or rather "Physics for New Agers and Aging Hippies" :-)

Lecture 1 with additional problems and additional remarks on Einstein's equivalence principle, aberration, mechanical force, and Feynman's method of alternative histories of parallel coexisting mutually interfering worlds.

Systematic Review of Hawking's new book by Jack Sarfatti

I. Hawking's new book, with its "nonlinear" treelike branching lavish graphics, is more a sequel to John Archibald Wheeler's really splendid 1990 "A Journey into Gravity and Spacetime" than to his own 1988 "A Brief History of Time". Hawking writes with brevity like Hemingway, which is good for the masses yearning for an enlightened entertaining rational secular non-fundamentalist scientific understanding of the universe and the meaning of existence. Hawking's information, unlike all New Age books, is reliable as far as it goes. I only have minor quibbles with some of the details that may be editorial blunders in some cases.

The health of the human spirit requires "an ever expanding horizon of possibilities."
(Foreword, p. viii)

The Taliban and al Qaeda et-al, and their Christian fundamentalist mirror images, of course, wishes to constrict that horizon and to crunch it back to the initial singularity and us all into oblivion - The Death of the Human Spirit. New Age psychobabble promoting Cargo Cult toxic cosmologies, based on not even wrong clichés and a host of fatuous confusions, has a similar, though not as deadly, numbing effect on immature minds not sufficiently educated in the methods of science and critical reason.

Einstein's 1905 special relativity (Ch. 1). The issue of the "ether". Certainly not a Galilean ether where for two frames of reference (x,t) and (x't') in relative uniform motion u:

$$\begin{aligned}x' &= x - ut \\t' &= t \\ \frac{dx'}{dt} &= \frac{dx}{dt} - u\end{aligned}\tag{1.1}$$

Newton's absolute time is expressed in the equation $t' = t$. This "Galilean relativity", of time split off from space with an infinite speed of light signaling, is the substratum of Newton's mechanics with common sense addition of velocities used in computing speeding ticket fines by CHP). Galilean relativity is a good approximation in everyday life only because the speed of light in vacuum is so huge 186,000 miles per second.

In simple 1 + 1 "string spacetime" to make the high school algebra simpler sans several aberration effects from more space dimensions.

But what of (e.g. Joe Firmage's favorite also professed by J.P. Vigiier BTW) Fitzgerald and Lorentz's relativistic ether? That is, spacetime still an active dynamical medium, like in general relativity, where "bodies moving through the ether would contract and that clocks would slow down. This contraction and the slowing down of clocks would be such that people would all measure the same speed for light, no matter how they were moving with respect to the ether." (p. 6).

$$\begin{aligned}x' &= \gamma(x - ut) \\t' &= \gamma\left(t - \frac{ux}{c^2}\right) \\ \gamma &= \frac{1}{\sqrt{1 - \left(\frac{u}{c}\right)^2}}\end{aligned}\tag{1.2}$$

Problem 1

Use (1.2) to show the invariance of the spacetime interval between two point in globally flat 1+1 spacetime.

$$(ct')^2 - x'^2 = (ct)^2 - x^2\tag{1.3}$$

Note that in the limit $u/c \rightarrow 0$, the special relativistic mechanics of Einstein reduces exactly to the Galilean relativistic mechanics of Newton given by eqs. (1) above.

Note the new counter-intuitive velocity addition law

$$\begin{aligned}v' &= \frac{(v-u)}{\left(1 - \frac{vu}{c^2}\right)} \\v' &\equiv \frac{dx'}{dt'} \\v &\equiv \frac{dx}{dt}\end{aligned}\tag{1.4}$$

Problem 2

Let $v \rightarrow c$, keeping u , the relative speed between two uniformly moving inertial observers Alice and Bob, fixed. Compute v' . What do you conclude from your result?

Problem 3.

Investigate the above equations when $u > c$

"I've many cheerful facts about the square of the hypotenuse." Major General Stanley, "Pirates of Penzance", Gilbert & Sullivan (e.g. film "Topsy Turvy" also movie of Pirates with Kevin Kline, Angela Lansbury and Linda Ronstadt <http://www.imagi-nation.com/moonstruck/albm66.html>).

Mathematically, formally, the earlier Fitzgerald-Lorentz active dynamical ether, is exactly the same as Einstein's later special relativity math. However, the "informal language" (Bohm) the metaphysical or philosophical interpretation or intuitive "world picture", or "explanation" in common language, is very different. For example, Hawking writes:

"However, in a paper written in June 1905, Einstein pointed out that if one could not detect whether or not one was moving through space, the notion of an ether was redundant." (p.9)

Problem 4

If Einstein were alive today would he still say that?

Hints, see Einstein's 1924 essay "On the Aether".

Cosmic microwave background thermal radiation is isotropic to high accuracy in a locally preferred "Hubble flow" reference frame.

Spacetime is "rigid" in Einstein's 1905 special relativity, like Newton's absolute time, but it is not rigid in Einstein's 1915 general relativity of gravity as the dynamic direct back

action response of spacetime geometry to local concentrations of real quanta "on mass shell". No Yilmaz term as in Hal Puthoff's "PV" model is needed here.

Einstein's meeting with Heisenberg ~ 1925 in which Heisenberg is startled by Einstein's view on the logical positivism of the Vienna Circle. See Henry Stapp's "Matter, Mind and Quantum Mechanics" (Springer-Verlag).

Problem 5

Use (1.2) above.

Alice is in the (x',t') global inertial frame of reference (GIF').
Bob is in the (x,t) global inertial frame of reference (GIF).
 u is the constant relative speed along the x axis between Alice and Bob.

Consider two objective invariant spacetime events $A1$ & $A2$ that are simultaneous for Alice.

Will these same two events be simultaneous for Bob?

Compare the spatial separations between these same two events $A1$ & $A2$ measured by Alice and by Bob.

Relativity is a theory of space and time correlating observations at the same pairs of objective events $P1$ & $P2$ or happenings made by different pairs of observers Alice and Bob in different states of relative motion to each other. Alice and Bob are not accelerating relative to each other in special relativity. In general relativity, they can be. Also in general relativity, Alice and Bob must be approximately coincident with each other in instantaneous relative motion with the two events $P1$ & $P2$ in the same neighborhood of each other and Alice and Bob. That is, general relativity is a local classical field theory. Once that is done however, Alice and Bob can send signals to Charlie very far away and comparisons on similar systems can be made. For example, Alice and Bob may look at a particular spectral line of atomic hydrogen close to them. Suppose Alice and the atom are both at rest relative to a massive source. Charlie, very far from the massive source, has an identical atom. Both Charlie and Alice measure the same local number for the peak frequency of light from their respective identical atoms at rest relative to them. However, if Alice sends the light from her atom to Charlie he will see that light red shifted to lower frequencies. Similarly, if Charlie sends his atomic light to Alice she will see it blue shifted to higher frequencies. What about Bob coincident with Alice? Bob is free floating or freely falling relative to Alice. Bob is then equivalent to Charlie, both are "Local Inertial Observers" (LIF). Alice is a "Local Non Inertial Observer" (LNIF). Bob will see Alice's atomic light red shifted to lower frequencies and longer wavelengths by the same amount as Charlie sees it red shifted because there is no local gravitational field for Bob even though he is almost coincident with Alice. Bob in free float locally eliminates the gravity field! Alice will see atomic light from Bob blue shifted the same as from Charlie. This is Einstein's principle of equivalence in action!

Note, however, if Bob sends his atomic light to Charlie, Charlie will see Bob's light red shifted just like Alice's because the propagation of the light signal is affected cumulatively by the local gravity fields. So there are many different cases to consider here. All of these examples are what Einstein and Bohr called "thought experiments" or "gedankenexperiments". Einstein and Bohr had a 30-year debate on the meaning of quantum physics using the method of gedankenexperiments. The debate was never settled and still rages today with several competing reality pictures for the meaning of the quantum.

Problem 6

Bob has a clock and notes the clock reading at events B1 & B2 on the clock. Therefore, the clock is at the same spatial location for Bob at these two objective invariant events. What is Alice's measurement of the time interval between these same two events and how does it compare to Bob's?

Problem 7

Go from 1-dim space to 3-dim space, the relevant "global" special relativity frame transformation is then

$$\begin{aligned}x' &= \gamma(x - ut) \\t' &= \gamma\left(t - \frac{ux}{c^2}\right) \\y' &= y \\z' &= z\end{aligned}\tag{1.5}$$
$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{u}{c}\right)^2}}$$

Compare dy'/dt' to dy/dt . Note the symmetry between the "transverse" y and z directions, with x the direction of the relative speed u between frames of reference (Alice and Bob) called the "longitudinal" direction.

Problem 8 (aberration)

Define

$$\begin{aligned}r^2 &= x^2 + y^2 + z^2 \\z &= r \cos \theta \\x &= r \cos \theta \cos \phi \\y &= r \cos \theta \sin \phi\end{aligned}\tag{1.6}$$

similarly for r' compare dr'/dt' to dr/dt , compare $(dy'/dt')/(dr'/dt')$ to $(dy/dt)/(dr/dt)$. Suppose $dr/dt = c$, what is dr'/dt' ? Combine (1.5) with (1.6) to compare $\cos\theta'$ with $\cos\theta$, similarly for ϕ .

Problem 8. Difficult Advanced Thought Problem

How do energy and momentum fit into this picture?

Consider the quantum laws¹

$$E = hf \tag{1.7}$$

E is the energy of the material “particle” quantum, f is the frequency of the mental “qubit” information “pilot wave”² from which the particle receives its marching orders. This is precisely the way that thought, a physical information field, moves matter in our free will.

$$p = \frac{h}{\lambda} = hk \tag{1.8}$$

p is the particle momentum, λ is the wavelength of the pilot wave, k is the wavenumber.

h = Planck's constant $\sim 6 \times 10^{-27}$ erg-seconds, which is very tiny on our macroscopic scale.

Hint, objective frame invariant is the dimensionless phase Θ of the wave forming a family of 3-dim surfaces or “wave fronts” of constant phase in 4-dim spacetime.

In the simpler 1 + 1 spacetime with only one space dimension, the small frame invariant change of phase in a small spacetime displacement (dx, dt) is

$$\begin{aligned} d\Theta &= k_x dx - f dt \\ k_x &= \frac{\partial\Theta}{\partial x} \\ f &= \frac{\partial\Theta}{\partial t} \end{aligned} \tag{1.9}$$

¹ Planck 1900 black body radiation, Einstein 1905 photoelectric effect

² de Broglie, Bohm “quantum realism”. Einstein was a realist. Bohr was an idealist. The quantum information pilot wave is literally outside of or beyond material spacetime in its own physically real mental space of “qubits” called “Hilbert’s space”.

Therefore, f is the partial time derivative of the invariant phase in a given frame, and k is the partial space derivative. These partial derivatives are not themselves frame invariants. Deduce the transformation between (k',f') and (k,f) .

Can you define

$f = 1/dt$ and $k = 1/dx$ etc.

and get a sensible answer?

Here the wave fronts are 1-dim curves in the t - x plane. Quantum mechanics uses configuration space $(\vec{r}_1, \vec{r}_2, \vec{r}_3 \dots \vec{r}_N, t)$ with $3N$ space dimensions for the “ N -particle problem”. The N particles are all “entangled” or “nonlocally quantum connected”. All of the 3-vectors \vec{r} lie on the same 3-dim “spacelike surface” labeled by t . There is no “collapse” in a “measurement” of the quantum information pilot wave in the realist ontology I use in this course. One can also compute temporal correlations at different times t and t' . There is a big difference between special relativity of globally flat spacetime and the locally curved spacetime of general relativity where one must use a new kind of connection field that is zero in special relativity.³

Overview of important new ideas not found anywhere else!

Note that dimensionless phase Θ of the "thought like" quantum pilot wave $\psi = 2\pi$ (Material Classical Action S_c)/(Planck's Constant $\hbar = h/2\pi$), i.e.

$$\psi(x) = |\psi(x)| e^{i\Theta(x)} = \sqrt{\rho_{qm}(x)} e^{iS_c/\hbar} \quad (1.10)$$

For now think of x as a point event in 4-dim spacetime. This is actually the case in a superfluid and in the physical quantum vacuum of the universe because a huge number of *disentangled* quanta occupy the same “single-quantum state” in what is called “Bose-Einstein condensation” or “ODLRO”. For superfluid helium and electrical superconductors these quanta are “real”. This means the linear momentum p and the total energy E of the quanta are not independent of each other. They are “on the mass shell”. In contrast, the quanta of the physical quantum vacuum are “virtual”. This means that the linear momentum p and the total energy E of the quanta are independent of each other. They are “off the mass shell”. The mass shell term comes from Feynman’s quantum electrodynamics (QED) for the “propagators” of the quanta. Equation (1.10) then describes a long range phase coherent local order parameter in ordinary 4-dim spacetime. The normally random zero point quantum vacuum fluctuations are made nonrandom by $\psi(x)$ in what is called “spontaneous broken Goldstone symmetry”. The situation where

³ One must supplement Bohm’s realism with the Feynman-Wheeler idea of using both advanced and retarded pilot waves to explain the seemingly instantaneous action at a distance of the quantum potential. John Cramer’s transactional interpretation of the Einstein-Podolsky-Rosen effect tied to irreversible preparations and detections makes the correlated detection results frame independent.

$\psi(x) = 0$, as in the *wrong* Haisch-Puthoff theory for the “origin of inertia and gravity” is a nonphysical “false vacuum” of higher energy than the superfluid vacuum where $\psi(x) \neq 0$. Indeed, the random zero point fluctuations in the false Haisch-Puthoff vacuum must *antigravitate*, i.e., universal repulsion rather than universal attraction, and, in fact, classical spacetime is impossible there. The physics of the false vacuum is internally inconsistent. There is no simple classical limit $\hbar \rightarrow 0$ in the false vacuum because the zero point energy density is infinite in that limit. This infinity anomaly is quite similar to the black body radiation infinity of 100 years ago that forced Max Planck in 1900 to his quantum equation $E = hf$. The situation is completely different when $\psi(x) \neq 0$, now there is a “bootstrap” self-organizing consistent macroscopic quantum limit as in superfluid helium near absolute zero temperature. Indeed the variations in the phase Θ form Einstein’s 1915 “geometric field” $g_{\mu\nu}(x)$ for gravity as curved spacetime. This emergence of classical spacetime from the random false vacuum in a phase transition to the lower energy true vacuum from the cohering of the zero point fluctuations of the unified field also explains why the cosmological field Λ is so very small on the large scale cosmological structure of the universe. Einstein first called Λ his greatest blunder. In fact it is one of his greatest triumphs. Local variations in Λ are from local variations in the modulus $|\psi(x)|$ in equation (1.10). These amplitude modulations on the “cosmic signal”⁴ are coupled to the phase Θ modulations. The latter phase modulations are controllable by external electromagnetic fields through the Josephson effect. This effect seems to bypass the spacetime stiffness barrier

$$\frac{G}{c^4} = \frac{L_p^2}{\hbar c} = \frac{1 \text{ fermi}}{4 \text{ billion} - \text{metric} - \text{tons}} \quad (1.11)$$

called the Feynman number.

$\Lambda(x) > 0$ is “exotic” antigravity in which the expansion of the universe speeds up rather than slows down. In smaller scales this may well enable stable wormhole Star Gate Time Machines and “warp drives” without g-forces on artificially created “free float” timelike geodesics.

$\Lambda(x) < 0$ is gravitating “dark matter”.

In the general case of “entangled quanta” and “decoherence” with local quantum randomness enforcing “signal locality”⁵, x , and consequently ψ , is in $3N + 1$

⁴ The Word of God to use a theological metaphor

⁵ Absence of what Einstein called “spooky telepathic action at a distance” forbidding remote viewing, especially precognition, and violating brain data of Libet, Radin and Bierman. Quantum physics requires this absence. Therefore, mental phenomena violate quantum physics. That is, quantum physics with signal locality is a limiting case of post-quantum physics with signal nonlocality in the same way that special relativity without gravity is a limiting case of general relativity with gravity.

dimensional configuration space for N massive lepto-quark particles, or infinite dimensional classical field configuration space for Higgs Goldstone bosons, photons, weak mesons, strong gluons and gravitons. The lepto-quarks are actually large vibrating strings at the Compton wavelength h/mc that look like point particles in QED scattering because the large hyperspace dimensions of Super Cosmos make gravity strong at short range in ordinary 3 dim space. We shall come back to these ideas.

End of overview of important new ideas.

Problem 7 Mechanical Force

$$F_x \equiv \frac{dp_x}{dt}$$

$$F'_{x'} \equiv \frac{dp'_{x'}}{dt'}$$
(1.12)

Compare F_x to $F'_{x'}$.

The basic differential frame invariant between two nearby events in a flat spacetime is

$$ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 = c^2 dt'^2 - dx'^2 - dy'^2 - dz'^2$$
(1.13)

where

$$dx' = \gamma(dx - udt)$$

$$dt' = \gamma\left(dt - \frac{udx}{c^2}\right)$$

$$dy' = dy$$

$$dz' = dz$$

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{u}{c}\right)^2}}$$
(1.14)

$$\tilde{F}_x \equiv \frac{dp_x}{ds}$$

$$\tilde{F}'_{x'} \equiv \frac{dp'_{x'}}{ds}$$
(1.15)

Compare F_x with \tilde{F}_x .

Next go to 3-dim space, compare the "longitudinal" F_x & F_x' along the x axis, to the "transverse" F_y & F_y' along the y axis, where the relative uniform motion between Alice and Bob is along the x axis. Do the same for the corresponding \tilde{F} force, i.e. the rate of change of linear momentum, with respect to frame-invariant proper time differential ds rather than frame-dependent coordinate time differentials dt & dt' respectively in Alice's & Bob's Global Inertial Frames (GIF) in flat spacetime. Note that the 3-dim linear momentum p and the total energy E form a 4-vector also called a first rank tensor under the Lorentz group of rotations in 4-dim flat spacetime.

Lecture 2

Additional difficult advanced Problem 8. Einstein in 1905 did not use the formal method below to deduce

$$\begin{aligned}
 E &= Mc^2 \\
 E^2 &= (mc^2)^2 + (pc)^2 \\
 \lim_{p/mc \rightarrow 0} M &= \sqrt{m^2 + \left(\frac{p}{c}\right)^2} \approx m \left(1 + \frac{1}{2} \left(\frac{p}{mc}\right)^2\right) = m + \frac{p^2}{2mc^2} \quad (2.1) \\
 E &\approx mc^2 + \frac{p^2}{2m}
 \end{aligned}$$

"on mass shell" for ordinary subluminal matter where m is the rest mass and M is the total mass.

How did Einstein do it? His original papers are easily available on line and in the Dover "Principles of Relativity".

Note that Einstein's original 1905 paper "On the Electrodynamics of Moving Bodies" does have kinetic energy $K = (M-m)c^2$ explicitly in it from work done by a force on the particle displacing it through space. This is not general enough. Note the notions of transverse and longitudinal mass. Why don't they matter to the final result? There is a second short paper "Does the Inertia of a Body Depend Upon Its Energy-Content?" That paper concludes with

"If a body gives off the energy L in the form of radiation, the mass diminishes by L/c^2 ."

Give your version of Einstein's logic and intuition in getting to this conclusion. Is this like a mathematical proof of a theorem?

Also Einstein intuites the nuclear fission and fusion bombs 40 years in his future with

"The mass of a body is a measure of its energy content; if the energy changes by L , the mass changes in the same sense by $L/9 \times 10^{20}$, the energy being measured in ergs, and the mass in grammes".

Photons have $m = 0$ to a good approximation, except inside a superconductor where the photon rest mass is $m = hc/(\text{penetration depth of static magnetic field into superconductor})$, i.e. Meissner effect with quantized magnetic flux.

Quibble 1

Back to Hawking p.9. Example of two airplanes one flying west to east in the same sense as the Earth's spin about its polar axis. The other plane flies east to west opposite to the Earth's spin. This experiment has actually been done with atomic clocks BTW. Hawking writes of it

"two accurate clocks were flown in opposite directions around the world and returned showing very slightly different times if one wanted to live longer, one should keep flying to the east so that the plane's speed is added to the earth's rotation"

But is this really a good explanation? It suggests an absolute notion of velocity inconsistent with the key special relativity idea that "one could not detect whether or not one was moving through space". We ignore the Hubble flow of the expanding 3 dim space of the universe and the cosmic microwave background here which was not known to Einstein in 1905. What is the speed of the earth's rotation measured relative to? The speed of the other plane flying to the west is less than that of the Earth's rotation -- but with respect to what? Clearly, along with Einstein's inspiration Ernst Mach, let's say with respect to the distant stars. Note that all the relevant paths here are accelerated motions. Let's suppose, for simplicity, and to maximize the small effect, that the planes fly opposite to each other around the Earth's equator. Let r be the radial distance of each plane's instantaneous position from the polar spin axis of the Earth E . A point on the surface of the Earth is at distance R from the spin axis and the rotation rate is $\omega(E)$. The instant tangential speed of a point on the surface relative to the stars is then

$$v_{\phi}(E) = r(E)\omega(E) \quad (2.2)$$

The two planes A_1 and A_2 can be at equal radial distances r from the spin axis.

since speeds are small compared to c we can use ordinary addition of velocities to a good approximation. Basically

$$\begin{aligned} r(A) &\approx r(E) \equiv r \\ \omega(A_1) &> \omega(E) > \omega(A_2) \end{aligned} \quad (2.3)$$

A_1 is flying to the east, and A_2 is flying to the west. The universal Earth's gravity field acceleration is then

$$g = \frac{GM}{r^2} \quad (2.4)$$

M = mass of the earth $\sim 6 \times 10^{27}$ grams $GM/c^2 \sim 0.44 \text{ cm}$. That is, if all the mass of the Earth were packed into a black hole, the surface area of that hole would be $4\pi (0.44)^2 \text{ cm}^2 \sim 3 \text{ cm}^2$. The radius of the Earth is $6.4 \times 10^8 \text{ cm}$.

$$\frac{GM}{c^2 r} \sim 7 \times 10^{-10} \quad (2.5)$$

The net acceleration of gravity at A_1 is then from Einstein's principle of equivalence of 1915 general relativity not 1905 special relativity as Hawking is suggesting

$$g(A_1) \approx g(E) - \omega(A_1)^2 r \quad (2.6)$$

including the effective gravity of the centrifugal acceleration since the airplanes are on nongeodesic timelike paths. They are not freely floating geodesic like the Space Shuttle with engines off. Similarly

$$g(A_2) \approx g(E) - \omega(A_2)^2 r \quad (2.7)$$

Therefore, because of the spherical symmetry

$$\Delta g = g(A_1) - g(A_2) = r \left[\omega(A_1)^2 - \omega(A_2)^2 \right] \quad (2.8)$$

This is then the gravitational red shift when the two clocks are compared is. That is, the effective gravity potential difference is

$$\Delta V = V(A_1) - V(A_2) = \frac{r^2}{2} \left[\omega(A_1)^2 - \omega(A_2)^2 \right] \quad (2.9)$$

Gravity Redshift/Mean Frequency \sim

$$\frac{\Delta V}{c^2} \approx \frac{df}{f} = -\frac{dT}{T} \quad (2.10)$$

This is actually an effective isotropic 3 dim harmonic oscillator well gravity potential. The Newtonian potential from the Earth cancels out of the problem to dominant order - we neglect gravimagnetic frame drag here from the rotating Earth as a still smaller post-Newtonian correction because

$$\begin{aligned} f &\equiv \frac{1}{T} \\ df &= -\frac{dT}{T^2} \\ \frac{df}{f} &= -\frac{dT}{T} \end{aligned} \tag{2.11}$$

T is the period of a single oscillation of the atomic clock. Therefore, the clocks will tick at different rates.

Note that plane A₂ flying to the west above the equator anti parallel to the Earth's spin ages more rapidly than the twin plane A₁ flying parallel to the Earth's spin. The reason for this is that A₂ is in a higher gravity potential than A₁ whose gravity binding energy is greater. That is, the effective local curvature of A₂ is smaller than the effective local curvature of A₁. In other words, A₂ anti-parallel to Earth's spin is closer to flat spacetime than is A₁ parallel to Earth's spin. Equivalently, A₂'s world line is closer to being a timelike geodesic than is A₁'s. A clock on a timelike geodesic ages more rapidly than any clock on any other nearby world line with the same starting and initial points. This is Einstein's basic action principle of general relativity. A lot of authors get this wrong, e.g. latest CIPA paper by Haisch and Rueda on the "Rindler flux" say this wrong.

Is Hawking correct, that we do not need to use ideas of general relativity to explain this actual experiment? Can we do it using only global special relativity or did Hawking make a mistake here? Clearly, general relativity is sufficient for this problem, but is it necessary?

Lecture 3 A Quick Look Ahead to O Brane New World, Hawking's Ch 7

Hawking writes

"We don't know exactly what the fundamental Planck length is in M-theory." p. 176

Planck length = L_p

L_p² = Gh/c³ = 1 Shannon c-bit of information in quantum gravity of black hole surfaces

G = Newton's classical gravity constant = 6.7 x 10⁻⁸ cm³ sec⁻² grams⁻¹

h = Planck's quantum constant = 6.6 x 10⁻²⁷ erg sec

$$\text{erg} = \text{gram cm}^2 \text{ sec}^{-2}$$

$$c = \text{Einstein's classical vacuum speed of light} = 3 \times 10^{10} \text{ cm sec}^{-1}$$

$$L_p = 1.6 \times 10^{-33} \text{ cm in naive quantum gravity}$$

$$hc / L_p \sim 2.2 \times 10^{-5} \text{ grams}$$

M-theory is Ed Witten's guess at the TOE (Theory of Everything). Witten is at Princeton.

It From Bit (Wheeler)

“It” = “geometrodynamics” i.e. classical spacetime geometry, classical force fields and source matter = Bohm's “particle”.

“Bit” = quantum information (qubit) Bohm “pilot wave” landscape.

It From Bit + Bit From It = Wheeler's “self-excited circuit” Universe

Bohm's “causal” theory ~ It From Bit

Bohm's “quantum potential” is “fragile” with “signal locality” if only “It From Bit”.

It From Bit as freezing out of Kleinert's “world crystal lattice” $\xi_\mu(x)$ from the superfluid quantum vacuum local order parameter $\psi(x)$ in spontaneous symmetry breaking from the false vacuum of all random zero point fluctuating quantum gauge foam to the “two fluid” physical vacuum.

It From Bit in Seven Steps

$$\begin{aligned}
 G_{\mu\nu} &= -8\pi \left(\frac{G}{c^4} \right) T_{\mu\nu} \\
 \frac{G}{c^4} &= \frac{L_p^2}{\hbar c} \\
 G_{\mu\nu} &= R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} \\
 g_{\mu\nu} &= \eta_{\mu\nu} + \frac{1}{2} \left(\frac{\partial \xi_\mu}{\partial x^\nu} + \frac{\partial \xi_\nu}{\partial x^\mu} \right) \\
 \xi_\mu &= L_p^2 \partial_\mu \Theta \\
 \Theta &= \frac{\Phi}{\Phi_0} - \frac{e}{\hbar c} \int A_\mu dx^\mu \\
 \psi &= |\psi| e^{i\Theta}
 \end{aligned} \tag{3.1}$$

The first line is Einstein's local field equation with zero cosmological local field $\Lambda(x)$. The second line is Feynman's spacetime stiffness factor of 1 fermi per four billion metric tons. Hyperspace can considerably soften the spacetime stiffness giving much bigger bending for the same applied electromagnetic stress-energy density. That is the Planck scale L_p gets larger and is also a local field $L_p^*(x)$.⁶ The third line defines Einstein's spacetime curvature tensor in terms of Ricci's curvature tensor and Ricci's curvature scalar. A tensor equation is form invariant or "covariant" looking the same to all *locally coincident* observers in arbitrary motion relative to each other making their own local measurements of the same events. The fourth line is the definition of the curved spacetime geometrodynamical field in terms of the globally flat special relativity metric of the perfect world crystal lattice added to the local strain tensor coming from string disclination defects causing curvature and string dislocation defects causing torsion.⁷ The torsion is zero in the above Einstein GR model from 1915. The local world crystal distortion field $\xi_\mu(x)$ is Einstein's infinitesimal translations limit of his general coordinate transformation group $\partial x^\mu / \partial x^{\mu'}$ for the locally coincident observers. The fifth line is Bohm's pilot wave de Broglie "phase lock" to particle constraint, which is also the basis of the Josephson effects. In this case, the superfluid flow coefficient \hbar/m is replaced by the elastic distortion coefficient L_p^2 that is 1 Bekenstein quantum gravity bit as it should be when Einstein's classical geometrodynamics emerges in the modulation of the long range phase coherent field of the vacuum order cohering a large fraction of the random zero point fluctuations of the false vacuum. This quieting down, or

⁶ x means local spacetime point event unless otherwise stated explicitly.

⁷ This has all been worked out classically, without my quantum Bit to It, by Hagen Kleinert of the Free University of Berlin.

derandomizing, of the false vacuum's quantum zero point noise, is the origin of smooth classical spacetime. The sixth line defines the dimensionless phase Θ of the quantum vacuum complex number order parameter in terms of the Goldstone phase Φ , the generalized "charge" magnetic flux quantum $\Phi_0 = \hbar/e$ for vortex string world crystal defects and the path integral dependent "anholonomic" Josephson phase shifts from generally non-Abelian Yang-Mills gauge force fields A_μ .⁸ The Goldstone collective phase modes cohering the random zero point quantum gauge foam of the false vacuum⁹ creating Einstein's classical geometrodynamics field restore the spontaneous broken symmetry by creating classical spacetime, hence our universe, as "emergent order" in what P.W. Anderson calls "More is different." The robust quantum vacuum local order parameter, with long range phase coherence making $g_{\mu\nu}(x)$, in turn obeys a curved spacetime "Bit From It" Landau-Ginzburg equation to close the open "It From Bit" circuit, hence our spontaneously self-organizing plurality of cross-talking parallel universes of Super Cosmos creating themselves from their own futures. This is the physics from the future that Andre Sakharov saw dimly "through the glass darkly" back in 1966 with his vague vision of "metric elasticity" i.e. of gravity emerging from the ZPE quantum gravity foam of metric fluctuations into the elastic "world crystal".¹⁰

The Universe Next Door

Think of "branes" in M-theory as parallel universes floating close to each other in the hyperspace of Super Cosmos.

"In the M-theory network of mathematical models, spacetime has ten or eleven dimensions. Up to recently it was thought that the six or seven extra dimensions would all be curled up very small ... However there has recently been the suggestion that one or more of the extra dimensions might be comparatively large or even infinite ... Large extra dimensions are an exciting new development ... They would imply that we live in a brane world, a four dimensional surface or brane in a higher-dimensional spacetime. Matter and nongravitational forces like the electric force would be confined to the brane. Thus everything not involving gravity would behave as if in four dimensions. In particular the electric force between the nucleus of an atom and the electrons orbiting around it would fall off with distance at the right rate for atoms to be stable ... On the other hand, gravity in the form of curved space would permeate the whole bulk of the higher dimensional spacetime ... because gravity would spread out in the extra dimensions, it would fall off more rapidly with distance than one would expect. ... If this

⁸ Steven Weinberg's Volume II of "Quantum Theory of Fields" on superconductors from the vacuum order parameter spontaneous broken symmetry POV.

⁹ The Haisch-Puthoff program is wrong because it uses the antigravitating false vacuum without a consistent classical limit.

¹⁰ PW Anderson did not come out with his "More is different" until 1967 at UCSD where I was. Goldstone did not come out with his ideas until 1966 also. I wrote one of the first papers on a Jahn-Teller 3-dim crystal as Goldstone's spontaneous broken ground state symmetry in 1966 at UKAERE Harwell with Marshall Stoneham. (Proceedings of the Physical Society of London, 1967 cited in American Institute of Physics Resource Letter on "Symmetry in Physics").

more rapid fall off of the gravitational force extended to astronomical distances, we would have noticed its effect on the orbits of the planets. In fact they would be unstable ... However this would not happen if the extra dimensions ended on another brane not that far away from the brane on which we live. Then for distances greater than the separation of the branes, gravity would not be able to spread out freely but would be effectively confined to the brane, like the electric forces, and fall off at the right rate for planetary orbits. On the other hand, for distances less than the separation of the branes, gravity would vary more rapidly. The very small gravitational force between heavy objects has been measured accurately ... but the experiments so far would not have detected the effects of branes separated by less than a few millimeters.” P.183

Therefore parallel universes next door may be very close to us across tiny distances in the universe’s unseen space dimensions. The quantum vacuum may be a superfluid, which means Josephson tunneling between the parallel universes since superfluid leaks across the weak hyperspace link. The electrically neutral quantum vacuum superfluid is caused by the “Bose-Einstein condensation” of huge numbers of “virtual” force quanta and source particle-antiparticle nonlocally connected Einstein-Podolsky-Rosen pairs into the same single-particle and single-pair quantum states. This leakage of superfluid through hyperspace connecting the branes is what is needed to form a “Star Gate” when the superfluid balance against random zero point fluctuations (ZPF) is “quintessent” with exotic repulsive antigravity. The balance can go the opposite way, which would look like “dark matter”, that is almost all the actual mass in the universe.

The exotic quintessent local cosmological superfluid quantum vacuum field enables Kip Thorne’s “traversable wormholes”¹¹ without infinite crunch stretch-squeeze singularity and without one-way "event horizon" surface. That is what we mean by a “Star Gate+”, i.e. instant travel to the stars in our universe. But now do the “twin paradox” on one of the two mouths, or doorways, of the Star Gate. That is, keep one mouth on a timelike geodesic with fastest aging rate possible. Put the other mouth on a timelike non-geodesic. The world lines of the two mouths were together in the past and are brought together in the future. The mouth on the non-geodesic is in the relative past of the mouth that stayed on the geodesic. Therefore, if you walk through the geodesic mouth you will exit in your own past! If you go the opposite way you will exit into your future. The time it takes to walk through the Star Gate is insignificant.

¹¹ Also Alcubierre’s “warp drive”.

Comment on the NOVA “time travel” show

<http://www.pbs.org/wgbh/nova/time/>

OK what about time travel paradoxes? Novikov came to the same conclusion I did, i.e. global self-consistency. However, Novikov in Moscow did more hard work than me. He showed how in the classical Newtonian mechanics of playing billiards with pockets on the table that are time machines to the past, that there are always self consistent solutions! One then conjectures that the Feynman quantum amplitudes vanish for all classical mechanical histories that are not self-consistent. I formulated the last condition independently before I knew of Novikov. Therefore, we do not need parallel universes like David Deutsch thinks in "Fabric of Reality".

I think Deutsch’s basic idea is wrong because he only has the wave and not the particle. He does not use Bohm’s realism and because of that he makes an error confusing the mental pilot “wave” parallel universes with the material “particle” universes net door or “branes” floating in the unseen hyperspace dimensions of Super Cosmos. We don’t need any “shadow particles” to explain the build up of the wave interference statistical pattern in the double slit experiment. David’s explanation there on NOVA is wrong. Note I am on a similar Time Travel Program with David Deutsch on Discovery/Learning Channel’s “Ultra Science”.

You cannot time travel to the past to before the time machine is built!

OK what about stability of the Star Gate? Normally they collapse before you can use them! But if you have exotic matter you can keep them open long enough to use them. What is exotic matter? Well the zero point energy of quantum fields is exotic it turns out. Exotic is not negative energy density. It really takes negative pressure with positive energy density. In the weak field static limit, Newton's Poisson equation reduces to

$$\nabla^2 V = \frac{4\pi G}{c^2}(\rho c^2 + 3p) \quad (3.2)$$

i.e., Laplacian of Newton’s gravity potential = $-(G/c^2)(\text{energy density} + 3 \text{ pressure})$

Details are in <http://stardrive.org/Jack/Cosmo1.pdf>

This is attractive gravity when

$$\rho c^2 + 3p > 0 \quad (3.3)$$

It is “exotic”¹² repulsive antigravity when

$$\rho c^2 + 3p < 0 \quad (3.4)$$

John Peacock on p.25 of "Cosmological Physics" shows that for the ZPE of any quantum field, zero point energy density = - zero point pressure, i.e.,

$$\rho(ZPE)c^2 + p(ZPE) = 0 \quad (3.5)$$

Therefore, for positive zero point energy density

$$\rho(ZPE) > 0 \quad (3.6)$$

$$\rho(ZPE)c^2 + 3p(ZPE) < 0 \quad (3.7)$$

$$\rho(ZPE)c^2 + 3p(ZPE) = -2\rho(ZPE)c^2 \quad (3.8)$$

$$\rho(ZPE)c^2 \approx \frac{\hbar c}{L_p^2} \Lambda(x) \quad (3.9)$$

$$\frac{G}{c^2} = \frac{cL_p^2}{\hbar} \quad (3.10)$$

$$\nabla^2 V(x) \approx -8\pi c^2 \Lambda(x) \quad (3.11)$$

$\Lambda(x) > 0$ gives the exotic quintessent universally repulsive antigravity needed to keep the Star Gate stable for practical use. Are we in business yet? NO! Why? Because we have too much of a good thing! That is, in the false vacuum, prior to virtual superfluid spontaneous symmetry breaking to a new quantum vacuum of lower energy density

$$\Lambda(ZPE) \approx \frac{1}{L_p^2} \quad (3.12)$$

The false vacuum zero point stress energy tensor is, in this case,

$$T_{\mu\nu}(ZPE) \approx \frac{\hbar c}{L_p^4} g_{\mu\nu} \sim \frac{1}{\hbar} \xrightarrow{\hbar \rightarrow 0} \infty \quad (3.13)$$

¹² Hal Puthoff's $K < 1$ definition of “exotic” in his PV alternative to Einstein seems to have no connection with what Kip Thorne means by the same term, which is what we mean here.

That is, there is no consistent simple classical limit, in the sense of Bohr's correspondence principle, when one adds Heisenberg's quantum uncertainty principle to Einstein's classical geometrodynamics local gravitational field equation of 1915.

The problem here is that this zero point quantum vacuum fluctuation gives us the enormous cosmological constant in

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = -8\pi \frac{L_p^2}{hc} T_{\mu\nu} \quad (3.14)$$

$L_p^2 = Gh/c^3 \sim 10^{-66} \text{ cm}^2 = 1$ Bekenstein of black hole surface information $\Lambda(\text{ZPE}) \sim 1/L_p^2 = 10^{66} \text{ cm}^{-2}$. $\Lambda(\text{measured}) \sim (H/c)^2 \sim 10^{-56} \text{ cm}^{-2}$.

So we are in deep doo doo!

Not to worry, virtual superfluidity of the quantum vacuum comes to the rescue to give us

$$\Lambda(x) = \Lambda(\text{ZPE}) \left(1 - L_p^3 |\psi(x)|^2\right) \approx \left(\frac{1}{L_p^2}\right) \left(1 - L_p^3 |\psi(x)|^2\right) \quad (3.15)$$

where $\psi(x)$ is the ZPE spontaneous broken symmetry ODLRO order parameter of the virtual quanta in the vacuum forming a coherent superfluid whose gauge invariant Josephson phase gradients give Einstein's infinitesimal general coordinate transformations as Kleinert's world crystal distortion field. The elastic strain tensor is then Einstein's 1915 geometrodynamics field $g_{\mu\nu}$. Classical spacetime is then a kind of Josephson effect in the phase of $\psi(x)$. By $\psi(x)$ control $\Lambda(x) > 0$ is the antigravity quintessence on a large scale (acceleration in rate of universe's expansion) also needed to keep the Star Gate stable on a much smaller scale. We also get a nice bonus, i.e. dark matter $\sim 90\%$ of gravitating mass of universe is simply local regions where $\Lambda(x) < 0$

OK are we there yet? Not quite. Hawking using his semi classical model that gives evaporating black holes says that photons circulating in closed light like loops in time pile up in an enormous gravity blue shift that make the two mouths of the Star Gate explode just as the condition of being able to step through it into your past is achieved! This is a Catch 22. Just as quantum randomness conspires to prevent faster than light communication, except that Nimtz in Germany seems to be able to do it, so also quantum randomness seems to prevent actual travel to the past as well as sending messages to the past. Just like Nimtz, some scientists like Radin and Bierman report messages to the past continually on a time scale of a fraction of a second or so in the everyday operation of our brains doing normal things - not paranormal.

NOVA ends with Igor Novikov guessing that time travel to the past is possible. Hawking and Kip Thorne think probably not, but Hawking has a failure of nerve about his own

"chronology protection conjecture" saying at end he is not willing to bet time travel to the past is impossible!

PS Matt Visser says you need a Jupiter exotic mass to keep a Star Gate one meter across stably open. In fact advanced civilization do not need that because they can control Planck scale L_p with M-theory. Look at Lecture 3 on Hawking's new book. So IMO it's much easier than Matt realizes as yet! ☺

Problem 9. What if Michio Kaku's "Masters of Hyperspace", forming what Alan Turing's assistant I. J. Good called "GOD(D)" as a superluminal post-quantum telepathic Cosmic Intelligence Agent with signal nonlocality, same as Fred Hoyle's "Black Cloud" and Olaf Stapledon's "Star Maker", could control the size of the extra dimensions in limited regions of ordinary spacetime? What then?

Lecture 4 of Sarfatti's Physics 101

<http://www.pbs.org/wgbh/nova/time/>

<http://www.pbs.org/wgbh/nova/time/sagan.html>

Further Comment on the NOVA "time travel" show

First Nimtz vs. Chiao on faster than light signals with microwaves tunneling through barrier. Nimtz plays Mozart's 40th symphony, with some noise degradation, from the photons that tunneled. Now Chiao seems to admit that the tunnel time is faster than light but gives the usual argument of quantum randomness preventing the signal, yet the signal is there! Still the key is whether the modulation envelope carrying Mozart's 40th is coming through faster than light? I am not clear how Nimtz can prove that. Chiao, who I know, is no dummy. This is an interesting experimental debate.

If Nimtz is right it means we can make a really fast classical computer, at least, right now using his microwave technique. It would not be a quantum computer unless the switches were qubits not c-bits.

Experiment on time dilation with airplane and atomic clocks shown. This time compared with clock on ground rather than in counter circulating second airplane. Neither of these clocks are on timelike geodesics in flat spacetime of global special relativity so you really need to use general relativity since both atomic clocks are on timelike non geodesic world lines. One of the two will be closer to a timelike geodesic than the other. That's why one sees the time lag between identical starting and ending events of intersecting world lines of the two atomic clocks. The effective centrifugal gravity redshift potentials are that of an isotropic harmonic oscillator. The Newtonian potential cancels out of the problem. In weak field limit the effective centrifugal potential is $(1/2)v^2$ where v is the instantaneous tangential speed of the clock, so the gravity time shift will mimic special relativity in the case where $v/c \ll 1$. Since, the effective g of the centripetal potential is pointing radially outward away from the Earth, the clock on the surface of the Earth is in a lower effective

potential than the airplane clock. That is the airplane clock is deeper into the negative effective gravity potential hence it feels a larger redshift than the clock on the Earth's surface. Therefore, time slows down for the atomic clock in the airplane moving to the East in same sense of rotation as the Earth relative to the identical atomic clock on the Earth. Although the Newtonian gravity is opposite radially inward opposite to the centrifugal effect, the former is the same for both clocks to excellent approximation so it cancels out of the problem. For the other airplane going the opposite way the time dilation effect also goes the opposite way. So you double the size of the effect if you compare clocks on airplanes going in opposite directions around the equator of the Earth. The point here, is that the fact that the actual formulas are effectively the same as in special relativity to order $(v/c)^2$ in this case in this limit is really fortuitous. What this experiment really tests is general relativity not special relativity.

The effective gravity potential energy per unit mass is simply that of the isotropic harmonic oscillator

$$V(r) = -\frac{v_{\phi}^2(r)}{2} = -\frac{(r\omega)^2}{2} \quad (4.1)$$

ω is the rotation rate around the polar axis of the Earth.¹³

For the static spherically symmetric effective metric field of purely azimuthal rotation around the equator.

$$\begin{aligned} ds^2 &= \frac{1}{1 - \frac{2V(r)}{c^2}} (cdt)^2 - r^2 (\omega dt)^2 \\ &= \frac{1}{1 - \frac{2(r\omega)^2}{c^2}} (cdt)^2 - r^2 (\omega dt)^2 \end{aligned} \quad (4.2)$$

¹³ At equatorial latitude to make the problem mathematically a bit simpler.

In the weak field approximation $r\omega/c \ll 1$

$$\begin{aligned}
 ds^2 &= \frac{1}{1 - \frac{2(r\omega)^2}{c^2}} (cdt)^2 - r^2 (\omega dt)^2 \\
 &\approx \left[1 + \frac{2(r\omega)^2}{c^2} \right] (cdt)^2 - r^2 (\omega dt)^2 \\
 &\approx \left[1 + \frac{(r\omega)^2}{c^2} \right] (cdt)^2 \approx \frac{1}{1 - \frac{(r\omega)^2}{c^2}} (cdt)^2
 \end{aligned} \tag{4.3}$$

Clock on Earth is E, clock on airplane is A ds/c is proper time along each world line similarly for E

Note $r(A) \sim r(E)$ to excellent approximation.

Note the subtle cancellation effect. The centrifugal potential points opposite to the way the Newtonian one does. There is a partial cancellation with the azimuthal motion to MIMIC special relativity to first order in $(v/c)^2$!

Therefore,

$$\frac{ds(A)}{ds(E)} \approx \frac{\sqrt{\left[1 - \frac{(r\omega(A))^2}{c^2} \right]} (cdt)}{\sqrt{\left[1 - \frac{(r\omega(E))^2}{c^2} \right]} (cdt)} = \frac{\sqrt{\left[1 - \frac{(r\omega(A))^2}{c^2} \right]}}{\sqrt{\left[1 - \frac{(r\omega(E))^2}{c^2} \right]}} \tag{4.4}$$

When $\omega(A_1) > \omega(E)$ i.e. plane flies to East in same direction of Earth's spin sense

$$\frac{ds(A_1)}{ds(E)} \approx \frac{\sqrt{\left[1 - \frac{(r\omega(A_1))^2}{c^2} \right]}}{\sqrt{\left[1 - \frac{(r\omega(E))^2}{c^2} \right]}} < 1 \tag{4.5}$$

The clock on the plane moving East $\omega(A_2) < \omega(E)$ is younger than clock on Earth. This is really the gravity redshift from Einstein's principle of equivalence. Now reverse plane's direction. It now flies to West. The clock on plane is now older than the one on Earth!

$$\frac{ds(A_2)}{ds(E)} \approx \frac{\sqrt{1 - \frac{(r\omega(A_2))^2}{c^2}}}{\sqrt{1 - \frac{(r\omega(E))^2}{c^2}}} > 1 \quad (4.6)$$

This is really the gravity blue shift from the principle of equivalence. Therefore, Hawking's example is one of time dilation in local general relativity not in global special relativity. Note, however, how this looks like special relativity.

On Carl Sagan and "Contact" see <http://stardrive.org/Jack/contact.pdf> by Saul-Paul Sirag.

Carl asks Kip. Kip comes up with traversable wormhole. This is ~ 1986? Igor Novikov in Moscow reads Kip's paper and comes out of the closet. Igor working secretly on same problem!

"Blackholes and Time Warps" by Kip Thorne

"River of Time" by Igor Novikov

"Lorentzian Wormholes" by Matt Visser (advanced math)

Kip's first traversable wormhole solution of Einstein's 1915

Lecture 5

Real quanta are on mass shell, i.e. energy and momentum are dependent variables obeying the constraint

$$E^2 = Mc^2 = (mc^2)^2 + (pc)^2 \quad (5.1)$$

which is an equation in Einstein's 1905 CLASSICAL special theory of relativity. For a photon, zero rest mass $m_\gamma = 0$ is assumed. That may not be correct. It may turn out that

$$m_\gamma = \frac{hH}{c^2} \sim 10^{-27}10^{-17}10^{-21} \sim 10^{-65} \text{ grams} \quad (5.2)$$

H is the Hubble cosmological parameter

$$H \equiv \frac{dR/dt}{R} \quad (5.3)$$

of the RW cosmology metric where R(t) is the spatial scale factor and t is the cosmic time.

$$\Lambda \approx \left(\frac{H}{c}\right)^2 \approx \left(\frac{1}{L_p^2}\right) \left(1 - L_p^3 |\langle \psi \rangle|^2\right) > 0 \quad (5.4)$$

for a tiny cosmological antigravity quintessent acceleration of the expansion of the universe.

Note that $\Lambda(\text{ZPF}) \sim 1/L_p^2$. Therefore

$$\frac{\Lambda(\text{ZPE})}{\Lambda} \approx \left(\frac{c}{HL_p}\right)^2 \sim 10^{21}10^{34}10^{66} = 10^{121} \quad (5.5)$$

That is, $\langle \psi \rangle$, the mean coherence order parameter on the cosmological scale of the quantum vacuum ZPE, renormalizes the cosmological field down by 121 powers of 10 at this cosmological epoch. It leaves a tiny bit over to accelerate the expansion of the universe as recently observed.

Now for the virtual quanta of the ZPF the above mass shell constraint is not obeyed. Therefore, E and p are independent variables for the virtual quanta of the random normal fluid part of the quantum vacuum and also for the virtual quanta in coherent states making Psi, the superfluid part of the quantum vacuum.

Einstein's classical g_{uv} geometrodynamical field is essentially the elastic strain tensor of Kleinert's world crystal distortion field. The latter is simply the Josephson shift from modulating the gauge force invariant Goldstone phase field of $\langle \psi \rangle$ whose nonrandom fluctuations $\delta\psi(x)$ is a complex numbered local field at spacetime event x.

We saw earlier how this explains how classical material spacetime emerges out of the quantum foam via spontaneous symmetry breaking. The symmetry is restored by a coherent macroscopic mode, which is essentially Einstein's classical geometrodynamical field of 1915.

Einstein curvature comes from disclination line defects in Kleinert's world crystal. If we add dislocation line defects we get torsion beyond Einstein's 1915 GR. The coherent stressed world crystal freezes out of the random ZPE foam of the unified quantum field because that gives a lower energy vacuum. The released energy pumps the expansion of the universe and our own consciousness.

Lecture 6

Model for a Post-Quantum Physics of Consciousness with Signal-Nonlocality

$$\tau = \frac{1}{HN} \tag{6.1}$$

τ = duration of moment of consciousness for N qubits forming a post-quantum computer.

$$\langle \Lambda \rangle \approx \left(\frac{H}{c} \right)^2 \approx 10^{-56} \text{ cm}^{-2} \tag{6.2}$$

$$\tau \approx \frac{1}{cN\sqrt{\langle \Lambda \rangle}} \rightarrow \frac{1}{3 \times 10^{10} 10^{18} 10^{-28}} \approx \frac{1}{3} \text{ sec} \tag{6.3}$$

$N = 10^{18}$ qubits in human brain in the hydrophobically caged single electron nanotransistors enslaved by Crick near field at 40 Hz, i.e. coherent state of virtual photons for which $f \neq kc$. Power dissipation $\sim 10^{-2}$ Watts to maintain stream of consciousness in human brain.

The macrocoherent quantum action of pilot qubit information wave on matter must balance the post-quantum reaction of matter back on pilot qubit information wave.

$$\text{Action} = \text{Reaction}$$

Ansatz, the quantum action of wave on an electron qubit is h . The post-quantum virtual photon mediated reaction of a single particle in a Bose-Einstein Frohlich condensate¹⁴ of N particles back on its $\psi(x)$ local order parameter in the living brain is to first order $\sim \alpha mc^2/HN^2$. When $N \sim 1$, the quantum action \gg cosmological Λ field dependent post-quantum reaction. This explains why quantum theory with signal locality works so well in this orthodox micro-quantum limit with a “fragile” Bohm quantum potential enforcing “passion at a distance”, “no quantum cloning”, locally uncontrollable quantum randomness (decoherence) in entangled systems. Balancing quantum action with post-quantum reaction in the effective nonequilibrium condensate gives $N^2 \sim (e^2/hc)mc^2/Hh \sim$

¹⁴ The coherent EM Crick near induction field of large numbers of virtual photons of longitudinal polarization enslaves the electric dipole oscillations of the hydrophobically caged electrons inside the sub neuronal microtubules – is the conjecture here.

$10^{-2} 10^{21} 10^{17} = 10^{36}$ Therefore, $N \sim 10^{18}$ computed from action reaction principle. This number agrees with experiment.

re: <http://stardrive.org/Jack/Physic101.pdf>

Lecture 7 Elementary Einstein Relativity from an Advanced Perspective

Einstein's classical mechanical principle of relativity is that the laws of nature are local in space and time and are independent of the state of motion of the observer. This is also called "covariance".

The classical special principle of relativity applies only to non-accelerating inertial observers in globally flat spacetime. The special principle of relativity is obeyed in Newton's mechanics with absolute time (simultaneity) in the $v/c \ll 1$ limit of Galilean relativity. v is the speed of a test particle under observation and also it can be the relative speed of the two observers Alice and Bob tracking and continuously measuring the motion of the same test particle. c is the speed of light in vacuum 186,000 miles per second.

The general principle of relativity allows arbitrary relative accelerations between two momentarily coincident generally non-inertial observers Alice and Bob. This means that the separation between Alice and Bob must be small compared to the radii of space-time curvatures. Special relativity works locally not globally if Alice and Bob are on free floating timelike geodesic world lines. Gravity is locally cancelled on a time like geodesic. "Time like" means motion of a body with real invariant mass m that must be slower than light. A "space like" world line means faster than light motion for a test particle with imaginary invariant mass m . This is Einstein's local principle of equivalence of gravity to inertia. Motion on time like non-geodesic world lines is equivalent to a local gravitational field. When we have strings instead of point particles, world lines are replaced by world sheets and the topology of holes in the world sheets plays a key role lumping together infinite numbers of Feynman diagrams with world lines into the same equivalence class.

In quantum mechanics, we must use higher dimensional configuration space with many-fingered time for entangled test particles rather than space and time. The events of preparation and detection play "anchor roles" pinning down the quantum process in the intermediate points on world line for weak nondemolition quasi-measurements. For example, the creation of an EPR neutron pair is a \vee space-time diagram in Bohm's realism with actual particles on definite world lines sharing a common pilot field of qubits. The bottom vertex is the preparation event. The tips at the tops of the two line segments are the detection events. Quantum information flows both ways in time connecting these 3 anchor events to create globally self-consistent loops in time of correlated data of actual measurements. The nonlocal correlations do not disappear at a critical relative speed of the two detectors, or relative speeds of detectors to common source when Doppler corrections are made. Gisin is wrong to claim that Bohm's quantum realism predicts a disappearance of the correlations under the conditions of his actual experiment.

The classical mechanical local principle of relativity need not apply in the context dependent quantum domain which is non-mechanical. This means that the solutions of the laws of nature feedback directly to those laws. Einstein never meant his principle of relativity to apply to the solutions of the laws of nature only to the laws themselves.

Even in classical general relativity, the solution need not have all the symmetries of the local tensor laws of nature. In particular, the quantum cosmic black body radiation provides an operational definition of local rest in which that radiation is maximally isotropic. The absolute temperature of that radiation is also a universal measure of the time since the initial singularity.

The experiment on time dilation of the airplanes flying around the Earth (Hawking p.9) requires local 1915 general relativity GR for its explanation not 1905 global special relativity (SR). The basic action principle idea, that the timelike geodesic has maximal aging relative to all timelike non-geodesics between a pair of common intersection points of the bundle of neighboring world lines, is equally true, of course, in both global special relativity (1905) and local general relativity (with locally flat tangent spacetime) of 1915. The circular motions of the airplanes are equivalent to a local centrifugal hyperbolic gravity field at the airplanes superimposed on the static elliptical Newtonian gravity field directed opposite to it. The latter Newtonian static field cancels out of the problem BTW. The atomic clock inside the airplane moving to East in the same direction that the Earth turns about its polar axis suffers a gravity redshift relative to an identical atomic clock on the surface of the Earth. The other airplane's atomic clock moving to the West opposite to the Earth's spin suffers a gravity blue shift relative to the Earth surface's atomic clock. Therefore, the observed time dilation is showing the principle of equivalence of Einstein's 1915 GR rather than the spacetime kinematics of Einstein's 1905 global SR.

ref: "A Journey into Gravity and Spacetime" by John Archibald Wheeler

One must be careful not to over extend Einstein's 1905 global special relativity GSR beyond its limited domain of validity of global inertial frames GIF. In 1915 GR, GSR is violated and is replaced by local special relativity LSR with local free float inertial frames LIF. The local map from an LIF to a local non-inertial frame is the "tetrad map".

LIF \rightarrow LIF' is a local Lorentz transformation at a fixed local spacetime event E (not with the translation group which is locally gauged in the form of Einstein's holonomic (integrable) infinitesimal general coordinate transformations. These little infinitesimal local translations correspond to Kleinert's local World Crystal distortion field. The symmetric strain tensor of this distortion field is the curved part of Einstein's $g_{\mu\nu}(x)$ metric field. The distortion field is a Josephson effect of coherent phase modulation on the locally gauge invariant phase of the local order parameter Goldstone $\psi(x)$ spontaneously breaking the GSR symmetry of the false quantum vacuum of completely locally random zero point energy fluctuations of the U(1)xSU(2)xSU(3) gauge force and lepto-quark spinor source quantum fields.

LIF \rightarrow LNIF is the local tetrad map at a fixed local spacetime event E.

LNIF \rightarrow LNIF is the topology conserving generic local holonomic Einstein coordinate transformation Diff⁴. The unseen hyperspace dimensions make this anholonomic (nonintegrable) with dynamic topology changes in the $g_{\mu\nu}(x)$ field.

Lecture 8 Hawking on the cosmological field as "a great problem".

"This was one of the great missed opportunities of theoretical physics. If Einstein had stuck with his original equations, he could have predicted that the universe was either expanding or contracting ... Einstein later called the cosmological constant the greatest mistake of his life. However, it now seems that it may not have been a mistake after all ..." p. 21 (Hawking)

"Einstein's general theory of relativity transformed space and time from a passive background in which events take place to active participants in the dynamics of the universe." p. 21

Based on Einstein's 1924 "Essay on the Aether" and John Wheeler's "A Journey into Gravity and Spacetime" I would have written instead

Einstein's general theory of relativity transformed space and time from a rigid background in which events take place to mutable participants in the dynamics of the universe.

That is, even in global special relativity of 1905 matter, in absence of the electromagnetic force, receives its marching orders from the immutable everywhere flat rigid 4-dim spacetime to move on a timelike geodesic world line. Similarly, light gets its marching orders to move on a null geodesic world line. Both are still true in local 1915 general relativity, however, now there is direct back action of matter stress energy density on spacetime locally curving it. That direct local curving propagates into the vacuum where there is no actual matter stress energy density. Therefore, in 1905 global special relativity spacetime geometry is active but rigid not directly responding to matter whose motion it pilots. In 1915 local general relativity spacetime geometry locally responds to matter and adapts to that matter even in vacuum regions empty of "real" matter. That is, spacetime is now active and responsive to the matter whose motion it pilots according to the action principle.

"This led to a great problem that remains at the forefront of physics in the twenty first century. The universe is full of matter, and matter warps spacetime in such a way that bodies fall together. Einstein found that his equations didn't have a solution that described a static universe, unchanging in time. Rather than give up such an everlasting universe ... he fudged the equations by adding a term called the cosmological constant, which warped spacetime in the opposite sense, so that bodies move apart." p. 21

This "fudge" at the classical level where Einstein was in the early 1920's is kosher because it does not violate any principles of general relativity. Things get more complicated at the quantum level not known to anyone at that time.

The vacuum has real zero point energy fluctuations (ZPEF), for example, of the electromagnetic field. It is now well known that this ZPEF gives a huge repulsive cosmological constant

$$\Lambda(ZPE) \approx \frac{1}{L_p^2} \equiv \frac{c^3}{G\hbar} \approx 10^{66} \text{ cm}^{-2} > 0 \quad (8.1)$$

Note that $\Lambda \rightarrow \infty$ in the "classical limit" $\hbar \rightarrow 0$ for fixed c (vacuum speed of light) and fixed G (Newton's constant). This is a fatal conflict between classical general relativity and Heisenberg's uncertainty principle. I think I have solved this problem.¹⁵ The above totally random vacuum is a "false vacuum". The actual vacuum has a lower energy density because of a complex number coherent order $\psi(x)$ that *derandomizes* part of the ZPEF creating Einstein's classical spacetime geometry in the cohering process. The cosmological constant is actually a variable local field $\Lambda(x)$

$$\Lambda(x) \approx \left(\frac{1}{L_p^2} \right) \left[1 - L_p^3 |\psi(x)|^2 \right] \quad (8.2)$$

the dimensionless phase

$$\Theta = 2\pi \frac{\Phi_a}{\Phi_0^a} - \left(\frac{e_a}{c\hbar} \right) \int A_\mu^a dx^\mu \quad (8.3)$$

of the complex number $\psi(x)$ determines Einstein's warped geometrodynamical field $g_{\mu\nu}(x)$ at spacetime event x . Note that the index a is in internal symmetry space. I include the full Yang-Mills theory of the electro-weak-strong forces.¹⁶ Φ_0^a is a generic Yang-Mills flux quantum. Φ_a is a possible generic spontaneous broken symmetry Goldstone phase with the dimensions of the gauge flux as shown in general by Weinberg in Volume II of his Quantum Field Theory Trilogy. I use summation convention over repeated indices.

$$g_{\mu\nu}(x) = \eta_{\mu\nu} + L_p^2 \left[\partial_\mu \partial_\nu + \partial_\nu \partial_\mu \right] \Theta \quad (8.4)$$

This is what Andre Sakharov was looking for in 1966 but did not find. It was too soon.

¹⁵ I could be wrong of course.

¹⁶ In particular QCD is included.

$\langle \Lambda(x) \rangle \ll 10^{+66} \text{ cm}^{-2}$ on average for large scale structure of the universe . Indeed,

$$\langle \Lambda(x) \rangle \sim 10^{-56} \text{ cm}^{-2} .$$

$\Lambda(x) > 0$ is a repulsive quantum vacuum phase causing the expansion of the universe to speed up rather than slow down.

$\Lambda(x) < 0$ is attractive "dark matter" quantum vacuum phase in limited regions like the galactic halo.

This formula allows a consistent macroscopic quantum limit for classical spacetime to come into being since $\psi(x)$ adjusts to keep Λ finite as $\hbar \rightarrow 0$. Note that the stress energy density tensor of the virtual quanta in the physical vacuum is

$$t_{\mu\nu}(x)_{vac} \approx \left(\frac{\hbar c}{L_p^2} \right) \Lambda(x) g_{\mu\nu}(x) \quad (8.5)$$

$\psi(x)$ adjusts such that

$$t_{\mu\nu}(x)_{vac} \ll T_{\mu\nu}(x) \quad (8.6)$$

Where $T_{\mu\nu}(x)$ is the stress-energy density tensor for real quanta excitations above the physical vacuum. Therefore, Einstein's 1915 local classical field equation

$$R_{\mu\nu}(x) - \left(\frac{1}{2} \right) R(x) g_{\mu\nu}(x) \approx -8\pi \left(\frac{L_p^2}{\hbar c} \right) T_{\mu\nu}(x) \quad (8.7)$$

is a good approximation under many, but not all, circumstances. ¹⁷

Lecture 9

Jack: "Feynman, with great passion in his voice, told me personally in 1968 in his Cal Tech Office in an hour meeting he not only thought renormalization was a problem, but that it was a "shell game" and a "scandal" that no one had a better idea than he (and Schwinger & Tomonaga).

¹⁷ I use the GR sign conventions of John Peacock's "Cosmological Physics" (Cambridge) not same as MTW's.

Professor X: "I don't give a Fig Newton for quantum gravity."

Jack: Odd reply. Whether you are interested in it or not, it is there like Mount Everest. :-)
Could you summarize the main idea here - the point? Thanks.

Professor X: "The point, accepted by mainstream pundits, is that since we don't understand what is really going on theoretically, there is no sense worrying about the fact that we get infinities."

Jack: Aha! I thought it would come down to that. Well, that is not good enough for me.

Professor X: "It is for me. There are no experiments for quantum gravity. I think most attempts to go beyond the standard model are doomed to be failures."

Jack: Well, I am arguing that, just like electricity, magnetism and light were aspects of the same thing, just like time and space were aspects of the same thing (within the limits Einstein set of course he did not mean the arrow of time only the time in the mechanical laws of nature), so I say that the following observations based on good experiments

1. smallness of the cosmological constant
2. acceleration of the expansion of the universe rather than expected slowing down
3. most of the matter in the universe is dark
4. electrons extended at $h/mc \sim 10^{-11}$ cm from the wave perspective scatter like point particles of size $< 10^{-16}$ cm. Similarly for quarks inside hadrons as seen in deep inelastic scattering with virtual spacelike photon probes.
5. Regge trajectories of universal slope $G^*/\hbar c^5 \equiv \alpha' \approx 1/(1\text{Gev})^2$

All five of these sets of experimental data have a common theoretical explanation. I also get Einstein's classical $g_{\mu\nu}(x)$ field popping out when the symmetry of the quantum vacuum is spontaneously broken analogous to a normal metal going superconducting.

Professor Y: "I agree with Feynman's opinion (as well as with Dirac's and some others...). Of course it is not so easy to create something better than Tomonaga-Schwinger- Feynman done - they have been pretty smart guys - Dirac tried for a few decades and failed... and he was a pretty smart guy too..."

Jack: I have done it, I think. It's right under your nose - the beginning of it. It also shows why Bernie Haisch and Hal Puthoff are barking up the wrong tree. However, for the historical record, I would not have found the right tree without them. Correcting their errors led me to the correct idea. time. details at <http://stardrive.org/Jack/Cosmo1.pdf>

Hal Puthoff is completely inconsistent in the logic of his argument that both zero point fluctuations are real (e.g. Casimir force), on the one hand, and that zero point fluctuations do not curve spacetime, on the other hand. You cannot have both. You cannot have that

cake and eat it too. That is like saying that orthodox quantum physics is both objective and local. You cannot have both. Note, e.g. Hawking writes of Hal Puthoff's kind of wishing will make it so pretending that the problem is not there:

"One might hope to solve the problem of this seeming contradiction between observation and theory by saying that the ground state fluctuations have no gravitational effect, but this would not work. One can detect the energy of ground state fluctuations by the Casimir effect ... This difference in [zero point] energy gives rise to a force pulling the plates together. Forces are a source of gravity in general relativity, just as matter is, so it would not be consistent to ignore the gravitational effect of this energy difference." p. 46 "The Universe in a Nutshell"

Hal cannot squirm out of this by pointing to Hawking's words "energy difference" as a look at Peacock's "Cosmological Physics" ~ p 25 (Cambridge). From that we get the zero point energy (ZPE) contribution to the source stress energy tensor field as

$$t_{\mu\nu}(x)_{ZPE} \approx \left(\frac{\hbar c}{8\pi L_p^2} \right) \Lambda(x)_{ZPE} g_{\mu\nu}(x) \quad (9.1)$$

(eq. 1.87) p. 26 Peacock, where

$$\Lambda(x)_{ZPE} \approx \frac{1}{L_p^2} > 0 \quad (9.2)$$

i.e. anti gravity repulsion because

$$\nabla^2 V(x)_{vac} \approx c^2 \Lambda(x)_{ZPE} \quad (9.3)$$

i.e. Laplacian of Newton's potential¹⁸ of the quantum vacuum in the weak field limit. Peacock's sign conventions are such that a negative sign source is antigravity in Poisson's equation (9.3).

Note that a positive ZPE energy density has a negative ZPE quantum pressure.

Poisson's equation for the relativistic fluid in weak field limit is

$$\nabla^2 V(x) = 4\pi \frac{G}{c^2} [\rho(x)c^2 + 3p(x)] \quad (9.4)$$

¹⁸ Dimension of Newton's potential is energy per mass = velocity squared. Dimension of the cosmological Λ field is 1/length squared, and the dimension of the Laplacian differential operator is 1/length squared. Check that the dimensions on each side of equation (9.3) match at 1/time squared.

where

$$T_{\mu\nu}(x) = \left(\rho(x) + \frac{p(x)}{c^2} \right) \frac{dx_\mu}{d\tau} \frac{dx_\nu}{d\tau} - p(x) g_{\mu\nu}(x) \quad (9.5)$$

In the weak field non relativistic limit $v/c \rightarrow 0$, $dx_0/d\tau \rightarrow c$, therefore

$$T_{00}(x) \rightarrow \rho(x)c^2 + p(x)[1 - g_{00}(x)] \approx \rho(x)c^2 \quad (9.6)$$

$$\begin{aligned} T \equiv T^\mu_\mu &= \left(\rho(x) + \frac{p(x)}{c^2} \right) \frac{dx_\mu}{d\tau} \frac{dx^\mu}{d\tau} - p(x) g^\mu_\mu(x) \\ &= \rho(x)c^2 + p(x) - 4p(x) = \rho(x)c^2 - 3p(x) \end{aligned} \quad (9.7)$$

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = -8\pi \frac{G}{c^4} T_{\mu\nu} \quad (9.8)$$

$$R^\mu_\mu - \frac{1}{2} R g^\mu_\mu = -R = -8\pi \frac{G}{c^4} T \quad (9.9)$$

$$\begin{aligned} R_{\mu\nu} &= -8\pi \frac{G}{c^4} \left[T_{\mu\nu} - \frac{1}{2} T g_{\mu\nu} \right] \\ &= -8\pi \frac{G}{c^4} \left[T_{\mu\nu} - \frac{1}{2} (\rho c^2 - 3p) g_{\mu\nu} \right] \end{aligned} \quad (9.10)$$

$$\begin{aligned} R_{00} &= -8\pi \frac{G}{c^4} \left[T_{00} - \frac{1}{2} (\rho c^2 - 3p) g_{00} \right] \\ &\approx -8\pi \frac{G}{c^4} \left[\rho c^2 - \frac{1}{2} (\rho c^2 - 3p) \right] = -4\pi \frac{G}{c^4} [\rho c^2 + 3p] \end{aligned} \quad (9.11)$$

$$R_{00} \rightarrow -\frac{1}{c^2} \nabla^2 V \quad (9.12)$$

$$\nabla^2 V \approx 4\pi \frac{G}{c^2} (\rho c^2 + 3p) \quad (9.13)$$

This is eq. (1.85) p. 25 Peacock. The sign conventions are such that a positive source on RHS of (9.13) generates a gravitating attractive potential.

For ZPE case of any boson quantum field, the equation of state is

$$\rho(x)_{ZPE} c^2 + p(x)_{ZPE} = 0 \quad (9.14)$$

Substitute (9.14) into (9.13) and eliminate the quantum ZPE pressure to get

$$\nabla^2 V(x)_{ZPE} \approx -8\pi \frac{G}{c^2} \rho(x)_{ZPE} c^2 \quad (9.15)$$

for the weak field limit of the effective gravitating potential of the zero point quantum vacuum gauge field fluctuations. Therefore, a positive ZPE energy density anti gravitates (in free space) because its corresponding negative pressure over powers it by a factor of 3 in the weak field limit.

Indeed, Peacock writes:

"a negative-pressure equation of state that achieved

$$\rho(x)_{ZPE} c^2 + p(x)_{ZPE} < 0 \quad (9.16)$$

would produce gravitational repulsion ... the cosmological constant has refused to die and has assumed a central role in modern cosmology. What is its physical meaning? it represents the curvature of empty space the apparently trivial act of moving the Λ term to the right hand side of the field equations

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = -8\pi \frac{G}{c^4} T_{\mu\nu} \quad (9.17)$$

$$\rightarrow G_{\mu\nu} = -8\pi \frac{G}{c^4} T_{\mu\nu} - \Lambda g_{\mu\nu} \equiv -8\pi \frac{G}{c^4} [T_{\mu\nu} + t_{\mu\nu}(Vac)]$$

$$t_{\mu\nu}(Vac) \equiv \frac{\Lambda c^4}{8\pi G} g_{\mu\nu} = \frac{\Lambda \hbar c}{8\pi L_p^2} g_{\mu\nu} \quad (9.18)$$

This is (1.87) p. 26 Peacock, who writes:

“How can a vacuum have a non-zero energy density and pressure? we can be sure of one thing: the absence of a preferred frame means that $t_{\mu\nu}(Vac)$ must be the same for all observers in special relativity. Now apart from zero there is only one isotropic tensor of rank 2 .. $\eta_{\mu\nu}$.” [the metric of special relativity]

At this point Peacock is a bit sloppy. I would simply invoke Einstein's principle of equivalence (formally a tetrad map at fixed event P from a timelike geodesic weightless free float LIF to a coincident timelike non-geodesic with "weight" LNIF, to get Peacock's "it must be proportional to the metric tensor" not just in the local tangent fiber flat spacetime of special relativity at P for the LIF, but also in the local curved spacetime base space of general relativity in the neighborhood of P.

"Therefore, it is inevitable that the vacuum will have a negative pressure equation of state

ZPE pressure = - ZPE energy density" Eq. (1.88) p. 26

Note, we assume, of course, that

ZPE energy density > 0

Note, that in the Casimir Force experiment,

ZPE energy density < 0

Which explains why the Casimir Force is attractive in that special finite geometry. This is the case Hawking treats on p.47 Fig. 2.11.

Note that the shape of the ZPE energy density is

$$t_{00}(Vac) = \frac{\Lambda \hbar c}{8\pi L_p^2} g_{00} \quad (9.19)$$

In my new theory <http://stardrive.org/Jack/Cosmo1.pdf>

$$\Lambda \rightarrow \Lambda(x) \approx \frac{1}{L_p^2} \left[1 - L_p^3 |\psi(x)|^2 \right] \quad (9.20)$$

where the complex order parameter $\psi(x)$ spontaneously breaks the symmetry of the false vacuum creating $g_{\mu\nu}(x)$ by partially cohering the hitherto random zero point fluctuations of the gauge fields. Consequently, $\Lambda(x)$ can be negative or positive in general as we move from spacetime event P to spacetime event P' along a given path. In the parallel universes, or dynamic "3-branes" of M-theory, $t_{\mu\nu}(Vac)$ may not be a state function. Paths through Star Gates will take us to a different universe. As an analogy, think of going around a branch point on a Riemann surface in the theory of functions of a complex variable.

However, in the present case, when

ZPE energy density > 0

as it is, for example, in the SED (Stochastic Electro Dynamics) model of the ZPE used by Haisch, Rueda & Puthoff, for example, the pressure is negative, therefore, the ZPE is "exotic" with

energy density + 3pressure = -2 energy density < 0

We can make Kip Thorne's "traversable wormhole" without event horizons, without fatal stretch-squeeze singularities, and we can make timelike geodesic warp drives (vacuum propellers) without splattering g-forces with this exotic "vacuum" stuff. Finally Peacock says

"a positive Λ will cause a large scale repulsion" p. 26

Now remember in my new theory, like in Giovanni Modanese's special model not for the vacuum, but for a real superconductor, Λ is not a constant, but is, rather, a local scalar "cosmological field". Also one must do coarse-graining so the field can show emergent orders on different scales of resolution. The details of the action of that unified field are not really important for the conclusions of my theory at its present stage. This is well known in superconductivity where certain key features like flux quantization and the Meissner effect exclusion of flux in bulk do not depend on microscopic details. The Landau-Ginzburg effective field theory works well -- similarly here.

$\Lambda(x)$ can be zero, positive, or negative, in different regions x of spacetime and at different levels of coarse graining.

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"What I cannot create. I do not understand." Richard Feynman