

THE ZERO POINT SOURCE OF ACCELERATED EXPANSION

By: Dr. Paul Karl Hoiland

Abstract: I will show by the following thought experiment applied to the possible generation of a warp field by harnessing quantum effects that there exists evidence in this exercise that the Universe should display an Exponential growth rate over time we'd observe as an accelerated expansion.

In 1993, Bennett et al. showed that if Alice and Bob each hold one of two particles which are entangled together, a quantum state can be transmitted from Alice to Bob completely by sending fewer classical bits than would be required without the entanglement. The aspect I have been attempting to show is that one can even reduce this set further into what is best term quantum information transfer and as such, possibly control the velocity of classical information transfer and even rewrite the classical information for any zero point state or higher.

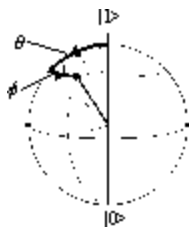
But let's examine this a bit further here. In every q-bit there is one e-bit of information stored. A quantum bit (or qbit) is a two dimensional Hilbert space, with basis states $|0\rangle$ and $|1\rangle$, The general state of qbit is:

$$\Psi = e^{i[(\phi)/2]} \cos\left(\frac{\theta}{2}\right) |1\rangle + e^{-i[(\phi)/2]} \sin\left(\frac{\theta}{2}\right) |0\rangle$$

usually shortened to

$$\Psi = \alpha|1\rangle + \beta|0\rangle$$

The qbit may be represented by a point on a sphere of unit magnitude (Bloch sphere).



The inner product of two qbits is

$$\langle \Psi | \Psi' \rangle = \alpha^* \alpha' + \beta^* \beta'$$

For any given qbit state, there is exactly one other qbit state with which it has a zero inner product. This other state corresponds to the point in exactly the opposite direction on the Bloch sphere. $|1\rangle$ and $|0\rangle$ are 'opposite' to each other, and as the choice of a basis for $|1\rangle$ and $|0\rangle$ is arbitrary, this may be taken as the quantum generalization of 'oppositeness' of bits. However, if one can rewrite the information at the zero point level then the choice is no longer arbitrary. In fact, zero information in theory could be written to either point on the Bloch sphere, however, as already mentioned elsewhere nature tends to abhor a pure empty vacuum state and will refill such a state itself as properly referenced by Ford and others(1).

So, the idea here when it comes to generating a warp drive field is to rewrite the forward portion of the field so that it, once translated, displays a higher vacuum energy density than normal and to rewrite the rear field so that it displays less vacuum energy density than normal while keeping the local field around the ship at a normal unaccelerated condition which translates to having to eliminate or rather counter the Unruh effect in general in that region.

To achieve normal entanglement a qbit 'opposite' to $|n\rangle$ will be represented by $| -n \rangle$. For the inner product to be 1, the two qbits must be at the same point on the Bloch sphere, and will be in the 'same' quantum state. The same generally applies to how one begins to rewrite the quantum e-bit encoded into each q-bit. We can only rewrite one qbit per each point on the Bloch sphere. This translates to whatever field generator we attempt to construct having to have to have an effect on the actual zero point itself.

To begin we need the logical operations one can perform upon qbits, and it turns out that a single gate is sufficient to represent all of them.

$$C(a,b,c) = |0\rangle\langle 0|_A \otimes I_B + |1\rangle\langle 1|_A \otimes U(a,b,c)_B$$

$$U(a,b,c) = \begin{pmatrix} e^{ia} \cos b & -e^{ic} \sin b \\ e^{-ic} \sin b & e^{-ia} \cos b \end{pmatrix}$$

If we take the basis states of $|0\rangle$ and $|1\rangle$ as the 'classical' states 0 and 1, we can reconstruct classical logic gates from this. In particular, the classical CNOT gate is equivalent to $C(0, \pi/2, \pi)$.

When receiving a classical bit one can simply open the box, find out what it is, and gain one bit of information. However, for a qbit, this is not possible. One must make a measurement, along a particular axis. If he chooses the conventional axis, he gets the probabilities

$$\Pr(|0\rangle) = \sin^2\left(\frac{\theta}{2}\right)$$

$$\Pr(|1\rangle) = \cos^2\left(\frac{\theta}{2}\right)$$

and afterwards the qbit is in state $|0\rangle$ or $|1\rangle$ respectively.

Although a large number of identically prepared qbits will eventually yield up the value of θ , one doesn't get any information about ϕ , one could be sending qbits pointing in different directions. As the measurement described has only two outcomes, it turns out one can get, at most, one classical bit of information from the transmitted qbit. With an infinite amount of qbits, one can find θ exactly, but this is the same as the infinite amount of bits necessary to specify a continuous parameter. The average information conveyed by each qbit is still one ebit, even if that ebit encodes a lot of information itself.

One can now set up a second set of qbits, in some random, but identical state, $|n'\rangle = \alpha'|1\rangle + \beta'|0\rangle$. We can now measure the qbits, the probability of passing is $\cos^2\left(\frac{\theta}{2}\right)$ where θ is the angle between both directions. The mean fidelity of each bit is $F = 1/2$ and the joint fidelity (the probability of getting both right) $F_J = 1/3$. This random type of guessing only sets for us a baseline and nothing more.

We now measure the bit in some basis (for convenience, we use $|1\rangle, |0\rangle$), and send back two bits in the direction the measurement gives. This gives a density matrix $\rho = |\alpha|^2 |11\rangle\langle 11| + |\beta|^2 |00\rangle\langle 00|$ and average fidelities $F = 2/3, F_J = 1/2$.

We now perform a FANOUT process and copy the qbit state we desire thus forming an entangled set. One set of these entangled pairs is injected into a warp conduit confined region of space-time around the craft. The other set is kept within a smaller version of the field we are trying to generate externally. In essence we replace the local vacuum around the craft with our own photons which being entangled we can then alter the external region once constructed via altering the internal copy region onboard the craft at a rate only governed by the maximum flow rate for quantum information. This path to field control does involve transporter concepts. But it is a simple path to control of our field for warp drive generation. We never actually open the box, so to speak in this approach. This produced a perfect solution with classical bits encoded into both sets, one

of which we have direct control over and one we have indirect via quantum information exchange over.

Can we build a quantum FANOUT?

If we take an initial, unknown qbit, and an auxiliary system, prepared in a known state, does there exist any unitary operation of the form:

$$\text{CLONE}(|n\rangle | \text{Aux0} \rangle) = |n\rangle |n\rangle | \text{Aux}(n) \rangle$$

where $| \text{Aux0} \rangle$ is the initial auxiliary system, and $| \text{Aux}(n) \rangle$ is an n dependant 'junk' output, which works for all values of n ? The answer to this was answered in the negative by Wootters and Zurek(2). The proof of the non-existence of CLONE can be found from the unitary operation preserving the inner product between states

$$\langle n | n' \rangle \langle \text{Aux0} | \text{Aux0} \rangle = (\langle n | n' \rangle)^2 \langle \text{Aux}(n) | \text{Aux}(n') \rangle$$

However, the inner product of two states obeys the relation

$$| \langle i | j \rangle | \leq 1$$

with equality holding only when $i = j$. The required relationship can only hold when either $n = n'$ or when $\langle n | n' \rangle = 0$, but cannot hold for general values of n . An obvious case for $\langle n | n' \rangle = 0$, is where $n = 1$, $n' = 0$. So classical information can be cloned. And there is a way to improve on this also.

It is possible to build imperfect cloning machines, that produce a fidelity better than simply 'measure and copy' approach. An example of an optimal quantum cloning, in which the fidelity of the output is independent of the input state, is given by the following unitary operation:

$$\begin{aligned}
|0\rangle|00\rangle &\rightarrow \frac{1}{\sqrt{3}} \left(\frac{2}{\sqrt{2}} |000\rangle + \frac{1}{\sqrt{6}} |011\rangle + \frac{1}{\sqrt{6}} |101\rangle \right) \\
|1\rangle|00\rangle &\rightarrow \frac{1}{\sqrt{3}} \left(\frac{2}{\sqrt{2}} |111\rangle + \frac{1}{\sqrt{6}} |010\rangle + \frac{1}{\sqrt{6}} |100\rangle \right)
\end{aligned}$$

For a general input qbit of $|n\rangle$ in the first position, this produces output qbits in the first and second positions of $\rho = 5/6|n\rangle\langle n| + 1/6| -n\rangle\langle -n|$. The third qbit is the 'junk' auxiliary output. The fidelity is $F = 5/6$, with a joint fidelity of $F_j = 2/3$

An example of an optimal quantum cloning, in which the fidelity of the output is independent of the input state, is given by the following unitary operation:

$$\begin{aligned}
|0\rangle|00\rangle &\rightarrow \frac{1}{\sqrt{3}} \left(\frac{2}{\sqrt{2}} |000\rangle + \frac{1}{\sqrt{6}} |011\rangle + \frac{1}{\sqrt{6}} |101\rangle \right) \\
|1\rangle|00\rangle &\rightarrow \frac{1}{\sqrt{3}} \left(\frac{2}{\sqrt{2}} |111\rangle + \frac{1}{\sqrt{6}} |010\rangle + \frac{1}{\sqrt{6}} |100\rangle \right)
\end{aligned}$$

For a general input qbit of $|n\rangle$ in the first position, this produces output qbits in the first and second positions of $\rho = 5/6|n\rangle\langle n| + 1/6| -n\rangle\langle -n|$. The third qbit is the 'junk' auxiliary output. The fidelity is $F = 5/6$, with a joint fidelity of $F_j = 2/3$

What if they are in opposite states - how much information have we gained? Two qbits in unknown, opposite states have a averaged density matrix of

$$\rho(|n, -n\rangle) = \begin{pmatrix} 1/6 & 0 & 0 & 0 \\ 0 & 1/3 & -1/6 & 0 \\ 0 & -1/6 & 1/3 & 0 \\ 0 & 0 & 0 & 1/6 \end{pmatrix}$$

or

$$\begin{aligned} \rho(|n, -n\rangle) &= \frac{1}{6} (|u, u\rangle\langle u, u| + |u+\rangle\langle u+| + |-u, -u\rangle\langle -u, -u|) \\ &\quad + \frac{1}{2} (|u-\rangle\langle u-|) \\ &= \frac{1}{2} \rho(|n, n\rangle) + \frac{1}{2} (|u-\rangle\langle u-|) \end{aligned}$$

with $|u-\rangle = [1/(\sqrt{2})](|u, -u\rangle - |-u, u\rangle)$ This has $H = (2 - [1/2]\log 12) = 0.208$ bits, exactly half the information of the same states.

Why there exists a problem on getting 1 bit of correlation information

If we expand the pure states, in the conventional basis, we obtain:

$$\Psi(|n,n\rangle) = \alpha^2|11\rangle + \frac{2\alpha\beta}{\sqrt{2}} \left(\frac{|01\rangle + |10\rangle}{\sqrt{2}} \right) + \beta^2|00\rangle$$

$$\Psi(|n,-n\rangle) = \alpha\beta^*|11\rangle + \left(\frac{|\alpha|^2 - |\beta|^2}{\sqrt{2}} \right) \left(\frac{|01\rangle + |10\rangle}{\sqrt{2}} \right) + \left(\frac{|\alpha|^2 + |\beta|^2}{\sqrt{2}} \right) \left(\frac{|01\rangle - |10\rangle}{\sqrt{2}} \right) - \alpha^*\beta|00\rangle$$

When measured in a different basis to the preparation basis, the same-state qubits may yield opposite results.

Although the separation between the two cases is guaranteed by the no-spin flip theorem, this does not explain why oppositeness conveys so much less information than sameness.

The wave functions and density matrices above, were expressed in the basis

$$\Phi_1 = |11\rangle \quad \Phi_2 = [1/(\sqrt{2})](|10\rangle + |01\rangle)$$

$$\Phi_3 = [1/(\sqrt{2})](|10\rangle - |01\rangle) \quad \Phi_4 = |00\rangle$$

In $[\bar{\rho}(|n,n\rangle)]$, the probability of finding the state Φ_3 is zero, while for $[\bar{\rho}(|n,-n\rangle)]$, it is one half.

Using the notation

$$|1\rangle_x = [(|1\rangle_z + |0\rangle_z)/(\sqrt{2})] \quad |0\rangle_x = [(|1\rangle_z - |0\rangle_z)/(\sqrt{2})]$$

$$|1\rangle_y = [(|1\rangle_z + i|0\rangle_z)/(\sqrt{2})] \quad |0\rangle_y = [(i|1\rangle_z + |0\rangle_z)/(\sqrt{2})]$$

we can construct the Φ basis from a superposition of opposite states:

$$\Phi_1 = \frac{(1-i)}{2} (|01\rangle_z - |10\rangle_z) + |10\rangle_x - i|10\rangle_y$$

$$\Phi_2 = \frac{1}{\sqrt{2}} (|10\rangle_z + |01\rangle_z)$$

$$\Phi_3 = \frac{1}{\sqrt{2}} (|10\rangle_z - |01\rangle_z)$$

$$\Phi_4 = \frac{(1+i)}{2} (|10\rangle_z - |01\rangle_z) - |10\rangle_x - i|10\rangle_y$$

however, we can only construct 3 out of the 4 basis from same states:

$$\Phi_1 = |11\rangle_z$$

$$\Phi_2 = \sqrt{2}|11\rangle_x - \frac{1}{\sqrt{2}} (|11\rangle_z + |00\rangle_z)$$

$$\Phi_4 = |00\rangle_z$$

The space of the two qbits $SU(2) \times SU(2)$ has two invariant subspaces, under global rotations: a symmetric subspace, of dimension 3, and an anti-symmetric subspace, of dimension 1. 'Sameness' means that the qbits can only be found within the symmetric subspace, and are evenly distributed throughout it. While in the classical case, the correlation information restricts the bits to a two dimensional subspace (and therefore represents an ignorance of $\log(2)$ bits) in the quantum case the restricted subspace is 3 dimensional, and the ignorance is $\log(3)$ bits. The opposite qbits are distributed throughout the entire state space - but they are likely to be found in the antisymmetric subspace, so 'oppositeness' does give some correlation information.

The theory of reversible computation was developed following the discovery of Landauer's principle(3)], that only logically irreversible operations implied an irretrievable loss of energy (prior to that, it was thought that each logical operation involved a dissipation of $kT \ln(2)$ per bit). The amount of lost energy is directly proportional to the Shannon measure of the information that is erased. The objective of reversible computing is to reduce the amount of the free energy invested into the calculation that cannot be recovered at the end without losing the results of the

computation. A reversible calculation may be defined as one which operates, upon an input state i and an auxiliary system, prepared in an initial state $Aux0$, to produce an output from the calculation $O(i)$, and some additional 'junk' information $Aux(i)$:

$$F:(i,Aux0) \rightarrow (O(i),Aux(i))$$

in such a manner that there exists a complementary calculation:

$$F':(O(i),Aux(i)) \rightarrow (i,Aux0)$$

The existence of the 'junk' information corresponds to a history of the intervening steps in the computation, so allowing the original input to be reconstructed. A computation that did not keep such a history, would be irreversible, and would have lost information on the way. The information lost would correspond to an amount of free energy invested into the system that could not be recovered.

However, $Aux(i)$ is not generally known, being non-trivially dependant upon the input, i , and so represents free energy that cannot be recovered. A general procedure for discovering the complementary calculation F' can be given like this: take all the logical operations performed in F , and reverse their operation and order. As long as all the logical operations in F are reversible logic gates, this is possible. It is known that the reversible Fredkin-Toffoli gates are capable of providing all classical logical operations. So it is always possible to make a computation reversible. However, this is not immediately very useful: although we could recover the energy by reversing the computation, we lose the output $O(i)$ in doing so.

Bennett(4) showed that a better solution was to find a different reverse calculation F''

$$F'':(O(i),Aux(i),Aux0) \rightarrow (i,Aux0,O(i))$$

The only additional unknown information is $O(i)$, which is simply the output we desired (or extra information we needed to know). A general procedure for F'' , is: copy $O(i)$ into a further auxiliary system $AuxO$ by means of a FANOUT gate, then run F' on the original system.

Considering a general quantum operation, unitarity requires that the inner products between different input states and between the corresponding output states is unchanged by the computation. Reversibility must always hold.

$$\text{REVERSIBLE} : \langle i | j \rangle \langle \text{Aux0} | \text{Aux0} \rangle = \\ \langle O(i) | O(j) \rangle \langle \text{Aux}(i) | \text{Aux}(j) \rangle$$

$$\text{TIDY} : \langle i | j \rangle \langle \text{Aux0} | \text{Aux0} \rangle \langle \text{AuxO} | \text{AuxO} \rangle = \\ \langle i | j \rangle \langle O(i) | O(j) \rangle \langle \text{Aux0} | \text{Aux0} \rangle$$

We can eliminate $\langle \text{Aux0} | \text{Aux0} \rangle = 1$ and $\langle \text{AuxO} | \text{AuxO} \rangle = 1$, leaving only three cases.

The output states are orthogonal set:

$$\langle O(i) | O(j) \rangle = \delta_{ij}$$

Reversibility *requires* the input states to be an orthogonal set $\langle i | j \rangle = 0$, and the TIDY condition will hold. This is not too surprising, as an orthogonal set of outputs *can* be cloned, and so can be tidied using Bennett's procedure.

The input states are orthogonal set $\langle i | j \rangle = \delta_{ij}$, but the output states are not. To satisfy unitarity, the *auxiliary* output states must be orthogonal.

$$\langle \text{Aux}(i) | \text{Aux}(j) \rangle = \delta_{ij}$$

There is a unitary operator for tidying the computation, without losing the output. However, this tidying computation is not Bennett's procedure. If we cloned the auxiliary output, and run the reverse operation, we would lose the output, and be left with the 'junk'! Whether there is an equivalent general procedure for obtaining F'' is not known.

One obvious method is to examine the resulting auxiliary output states, construct a unitary operator from

$$U_G |Aux(i), O(i)\rangle = |Aux0, O(i)\rangle$$

and decompose U_G into a quantum logic circuit. However, it is not clear whether the operator can be constructed without explicitly computing each of the auxiliary output states - which may entail running the computation itself, for each input, and measuring the auxiliary output basis. Alternatively, examine the form of the auxiliary output (eg. (A OR NOT B) AND (C XOR D)) and devise a logic circuit that reconstructs the input state from this. This simply restates the problem: although some such circuit (or U_G) must exist.

The input states are a non-orthogonal set. If we look at the requirements for a tidy computation, this leads to:

$$\langle O(i) | O(j) \rangle = 1$$

The output is always the same, regardless of the input! Obviously for a computation to be meaningful, at least some of the output states must depend in some way upon the particular input state. So there does not exist *any* non-trivial ($|O(i)\rangle \neq |O(j)\rangle$) computations of the form

$$G: |i\rangle |Aux0\rangle |AuxO\rangle \rightarrow |i\rangle |Aux0\rangle |O(i)\rangle$$

for which $\langle ij \rangle \neq \delta_{ij}$.

It should be clear: this does NOT mean useful, reversible quantum computations of the form

$$F: |i\rangle |Aux0\rangle |-\rangle \rightarrow |Aux(i)\rangle |O(i)\rangle$$

do not exist when $\langle ij \rangle \neq \delta_{ij}$ - simply that such computations cannot be 'tidy'.

The only way to achieve what we are after is to simply use quantum error correction methods to try and eliminate the error as much as possible which means we have to live with a loss of energy in our field generator in the form of heat and with some error in our desired output.

Quantum states are very delicate. The primary difference between a quantum state and a classical state is that a quantum state can be in a superposition of multiple different classical states. However, any measurement of the superposition will collapse the quantum state into one of its component classical states. In fact, most interactions with the environment will act just like a measurement and will collapse the state. This is the reason the world at a human scale looks classical - big objects are very likely to interact at least a little bit with their environment, so they are constantly collapsing into classical states. This process is known as decoherence.

This, as shown before poses us with a problem when it comes to engineering the vacuum at the Plank scale or less. Daniel Lidar and K. Briggitta Whaley(5) addressed this issue for a simple collective error model. The first explanation of how to perform such universal quantum computation on a decoherence-free subspace under the physically important realization of collective decoherence was explained in a paper written with Julia Kempe, Daniel Lidar and K. Briggitta Whaley(6). Analysis of decoherence-free subspaces conditions and the ability to perform operations on such subspaces for a particular set of symmetries was carried out in two papers written with Daniel Lidar, Julia Kempe, and K. Briggitta Whaley(7).

The simplest classical error-correcting code is the repetition code. We encode a 0 as 000 and a 1 as 111. Then if only one bit is flipped, we might get the state 011, and we can deduce that the original state was 111.

For a quantum code, we need a bit more. The signs of states in a quantum superposition are important, so we need to be able to correct sign errors as well as bit flip errors. To do this, we could use nine qubits instead of three:

$$|0\rangle \rightarrow (|000\rangle + |111\rangle) (|000\rangle + |111\rangle) (|000\rangle + |111\rangle)$$

$$|1\rangle \rightarrow (|000\rangle - |111\rangle) (|000\rangle - |111\rangle) (|000\rangle - |111\rangle).$$

Then by comparing qubits within blocks of three, we can detect bit flip errors, and by comparing the signs of the three blocks, we can detect sign errors. Using this code, we can correct an arbitrary single-qubit quantum error.

What we end up with is having to generate onboard our craft a larger copy of the external space we are trying to rewrite via entanglement so as to perform basic quantum level error correction to have a better control on the outcome sub-space region externally. So, to get an idea on the scope involved here for whatever volume region of a sub-space field one is attempting to generate externally each zero point externally will require no less than nine stored internally zero point states to perform the operations we are after with only one of these internal zero point states being the actual clone of the external one. The rest are needed for error correction using this simplest model as a basis. This then sets some physical limits on both external field dimension and internal field generator size.

The reason I followed through with this exercise was to demonstrate something so profound that it has rather been overlooked to this point. If the universe operates along similar lines to how we presently understand quantum computers then the fact that we detect an accelerated expansion rather makes sense. If we consider each zero point itself as an Ebit state and suppose that the universe would have to apply its own version of quantum error correction then the minimum requirement I just referenced in this work applies as well to such a state and as such the amount of vacuum states with simply virtual particles present would have to increase with time Exponentially following some exponential function. This implies when gravity is taken into account as a slowing function to just what we have begun to observe from the cosmos.

REFERENCES

- 1.) Michael J. Pfenning, L.H. Ford The unphysical nature of "Warp Drive, *Class.Quant.Grav.* 14 (1997) 1743-1751
- 2.) Wootters WK, Zurek WH, *Nature* Vol 299, 802-803 (1982)
- 3.) Landauer R, *IBM J Res Develop*, Vol 5, 183-191 (1961)
- 4.) Bennett CH, *IBM J Res Develop*, Vol 17 525-532 (1973), Bennett CH, *Int J Theor Phys*, Vol 21, 905-940 (1982)
- 5.) D.A. Lidar, D. Bacon, and K.B. Whaley, Concatenating Decoherence-Free Subspaces with Quantum Error Correcting Codes. *Physical Review Letters*, 82, 4556-4559 (1999)
- 6.) D. Bacon, J. Kempe, D.A. Lidar, and K.B. Whaley, Universal Fault-Tolerant Quantum Computation on Decoherence-Free Subspaces. *Physical Review Letters*, **85**, 1758--1761 (2000)
- 7.) D.A. Lidar, D. Bacon, J. Kempe, and K.B. Whaley, Decoherence-Free Subspaces for Multiple-Qubit Errors. I. Characterization. *Physical Review A*, **63**, 022306-01-022306-13 (2001) and D.A. Lidar, D. Bacon, J. Kempe, and K.B. Whaley, Decoherence-Free Subspaces for Multiple-Qubit Errors. II. Universal, Fault-Tolerant Quantum Computation. *Physical Review A*, **63**, 022307-01-022307-18 (2001)