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"What is the Universe made out of?"

Jack Sarfatti
ISEP, San Francisco

"The Question is: What is The Question?" John Archibald Wheeler, April 2003, APS
Philadelphia

The new observational data of "precision cosmology" has drastically changed our conception of the cosmos beyond what anyone imagined even as late as 1999. It is now known with a precision uncertainty of about 2% that only 4% of the "stuff" of our spatially flat universe we detect with our telescopes on the large scale of 10 megaparsecs and greater is made out of cosmic rays, ordinary atoms, electromagnetic and gravity radiation, ionized plasma, MHD near fields, neutrinos etc. A whopping 96% of all the stuff of the world is something else! What is it?

All the King's Horses and All The King's Men are, I suggest, asking the wrong question of Dame Nature. They are looking for some kind of real "on-mass-shell" new "particle" pole of a Feynman propagator outside the vacuum to explain the "dark matter" that is ~ 23% of the "missing mass" as shown from gravitational lensing, COBE, WMAP etc. It started to become clear in 1999 with the type 1a supernovae data that ~ 73% of the "missing" stuff of the universe in the past light cones of our telescopes is an exotic anti-gravitating zero point energy density phase of the quantum vacuum with local Diff(4) covariant $w = \text{pressure}/(\text{energy density}) = -1$. The zero point energy vacuum fluctuations of all the quantum fields obey $w = -1$ and it is the quantum zero point pressure that dominates Einstein's generalized Newton-Poisson local field equation for the gravitational properties of the vacuum. Einstein's cosmological constant Λ is the net large scale effect of the quantum zero point vacuum fluctuations in the FRW metric of standard cosmology.

It has been a big mystery, comparable to the black body radiation paradox that Max Planck faced 100 years ago, why Λ is so small $\sim (H_0/c)^2 \sim (10^{28} \text{ cm})^{-2}$ when naive arguments suggest it is enormous $\sim L_p^{-2} \sim (10^{-33} \text{ cm})^{-2}$. This is a fatal discrepancy of ~ 122 powers of ten between theory and observation! I claim to have solved this problem by noticing that the Dirac filled "negative energy" off-mass-shell virtual electron vacuum is intrinsically unstable to the non-perturbative "ODLRO"/ "BCS" pairing of virtual electrons and positrons exchanging virtual photons near the zero Fermi energy of momentum $\sim 10^{19} \text{ GeV}/c$ at the edge of the Dirac sea. This spontaneous breaking of gauge symmetry in the vacuum coheres the random zero point fluctuations from all the quantum fields like throwing oil on the turbulent waters, calming them, giving rise to a local scalar vacuum field $\Lambda_{\text{zpf}}(x)$ that is closely related to the complex macro-quantum scalar field $\text{PSI}(x)$ with Higgs amplitude $|\text{PSI}(x)|$ and Goldstone phase $\text{argPSI}(x)$ of chaotic inflationary cosmology. Indeed Einstein's geometrodynamical field $g_{\mu\nu}(x)$ also

emerges out of the modulation of the Goldstone phase of the complex scalar inflation field consistent with Hagen Kleinert's idea of the 4D "world crystal lattice" with curvature as disclination defect density and torsion as dislocation defect density. The local field $\Lambda_{zpf}(x)$ merges to Einstein's cosmological constant for the large scales described by the FRW metric of orthodox cosmology.

One uses macro-quantum ODLRO and a "wavelet transform" generalization of the Wigner phase space density replacing momentum with scale. The result is that $\Lambda_{zpf}(x) = 0$ is the ordinary non-gravitating vacuum of common sense corresponding to a critical "vacuum superfluid density" $\sim L_p^{-3}$. However, $\Lambda_{zpf}(x)$ can be positive and negative as well as zero. $\Lambda_{zpf}(x) > 0$ is "dark energy" with negative zero point quantum pressure forming an anti-gravitating exotic vacuum that is $\sim 73\%$ of the large scale structure of the universe causing the cosmological expansion to accelerate rather than slow down. Similarly $\Lambda_{zpf}(x) < 0$ is the elusive "dark matter" demystified with positive zero point quantum pressure forming a gravitating exotic vacuum region like the spherical halos holding galaxies together. A large clump of dark matter exotic vacuum $\Lambda_{zpf} < 0$ whose internal structure is $w = -1$ nevertheless moves slowly relevant to the Hubble flow as a coherent rigid blob with an apparent $w \sim 0$.

"As Above So Below" because this same idea works for elementary particles justifying J.P. Vigié's idea of the spatially extended electron for example that arises in his "tight atomic state" theory for a new form of atomic energy release being tested in Beograd by Dragić and Marić and also possibly in Kiev. The rotating electron is Newton's "hard massy sphere" of size $e^2/mc^2 \sim 1$ fermi with a strongly gravitating $\Lambda_{zpf} \sim -(1 \text{ fermi})^{-2}$ dark matter core preventing the self-charge from exploding and also balancing the centrifugal inertial force from the $h/4\pi$ rotation. This real on-mass-shell electron is a Bohm "IT" hidden variable surfing its own de Broglie quBIT pilot wave surrounded by a plasma cloud of virtual electron-positron pairs extending out to the Compton wave length $h/mc \sim 10^{-11}$ cm (more accurately ~ 137 times the classical electron radius). But the electron looks like a point particle no larger than $\sim 10^{-16}$ cm in high energy scattering. That is easily explained as strong zero point energy induced micro-curvature excited by deep probe momentum transfers of the Heisenberg scattering microscope. The same idea applies to lepto-quarks in general and is consistent with the "QCD Lite" bag model in which the hadronic masses are $\sim 1 \text{ Gev}$ mostly from trapped kinetic energy of the light lepto-quark rest energies $mc^2 \sim e^2/|\Lambda_{zpf}|^{1/2} \sim 1 \text{ Mev}$. The hadronic Regge trajectory data is also almost trivially understood in this picture since the universal microscopic $|\Lambda_{zpf}| \sim 1/(1 \text{ fermi})^2$ simply determines the measured "string tension" hadronic slope $\alpha' \sim 1/(1 \text{ Gev})^2$. where hadronic resonance spin $\sim \alpha' (\text{energy of resonant peak})^2$. Susskind's "holographic universe" plays a key role in the new model because, the micro $|\Lambda_{zpf}| = L_p^{-4/3}(c/H_0)^{-2/3}$ from quantum gravity and cosmology together where $L_p^2 = hG/c^3 \sim 10^{-66} \text{ cm}^2$, and $1/H_0 \sim 13.7$ billion years so that $c/H_0 \sim 10^{28} \text{ cm}$.

Not quite last, but not least, new vistas for Hal Puthoff's dream of "metric engineering" space-time open up with a simple example of how these macro-quantum cohered zero point energy ideas apply to Alcubierre's toy model free float warp drive metric as well as to recent notions of the coupling of rotating superconductors to the space-time continuum

for potential application to propellantless space vehicle propulsion. The bow of the "star ship" in "warp drive" has an exotic vacuum "dark matter" layer $\Lambda_{\text{zpf}} < 0$ causing space to contract ahead of the ship creating an anomalous gravity red shift that opposes the motional Doppler blue shift. Similarly, the stern of the star ship has an exotic vacuum "dark energy layer" $\Lambda_{\text{zpf}} > 0$ causing space to expand behind the ship creating an anomalous gravity blue shift that opposes the motional Doppler redshift. This "reverse Doppler effect" is a universal signature of any "warp drive" from metric engineering the physical vacuum. The ship is locally on a free float or weightless timelike geodesic of the local spacetime geometry it is creating. Roughly speaking, the local zero point energy density field $(c^4/8\pi G^*)\Lambda_{\text{zpf}}$ is proportional to the trace of the extrinsic spatial curvature tensor or "second fundamental form" of the space-geometry in the 3+1 formalism of GR as computed in Alcubierre's famous paper. The local $\Lambda_{\text{zpf}}(x)$ field configuration is controlled by a Bohm-Aharonov-Josephson coupling between a real superconductor with ground state $|g\rangle$ having ODLRO macro-quantum coherent local order parameter $\langle g|e^{-i\phi(x)}e^{-i\phi(x)}|g\rangle$ beating against the macro-quantum coherent local order parameter of the physical vacuum $|0\rangle$ dominated by $\langle 0|e^{i\phi(x)}e^{-i\phi(x)}|0\rangle$ where the relative phase difference is controlled by line integrals of the photon 4 potential A_μ and also by Berry phases. Alcubierre's basic idea of a "vacuum propeller" was already understood more roughly by both Herman Bondi and Yakov Terletsii almost 50 years ago using their more primitive classical notion of "negative matter" that is in reality the exotic vacuum "dark energy" phase $\Lambda_{\text{zpf}} > 0$.

As an epilogue, John Archibald Wheeler and his students (notably W.H. Zurek) are fascinated with IT FROM BIT, i.e. geometry and matter-energy from information. Wheeler also envisions the "participatory universe" as a "self-excited circuit". What is missing from Wheeler's Vision is the complementary "BIT FROM IT" forming a "two way relation" in the sense of Bohm and Hiley in which the parallel universes on a single post-inflationary bubble self-organize and emerge in the entropy-lowering spontaneous breakdown of vacuum symmetry from the BCS pairing of virtual electrons and positrons that sets the direction of the initial irreversible arrow of time of the global cosmic clock in our Hubble-horizoned FRW metric large scale universe on the bubble. Our bubble is one of an infinity of bubbles. A single post-inflationary bubble can be pictured as an expanding and accelerating flat infinite rubber sheet with a lattice of circular "vortex core" Hubble horizons that are Goldstone phase singularities analogous to the lattice of vortex cores in a type II superconductor where the local macro-quantum order parameter $\Psi(x)$ vanishes. In fact, the rubber "sheet" is a 3D spacelike slice "hypersurface" of 4D spacetime. The vortex core is therefore a 2-dimensional distorted spherical surface not a line. In fact it is the last light wave front surface in the past light cone emerging from the micro \rightarrow macro quantum vacuum phase transition $\Psi = 0$ to $\Psi \neq 0$. This "last light wave front" is the 2D "hologram" in Lenny Susskind's sense whose projected "image" is our 3D space. There is also the advanced "influence functional" from the future universe that needs to be considered in the sense of Hoyle-Narlikar and Yakir Aharonov's notion of both a "history" and a "destiny" state vector influence on "here-now".

On Wednesday, August 27, 2003, at 08:07 AM, wrote:

"Dear Dr. Sarfatti,

The following is with reference to a couple of your recent mail, only some of what I can understand.

I am not a particle physicist as you, but a cosmologist, after my own fashion. You say "dark energy" is an exotic vacuum phase of negative quantum zero point fluctuations, and dark matter is the positive quantum Λ_{zpf} . But "dark energy" is a positive energy form left over from the inflation of space. The dark energy flux is an accounting gimmick to explain the negative energy (work) required to inflate space (and have the universe remain flat). In fact, I don't see any reason to suspect that "dark energy" is necessarily any different than regular matter."

No you do not understand the basic physics here and have not properly described above what I am talking about.

Part of the basic physics is on pages 25-26 of John Peacock's "Cosmological Physics" showing why covariance requires $w = -1$ for zero point fluctuations of all quantum fields.

Dark energy has $\Lambda_{zpf} > 0$, i.e. positive zero point energy density with equal and opposite negative zero point pressure.

What matters in Einstein's GR is energy density + 3pressure in the Poisson equation for the system, in this case, the exotic quantum vacuum.

Dark matter is simply $\Lambda_{zpf} < 0$, i.e. negative zero point energy density with equal and opposite positive zero point pressure.

This explains the dark matter not only in large scale but also in micro-scale i.e.

1. Why self-charge does not cause electron to explode, i.e. the old Abraham-Becker self-energy problem.
2. Why the electron looks like a point particle in high energy scattering yet $e/mc^2 \sim 1$ fermi and $\hbar/mc \sim 137e^2/mc^2$
3. Zero point origin of lepto-quark "Higgs" rest mass $mc^2 \sim e^2/|\Lambda_{zpf}|^{1/2}$ where microscale dark matter cores of lepto-quarks have $\Lambda_{zpf} < 0$ and $|\Lambda_{zpf}| \sim (1 \text{ fermi})^{-2}$
4. This same micro Λ_{zpf} gives the correct universal Regge slope of hadronic resonances $\alpha' \sim (1 \text{ GeV})^{-2}$
5. The universal micro dark matter exotic vacuum core of the lepto-quarks is

What is the Universe made of? Jack Sarfatti, 8/27/03, 11:44 AM, p.5 of 6

$|\Lambda_{\text{eff}}| \sim L_p^{-4/3}(c/H_0)^{-2/3}$ from Susskind's "world hologram" model.

$$L_p^2 = hG/c^3$$

For more details go to <http://qedcorp.com/APS/Ukraine.doc>

<http://qedcorp.com/APS/Vigier4.pdf>

My theory predicts null results for all conventional dark matter "particle detection" experiments -- like null result of Michelson-Morley.

I explain both large scale and small scale structure of universe with one simple mainstream idea from P.W. Anderson "More is different" (ODLRO from spontaneously self-organizing BCS pairing of virtual lepto-quarks with virtual anti lepto-quarks inside the physical vacuum creating the complex scalar inflation field.) - Occam's Razor.

"If I haven't offended your scientific sensibilities yet, I would like to ask you what particle physicists have as a way of explaining space. Does it exist? What are its properties? Is there any room for Mach's principle in this picture? You will recall that Mach claimed that inertial frames are determined by the disposition of matter in the surrounding universe. Does your concept of space allow for the succinct derivation of the fundamental equation, $F=ma$?"

Yes, of course. Read my papers above. :-)

$F = ma$ is basically timelike geodesic equation for neutral test particles generalized to non-geodesic motions with electric charge in EM fields.

I derive Einstein's GR from the modulation of the local Goldstone phase field of the broken symmetry macro-quantum vacuum, hence the geodesic equation is an automatic result.

Global special relativity and quantum field theory is already built into the unstable Minkowski space.

Basic force laws come from the quantum action principle in the standard way.

In other words " $F = ma$ " is built into the Feynman path quantum action principle for "test particles".

Mach's principle is inherent in the Feynman path-Hoyle-Narlikar "influence functional" response of the universe approach to cosmology from the quantum action principle. That is consistent with my theory. Aharonov's advanced "destiny quantum state vector" is automatically built in with the Costa De Beauregard/John Cramer "Feynman Zig Zag" explanation of micro-quantum EPR nonlocal correlations violating

Bell's locality inequality.

References:

<http://qedcorp.com/APS/Ukraine.doc> to be published in Progress in Quantum Physics Research (Nova)

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<http://qedcorp.com/APS/warpdrivephysics.pdf>

April 2003 Physics Today (articles by Turner, Schwarzschild and Perlmutter)

May 2003 Scientific American, "Parallel Universes" by Max Tegmark

"The warp drive: hyperfast travel within general relativity" M. Alcubierre, Class.

Quantum Grav. 11, (1994) L73-L77

"Negative Matter Propulsion", Robert Forward, J. Propulsion, 6, (1990), 28 - 37 describes the Bondi-Terletsii history

"On the Possible Existence of Tight Bound States in Quantum Mechanics", J.P. Vigiier, Z. Maric and A. Dragic

"Superconductors as transducers for gravitational and electromagnetic radiation", Ray Chiao, arXiv:gr-qc/0204012

Giovanni Modanese <http://ect.it/postdoc/modanese/pub.html> especially

<http://xxx.lanl.gov/abs/gr-qc/?9612022>

August 2003 Scientific American, Jacob Bekenstein's "Information in the holographic universe"

Hagen Kleinert, <http://www.physik.fu-berlin.de/~kleinert/>

e-mail exchange with Dr. Bruce Cornet on his empirical measurements, also exchange with Tony Smith on $w \sim 0$ dark matter.