Aqautex5.tex

APPLIED QUANTUM SYSTEMS AND QUANTUM FOUNDATIONS COLLABORATION

BCI1

Abstract. **Quantum Automata and Quantum Computing**

A *quantum auotmaton* is a device closely related to –but more general than– quantum computers that makes direct use of quantum mechanical processes]], such as quantum superposition/superposition and quantum entanglement, and the collapse of the wave function to perform operations on quantized nano-systems and or digital data. The basic principle behind quantum automata is that several quantum properties can be used to act on other quantum devices or molecules, and in particular to process data and perform programming instructions /operations on such molecules and data.

$http : //www.media.mit.edu/physics/html$

("Quantum Computing with Molecules", *Scientific American* by Gershenfeld and Isaac L. Chuang).

Both practical and theoretical research on quantum automata and quantum computer development is currently of great interest and has already acquired substandtial research and development funding, including multi-billion dollars for *nanomaterials* research:

($http : //qist.lanl.gov/qcomp_map.shtml$

Quantum Information Science and Technology Roadmap.

Several nano-robot architectures have already been reported, such as those based upon and including as a controlling device, or 'head' an optical computers may employ the superposition of electromagnetic waves.

$http : //espace.library.uq.edu.au/eserv/UQ : 10849/n9905086.pdf$

(*One photon Grover algorithm.*)

— author = Lieven M.K. Vandersypen et al. — title = Separability of Very Noisy Mixed States and Implications for NMR Quantum Computing, — journal = Phys. Rev. Lett — volume = 83, — pages = 10541057,— date = 1999, — $doi = 10.1103/PhysRevLett.83.1054$.

Quantum Automata Construction Principles

A so-called Bloch sphere depicts a *qubit*, one the possible building blocks of both quantum automata and quantum computers.

$Image : Bloch_sphere.svg|thumb|$

Experiments have been reported in which quantum 'computational operations' were executed on a small number of *qubits* (**qu** antum **bi** nary digi **ts**). A quantum computer maintains a sequence of *qubits*. A single qubit can hold a one, a zero, or, crucially, any quantum superposition of these; moreover, a pair of qubits can be in any quantum superposition of 4 states, and three qubits in any superposition of 8 states. In general a quantum automaton or computer with n qubits can be in an arbitrary superposition of up to n^2 different states simultaneously (this compares to a normal computer that can only be in "one" of these n^2 states at any one time). A quantum automaton may operate sequentially with n-states ($n >> 3$), based on non-commutative, non-distributive many-valued quantum logics and n-state logic switches, whereas a quantum computer is currently limited to manipulating qubits with a fixed sequence of quantum gate/quantum logic gate]]s. Such a sequence of logic gates that would be employed for 'quantum computations' was previously called a *quantum algorithm*. In actual fact, most quantum computing schemes appear to be based on spin state manipulation, and is thus reduced to representations of Pauli spin matrices, and their corresponding symmetry groups.

On the other hand, quantum automata may employ more general, so called extended quantum symmetries or supersymmetry, already characterized by quantum superoperators and quantum supergroups. The following is an important novel definition of such quantum automata in an abstract setting encompassing all quantum computers, sequential machines, universal Turing machines (UTM) and much more.

Date: February 23th, 2009.

1. Quantum Automata and Quantum Computing

1.1. **Quantum automata.** A *quantum auotmaton* is a device closely related to –but more general than– quantum computers that makes direct use of quantum mechanical processes]], such as quantum superposition/superposition and quantum entanglement, and the collapse of the wave function to perform operations on quantized nano-systems and or digital data. The basic principle behind quantum automata is that several quantum properties can be used to act on other quantum devices or molecules, and in particular to process data and perform programming instructions /operations on such molecules and data.

$http://www.media.mit.edu/physics/publications/papers/$

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$http://espace.library.uq.edu.au/eserv/UQ:10849/n9905086.pdf$

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1.1.1. *Basic principles and definitions.* A classical computer has a memory made up of bits, where each *bit* holds either a one or a zero. A quantum computer maintains a sequence of *qubits*. A single qubit can hold a one, a zero, or, crucially, any quantum superposition of these; moreover, a pair of qubits can be in any quantum superposition of 4 states, and three qubits in any superposition of 8. In general a quantum automaton or computer with $\mathbf{n}$ qubits can be in an arbitrary superposition of up to $\mathbf{n}^2$ different states simultaneously (this compares to a normal computer that can only be in "one" of these $\mathbf{n}^2$ states at any one time). A quantum automaton may operate sequentially with $\mathbf{n}$-states (for $\mathbf{n}$ ¿¿ 3) based on many-valued quantum logics and $\mathbf{n}$-state logic switches, whereas a quantum computer is currently limited to manipulating qubits with a fixed sequence of quantum gate—quantum logic gates. Such a sequence of logic gates that would be employed for 'quantum computations' was previously called a quantum algorithm.

Image:$Bloch_sphere.svg$

A so-called Bloch sphere depicts a qubit, one the possible building blocks of both quantum automata and quantum computers.

In actual fact, most quantum computing schemes appear to be based on spin state manipulation, and is thus reduced to representations of Pauli spin matrices, and their corresponding symmetry groups.

On the other hand, quantum automata may employ more general, so called extended quantum symmetries or supersymmetry, already characterized by quantum superoperators and quantum supergroups. The following is an important novel definition of such quantum automata in an abstract setting encompassing all quantum computers, sequential machines, universal Turing machines (UTM) and much more.

Definition 1.1. Let us recall that as a quantum algebraic topology object, a *quantum automaton* is defined by the *quantum triple* $Q_A = (\mathsf{G}, \Re_G(\mathcal{H}), Aut(\mathsf{G}))$, where G is a *locally compact quantum groupoid*, $\Re_G(\mathcal{H})$ are the unitary representations of G on rigged Hilbert spaces $\Re_G$ of quantum states and quantum operators on the Hilbert space $\mathcal{H}$, and $Aut(\mathsf{G})$ is the transformation, or *automorphism groupoid of quantum transitions* that represents all flip–flop quantum transitions of one cubit each between the permitted quantum states of the quantum automaton.

With the data from above definition we can now define also the category of quantum automata as follows.

Definition 1.2. The *category of quantum automata* Q_A is defined as an algebraic category whose objects are triples $(\mathcal{H}, \Delta : \mathcal{H} \to \mathcal{H}, \mu)$ (where $\mathcal{H}$ is either a Hilbert space or a rigged Hilbert space of quantum states and operators acting on $\mathcal{H}$, and μ is a measure related to the quantum logic, LM, and (quantum) transition probabilities of this quantum system), and whose morphisms are defined between such triples by homomorphisms of Hilbert spaces, $\Omega : \mathcal{H} \to \mathcal{H}$, naturally compatible with the operators Δ, and by homomorphisms between the associated Haar measure systems.

An alternative definition is also possible based on *Quantum Algebraic Topology*.

Definition 1.3. A *quantum algebraic topology* definition of the *category of quantum algebraic automata* involves the objects specified above in **Definition 0.1** as quantum automaton triples Q_A, and quantum automata homomorphisms defined between such triples; these Q_A morphisms are defined by groupoid homomorphisms $h : \mathsf{G} \to \mathsf{G}^*$ and $\alpha : Aut(\mathsf{G}) \to Aut(\mathsf{G}^*)$, together with unitarity preserving mappings u between unitary representations of G on rigged Hilbert spaces (or Hilbert space bundles).

1.2. **Qubits or bits ?** $Image : Quantumcomputer.jpg|thumb|200px|$

Qubits are made up of controlled particles and the means to control (e.g. devices that trap particles as well as switch their states, thus acting as *quantum switches*-- an elementary type of quantum automata).

cite book —last = Waldner —first = Jean-Baptiste —authorlink = Jean-Baptiste Waldner —title = Nanocomputers and Swarm Intelligence —publisher = [[ISTE]] —place = London —date = 2007 — pages = p157 —*isbn* = 2746215160

The state of a three-qubit quantum computer may be described by an eight-dimensional vector

$(''a'','' b'','' c'', ... to,'' h'')$,

called a wavefunction.

However, instead of adding to one, the sum of the "squares" of the coefficient magnitudes, $|a|^2 + |b|^2 + ... + |h|^2$, must equal one. Moreover, the coefficients are complex numbers that can be negative. The fact that the coefficients can be negative as well as positive allows for cancellation, or interference, between different computational paths, and is a key difference between quantum computing and probabilistic classical computing. (DiVincenzo, 1995).

If one measures the three qubits, then one observes a corresponding three-bit string. The probability of measuring a string will equal the squared magnitude of that string's coefficients. Thus a measurement of the quantum state with coefficients $(''a'','' b'', ...,'' h'')$ gives the classical probability distribution $(|a|^2, |b|^2, ..., |h|^2)$. In one interpretation of quantum theory this is interpreted as the "collapsing" or projection of one or several quantum states onto a single classical state, which is the one measured or observed.

1.3. **Operation of Quantum Automata.** Whereas a classical three-bit state and a quantum three-qubit state are both eight-dimensional coordinate vectors, they are manipulated quite differently for classical or quantum computation, respectively. For more details on the sequences of operations used for various algorithms, see universal quantum computer, Shor's algorithm, Grover's algorithm, Deutsch-Jozsa algorithm, quantum Fourier transform, quantum gate, (Adiabatic quantum computation—quantum adiabatic algorithm and quantum error correction).

Quantum mechanically, one "quantum measures" or observes for example the three-qubit state, which is equivalent to 'collapsing the quantum state' to a classical distribution (with the coefficients in the classical state being the squared magnitudes of the coefficients for the quantum state, as described above) followed by sampling from that distribution.

1.4. **Automata and Nanotechnologies.** $Grover'salgorithm$ can also be used to obtain a quadratic speed-up over a brute-force search for a class of problems known as $NP-complete$.

Because chemistry, nanotechnology and biochemistry rely on understanding quantum systems, and such systems are impossible to simulate in an efficient manner classically, many believe Universal quantum simulator will be one of the most important applications of quantum computing.

$http://www.wired.com/science/discoveries/news/2007/02/72734$

There are several practical difficulties in building any quantum computer, and thus far quantum computers have only solved a few, rather trivial problems. On the other hand, many such obstacles do not occur or can be resolved in the extended symmetry context of quantum automata.

Several NMR techniques have had some early success, but it is quite difficult to resolve many NMR frequencies for individual qubits as the number of qubits increases. Other techniques have also shown great promise in this field, and new 2D-FT NMR techniques are also being developed.

D avid DiVincenzo at IBM, listed the following requirements for a practical quantum computer: (cite web — url= $http://arxiv.org/abs/quant-ph/0002077$

— title=The Physical Implementation of Quantum Computation — accessdate=2006-11-17 — author=David P. DiVincenzo, IBM — date=2000-04-13)

* scalable physically to increase the number of qubits;

* qubits can be initialized to arbitrary values;

* quantum gates faster than decoherence time;

* universal gate set;

* qubits should be readily detected.

Recently, DiVincenzo classified the main ingredients that a physical system should possess in order to be a valid candidate for a quantum computer. They are: * "'Read-out"': The ability to reliably measure the state of individual qubits that are the computational basis of such devices; * "'Quantum register"': A scalable physical system with well characterized representing qubits that in turn compose the quantum register. * "'Initialization"': The ability to prepare the state of the register in a initial state. * "'Universal set of gates"': The ability to implement a universal set of logic gates. * "'Low error and decoherence rate"': High fidelity of gate operation, with probability per gate of much less than 10-3 and qubit decoherence times that are longer than the gate operation time.

1.5. **Devices for quantum practical implementations.** There are several existing devices that might be useful for devloping working prototypes of quantum automata and also for quantum computing candidates, such as :

*Superconductor-based quantum devices (including perhaps certain SQUID-based quantum computers name

"ClarkeWilhelm2008" citation

— url = $http://www.nature.com/nature/journal/v453/n7198/full/nature07128.html$ — journal = Nature, — year = 2008, — date = [[June 19]] [[2008]] — title = Superconducting quantum bits, — John Clarke — Frank Wilhelm — volume = 453 — pages = 1031–1042 — $doi = 10.1038/nature07128$

*Trapped ions nano-automata quantum computers

*Topological quantum automata and computers

*Quantum dot on surface (e.g. the [[Loss-DiVincenzo quantum computer]])

*2D-FT Nuclear magnetic resonance and FT multi-nuclear magnetic resonance on molecules in solution (liquid NMR) or liquid crystals

*Solid state NMR devices (the so-called “Kane quantum computers”)

*Molecular magnets and nano-magnets, mictomagnets

*‘Condensed Electrons’ at liquid helium temperatures for quantum computers

*Fullerene-based, Electron paramagnetic resonance—ESR quantum nano-robots and computers

*Optical lattices and laser tweezers

*Cavity quantum electrodynamics (CQED)

*Optical quantum computers (Quantum optics)

* Diamond-based quantum computer (Nizovtsevetal2004)

$url = http : //www.springerlink.com/content/5p6554lg35716085/$

— journal = Optics and Spectroscopy, — year = 2005, — date = [[October 19]] [[2004]] — title = “A quantum computer based on NV centers in diamond: Optically detected nutations of single electron and nuclear spins” — A. P. Nizovtsev, S. Ya. Kilin, F. Jelezko, T. Gaebal, I. Popa, A. Gruber, J.Wrachtrup — volume = 99 — issue = 2 — pages = 248–260

$url = http : //www.tgdaily.com/content/view/32306/118/$

Research indicates diamonds could be key to quantum storage —

accessdate=2007-06-04 — author=Wolfgang Gruener, TG Daily — date=2007-06-01 name = Neumannetal2008

$url = http : //www.sciencemag.org/cgi/content/abstract/320/5881/1326$

— journal = Science, — year = 2008, — date = [[June 6]] [[2008]] — title = “Multipartite Entanglement Among Single Spins in Diamond” — first1 = P. — Neumann, N. Mizuochi, F. Rempp, P. Hemmer, H. Watanabe, S. Yamasaki, V. Jacques, T. Gaebel, F. Jelezko, J.Wrachtrup — volume = 320, — issue = 5881, — pages = 1326–1329 — $doi = 10.1126/science.1157233, |pmid = 18535240$

* BoseEinstein condensate-based quantum computer

$url = http : //www.itpro.co.uk/news/121086/ // trapped - atoms - could - advance - quantum - computing.html$

title=Trapped atoms could advance quantum computing — accessdate=2007-07-26 — author=Rene Millman, IT PRO — $date = 2007 - 08 - 03$

* Transistor-based quantum computer - string quantum computers with entrainment of positive holes using a electrostatic trap

*Spintronics/Spin-based quantum computer

*Adiabatic quantum computation

$url = http : //arxiv.org/pdf/quant - ph/0403090$

— title=Scalable Superconducting Architecture for Adiabatic Quantum Computation — accessdate=2007-02-19 — author=William M Kaminsky, MIT —

*Rare-earth-metal-ion-doped inorganic crystal based quantum computers Ohlsson2002

$url = http : //www.sciencedirect.com/science/$

$article/B6TVF - 44J3RM9 - J/2/307aab59d157ddd2ebb8281f76f89138$ — journal = Opt. Commun., — year = 2002, January 1,2002 — title = Quantum computer hardware based on rare-earth-ion-doped inorganic crystals — N.Ohlsson , R. K. Mohan , S. Kr´oll — volume = 201, — issue = 1–3, — pages = 71–77.

Longdell2004:

$|url = http : //prola.aps.org/abstract/PRL/v93/i13/e130503$ — journal = Phys. Rev. Lett., — year = 2004, — date = [[September 23, 2004 — title = “Demonstration of conditional quantum phase shift between ions in a solid” J. J. Longdell, M. J. Sellars, N. B. Manson 93 , $|issue = 13|pages = 130503$

The large number of candidates shows explicitly that the topic, in spite of rapid progress, is still in its infancy. But at the same time there is also a vast amount of flexibility.

In 2005, researchers at the University of Michigan built a semiconductor chip which functioned as an ion trap. Such devices, produced by standard lithography techniques, may point the way to scalable quantum computing tools.

$url = http : //www.umich.edu/news/index.html?Releases/2005/Dec05/r121205b$

— title= U-M develops scalable and mass-producible quantum computer chip — accessdate=2006-11-17 — author=Ann Arbor — date=2005-12-12 An improved version was made in 2006.

1.6. **Quantum computing in computational complexity theory (CCT).** Conjectured relationship of BQP to other problems involving spaces. (Nielsen and Chuang, 2000) This section discusses briefly what is currently known mathematically about the power of quantum computers. It describes the known results from computational complexity theory and theories of computation dealing with quantum computers.

Image:BQP complexity class diagram.svg

The class of problems that can be efficiently solved by quantum computers is called **BPP**, for "bounded error, quantum, polynomial time". Quantum computers only run probabilistic algorithms, so **BPP** on quantum computers is the counterpart of **BPP** on classical computers. It is defined as the set of problems solvable with a polynomial-time algorithm, whose probability of error is bounded away from one quarter. Nielsen Chuang 2000 :

A quantum computer is said to "solve" a problem if, for every instance, its answer will be right with high probability. If that solution runs in polynomial time, then that problem is in **BPP**.

BPP is contained in the complexity class "[[Sharp-P— no.P]]" (or more precisely in the associated class of decision problems $P^n o.P$ (

BernVazi¿Bernstein and Vazirani, Quantum complexity theory, [[SIAM Journal on Computing]], 26(5):1411-1473, 1997. *http : //www.cs.berkeley.edu/ vazirani/bv.ps*

which is a subclass of **PSPACE**.

BPP is suspected to be disjoint from NP-complete and a strict superset of **P (complexity)**, but that is not known. Both integer factorization and discrete logarithm problem are in **BQP**. Both of these problems are **NP** problems suspected to be outside **BPP**, and hence outside **P**. Both are suspected to not be NP-complete. There is a common misconception that quantum computers can solve NP-complete problems in polynomial time. That is not known to be true, and is generally suspected to be false (BernVazi).

Quantum gates may be viewed as LINEAR TRANSFORMATION CIRCUITS. Daniel S. Abrams and Seth Lloyd have shown that if nonlinear transformations are permitted, then NP-complete problems could be solved in polynomial time. It could even do so for Sharp-P-complete—No. P-complete problems. They do not believe that such a machine is possible.

1.7. **Conjecture:** Although quantum computers may be faster than classical computers, those described above can't solve any problems that classical computers can't solve, given enough time and memory (albeit possibly an amount that could never practically be brought to bear). A Turing machine can simulate these quantum computers, so such a quantum computer could never solve an undecidable problem like the halting problem. The existence of "standard" quantum computers does not disprove the Church–Turing thesis.(Nielsen and Chuang , 2000).

1.8. **Related entries.** Quantum computer

* [[List of emerging technologies]]
* [[Quantum bus]]
* [[Timeline of quantum computing]]

* [[Chemical computer]]
* [[DNA computer]]
* [[Mathematical biology]]
* [[Molecular computer]]

1.9. **Web links.** * [$http : //jquantum.sourceforge.net/jQuantumApplet.html$
jQuantum: Virtual automaton: the Java quantum circuit simulator
* $http : //www.phys.cs.is.nagoya - u.ac.jp/\ watanabe/qcad/index.html$
QCAD: Quantum circuit emulator
* $https : //gna.org/projects/quantumlibrary$ C++ Quantum Library
* $http : //hackage.haskell.org/cgi - bin/$,
$hackage - scripts/package/quantum - arrow$ Haskell Library for Quantum computations
* $http : //www.quiprocone.org/Protected/DD_lectures.htm$
Video Lectures by David Deutsch
* $http : //x - machines.comoj.com/hyper - electromagnetics/index.html$
Quasi–quantum automata

1.10. **Quantum automata.** [[Category:Quantum nanorobots]]
[[Category:Quantum teleportation]]
[[Category:Information theory]]
[[Category:Quantum information science—]]
[[Category:Computational models]]
[[Category:Computational complexity theory]
[[Category:Classes of sequential machines, Turing machines and computers]]
[[Category:Automata theory and theoretical computer science]]
[[fr:Calculateur quantique]]

2. Quantum Theory Foundations

A novel Algebraic Topology approach to SUSY, supersymmetry and symmetry breaking in Quantum Field and Quantum Gravity theories is presented with a view to developing a wide range of physical applications (such as, nuclear fusion and other nuclear reactions in quantum chromodynamics, nonlinear physics at high energy densities, dynamic Jahn-Teller effects, superfluidity, high temperature superconductors, multiple scattering by molecular systems, molecular or atomic paracrystal structures, nanomaterials, ferromagnetism in glassy materials, spin glasses, quantum phase transitions, supergravity, and so on). This approach requires a unified conceptual framework that utilizes extended symmetries and quantum groupoid, algebroid and functorial representations of non–Abelian higher dimensional structures pertinent to quantized spacetime topology and state space geometry of quantum operator algebras.

2.1. **Fundamental Concepts of Algebraic Topology with Potential Application to and Space-Time Structures.** We shall consider briefly the potential impact of novel Algebraic Topology concepts, methods and results on the problems of defining and classifying rigorously Quantum space-times. With the advent of Quantum Groupoids–generalizing Quantum Groups, Quantum Algebra and Quantum Algebraic Topology, several fundamental concepts and new theorems of Algebraic Topology may also acquire an enhanced importance through their potential applications to current problems in theoretical and mathematical physics, such as those described in an available preprint (Baianu, Brown and Glazebrook, 2006), and also in several recent publications (Baianu et al 2007a,b; Brown et al 2007).

Now, if quantum mechanics is to reject the notion of a continuum, then it must also reject the notion of the real line and the notion of a path. How then is one to construct a homotopy theory? One possibility is to take the route signalled by Čech, and which later developed in the hands of Borsuk into 'Shape Theory' (see, Cordier and Porter, 1989). Thus a quite general space is studied by means of its approximation by open covers. Yet another possible approach is briefly pointed out in **AN-2.6**. A few fundamental concepts of Algebraic Topology and Category Theory are summarized in **AN-2.6** that have an extremely wide range of applicability to the higher complexity levels of reality as well as to the fundamental, quantum level(s). We have omitted in this section the technical details in order to focus only on the ontologically-relevant aspects; full mathematical details are however also available in a recent paper by Brown et al (2007) that focuses on a mathematical/conceptual framework for a completely formal approach to categorical ontology and the theory of levels.

2.2. Selective Boundaries and Homeostasis. Varying Boundaries *vs* Horizons.

Boundaries are especially relevant to *closed* systems. According to Poli (2008): *"they serve to distinguish what is internal to the system from what is external to it"*, thus defining the fixed, overall structural topology of a *closed* system. By virtue of possessing boundaries, a whole (entity) is something on the basis of which there is an interior and an exterior (*viz.* Baianu and Poli, 2007). One notes however that a boundary, or boundaries, may either change/*vary* or be quite *selective*/directional–in the sense of *dynamic fluxes crossing such boundaries*– if the system is *open*. In the case of an organism that grows and develops it will be therefore characterized by a *variable topology* that may also depend on the environment, and is thus *context-dependent*, as well. Perhaps one of the simplest example of a system that changes from *closed to open*, and thus has a *variable topology*, is that of a pipe equipped with a functional valve that allows flow in only one direction. On the other hand, a semi-permeable membrane such as a cellophane, thin-walled 'closed' tube– that allows water and small molecule fluxes to go through but blocks the transport of large molecules such as polymers through its pores– is *selective* and may be considered as a primitive/'simple' example of an open, selective system. Organisms, in general, are *open systems with specific types or patterns of variable topology* which incorporate both the valve and the selectively permeable membrane boundaries –albeit much more sophisticated and dynamic than the simple/fixed topology of the cellophane membrane; such variable structures are essential to maintaining their stability and also to the control of their internal structural order, of low microscopic entropy. (The formal definition of this important concept of 'variable topology' was introduced in our recent paper (Baianu et al 2007a) in the context of the space-time evolution of organisms, populations and species.)

As proposed by Baianu and Poli (2008), an essential feature of boundaries in open systems is that they can be crossed by matter; however, all boundaries may be crossed by either fields or by quantum wave-particles if the boundaries are sufficiently thin, even in 'closed' systems. The boundaries of closed systems, however, cannot be crossed by molecules or larger particles. *On the contrary, a horizon is something that one cannot reach.* In other words, *a horizon is not a boundary.* This difference between horizon and boundary appears to be useful in distinguishing between systems and their environment (v. **AN-4.1**). Boundaries may be fixed, clear-cut, or they may be vague/blurred, mobile, varying/variable in time, or again they may be intermediate between these any of these cases, according to how the differentiation is structured. At the beginning of an organism's ontogenetic development, there may be only a slightly asymmetric distribution in perhaps just one direction, but usually still maintaining certain symmetries along other directions or planes. Interestingly, for many multi-cellular organisms, including man, the overall symmetry retained from the beginning of ontogenetic development is bilateral–just one plane of mirror symmetry– from Planaria to humans. The presence of the head-to-tail asymmetry introduces increasingly marked differences among the various areas of the head, middle, or tail regions as the organism develops. The formation of additional borderline phenomena occurs later as cells divide and differentiate thus causing the organism to grow and develop

v. (AN-4.2.) AN4.2

Brown and Higgins, 1981a, showed that certain multiple groupoids equipped with an extra structure called *connections* were equivalent to another structure called a *crossed complex* which had already occurred in homotopy theory. such as *double, or multiple* groupoids (Brown, 2004; 2005). For example, the notion of an *atlas* of structures should, in principle, apply to a lot of interesting, topological and/or algebraic, structures: groupoids, multiple groupoids, Heyting algebras, n-valued logic algebras and C^*-convolution -algebras.

AN5-2 section 5 Point (5a) claims that a system should occupy either a macroscopic or a microscopic space-time region, but a system that comes into birth and dies off extremely rapidly may be considered either a short-lived process, or rather, a 'resonance' –an instability rather than a system, although it may have significant effects as in the case of 'virtual particles', 'virtual photons', etc., as in quantum electrodynamics and chromodynamics. Note also that there are many other, different mathematical definitions of systems, ranging from (systems of) coupled differential equations to operator formulations, semigroups, monoids, topological groupoid dynamic systems and dynamic categories. Clearly, the more useful system definitions include algebraic and/or topological structures rather than simple, discrete structure sets, classes or their categories (cf. Baianu, 1970, and Baianu et al., 2006).

It can be shown that such organizational order must either result in a *stable attractor* or else it should occupy a *stable space-time domain*, which is generally expressed in *closed* systems by the concept of *equilibrium*. On the other hand,

Quantum theories (QTs) were developed that are just as elegant mathematically as GR, and they were also physically 'validated' through numerous, extremely sensitive and carefully designed experiments. However, to date, quantum theories have not yet been extended, or generalized, to a form capable of recovering the results of Einstein's GR as a quantum field theory over a GR-space-time altered by gravity is not yet available

2.3. QA/QC References.

2.4. General references.

author=Derek Abbott,[Charles R. Doering, Carlton M. Caves, Daniel Lidar—Daniel M. Lidar, Howard Brandt—Howard E. Brandt, Alexander R. Hamilton,

David K. Ferry, Julio Gea-Banacloche, Sergey M. Bezrukov,

and Laszlo B. Kish — title=Dreams versus Reality: Plenary Debate Session on Quantum Computing — journal=Quantum Information Processing — year=2003 — volume=2 — issue=6 — pages=449–472 —

$doi = 10.1023/B : QINP.0000042203.24782.9a$

$Arxiv|archive = quant - ph|id = 0310130$

Alternative Location (free)at Michigan university's repository Deep Blue-

$http : //hdl.handle.net/2027.42/45526$

*David P. DiVincenzo (2000). "The Physical Implementation of Quantum Computation."

"Experimental Proposals for Quantum Computation". Arxiv — archive=quant-ph — id=0002077

*— author=David P. DiVincenzo — title=Quantum Computation — journal=Science — year=1995 — volume=270 — issue=5234 — pages=255–261 — $doi = 10.1126/science.270.5234.255$ Table 1 lists switching and dephasing times for various systems.

*— author=Richard Feynman — title=Simulating physics with computers — journal=International Journal of Theoretical Physics — volume=21 — pages=467 — year=1982 — $doi = 10.1007/BF02650179$

* author=Gregg Jaeger — title=Quantum Information: An Overview — publisher=Springer — location=Berlin — year=2006 — $isbn = 0 - 387 - 35725 - 4|oclc = 255569451$

$http : //www.springer.com/west/home/physics?$

SGWID=4-10100-22-173664707-detailsPage=ppmmedia—toc *— author= Michael Nielsen and Isaac Chuang — title=Quantum Computation and Quantum Information — publisher=Cambridge University Press — location=Cambridge — year=2000 —

$isbn = 0 - 521 - 63503 - 9|oclc = 174527496$ * — author= Stephanie Frank Singer — title=Linearity, Symmetry, and Prediction in the Hydrogen Atom — publisher=Springer — location=New York — year=2005 — $isbn = 0 - 387 - 24637 - 1|oclc = 253709076$ *— author= Giuliano Benenti — title=Principles of Quantum Computation and Information Volume 1— publisher=World Scientific — location=New Jersey —

$year = 2004|isbn = 9 - 812 - 38830 - 3|oclc = 179950736$

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MSC

Extended Quantum Symmetries, Groupoids and Algebroids; Quantum Algebraic Topology (QAT); Algebraic Topology of Quantum Systems; Symmetry Breaking, Paracrystals, Superfluids, Spin Networks and Spin Glasses; Convolution Algebras and Quantum Algebroids; Nuclear Frechet spaces and GNS Representations of Quantum State Spaces–QSS; Quantization; Quantum Algebras: Von Neumann algebra Factors, Paragroups and Kac algebras; Quantum Groups and Ring structures; Lie algebras and Lie Algebroids; Hopf, Grassmann–Hopf, Weak C*–Hopf and Graded Lie algebras; Lie and Weak C*–Hopf algebroids; Compact Quantum Groupoids; Quantum Groupoid C*-algebras; Gauge Transformations; Relativistic Quantum Gravity (RQG), Supergravity and Supersymmetry theories; Fluctuating Quantum spacetimes; Intense Gravitational Fields; Hamiltonian

Algebroids in Quantum Gravity; Poisson-Lie Manifolds and Quantum Gravity Theories; Quantum Fundamental Groupoids; Tensor Products of Algebroids and Categories; Quantum Double Groupoids and Algebroids; Higher Dimensional Quantum Symmetries; Applications of Generalized van Kampen Theorem (GvKT) to QSS and Quantum Spacetime invariants. **Mathematics Classification**: 22A22, 22D25, 43A25, 43A35, 46L87, 20L05, 42A38, 46L08.

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