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A Theoretical Model of Multi-Agent Quantum Computing

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ABSTRACT

The best design for practical quantum computing is one that emulates the multi-agent quantum logic function of natural biological systems. Such systems are theorized to be based upon a quantum gate formed by a nucleic acid Szilard engine (NASE) that converts Shannon entropy of encountered molecules into useful work of nucleic acid geometric reconfiguration. This theoretical mechanism is logically and thermodynamically reversible in this special case because it is literally constructed out of the (nucleic acid) information necessary for its function, thereby allowing the nucleic acid Szilard engine to function reversibly because, since the information by which it functions exists on both sides of the theoretical mechanism simultaneously, there would be no build-up of information within the theoretical mechanism, and therefore no irreversible thermodynamic energy cost would be necessary to erase information inside the mechanism. This symmetry breaking Szilard engine function is associated with emission and/or absorption of entangled photons that can provide quantum synchronization of other nucleic acid segments within and between cells. In this manner nucleic acids can be considered as a natural model of topological quantum computing in which the nonabelian interaction of genes can be represented within quantum knot/braid theory as anyon crosses determined by entropic loss or gain that leads to changes in nucleic acid covalent bond angles. This naturally occurring biological form of topological quantum computing can serve as a model for workable man-made multi-agent quantum computing systems.

Keywords: nucleic acid, Szilard engine, NASE, quantum gate, topological quantum computing, Shannon entropy, quantum synchronization, quantum coherence

1. INTRODUCTION

Man-made quantum computing should be modeled after the multi-agent system of quantum logic that naturally occurs in biological systems. Schrödinger had predicted that quantum leaps of electrons between energy states of the covalent bonds within an "aperiodic crystal" carrying genetic information in the nucleus of the cell would be the basis of adaptation and of the system coherence necessary for "life".[1] The quantum gate that forms the basis of such a quantum logic system is a theoretical Szilard engine function of nucleic acids that converts the energy associated with the Shannon entropy of molecules encountered by the nucleic acid into the useful work of geometric conformational change of the nucleic acid molecule. This nucleic acid Szilard engine (NASE) function is logically and thermodynamically reversible because the information about the event of its function is retained coherently in the geometric reconfiguration of the nucleic acid molecule, and because this is a special case of a Szilard engine that is literally and physically constructed out of (nucleic acid) information, which means that there is no thermodynamic energy cost to erase information that would build up inside the theoretical mechanism. The function of the NASE mechanism is a symmetry breaking event that can be associated with photon emission and/or absorption. Photons generated in such a manner would be entangled with the coherent information retained in the geometric reconfiguration of the nucleic acid, and potentially with other photons emitted at the same time, and those photons can theoretically be used to coordinate relative geometric positioning and configuration of other nucleic acid segments. This can be considered topologically via quantum knot/braid representation.

Such interactions of what can be considered as entangled nucleic acid segments can further develop and extend the coherence that is established and maintained by those initial entangled photons. With each interaction of segments of nucleic acid source code there is a growth of the superimposed information that is synchronized by that initial photon entanglement. Thus it is necessary for such a multi-agent quantum logic system to develop and extend interactions of its source code in order to allow for the extension of coordination of information within the system.

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2. NUCLEIC ACID SZILARD ENGINE

Shannon had theorized that information traveling through a conduit should be considered to be high in entropy while the conduit that carries the information should be considered to be low in entropy.[2] Consequently a molecule travelling through the conduit of extracellular or intracellular fluid can be considered to be high in "information entropy" or Shannon entropy. Such an entropic data molecule (e.g. an enzyme or binding protein) might be encountered by a nucleic acid molecule, and if geometrically appropriate because of recognition by the nucleic acid structure, the two molecules could bind together. In the process of such binding the nucleic acid can be theoretically envisioned to act as a Szilard engine to lower the entropy of the entropic data molecule via the information contained in its coded structure, and thereby transform the energy associated with such entropy into higher energy states of electrons involved in the covalent bonds of the nucleic acid. This would lead to increased bond angles of those covalent bonds and thereby retain the information about the logically reversible event. The essence of a Szilard engine's function is that it uses information to convert the energy associated with entropy into useful work[3], and in this case the information used is the information of the nucleic acid code, the entropy involved is the Shannon entropy of the entropic data molecule, and the useful work is nucleic acid bond angle change.

What is special about this case of the nucleic acid Szilard engine (NASE) is that the mechanism of this theoretical engine is literally and physically constructed out of the information necessary for its function, and this implies that the information by which it functions essentially exists on both sides of the theoretical Szilard engine mechanism. Bennett had reasoned that a Szilard engine as traditionally theorized could not be thermodynamically reversible because there would be an inevitable build-up of information inside the mechanism that would require a thermodynamic energy cost to erase[4], but in this special case of the NASE there is no build-up of information within the mechanism and consequently no energy cost necessary to erase it. Therefore, because the NASE mechanism is both logically and thermodynamically reversible it essentially functions as a quantum gate by which qubits consisting of the superimposed information of nucleic acid geometric configuration can interact with the environment and with each other.[5]

The significance of the NASE quantum gate's existence within the source code of biological systems should not be underestimated because it provides for a theoretical model of biological quantum logic with coherence times of duration long enough to support the long-term existence of biological systems. That long-duration coherence time is made possible by the crystalline characteristics of the DNA molecule, just as Schrödinger had correctly intuited. Also, it is necessary that the entropy-lowering quantum logical operation of a biological system must take place within the source code by which that system is organized, in order to enable coherent function of all of the parts (i.e. cells or agents) of that system that share that source code.

3. TOPOLOGICAL QUANTUM COMPUTING

The NASE mechanism forms a quantum gate by which the energy associated with the Shannon entropy of the data represented by an entropic data molecule, is encountered by the nucleic acid molecule and is transformed into useful energy that raises the covalent bond electron energy state in a particular covalent bond of the nucleic acid, and thereby widening the bond angle of that covalent bond. In a nucleic acid an increased bond angle is associated with decreased entropy, and a decreased bond angle is associated with increased entropy.[6] If the molecule acting as the entropic data molecule were to be a (segment of) nucleic acid that is different from the one that forms the NASE mechanism, then a situation occurs in which the two segments of nucleic acid would interact or cross through a quantum gate (i.e. the NASE mechanism) where there would be a coherent transfer of energy from one nucleic acid (segment) to the other. At such an interaction or nucleic acid cross, bond angle changes would be induced in both entities of the interaction. The covalent bond electron energy state in the segment of nucleic acid acting as the NASE would increase and this would lead to an increased covalent bond angle in that nucleic acid segment, while the covalent bond electron energy state would be decreased in the segment of nucleic acid acting as the entropic data molecule and this would lead to a decrease in the covalent bond angle of that nucleic acid segment.

It is by such a mechanism that nucleic acids thus act as a type of topological quantum computer with the positive and negative crosses of quantum knot/braid representation[7] being defined by how such a cross would contribute to the entropy of the involved nucleic acid source codes. A positive cross can be (arbitrarily) defined as an interaction of the two nucleic acid segments that lowers entropy of the NASE nucleic acid segment and consequently increases a covalent bond energy and angle of that segment, while a negative cross can be (arbitrarily) defined as an interaction of the two nucleic acid segments that increases the entropy of the NASE nucleic acid segment and consequently decreases a covalent bond energy and angle of that segment. In such a model genes can be considered as anyons in what would necessarily be considered as a nonabelian quantum biological system.

4. QUANTUM COHERENCE

The event of the function of a Szilard engine is a symmetry breaking event that is essentially a quantum measurement[8], and therefore there would necessarily be a photon emission in such a quantum search event that would involve molecular geometric reconfiguration. What is measured in the event of function of the Szilard engine of nucleic acid nature is that the entropic data molecule is compared to the nucleic acid source code to see if it "measures up" to being recognized by the source code, and if it does then a quantum decision/measurement is made as the data molecule (e.g. binding protein) geometrically fits to the nucleic acid. Photon emission or absorption is associated with the molecular reconfiguration resulting from changes in the energy states of the electrons involved in covalent bonding. Photons have been shown to be both emitted and absorbed by nucleic acids[9], and can be envisioned to effect and/or coordinate geometric reconfiguration of other nucleic acid segments. A single photon emitted in association with NASE function could be considered to be entangled with the logically and thermodynamically reversible geometric configurational change involved, but also there is no reason why a pair of entangled photons could not be emitted simultaneously as a consequence of the function of the NASE mechanism.

As nucleic acids interact or actively cross, coherent entangled photons would be emitted from one nucleic acid segment and absorbed by the other, and the more the nucleic acid segments interacted with each other, the more superimposed information associated with those entangled photons would be exchanged leading to greater coherence between the two nucleic acid segments. So coherence can be built by exchanging coherent entangled photons between two segments of source code, and if during mitosis those segments went to separate cells, then the potential would exist for non-local coherence between those two cells via their entangled source codes. Thus coherence between separate cellular agents is developed as the biological system grows and/or reproduces.

5. MULTI-AGENT QUANTUM COMPUTING

In biological systems entangled photons generated by function of the mechanism of the NASE quantum gate provide a synchronization backbone for quantum coherence between the nucleic acids of cells in a multi-cellular organism. This naturally occurring model of multi-agent quantum computing serves to not only validate the viability of the concept of "distributed quantum computing"[10][11], but also serves to provide a theoretical basis for leaping beyond rudimentary entangled computer linkages to workable applications of quantum coherent computer systems. Such systems are envisioned to begin with linking the source codes of computers within conventional systems with entangled photons generated by a mechanism similar to that used in currently available quantum encryption systems, and then extending the amount of data synchronized by those entangled photons through interactions of the various computers in the system using the involved computer source code. Appropriate interactions of those computer source codes via conventional linkages can be used to broaden the amount of super-positioned data within the quantum synchronization of each entanglement, thereby extending the effect of each entanglement. In other words, each interaction of the source codes of the conventionally linked computers has the potential to increase the amount of superimposed information that can be synchronized by a single entangled linkage. Information that is synchronized by a first entanglement can thus be extended with conventional computer interactions, and then undergo a second entanglement, etc. In this way the growth and development of a biological quantum logic system can be emulated.

In such a system the computers themselves can serve as the individual agents but, using this same multi-agent model for quantum computing, intelligent agents can be developed to carry out the same functions as hardware agents. In this paradigm of multi-agent quantum computing such intelligent agents can be envisioned to interact with each other and thereby extend or enhance the nidus of coherence provided by the entangled photons of the system. Intelligent agents operating and reproducing in such a manner would maintain coherence between portions of their source codes, and could conceivably provide a means to order and search the entire system. Also, such a system that is built upon the biological example of multi-agent quantum computing would be able to utilize naturally-occurring means of preventing decoherence.

6. CONCLUSION

Biological systems are quantum coherent systems that are built around a quantum gate made possible by a theoretical Szilard engine mechanism that is literally constructed out of the information that is a nucleic acid. This nucleic acid Szilard engine (NASE) is logically reversible because information about its function is retained in the geometric reconfiguration that it effects in the nucleic acid, and it is thermodynamically reversible because there is no need to erase information inside the theoretical mechanism because the information by which it functions exists on both sides of the mechanism simultaneously.

This model of biological quantum gate function provides a theoretical mechanism by which nucleic acids can be represented as a working system of topological quantum computing. In such a naturally occurring nonabelian system the results of the interactions of nucleic acid segments are determined by entropic relationship to the source code that includes those interacting nucleic acid segments. A positive cross can be arbitrarily defined as one that decreases the entropy of the segment of nucleic acid by increasing the energy state(s) of electrons involved in covalent nucleic acid bonds and thereby increasing those bond angles, while a negative cross can be arbitrarily defined as one that increases the entropy of the segment of nucleic acid by decreasing the energy state(s) of electrons involved in covalent nucleic acid bonds and thereby decreasing those bond angles.

The logically and thermodynamically reversible Szilard engine function of nucleic acids is also a reversible symmetry-breaking mechanism that can emit and absorb photons. Such photons would be entangled with changes in nucleic acid segment geometry and theoretically with simultaneously generated photons, and can theoretically coordinate relative changes in the geometry between nucleic acid segments within and between cells, thereby providing a stable mechanism for long-duration quantum coherence throughout a biological system.

These heretofore unrecognized concepts provide a model of biological quantum logic and coherence that is consistent with proposed ideas of "distributed quantum computing", but also provide a theoretical basis to leap beyond rudimentary designs to a workable system of extensively coherent man-made "multi-agent quantum computing", the development of which can be envisioned using currently available technology. A quantum gate formed by the unique properties of a nucleic acid Szilard engine that serves as the synchronization backbone of topological quantum computing within the source code of a biological system should be seen as a potentially disruptive concept, and the implications of this new scientific vista extend beyond quantum complexity and biological systems to any multi-agent complex adaptive system.

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