# Nonlocal Quantum Computing Theory

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## ABSTRACT

A new kind of science in quantum parallel computing theory is presented here. Four complete sets of 16 nonlocal operator-state relations are shown to replace the 16 Boolean operations in classical sequential computing. Planar and spherical time crystals are shown and the origin of time as a parameter of space, not an independent variable, is claimed.

## Keywords

quantum computing, time crystals

## 1. INTRODUCTION

The slow progress of our current quantum parallel computing research has been due to the missing new concepts needed in addition to the two main ingredients, superposition and entanglement. We need to attack those problems from the top downwards and not from the bottom upwards as scientists had employed for classical electronic computer over 80 years ago.

From the top view, we observed there are two problems: (1) the foundation of classical computer is based on 16 Boolean operations and then there is a logic gate associated with each of the 16 operations. But those logic gates are operated one at a time to establish the sequential nature of the classical computing. Quantum computing is a massive parallel "phase computing" and some of our scientists still would not accept the parallel nature. In a parallel computing environment, there are the corresponding 16 parallel rules needed to replace the 16 Boolean sequential operations in classical computing. So, the question to be answered is: where are those 16 rule sets? (2) Parallel computing means there are millions of "interconnected identical processors" spreading over the space. Therefore, the number of interconnections must be maintained at a minimum for each processor with respect to its neighbors. This minimum interconnection requirement establishes that the parallel computer must be based on a cellular automata architecture, the only architecture that provides the minimum interconnections.

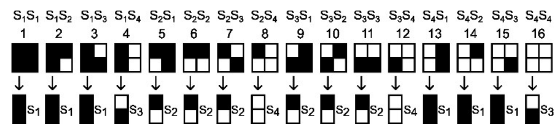


**Fig. 1: Computation-state transformation rules for "addition operation" in Euclidean Geometry for general-purpose computing.**

Quantum computing research must then be investigated based on the above two top views as the starting point. The paper here is the address those two concepts needed. First, we need to bring back the original nonlocal nature of computing in general. Starting from the addition operation of two springs of numbers, in decimal or digital numbering systems, when a "carry" concept was introduced thousand years ago, the nonlocal nature of addition operation is reduced to a "local" nature of a single full adder processor and then operated in a sequential manner. That is to use 8 computation states with the capability of generating two outcomes ("sum" and "carry") to satisfy the 16 Boolean operations. The nonlocal nature was discussed by Alan Turing in his Turing adder machine. Nonlocal means there are spatial relations. That means an operator and the states to be operated on are in two different locations, the neighboring relation or far away, for example.

Unfortunately, Turing used the concept of two computation states that coincided with the two digits used. The processor proposed is shown to need to generate 8 different results to cover the 16 operations. This is the same problem when qubit concept is employed. Namely, a tiny one-bit (two states, or black and white squares) processor is over-taxed to produce 8 different instructions. This could not be done

The correct way is to use 4 computation states in two layers. Each 2-bit-processor will then have 4 instruction capability to produced 16 outcomes. The top layer is the nutrition layer. The nutrition drips down from the top layer to the lower resultant layer through the instructions. When the nutrition layer is empty, the computation is finished. The 16-nonlocal operator-state relations to replace the 16 Boolean operations is shown below in Fig.1.

Now remember any "addition operation" is a "man-made" concept based on Euclidean geometry and such computing machine is also "man-made" to satisfy the human concept. But human concept is increasing in scope over years. From algebra to the development of calculus and differential equations, 340 years ago, and to the construction of classical electronic sequential computer, a local computing concept is firmly anchored in human's mind.

The local concept is facing a challenge when scientists are investigating quantum parallel computing. A new kind of science is emerging to supplement algebra and calculus/differential equation's local approach with various new 16 parallel nonlocal operator-state relations. Because those relations are different from Fig.1, they are for non-Euclidean computing in general. Quantum computing is one of those non-Euclidean computing (or piece-wise-Euclidean) and thus is "incompatible" with any addition operations. In quantum computing, it is also necessary to use 4 computation states, $S_1$, $S_2$, $S_3$ and $S_4$, in two layers as shown in Fig. 2. The four sets of 16 concurrent nonlocal operator-states relations to replace the 16 Boolean sequential operations is shown in Fig. 3.

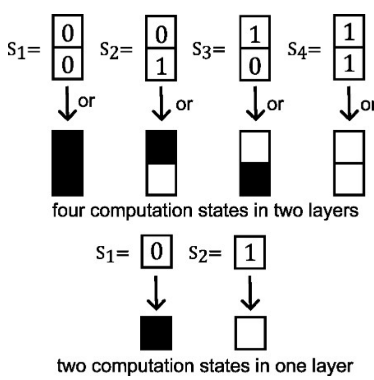


**Fig. 2: Notation of computation state.**

Those four sets of 16 computation-states with an equal-probability of outcomes correspond to four possible cyclic nonlocal operator-state relations. Let us explain the first set in Fig.3. The origin is from the superposition of four eigen-states in an atom. Note that qubit used superposition of only two eigen-states which is incomplete and is not capable of generating the 16 needed relations.

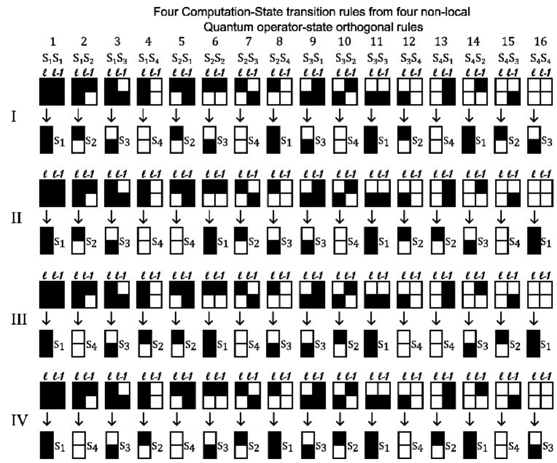


**Fig. 3: Rule I, II, III, and IV of computation state transitions.**

Superposition of four eigen states, $\overline{S_1}$, $\overline{S_2}$, $\overline{S_3}$ and $\overline{S_4}$ is the Fourier transform of those four eigen-states into the momentum-space within an atom to form the four computation states, $S_1$, $S_2$, $S_3$ and $S_4$ as shown in Fig.4, in a unitary transformation.

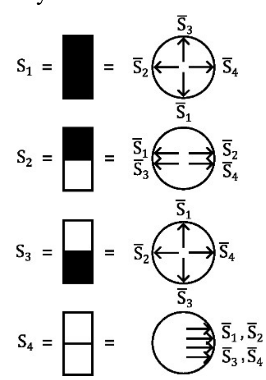

**Fig. 4: Superposition of four eigen-states $\overline{S_1}$, $\overline{S_2}$, $\overline{S_3}$, and $\overline{S_4}$ to form four computation states $S_1$, $S_2$, $S_3$, and $S_4$ in one atom.**

In addition, the inter-atomic Fourier transform on the eigen-states of the same energy further establishes the "entanglement" between atoms. That entanglement requires a set of quantized distances between two adjacent atoms so that the external Fourier transform can be achieved. The orthogonality of the eigen-states results in the tensorial relations of nonlocal eigen-states that is shown in Fig. 5.

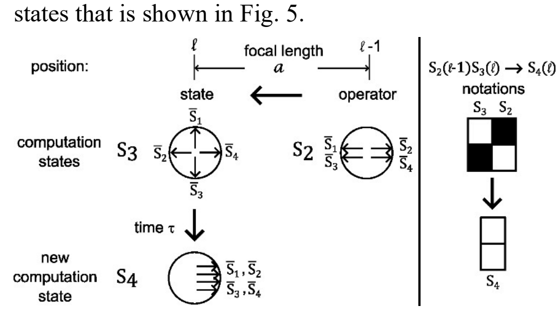

**Fig. 5: Nature-enabled quantum phase computing.**

For example, a computation state, $S_3(\ell)$, located at position l, has a right neighbor computation state $S_4(\ell-1)$ at position $\ell-1$. The separation distance is at a minimum focal distance of "$a$". Since the both computation states are composed from their respective superposition of the eigen-states as shown in Fig. 4, the eigen-vector $S_1(\ell-1)$ has the orientation of $180°$. When the eigenvector is transported to location at $\ell$, it will operate on the eigen $S_1(\ell)$ after gaining the additional phase of $90°$. $S_1(\ell)$ eigenvector has its $90°$ phase. Thus, the resultant $S_1(\ell)$ has the phase vector of $360°$ (See Fig. 5 of the new computation state). On the similar arguments for $S_2$, $S_3$ $S_4$ eigenvectors, the results are shown in Fig. 5 to demonstrate quantum parallel computing as the conservative phase computing.

Thus, the basic quantum computing theory comes from the four-tensor nonlocal operator-state relations among the four eigen-vectors which are listed in Fig. 6 as the entanglement conditions in Rule I, II, III and IV. The corresponding computation states are shown on the right side of the figure. Note that there are mixed conjugated relations such as $\bar{S_1}^*(\ell)\bar{S_1}(\ell-1) = i\bar{S_1}^*(\ell)$ as shown in Rule III, which does not exist in qubit theory.

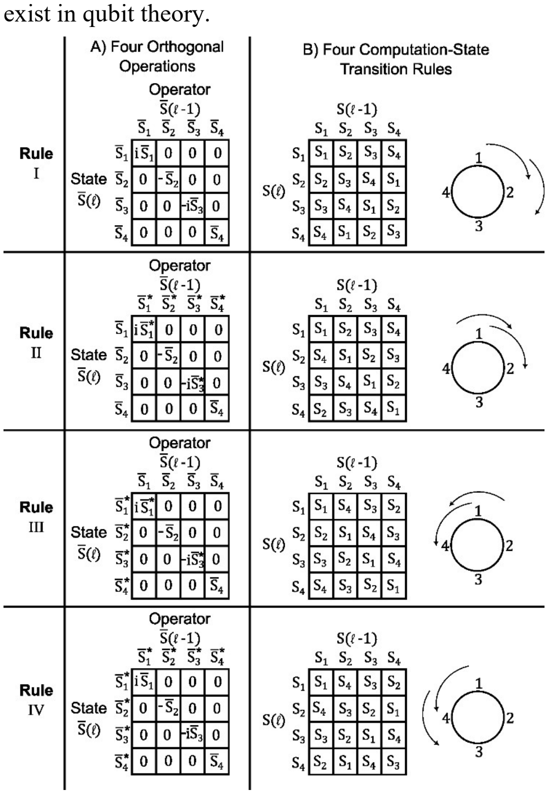


**Fig. 6: A) Four fundamental diagonal nonlocal operator-state relations for and operator $\bar{S}(\ell-1)$ at location, $\ell-1$, to operate on the state $\bar{S}(\ell)$ at location, $\ell$, on the chain. The diagonal results are the states located at $\ell$. B) The four corresponding computation-sates are in four complete cyclic form as shown in the four sequences. The inner arrows first and then the outer arrows. The four 16-rule sets are shown as Rule I-IV.**

The origin of "time" comes from the entanglement of two neighboring eigen states, $S_1(\ell-1)$ and $S_1(\ell)$, such that $k_1 a = \pi/2$. Here $E_1 = \frac{(\hbar k_1)^2}{2m_e}$ is the electron energy associated with eigenvector $S_1$. The interaction time, $\tau = \frac{4a^2 m_e}{\hbar}$. Thus, time is just a parameter of space under consideration (Fig. 7). Since space is not continuous as a Sierpinski triangle is generated, time is also not continuous. In fact, both planar time crystals and spherical time crystals can both exist.

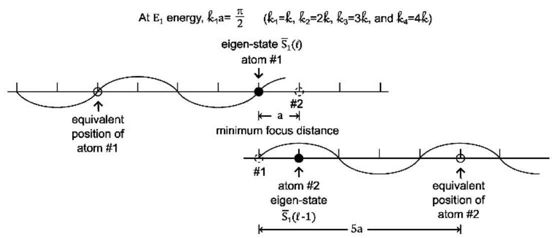


**Fig. 7: Four computation state picture and the origin of time $\tau$. Two atoms in entanglement. Each atom is of semi-infinite extent. They are separated by a minimum focus distance, $a$, such that $k_1 a = \pi/2$. The eigen-state of atom #2, $\bar{S_1}(\ell-1)$ can transverse the distance, $a$, with time $\tau = \frac{4a^2 m_e}{\hbar}$ to eigen-state $\bar{S_1}(\ell)$ location and operate on the state $\bar{S_1}(\ell)$ such that a gaining of $\pi/2$ phase is obtained so that $\bar{S_1}(\ell) \leftarrow \bar{S_1}(\ell-1) = e^{i\frac{\pi}{2}}\bar{S_1}(\ell) = i\bar{S_1}(\ell)$ is established.**

The origin of time can be explained through Fig.7. Two plane waves of semi-infinite extent representing from two separate atoms with well-defined wavelength. They are placed at the entanglement condition, the Fourier transform condition as indicated in Fig.7. Overall, it appears that there is the existence of a complete plane wave of infinite extent only. But they are actually composed by the two half plane waves from the right-side and the left-side atoms. Each semi-infinite plane wave from the atom then has a tendency to extend half of the plane wave to cover the entire infinite space by itself. The separation distance is the minimum focal distance "a". The lowest eigen-vector of the right side atom and that of the left-side are in phase and therefore will form a nonlocal operator-state relation such that at every interval of time when the distance "a" is travelled, the phase change of left eigenvector is achieved as described in the Figure caption. Similarly, Rule II,III and Rule IV complete all the possibilities of the phasing changing mechanism. Time crystals are the nature's parallel phase computing results, and they are perpetual with a well-defined Poincare cycle from the Sierpinski fractal (Fig. 8).

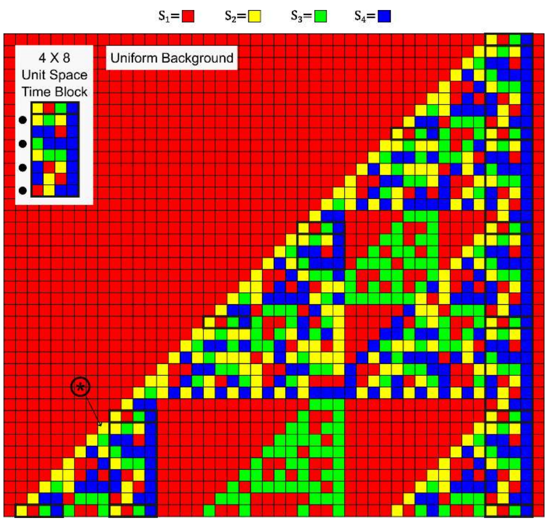


**Fig. 8: Sierpinski triangle and time crystals.**

From Fig.8, we showed only the Rule I result. For Rule II,III and IV, the results are similar, except every other steps of the time crystals are different as indicated by the black dots on the upper left corner of Fig.8, which is the basic time crystal structure of generally N by 2N structure. From the Sierpinski fractal structure, space is not continuous. But the time is a parameter of space associated at a certain space scale under consideration. So that time has a meaning valid only at the space scale. From Sierpinski fractal, we also observe the "birth-and-death" feature of time crystals. More quantity generated means better quality and hence the higher-order intelligence. This is the foundation of true artificial intelligence.

## 2. References

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