Topological quantum computation (TQC) is one of the most promising approaches to quantum computation. The coding of logical qubits to the entanglement of topological quantum numbers promises to solve the de-coherence problem whereas the S-matrices of topological field theories (modular functors) providing unitary representations for braids would give a realization of quantum computer programs with gates represented as simple braiding operations. Because of their effective 2-dimensionality anyon systems are the best candidates for realizing the representations of braid groups.

TGD allows several new insights related to quantum computation. TGD predicts new information measures as number theoretical negative valued
entanglement entropies defined for systems having extended rational entanglement and characterizes bound state entanglement as bound state
entanglement. Hierarchy of Planck constants labelling phases of dark matter
makes possible macroscopic quantum coherence. Negentropy Maximization
Principle and p-adic length scale hierarchy of space-time sheets encourage
to believe that Universe itself might do its best to resolve the de-coherence problem. The new view about quantum jump suggests strongly the
notion of quantum parallel dissipation so that thermalization in shorter
length scales would guarantee coherence in longer length scales. The possibility of negative energies and communications to geometric future in
turn might even trivialize the problems caused by long computation times:
computation could be iterated again and again by turning the computer on in
the geometric past and TGD inspired theory of consciousness predicts that
something like this occurs routinely in living matter.

K\"ahler action defines the basic
variational principle of classical TGD and predicts extremely complex but non-chaotic magnetic flux tube structures, which can get knotted and linked. The dimension of $CP_2$ projection for these structures is $D=3$. These structures are the corner stone of TGD inspired theory of living matter and provide the braid structures needed by TQC.

Anyons are the key actors of TQC and TGD leads to detailed model of anyons as systems consisting of track of a periodically moving charged particle realized as a flux tube containing the particle inside it. This track would be a space-time correlate for the outcome of dissipative processes producing the asymptotic

self-organization pattern. These tracks in general carry vacuum K\"ahler charge which is topologized when the $CP_2$ projection of space-time sheet is $D=3$. This explains charge fractionization predicted to occur also for other charged particles. When a system approaches chaos periodic orbits become slightly aperiodic and the correlate is flux tube which rotates $N$ times before closing. This gives rise to $Z_N$ valued topological quantum number crucial for TQC using anyons ($N=4$ holds true in this case). Non-Abelian anyons are needed by TQC, and the existence of long range classical electro-weak fields predicted by TGD is an essential prerequisite of non-Abelianity.

Negative energies and zero energy states are of crucial importance of TQC in TGD. The possibility of phase conjugation for fermions would resolve the puzzle of matter-antimatter asymmetry in an elegant manner. Anti-fermions would be present but have negative energies. Quite generally, it is possible to interpret scattering as a creation of pair of positive and negative energy states, the latter representing the final state. One can characterize precisely the deviations of this Eastern world view with respect to the Western world view assuming an objective reality with a positive definite energy and understand why the Western illusion apparently works. In the case of TQC the initial {\it resp.} final state of braided anyon system would correspond to positive {\it resp.} negative energy state.

The light-like boundaries of magnetic flux tubes are ideal for TQC. The point is that 3-dimensional light-like quantum states can be interpreted as representations for the time evolution of a two-dimensional system and thus represented self-reflective states being \blockquote{about something}. The light-likeness (no geometric time
flow) is a space-time correlate for the ceasing of subjective time flow during macro-temporal quantum coherence. The S-matrices of TQC can be coded to these light-like states such that each elementary braid operation corresponds to positive energy anyons near the boundary of the magnetic flux tube A and negative energy anyons with opposite topological charges residing near the boundary of flux tube B and connected by braided threads representing the quantum gate. Light-like boundaries also force Chern-Simons action as the only possible general coordinate invariant action since the vanishing of the metric determinant does not allow any other candidate. Chern-Simons action indeed defines the modular functor for braid coding for a TQC program.

The comparison of the concrete model for TQC in terms of magnetic flux tubes with the structure of DNA gives tantalizing hints that DNA double strand is a topological quantum computer. Strand {\it resp.} conjugate strand would carry positive {\it resp.} negative energy anyon systems. The knotting and linking of DNA double strand would code for 2-gates realized as a unique maximally entangling Yang-Baxter matrix R for 2-state system. The pairs A-T,

T-A, C-G, G-C in active state would code for the four braid operations of 3-braid group in 1-qubit Temperley Lieb representation associated with quantum group $SL(2)_q$. On basis of this picture one can identify N-O hydrogen bonds between DNA strands as structural correlates of 3-braids responsible for the nontrivial 1-gates whereas N-N hydrogen bonds would be correlates for the return gates acting as identity gates. Depending on whether the nucleotide is active or not it codes for nontrivial 1-gate or for identity gate so that DNA strand can program itself or be programmed dynamically.

The more recent work has demonstrated the the particular physical realization
discussed in this chapter is only one possibily, and that braiding naturally generalizes to 2-braiding in TGD framework with braiding defined
for string world sheets in 4-D space-time. Zero energy ontology allows
also to understand why TQC programs - naturally identiable as biological programs - are selected as those associated
with the maxima of K\"ahler function, which are now space-time surfaces
rather than 3-surfaces.

%\end{abstract}