

## Microtubules in TGD inspired biology

1. Background:
  - (a) There is a lot of empirical support for the special role of in neuroscience.
  - (b) In Penrose-Hameroff theory of consciousness microtubules have key role as candidates for macroscopically quantum coherent systems.
  - (c) Microtubules consists tubulins molecules which are dimers formed from  $\alpha$  and  $\beta$  tubulins and possess two basic conformations suggesting interpretation as bits.
  - (d) Microtubule is cylindrical lattice with periodicity of 13 units. It has been theorized to possess A and B forms. A form possesses helical symmetry. For B form this symmetry is broken and basic unit is 13 tubulins long.
  - (e) P and H assume that A forms dominates in living matter. It however seems that it is the B form which is stable. This is a serious objection against P-H theory.
  - (f) Second objection is that macroscopic quantum coherence is not possible at physiological temperatures in standard physics.
2. The findings of the team led by Anirban Bandyopadhyay (hereafter B) provide proof for macroscopic quantum coherence if true.
  - (a) Studies the effects of AC currents flowing through microtubule in different situations. There are three frequency scales corresponding to kHz, MHz, and GHz in correspondence with the structure of microtubule. The microtubule interior is either filled with water or does not contain it. Effects suggesting macroscopic quantum coherence appear only if water is present.
  - (b) B claims having found evidence for current carrying helical conduction pathways. The resistance does not depend on the length of the microtubule suggesting that the current is supracurrent inside the pathway and resistance is associated with its ends. The fact that resistance does not depend on temperature suggests the same.
  - (c) B claims of having detected 8 resonance frequencies in MHz range assignable to some kind of quantal excitations.
  - (d) Also evidence for square like ferroelectric hysteresis curve has been reported for current as a function of voltage suggesting quantum phase transition.
  - (e) Finds also that the properties of microtubule (in particular electronic energy levels) are same as those of tubulin. All tubulin electrons are in same vibrational state suggesting analog of Bose-Einstein condensate.
3. TGD inspired model is based on magnetic flux tubes as carriers of supra currents.
  - (a) Flux tubes would form a helical grid at the surface of microtubule in A type state generated via a phase transition from B type state induced by AC current at resonance frequency or by dark photons.
  - (b) The phase would contain super-conducting dark electrons at flux tubes. This would resolve the basic objection against biological role of A type microtubules.
  - (c) The nodes of the grid would correspond to tubulin molecules.
  - (d) Ferro-electric square hysteresis curve would correspond to quantum phase transitions changing the direction of dark electron current.
  - (e) The TGD based model for findings of Pollack suggests that the water inside MT corresponds to "fourth phase of water" obeying stoichiometry  $H_{3/2}O$  and being negatively charged due to the transfer of protons to dark protons at magnetic flux tubes outside MT.
  - (f) Microtubules could also act as quantum antennas. The continual variation of microtubule length would induce frequency modulation perhaps allowing to code information in same manner as in the case of "whale's song".

#### 4. Predictions

- (a) Flux tubes would form a braid strands. At each node flux tube goes over or below the second one. This bit could be coded by tubulin conformation. One obtains braiding defining topological quantum computation (TQC) program.
- (b) Flux tubes are identifiable as strings whose orbits can get knotted and form 2-braids at 4-D space-time surface. This defines generalization of TQC using 2-braiding.
- (c) The reconnection of flux possibly occurring in node defines stringy vertex. This together with the braiding operation means that each node involves 2 bits. This lattice of bits defines TQC program.
- (d) This picture is expected to apply quite generally by fractality of TGD and magnetic flux tube web.
- (e) If one has 3-D coordinate grid formed by flux tubes and 3 flux tubes meet at each node,  $3 \times 2 = 6$  bits are needed at each node to characterize TQC program. There are  $2^6 = 64$  genetic codons. A connection?