

The 'Orch OR' theory of consciousness as quantum computation in brain microtubules – Status and update after 20 years

Stuart Hameroff MD
Professor of Anesthesiology and Psychology
Director, Center for Consciousness Studies
Banner-University Medical Center
The University of Arizona, Tucson, Arizona

Abstract:

The nature of consciousness, the mechanism by which it occurs in the brain and its place in the universe are unknown. In the mid 1990's Sir Roger Penrose and I suggested that consciousness depends on biologically 'orchestrated' coherent quantum processes in collections of microtubules within brain neurons, that these quantum processes correlate with, and regulate, neuronal activity, and that the continuous Schrodinger evolution of each such process terminates in accordance with the specific Diosi-Penrose ('DP') scheme of objective reduction ('OR') of the quantum state. 'Orchestrated' OR activity ('Orch OR') is taken to result in moments of full conscious awareness and/or choice. The DP form of OR is related to the fundamentals of quantum mechanics and space-time geometry, so Orch OR suggests a connection between brain biomolecular processes and the basic structure of the universe. I will review Orch OR in light of criticisms, presenting experimental evidence for 1) hierarchical microtubule quantum resonances (terahertz, gigahertz, megahertz, kilohertz), and 2) anesthetics preventing consciousness through quantum actions on microtubules. Further novel Orch OR suggestions include 1) topological quantum bits ('qubits') intrinsic to microtubule geometry, 2) interference 'beat frequencies' of fast (e.g. megahertz) microtubule vibrations producing slower electro-encephalographic (EEG) correlates of consciousness, 3) mental state alterations caused by brain stimulation with megahertz mechanical vibrations (ultrasound), and 4) OR-based primitive feelings prompting life's origin and evolution. Orch OR is rigorous, consistent with neuronal-level approaches and better supported experimentally than other theories of consciousness.

Reference: Hameroff & Penrose (2014) Phys. Life Rev., 11(1):39-78
<http://www.sciencedirect.com/science/article/pii/S1571064513001188>