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### A quantum model for seizures

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Understanding the complex behavior of neuronal dynamics has become one of the most important topics in modern neurology and biophysics since it is directly connected with neuronal disorders. The brain is responsible for controlling multiple processes such as emotions, vision, motor skills, breathing, and memory. The main structure that makes this accurate level of control possible is the neuronal network, capable of sending and receiving electrical stimuli along the whole body, where different signals are interpreted as a specific sensation or command. Based on the intensity of received electrical stimulation, a neuron can either become excited and generate a firing response or remain at rest. When the stimulus is sufficiently strong, reaching an electrical potential threshold of approximately -55 mV, the neuron's cell membrane depolarizes due to an influx of sodium ions, generating a signal known as the action potential. (1) Information is propagated within the neuronal network through electrical synapses, which are gap junctions allowing direct communication, and chemical synapses, involving the release of neurotransmitters. These synapses can result in excitatory or inhibitory responses in postsynaptic neurons. The balance between excitation and inhibition is crucial for normal brain function. However, when this balance is disrupted and excitation prevails over inhibition, neurons may begin to fire synchronously, leading to partial or generalized seizures, involving a specific or total area of the brain respectively. In 1996, Penrose and Hameroff proposed the hypothesis that microtubules present in neurons could exhibit quantum behavior in a state of superposition. (2) Despite this proposal, no observations were obtained confirming the existence of quantum coherence in brain microtubules. Thus, the idea of quantum effects in the brain had not been widely accepted and remained an open topic of investigation. However, recent experimental evidence presented by Kerskens and Pérez, who collected signals through nuclear magnetic resonance, may indicate entanglement mediated by consciousness-related brain functions. (3) Along the line of approaching biological phenomena through quantum mechanics, we describe the neuronal network as a set of coupled spin-boson open quantum systems. Consequently, the synchronous firing characterizing seizures is modeled as a superradiance-like phenomenon, the superradiance being a collective effect that occurs when a moderately dense atomic sample interacts with its environment and the electromagnetic radiation it emits. Instead of emitting radiation independently and randomly, the atoms synchronize their emissions to release energy in a highly coherent pulse. In our neuronal network description, we demonstrate that a synchronized emission of multiple superradiant pulses is generated when the neurons are strongly connected to each other, corroborating the fact that both the frequency and the intensity of the pulses are distinctive features of seizures.

**Palavras-chave:** Seizures. Spin-boson model. Superradiance.

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