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The Quantum Biology of Reactive Oxygen Species

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Abstract

Introduction: Quantum biology is the study of quantum effects on biochemical mechanisms and biological function. The biological production of reactive oxygen species (ROS) in live cells can be influenced by coherent electron spin dynamics, providing a new example of quantum biology in cellular regulation. Oscillating magnetic fields at Zeeman resonance alter relative yields of cellular superoxide (O_2^-) and hydrogen peroxide (H_2O_2) ROS products, indicating coherent singlet-triplet mixing at the point of ROS formation.

Methods: Cells were grown and maintained then seeded and allowed to rest for 24h under the same magnetic background conditions, after which timed magnetic exposures began. The magnetic field exposure conditions include control exposed to 45mT static magnetic fields (SMFs) along the z-axis and one experimental condition: 45mT SMF superimposed with 5 or 10MHz, 10m T_{RMS} horizontal RF magnetic field. The magnetic field exposure effects on cellular proliferation were determined by direct cell counts after each termination point.

Results and discussion: In summary, the present work shows low level magnetic fields (LLF) suppress H_2O_2 production in fibrosarcoma cancer cells, Effect of SOD mimetic on H_2O_2 production in fibrosarcoma cells, H_2O_2 production in pancreatic cancer cell become indistinguishable between LLF and geomagnetic field, LLF also inhibits H_2O_2 production in endothelial cells. The ROS product distribution is thought to occur by decoupling hyperfine energies that modulate singlet-triplet states and thus determine reaction-product yields.

Conclusion: The results demonstrate an overall magnetic field-induced biological effect that causes elevated H2O2 levels with accompanying decrease in cellular growth rates. Because of the indirect measurement of spin effects in metabolism, we cannot rule out other possible mechanisms for magnetic field effects in ROS production and cell proliferation.

Keywords: Quantum biology, Reactive oxygen species (ROS), Quantum coherence, History of physics

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