A Geant4 Monte Carlo Simulation of a Quantum Entanglement Experiment of the Decay of Spin-Singlet State Positronium: Computer Replication and Multiple Scattering Mitigation

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The quantum entanglement phenomenon regarding the decay of the spin-singlet state of positronium has experimental results revealing quantitative evidence to support the entanglement of the annihilation photons as the two emitted photons must have linear polarizations 90° apart. The present research is focused on a novel Geant4 Monte-Carlo simulation that replicates an experiment which can measure the orthogonal linear polarizations of the two photons. The geometry and radioactive source in the simulation are based on a physical experiment. The Monte-Carlo calculations present within Geant4 provide a natural model of the radioactive decay and interaction of radiation with matter. The primary emphasis of the simulation is to mitigate the effects of unwanted events that are present in the physical experiment, namely the multiple scattering events unaccounted for in the mathematical model. The multiple scattering cannot be filtered or removed in the physical experiment, but they can be removed in the simulation by a novel application of a logic counter. The results produced by the initial simulation are in agreement with the results of the physical experiment and published papers. The results produced after removing the multiple scattering yields a greater anisotropy that is closer to the theoretical maximum and also quantifies the attenuation of the anisotropy by multiple scattering within the physical experiment. Future research will focus on the efficiency of the simulation and quantifying the effects of the solid angles of the detectors on the anisotropy. Applications of my research include increasing the resolution of nuclear medicine imaging techniques such as positron emission tomography (PET) scans, improving the accuracy of detectors, and designing new detectors.