Summary

The past few decades have witnessed a paradigm shift in computational sciences with the advent of quantum computing, a cutting-edge technology promising to revolutionize data processing by leveraging quantum mechanical phenomena. This paper delves into the intricate concepts that underpin quantum computing and their simulation, providing an extensive exploration of this domain that ranges from its fundamental principles to intricate quantum algorithms.

Beginning with a historical overview, we journey through the genesis and development of quantum computing, setting a solid foundation upon which to build a comprehensive understanding of the field. We delve into the six postulates of quantum mechanics and Dirac's relativistic matrix mechanics, pivotal in understanding the theoretical framework of quantum physics. To clarify these complex theories, we illuminate the mathematical formulations of quantum mechanics through Dirac notation, vector, matrix, and Tensor Product mathematics.

We then explore the enigmatic phenomena at the heart of quantum mechanics: superposition, entanglement, and quantum operators. By investigating experiments such as the 3 Polarizer Paradox and Stern-Gerlach, we seek to bring clarity to these seemingly paradoxical phenomena.

The exploration of quantum mechanics would be incomplete without a dive into its most transformative applications: quantum algorithms. The paper discusses fundamental quantum algorithms like Deutsch, Deutsch-Jozsa, Shor's factoring algorithm, and Grover's search algorithm. These algorithms, running on quantum computers, have the potential to solve problems significantly faster than classical computers, thus underscoring the power of quantum computing.

In addition, we simulate key principles and operations in quantum mechanics, like the Aharonov-Bohm effect and the solution of the Schrödinger wave equation for the propagation of an electron. By probing the quantum eraser and the unique characteristics distinguishing fermions from bosons, we strive to illuminate the idiosyncrasies of the quantum world.

Throughout this exploration, our objective is not merely to understand quantum computing, but to demystify it, to bring it into the realm of the comprehensible, and to simulate these phenomena using classical analytic math tools such as Mathcad, Maple Flow, CalcTree.