Chapter 7

YinYang Bipolar Quantum Entanglement: Toward a Logically Complete Theory for Quantum Computing and Communication

ABSTRACT

YinYang bipolar relativity leads to an equilibrium-based logically complete quantum theory which is presented and discussed in this chapter. It is shown that bipolar quantum entanglement and bipolar quantum computing bring bipolar relativity deeper into microscopic worlds. The concepts of bipolar qubit and YinYang bipolar complementarity are proposed and compared with Niels Bohr’s particle-wave complementarity. Bipolar qubit box is compared with Schrödinger’s cat box. Since bipolar quantum entanglement is fundamentally different from classical quantum theory (which is referred to as unipolar quantum theory in this book), the new approach provides bipolar quantum computing with the unique features: (1) it forms a key for equilibrium-based quantum controllability and quantum-digital compatibility; (2) it makes bipolar quantum teleportation theoretically possible for the first time without conventional communication between Alice and Bob; (3) it enables bitwise encryption without a large prime number that points to a different research direction of cryptography aimed at making prime-number-based cryptography and quantum factoring algorithm both obsolete; (4) it shows potential to bring quantum computing and communication closer to deterministic reality; (5) it leads to a unifying Q5 paradigm aimed at revealing the ubiquitous effects of bipolar quantum entanglement with the sub theories of logical, physical, mental, social, and biological quantum gravities and quantum computing.

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INTRODUCTION

After conquering his general theory of relativity regarding space, time, and gravity, there must be few physical phenomena left to freak out Albert Einstein. Yet quantum entanglement caused Einstein to use the word “spooky.” Take a pair of entangled photons, for instance, it seems that performing an experiment on one of them instantaneously affects another no matter how far apart are the two, whether they are in the same room, or at two opposite ends of the universe. The simultaneous multiple appearances are called superposition. Einstein once called this intuitively supernatural behavior “spooky action at a distance.”

The EPR paradox (Einstein, Podolsky & Rosen, 1935) challenged long-held ideas about the relation between the observed values of physical quantities and the values that can be accounted for by a physical theory. It was their theoretical possibility or impossibility that led Einstein to reject the idea that quantum mechanics might be a fundamental physical law. Instead, Einstein deemed it an incomplete theory. The missing part has been referred to as “hidden variables” in the literature.

Three decades later, Bell’s theorem (Bell, 1964) extended the argument of the EPR paradox and proved the validity of quantum entanglement from a statistical perspective with probability distributions. Despite its practical significance in quantum computing, Bell’s theorem so far hasn’t led to a logical unification of general relativity and quantum mechanics. The so-called “hidden variables” never really surfaced in simple logically definable terms.

Thus, quantum mechanics at the Planck scale needs to be further reconciled with general relativity. That is the goal of quantum gravity. Until this day, however, the searching for quantum gravity has failed to find a decisive battleground; quantum computing is still years away from reality. Nevertheless, since the 1980s, many successful experimental results have shown the physical existence of quantum entanglement.

Besides the quantum observability problem, another major obstacle in quantum information processing is the difficulty or even impossibility of cloning an unknown quantum state. While classical information can be copied or cloned for storage and retrieval, the quantum “no cloning” theorem (Dieks, 1982; Wootters & Zurek, 1982) asserts the impossibility of cloning an unknown quantum state. Without being copied or cloned quantum information cannot be stored for retrieval.

Consequently, despite numerous reported experimental successes in testing quantum entanglement (e.g. Furusawa et al., 1998; Buchanan, 1998; Ghosh et al., 2003; Salart et al., 2008; Jost et al., 2009), the quantum observability controversy and no cloning dilemma remain unresolved. Now many physicists have subscribed to the instrumentalist interpretation of quantum mechanics with the slogan “Shut up and calculate!” Some others including several of the best living theoretical physicists feel compelled to question the basic assumptions of relativity and quantum theory. As described by theoretical physicist Lee Smolin they “learn it, and they can carry out its arguments and calculations as well as anyone. But they don’t believe it.” (Smolin, 2006, p. 319).

Nevertheless, the “spooky” quantum phenomenon has become a fundamental concept in quantum computing even though, until recently, physicists have only been able to demonstrate quantum entanglement through either highly esoteric examples or under extreme conditions. Without a decisive victory in the quest for quantum gravity, it is fair to say that something fundamental must still be missing from the big picture.

The missing fundamental concept is often traced back to the ultimate unknown cause-effect relationship in quantum entanglement. Without logically definable causality, quantum entanglement could be