Is Quantum Mechanics Wrong?: Verification of Bell-Type Inequality Violation and Suggestion of the Improved Form Inequality

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Does quantum mechanics embed the possibility to be a true theory that corresponds to the principle of nature? If locality and reality, common assumptions of physics, are valid, quantum mechanics is wrong. So, quantum mechanics embed the possibility to be true only if locality and reality are falsified. Bell-type inequality is the type of inequality that should be experimentally satisfied if locality and reality hold on the nature of the universe. Here, we show the violation of Clauser-Horne-Shimony-Holt's (CHSH) inequality, a particular form of Bell-type inequality, by conducting a quantum optical experiment and using a quantum computer. Then, we suggest a new improved form of Bell-type inequality and demonstrate its violation. For optic experimental verification, we produce pairs of entangled photons by the SPDC (Spontaneous Parametric Down Conversion) phenomenon of the BBO (beta-Barium Borate) crystal. To advance experiments and obtain precise value, we introduce apparatuses and methods such as a polarized beam splitter, polarizer, iris, and correction factor calculation. Based on the experiment setting validity verification through pre-experiments, we show the violation of the CHSH inequality from the coincidence counts of photons at 16 different polarization observation basis combinations ($S=2.43\pm0.0308>2$). Meanwhile, using an IBM quantum computer, we confirm violations of two Bell-type inequities: CHSH inequality and Alford's inequality (CHSH: $S=2.4265>2$, Alford: $P=0.27<0.33$). Then, we suggest improved Bell-type inequality, UCV inequality, which is intuitive and gives new insight to the computational approach. Finally, we demonstrate the violation of the new inequality using the quantum computer (UCV: $3.23>3$) once again.

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