Commentary for Microscopic Quantum Jump: An Interpretation of Measurement Problem

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Commentary

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ABOUT THE STUDY

Quantum mechanics is excellent in telling us about what we observe. However, if we start asking about what there exists, the situation becomes very complicated. This is the measurement problem. Following questions arise. What is the quantum origin of classicality? How does the transition from quantum to classical occur? What process is irreversible? Is the transition smooth or abrupt? These are the questions which have persisted from the birth of quantum mechanics.

We first scrutinize basic postulates adopted by existing theories, and identify the Postulate of Classicality of Apparatus (PCA) to be the origin of the trouble. Due to this PCA, superposition of macroscopic states necessarily occurs and also a single quantum system interacts with enormously many degrees of freedom in the apparatus.

The PCA has been adopted without any doubt by the researchers of measurement problem including von Neumann and Bohr. We show that a single quantum system interacts with only one particle in the apparatus at a time and that the PCA does not hold.

Now we turn our eyes upon actual experimental setups. Here we describe one of the four experimental setups discussed in the paper. We consider a single photon detection by a two-dimensional photon counting detector composed of a photocathode with a Micro-Channel Plate (MCP). A visible photon is the observed system S and the photocathode plus MCP is the apparatus A.

The photon hits one point on the photocathode surface, gets absorbed and a photoelectron is emitted. This photoelectric effect is a Microscopic Quantum Jump (MIJ). The System Eigenvalues (SEVs) are two-dimensional position and arrival time. The emitted photoelectron is a Microscopic Particle (MIP) which carries the information of the SEVs potentially. We know the probability of where the photon arrives, but we never know how the point of photon's arrival is selected. We do not know the mechanism of the MIJ before the selection of the SEVs, which is outside the domain of science, because it cannot be investigated by experiments. However we at least know the physics of the MIJ after the selection of the SEVs, which is the photoelectric effect.

The MCP is an array of capillary shaped electron multipliers. The photoelectron as a MIP enters one of the channels, triggers cascade avalanche of secondary electrons, which we call Intermediate Particles (IMPs). The IMPs are a few originally, but become plenty after amplification. The number of the IMPs is order of ten million.

The IMPs exit the channel on the opposite side of the MCP where they are collected on an anode, which is designed to allow spatially resolved collection. At the anode, a current pulse which carries the information of the SEVs in actuality is generated as a Macroscopic Observable (MAO). At this point one measurement is complete. The amplification in the MCP is outside the domain of quantum mechanics because it occurs after the MIJ.

In summary, Standard Quantum Mechanics (SQM) tells us about what happens stochastically when a MIJ happens. SQM does not tell us about the mechanism of a MIJ, which is outside the domain of science. SQM covers up to the stage of the MIJ and it does not tell us about the mechanism of amplification. Only difference between previous quantum jumps and ours is that our jump is from microscopic to microscopic. Our MIJ interpretation is consistent with SQM.