

6. THE PARTICIPANT

Niels Bohr, the principal architect of quantum philosophy, wrote that we cannot forget "that in the drama of existence we ourselves are both actors and spectators." [Essays 1958/62 on Atomic Physics and Human knowledge, p.15] This comment succinctly captures a key point of quantum theory: the human observers are no longer passive witnesses to a flow of physical events that they cannot influence. They are essential players in the action: their "free" choices can influence the flow of physical events.

Quantum theory, in spite of its idealistic content, is formulated in a completely realistic and practical way. It is structured around the activities of human agents, who can probe nature in any of many possible ways. Bohr emphasized this freedom of the experimenters in passages such as:

"The freedom of experimentation, presupposed in classical physics, is of course retained and corresponds to the free choice of experimental arrangement for which the mathematical structure of the quantum mechanical formalism offers the appropriate latitude."

The point here is that quantum theory, in its original form, is set up in terms of an interaction between conscious human agents and an invisible quantum system. As already discussed, that system is represented in the theory by a vector in Hilbert space. This vector usually evolves according to the quantum law of motion, the Schroedinger equation. But to get information about that system the experimenter must ask specific questions by setting up corresponding probes. For example, the experimenter can orient the crystal in the photon experiment described earlier

in any way he chooses. Different choices correspond to different choices of the two perpendicular directions A1 and A2. Moreover, the human agent can choose to do or not do the experiment, or to do it sooner or later. These choices are, according to our basic physical theory, quantum theory, not fixed by any yet-known laws of nature. Hence these choices are, in that specific sense, "free choices".

We have now arrived at the crux of the matter! Quantum theory, in its orthodox formulation, involves the human observer not merely as a passive recipient of data, but also as an active agent that enters into natural process in ways that are not controlled by the known physical laws. His specific role, *as it appears in the world of experience*, is to select which experiment is to be performed: i.e., to choose which aspect of nature will be probed. This role, *as it appears in the mathematics*, is to select some one single projection operator P. This P is the projection operator such that the initial vector V will become PV if nature delivers the affirmative answer 'yes' to the posed question, but will become the vector P'V if nature delivers the negative answer 'no'. Here P' is the projection operator that keeps the vectors that P eliminates, and hence satisfies the condition $PV + P'V = V$ for all V.

[Sometimes a complex question involving a combination of several projection operators can be considered. But these can be regarded as a sequence of individual P's, and I shall adopt this simpler way of speaking.]

The essential point here is that, according to orthodox ideas, nature's process of generating the experiences that appear in our streams of consciousness cannot proceed without particular questions being posed. But then the key questions become:

If the known physical laws do not determine the choices that need to be made by the human agents in order for nature's process of generating human experiences to proceed, then what sort of considerations do influence or determine these choices?

and

What effect do these "free" choices have on the course of physical events?

The evolution of the unseen system involves a sequence of questions with Yes or No answers. Hence the interaction between nature and agent is like a game of twenty-questions: the agent is free to choose a sequence of Yes-No questions, and nature delivers an answer, Yes or No, to each, in the form of an experience that answers the posed question. The choice of question is represented within the mathematical description as the selection of one projection operator P from among an infinite continuum of possibilities. Each possible P corresponds to *particular* way of orienting a set of N mutually perpendicular vectors, and, then, a *particular* choice of which of these N vectors will be eliminated to form PV . The process of making these *particular choices* of P 's is not specified by the Schroedinger equation, which controls the *continuous* evolution of the physical state between observations, but neither the agent's choices of the questions nor nature's choices of the answer. In particular, a complete account of the dynamics needs to explain an as-yet-unexplained process that picks a sequence of particular P 's from a continuum of possibilities. This selection process is associated, according to orthodox quantum theory, with consciously made free choices on the part of human beings. And, according to the quantum rules

themselves, these "free choices" can influence the course of physical events, as we shall presently see.