PHILOSOPHICAL PROBLEMS OF THE STATISTICAL INTERPRETATION OF QUANTUM MECHANICS

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1. Classical physics

A striking characteristic of contemporary physics is the extensive utilization of statistical concepts. Statistical method is employed in the reduction of observations and in formulations of fundamental theory. It shall be the restricted purpose of this paper to discuss the role of statistics in basic physical theory.

The employment of statistical concepts in the construction of physical theory arises from the circumstance that observable physical phenomena are the resultants of large numbers of elementary processes. The reduction of large scale, macrophysical phenomena to fine scale, microphysical processes already required the use of statistical methods in classical physics. As background for the more recent quantum theoretical discussions I shall first sketch the function of statistics in classical physical theory. Classical physics was based upon the conception that observable physical phenomena have position within frames of space and time and proceed in conformity to causal laws. A causal law expresses regularity in phenomena, so that if specific data are initially given, possible data at other times can be inferred. Successful application of this conception is exemplified by the classical theories of mechanics, electromagnetism and thermodynamics. The development of fundamental theory for elementary, microphysical processes was initially molded by the foregoing classical conception. A classical microphysical theory assigned classically conceived physical quantities to elementary, microphysical processes. For example, in the kinetic theory of gases, which has served to explain large scale properties of gases, coordinates of position and components of velocity were attributed to the molecules of which the gas was assumed to be constituted. Now, the detailed specification of the state of a collection of molecules is impossible in practice. Simultaneous perception of all the molecules of a gas and therefore measurements of their simultaneous positions and velocities is beyond the power of human observation. Since an initial state of a collection of molecules could not be specified, states at other times could not be inferred with the aid of the causal laws of mechanics, which for classical microphysical theory had been extrapolated from the realm of large scale, macrophysical phenomena to the realm of fine scale, microphysical processes.

In the face of practical inability to specify in detail the microphysical state of a gas, the physicist had recourse to the theory of probability. It is well known that