THEORY OF PRECOMPOUND PROCESSES

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The need for an important extension of the theory of nuclear reactions has been demonstrated by the observation of deviations from the traditional statistical theory of nuclear reactions on the one hand, and from the predictions of the simple DWBA one-step direct reaction theory on the other. A number of theories based primarily on Griffin's [1] schematic model and variously referred to as the theory of "Pre-Compound" or "Pre-Equilibrium" processes have been developed and are reviewed by Blann [2]. The generalization of the DWBA reaction theory has led to the inclusion of multi-step processes. Formally this requires the solution of a coupled set of Schroedinger equations whose number increases projectile and excitation energy as a consequence of the many steps from the initial to the final state which become possible. The development of a simplified method for treating the large number of coupled equations is desirable as well as a unified formalism which yields a description of both the "pre-equilibrium" and multi-step direct processes.

Two such theories have been recently proposed and will be reviewed in this lecture. Both of these [3,4] are statistical theories making use of the random phase hypothesis, the resolution of the wave function into components classified according to their complexity, and the chaining hypothesis which assumes that the residual interaction connects only states of neighboring complexity. In the first group of papers [3] two processes are distinguished, the statistical multi-step compound and the statistical multi-step direct. In the first the angular distribution of the reaction products is symmetric about 90° and in a well specified limit goes over to the statistical theory of nuclear reactions. The second process predicts generally anisotropic angular distributions and in a well defined limit reduces to the single-step direct process. The statistical multi-step direct process is thought to be the dominant process over most of the energy range. At high energies it becomes a cascade theory in momentum space. The relation between the two theories [3] and [4] will be discussed.

Heavy ion reactions, among others, require an extension of these results so as to include many particle final states and to include descriptions of the reaction employing macroscopic variables such as deformation particle and charge transfer. Correction to the Pauli master equation description of the pre-equilibrium process have been especially considered in References [4] as well as the effects due to isolated doorway states. The relation between these theories and those based on the Fokker-Planck equation will be considered.

Further theoretical developments which suggest themselves will be discussed.

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