New theory of deuteron stripping to bound states and resonances

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Production of unstable nuclei close to proton and neutron drip lines has become possible in recent years, making deuteron stripping reactions (d,p) and (d,n) on these nuclei (in inverse kinematics) not only more and more feasible as beam intensity increasing but also a unique tool to study unstable nuclei and astrophysical (n,γ) and (p,γ) processes. The deuteron stripping reactions populating resonance states of final nuclei are important and most challenging part of reactions on unstable nuclei. If for nucleon transfer reactions populating bound states for about fifty years experimentalists used the DWBA, which is now gradually being replaced by more advanced approaches like adiabatic DWBA (ADWBA) , coupled reaction channels (CRC) and the coupled channels in Born approximation (CCBA) available in FRESCO code , an adequate theory for transfer reactions to resonance states yet to be developed. There are two main reasons for absence of the practical theory of stripping to resonance states which can be used by experimental groups. First one is the numerical problem of the convergence of the DWBA matrix element when the full transition operator is included. However, it is only a technical problem. The second pure scientific unsolved problem is what spectroscopic information can be extracted from the analysis of transfer reactions populating the resonance states. It was always a temptation to develop the theory of stripping into resonant states which is fully similar to stripping to bound states. The theory of the deuteron stripping into bound and resonance states A(d,p)B based on the surface formulation of the reactions has been developed. In this approach the reaction amplitude is parameterized in terms of the reduced width amplitudes (asymptotic normalization coefficients (ANCs)) and boundary conditions, i.e. the same parameters, which are used in the conventional R-matrix method for analysis of binary reactions. Thus, new theory leads to generalization of the R-matrix method for stripping reactions. This theory provides a new tool to experimentalists, which allow them to analyze stripping reactions and binary resonance reactions using the same R-matrix parameters. The theory includes continuum discretized coupled channel approach. Different examples are presented.