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On the validity of three-body model calculations

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Three-body model calculations, differing from the well-known Faddeev equations on loosely bound projectile breakup in elastic scattering on heavy nuclei have been of great success and is very easy to use in numerical calculations compared to Faddeev equations. These calculations are based on the method of Continuum Discrete Coupled Channels method (CDCC) and this has been under criticisms though the CDCC has been very successful in describing light projectile breakup reactions on heavy nuclei. In this method the total wave function is expanded in a complete set of projectile wave functions and the resulting coupled channel equations are integrated using a standard method of integration and the set of equations are solved using asymptotic boundary conditions at a small matching radius such as 20 fm or so even though the coupling potentials are long-range. This practice has to be justified mathematically. However, the results obtained by this method are in very good agreement with the experimental results. It can be shown that the diagonal potentials in the coupled channel equations are long-range and those decay as the inverse square of radius and the non-diagonal potentials are fairly short-range. By considering this, we have shown that the diagonal wave functions at large radial distance are not changed drastically taking into account their asymptotic phase using elementary mathematics. Therefore, the S-matrix element corresponding to each channel is not affected by the long-range potential tails of the diagonal potential if the laboratory energy is of a few million electron volts, and setting the asymptotic boundary condition with respect to the CDCC method at a short matching radius is justified.

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