Relation between dynamical eikonal approximation (DEA) and continuum-discretized coupled-channels method (CDCC)

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The continuum-discretized coupled-channels method (CDCC) [1] is widely known as one of the most efficient and accurate reaction models that treats breakup of loosely-bound projectiles non-perturbatively. CDCC has been highly successful in describing various breakup processes. At intermediate energies, some simplification can be made in the description of scattering wave functions. In Ref. [2], CDCC with eikonal approximation, *eikonal CDCC* (E-CDCC), was proposed. E-CDCC works well even at 30 MeV/nucleon for the breakup process of ^{8}B. Furthermore, a possible difference of about 10% between the results of E-CDCC and CDCC can be removed if one makes a quantum-mechanical (QM) correction to the amplitudes for lower partial waves.

The dynamical eikonal approximation (DEA) [3] is another successful reaction model for breakup processes at intermediate energies. DEA adopts the eikonal approximation for the projectile-target relative wave function but treats quantum mechanically the projectile wave functions during the breakup process, as E-CDCC. It will be important to clarify the relation between DEA and E-CDCC, which is the purpose of this study.

We have confirmed that, when all Coulomb interactions are switched off, DEA and E-CDCC solve exactly the same equation. Difference exists only in how to solve it: E-CDCC is based on the partial-wave expansion of the projectile wave function, whereas DEA obtains it in a three-dimensional mesh, i.e., with no partial-wave expansion. The two should give the same result, but it is not trivial because of limit of numerical calculation. Figure 1 shows the result of comparison between DEA (solid line) and E-CDCC (dashed line); the angular

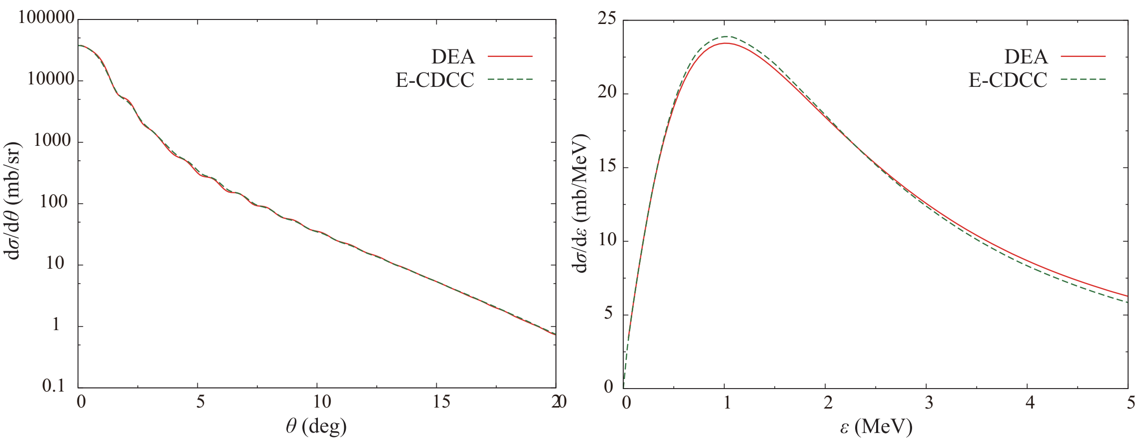

Figure 1: Comparison between DEA and E-CDCC. See the text for detail.

distribution (left panel) and energy spectrum (right panel) for the breakup cross section of ^{15}C (to ^{14}C+n) on ^{208}Pb at 20 MeV/nucleon are shown. We switch off all Coulomb interactions, hence this comparison is purely theoretical. It can be seen that the two agree very well with each other, within 1.5% difference. This remarkable agreement is obtained only when a very large model space is taken in the calculation of each model. Typically, the maximum angular momentum between ^{14}C and n in E-CDCC is 10 and the number of channels is 4,236. Thus, DEA and E-CDCC are shown to be equivalent when we have no Coulomb interactions. Investigation on effects of Coulomb distortion and Coulomb breakup is ongoing.

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